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ANNALS OF BOTANY

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ASSISTED BY OTHER BOTANISTS

VOLUME V

With XXVII Plates, in part coloured, and 4 Woodcuts

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ERRATA.

- Page 6, footnote 2, *after* 'wiss.' *insert* 'Bot.'
- „ 35, line 6, *for* 'germ-spore' *read* 'germ-pore.'
- „ 63, for corrections in the Revised List of the British Marine Algae see the 'Appendix' on p. 522.
- „ 122, line 21, *for* 'Zeille' *read* 'Zeiller.'
- „ 297, Postscript, line 11, *omit* 'not' *after* 'Cucurbitaceae.'
- „ „ „ „ 29, *for* 'when' *read* 'where.'

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On the Morphology of the Sporophyte of *Splachnum luteum*.

BY THE LATE

J. R. VAIZEY, M.A.,
of Peterhouse, Cambridge.

—♦—
With Plates I and II.
—♦—

[After Mr. Vaizey's death there were found among his papers a number of drawings, which were intended to illustrate his memoir on the Sporophyte of *Splachnum luteum*; a preliminary account of his observations had already appeared in the Proceedings of the Royal Society. There were also found a few sheets of manuscript, consisting chiefly of a description of the structure as illustrated by the figures, but the discussion of the morphological question which is indicated in the last paragraph of the paper in the Proceedings of the Royal Society was not entered upon. It has been found possible, by putting together these fragments, to present them in a connected and intelligible form, so as to demonstrate the careful observation and draughtsmanship which characterised Mr. Vaizey's work: excepting a few verbal alterations, the text, though rearranged, is entirely his own. The Editors are indebted to the Council of the Royal Society for permission to make use of the paper which appeared in the Proc. Roy. Soc. No. 274, Dec. 1888].

THE investigations of Haberlandt¹, published in the latter part of 1886, together with the results of investigations of my own, which were then just completed, and communicated to the Linnean Society² early in 1887, convinced me of the importance of obtaining further knowledge of the highest development to which the sporophyte of the Mosses attains, as being likely to throw light indirectly on the phylogeny of the higher Cryptogams and Phanerogams. Inquiring into the

¹ Beiträge zur Anatomie und Physiologie der Laubmoose; Jahrb. für wissens. Bot., vol. XVII.

² Vaizey: On the Anatomy and Development of the Sporogonium of the Mosses. Linn. Soc. Journ., Bot., vol. XXIV.

[Annals of Botany, Vol. V. No. XVII. December 1890.]

matter, I found that *Splachnum luteum*, *Splachnum rubrum*, and some few other forms were the most likely to yield the best results; I determined, therefore, to obtain material for investigating their morphology. These forms being arctic or subarctic, I put myself in communication with Professor Axel Blytt, of Christiania, to find out if he could either procure me material properly preserved for the purpose, or put me in the way of obtaining material if I went myself to Norway. From my correspondence with Professor Blytt, I concluded that the only really practicable course was to go myself, and obtain my own material in the different stages in which I required it. To carry out this project, I applied for, and was granted, assistance by the Royal Society. I, therefore, now tender to the Society a brief outline of the first of my results.

I obtained after considerable search, in which I was fortunate in having the invaluable assistance of Professor Blytt and Dr. F. C. Kiaer, whose knowledge of the habitats of Norwegian Mosses is notorious, a large quantity of *Sp. luteum* in many different stages of development; of *Sp. rubrum* I only obtained one specimen; but beyond the mere difference of colour there is little or no difference between the two species. The material was obtained in the marshy land on the top of the watershed between the River Glommen and Lake Miosen, and on the south-eastern side of the Dovrefjeld region.

In the sporophyte of *Splachnum luteum* we have a structure with a remarkable similarity to an umbrella, the handle-end of which is inserted in the tissues of the oophyte, and is known as the foot (Fig. 1). The seta is much elongated, frequently attaining a length of 150 mm.: it bears the umbrella-like expansion, the apophysis, at the top just below the sporangium. It is the structure of the apophysis and certain of the organs of the sporophyte with which we are now concerned.

A transverse section through the vaginula, including the foot of the sporophyte, shows that the tissues of the oophyte in this part contain a considerable quantity of organic sub-

stance, and this is seen to be more particularly the case in the layers of cells next to the foot (Fig. 3)¹. The foot itself is seen to consist of a cylindrical mass of parenchyma, with an external layer of epidermal cells of a somewhat columnar form, which contain a considerable quantity of protoplasm, together with large distinct nuclei (Fig. 4). The protoplasm of these cells is found to be aggregated towards the peripheral surface, the nucleus being usually found in the mass of protoplasm next to the outer wall of the cell. The large vacuoles of these cells are traversed by fine protoplasmic filaments. These cells, as well as those of the cortical layer beneath the epidermis, contain a number of very small protoplasmic bodies, which are found congregated in large numbers round the nuclei of the cells, there being also some in other parts of the cell, both in the peripheral layer and in the fine protoplasmic filaments traversing the vacuole. In the epidermal cells these bodies are particularly numerous, and are found principally in the aggregated mass of protoplasm on the outer side of the cells. These bodies may, I think, be safely regarded as leucoplastids. From their number and position, I am inclined to believe that they are concerned in absorbing substances from the tissue of the oophyte for the nourishment of the sporophyte. No starch has been found in the foot. The general relation of the foot to the vaginula is shown in longitudinal section in Fig. 5.

In the centre of the foot there is a definite central strand consisting of two kinds of tissue, an outer phloëm-like layer of cells containing protoplasm by means of which it is probable that organic substance travels, and an inner strand of very thin-walled cells without any protoplasmic contents² which conduct the water up the seta (Fig. 6 and 6 bis). In the foot the protoplasm of the phloëm-like cells is aggregated in each cell towards the periphery as in the epidermal cells, but there are no plastids present. The strand of thin-walled

¹ [N. B. The cell-contents are not drawn in Fig. 3.]

² Cf. Vaizey, *loc. cit.* The terms leptophloëm and leptoxylem have been used to indicate these tissues. For fuller explanations, see paper referred to.

empty cells¹ I have been able to prove in other species of *Splachnum* conveys the water absorbed by the foot up the seta into the tissues of the apophysis.

The seta has a distinct epidermis beneath which there is a layer of sclerotic supporting-tissue, and then a layer of parenchyma, the two together forming the cortex. In the centre is the central strand, which in the lower end of the seta has almost the same structure as that described for the central strand of the foot, from which it is distinguished by being larger and less distinctly delimited from the cortex (Fig. 7). Higher up in the seta there is a large intercellular canal formed in the middle of the axile strand of thin-walled empty cells which extends for nearly its whole length. This intercellular space is lysigenous in origin. A similar passage or canal occurs in several other species (Fig. 8).

A longitudinal median section through the umbrella-shaped apophysis (Fig. 9, Plate II) shows that the central strand here swells out into a large pear-shaped mass of cells which, in the mature sporophyte, contain no protoplasm, and even in the younger states only a very small quantity with small, inconspicuous nuclei. Chlorophyll-bodies are absent except in the two outermost layers of cells, even in the youngest specimens observed, and even here there are only a very few. The cells are all thin-walled, and cubical in shape, with no intercellular spaces between them. In this tissue, which may be regarded as a kind of aqueous tissue, large masses of crystalline inorganic matter were frequently found.

Outside the aqueous tissue (Fig. 10) there is a quantity of parenchymatous tissue, with numbers of communicating intercellular spaces. The cells all contain large numbers of chlorophyll-bodies. This tissue extends into the umbrella-shaped organ. On the upper surface in the proximal region the cells are arranged close to one another, and show a distinct tendency to an elongation of their axes in a direction vertical to the surface, thus forming a palisade-tissue similar

¹ Vaizey: Note on the Transpiration of the Sporophore of the Musci. *Annals of Botany*, vol. I.

to that in the tissues of the vascular plants¹. This is rendered more striking by a comparison with the parenchyma of the lower surface in the same region, where the cells are much elongated in a direction parallel to the surface, and with very much larger intercellular spaces. The distal region of the apophysis shows that the cells of both upper and lower surfaces have undergone a considerable lengthening in the direction parallel to the surfaces, but that the upper as compared with the lower has still a resemblance to palisade-tissue (Figs. 11, 12).

The epidermis covering the apophysis is of a pale brown tint resembling most closely the epidermis of the leaf of a typical Phanerogam, the external wall of the cells being the thickest (Figs. 10, 12). On the upper surface of the part of the apophysis which is nearer the sporangium the epidermal cells are flattened; as the periphery is approached they become cubical, and in young specimens are even columnar in form (Fig. 11). On the under surface the same state of things is found, the epidermal cells nearest the seta being very much flattened. There is distinct cuticularisation of the epidermal cell-walls, and a distinct cuticle is present on the external surface, as is shown by the action of Schulze's solution. The outer walls of the epidermis are thicker on the upper side of the apophysis than on the under, and a cuticle is also present on the under surface of the apophysis. Cuticularisation does not extend completely through the walls of the epidermal cells; the inner layers of cell-wall becoming bright blue with Schulze's solution, thus showing that those layers consist of pure cellulose. A plate of cuticularised membrane extends down the middle of the radial cell-walls from the external cuticularised layer. As far as I could determine, there were in the epidermal cells only a very few small chloroplastids present, in which starch is sometimes to be found, but only in small quantities.

¹ Haberlandt (*loc. cit.*) also makes a comparison between the chlorophyll-containing tissue of the sporophyte of the Mosses and the palisade-tissue of true leaves; but in none of the forms which he investigated is this structure as striking as it is in *S. luteum*.

There are a number of stomata on the upper surface of the apophysis, the position of which is shown in the diagram (Fig. 9): one only is drawn in Fig. 10, although a median longitudinal section may pass through as many as three. Fig. 15 gives a surface view of a stoma from a young apophysis at a time previous to the development of the surrounding epidermal cells into the radiate arrangement, which they assume in the mature apophysis (Fig. 16). The guard-cells are quite separate, as in the vascular plants, thus differing from the guard-cells of the stomata of the *Polytrichaceae* and *Funaria*. A transverse section (Fig. 13) through the middle of the stoma shows that the form of the lips is quite normal, here again differing from the *Polytrichaceae*¹ (Fig. 18) and some other Mosses². The stoma opens into an intercellular cavity of considerable size (Fig. 13), the full extent of which is seen on comparing longitudinal (Fig. 14) with transverse sections (Fig. 13). The guard-cells of the stomata contain a considerable number of large and well-defined chloroplastids, thus differing from the rest of the epidermal cells. The action of Schulze's solution shows that on the external surface of the stomata there is a distinct cuticle (Fig. 17), which extends through the stomatal opening and on to the inner surface of the guard-cells. The innermost layers of the cell-wall of the guard-cells swell up to a much greater extent, and become a much deeper blue with Schulze's solution than do any of the rest of the cell-walls throughout the whole of the apophysis. A similar state of things was found in the stomata of *Polytrichum commune*, where cuticularisation has extended completely through the whole thickness of the cell-walls of the ordinary epidermal cells, but in the guard-cells the inner layers swell up with Schulze's solution, and are coloured deep blue.

A large quantity of starch is formed in the cells of the

¹ Vaizey, on the Anat. and Develop. of the Sporogonium in the Mosses. Journ. Linn. Soc. vol. XXIV.

² Haberlandt, Beiträge z. Anat. und Phys. d. Laubmoose; Jahrb. f. wiss. XVII. 1886. [Compare also E. Bünger, Bot. Centbl. 1890, Bd. XLII, p. 193, &c.]

apophysis by the chloroplastids, each chloroplastid containing a number of separate starch-grains. When the apophysis is quite young, at this time being green, immediately on its beginning to become umbrella-shaped, and before the spores ripen, the starch begins to be formed. At a later stage the starch disappears, the starch-forming plastids, which before were large and well-formed, degenerate into small and comparatively inconspicuous bodies, the starch apparently being used up in the formation of spores. In all probability there is at this period a formation of xanthophyll, which would account for the yellow colour of the apophysis in the mature condition of the sporangium, and hence the name of the species.

That the apophysis performs the functions of a leaf, and is therefore *analogous* with the leaves of vascular plants, I think there can now be no doubt. And as this structure is a development of the sporophyte, the possibility of its being also *homologous*, either directly or indirectly, suggests itself. I am myself inclined to believe that the two are homologous; but to give a full discussion of that question would be beyond the scope of the present communication.

The structure of the spore-capsule is quite typical: it is covered by a dark reddish-brown epidermis, which is cuticularised. The outer walls of the epidermal cells are rather thin, but the radial and anticlinal walls are thickened in a peculiar and characteristic way (Fig. 19): it will be observed that on the thickened side-walls of the epidermis there are large pits of varying form, as seen when looking on to the walls in the plane of the section; at the same time the walls which are at right angles show thickenings of an elliptical or cordate shape: similar thickenings occur in other species of *Splachnum*¹. Beneath the epidermis there are two or three layers of cortical cells, and then the large intercellular space (I) in Figs. 9 and 10, characteristic of the Moss-capsule. The columella has the same structure as I described in a

¹ Vuillemin, Sur les homologues des Mousses; Nancy, 1886.

former paper¹ in the sporogonium of *Catharinea* (*Atrichum*). The peripheral portion of the columella consists of nearly cubical, or hexagonal cells, with longitudinal and transverse diameter approximately equal, while the central part of the columella is occupied by cells which are very distinctly elongated and narrow (Fig. 10). The structure of the teeth of the peristome in this genus is so remarkable that I cannot pass it by without mention, although Lantzius-Beninga² did not omit to treat of it in his classical work on the peristomes of Mosses. On the radial walls of the cells which go to form the peristome there are a number of horizontal thickenings which in longitudinal section have a remarkable similarity of appearance to the thickenings in the protoxylem of Vascular Plants, and at the same time recall the thickenings in the elaters and cells of the walls of the sporangia of many Hepaticae.

[Here the MS. ends. Other figures, besides those now published, were also found among Mr. Vaizey's papers; but as they were not referred to in the MS. and did not form any connected series, it was thought best not to publish them. This is especially the case with some drawings illustrating the development of the sporogonium, which Mr. Vaizey had begun to study in *Splachnum vasculosum*, but the series is too fragmentary to be of material use.]

¹ Vaizey, Anat. and Develop. of Mosses; Journ. Linn. Soc. vol. XXIV.

² Beit. z. Kenntniss des Baues d. ausgew. Mooskapsel, in besonderem d. Peristomes; Nov. Act. Akad. Leopold. Carol. vol. XXII, 1847, p. 577.

EXPLANATION OF FIGURES IN PLATES
I AND II.

Illustrating the paper of the late Mr. J. Reynolds Vaizey on the Morphology of the Sporophyte of *Splachnum luteum*.

The descriptions are based upon short notes written by Mr. Vaizey upon the margins of the drawings.

Fig. 1. Mature Plant of *Splachnum luteum*. *o*=oophyte. *sp*=sporophyte. *s*=seta. *ap*=apophysis. *c*=capsule. ($\times 2$).

Fig. 2. *a-i* successive stages of development of the sporogonium, illustrating the mode of origin of the discoid, or bell-shaped apophysis. *a-e* are slightly enlarged. *f-i* are natural size. *h* is an old specimen in which the apophysis has become discoid.

Fig. 3. Transverse section of the foot of the sporogonium (*f*) and of the vaginula (*v*). The cells of the leptophloem, which are shaded, are full of protoplasm in the upper and middle part of the foot, in sections from the lower part they are empty. The cells within this layer are the leptoxylem; they are empty and perform the function of conducting water. [N.B. The cell-contents of the external layer of the foot, though referred to in the text, are not drawn in this figure, but they are shown clearly in fig. 4.] Crouch $\frac{2}{3}$, oc. 4, reduced to two-thirds.

Fig. 4. This figure was not named by Mr. Vaizey, but it is believed to represent the external epidermal layer of columnar cells referred to in the text, in contact with the tissue of the vaginula. The MS. description is as follows: 'N.B. Little round bodies are plastids, stained with Hoffman's blue, and haematoxylin, not stained by methylene-blue.' Zeiss F, oc. 2.

Fig. 5. Apex of the foot of *Splachnum luteum* within the vaginula, as seen in longitudinal section. No magnifying power is stated.

Fig. 6. Transverse section through the central strand of the foot, from a section stained with haematoxylin. *l.ph*=leptophloem. *l.xy*=leptoxylem. Crouch $\frac{1}{3}$, oc. 2 (reduced to $\frac{2}{3}$).

Fig. 6 bis. Longitudinal section of part of the central strand of the foot of *Splachnum luteum*, and of the cortex (*c*) immediately surrounding it. Mr. Vaizey notes that the section is 'not median but distinctly tangential, the faint lines in the leptoxylem (*l.x*) show where the cells next to those in section join on.' *l.ph*=leptophloem. Crouch $\frac{1}{3}$ obj., oc. 1, reduced to two-thirds.)

Fig. 7. Central part of a transverse section of the seta between 1 and 2 centimetres above the vaginula, showing the central strand of thin-walled cells of water-conducting tissue. Zeiss F, oc. 2, reduced to two-thirds.

Fig. 8. Transverse section of the mature seta of *Splachnum luteum*, showing the central lysigenous intercellular space. (Zeiss D, oc. 2.)

Fig. 9. Median longitudinal section of the upper part of the sporogonium. *s*=seta. *ap*=apophysis. *c.s*=central strand. *st*=stomata. *M*=mesophyll. *C*=capsule. *cl*=columella. *As*=archesporium. *I*=intercellular space. *P*=peristome. The area enclosed in the dotted lines is drawn on a larger scale in Fig. 10.

10 Vaizey.—On the Sporophyte of *Splachnum luteum*.

Fig. 10. Part of a similar section drawn on a larger scale. *pal.* = palisade-parenchyma. *sp. s* = spore-sac. (Zeiss A, oc. 2, reduced to one-half.)

Fig. 11. Similar section of the edge of the apophysis showing the relation of epidermis and mesophyll (*mes*). (Zeiss obj. $\frac{1}{8}$, oc. 2.)

Fig. 12. Epidermis (*ep*) and parenchyma from the upper side of the apophysis. (Zeiss D, oc. 2.)

Figs. 13, 14. Views of stomata in transverse and longitudinal section. *ep* = epidermis. *g. st.* = guard-cell of stoma. (Zeiss D, oc. 2.)

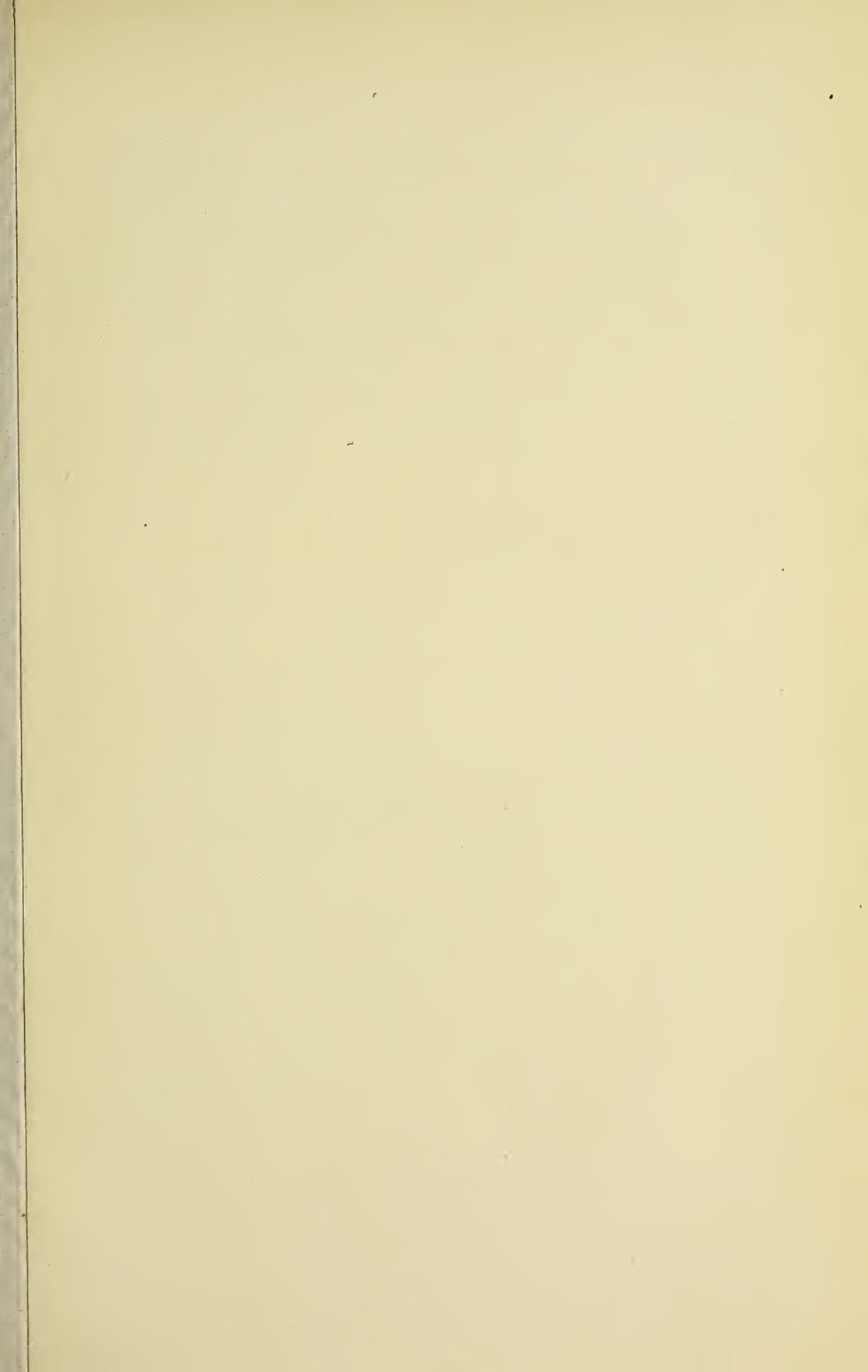
Fig. 15. Young stoma in surface view. (Zeiss D, oc. 2.)

Fig. 16. Stoma and surrounding cells from a full-grown apophysis. ($\frac{1}{8}$ obj., oc. 1.)

Fig. 17. Section through the guard-cells and epidermal cells from a transverse section of the apophysis of *Splachnum luteum*.

Fig. 18. Section through a stoma of *Polytrichum commune*. *g* = guard-cell. *ep* = cells of epidermis. *c* = cortical parenchyma.

Fig. 19. Epidermis from the sporangium of *Splachnum luteum* in transverse section.



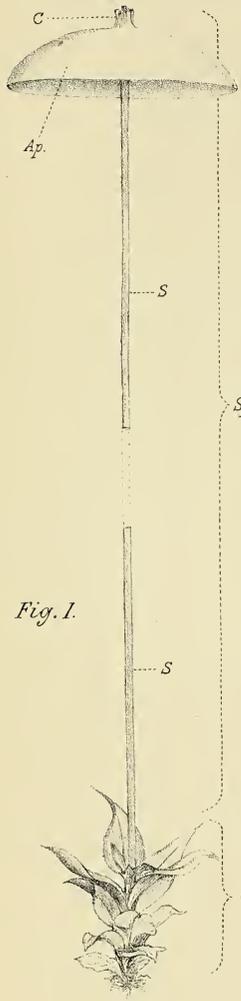


Fig. 1.

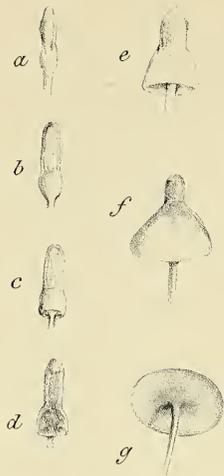


Fig. 2.

Fig. 3.

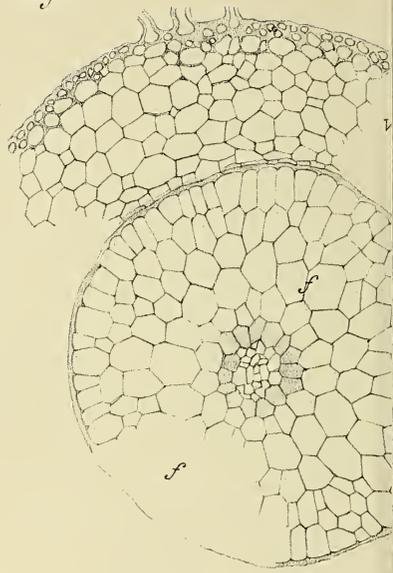


Fig. 7.

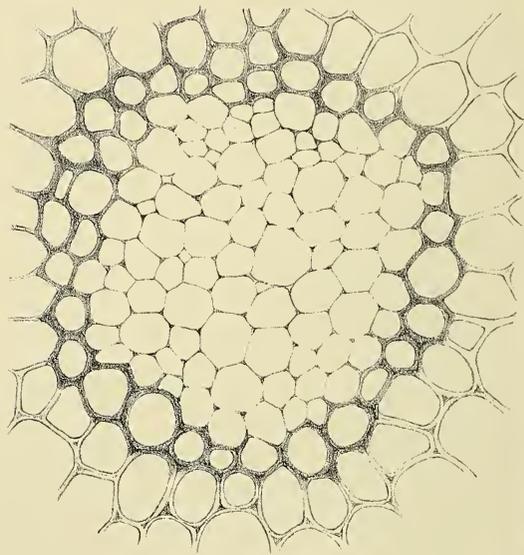
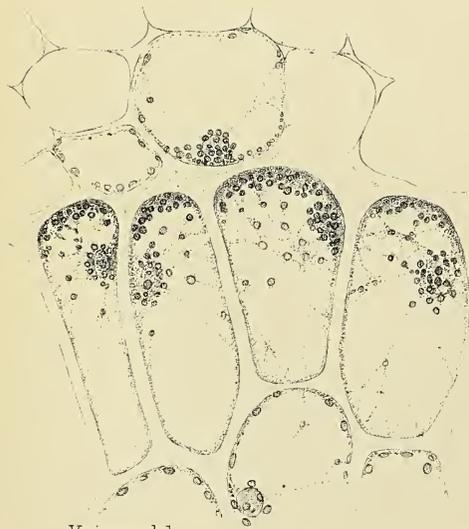


Fig. 4.



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Fig. 6.

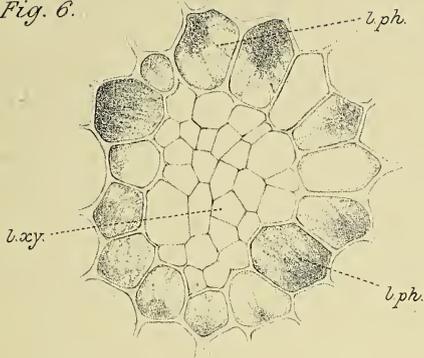


Fig. 6. bis.

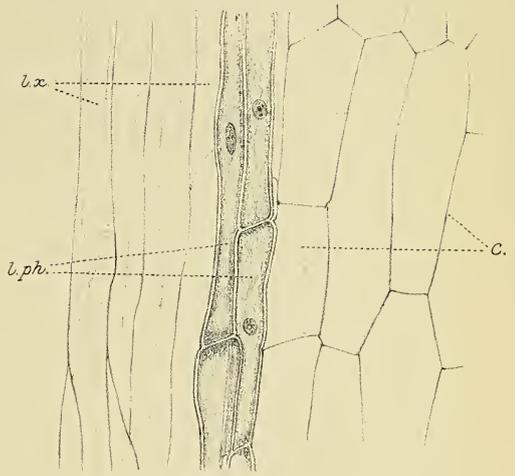


Fig. 5.

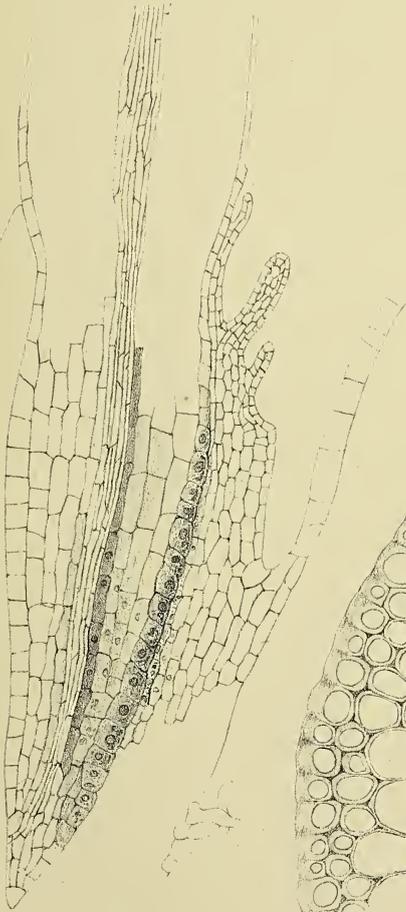
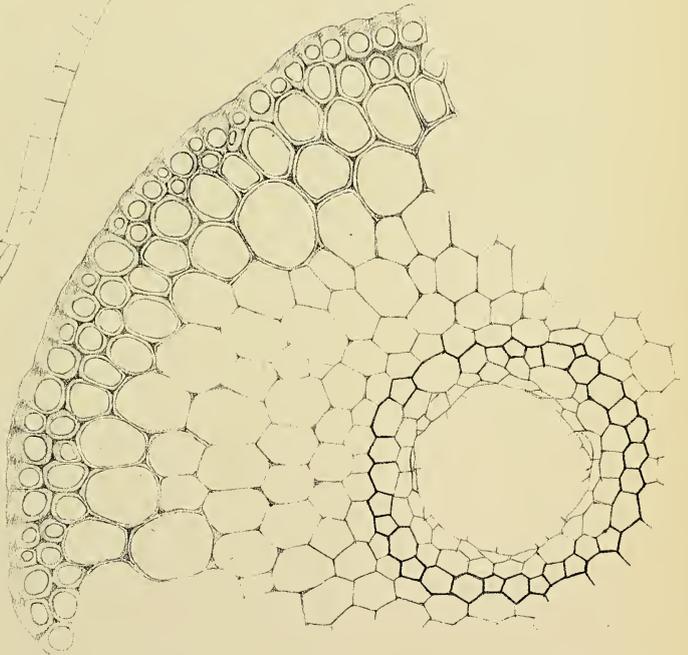


Fig. 8.



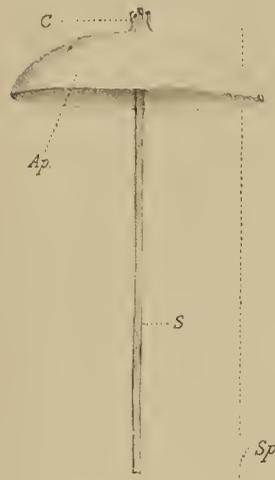


Fig. 2.

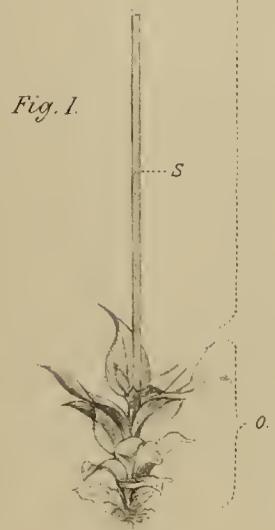


Fig. 1.

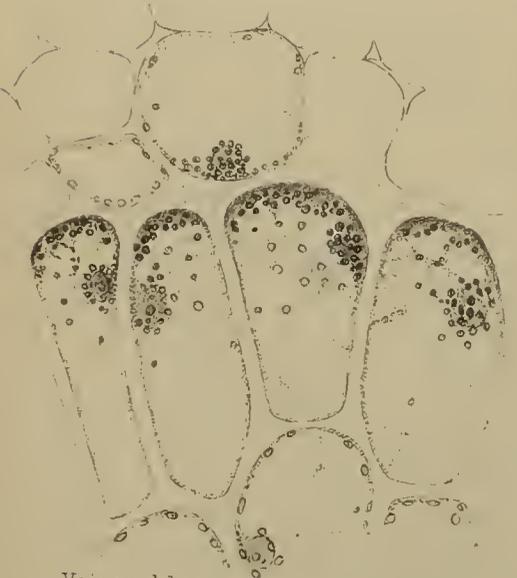


Fig. 4.

Fig. 3.

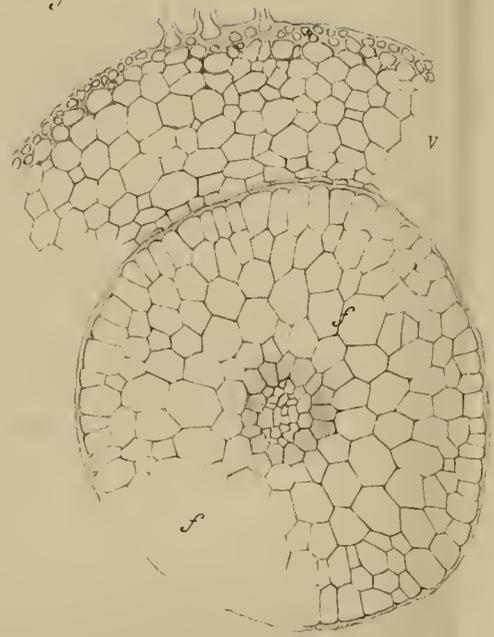


Fig. 7.

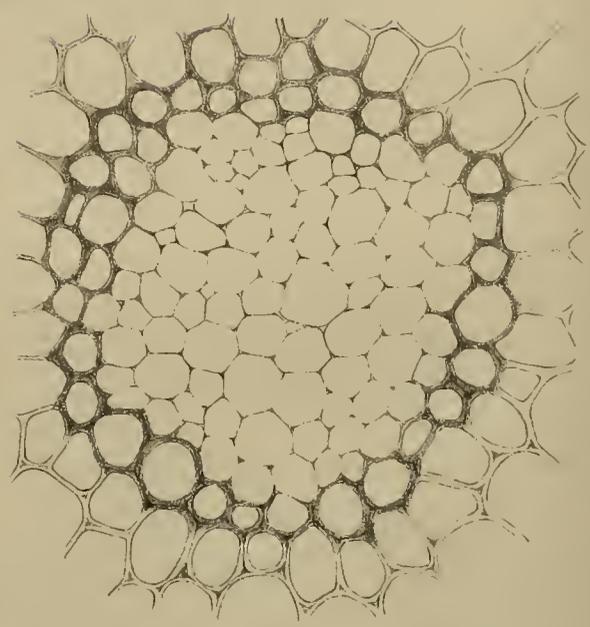


Fig. 6.

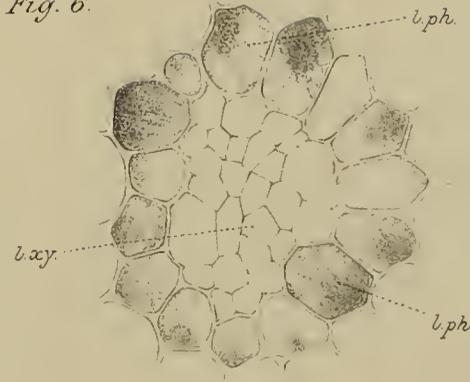


Fig. 5.

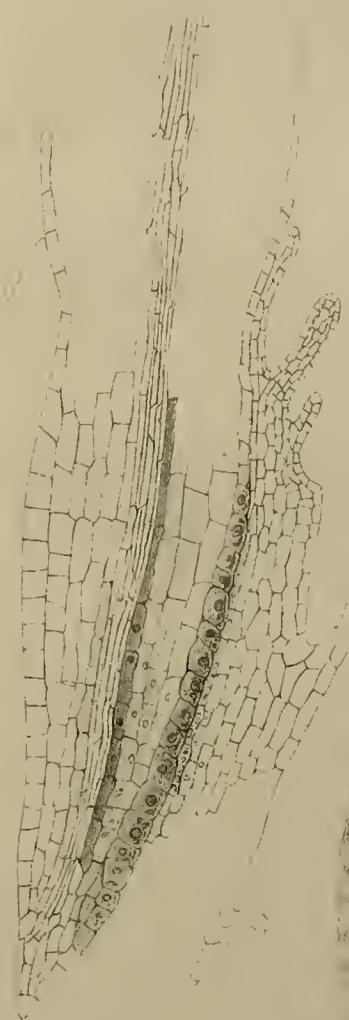


Fig. 6. bis.

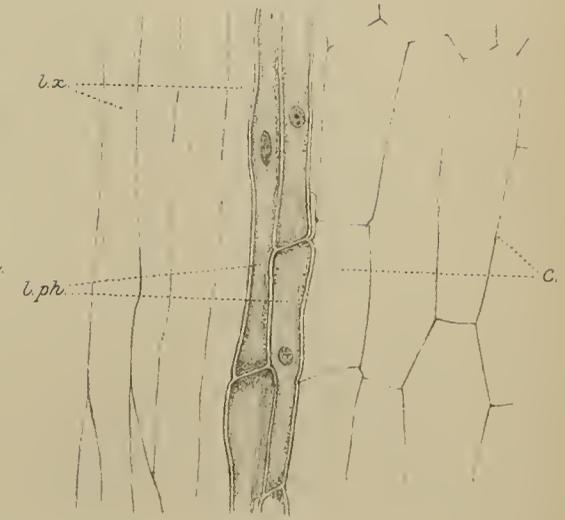
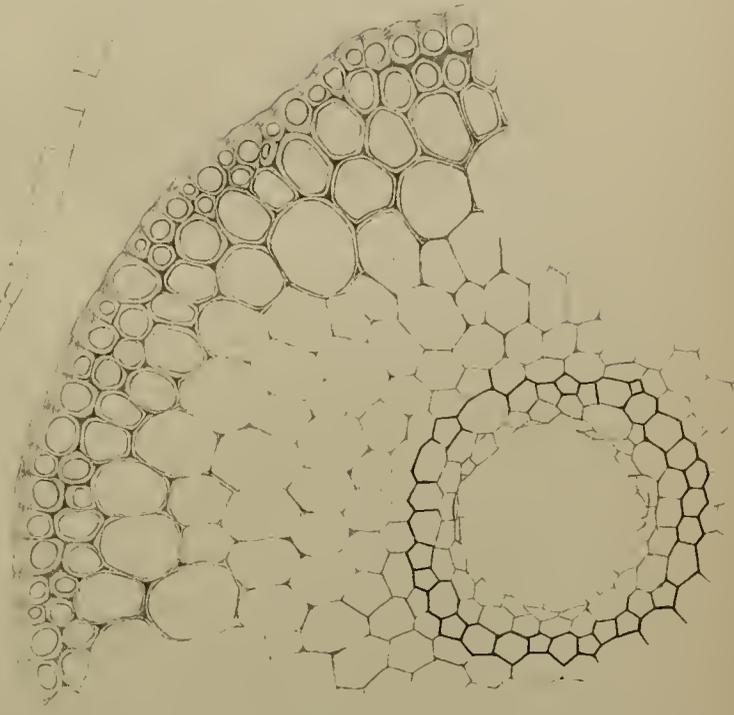
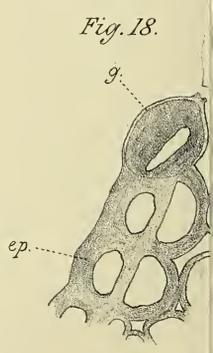
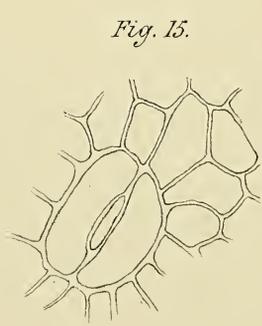
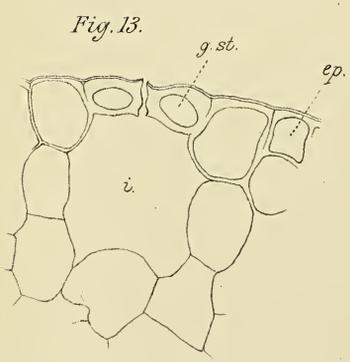
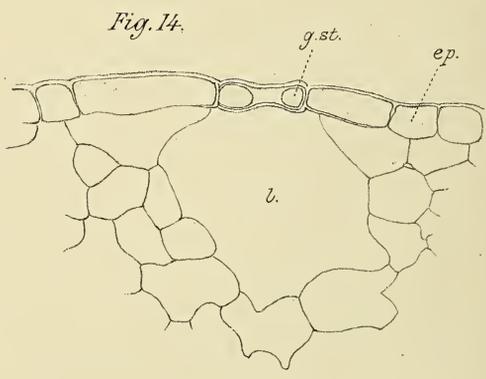
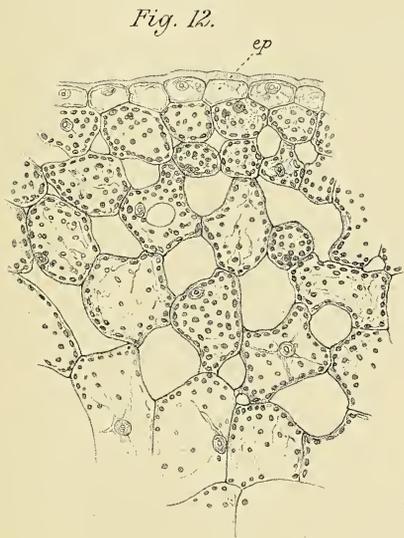
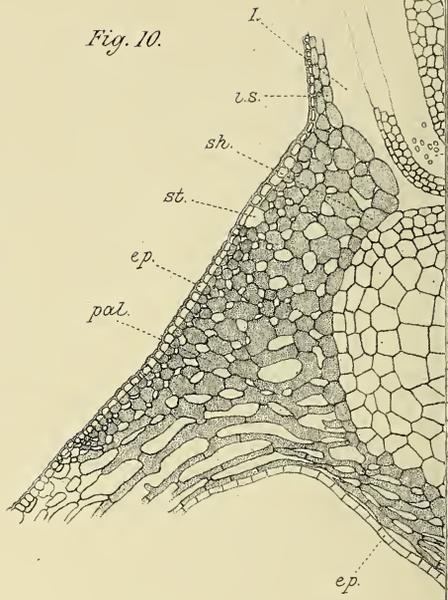
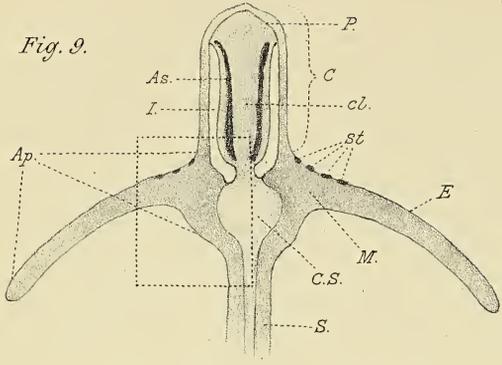


Fig. 8.



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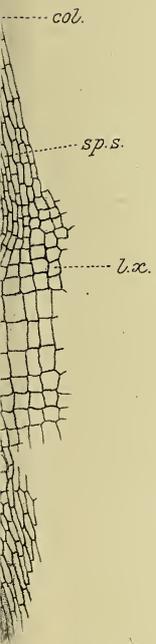


Fig. 11.

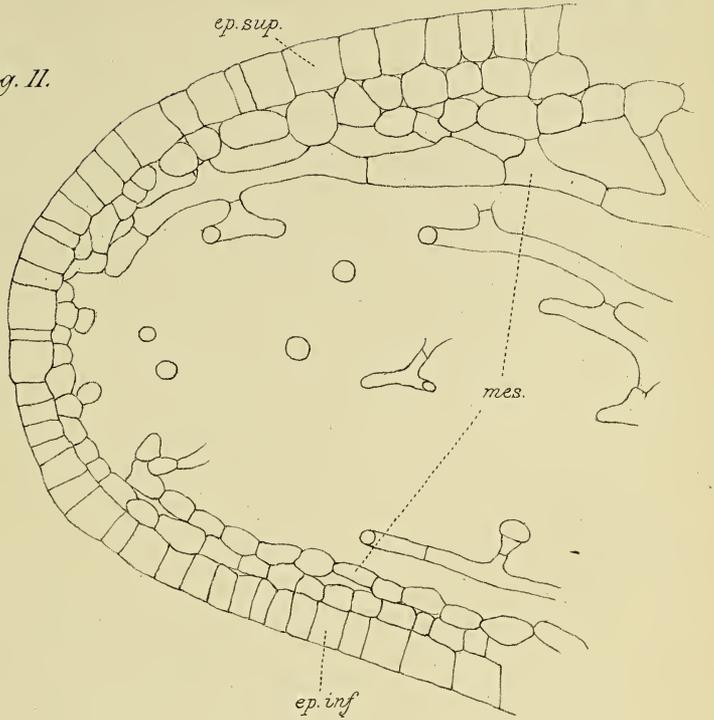


Fig. 16.

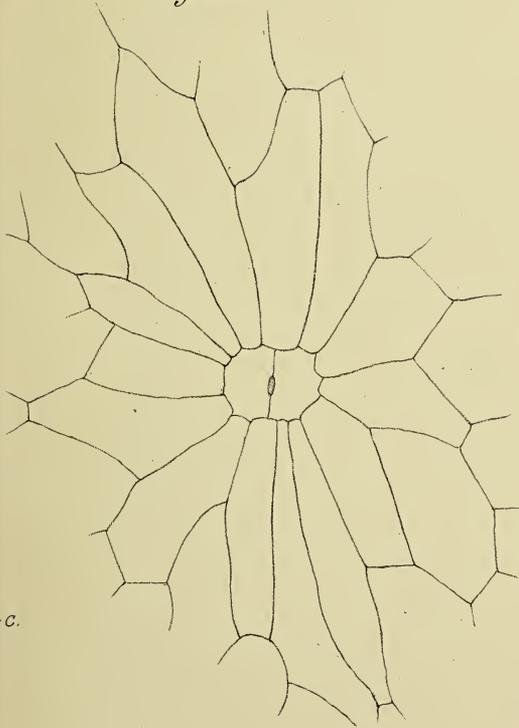


Fig. 17.

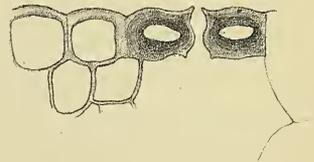
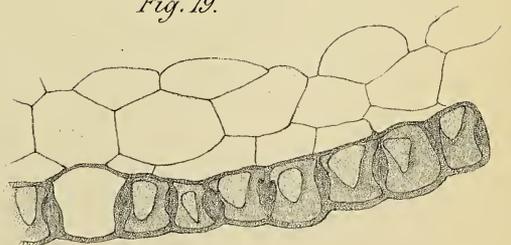
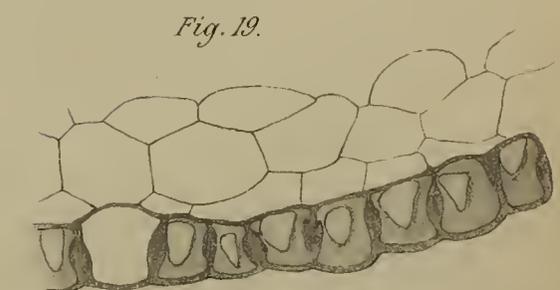
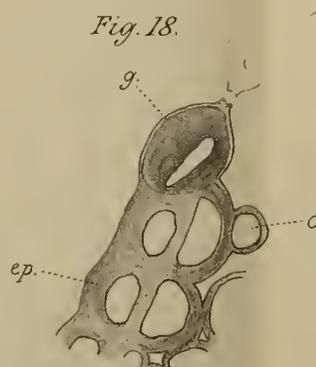
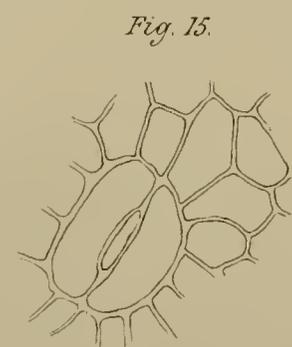
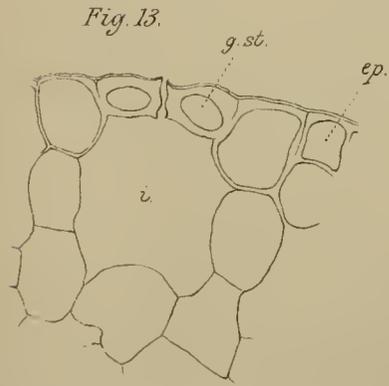
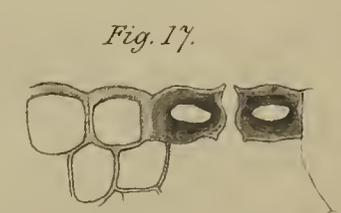
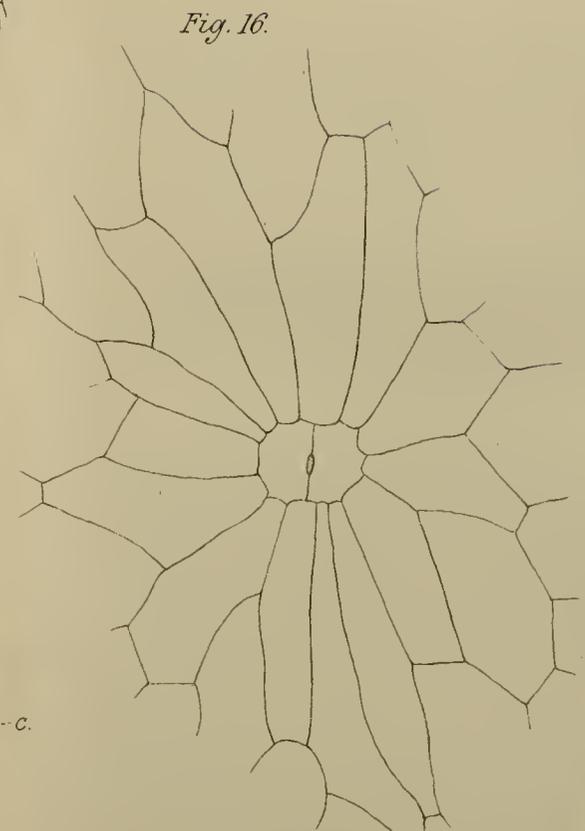
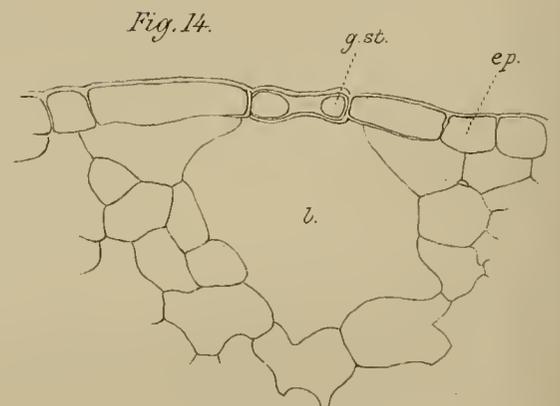
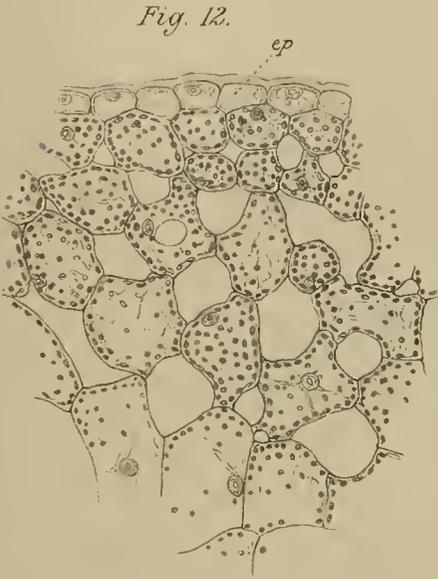
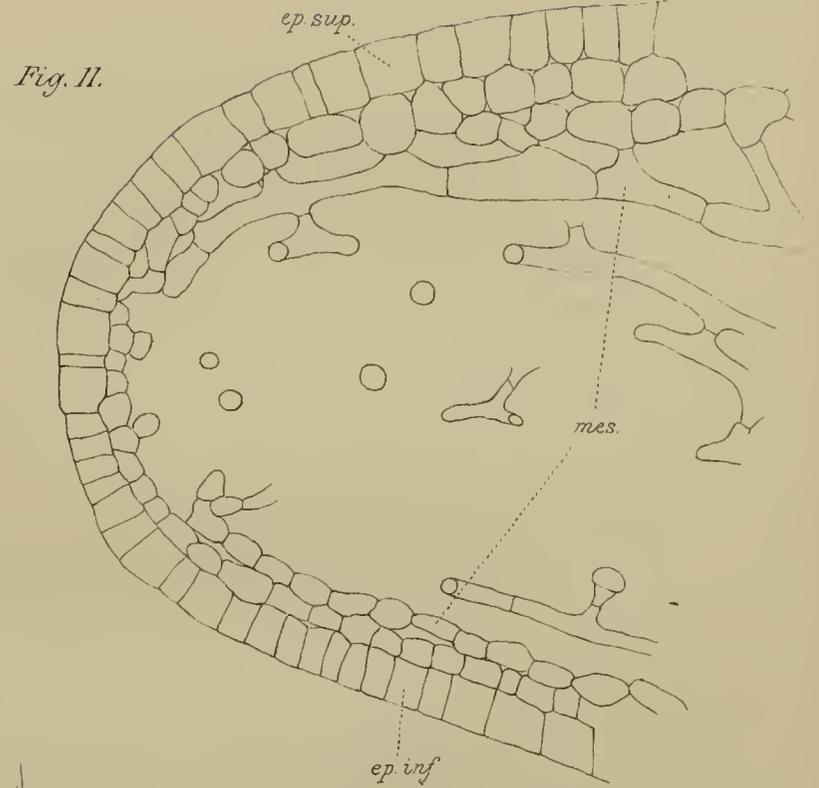
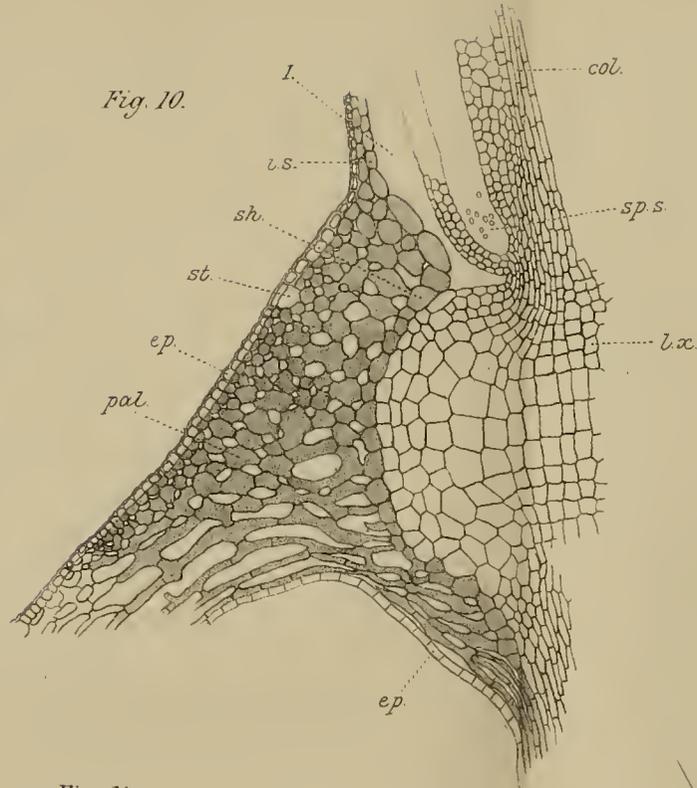
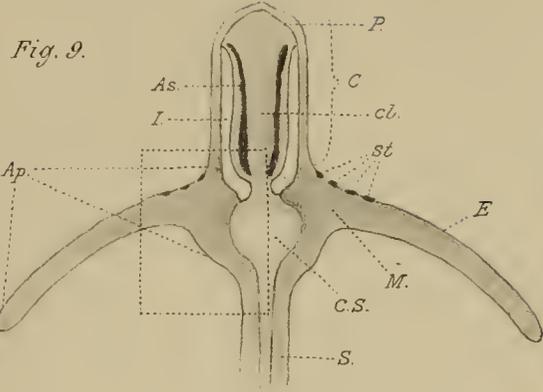


Fig. 19.





Vaizey del.

On the Structure and Function of the Septal Glands in *Kniphofia*.

BY

E. R. SAUNDERS,

Newnham College, Cambridge.

—♦—
With Plate III.
—♦—

AMONG the more recent additions to the literature which deals with the subject of septal glands in plants may be mentioned the papers of Grassmann¹ and Acton². Grassmann's work gives an account of the general structure and distribution of septal glands, while Acton is chiefly concerned with the question of sugar-formation in the gland-cells. The wider subject of floral nectaries is treated of in the earlier papers of Bonnier³ and Behrens⁴, but none of these observers includes in his account a detailed description of the minute structure of the secretory cells. It was suggested to me that careful histological examination of these cells might reveal the existence of interesting relations between their structure and their manifestation of secretory activity. I therefore made a preliminary examination of the septal glands of various species of *Kniphofia*, *Gladiolus*, *Narcissus*, *Agave*, and *Polygonatum*, and was led to select the first of these plants as being the most suitable for investigation. The ovary is of small size in this genus, but this drawback is more than counterbalanced by the following obvious advantages: (1) the amount of nectar secreted is considerable; a fully open

¹ Flora, 1884.

² Annals of Botany, 1888.

³ Ann. des. Sci. Nat. 1878-79.

⁴ Flora, 1879.

flower contains two or three drops of very sweet nectar at the base of the flower tube, and (2) the size of the secretory cells is comparatively large.

After trying various hardening reagents, I found that the structure of the cells was best preserved by treatment for three or four days with a 2 per cent. solution of ammonium or potassium bichromate (as a rule the former gave the best results). The ovaries only were hardened, and in order to ensure that the solution should penetrate as rapidly as possible, portions of the external cuticle were stripped off, and the extremities of the ovary itself were removed by transverse section, before it was placed in the hardening fluid.

I examined the following species of *Kniphofia*; *K. nobilis*, *media*, *aloides* var. *max.*, and *uvaria*, but I was unable to detect any differences in the histological appearances which I could regard as specific; the following account therefore applies equally to them all. I propose to describe

I. The position and course of the glands, and

II. The minute structure of the cells which compose the gland.

I. POSITION AND COURSE OF GLANDS.

The glands are normally three in number, one occurring in each septum of the trilocular ovary; they are simple and extend almost throughout the whole length of the septum (Fig. 2). Each arises at a level only slightly above that at which the ovary-cavities make their appearance, and here forms a compact group of coherent cells, which however split apart almost immediately, and surround a central cavity,—the lumen of the gland. The lumen opens on to the external surface immediately below the base of the style (Fig. 2), and here the gland-cells which bound the lumen become continuous with the epidermal cells of the external wall of the ovary. The short passage (leading on to the surface) in which this transition takes place may be conveniently termed the neck of the gland (Fig. 2, *n.*). In transverse section the glandular area has roughly the form of an ellipse, the long

diameter of which coincides with that of the septum. This area is fairly constant at all levels except that of the neck and of the extreme base of the gland, where it diminishes, gradually in the latter case, rather more rapidly in the former. The lumen is wider in the upper and lower extremities of the gland than in the middle (Fig. 3), where the cells on either side approximate, especially at the inner margin of the gland.

II. THE MINUTE STRUCTURE OF THE CELLS WHICH COMPOSE THE GLAND.

The gland-tissue consists of—

- (1) A single layer of *epidermal* cells ;
- (2) A variable number of layers (generally four or five) of modified parenchymatous cells, which lie behind the epidermal cells, and to which I shall henceforth refer as the *sub-epidermal* cells.

Behind the sub-epidermal cells lie the ordinary unmodified parenchymatous cells of the septum, and the fibro-vascular tissue. There are from eight to twelve small fibro-vascular bundles in each lateral half of the septum ; these bundles arise at fairly regular intervals, and are offshoots from the fibro-vascular tissue running vertically in the central axis of the ovary. They bend outwards at a more or less acute angle, and, running nearly horizontally outwards in the septum, finally curve round into the wall of the ovary and there resume their vertical course (Fig. 1, *f. v.*). Since these bundles sometimes run in the unmodified parenchymatous tissue of the septum, and sometimes between it and the glandular tissue, they do not form such a well-marked line of separation between the two, as is the case, e.g. in some (?) species of *Gladiolus*, in which plants moreover their course in the septum is vertical.

To return to the minute structure of the gland-cells.—I shall begin by describing the histological appearances which are exhibited by a typical (*a*) epidermal, and (*b*) sub-epidermal cell when quite young, such cells for example as are to

be seen in a very young flower-bud, and shall then trace the changes which take place in (α) cell-wall, (β) nucleus, (γ) cell-contents, during the period of development from the young bud to the fully open flower, noting finally the extent to which these changes are dependent on the relative position of the cells.

A. **Very young Bud** (Fig. 4).

(a) The epidermal cells are cubical to columnar in shape, and somewhat smaller than either the sub-epidermal cells, or the unmodified parenchymatous cells of the septum.

(α) The external wall (bounding the lumen) is uncuticularised, and at first exhibits a plane surface; the lateral and basal walls are continuously applied to those of the neighbouring cells.

(β) The nucleus occupies a very large proportion of the cell-cavity, it is generally spherical or oval in shape, and lies centrally; one, two, or three nucleoli are often present.

(γ) The protoplasm occupying the rest of the cell is dense and granular, and in that part of it which immediately surrounds the nucleus minute starch-grains very soon make their appearance.

(b) The histological modifications of the sub-epidermal cells are always most marked in those lying immediately beneath the epidermis, and gradually become less and less so in those lying further from the lumen, so that there is no sharply defined boundary between these deeper layers and the unmodified parenchymatous cells of the septum, but a gradual transition from the one to the other.

(a) The sub-epidermal cells vary considerably in shape, but as a rule all three diameters are roughly equal. Their arrangement is less regular and compact than that of the epidermal cells, and this character becomes gradually more marked in the deeper layers, where inter-

cellular spaces occur, and where the cells are generally slightly larger than those which are immediately hypodermal.

(β) The nuclei resemble those of the epidermis, but are smaller in proportion to the size of the cells.

(γ) The protoplasm is less dense, and the starch-grains more numerous than in the epidermal cells.

Starch is present in the unmodified parenchyma of the septum, and occurs also in abundance in the central axis, where the grains are much larger.

B. An older Bud (Fig. 5).

(a) The epidermal cells are about the same size as the sub-epidermal cells, or only very slightly smaller.

(a) The external wall is slightly convex, and has undergone an increase in thickness; in the largest buds it is seen to be differentiated into two layers, a very narrow external one which is sharply defined, and a broad internal one, the inner outline of which is much less distinct than it was before the thickening took place; in fact it has the appearance of having undergone corrosion. This thickening of the cell-wall is probably due to mucilaginous degeneration of the inner layers, for the broad internal band no longer gives the reactions of cellulose, whereas the narrow external band still appears to be coloured a pale violet by Schultze's solution, though of this I could not be quite sure owing to its extreme thinness. This change never seems to involve the whole wall, since in older flowers, where the degeneration has reached its maximum, this thin membrane of unaltered cellulose can still be distinguished.

(β) The form and position of the nucleus are not appreciably altered.

(γ) The protoplasm is not so dense as in the cells of the younger bud, vacuoles being often apparent; in still older buds however this vacuolation becomes less marked

owing to an increased formation of granular substance in the cells—probably a deposition of granules of metaplastm in the cell-protoplasm. The starch-grains are larger as well as more numerous, and their outline is more distinct; they are frequently arranged in a more or less complete ring round the nucleus, though a few are sometimes scattered in the more remote parts of the cell.

(b) The depth of the sub-epidermal cells is generally greater than their width, i.e. they are elongated in a direction perpendicular to the lumen.

(a) The nucleus is central or parietal, in the latter case it is frequently more or less flattened.

(β) The changes in the cell-contents are similar to those which occur in the epidermis; at first during the rapid growth of the cells distinct vacuoles are formed, later there is a slight increase in the granular cell-contents. The vacuolation however is generally carried to a greater extent, and the deposition of the metaplastic granules is less marked than in the epidermal cells. Starch is very abundant, large grains occurring in all parts of the cell. Both here and in older flowers most of the large grains of starch which appear to be simple are in reality compound; by treatment with potash and iodine they can be shown to consist of several small grains held together by the ground substance of the plastid, which only becomes obvious after it is swollen by some reagent.

C. Flower-tube open, anthers still closed (Fig. 6).

(a) The epidermal cells show much the same characters as in the older buds, but in a more pronounced form.

(a) The mucilaginous swelling of the external wall, which has now become distinctly convex, is greater, and the corroded appearance of the internal surface more marked; in most cells the upper part of the lateral walls is also involved in the former change; the narrow external layer is obvious here and in all later stages.

(β) At first starch-grains are still very abundant, but later they become disorganised, and begin to disappear; this disorganisation is especially apparent in the more external part of the cells. In the majority of the cells there is a considerable increase in the amount of granular substance; in a few here and there the protoplasm is arranged in the form of a coarse meshwork¹, as a result of vacuolation.

(*b*) In the sub-epidermal layers there is even less alteration in the appearance of the cells; the starch-grains are beginning to break down, and the granular substance has increased in amount; here too, as in the epidermal cells, the formation of a protoplasmic meshwork and vacuoles is occasionally seen.

D. Flower-tube open, some or all of the anthers having dehisced (Fig. 7).

(*a*) In this stage there is a marked alteration in the appearance of the cells.

(*a*) The characters of the external wall are similar to those described in the preceding stage, but are slightly exaggerated; about this time the mucilaginous degeneration reaches its height.

(β) Very little starch is to be found in the cells, in fact so rapid has its disappearance been, that in those flowers in which all the anthers have dehisced, most of the cells are entirely free from it. The protoplasmic meshwork, which in the previous stage is not unfrequently to be found here and there occupying a small part of an isolated cell, is now almost universal; it extends from the denser perinuclear protoplasm to that which lines the cell-wall, and is generally closer towards the lumen than at the base of the cell. The meshes are spherical or polygonal,

¹ I have intentionally used the term *meshwork* in preference to *network*, since I am inclined to believe that this structure ought not to be regarded as a true network.

and they vary considerably in size ; owing to this irregularity, and to the position of the nucleus (generally central), it is difficult to determine the average number of meshes in a cell. In those cases where the meshes are large and few in number (Fig. 9), the cells in all probability represent a slightly more advanced stage of activity, and one through which those containing a large number of smaller vacuoles will have to pass before reaching the next and final stage ; for it is not at all uncommon, as I shall have occasion to point out later, for the cells at the same level to exhibit different stages of activity.

- (*b*) In the sub-epidermal cells (Fig. 8) the appearance is even more striking, for since the position of the nucleus is most frequently parietal, the meshwork stretches uninterrupted throughout the cell. Such at least is generally the case when the dehiscence of the anthers is complete ; during the period of dehiscence the regularity of the meshwork is somewhat broken by the starch, which is still fairly abundant, and the disappearance of which takes place later here than in the epidermal cells ; so much so indeed, that some may still be found in almost every sub-epidermal cell, when the epidermis contains none. The breaking down of the starch begins in the superficial cells, and extends gradually to those lying deeper. The average number of meshes in the long diameter of the cell is about twelve.

A good deal of the starch has disappeared from the unmodified parenchyma of the septum, but there is still a considerable amount in the cells of the central axis.

E. Pollen mostly shed, and perianth often beginning to wither (Fig. 10).

- (*a*) (*a*) The external wall presents the same appearance as in the previous stage.

(*β*) The nucleus, which may be much flattened, is generally parietal.

(γ) The cell-cavity is occupied by a large central vacuole, the meshwork having entirely disappeared. In some of the cells the protoplasm has a highly refractive and homogeneous appearance; in others it is granular as in the preceding stages. Sometimes the nucleus projects into the vacuole, and the perinuclear protoplasm is connected with that lining the cell-wall by one or more strands; occasionally it may lie right across the cell. (Fig. 10 b.)

- (δ) The disappearance of the meshwork is not confined to the epidermis, it occurs also in the sub-epidermal cells, though not synchronously; but just as was the case with the starch in the preceding stage, so here, the change occurs later, lasts longer, and proceeds gradually from the more superficial to the deeper layers; even after the perianth has begun to wither the meshwork is still present in many of the cells.

All the starch has disappeared from the unmodified cells of the septum, but it is still to be found in the central axis.

Such is a brief account of the structural changes, exhibited by the gland-cells, during the development of the young bud into the fully open flower. There are, however, other slight variations in histological appearance, which appear to depend, not on the age of the cells, but on their position in the gland. Thus those epidermal cells which bound the peripheral margin of the lumen (Fig. 2 *p.m.*) are smaller than the other epidermal cells of the same level, and the changes which they display are less marked, e. g. the degeneration of the external wall and the deposition of starch are inconsiderable, and the meshwork is never prominent. On the other hand, those cells which bound the central margin of the lumen (Fig. 2 *c.m.*) are generally larger than the remaining cells of the same level; the deposition of starch is greater, and its disappearance slower, here than elsewhere; hence in flowers which are either opening or fully open, these cells exhibit a less advanced stage of activity than the others at that level.

Corresponding local modifications are much less marked when the gland is examined vertically. In the neck, however, there is a somewhat sudden alteration in the structural features of the epidermal cells; they lose their special secretory characters, and do not differ from ordinary epidermal cells. The external wall does not undergo mucilaginous degeneration, and possesses a distinct cuticle, which at the mouth of the gland is continuous with that of the ovary-wall. There is no deposition of starch, and no characteristic meshwork; the nucleus is generally central, and except in quite young cells the protoplasm is scanty, and contains a few large vacuoles.

Probably all, or nearly all, the cells of a gland pass through the whole series of changes above described, yet these changes do not always occur simultaneously in the cells. This is shown by the fact that in any section of a gland the cells are not all found in the same stage of activity, a condition of things particularly obvious in flowers in which the gland-cells have been fairly active, and in which the slight differences present in the earlier stages have had time to accumulate. Thus a section, in which the majority of the epidermal gland-cells are passing through the meshwork stage, is sure to contain some which have already reached the final stage, with parietal nucleus, large central vacuole, and no meshwork; while in others starch may be present, and the meshwork not yet apparent. In consequence of this unequal manifestation of activity, no one particular stage of the secreting cells can be said to be coincident with, and entirely confined to, one particular stage in the development of the flower. At the same time that appearance which is most common among the gland-cells at any one stage of the flower may be regarded as 'typical' of that stage, it being always understood that cells exhibiting those stages which precede and follow the typical one may be, and generally are, present as well.

The following table indicates those characters of the gland-cells which are typical of the various stages in the development of the flower:—

Function of the Septal Glands in Kniphofia. 21

TYPICAL APPEARANCE OF—		
Stage in the develop- ment of the flower.	Epidermal cells.	Sub-epidermal cells.
A. Young Bud.	External wall exhibits plane surface—no mucilaginous degeneration.	
	Nucleus central in position.	Nucleus and cell-contents as in epidermal cells.
B. Older Bud.	Starch-grains few and small.	
	External wall slightly convex—mucilaginous degeneration beginning.	
	Nucleus central.	Nucleus central or parietal.
C. Flower open, anthers closed.	Protoplasm at first vacuolated, later becoming more granular. Starch-grains larger and more numerous.	Cell-contents as in epidermal cells.
	External wall convex,—mucilaginous degeneration considerable.	
	Nucleus central.	Nucleus generally parietal.
	Starch abundant at first, disappearing gradually later.	Starch as in epidermal cells.
D. Some or all the anthers open.	Cell-contents very granular.	Cell-contents rather more granular than in B.
	Mesh-work rare.	
	External wall as in C.—mucilaginous degeneration about at its maximum.	
	Nucleus central.	Nucleus generally parietal.
	Meshwork almost universal.	Meshwork fairly general.
E. Flower be- ginning to wither.	Starch generally wanting.	Starch-grains few.
	External wall as in D.	
	Nucleus parietal.	Nucleus parietal.
	Meshwork disappeared—replaced by large central vacuole.	Meshwork still general.
	Starch wanting.	Starch generally wanting. As the flower withers still more the meshwork disappears as in the epidermal cells.

It now remains to consider the significance of these structural changes, and their relation to the process of secretion. Already in the bud there is indication of considerable activity on the part of the gland-cells, for there occurs in them a continued formation and accumulation of starch (forming a

temporary reserve material), and also of granular proteid substance (metaplasm). Further, in the epidermal cells these processes are accompanied by a change in the character of the external wall, a change which continues until it reaches a maximum in the fully open flower; the internal part swells, becomes mucilaginous, and loses its clear inner outline, the appearance of the internal surface being such as to suggest an active destructive influence on the part of the protoplasm. As the secretion must pass through both layers of the external wall before reaching the lumen, it is possible that some of the mucilage contained in it may be derived from the inner layers of the wall, and may have been carried along by the flow of the secretion. When the flower-tube opens the starch begins to diminish, the large apparently single grains break up into the separate grains which compose them, and these rapidly disappear. The question at once arises, are these starch-grains converted into some form of soluble carbohydrate which is then excreted? Has their disappearance from the cells any direct connection with the presence of sugar in the secretion? Before attempting an answer to these questions, it was necessary to determine at what stage in the development of the flower the sugar first made its appearance. With this object in view I treated sections from flowers of different ages with Fehling's solution, but with extremely unsatisfactory results; the reduction was always most diffuse, and was evidently caused by substances other than sugar. Abandoning this method as useless in this particular case, I was obliged to fall back upon the extremely rough plan of tasting; no sweet taste could be detected, nor was there any liquid visible in the flower-tubes of buds, nor in those flowers in which the perianth had just opened; but in those in which the stamens were projecting from the open flower-tube, though the anthers were still closed, it was possible to detect a sweet taste¹. Now the histological appearances which are charac-

¹ In thus testing for sugar, I used almost exclusively flowers of *K. media*; in *K. nobilis*, owing to the greater length of the flower-tube, the stamens do not project through the open tube while the anthers are still closed; consequently the

teristic of this stage in the development of the flower are those which have been described as occurring towards the end of stage C. It would therefore appear that by the time that the disintegration of the starch is well-advanced, and has become general in the gland-cells, an appreciable amount of nectar has been secreted. How much earlier than this the sugar makes its appearance I am unable to state, but it seems not improbable that some is formed simultaneously with the *first* indication of a breaking down of the starch, but that the amount is too small to be detected by the above-mentioned method, and that the disappearance of the one is directly connected with the appearance of the other. This change is doubtless effected by the protoplasm, and is presumably due to some ferment-action.

As the starch disappears from the cells the protoplasm again becomes vacuolated, and assumes a most characteristic arrangement, viz., that of a coarse meshwork which gradually extends throughout the whole cell. As secretion continues the protoplasm gradually decreases in amount, and seems to be used up in the process; the strands become fewer, and the vacuoles, owing to the consequent fusion, larger. This continues until the strands have all disappeared, the fusion is complete, and the cells contain a single large vacuole.

As the strands disappear the nuclei of the epidermal cells, either pushed by the enlarging vacuoles, or carried with the retreating protoplasm, are gradually withdrawn from their position in the centre of the cell into the protoplasm lining the cell-wall; in the sub-epidermal cells this migration of the nucleus takes place earlier.

In this last stage then, when the period of secretion has come to a close, the appearance of both kinds of cells is similar to that of ordinary adult parenchymatous cells.

recognition by any external mark of a stage intermediate between that at which the perianth is just opening and that at which the anthers have begun to dehisce is very difficult. Since however the histological changes run the same course in the gland-cells of both species, it seemed to me not unjustifiable to assume that the appearance of the nectar is probably coincident with the same typical stage in both cases.

The changes which here accompany secretion seem slight when compared with those generally met with in the gland-cells of animals; it must, however, be borne in mind that here the act of secretion occurs only once; it begins, lasts for a longer or shorter time, and ceases as the flowers pass maturity, but does not recur. Consequently there is no repetition of the cycle of changes, nor is there any indication of the active constructive metabolism, of the regeneration of the protoplasm, which must necessarily take place in cases where the cells exert their secretory power again and again. Moreover, it almost necessarily follows from the comparatively long period of time over which the one act of secretion extends, that the changes which do occur should be very gradual.

There is one other point which may be mentioned in connection with the histological appearance of the glands. After the ovaries have lain for several weeks in alcohol, bodies sometimes spherical, sometimes more or less irregular, and often exhibiting a double outline, make their appearance; they are most abundant in the gland-cells, and especially in the later stages. They appear to resist the action of both acids and alkalies; with regard to staining reagents they behave like and are probably identical with the 'amyloid-bläschen' mentioned by Behrens¹; these latter were regarded by him as being probably some form of carbohydrate originally in solution, but which separated out owing to the prolonged action of the alcohol.

¹ Flora, 1879, p. 85.

EXPLANATION OF FIGURES IN PLATE III.

Illustrating Miss E. R. Saunders' paper on the structure and function of the septal glands in *Kniphofia*. All the figures were drawn with obj. F. oc. 2 (Zeiss) except figs. 1, 2, 3, and 11.

Fig. 1. (diagrammatic). Part of a transverse section of an ovary showing one septum, and the position of the gland-lumen. *l.* lumen: *f. v.* fibro-vascular bundles: *e.* external wall of the ovary: *o.* loculi of the ovary.

Fig. 2. (diagrammatic). Septum in optical longitudinal section. To show the position and extent of a gland, the area of which is shaded. *n.* neck: *p. m.* peripheral margin: *c. m.* central margin: *st.* style.

Fig. 3. (diagrammatic). Septum in longitudinal vertical section. *o. e. l.* as in fig. 1. (The ovules have been omitted from the drawing).

The following lettering applies to all the succeeding figures. *n.* nucleus: *v.* vacuole: *s.* starch-grains: *a.* thin outer layer of external wall: *β.* broad inner layer: *δ.* metaplast: *m.* mesh-work.

Fig. 4. Epidermal gland-cells from a young bud.

Fig. 5. Epidermal cells from an older bud with numerous large starch-grains, granular contents, and in some cases vacuoles. External wall shows slight thickening.

Fig. 6. Epidermal gland-cells from an open flower in which the anthers are still closed. The mucilaginous degeneration is now well-marked, the thin cellulose membrane is indicated by the thick dark line (*α*), the mucilaginous layer by the broad band (*β*). The cells contain very many large compound starch-grains, and much granular metaplast.

Fig. 7. Three epidermal cells from a fully open flower. To show the meshwork stage. Starch absent.

Fig. 8. To show the same stage in sub-epidermal cells. In all but *d.* the nucleus has been omitted, and in *c.* and *d.* the meshwork has been ruptured in the preparation.

Fig. 9. An older stage than fig. 7. The meshwork is beginning to disappear, and the nucleus is being withdrawn from its central position.

Fig. 10. Epidermal gland-cells in the last stage. The meshwork has disappeared, and been replaced by large vacuoles, and in *a* and *c* the nucleus is parietal.

Fig. 11. Obj. cc, oc. 2. (Zeiss). Transverse section of part of a septum. To show the relation of the glandular area (*gl*) to the unmodified tissue of the septum (*u.t.*).

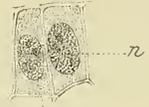


Fig. 4.

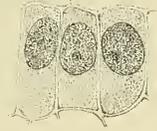


Fig. 6.

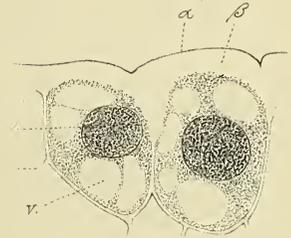
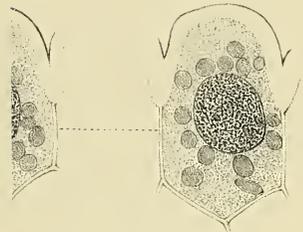


Fig. 11.

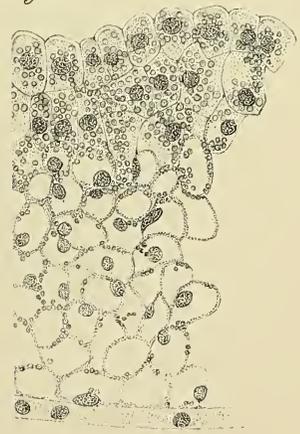


Fig. 1.

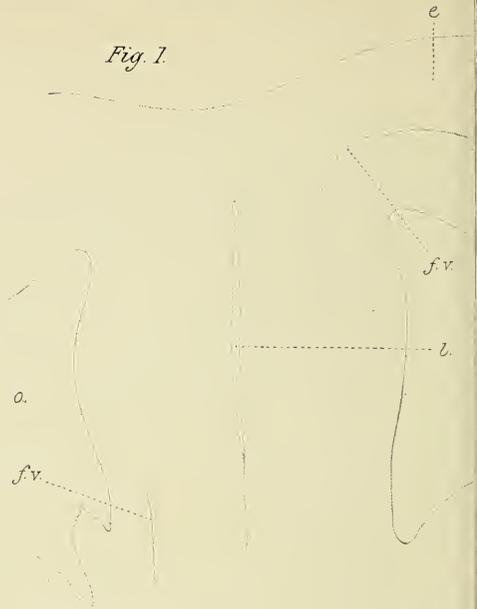


Fig. 7.

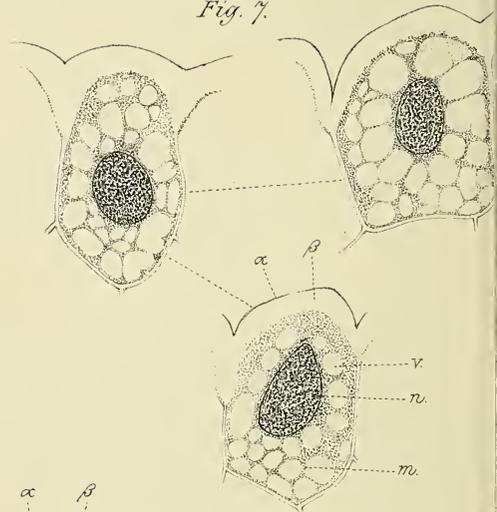
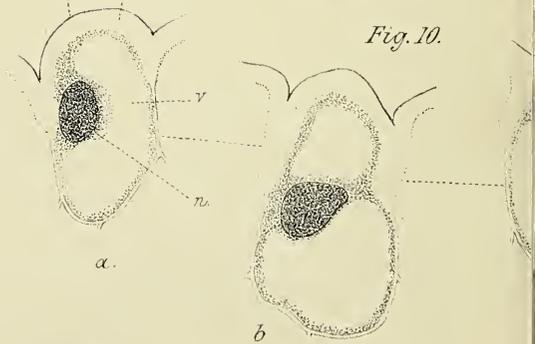


Fig. 10.



Saunders del.

Fig. 2.

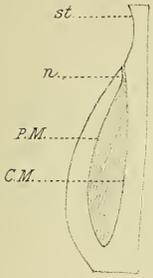


Fig. 3.

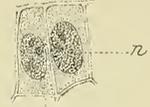
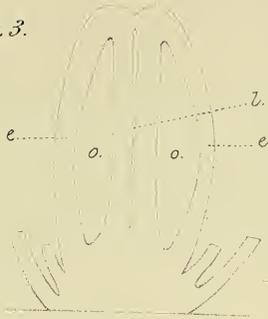


Fig. 4.

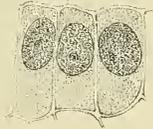


Fig. 5.

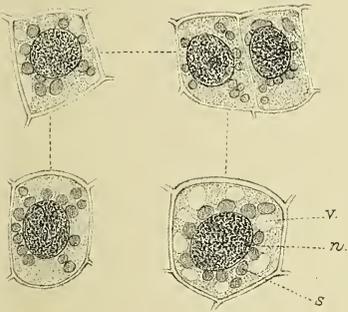


Fig. 6.

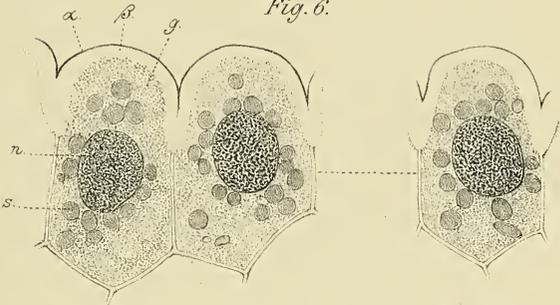


Fig. 9.

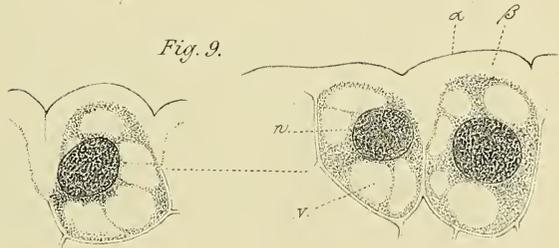


Fig. 8.

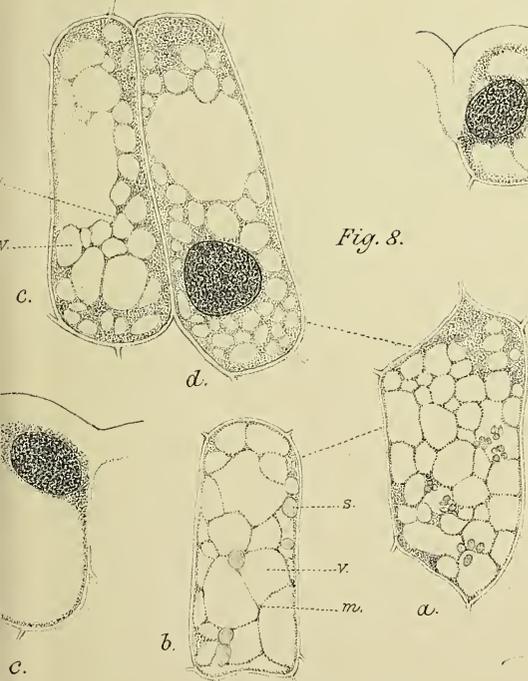


Fig. 11.

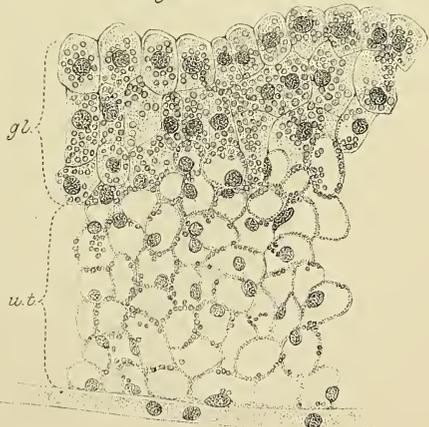


Fig. 1.



Fig. 2.

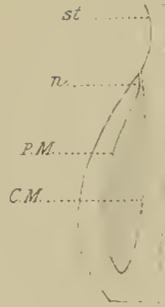


Fig. 3.

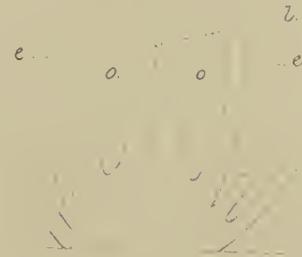


Fig. 4.

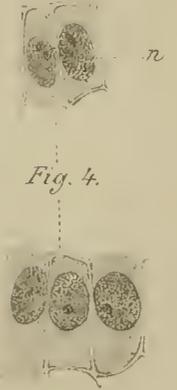


Fig. 5.

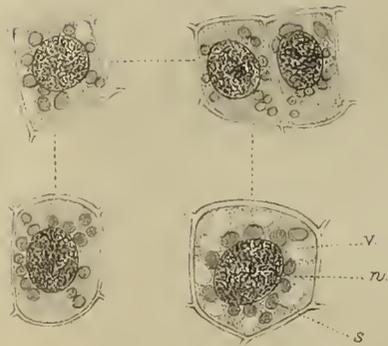


Fig. 6.



Fig. 7.

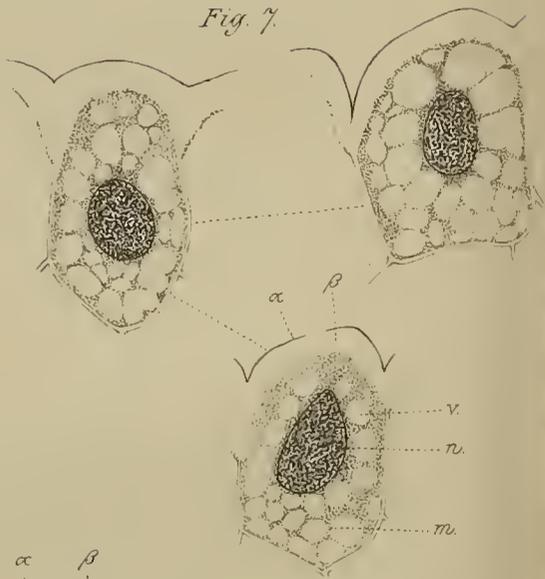


Fig. 9.

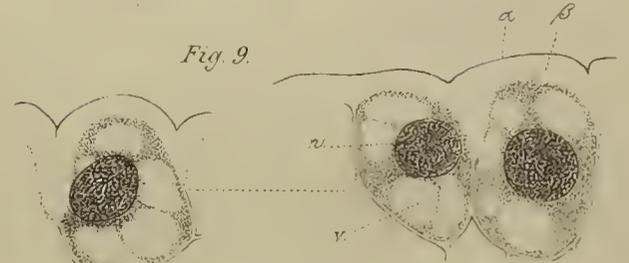


Fig. 8.

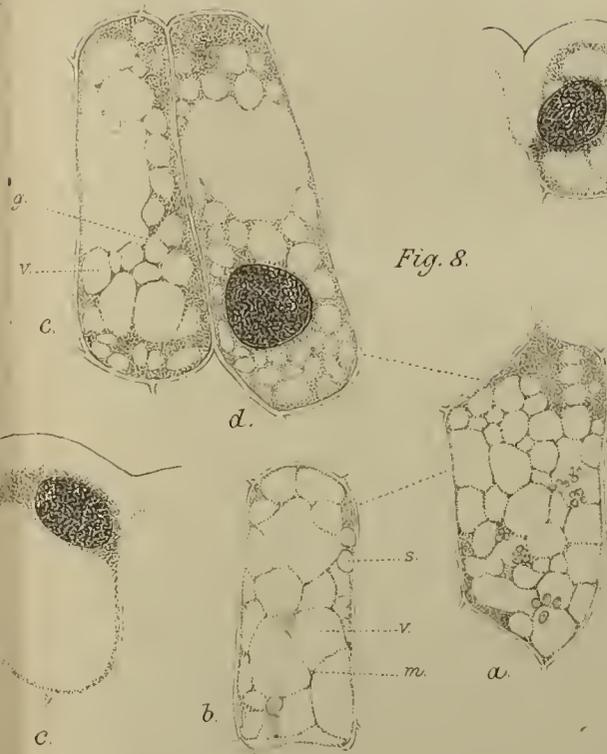


Fig. 11.



Fig. 10.



On the Life-history of *Puccinia Geranii silvatici*, Karst., var. *himalensis*.

BY

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—*—
With Plate IV.
—*—

IN this paper I propose to describe the life-history of a *Puccinia* on *Geranium Nepalense*, Sweet, which is interesting in several respects. In the first place it is complete without any other form of spore-formation than the teleutospore: in the second place there are two distinct crops of these spores during the spring and summer: and in the third place it is both a *Leptopuccinia* and a *Micropuccinia*.

I am of course aware that the first point, viz. the absence of any other spore-form in an otherwise complete species, is not unique; but experimentally proved instances of such cases are few enough to render any additional example interesting. Thus for example *P. Arenariae*, Schum. (*P. Dianthi*, D. C.), a so-called *Leptopuccinia*, is, I believe, complete without any other spore-form; and so also is *P. Adoxae*, D. C., a *Micropuccinia*. Plowright¹ writes of the latter:—‘Mr. Soppitt placed some over-wintered teleutospores in active germination on healthy plants, in March, 1888; in ten days the teleutospores had reproduced themselves without the intervention of either uredospores or aecidiospores.’ Lastly, *Chrysomyxa Abietis*, Wallr. is another example of the same kind.

I have had this fungus under observation in nature for

¹ ‘British Uredineae and Ustilagineae,’ p. 208.

several years, and during the last two years under special observation in my laboratory. In a Descriptive List of the Simla Uredineae¹ I referred the species provisionally to *Puccinia Geranii silvatici*, Karst., and, indeed, its general habit and morphological characters approach those of that species closely; but a more minute and careful study of it convinces me that it is at any rate a very marked variety.

The host is in full vegetative activity in March, and on the 24th of that month (1889) I found numerous plants largely attacked in two localities especially though also elsewhere; and very frequently a small area bearing many plants had every plant attacked, so that it was difficult to find one free. This led me to suspect that the spores were self-attacking, i.e. that the fungus was autoecious. Shortly after this the host having flowered died out more or less completely, and the fungus was for a time entirely missed. But towards the end of June a new crop of the host springs up, on the setting in of the monsoon rains. I was surprised to find that in these two localities in which the fungus was very abundant in March and April, this new crop of Geranium plants was again as extensively attacked. The fungus thereafter continues to be met with until August, when it disappears for the year, not to reappear until the following spring. The whole cycle of development is then repeated. In each crop I looked carefully for the other usual spore-forms, and especially for uredospores and spermogonia; but I could find no trace of either, and convinced myself that no other spore-form is developed by the fungus.

(Expt. 1.)—On the 24th March I placed some spores of the first crop in water in a watch-glass, and also in a hanging drop of water in a closed cell. No germination ensued in the hanging drop; but on the 28th (24 × 4 hours) I found that numerous spores in the watch-glass had thrown out promycelia bearing sporidia. The promycelia were mostly aërial, and the spores which had become submerged did not

¹ Journal of the Asiatic Society of Bengal, vol. lviii. Pt. ii. No. 2, 1889.

germinate. Up to the 28th only a spore here and there germinated; but on that date germination was general. Hence the spores are slow in commencing to germinate. (Expt. 2.)—Similarly I floated freshly gathered spores of the second crop on water in a watch-glass on the 13th June, and on the 15th (24 × 2 hours) noted that some, though not many, had germinated, and had produced sporidia. (Expt. 3.)—As a comparative experiment I also placed some spores of the first crop, which I had collected on the 23rd March, in another watch-glass under exactly similar conditions. These germinated very freely, producing many more sporidia than the fresh spores of the second crop.

(Expts. 4, 5.)—I transferred the sporidia from each watch-glass (Expts. 2 and 3) to two halves of a healthy plant bearing young leaves, which I had uprooted carefully on the 15th June, and had placed in a glass vessel with the roots in water. The plant was then kept in my laboratory under a glass shade. On the 25th the part inoculated with the sporidia of the first crop showed two distinct points of attack on one leaf, while the other part remained free from visible attack. On the 28th the former inoculated part showed other two small crops of pustules on the stems. The part inoculated with freshly gathered spores of the second crop remained free from any sign of attack so long that on the 12th July I removed it from under the shade, and left it naked on a shelf in my laboratory, and did not look at it again until the 22nd, when to my surprise I found one leaf typically crumpled, with *numerous* black teleutospore-pustules. (Expt. 6.)—The spores taken from the last were placed in water in a watch-glass on the 22nd July; but they refused to germinate, and I had evidently come to the end of the series of teleutospore-generations, and had reached those destined to lie dormant until the following spring. I preserved some of these spores for use next spring; but unfortunately they became mouldy, and were presumably killed, as they did not germinate in March. This unfortunate mishap has prevented my completing experimentally the whole

life-cycle of the parasite from one year to another. But there can be no reasonable doubt that the teleutospores formed at the end of summer lie dormant until the following spring.

These promising results induced me to continue my observations in the following year. (Expt. 7.)—On the 2nd April, 1890, I collected some fresh spores and put them into water: on the following day there was no sign of germination: from the 4th to the 7th I was absent from my laboratory; but on the 8th (24×6 hours), on my return, I found that they had germinated very freely, the water containing numerous sporidia. (Expt. 8.)—Again, on the 11th I collected fresh spores and put them into water on the 12th. On the 13th and 14th there was no germination: on the 15th (24×3 hours) some had germinated, and there were some sporidia in the water; but it was not until the 19th (24×7 hours) that germination had become free, and the water held immense numbers of sporidia. (Expt. 9.)—Lastly, on the 19th April I collected more fresh spores and put them into water: on the 20th there was no germination: on the 21st a good many had germinated: on the 22nd (24×3 hours) germination was general.

At the same time I undertook some inoculation experiments, and will give the details of two, which establish the life-history of the fungus. (Expt. 10.)—I inoculated a potted plant, which I had in confinement since the preceding autumn, several times with sporidia during April. On the 23rd I noticed two distinct points of attack on one leaf, though as yet there was no spore-eruption. This, however, occurred on the 29th, when I saw two or three black pustules on each spot of attack. On the 9th May I noticed that another leaf was wholly attacked, including the whole of the petiole. (Expt. 11.)—On this date I removed some spores and placed them in water under a glass shade. On the following day some had germinated and had produced sporidia (Fig. 3); but on the 13th (24×4 hours) germination was free and complete.

(Expt. 12.)—Having uprooted a healthy plant, and having placed its roots in a glass vessel containing water, I inoculated it freely on the 25th April with sporidia from a cultivation started on the 23rd, and kept it in my laboratory under a glass shade. On the 4th May (nine days) I noticed several foci of attack on three leaves; but there was as yet no spore eruption. On the 9th May (fourteen days) the plant was very extensively attacked in leaves, petioles, and stems, with marked hypertrophy of the latter, and large spore-eruption (Fig. 1). (Expt. 13.)—On this date I removed some spores and placed them in water as a parallel cultivation with that described above (1). On the 10th none had germinated, but on the 13th (24 × 4 hours) germination was free, though not quite so general as in the parallel cultivation. This was probably due to many of the spores being much younger and more immature.

These experiments prove that the spores of the first (Expts. 1, 3, 7, 8, 9, 11, 13) and second (Expts. 2 and 6) crop are both *Micropuccinia* and *Leptopuccinia*; and that the fungus is complete and autoecious with teleutospore-formation only (Expts. 4, 5, 10, and 12). I venture to think that the establishment of the former point, namely the power the spores of each crop possess of both germinating at once and after rest, more or less prolonged, is important, since it shows that Schröter's divisions *Lepto-* and *Micro-puccinia*, though they may prove useful artificial classes in those cases in which the life-histories are unknown, are not based on fundamental biological facts as he supposed. Schröter writes¹ that the mycelia produced by sporidia derived from teleutospores which have passed through a period of rest bear spermogonia and aecidia, while those produced by sporidia derived from teleutospores which have germinated at once bear only teleutospores again. With reference to the former proposition we have here an experimental demonstration that the sporidia of even over-wintered teleutospores can reproduce teleutospores;

¹ Die Pilze Schlesiens, page 297.

and with regard to the latter statement we have an experimentally proved case to the contrary in *Puccinia Polliniae* (Heteropuccinia), the life-history of which I have described elsewhere¹, and where it was shown that the teleutospores germinated both at once and after a period of winter rest, in each case producing a mycelium bearing aecidiospores. I advanced the view then that in the case of *P. Polliniae* the immediate germination of the teleutospores helped to distribute the fungus, vicariously taking up the function of uredo- and aecidio-spores, the former of which are not abundant in this species. I also developed this view in a paper recently submitted to the Linnean Society on the life-history of the remarkable *Uromyces Cunninghamianus*. In the present case, and in all similar cases, where no separate spores are produced for distributive purposes (uredo- and aecidio-spores) the teleutospores *must* perform both distributive and preservative functions (unless there is a perennial mycelium, which there is not in the case under consideration); and in order to accomplish the former the spores must be capable of germination immediately, and to accomplish the latter must also be able to rest. In similar cases, where only teleutospores are produced, if there be a perennial mycelium to ensure the persistence of the species, it is conceivable that the teleutospores would subserve only a distributive function, being all immediately capable of germination. *Puccinia Adoxae*, Schum. would however be in evidence against this view, if it really has a perennial mycelium, and if the spores are really only capable of germination after a winter rest. It is quite possible however that an immediate power of germination after ripening has been overlooked in this species. But curiously enough it is exceptional to read of a so-called Leptopuccinia having a perennial mycelium, and if all those so classified are really complete fungi, which I think is extremely doubtful, their teleutospores will probably be found on careful examination to germinate both immediately after ripening and after a winter rest.

¹ On the Life-history of a new Aecidium on *Strobilanthes Dalhousianus*, Clarke, Sc. Memoirs by Medical Officers of the Army of India, Part II, 1887.

This I find is the case with *P. Urticae* which, also, has not a perennial mycelium¹. I have not yet succeeded in tracing its life-history; but it is certainly not connected with *Aecidium Urticae*, Schum., as I have elsewhere shown. It possibly runs a parallel course with *P. Geranii silvatici*; but it is more probably a heteroecious species. However this may be, I have frequently found the teleutospores which are produced in autumn (there are no uredospores) germinate freely at that time; and I have recently found that they germinate equally after a winter rest. I gathered some leaves bearing teleutospore-pustules in November, and upon floating them on water found them freely germinating when scraped off the living leaf. Again, on the 19th April following (5 months later), and lastly on the 5th July (8 months), spores from the same collection germinated very freely. This therefore is another excellent illustration of a teleutospore being both a Leptopuccinia and a Micropuccinia.

Before leaving this part of my subject I would draw attention to the somewhat tardy setting in of germination in the spores even under favourable circumstances. It will have been observed that general germination did not set in until the spores had been in water about three to four days, indicating the essentially halting nature of teleutospores. My usual experience has been that if teleutospores are going to germinate at all they do so within twenty-four hours, under the conditions in which I placed the Geranium-fungus spores. This halting germination occurred in all my cultures, and appears to be characteristic. Again, it is probable that the teleutospores of the first crop, when they exercise their resting properties, can do so only for a month or so, while those of the second crop must do so for several months. I have unfortunately not been able to demonstrate this by actual experiment. There can however be little doubt on this point.

The existence of the fungus in a plant is indicated both by the formation of brown spore-pustules on leaves, petioles, and

¹ Journal of Asiatic Society of Bengal, loc. cit., and Scientific Memoirs by Medical Officers of the Army of India, Part II, 1887, p. 38.

stems, and sometimes by considerable hypertrophy of the two latter. Invaded leaf-blades are often considerably crumpled when extensively attacked: oftener only a portion of the blade is involved, and frequently at the base. Petioles are very frequently attacked, and are then often hypertrophied. The main stalks are not so often attacked, but when this happens they are frequently very greatly hypertrophied, especially when the attack is at a node (Fig. 7). When the leaf-blade is attacked usually very numerous coalescing minute circular pustules are formed on the under surface, the upper surface opposite being pale or somewhat reddish. When attacked areas are small they are usually convex above, the lower concave surface bearing the spore-pustules. These spore-pustules are sometimes so closely aggregated that on superficial examination it would appear that the whole patch of spore-extrusion is one large spore-bed. Sometimes a few pustules burst from the upper leaf surface; but this is uncommon. When the leaf-blade is extensively attacked it is observable that the main nerves are thickened, showing a tendency for the mycelium to run along the vascular structures. On the petioles and stems the pustules are oval, and do not tend to coalesce so readily, due, to some extent I believe, to the extension of surface by hypertrophy.

The spores are very deciduous, falling off with only a fragment of stalk adhering. They are brown, rounded at both ends, with little or no constriction at the septum, and very uniform in size. The epispore is not thickened anywhere (though a very slight colourless tubercle at the free end may be seen in most) and is beset over both cells with warts or tubercles, not densely aggregated, those over the lower cell being somewhat finer than those over the upper (Figs. 2, 3). Spores are frequently found divided into three and four cells, naturally suggesting a comparison with *Phragmidium* (Fig. 5). Each cell exhibits a well-marked nuclear space. The fresh spores just moistened measure $30 \times 16 - 18 \mu$. On germination each cell throws out a short colourless promycelium, dividing as usual into four parts, each bearing a sporidium at the end

of a fairly long sterigma (Fig. 2). When germinating while floating on the surface of water the promycelia are frequently aërial. The upper promycelium emerges from the apex, while the lower comes from a point near the stalk, and not as usual from near the septum (Figs. 2, 3). This displacement of the germ-spore from near the septum to near the stalk is interesting as being the reverse of that which obtains in the spores of *Gymnosporangium*, where the same thing occurs in the upper spore-cell. I know of only one other *Puccinia* which exhibits this peculiarity, namely *P. Wattiana* on *Clematis puberula* (Fig. 4). The sporidia are oval and colourless and measure $14-12 \times 7-6 \mu$. Secondary sporidia are sometimes formed, but not frequently.

Having obtained specimens of *P. Geranii silvatici*, Karst. through the kindness of Dr. P. Dietel, gathered in the Engadine (St. Moritz and Pontresina), I compared it carefully with the Simla species. In general habit the two species appear to be very much alike, but the microscopic characters of the spores differ somewhat. In the first place I convinced myself that the surface of the lower cell is not tuberculated as a rule in the European species (Fig. 6); and in the second place the spores are larger, measuring (according to my own measurements) $33-24 \times 21-18 \mu$ after lying twenty-four hours in water. These differences are, however, slight, and not sufficient perhaps to warrant their separation as distinct species. But the Himalayan fungus may be regarded as a distinct variety.

EXPLANATION OF FIGURES IN PLATE IV.

Illustrating Surgeon-Major Barclay's paper on the Life-history of *Puccinia Geranii silvatici*, Karst (var. *himalensis*).

Fig. 1. Photograph showing result of artificial inoculation (experiment 12), natural size, photographed 17th May.

Fig. 2. Teleutospore, showing tuberculation over both cells; the upper with promycelium and sporidia (19th April) $\times 350$.

Fig. 3. Teleutospore, showing promycelia from both cells. Spore from experiment 11 (10th May) $\times 150$.

Fig. 4. Teleutospore of *Puccinia Wattiana*, Barclay, on *Clematis puberula*, showing promycelial formation as in fig. 3 (6th May) $\times 350$.

Fig. 5. Teleutospores divided into three and four cells (13th April) $\times 350$.

Fig. 6. Teleutospore from specimen from the Engadine, showing the upper cell only tuberculated, to compare with fig. 2 $\times 350$.

Fig. 7. Hypertrophied node, natural size.

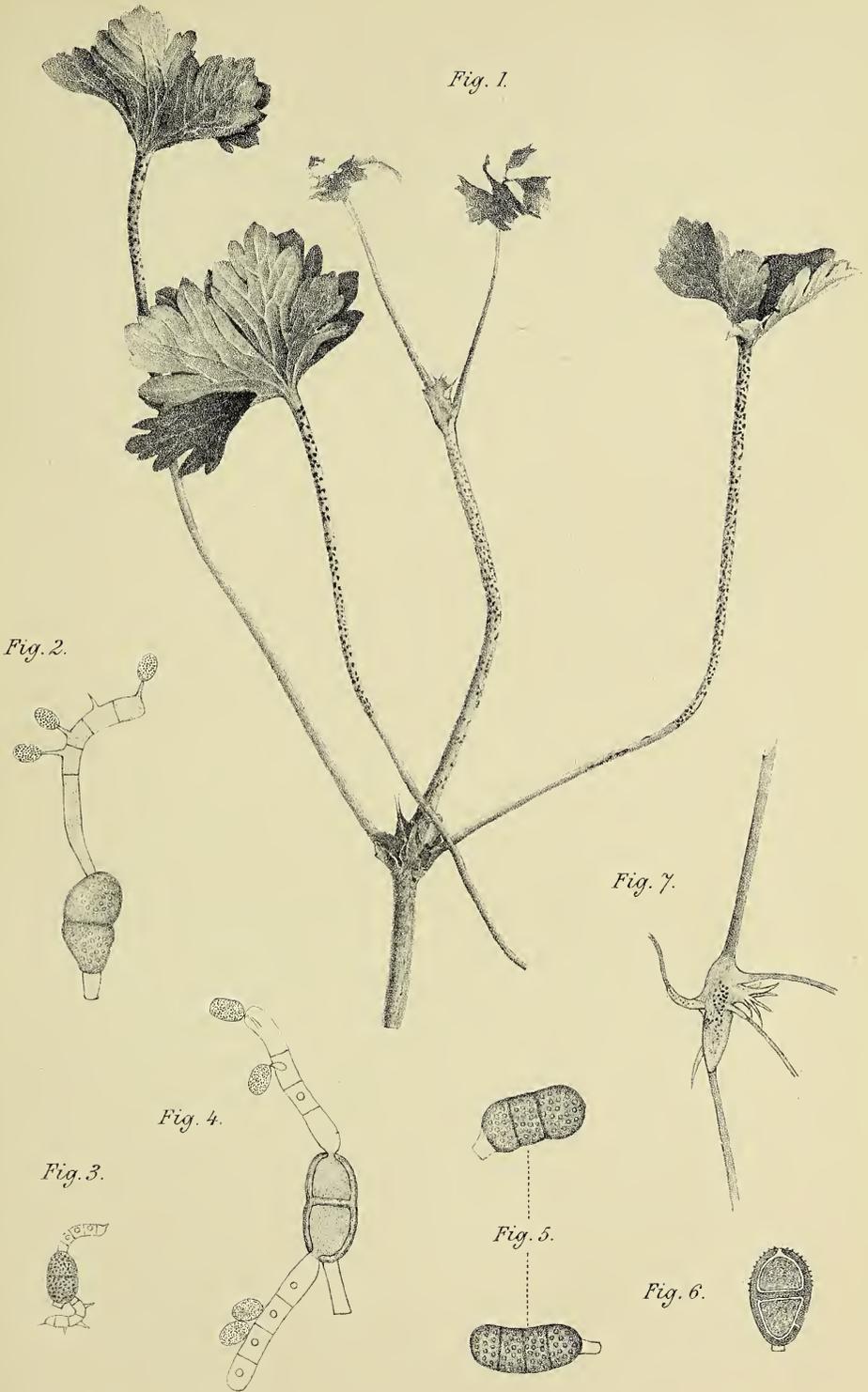


Fig. 1.

Fig. 2.

Fig. 7.

Fig. 4.

Fig. 3.

Fig. 5.

Fig. 6.

A. Barclay del.

University Press, Oxford

On *Isoetes lacustris*, L.

BY

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—♦—
With Plates V and VI, and Woodcut 1.
—♦—

FEW genera amongst the higher series of plants have attracted more general attention and interest than that which has for so long been centred round *Isoetes*. Regarded as a study in taxonomic research, the numerous points of contact which it displays with families which are otherwise sharply severed from each other in affinity, are sufficient to justify its claims on the comparative morphologist, whilst at the same time the anomalous character of its structure has long afforded ample and fruitful material for histological investigation.

The object of the present paper is to attempt the elucidation of some of the numerous points of development and organogeny which have hitherto, in spite of the numerous workers in the field, baffled or escaped explanation, and also as far as possible to give a connected account of the oophyte whose development has long remained obscure, in the hope that further light may thereby be thrown on the difficult question as to the position of *Isoetes* in the natural system.

Von Mohl¹, who may be said to be almost the first person who investigated carefully the structure of *Isoetes*, drew attention to its more important peculiarities, such as the arrange-

¹ V. Mohl, Ueber den Bau des Stammes von *Isoetes lacustris*, Linnæa, 1840; also Vermischte Schr.

[Annals of Botany, Vol. V. No. XVII. December 1890.]

ment of the roots and the character of the cambium, and secondary thickening. Wahlenberg¹ seems to have been the first to notice the peculiar mode of thickening characteristic of this plant. His remarks are as follows: 'Caudex radice constituitur taleola satis crassa quam nux avellanæ saepe majore in centro vegetante et ad ambitum moritura.' But without doubt to Von Mohl belongs the credit of having pointed out the fundamental differences existing between the stem of *Isoetes* and those of the other vascular cryptogams which were familiar to him.

Alexander Braun² further explained the relation of the leaf-arrangement to the conformation of the stem; and he also correctly described the branching of the roots as dichotomous, although he does not seem to have grasped so clearly as Mohl their connection with the stem.

The chief source of our information on the genus is to be found however in the classical memoir of Hofmeister³, in which the external morphology as well as microscopic structure and development, as far as his opportunities admitted, are for the most part dealt with in a masterly manner. He was, it is true, in error in his statements as to the character of the apices of the stem and root, in which he believed he had found apical cells; going so far, in the case of the stem, as to correlate the mode of segmentation with the 2- or 3-forking of the stem. Naegeli and Leitgeb⁴ also came to the conclusion that the root-apex was dominated by a 2-sided apical cell, although they confess that their view is based on negative rather than on positive evidence, and is arrived at after rejecting other apparently possible explanations. Their figures, like Hofmeister's, were wonderfully accurate, and later observers have not always paid them the attention which they deserve. The results of my own investigations will, I hope,

¹ Wahlenberg, Flora Lapponica, p. 264.

² Alex. Braun, Weitere Bemerkungen ueber *Isoetes*, Flora, 1847.

³ Hofmeister, Beitr. zur Kenntniss d. Gefässkryptogamen, Abh. Math. Phys. Kl. d. Kön. Sächs. Gesell. d. Wissenschaften, 1857.

⁴ Naegeli u. Leitgeb, Entstehung u. Wachst. d. Wurzeln, Beitr. zur Wiss. Bot. iv. Heft, 1868.

show the source of their misconception of the structure of the apex.

The structure and development of the Stem.—As far as the structure of the stem is concerned, however, it is much more difficult to understand on what grounds it was possible for so careful an investigator as Hofmeister to describe its growth as regulated by an apical cell. At no time is any cell-arrangement perceptible which would warrant this conclusion, and if the appearance presented by sections cut parallel to the furrow of the stem occasionally seems to point to it, more careful study of a series invariably leads to an opposite result, and clearly shows that the mistake is referable either to the obliquity of the section or to the fact of its having passed through the base of a leaf-rudiment. Comparison of transverse with longitudinal sections fully confirms this observation (Pl. V. Figs. 11, 13), and further affords proof that the apical meristem is even less regular than is the case in the Lycopodiaceae, judging at least from the figures published by Strasburger¹ and others. The entire apex of the stem is covered by a columnar layer of cells which divide chiefly anticlinally, periclinal divisions only occurring at rare intervals, a fact which is to be connected with the slight increase in length of the stem. I endeavoured to find out if the frequency of the periclinal divisions bore any relation to the number of leaves formed, but have been unable to ascertain that any such connection exists. The cells which lie beneath the superficial layer, though irregular in size and shape, indicate, in their general arrangement, a conformity with Sachs' law.

Hegelmaier² and Bruchmann³ have regarded the bundle of the stem as consisting partly of a sympodium of leaf-traces, and partly of a cauline portion, represented by xylem-elements derived from a supposed plerome-tissue which surmounts the woody portion of the bundle. A comparison of a great

¹ Strasburger, Coniferen u. Gnetaceen, Taf. xxv. figs. 29, 30.

² Hegelmaier, Zur Kenntniss einiger Lycopodinen, Bot. Zeit. 1874.

³ Bruchmann, Ueber Anlage u. Wachst. d. Wurz. bei *Lycopodium* u. *Isoetes*, Jen. Zeitsch. für Naturwissenschaften, VIII.

number of sections has however convinced me that Hofmeister's view is more in accordance with the facts, and that the axile bundle is really made up of leaf-traces, a view in which De Bary¹ also concurs. But in this case, like the alleged exogenous nature of the first root, to be considered subsequently, there is represented just one of those transitional stages where distinctions lie rather in the mind of the investigator than in the actual object before him. In this particular instance it is exceedingly difficult to draw a limit between a possible cauline and a common bundle in the older stages, although in young plants it is perfectly obvious. The cause of the discrepancy existing between the accounts of the various writers possibly lies in the great difficulty, without a complete series of sections, in reconstructing the entire vascular system with any degree of accuracy, and the difficulty is further increased by the great number of leaves which arise at almost exactly the same level on the stem.

About a year after germination, when the first few leaves are fully formed, the parenchyma around the vascular bundle of the stem (the *pericycle* of Van Tieghem) begins to divide periclinally to form the 'cambium.' The divisions extend around and above the axile bundle of the stem, but not so far as the youngest leaf-traces. And thus, whilst agreeing with Hegelmaier in the main features, I cannot but think that his description is misleading when he states that, whilst the cambium extends above the bundle in the form of a barrel, those cells which take part in the formation of a leaf-trace change their direction of division to one at right angles to that of the surrounding cells, in order to contribute to the trace. This statement is however only true of the appearance presented by older leaf-traces, which have become surrounded by, and enclosed in, the cambial zone. Originally, as I have said, the particular direction of their division is determined *before* the cells in their vicinity assume the freshly active merismatic condition.

The leaf-trace originates in the division of a row of cells, in

¹ De Bary, *Comp. Anat.* p. 280 (Engl. Trans.)

an upward and outward direction, which more or less irregularly connect the base of the leaf-rudiment with the central part of the stem, at the apex of the woody portion of the bundle. Thence the division extends upwards into the leaf and downwards into the stem. In all cases where I have been able to observe accurately, the tracheids of the trace are seen to join the axile strand in such a way as to afford conclusive evidence that they, with the tracheids of the neighbouring traces, form the entire mass of wood. No xylem-elements, so far as I could determine, are ever present *above* the insertion of the last leaf-trace.

The elements of the wood in the vascular cylinder of the stem are very short as compared with the corresponding cells of the trace, and are largely mixed with conjunctive parenchyma. At a short distance below its summit, the axile cylinder of vascular tissue in the stem shows signs of irregular splitting, owing to the disruption of its cells, and the whole structure rapidly becomes full of intercellular spaces. This result is indirectly brought about by the activity of the cambium. The traces of the roots and leaves which pass through this zone to join the axile vascular cylinder are subjected to great strain by the fact that whilst the cells round them are growing, and, so to speak, travelling outwards, they themselves are stationary, and can only increase in length by extension. This takes place to a limited extent, and effects a great distortion of their constituent cells, but finally the loose central tissue gives way, and they are partially relieved of the strain at the expense of the cohesion of the inner tissue. That such really represents the actual state of the case may be ascertained by inspecting longitudinal sections through parts of the stem where the process is being vigorously carried on, and it is indicated by the character of the cells in the photograph (Pl. VI. Fig. 27). It is difficult to assign any other reason for the occurrence, mere extension of the cells of the stem will at any rate give no explanation.

The cambium formed as above described, besides giving off cells peripherally, produces also the so-called *prismatic cells*

at its interior, which are continuous above with the phloem of the leaf-traces. Russow¹, partly for this reason, has regarded the prismatic layer as representing a bast or phloem, but quite apart from the fact that it is produced internally to the cambium, and would thus, from the point of view of its position, be anomalous, its structure is remarkably complex and heterogeneous. Hegelmaier² briefly indicated the zones observable in the tissue under consideration and assigned the cause of the appearance to alternating layers of clear and starch-filled cells. Transverse sections taken through the central part of the stem show that the prismatic layer which surrounds the central xylem is a band of varying thickness, being especially interrupted by the bundles which pass out to the roots. The zone-like arrangement consists in alternations of tubular thin-walled cell-rows of varying thickness, whose cell-contents are clear and watery, with others, whose cells are wider in the radial direction, and filled densely with starch. Occupying a middle position in the latter zone, is embedded an irregular ring of cells whose walls are thickened like those of the tracheids, but these too, unlike the latter, often contain protoplasm and starch. (The dark bands in Pl. VI. Figs. 26 and 27.) The number of the zones or bands varies with the thickness of the stem, and therefore presumably with its age, and also with the height at which the section is cut. The longitudinal section is especially instructive in explaining the relation which exists between the number of the zones at different heights. The bands are seen to converge towards the axile xylem in the order of their position; the outermost one being of course inserted highest. Their relative position naturally suggests some connection between their number and the periods of active growth, but I am unable to say if such a connection really exists. Fig. 27, which is a photograph of a section of *I. velata*, for the material of which I am indebted to the kindness of Prof. Pirota, shows the longitudinal arrangement of the bands through part of their length.

¹ Russow, *Vergl. Unters.* p. 139.

² Hegelmaier, *loc. cit.*

The cells lying between the apical merismatic layer of the stem and the xylem of the vascular bundle evince, as has been already said, a general convergence towards the apex, and it is at the periphery of this mass that the cambium is first differentiated, and it is gradually pushed outwards below by the products of its own activity. Hence, as in the higher plants, radial divisions are essential to admit of the attainment of the increased circumference which the zone occupies. There are two methods whereby these radial divisions are effected: (1) Either, a cell of the cambium divides into two equal halves

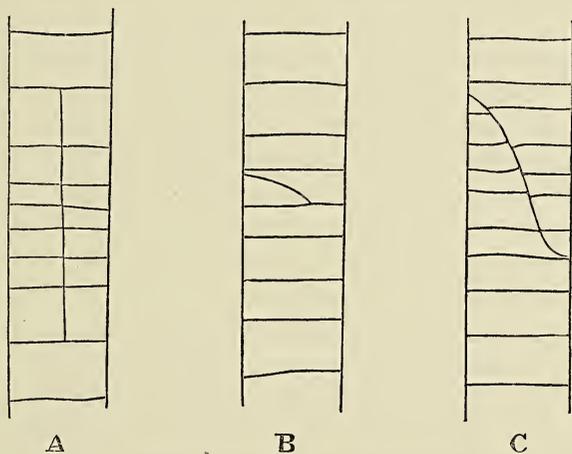


Fig. 1. Diagram of transverse section of cambial cells.

in the radial direction, and then each of the two sister-cells divides henceforth tangentially in the usual manner to form the secondary tissue (see Fig. A below): (2) Or, a cambial cell divides into unequal sister-cells by a wall which cuts one of the radial walls and the inner tangential wall, and then the first succeeding divisions are not quite tangential, but are curved to meet the rounded cell-wall; but finally the result is the same as in the first case, though the products can be more easily traced, at any rate inwards, on account of the pointed end by which such a cell-row is always characterised (Figs. B, C, above). These two modes of division are however

only extreme forms of the same process, and all conceivable transitional stages may be met with in good preparations, that is, the radial wall of (1) may incline more or less from the truly radial direction, until it passes over into the form of (2).

Around the apical meristem of the stem are situated the young leaves which originate as horseshoe- or crescent-like protuberances from the apical tissue. As is well known, they arise exclusively as outgrowths of the superficial layer of cells, and this point has been noticed as in some degree weakening the suggested resemblance to the Cycads, in which the periblem also enters into the formation of the leaf. It is however, I think, open to question how far this fact is of weight in either direction, for in *Cycas* the dermatogen and periblem of the stem lose their individuality in the actual apex, originating from a common layer of cells¹. If however it were wished to press the resemblances, *Isoetes* might be regarded as an instance where this suppression of the individuality extended beyond the point of origin of the leaves, thus making this genus occupy a position as regards *Cycas* analogous to that of *Cycas* as regards the Abietineae.

The Leaf and Ligule.—The leaf, after the rudiment is formed, by the luxuriant growth of the superficial cells, increases rapidly in size, and is at first completely enclosed by the sheath of an older leaf, which thus forms a kind of tube for its protection. The ligule is early discoverable at its base as a protuberant cell containing a nucleus of a very large size. It grows quickly, but never attains, in *I. lacustris*, to the proportions which it assumes in some other species, e.g. *I. velata*. In this latter plant it develops far more rapidly than the leaf which produces it, and, overtopping it, curves over the apex in such a manner as to protect the whole of the upper part of the leaf. The marginal cells of the expanded upper portion of the ligule are prolonged into short finger-like processes which not improbably contain a mucilaginous substance, and thus serve as additional means of protection against possible periods of dryness. In *I. lacustris* the ligule is, comparatively

¹ Strasburger, Coniferen, etc., pp. 335-6.

speaking, but little developed, and there is moreover in this plant no apparent need of special protection, especially as the older leaves so securely shelter the younger ones. It is only in exceptional cases that I have met with any prolongation of a few of its terminal cells at all comparable with that in *I. velata*, and the whole structure is smaller and simpler than in that plant. It is of course known that the slow-growing leaves of Ferns are commonly provided with some protective structure, and they may be regarded as representing the means for satisfying in a simple manner those requirements which in the higher plants involve the modification of potential foliage-leaves¹, stipules, etc. into scale-leaves. Without desiring to press the point too far, it may be noticed that these modifications are especially characteristic of the highest orders of plants, i.e. Phanerogams, and that in the lower members, such as *Cycas*, in which the early steps may be perhaps supposed to be observable, the arrangement is not such as to suggest that economy of material which is commonly to be seen in adaptive modifications. The stipules of *Marattia* and the curious structures described by Holle² for the Ophioglossaceae are familiar examples of the more complicated kinds of protective structures met with amongst the Vascular Cryptogams, whilst the simpler forms of the series are represented by the *ramenta* of so many Ferns. Much has been made of the ligule in *Isoetes* as indicating some affinity with *Selaginella* in which a similar structure occurs, but the two are in reality very different; that of *Selaginella* arises not from one cell, as in *Isoetes*, but as a multi-cellular protuberance; the mature structure is, moreover, not nearly so complete as in *Isoetes*, especially as regards its insertion. The point, however, which specially weakens the grounds for basing any theories of affinity on the common possession of the ligule by the two genera, is the much later development of this structure in *Selaginella* than in *Isoetes*. And even if this were not the case, outgrowths of a similar nature and belonging to the same category are so

¹ Goebel, Beitr. z. Morph. u. Physiol. des Blattes, Bot. Zeit. 1880.

² Holle, Ueber Bau u. Entw. d. veg. Organe d. Ophioglossen, Bot. Zeit. 1875.

numerous in plants otherwise widely distinct, that it appears scarcely legitimate to regard them as affording any other but confirmatory evidence in establishing a theory of relationship which has been already arrived at on broader grounds. It is of course well known that outgrowths of a somewhat analogous nature are found to be often remarkably constant in certain circles of affinity, such for instance as the stipules of Rosaceae and of Cupuliferae. But this fact really strengthens the case against the employment of the ligule of *Isoetes* as affording any evidence of affinity with *Selaginella*, for no one will refuse to admit that the relationship between the two is at the best but very remote, so different are they in all other important characters; to endeavour therefore to unite them on account of the presence of a ligule in each of them, even if this structure were more similar in the two plants than as a matter of fact is the case, is like an attempt to establish an affinity between the Rosaceae and Cupuliferae on the ground that stipules are common to both orders.

Development of the Leaf.—In describing the development of the leaf, it will be convenient to consider in the first place its growth in length. After its rudiment has become well pronounced as a flattened and conical papilla, further cell-division is chiefly restricted to a zone situated at or near the base of the young leaf. In plants in which sporangia have begun to be formed, the cells *below* the insertion of the ligule remain for some time merismatic, and thus space is provided for the large sporangium, and at the same time the zone, including the insertion of the ligule, is raised up. If, on the other hand, the leaf belongs to a plant which has not as yet begun to bear sporangia, the merismatic tissue is localised in the part of the leaf immediately *above* the ligule. This position is ultimately taken up by the merismatic tissue of all leaves, and it is to the activity of cell-division in this region that the greater part of the mature supraligular portion owes its existence. The cells which are thus formed differ in their subsequent growth, and thus differentiation is at an early period perceptible in the leaf above the meristem. Whilst the middle

cells, which form the vascular strand, grow mainly in length, and remain of small diameter, the parenchymatous cells which immediately surround them as a double or triple layer divide rapidly in the transverse direction. The same is also true of the two rows at the periphery of the leaf, although in this respect they exhibit certain minor differences (see Pl. V. Fig. 16). If the section has passed through the leaf in a direction other than that of the median plane, or one at right angles to it, the cells which occupy the space between the central strand and the periphery are seen to grow quite differently from the tissues on each side. They divide freely whilst in the merismatic region, but after emerging from it they scarcely increase in size at all and their nuclei are very small, a fact which is probably to be correlated with their arrested growth and extremely thin walls. Owing to this condition, and to the fact that the surrounding cells are largely increasing in length, the stationary cells are torn asunder in the longitudinal direction, cohesion being first lost at the centre, whilst the peripheral cells remain permanently attached by their transverse walls: in this way are formed the diaphragms which cross the four air-chambers found in the mature leaf of the plant. The diaphragm is thinnest at its centre, i.e. is of double concave lens-shape, and consists usually of only one cell-layer at this point, becoming thicker at the edges where it is suddenly inserted (*sit venia verbo*) on the outermost layer of the cells which were concerned in its formation (Fig. 16 in Pl. V). The earlier periclinal divisions which occur in the leaf are better seen in transverse than in longitudinal sections.

In transverse sections of young leaves in which the central strand has not as yet reached its final stage of differentiation, but which is, however, perfectly distinct, the outer cells of the leaf are seen to be increasing rapidly by periclinal or tangential divisions, which occur very regularly, and for the most part centrifugally. This is well illustrated by the photograph (Pl. VI. Fig. 22), in which the slight difference which exists between the development of the inner and the outer surfaces is already visible. It is only at a later stage that the diaphragm-

cells become clear and marked off from the four rays of parenchyma which always connect the central bundle with the periphery of the leaf (Pl. VI. Fig. 23). Division is not so regular in the lower part of the leaf, where the sheathing portion is formed as a wing-like outgrowth, which is rendered more evident as the base of the leaf becomes elevated above the level of the stem. The bundle of the leaf in its subulate portion pursues a straight course, and, bending out behind the insertion of the ligule, where also its character slightly changes, it finally curves inwards again below it, and passes as a trace into the stem. It is rudimentary in structure, but of very constant form, and is collateral, both in its course in the leaf and also after entering the stem, thus indicating a relationship with the higher Ferns and with the Phanerogams.

In the portion of the leaf near the apex, the lignified portion of the xylem is reduced to a single tracheid, which is surrounded by six or eight parenchymatous cells, representing the rest of the xylem, which occasionally suffer more or less complete lignification, especially in the lower part of the leaf. I am unable to confirm Russow's statements as to the development of the xylem; I do not find, at least in *I. lacustris*, that there is any definite direction in which the fresh xylem-elements are produced. Sometimes they are formed centripetally, sometimes in the opposite direction, and occasionally they spread unequally in the lateral direction.

The phloem is represented by a few cells which occur at the outer flanks of the xylem, and the protophloem tissues, where they can be distinguished, occur as distorted elements at the outer side of the wood. This slight tendency to encroach around the xylem is of interest, as pointing to an approach to the concentric type of the Fern-bundles proper; it is shown in Pl. V. Fig. 15, which was drawn with the camera lucida. I failed entirely to discover any sieve-plates in the phloem either of *I. lacustris* or *I. velata*; possibly, however, they might be found in a more pronounced terrestrial form. The elements of the xylem become more numerous as the bundle bends out behind the ligule, and at the same time much shorter; a fact

which is to be accounted for by the slight increase in length of the cells of this region. The arrangement both of xylem and phloem is also here obscured, and the curvature makes it almost impossible to determine their exact relation, though it is improbable that they differ from that already described for the upper part of the leaf.

The Sporangium.—The development of the sporangium has been so admirably worked out by Goebel¹, who has corrected and extended the observations of other investigators, that I have nothing to add to his results, which all my own work has confirmed. A comparison with some of the younger stages of *I. velata* and *I. Hystrix* has not yielded any new matter of importance, though it is not improbable that a more extended comparative research may throw light on the question as to the uni- or multi-locular nature of the sporangium in this genus. The facts are, briefly, that each hypodermal archesporial cell has a separate and individual growth; that certain of these form the sterile trabecular tissue, whilst the others form the sporogenous tissue. The exact development of the latter varies according to the macro- or micro-sporangial nature of the body in question. The tapetum in both cases is derived partly from the sporogenous archesporial cells, partly from the trabeculae, and, according to Goebel, partly also from the cells at the back of the archesporium: my observations have made me a little uncertain on the latter point, but it is in any case of no great morphological importance, as is shown by the variation which exists in this respect in Phanerogams. The trabeculae, then, really appear to serve two functions; first to provide a large amount of the tapetal nourishment, and secondly to provide a support for the outer wall of the somewhat bulky sporangium, and indeed from the close manner in which the leaves are packed together on the stem and the mutual pressure they must exert, it is probably a matter of some importance that some such protection should be supplied. The formation of sterile tissue, which is homologous with the actual sporogenous tissue, is well known in the

¹ Goebel, Beitr. z. vergl. Entw. d. Sporangien, Bot. Zeit. 1880.

Hepaticae, and it reaches its highest expression in forms like *Dendroceros*, in which there is a distinct resemblance to *Isoetes*. Of course, the sporangia of the Marattiaceae naturally suggest the explanation that the trabeculae represent the sporangial walls, but the inspection of a tangential section through a half-matured sporangium, especially of a micro-sporangium, tends to weaken the value of such a comparison. In any case, however, it must of course be admitted, that if *Isoetes* is actually allied, as I am convinced it is, with the Eusporangiate Ferns, the exceedingly common occurrence in them of numerous sporangia in close proximity would offer a contrast to *Isoetes* with its single sporangium. Such divisions in the sporangium as are formed by the trabeculae are not unknown in Phanerogams—in certain Onagraceae, for example—but I cannot regard this fact as in any way tending to establish the multi-ocular nature of the body in *Isoetes*.

The Root.—As regards the root, hardly two writers agree in their accounts of its structure and development. The facts that its apex ceases at an early age to remain in the meristematic condition, and also that the dichotomy of the apex takes place repeatedly while it is still enclosed in the original root-cap, serve to render the task of understanding its structure one of considerable difficulty.

Hofmeister, as is well known, regarded its growth as taking place by means of an apical cell, and Naegeli and Leitgeb also assumed its presence, although on negative rather than positive grounds. It is difficult to see how they missed the more correct explanation: their figures are extremely good, and they actually succeeded in unravelling some of the more difficult points, one of which, the nature of the plerome-initial, it is not easy to reconcile with any apical cell hypothesis such as they put forward: 'Der Cambiumcylinder ist anfangs immer einzellig¹.' Bruchmann², who studied the root in detail, believed he had succeeded in demonstrating three

¹ Naegeli u. Leitgeb, *Enst. u. Wachst. d. Wurzeln*, Beitr. z. wiss. Bot. 4. Heft, p. 134.

² Bruchmann, *Ueber Anlage u. Wachst. d. Wurzeln bei Lycopod. u. Isoetes*, Jen. Zeitsch. für Naturwiss. VIII. 1874.

histogenic layers at the apex, a calypstro-dermatogen, a double cortex or periblem, and a plerome. He practically confirms Naegeli and Leitgeb's previous description, when he says, 'Das Plerome wächst im wahrsten Sinne des Wortes mit einer Scheitelzelle,' although the investigators just mentioned had not apparently foreseen the conclusion to be drawn from their own observations. Kienitz-Gerloff¹, on the other hand, after criticising the views of his predecessors, arrives at the singular conclusion that the apex is occupied by an undifferentiated meristem: 'Am naturgemässesten scheint es mir . . . das Gewebe der Wurzelspitze von *Isoetes* als ein völlig indifferentes Meristem zu betrachten. In dem durch dieses Meristem abgeschiedenen Gewebe sondern sich dann später die verschiedenen Gewebesysteme aus' (p. 793). He was probably led into this error by confining himself to a study of optical sections of cleared apices, otherwise his account can hardly be explained at all. His figures do not give the correct relations which exist between the different tissues: the derivatives of the plerome-initial never appear to run straight down the root, as he represents them, except when seen in a plane at right angles to that in which it is alone possible to draw any correct inference as to their origin. And even some of Bruchmann's figures are open to question on this account. The latter investigator does not seem to have paid sufficient attention to the stronger roots of older plants, and I find myself unable to agree with him in his attempt to draw a sharp line of demarcation between the periblem and the meristem which lies externally to it.

I have invariably found the sharpest distinction to prevail between the inner and outer cortex (see Pl. V. Figs. 9, 10; Pl. VI. Fig. 30), while the outer layer of periblem-initials are in most cases not clearly separable from the layers giving rise to the epidermis and root-cap. The variation which seems to exist on this point is suggestive, taken in connection with the relation existing between the dermatogen and periblem

¹ Kienitz-Gerloff, Ueber Wachst. u. Zelltheil. und d. Entwickl. d. Embryo von *Isoetes lacustris*, Bot. Zeit. 1881.

in the Gymnosperms, in *Cycas* or *Pinus*, for example. The plerome, in all cases where I have been able to trace it clearly, grows certainly from a single initial cell, but from the excentric course which the pro-cambial cylinder pursues in the root, it is by no means easy to secure sections which pass through it in the right plane. The cells which are cut off behind the irregularly shaped cell at the apex are readily distinguishable on account of their large nuclei and protoplasmic contents, as well as their large size as compared with the surrounding cells. The cells thus forming a row, divide peripherally and longitudinally, leaving a much larger central cell, from which further cells are cut off longitudinally; this is figured by Hofmeister¹, and also by Naegeli and Leitgeb², and in both cases with remarkable accuracy. Hofmeister explained the large cell as the apical cell, but a series of transverse sections shows this view to be untenable (see Pl. V. Figs. 5, 6, 7, 8), and longitudinal sections (Figs. 9, 10, 30) also demonstrate clearly the actual state of the case. Hofmeister's sections were cut, as a matter of fact, below the actual apex of the plerome, and show the early stages of the development of the vascular bundle. The photograph (Fig. 30) shows how large the central cells are in proportion to those surrounding them, and also how they retain the dense protoplasmic contents and large nuclei which are commonly associated with merismatic structures. The xylem-elements of the monarch vascular bundle only make their appearance at a relatively late period. The two photographs (Figs. 28, 29) show pretty clearly the stages by which this is brought about; and they also show how the phloem-portion of the bundle is well differentiated before the xylem, which is not as yet formed in either, although in Fig. 29 its general future position is distinguishable. There is no need to further discuss the structure of the mature portion of the root, it having been sufficiently described by other investigators, and the split in the cortex has also been correctly explained by Bruchmann. As to the origin of the lateral roots from the stem, I have as yet been unable to

¹ Loc. cit. Plate XIII. Figs. 3, 4.

² Loc. cit. Plate XIX. Figs. 3, 6.

investigate this point independently, although the statements made in reference to it by Van Tieghem and Douliot¹ leave the matter in some doubt. I cannot, however, agree with these authors in regarding the cortex of the root as referable to a single layer of periblem-cells, nor do I find their figure (Pl. XL. Fig. 583) at all convincing. It does not represent anything like that which I have seen in perfectly median sections where the distinctions of the different tissues are much more clearly marked than in their figure, in which the plerome is very much larger in proportion to the size of the whole root than in any preparation I have met with.

I have been unable to follow out all the stages of the dichotomy of the root, but so far as my observations extend, they confirm Bruchmann's statements on these points.

As regards the exogenous character of the primary root my results are, in the main, in agreement with those of other writers; the first divisions certainly occur in the superficial layer of cells, and the inner of the two daughter-layers formed by this periclinal division again divides, giving off fresh root-cap-cells at its exterior. The inner meristems are, however, formed from cells within this layer, which only forms the outer cortex, as is partly indicated in Pl. V. Figs. 2, 3; and Kienitz-Gerloff also has arrived at the same result. The outer layers of the root are as a matter of fact exfoliated, and relying on this fact, the author just cited argues against the claims of the root to be regarded as exogenous. The difference between exogeny and endogeny in a structure such as this is, however, somewhat shadowy, and perhaps it would be well to regard it as representing actually a transition between the two. Of course many (comparatively speaking) exogenous roots are now known, amongst which may be quoted that of *Phylloglossum*. Van Tieghem and Douliot have attempted to correlate the relative time of development with the exo- or endo-geny, but I think that the instance of *Isoetes* shows that this principle, useful as it is in many cases, may be carried too far. The root

¹ Recherches comparatives sur l'origine des membres endogènes dans les plantes vasculaires, An. Sci. Nat. (Bot.) 1888.

of *Isoetes* is not perhaps, strictly speaking, a primary structure, and I incline rather to consider it as an early type of adventitious root. It is formed relatively much later than in the true Ferns, and yet it is far more exogenous in character than in them.

The Oophyte.—The development of the oophyte has long presented difficulties to those who have attempted its investigation, partly owing to the ease with which the contents of the spore are injured, and partly to the hardness and thickness of its coats.

Mettenius¹, who described the structure of the macrospore, correctly distinguished its three principal layers or coats. The outer glassy epispore or perinium is extremely hard and brittle, and its surface is beset with numerous prominences. It is without doubt derived from the plasma of the sporangium formed by the breaking down and solution of the tapetal cells (and probably the mother-cell walls), and it stains faintly with safranin. The exospore, a dark brown band of somewhat fibrous appearance, is clearly resolvable into a double layer, and the outer one of the two frequently splits again. The endospore is a rather thick cellulose-wall, of irregular thickness, and it is characterised by a brightly refractive appearance, recalling that presented by collenchymatous walls.

The contents of the spore are rendered obscure by the enormous quantity of oil, the removal of which can however be easily effected by turpentine or ether, when the protoplasm appears as a granular and reticulated structure. The granularity is caused by the numerous small proteid bodies which are embedded in its substance, whilst the reticular structure is due to the withdrawal of the oil which formerly filled the meshes. Starch-grains are also freely present, so that the protoplasm is thus very richly supplied with nutritive reserve material. At the upper end of the spore lies the nucleus, which is of very large dimensions, and contains a variable number of nucleoli of different sizes. These points are illustrated by the photographs (Figs. 24, 25). The nucleus, which

¹ Mettenius, Ueber *Azolla*, Linnæa, 1847, p. 269.

is separated from the cytoplasm by a well-marked membrane, is of a very watery consistency, and is so poor in chromatin as to be scarcely stained at all by reagents more especially used for nuclear structure, as methyl-green, safranin, or haematoxylin, although the nucleoli are rapidly and intensely coloured; and it is to these facts that the great difficulty of following out the changes which take place in the nucleus during the earlier stages of germination is to be attributed.

In the mature spore the apical portion (in which the nucleus is imbedded) is clearly separable from the remaining larger part by the dense character of its protoplasm, and the comparative absence from it of the reserve stores of starch and oil; and this differentiation becomes more and more obvious as the formation of cell-walls approaches. I have not, in spite of careful search through many hundreds of spores, succeeded in recognising the nucleus at this stage; probably the nucleoli, during its division, may suffer disintegration, and diffusion into the cytoplasm as the result of the heat necessarily employed in parafin-embedding.

But although the changes in the nucleus remain obscure, the other processes attending germination are clear enough. The mass of protoplasm already mentioned as occupying the apex of the spore becomes traversed by fine cracks coinciding in their general directions with the positions ultimately taken up by the young cell-walls. I have no doubt that this splitting is subsequent to, and perhaps conditioned by, the division of the spore-nucleus, though direct evidence is wanting on this point. After cell-formation has begun, it proceeds with great rapidity, though in a manner differing in the two regions of the spore already alluded to. Figure 17 exhibits one of the earlier stages, and is intelligible when it is borne in mind that the section has passed obliquely below the spore-apex. Figure 18 shows clearly the differences in the process of division prevailing in the upper and lower part of the spore, the extreme slowness with which the process is conducted in the lower part being strongly contrasted with the rapid cell-increase in the upper portion. The divisions in the latter region lead to the

formation of the archegonia, and so similar are the earlier formed cells of the outer layer all through this upper portion of the prothallium that it is impossible, until quite late, to predict which are destined to give rise to archegonia; all are apparently, and to an equal extent, potential reproductive-organ-forming cells. The archegonia are formed by the periclinal division of an outer cell into two daughter-cells, the outer of which forms the four (sometimes three) stories of neck-cells, whilst from the inner one are cut off successively the neck-canal and ventral canal cells, leaving the oosphere at the base. While these divisions are taking place the surrounding cells divide into a small-celled tissue in which the archegonium is buried, only its outermost neck-cells being free. The venter is thus formed, as in the highest Vascular Cryptogams and Gymnosperms, not from the mother-cell of the archegonium, but from the cells of the surrounding tissues. The neck-cell, when first cut off, divides into four cells arranged cross-wise, and then each of the four is divided into two cells transversely, and each of these again divides, once more forming the four stories of which the mature neck is commonly composed (Pl. V. Figs. 20, 21). The neck-canal-cell grows in between the neck-cells, thrusting them apart, and establishing, eventually, a connection between the exterior and the inner part of the archegonium. The neck-cell and the ventral canal-cell all finally become mucilaginous as in other Cryptogams.

Whilst these changes are rapidly proceeding in the upper part of the spore, the larger basal portion also undergoes changes. Its protoplasm is never so abundant as that of the upper cell-tissue, but the reserve material stored up in it is far more plentiful. It forms a cellular mass, but comparatively slowly, beginning at the periphery, and fortunate preparations show the large peripheral cells enclosing a central mass of protoplasm, as yet undivided, but in which are lying several free nuclei (Fig. 19). The whole appearance recalls the free cell-formation taking place in an embryo-sac during the formation of endosperm, though there is nothing more than analogy between the final products in the two cases. The lower portion of the spore

eventually becomes filled with cells which are always distinct from those of the upper portion, both on account of their size and their contents, and moreover they never form archegonia. The prothallium thus formed lies within the spore, but not connected with it, as its outer cells have their own external wall distinct from the endospore.

The formation of the prothallium in *Isoetes* presents certain striking features of resemblance with that of *Selaginella* as described by Pfeffer¹, and may perhaps help to explain some of the peculiarities which render the oophyte of the latter plant so remarkable. Pfeffer states, and I am able to confirm his results in their chief points, that the spore is first divided by a wall (diaphragm) into an upper portion in which cell-division goes on rapidly, and a lower and much larger portion in which cell-formation is long retarded, and of which the protoplasm contains large quantities of food-material. The 'Prothallium' (of Pfeffer) makes its appearance before the spore has reached its full size, and is only followed later, after sowing the spores, by a free cell-formation in the infradiaphragmatic portion. Cell-division is brought to a close here apparently through the gradually increasing inability to complete the process, the lower part, as I have sometimes seen in *S. Braziliensis*, still remaining undivided into cells when an embryo was already growing in the spore. Pfeffer has endeavoured to make a morphological distinction between the two kinds of tissue thus described, regarding the meniscus of small-celled tissue as the prothallium, and comparing the lower and looser mass to the endosperm of Angiosperms. I venture to think, however, that such a position is untenable, and that the facts are to be better explained in another way, especially when *Isoetes* and *Selaginella* are compared in respect of their sexual generation. In both there is a clearly marked upper portion in which cell-division proceeds with great rapidity; and a larger basal portion in which cell-formation takes place slowly. That this production of cells proceeds centripetally in *Isoetes*

¹ Pfeffer, Die Entw. d. Keimes d. Gattung *Selaginella*, Hanstein's Bot. Abhandl. Bd. I.

and basipetally in *Selaginella* I do not regard as a fact of great importance. The essential point is, that in each, a specially *reproductive* portion is separated from a specially *vegetative* and nutritive portion; the chief difference between the two cases lying in the greater completeness with which the differentiation is carried out in the case of *Selaginella*. It is natural to expect that a tissue which is required rapidly to give up its substance to a growing organism would not form a small-celled tissue. This cell-wall formation would involve an uneconomical expenditure, and its occurrence in the endosperm of Angiosperms may perhaps be correlated with the comparatively slow growth of the embryo which obtains in these plants.

Evidence is not wanting to show that a localisation of the reproductive organs of the oophyte, such as is required to support the suggested explanation of the structure in the two cases under discussion, is exactly the rule in a great number of widely different forms. This is especially true of the archegonia, with which we are here more directly concerned, and whose restriction to the 'cushion' of many Fern-prothallia, to the 'saddle' of *Salvinia*, to the central part of a *Pilularia*-prothallium, and to the more specially modified archegoniophores of many other plants, in each instance points in the same direction, and still further support is given by the Equisetaceae and the Lycopodiaceae.

It might have been expected that Gymnosperms would evince a more decided distinction, if these conclusions are to hold good, between the reproductive and vegetative portion of their prothallia; but apart from the fact that our knowledge on the early history of this structure in these plants is not very detailed, it may be pointed out that apparently the reduction has become so advanced, so far as the reproductive bodies are concerned, in the higher forms at least, that not more archegonial rudiments are formed than can be brought to maturity. Further investigation in this direction would probably yield interesting results.

I think that the above facts and considerations show plainly

that Pfeffer was in error in regarding the 'Endosperm' of *Selaginella* as representing anything more than the vegetative or specially nutritive portion of the prothallium: the differences in the character of the cell-division in the two regions arising from the fundamental difference between the respective protoplasts (in the widest sense of the word) which so modify the manner of cell-formation as to suit the ultimate requirements of each.

I believe these conclusions may serve further to throw light on the question of the significance of the changes which occur in the embryo-sac of Angiosperms up to the period when the oosphere is ready for fertilization. Just as in *Selaginella* and *Isoetes* the first divisions of the spore separate the reproductive from the vegetative protoplasm, each of which thenceforth develops on different lines, so also the first division of the nucleus of the embryo-sac produces two daughter-nuclei, whose further products are perfectly dissimilar, resulting finally in the production of the 'egg-apparatus' at the one end, and the antipodal cells at the other, with the definitive nucleus half-way. The antipodal cells do not, I believe, represent the whole prothallium, as they are usually considered to do, but only the reduced vegetative portion of it. And it would seem that the reduction has progressed so far that the original vegetative part is unable to, or at least does not, fulfil the needs of the growing embryo as regards nutriment, and hence the coalescence of the two nuclei, one from the *reproductive* (micropylar) and one from the *vegetative* (antipodal) part of the prothallium.

The definitive nucleus, formed in this manner, may probably be regarded as the result of a coalescence of nuclei analogous to that which obtains in actual fertilization, but with this difference, that in this case it is not an oosphere, but probably the *second polar body*, which descends from the generative apparatus and fuses with a vegetative nucleus which is derived from the opposite end of the spore. The union does not confer great power on the resultant nucleus: merely that of forming, under certain conditions, a number of similar cells—the endo-

sperm. It may be that the one nucleus contains sufficient histogenic plasma (to borrow Weismann's expression) to enable, under suitable circumstances, the 'reproductive substance' provided by the other nucleus (the *sister-nucleus* of the oosphere) to go through that simple form of segmentation which characterises the endosperm of Angiosperms.

This view of the matter makes the micropylar nucleus, before it divides into the four nuclei which compose the original 'egg-apparatus,' the equivalent of the 'central cell' of a Fern-archegonium; it cuts off successively two polar bodies, of which the first gives rise to the synergidae by further division, just as the neck-canal-cell of Ferns commonly divides further, after its separation from the central cell; and the second one, which I regard as representing the ventral canal-cell of the Fern, forms half the definitive nucleus. It is true the existence of a ventral canal cell has been denied in the case of some plants, but the point requires renewed investigation. And there is nothing surprising in such a reduction of the generative apparatus in the highest plants; such a process is indicated all through the various lines of descent of the different branches of Vascular Cryptogams, as well as of the Gymnosperms. In the Angiosperms indeed, bearing in mind how the tissue for the support of the growing embryo is not even capable of developing unless there is a chance of its being used, and also how this principle of saving material is carried yet further in the case of ovules of many Orchids, such a reduction as actually occurs in the embryo-sac is not only possible but inherently probable.

If these conclusions be accepted, *Isoetes* becomes additionally interesting as throwing light on some of the most obscure phenomena prevailing in Angiosperms. Its connection with *Selaginella* is equally interesting, as serving to explain the peculiarities of the sexual generation of this plant, but I do not regard the approximation in the character of the two oophytes as affording any weighty arguments for placing them near each other in the natural system. Rather we have an indication of one of those 'parallel developments,' which are

hinted at in so many other forms. The reduction of the oophyte has advanced along similar lines, wherever it has occurred, in the Vascular Cryptogams, and in the direction indicated above; and it is from broader and more general comparative and morphological characters that the criteria of affinity must be derived.

It is acknowledged by all modern writers that in reality *Isoetes* presents but little affinity with *Selaginella*. Goebel has even stated his belief that the ligule is perhaps the only important feature which they have in common, and I have attempted to show that the admitted community in this respect does not really advance the question at all. I myself entirely admit the force of Prof. Vines'¹ arguments in support of the affinity with the true Ferns, and I think that the general results contained in this paper do not in any way oppose such an alliance, although they show that it is not perhaps very close. This is however not a matter for surprise; the heterosporous character of the genus clearly indicates a great advance on the homosporous condition of the Filicinae.

¹ Annals of Botany, vol. ii.

EXPLANATION OF FIGURES IN PLATES V AND VI.

Illustrating Mr. Farmer's paper on *Isoetes lacustris*.

(N.B.—Figures Nos. 26 and 27 refer to *I. velata*.)

PLATE V.

Figs. 1, 2, 3. Sections through the root of the embryo. The lines through the small diagrams accompanying Figures 1 and 2 represent the direction of the section, which lies in the plane of the paper in Fig. 2.

Fig. 4. Transverse section through the vascular bundle at the base of an old root.

Figs. 5, 6, 7, 8. Transverse sections through young root-tips at successively greater distances from the actual apex.

Fig. 9. Longitudinal section through young root apex. *P*=plerome.

Fig. 10. Longitudinal section through another root apex. *P*=plerome, *E*=dermatogen.

Figs. 11, 12. Transverse sections of stem-apex. Fig. 11 shows superficies; xxxx the meristem; *L* a leaf rudiment. Fig. 12 from the same stem, but the plane of the section lies deeper than in Fig. 11.

Figs. 13, 14. Longitudinal section of stem with young leaf.

Fig. 15. Vascular bundle of leaf. *x*=xylem, *Ph*=phloëm, *s*=sheathing cells of the xylem.

Fig. 16. Longitudinal section through half a leaf. *E*=epidermis. The large cells on the left abut on the vascular bundle which is not shown.

Figs. 17, 18. Stages in germination of macrospore.

Fig. 19. Section through a spore cut parallel to the base.

Figs. 20, 21. Archegonia.

PLATE VI.

Fig. 22. Transverse section through young leaf, *L*. This is enclosed in the ligule (*Li*) of the next oldest leaf, and this again by that of a still older one. *x*=tracheid.

Fig. 23. Transverse section of leaf. *x*=tracheid.

Fig. 24. Section through a spore. *n*=nucleus, *k*=nucleolus, *s*=starch.

Fig. 25. Another spore, with well-marked nucleus and nucleoli.

Fig. 26. Transverse section of stem of *Isoetes velata*.

Fig. 27. Longitudinal section of the same.

Fig. 28. Transverse section of root of *Isoetes lacustris* just beneath the apex.

Fig. 29. Transverse section through the same root, separated by the thickness of one section.

Fig. 30. Longitudinal section through root. *P*=plerome.

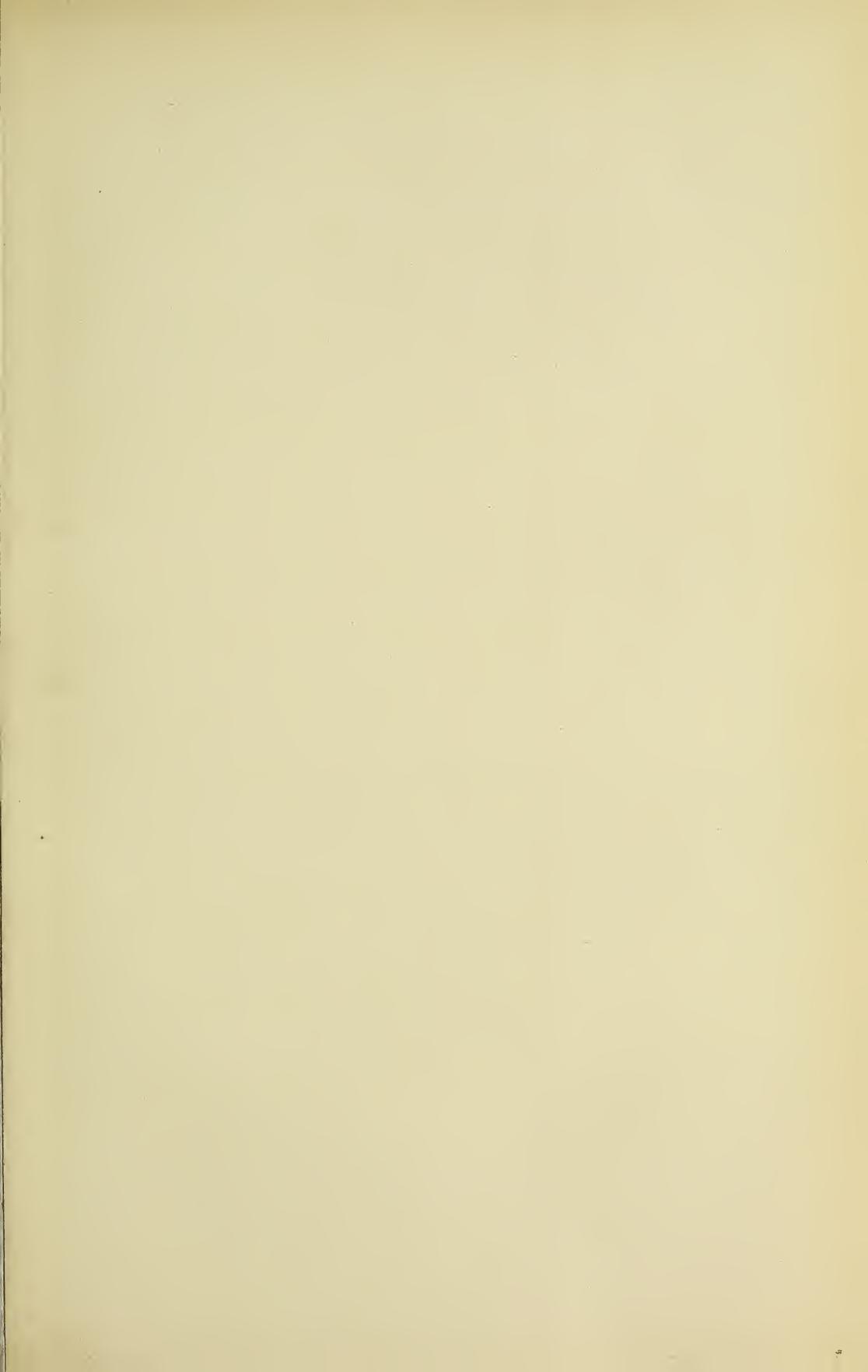


Fig. 1.

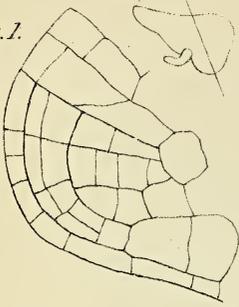


Fig. 2.

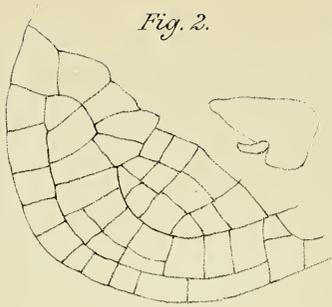


Fig. 3.

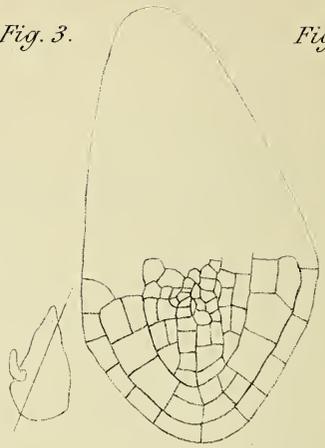


Fig. 4.

Fig. 7.

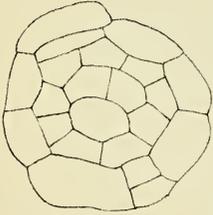


Fig. 8.

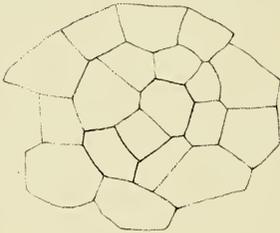


Fig. 9.

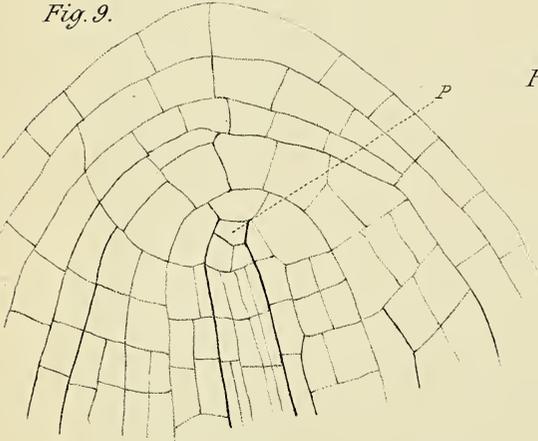


Fig. 10.

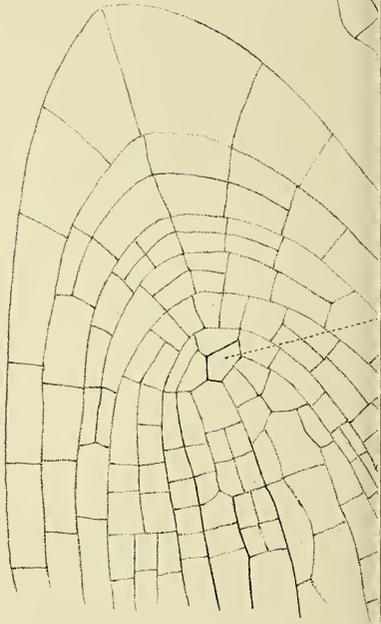


Fig. 18.

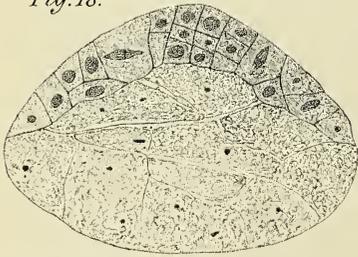


Fig. 19.

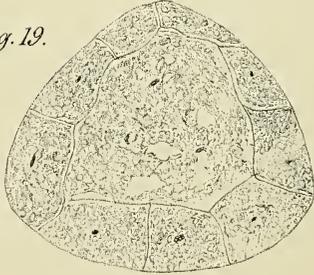


Fig. 20.



Farmer del.

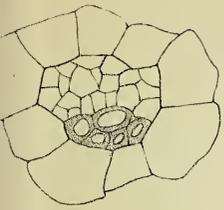


Fig. 5.

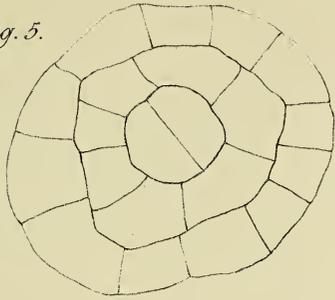


Fig. 6.

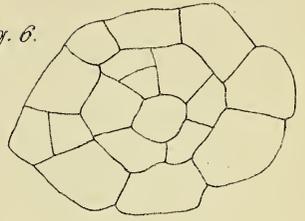


Fig. 11.

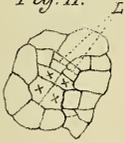


Fig. 13.

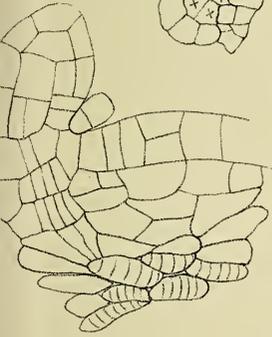


Fig. 12.

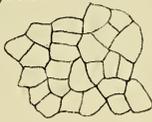


Fig. 14.

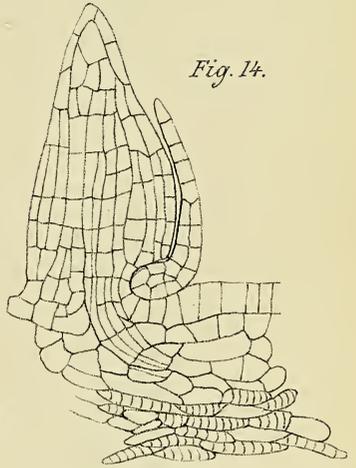


Fig. 15.

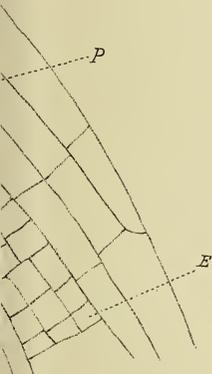
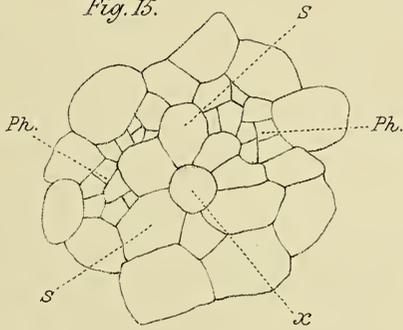


Fig. 17.

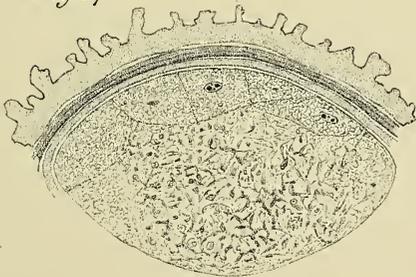


Fig. 16.

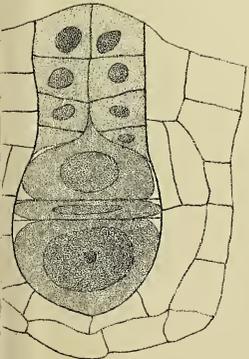
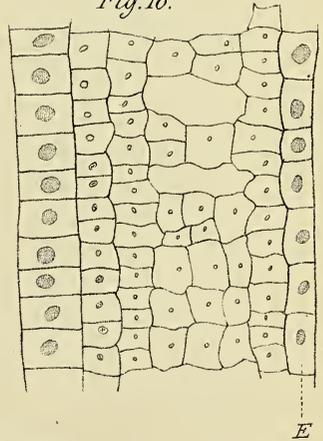


Fig. 21.

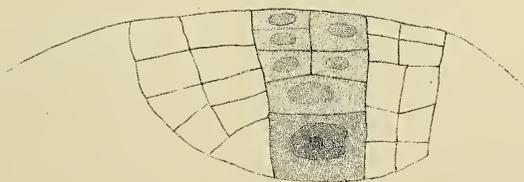


Fig. 1.

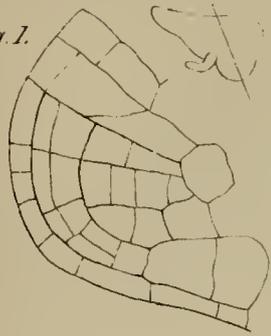


Fig. 2.

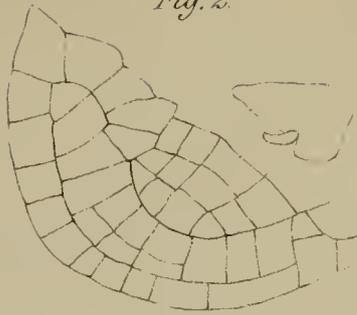


Fig. 3.



Fig. 4.

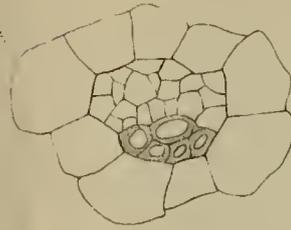


Fig. 5.

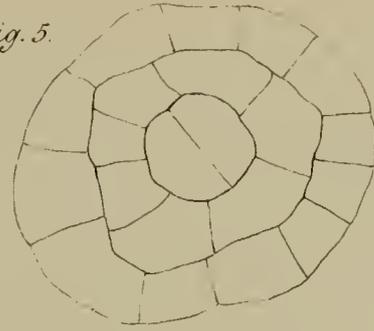


Fig. 6.

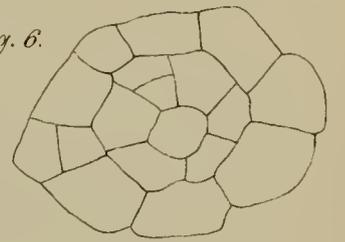


Fig. 7.

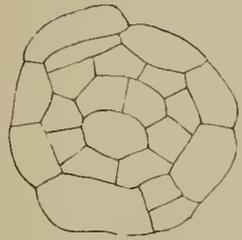


Fig. 8.

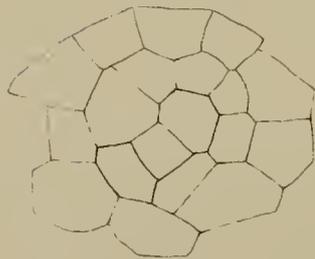


Fig. 13.



Fig. 11. L



Fig. 12.



Fig. 14.

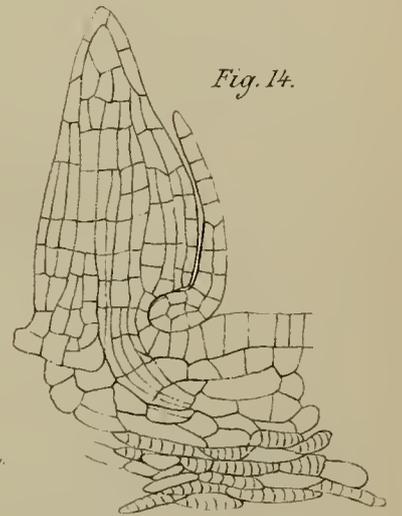


Fig. 9.

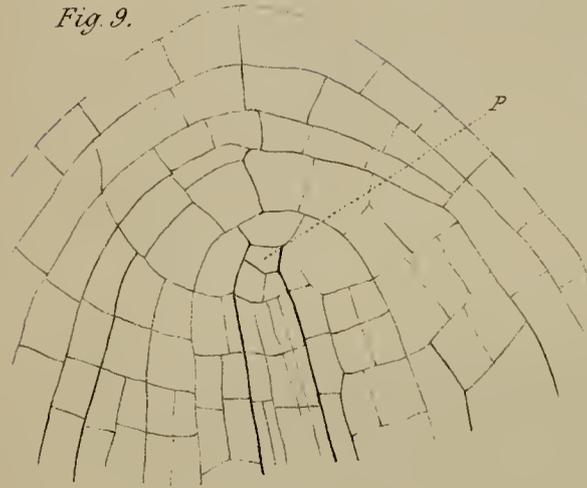


Fig. 10.

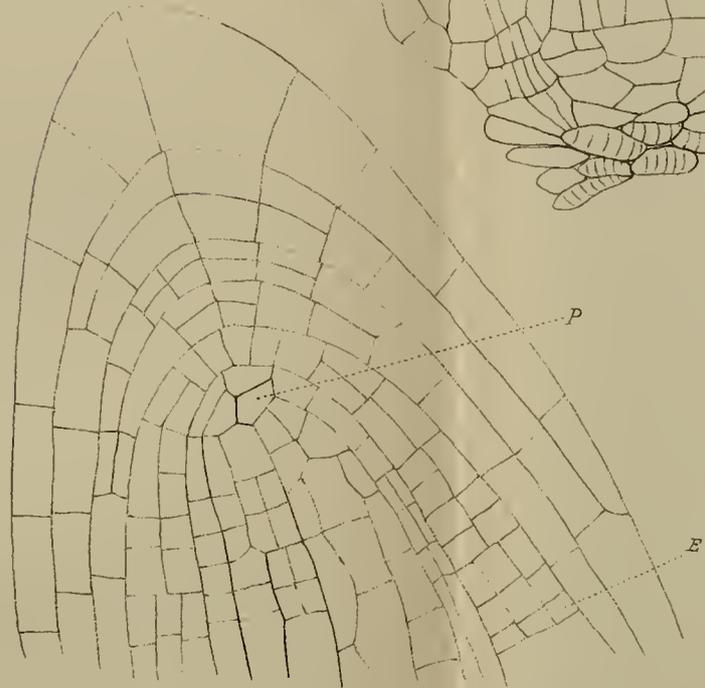


Fig. 15.

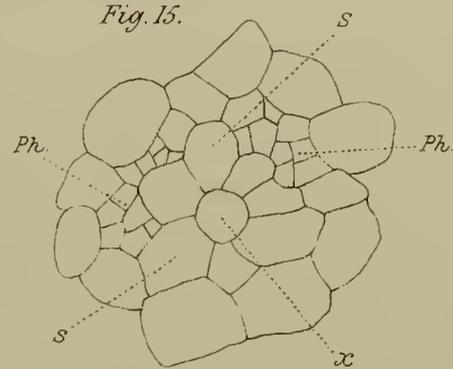


Fig. 16.

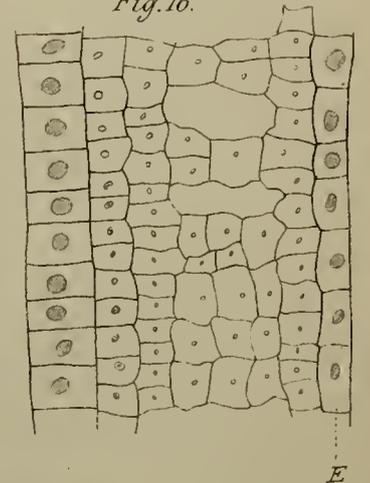


Fig. 18.

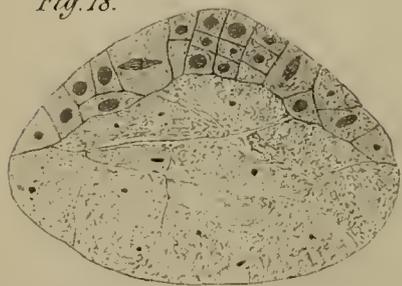


Fig. 19.

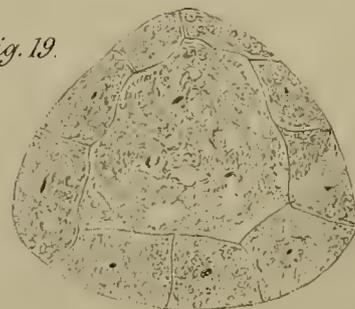


Fig. 20.

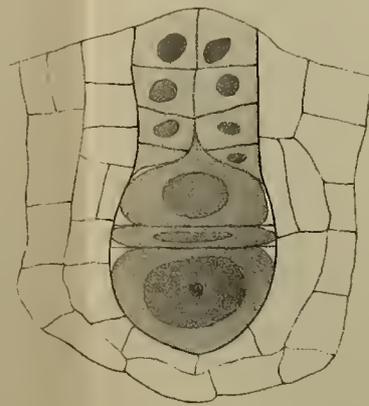
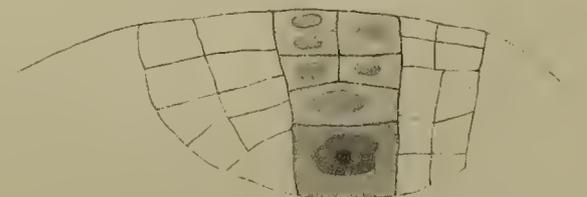


Fig. 17.

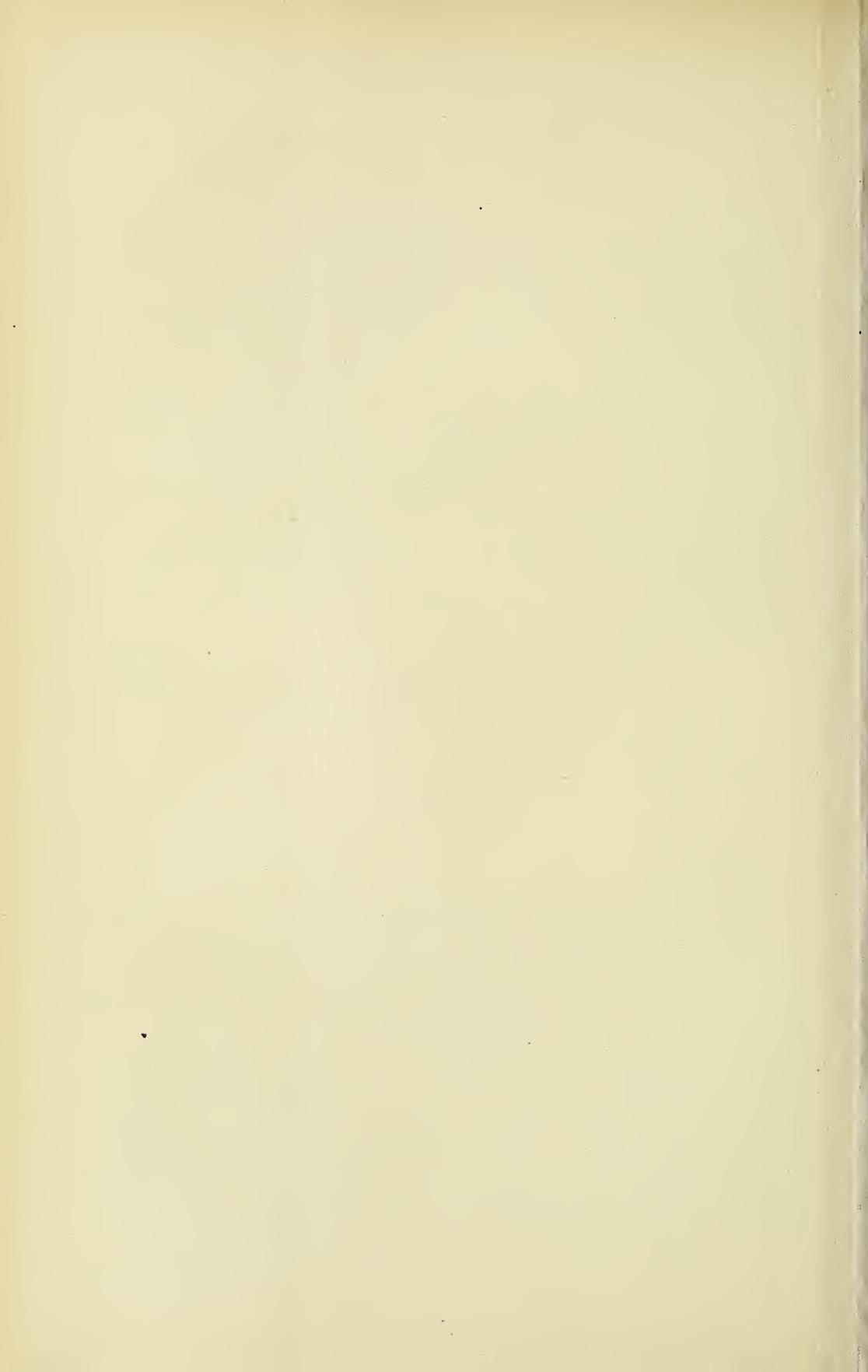


Fig. 21.



Farmer del.

University Press, Oxford.



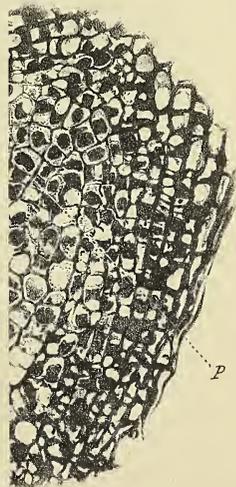
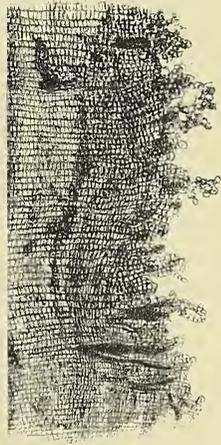
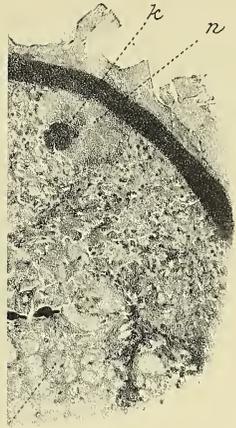


Fig. 22.

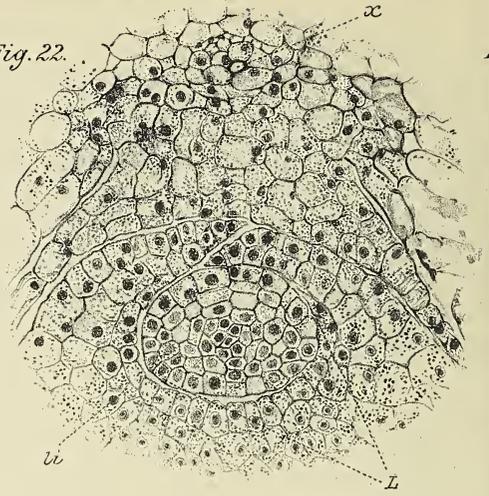


Fig. 25.

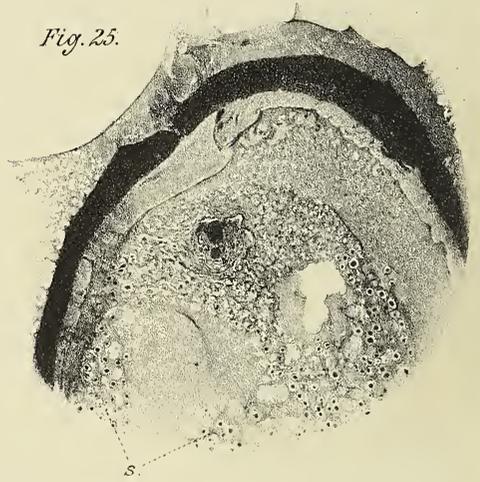
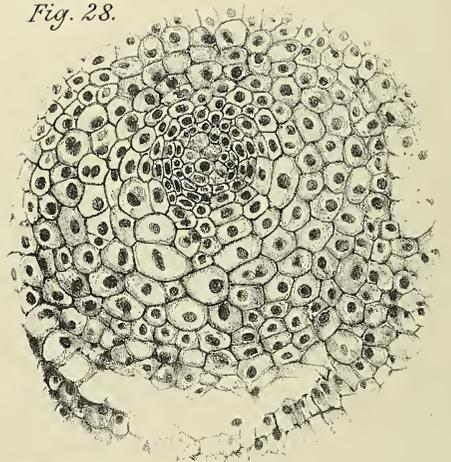


Fig. 28.



From Photo^s

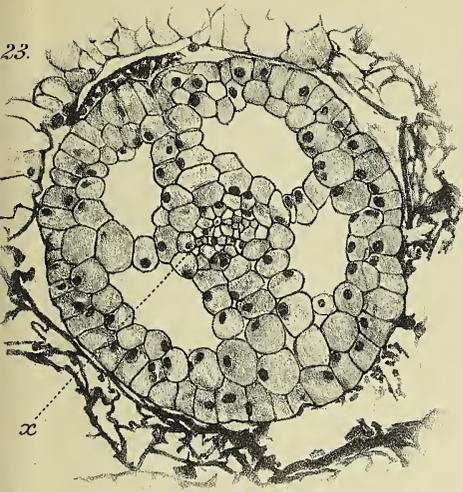


Fig. 24.

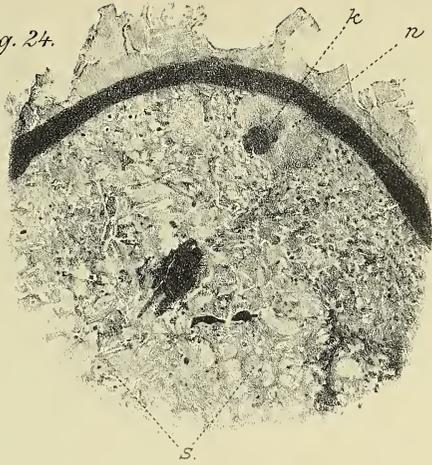


Fig. 26.

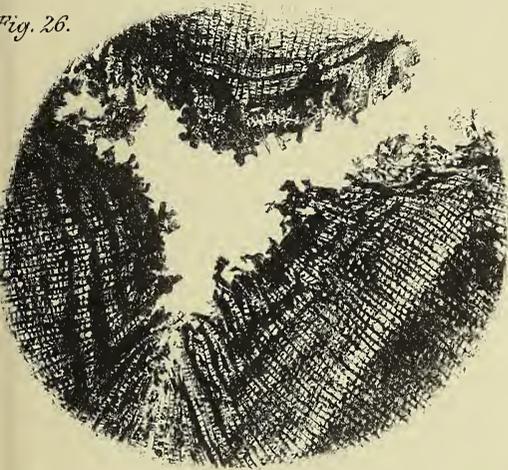
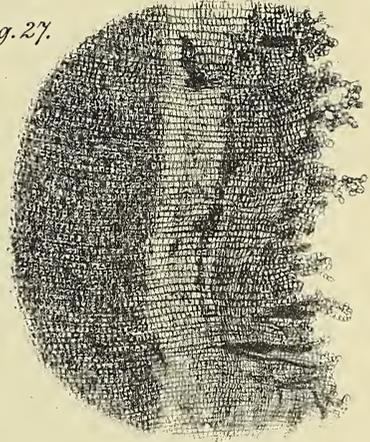


Fig. 27.



29.

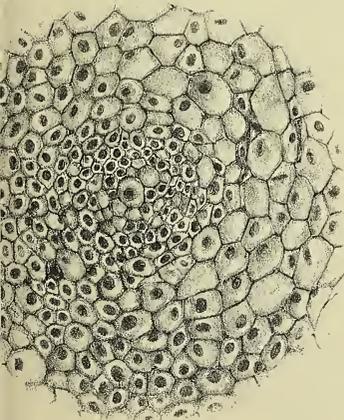
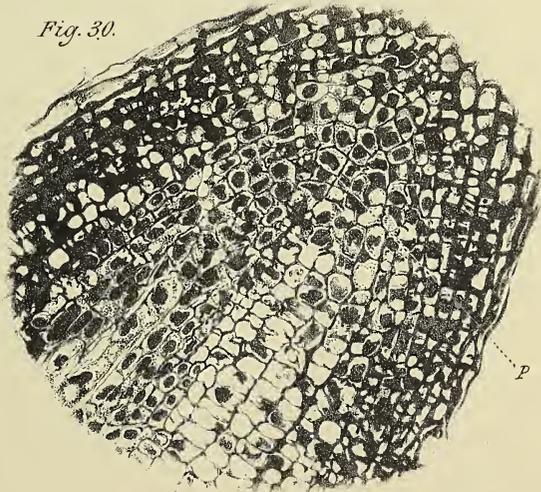
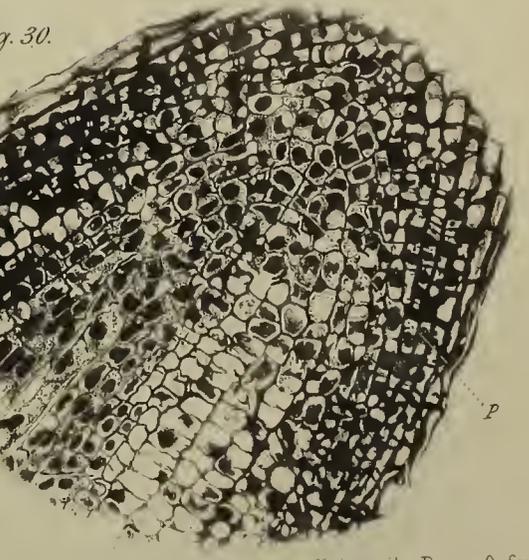
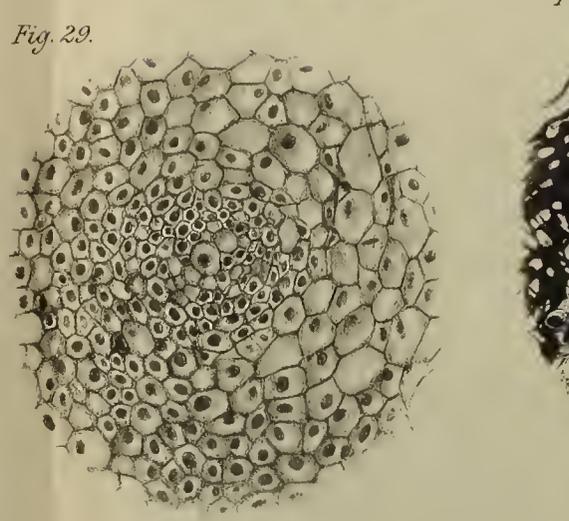
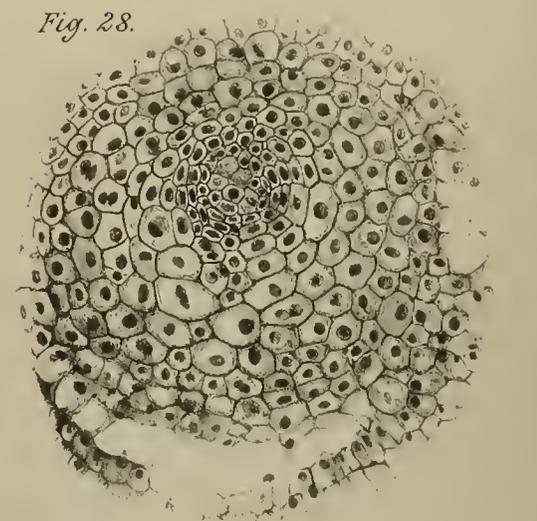
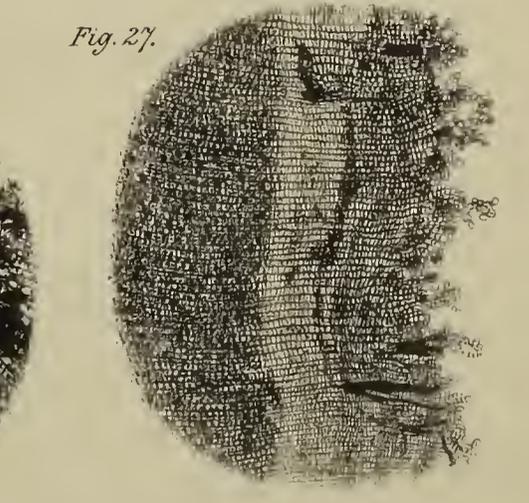
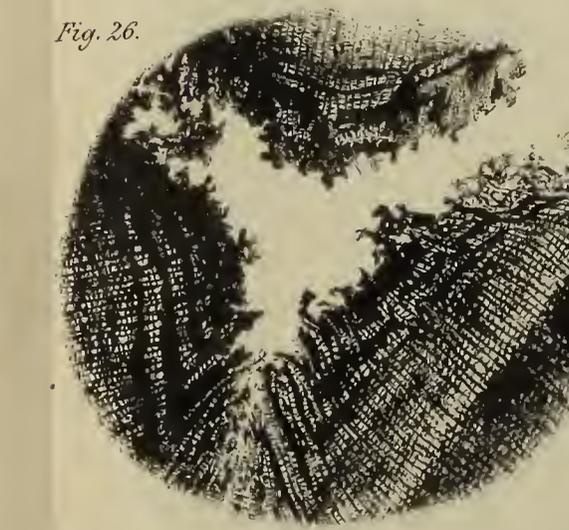
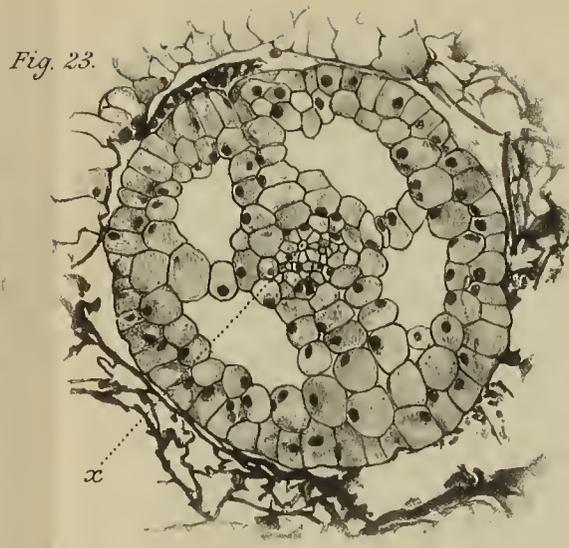
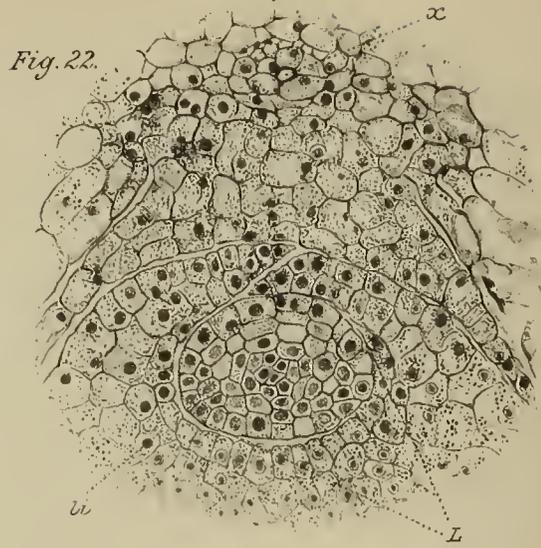


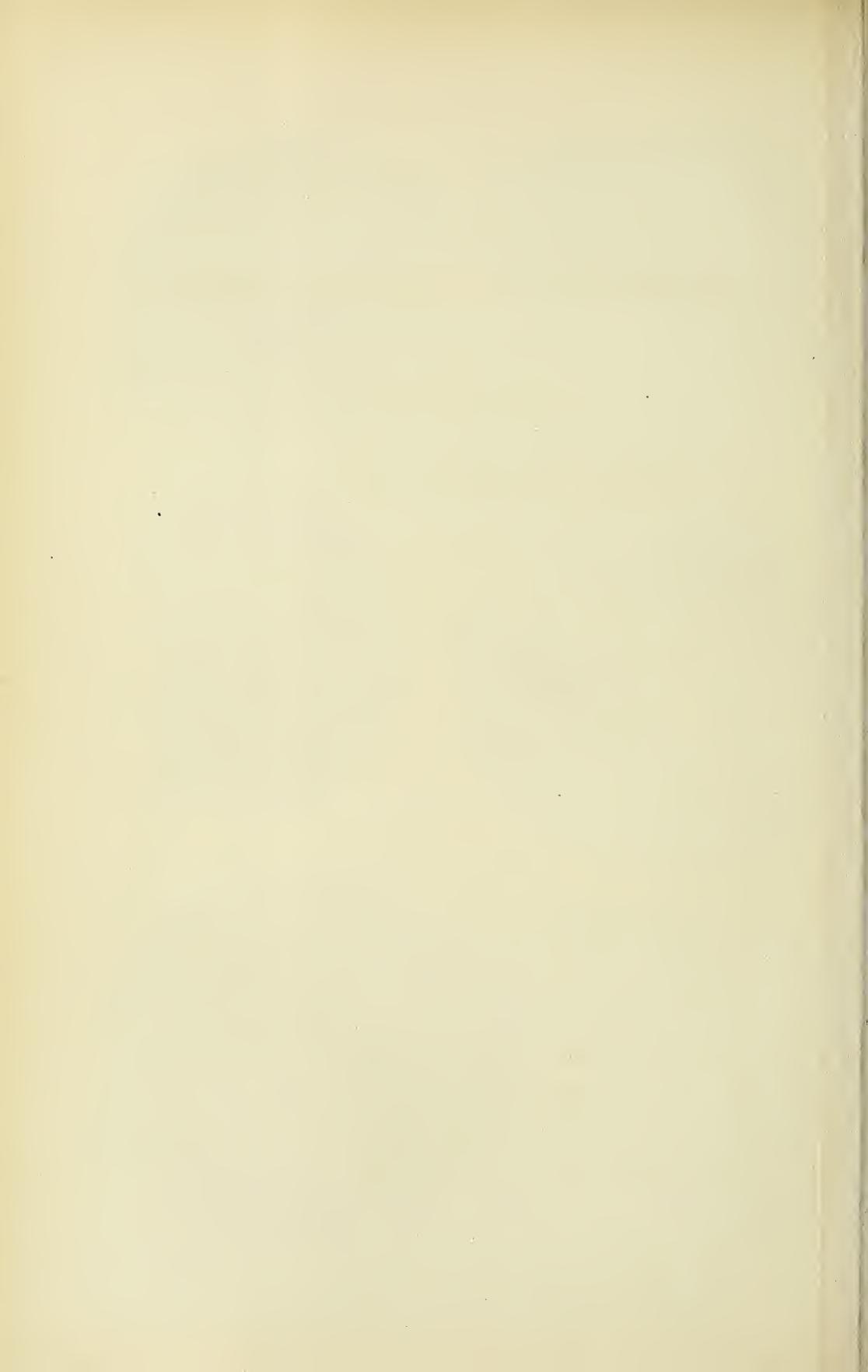
Fig. 30.





From Photo^s

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A Revised List of the British Marine Algae.

BY

E. M. HOLMES, F.L.S.

AND

E. A. L. BATTERS, B.A., LL.B., F.L.S.

SINCE the publication of Harvey's classical *Phycologia Britannica*, a very large number of species have been added to the British Marine Flora, and great progress has been made in the study of the modes of growth and reproduction of the various groups. Nevertheless, much still remains to be done before it will be possible to satisfactorily determine the systematic position, or even the right to specific rank, of many 'species.' Consequently, any classification that may be adopted at the present time must be regarded, to a certain extent, as a provisional one.

In preparing the following list it has been our object to bring it as nearly as possible into accordance with the most recent investigations, and to utilise, as far as possible, the terminology most generally accepted by algologists. An attempt has been made to give some degree of uniformity to the names adopted for the different groups, so that the nature of the group may be indicated by the terminal syllables of the name; but the alterations thus made are, we believe, insufficient to cause any inconvenience. It has not seemed to us desirable to indicate at present the characters distinguishing the different groups, such details being reserved for a handbook on the subject, which is already in progress, and which we hope to publish at a later date. Our aim has been rather

to enumerate in the form of a list, available as a check-list, all the British species which have up to the present time been identified.

There are still many species existing in our own and other herbaria which have not yet been examined, and which will probably hereafter still further enlarge the present list. In the form of an appendix we have given a list of species found on the Baltic and French coasts, which may not unreasonably be expected to occur on our own shores. Descriptions, or figures, or references to these will be found in the following works:—

Bornet et Flahault, *Revision des Nostocacées hétérocystées.* (Ann. Sc. Nat. vii série, Bot., tom. iii. iv. v. and vii.) Paris, 1886–1888.

Crouan, *Florule du Finistère.* Paris, 1867.

Hauck, *Die Meeresalgen Deutschlands und Oesterreichs.* Leipzig, 1885.

Kjellman, *The Algae of the Arctic Sea.* Stockholm, 1883.

Reinke, *Algenflora der Westlichen Ostsee.* Kiel, 1889.

Stromfelt, H. G. *Om Algvegetationen vid Islands Kuster.*

The authority given for the name of a species is in every case that of the botanist who first employed the name as it stands, not that of the author who first described the species under another name. We hold that the changes which have taken place in the nomenclature of a plant should be indicated in the list of synonyms which are usually appended to it in most descriptive works. The only deviation from this rule will be, to give in parentheses the old name under which the plant was described in *Phycologia Britannica*, or, if omitted in that work, in the last work on British Marine Algae in which it occurred. This plan will, we trust, render a reference to other works, and to herbaria, less toilsome.

The mode of classification adopted has been to proceed from the lower to the higher forms, those being regarded as the lowest in which the vegetative organs are the most simple or least differentiated, and in which the reproductive organs are either unknown, or belong to a low type of

development. In cases where the reproductive organs are of a higher type, and the vegetative organs of a very simple structure, as in *Vaucheria*, the plant will rank higher than one in which the vegetative system is highly developed, and the reproductive system very slightly so, as in *Desmarestia* and *Laminaria*. A preliminary attempt to give the distribution of species in the British Islands has been made, founded on published records, or on species seen by ourselves in herbaria. As it is desirable to indicate the part of the British Islands in which each species occurs, we have divided the British coasts into fourteen sections, which are as follows:—

1. From the Shetland Islands to the Sound of Mull.
2. From the Sound of Mull to the Solway Firth.
3. From the Shetland Islands to Aberdeen.
4. From Aberdeen to the Tweed.
5. From Solway Firth to Holyhead.
6. From Holyhead to the Scilly Islands.
7. From the Tweed to Cromer.
8. From Cromer to Dover.
9. From the Scilly Islands to Dover.

IRELAND.

10. From Malin Head to Roundstone Bay.
11. From Roundstone Bay to Bantry Bay.
12. From Malin Head to Dublin Bay.
13. From Dublin Bay to Wexford Harbour.
14. From Bantry Bay to Wexford Harbour.

In each case the locality first-named will be included in that section, but the second will not, the second locality being the starting-point for the next section. Where a general record without localities has been published, the initial letter of the country only will be given, thus—E. S. I. When a specimen for the district has been seen by us, it is indicated by a note of exclamation following the number. It is hoped that a foundation may thus be laid for working out the distribution of Marine Algae on our shores, this branch of the subject having as yet received too little attention.

Our grateful acknowledgments are due to the following distinguished algologists for frequent help afforded in the identification of critical species, and for valuable suggestions and friendly criticism:—Professor Dr. J. G. Agardh, Dr. E. Bornet, Dr. W. G. Farlow, the late Dr. F. Hauck, Mons. M. Gomont, Dr. F. R. Kjellman, Dr. O. Nordstedt, Major Reinbold, Professor Dr. J. Reinke, and Professor Dr. F. Schmitz; also to Professor E. Perceval Wright, M.D., for permitting reference to Harvey's type specimens. It may be useful to state that in the course of our investigations we have found that the type specimens of the following authors are deposited in the hereinstated herbaria:—

Dr. W. Arnott, Glasgow University.
 Rev. M. J. Berkeley, Kew Herbarium.
 W. Borrer, Kew Herbarium.
 Miss Cutler, British Museum Herbarium.
 Dr. R. K. Greville, Botanic Gardens, Edinburgh.
 Mrs. J. E. Gray, Cambridge University.
 Mrs. Griffiths, Linnean Society, London, &c.
 Professor W. H. Harvey, Trinity College, Dublin.
 R. Henedy, Anderson College, Glasgow.
 Dr. G. Johnston, Berwick-on-Tweed.

CLASS THALLOPHYTA.

SUBCLASS ALGAE.

Series I.—CYANOPHYCEAE.

Cohort I.—CHROOCOCCINAE.

Order I.—CHROOCOCCACEAE.

Gloeocapsa Näg.

G. crepidinum, Thur. 4! 5! 9!

Polycystis Kütz.

P. pallida, Farlow. 4!

Order II.—CHAMAESIPHONACEAE.

Dermocarpa Crn.

D. prasina, Born. 4! 7! 9!

f. *olivacea*, Holm. et Batt. 9!

var. *incrustans*, Holm. et Batt. 4!

D. violacea, Crn. 4!

ar *rosea*, Holm. et Batt. 4!

D. Leibliniae, Born. 4! 9!

D. Schousboei, Born. 4! 5! 8!

Hyella Born. et Flah.

H. caespitosa, Born. et Flah. 4! 9!

Order III.—HORMOSPORACEAE.

Hormospora Bréb.

H. ramosa, Thw. 4! 8!

Cohort II.—NOSTOCHINAE.

Section I.—HOMOCYSTEAE.

Order I.—OSCILLARIACEAE.

Tribe I.—Oscillarieae.

Spirulina Turp.¹

S. pseudotenuissima, Crn. 4! 5!

S. tenuissima, Kütz. 4! 5. 6. 8! 9! (*S. oceanica*, Crn.
Holm. Fasc. No. 73).

¹ The *Spirulina Hutchinsiae* from Cumbræ, in the Trinity College Herbarium, Dublin, is stated by M. Gomont to be *S. major*, Kütz. Harvey, Syn. p. 200, No. 379, remarks, under *S. Hutchinsiae*, Kütz., 'Unknown to me' (1857).

CYANOPHYCEAE (*continued*).

Spirulina major, Kütz. (*S. tenuissima*, Batt. Alg. Berw., pl. vii. f. 4). 2! 4!

Oscillaria Bory.

- O. brevis*, Rab. 4!
- O. colubrina*, Thur. 4!
- O. Corallinae*, Gom. 1! 9! (*Oscillatoria litoralis*, ¹Phyc. Brit. partim, et *O. capucina* Holm. Fasc. No. 69).
- O. infectoria*, Tassi. 4!
- O. intermedia*, Crn. 4!
- O. insignis*, Thw. 6! 7!
- O. laetevirens*, Crn. 4!
- O. nigroviridis*, Thw. 4!
- O. percursa*, var. *marina*, Kütz. 4!
- O. subuliformis*, Thw. 4! 6. 9!
- O. tenuis*, C. Ag. 4!

Phormidium Kütz.

- Ph. papyraceum*, Gom. (*Oscillatoria spiralis*, Phyc. Brit.).
- Ph. antliarium*, Gom. 4!

Tribe II.—**Lyngbyeae**.

Lyngbya C. Ag.

- L. semiplena*, J. Ag. 4! 6! 8! 9. (*Calothrix caespitula*, Phyc. Brit. et *L. luteofusca*, J. G. Ag. Holm. Fasc. No. 67).
- L. aestuarii*, Liebm. 4! 9! (*L. ferruginea*, Phyc. Brit.).
- L. majuscula*, Harv. 4! 9!
f. *crispa*, Holm. et Batt. 9!
- L. spectabilis*, Thur. in herb. 5!

Symploca Kütz.

- S. hydroides*, Kütz. 4! 9! (*C. semiplena*², Phyc. Brit.).
- S. fasciculata*, Kütz. 4! 9!

¹ The type of *O. litoralis*, Carm. examined by M. Gomont proves to be *Lyngbya aestuarii*, Liebm. with a few filaments of *O. Corallinae*, Gom.

² The specimens collected at Sidmouth by the Rev. R. Creswell under the name of *Calothrix pannosa*, Ag., as also those distributed by Harvey under the MS. name of *C. lamellata*, are referable to this species.

CYANOPHYCEAE (*continued*).

Tribe III.—Vaginarieae.

Hydrocoleum Gom.

H. lyngbyaceum, Kütz. 9!

var. *rupestris*, Kütz. 4! (*Microcoleus nigrescens*, Thur.
MS. Batt. Alg. Berw. p. 18).

Microcoleus Desm.

M. chthonoplastes, Thur. (*M. anguiformis*, Phyc. Brit.).
4! 6. 7! 9!

Schizothrix Gom.

S. Cresswellii, Harv. 9!

S. lardacea, Gom. 9!

Section II.—HETEROCYSTEAE.

Order II.—RIVULARIACEAE.

Tribe I.—Leptochaetaceae.

Amphithrix Kütz.

A. violacea, Born. et Flah. 2!

Tribe II.—Mastichotricheae.

Calothrix C. Ag.

a. Basilares.

C. confervicola, C. Ag. 4! 7! 9!

var. *a. purpurea*, Born. et Flah. 9!

C. consociata, Born. et Flah. 8!

C. scopulorum, C. Ag. 4! 7! 9!

C. pulvinata, C. Ag. 4! 9! II. 14. (*C. hydnoides*,
et *C. pannosa*, Phyc. Brit.).

C. parasitica, Thur. 9!

β. Intercalares.

C. aeruginea, Thur. 4! 9!

C. crustacea, Thur. 4! 9!

C. fasciculata, C. Ag. 2. 4! 7! 9! II.

Isactis Thur.

I. plana, Thur. 4! 9! (*Rivularia plana*, Harv. in Hook.
Brit. Fl. pt. I. p. 394).

var. *fissurata*, Born. 9!

Rivularia J. Ag.

R. Biasoletiana, Menegh. 4! 9! (*Schizosiphon War-*
reniae, Phyc. Brit.).

CYANOPHYCEAE (*continued*).

Rivularia atra, Roth.

var. *a. hemisphaerica*, 4! 7! 9!

var. *β. confluens*, Farl. 4! 9!

R. nitida, C. Ag. (*R. plicata*, Phyc. Brit.) 2. 4! 5! 9.

10. 11. 14.

R. bullata, Berk. (*R. nitida*, Phyc. Brit.) 1. 2. 5. 9. 11.

R. polyotis, Born. et Flah. 9!

R. australis, Harv. 9!

Order III.—**SIROSIPHONACEAE**.

Mastigocoleus Lagerh.

M. testarum, Lagerh. 4! 9!

Order IV.—**SCYTONEMACEAE**.

Microchaete Thur.

M. grisea, Thur. 4! 9!

Order V.—**NOSTOCACEAE**.

Nostoe Vauch.

N. Linckia, Born. 6. 8. (*Monormia intricata*, Phyc. Brit.).

Anabaena Bory.

A. variabilis, Kütz. 5. 6. 8! (*Sphaerozyga Thwaitesii*, Phyc. Brit.).

A. torulosa, Lagerh. 1. 4! 5! 6. (*Sphaerozyga Carmichaelii*, Phyc. Brit.).

Nodularia Mert.

N. Harveyana, Thur. 4! 6! (*Spermosira Harveyana*, Phyc. Brit.).

N. spumigena, Mert.

var. *β. litorea*, Born. et Flah. 5! 6! (*Spermosira litorea*, Phyc. Brit.).

Series II.—**CHLOROPHYCEAE**.

Cohort I.—**PROTOCOCCINAE**.

Order I.—**PROTOCOCCACEAE**.

Tribe I.—**Endosphaereae**.

Chlorochytrium Cohn.

Ch. immersum, Masee. 7!

Ch. inclusum, Kjellm. 9!

CHLOROPHYCEAE (*continued*).

Chlorocystis Rke.

- Ch. *Cohnii*, Rke. 12. (*Chlorochytrium Cohnii*, Wright,
R. I. Acad. Trans. XXVI. p. 355).

Tribe II.—Characieceae.

Sykidion E. P. Wright.

- S. *Dyeri*, E. P. Wright 12.

Characium A. Br.

- Ch. *strictum*, A. Br. 4!

Codiolum A. Br.

- C. *gregarium*, A. Br. 6! 9!
var. *longipes*, Holm. et Batt. 4! (*Codiolum longipes*,
Holm. Fasc. No. 33).

Cohort II.—**CONFERVINAE.**

Order I.—**BLASTOSPORACEAE.**

Schizogonium Kütz.

- S. *disciferum*, Holm. et Batt. 4! (*Ulothrix discifera*,
Holm. Exsicc. No. 99).

Prasiola C. Ag.

- P. *stipitata*, Suhr. 2! 4! 5! 9! (*Prasiola marina*, Holm.
Fasc. No. 21).

Order II.—**ULVACEAE.**

Pringsheimia Rke.

- P. *scutata*, Rke. 4!

Monostroma Thur.

- M. *Wittrockii*, Born. 4! 6! 9!
M. *latissimum*, Wittr. 9!
M. *laceratum*, Thur. 6! 9!
M. *Grevillii*, J. Ag. 1. 4! 7. (*Ulva Lactuca*, Phyc. Brit.,
et *Enteromorpha Cornucopiae*, Phyc. Brit.).
M. *Lactuca*, J. Ag. 9!
M. *Blyttii*, Wittr. 4!

Capsosiphon Gobi.

- C. *aureolus*, Gobi. 4!

Diplonema Kjellm.

- D. *confervoides*, Holm. et Batt. 4! 5! 9!

CHLOROPHYCEAE (*continued*).

Enteromorpha Link.

a. Clathratae.

- E. clathrata*, J. Ag. 5. 7. 9!
E. Hopkirkii, M'Calla. 4! 7! 9! 12.
E. Ralfsii, Harv. 4! 7! 9!
E. pulcherrima, Holm. et Batt.¹ (*E. erecta*, Phyc. Brit.).
E. erecta, J. Ag. 9! 14! (*Conferva paradoxa*, Dillw. Brit. Conf.).

β. Crinitae.

- E. percursa*, C. Ag.
 γ. *ramosa*, J. Ag. 4! 5! 7. 9. 12. (*E. percursa*, Phyc. Brit.).
E. lingulata, J. Ag. 1!
E. crinita, J. Ag. 9!
E. ramulosa, Harv. 4! 7! 9!

δ. Intestinales.

- E. Linkiana*, Grev. 1.
E. prolifera, J. Ag. 4! 9! (*E. compressa*, β. *prolifera*, Grev. Alg. Brit. p. 180).
E. compressa, Grev.
 f. *constricta*, J. Ag. 9!
 f. *complanata*, J. Ag. 9!
E. Linza, J. Ag.
 f. *lanceolata* 2. 4! 7. 8. 9! (*Ulva Linza*, Phyc. Brit.).
E. intestinalis, Link. 1. 4. 7. 9.
 f. *cylindrica*, J. Ag. 9!
 f. *clavata*, J. Ag. 9!
 f. *cornucopia*, J. Ag. 4!
 f. *gyrata*, J. Ag. 9!
 f. *maxima*, J. Ag. 9!
E. micrococca, Kütz.
 var. β. *tortuosa*, J. Ag. 9.
E. canaliculata, Batt. 4!
E. minima, Näg. 4! 8!

¹ *E. pulcherrima* is a plant that does not appear to be well known to European algologists. It is a very distinct species and adheres closely to paper when dry. It occurs in the Kew Herbarium under the name of *C. paradoxa* in Miss Hutchins' writing, but does not agree with Dillwyn's figure or with the description of his *C. paradoxa*.

CHLOROPHYCEAE (*continued*).

Ulva L.

U. latissima, J. Ag., E. S. I.

U. rigida, J. Ag. 9!

Order III.—**ULOTHTRICHACEAE.**

Ulothrix Kütz.

U. implexa, Kütz. 4! 5! (*Lyngbya Cutleriae*,¹ Phyc. Brit.).

Order IV.—**CHAETOPHORACEAE.**

Tribe I.—**Chaetophoreae.**

a. Trichophoreae.

Bolbocoleon Pringsh.

B. piliferum, Pringsh. 9!

Ochlochaete Thw.

O. Hystrix, Thw. 9²!

β. Atricheae.

Entoderma Lagerh.

E. viride, Lagerh. 9!

E. Wittrockii, Wille. 4!

Epicladia Rke.

E. Flustrae, Rke. 4! 8! 9!

Order V.—**CLADOPHORACEAE.**

Urospora Aresch.

U. penicilliformis, Aresch. 4! 6! 8. 9! (*Conferva Youngana*, Phyc. Brit.).

U. collabens, Holm. et Batt. 8. (*Conferva collabens*, Phyc. Brit.).

U. bangioides,³ Holm. et Batt. 6! 9.

¹ Miss Cutler appears to have collected two plants as *Lyngbya Cutleriae*, see Batters' List Mar. Alg. of Berwick-on-Tweed, p. 36. Since the publication of that work Harvey's type specimen has been unexpectedly found and proves to be *U. implexa*, Kütz.

² *Ochlochaete Hystrix*, Thw. was not found in frutification, and has not been detected in the original locality since its first discovery, so that it is not certain whether it should be placed in *Chaetophoraceae* or *Coleochaetaceae*.

³ *Urospora bangioides* has, we understand, been found by Mr. R. J. Harvey Gibson to produce the peculiar tailed spores of Areschoug's genus, but these have not yet been observed in the other species which we have provisionally placed here, in consequence of their similarity of habit and growth to *U. penicilliformis*.

CHLOROPHYCEAE (*continued*).

Urospora flacca, Holm. et Batt. 4! 9! (*Lyngbya flacca*
et *L. Carmichaelii*, Phyc. Brit.).

U. speciosa, Holm. et Batt. 4! (*Lyngbya speciosa*, Phyc.
Brit.).

Chaetomorpha Kütz.*a. Tortuosae.*

Ch. tortuosa, Kütz. 4! 6. 8. 9! (*Conferva tortuosa*,
Phyc. Brit.).

Ch. implexa, Kütz. 2.

Ch. litorea, Holm. et Batt. 1. 5. 9! (*Conferva litorea*,
Phyc. Brit.).

Ch. linum, Kütz. 2! 4! 6. 7! 8. 9! 11. (*Conferva sutoria*,
Phyc. Brit.).

Ch. crassa, Kütz. (*Conferva linum*, Phyc. Brit.). 12!

β. Strictae.

Ch. Melagonium, Kütz. 4! 7. 9! 10. (*Conferva Mela-*
gonium, Phyc. Brit.).

f. *typica*, Kjellm. 4!

f. *rupicola*, Aresch. 4!

Ch. aerea, Kütz. 4! 7. 9! (*Conferva aerea*, Phyc. Brit.).

Ch. chlorotica, Kütz. 1! (*C. cannabina*, Traill in Trans.
Bot. Soc. Edinb.).

Rhizoclonium Kütz.

Rh. riparium, 1. 4! 6. 7. 8. 9! 11.

f. *Casparyi*, Holm. et Batt. 6.

Rh. flavicans, Rab. 9! (*Conferva arenicola*, Phyc. Brit.).

Rh. tortuosum, Kütz. 4! 9! (*Conferva implexa*, Phyc. Brit.).

Rh. rigidum, Gobi. 4!

Rh. Kochianum, Kütz. 4! 9! 11.

Rh. arenosum, Kütz. 1. 14. (*Conferva arenosa*, Phyc. Brit.).

Cladophora Kütz.*a. Cartilagineae.*

C. prolifera, Kütz. 9!

C. pellucida, Kütz. 5! 9!

f. *comosa*, Kütz. 9!

f. *cristata*, Kütz. 11.

CHLOROPHYCEAE (*continued*).

- Cladophora Hutchinsiae, Harv. 2. 4! 7. 9! 11.
 f. divaricata, Harv. 9.
 f. diffusa, Holm. et Batt. 3. 6. 9! (*Cladophora diffusa*, Phyc. Brit.).
- C. utriculosa, Kütz.
 var. falcata, Holm. et Batt. 9. 11. (*C. falcata*, Phyc. Brit.).
 var. β . laetevirens, Hauck. 4! 9! (*Cladophora laetevirens*, Phyc. Brit.).
- C. rupestris, Kütz. 4! 8. 9! 11.
 var. nuda, Holm. et Batt. 12. (*Cladophora nuda*, Phyc. Brit.).
 var. distorta, Harv. 11.
- C. flexuosa, Griff. 9!
 C. glaucescens, Griff. 1. 4! 9!
 β . *Pulvinatae*.
- C. repens, J. Ag. 9!
 C. Brownii, Harv. 9! 13.
 C. retroflexa, Crn. 9! 11!
 C. Macallana, Harv. 9! 11.
 C. rectangularis, Harv. 9! 11!
 var. subnuda, Kütz.
 var. hispida, Kütz.
- γ . *Flavescentes*.
- C. hirta, Kütz. (*Conferva flexuosa*, E. B. et Holm. Fasc. No. 56). 4! 8!
 C. fracta, Kütz.
 var. patens, Holm. et Batt. 9! (*C. refracta*, Roth, Holm. Exsicc. No. 91).
 var. marina, Hauck. 4! 9!
 var. Magdalenae, Holm et Batt. (*Cladophora Magdalenae*, Phyc. Brit.).
- C. expansa, Kütz. 7! 9!
 C. flavescens, Kütz. 7! 9!
- δ . *Crystallinae*.
- C. albida, Kütz. 4! 9! 10. 11. 13.
 var. refracta, Holm. et Batt. 6. 9! 12. 14. (*Cladophora refracta*, Phyc. Brit.).

CHLOROPHYCEAE (*continued*).

Cladophora Rudolphiana, Kütz. 9. 11.

C. Balliana, Harv. 12.

C. crystallina, Kütz. 9!

C. trichocoma, Kütz. 11.

ε. *Radicantes*.

C. arcta, Kütz. 1. 2. 4! 5. 6. 7! 9!

f. *vaucheriaeformis*, Harv. 4! 9!

f. *centralis*, Harv. 4!

C. arctiuscula, Kütz. 4! 9!

C. lanosa, Kütz. 2. 4! 9!

f. *uncialis*, Thur. 1. 4! 6. 7. 9! 12. 13.

Order VI.—**GOMONTIACEAE**.

Gomontia Born. et Flah.

G. polyrrhiza, Born. et Flah. 4!

Cohort III.—**SIPHONINAE**.

Order I.—**BRYOPSIDACEAE**.

Bryopsis Lamour.

B. hypnoides, Lamour. 9!

B. plumosa, C. Ag. 4! 9!

f. *subsimplex*, Holm. et Batt. 6! 9!

Order II.—**DERBESIACEAE**.

Derbesia Sol.

D. tenuissima, Crn. (*Vaucheria marina*, Phyc. Brit.). 9!

Order III.—**VAUCHERIACEAE**.

Vaucheria DC.

V. dichotoma, Lyngb.

f. *marina*, C. Ag. 9! (*Vaucheria submarina*, Phyc. Brit.).

V. Thuretii Woron.¹ 1. 4! 5. 7. 9! (*Vaucheria velutina*, Phyc. Brit. partim).

V. synandra, Woron. 5.

¹ Harvey's plate gives one magnified filament with a stalked oogonium and another with a sessile one. The former is almost certainly *V. sphaerospora*, but the other may be *V. Thuretii*, although there are no antheridia figured, these being usually present on the same, or a branch of the same, thread.

CHLOROPHYCEAE (*continued*).

- Vaucheria sphaerospora*, Nordst. 1. 4! 9! 12.
f. *synoica*, Nordst. 5.
f. *dioica*, Rosenv. 1. 5. 8. 9! (*Vaucheria velutina*,
Phyc. Brit. partim).
var. *subsimplex*, Holm. et Batt. 9! (*Vaucheria piloboloides*,
Holm. Fasc. No. 50).
V. litorea, Hofm. Bang. et C. Ag. 3. 5. 6. 9! 12.

Order IV.—**CODIACEAE.**

Codium Stackh.

- C. adhaerens*, C. Ag. 9!
f. *amphibium*, Holm. et Batt. 9! 11.
C. tomentosum, Stackh. 5! 9!
C. elongatum, C. Ag. 1.¹
C. Bursa, C. Ag. 9! 12.

Series III.—**PHAEOPHYCEAE.**

Cohort I.—**ECTOCARPINAE.**

Order I.—**DESMARESTIACEAE.**

Desmarestia Lamx.

- D. viridis*, Lamx. 1-14.
D. aculeata, Lamx. 1-14.
D. ligulata, Lamx. 1. 4! 7! 8. 9!-14.
D. Dudresnayi, Lamx. 9! 10.

Order II.—**DICTYOSIPHONACEAE.**

Dictyosiphon Grev.

- D. foeniculaceus*, Grev. 1-14.
f. *hispida*, Kjellm. 4!
f. *flaccida*, Kjellm. 4!
D. hippuroides, Kütz. 2! 4! 7!
D. Chordaria, Aresch. 4!
D. Mesogloea, 4! 7!

Order III.—**PUNCTARIACEAE.**

Litosiphon Harv.

- L. pusillus*, Harv. 1-14.
L. Laminariae, Harv. 1-7! 9! 10.

¹ Mentioned by J. G. Agardh in Till Algernes Systematik as occurring on the Irish coast.

PHAEOPHYCEAE (*continued*).

Stictyosiphon Kütz.

- S. Griffithsianus, Holm. et Batt. (*Ectocarpus brachiatus*, Phyc. Brit.). 2. 4! 8. 9! 14.
 S. sub-articulatus, Hauck. 4! 6! 7! (*Phloeospora sub-articulata*, Holm. Fasc. No. 19).
 S. tortilis, Rke. 4! 7! (*Phloeospora tortilis*, Holm. Fasc. No. 20).

Striaria Grev.

- S. attenuata, Grev. 2. 3. 5. 6. 8. 9!

Desmotrichum Kütz.

- D. undulatum,¹ Rke. 1! 2!

Punctaria Grev.

- P. plantaginea, Grev. 1-14.
 P. latifolia, Grev. 1. 2. 3. 5. 9!-13.
 f. Zosteræ, Le Jol. (*P. tenuissima*, Phyc. Brit.). 4! 9!

Order IV.—**ASPEROCOCCACEAE.**

Myriotrichia Harv.

- M. clavaeformis, Harv. 1-14.
 f. filiformis, Farlow. 1-14. (*M. filiformis*, Phyc. Brit.).

Asperococcus Lamx.

- A. echinatus, Grev. 1-14.
 f. vermicularis, Griff. 1-14.
 A. bullosus, Lamx. (*A. Turneri*, Phyc. Brit.). 1. 2. 5. 9-14.
 A. compressus, Griff. 6! 9!

Order V.—**ECTOCARPACEAE.**

Streblonema Derb. et Sol.

- S. investiens, Thur. 9!
 S. fasciculatum, Thur. 4! 9!
 S. velutinum, Thur. (*Elachista velutina*, Phyc. Brit.). 1-14.
 S. simplex, Holm. et Batt. (*Ectocarpus simplex*, Holm. Fasc. 8). 9!

¹ This plant has been found by one of us (E. B.) to be mixed with *Punctaria tenuissima*, Grev. in Greville's own specimens, but it is not clear from Greville's description that he recognised it.

PHAEOPHYCEAE (continued).

Ectocarpus Lyngb.

- E. repens*, Rke. (*E. reptans*, Holm. Fasc. No. 35). 9!
- E. parvulus*,¹ Kütz.
- E. terminalis*, Kütz. 4! 5! 9!
- E. Holmesii*, Batt. 4! 9!
- E. pusillus*, Harv. 4! 9!
- E. irregularis*, Kütz. 9!
- E. caespitulus*, Kjellm. 4! 9! (*E. caespitulus*, J. Ag., Holm. Fasc. No. 62).
- E. insignis*, Crn. 4! 9!
- E. Lebelii*, Crn. 9!
- E. fenestratus*, Berk. 9!
- E. Crouani*, Thuret. 6! 9!
- E. Sandrianus*, Zan. 9!
- E. virescens*, Thuret. 6! 9!
- E. secundus*, Kütz. 9!
- E. hiemalis*, Crn. 9!
- E. longifructus*, Harv. 1. 9!
- E. arctus*, Kütz. (*E. confervoides*, f. *arcta*, Holm. Fasc. No. 64). 9!
- E. confervoides*, Le Jol. 1-14.
 - f. *siliculosa*, Kjellm.
 - f. *spalatina*, Kjellm. 9!
 - f. *patens*, Holm. et Batt. 9! (*E. siliculosus*, β . *longipes*, Phyc. Brit.).
 - f. *penicillata*, C. Ag. 9!
 - f. *typica*, Kjellm. 7!
- E. acanthophorus*, Kütz. 9!
- E. fasciculatus*, Harv. 1-14
 - f. *glomerata*, Holm. et Batt. 9!
 - f. *draparnaldioides*, Crn. 9!
- E. granulatus*, C. Ag. 1-14.
 - f. *tessellata*, Harv.
- E. ovatus*, Kjellm. 9!
- E. Hincksiae*, Harv. 1. 7. 9! 12.
- E. tomentosus*, Lyngb. 1-14.

¹ Determined by J. Agardh from specimen No. 211 in Hohenacker's Alg. Mar. sicc.

PHAEOPHYCEAE (*continued*).

Species requiring confirmation.

- Ectocarpus brachiatus, Crn. (*Conferva brachiata*, E. B.).
- E. crinitus, Carm. 1. 6.
- E. Landsburgii, Harv. 2! 11.
- E. distortus, Harv. 1!

Sorocarpus Pringsh.

- S. uvaeformis, Pringsh. 9!

Isthmoplea Kjellm. 1-6. 9!

- I. sphaerophora, Kjellm. (*Ectocarpus sphaerophorus*, Phyc. Brit.). 1-4! 9!

Pylaiella Bory.

- P. litoralis, Kjellm. (*Ectocarpus litoralis*, Phyc. Brit.). 1-14.
 - f. vernalis, Kjellm. 9!
 - f. ramellosa, Holm. et Batt. 6!
 - f. ferruginea, Kjellm. 9!
 - f. firma, Kjellm. 9!
 - f. compacta, Kjellm. 4! 9!
 - f. amphibia, Holm. et Batt. 6! (*Ectocarpus amphibioides*, Phyc. Brit.).

Order VI.—**ARTHROCLADIACEAE.**

Arthrocladia Duby.

- A. villosa, Duby. 1. 2. 4! 5. 7. 9! 13.

Order VII.—**ELACHISTACEAE.**

Myriactis Kütz.

- M. pulvinata, Kütz. (*Elachista attenuata*, Phyc. Brit.). 9! 10. 11.

Elachista Duby.

- E. stellulata, Aresch. 9!
- E. stellaris, Aresch. 1. 6! 9!
- E. Areschougii, Crn. 4!
- E. scutulata, Duby. 1-14.
- E. flaccida, Aresch. 1. 4! 6. 9!-12.
- E. Grevillii, Arnott. 2. 4! 9.
- E. fucicola, Fries. 1-14.

PHAEOPHYCEAE (*continued*).

Elachista Haydeni, Harv. 7!

E. curta, Harv. 6.

Halothrix Rke.

H. lumbricalis, Rke. 9!

Giraudia Derb. et Sol.

G. sphacelarioides, Derb. et Sol. 9!

Order VIII.—**SPHACELARIACEAE.**

i. *Sphacelariaceae crustaceae.*

Battersia Rke.

B. mirabilis, Rke. 4!

ii. *Sphacelariaceae genuinae.*

Sphacelaria Lyngb.

S. radicans, Harv. 1. 4! 5. 7. 9!

S. olivacea, Pringsh. 1. 4!

S. racemosa, Grev. 4!

S. tribuloides, Menegh. 4! 9!

S. cirrhosa, C. Ag. 1-14.

f. *nana*, Griff. 4! 9!

f. *patentissima*, Grev. 9!

f. *fusca*, Holm. et Batt. 1. 5! 6! 9! (*S. fusca*, Phyc. Brit.).

S. caespitula, Lyngb. 4!

S. plumula, Zan. (*S. pseudoplumosa*, Holm. Fasc. No. 24).
9!

S. plumigera, Holm. (*S. plumosa*, Phyc. Brit.). 1. 4!
7! 8. 9!

Chaetopteris Kütz.

Ch. plumosa, Kütz. 1. 2! 4! 6! (*Cladostephus plumosus*,
Holm. Fasc. No. 1).

Cladostephus C. Ag.

C. spongiosus, C. Ag. 1-14.

C. verticillatus, C. Ag. 1-14.

Halopteris Kütz.

H. filicina, Kütz. (*Sphacelaria filicina*, Phyc. Brit.).
6! 9! 10. 12. 13.

f. *patens* Harv. (*Sphacelaria Sertularia*, Phyc. Brit.).
9! 10. 14.

PHAEOPHYCEAE (*continued*).

Stypocaulon Kütz.

S. scoparium, Kütz. (*Sphacelaria scoparia*, Phyc. Brit.).

1-14.

f. *scoparioides*, Holm et Batt. 9! (*S. scoparioides*, Holm. Fasc. No. 97).

Order IX.—**MYRIONEMACEAE**.

Myrionema Grev.

M. strangulans, Grev. 1-14.

f. *punctiformis* (*M. punctiforme*, Phyc. Brit.). 4! 6! 9!

Ascocyclus Magnus.

A. Lichtensteinii, Holm. et Batt. 4!

A. Leclancherii, Magn. (*Myrionema Leclancherii*, Phyc. Brit.). 1-14.

A. reptans, Rke. 4! 9!

A. orbicularis, Rke. 9!

Ralfsia Berk.

a. *Stragularia*.

R. spongiocarpa, Batt. 4!

R. clavata, Crn. 2. 4! 9!

β. *Euralfsia*.

R. verrucosa, Aresch. (*R. deusta*, Phyc. Brit.). 1-14.

Order X.—**CHORDARIACEAE**.

Spermatocchnus Kütz.

S. paradoxus, Rke. (*Stilophora Lynghyei*, Phyc. Brit.).

1. 2! 9! 10.

S. Lejolisii, Rke.? 9! (*Stilophora Lejolisii*, Grevillea, xii. p. 142).

Stilophora J. Ag.

S. rhizodes, J. Ag. 1. 2! 6. 8. 9! 10. 12.

Chordaria C. Ag.

Ch. divaricata, C. Ag. 1. 12.

Ch. flagelliformis, C. Ag. 1-14.

Mesogloea C. Ag.

M. vermiculata, Le Jol. 1. 2. 4! 6. 9! 10. 11. 13.

Castagnea Herb. et Sol.

C. virescens, Thur. (*Mesogloea virescens*, Phyc. Brit.).

1-14.

PHAEOPHYCEAE (*continued*).

Castagnea Zosteræ, Thur. (*M. virescens*, β . *zostericola*, Phyc. Brit.). 9!

C. contorta, Thur. 9! (*Mesogloea gracilis*, Berk.?).

C. Griffithsiana, J. Ag. 9! 10. (*Mesogloea Griffithsiana*, Phyc. Brit.).

Myriocladia J. Ag.

M. Lovenii, J. Ag. 9!

Petrospongium Näg.

P. Berkeleyi, Näg. (*Leathesia Berkeleyi*, Phyc. Brit.). 6! 9!

11. 14.

Leathesia J. E. Gray.

L. difformis, Aresch. (*L. tuberiformis*, Phyc. Brit.) 1-14.

L. crispa, Harv. 3.

Cohort II.—**LAMINARINAE.**

Order I.—**SCYTOSIPHONACEAE.**

Phyllitis Kütz.

Ph. filiformis, Batt. 4!

Ph. zosterifolia, Rke. (*Phyllitis Fascia*, Holm. Fasc. No. 43). 4!

Ph. Fascia, Kütz. (*Laminaria Fascia*, Phyc. Brit.). 1-14.

Scytosiphon C. Ag.

S. lomentarius, J. Ag. (*Chorda lomentaria*, Phyc. Brit.).

1-14.

Order II.—**CHORDACEAE.**

Chorda Stackh.

Ch. Filum, Stackh. 1-14.

f. Thrix, Hook. 4! 9!

Ch. tomentosa, Lyngb. (*C. filum*, β . *tomentosa*, Phyc. Brit.). 4! 6. 7! 9! 12.

Order III.—**LAMINARIACEAE.**

Laminaria Lamx.

L. saccharina, Lamx. 1-14.

f. caperata, Farlow.

f. Phyllitis, Le Jol. (*L. Phyllitis*, Phyc. Brit.). 4! 7!

L. hieroglyphica, J. Ag. 1. 3. 4!

PHAEOPHYCEAE (*continued*).

Laminaria digitata, Edm. 1-14.

f. *stenophylla*, Harv. 1. 4! 6. 9! 12.

f. *valida*, Foslie. 4!

f. *typica*, Foslie. 4!

f. *ensifolia*, J. Ag.

L. hyperborea, Foslie (*L. digitata*, Phyc. Brit. pro parte).

1. 3. 4! 7! 9!

Saccorhiza De la Pyl.

S. bulbosa, De la Pyl. (*Laminaria bulbosa*, Phyc. Brit.).

1-14.

Alaria Grev.

A. esculenta, Grev. 1. 2. 3. 4! 5. 6. 7! 9! 10. 11. 12.

Cohort III.—**SPOROCHNINAE.**

Order.—**SPOROCHNACEAE.**

Sporochnus Kütz.

S. pedunculatus, C. Ag. 1. 2. 4. 5. 9! 10. 12.

Carpomitra Kütz.

C. Cabrerae, Kütz. 9! 11.

Cohort IV.—**CUTLERINAE.**

Order.—**CUTLERIACEAE.**

Aglaozonia Zan.

A. reptans, Kütz. (*Zonaria parvula*, Phyc. Brit.). 4! 9! 10.

Zanardinia Nardo.

Z. collaris, Crn. (*Zonaria collaris*, Phyc. Brit.). 9!

Cutleria Grev.

C. multifida, Grev. 1. 2. 7. 9! 10. 11.

f. *angustifrons*, Holm. et Batt. 9!

Cohort V.—**FUCINAE.**

Order.—**FUCACEAE.**

Fucus Dcne. et Thur.

F. anceps, Ward et Harv. 11!

F. distichus, Linn. 1! 4!

F. ceranoides, Linn. 1-14.

F. platycarpus, Thur. 1-11.

PHAEOPHYCEAE (*continued*).

Fucus vesiculosus, Linn. 1-14.

f. *sphaerocarpa*, J. Ag.

f. *laterifruca*, Grev.

f. *spiralis*, Linn. 4! 7. 8! 9!

f. *baltica*, J. Ag. 4! 8! 9!

f. *nana*, Batt. 4.

F. serratus, Linn. 1-14.

f. *latifolia*, Turn. 1!

Ascophyllum Stackh.

A. nodosum, Le Jol. (*Fucus nodosus*, Phyc. Brit.). 1-14.

f. *scorpioides*, Hauck. 7! 8!

A. Mackaii, Holm. et Batt. (*Fucus Mackaii*, Phyc. Brit.).

1! 2. 10.

Pelvetia Dcne et Thur.

P. canaliculata, Dcne et Thur. (*Fucus canaliculatus*, Phyc.

Brit.). 1-14.

Bifurcaria Stackh.

B. tuberculata, Stackh. (*Pycnophycus tuberculatus*, Phyc.

Brit.). 9! 10. 14.

Himanthalia Lyngb.

H. lorea, Lyngb. 1-14.

Halidrys Lyngb.

H. siliquosa, Lyngb. 1-14.

f. *gracilis*, Holm. et Batt. 4! 9!

Cystoseira C. Ag.

C. ericoides, C. Ag. 2! 7! 9! 10. 11. 14.

C. granulata, C. Ag. 5! 6! 9!

C. discors, C. Ag. (*C. foeniculaceus*, Phyc. Brit.). 6! 9!

10. 11.

C. fibrosa, C. Ag. 9! 10. 11. 14.

Cohort VI.—**TILOPTERIDINAE.**

Order.—**TILOPTERIDACEAE.**

Tilopteris Kütz.

T. Mertensii, Kütz. (*Ectocarpus Mertensii*, Phyc. Brit.).

1-4! 7. 9!

PHAEOPHYCEAE (*continued*).

Cohort VII.—**DICTYOTINAE.**

Order.—**DICTYOTACEAE.**

Dictyota Lamx.

D. dichotoma, Lamx. 1-14.

f. *implexa*, J. Ag. (*D. dichotoma*, f. *intricata*, Phyc. Brit.). 1-14.

f. *latifrons*, Holm. et Batt. 9!

D. ligulata, J. Ag. 9!

Taonia J. Ag.

T. atomaria, J. Ag. 4! 5. 6! 8! 9! 10. 11.

f. *divaricata*, Holm. et Batt. 9!

Padina Adans.

P. pavonia, Gaillon. 9!

Dictyopteris Lamx.

D. polypodioides, Lamx. (*Haliseris polypodioides*, Phyc. Brit.). 9! 10. 11. 14.

Series IV.—**RHODOPHYCEAE.**

Cohort I.—**PORPHYRINAE.**

Order.—**PORPHYRACEAE.**

Goniotrichum Kütz.

Goniotrichum elegans, Le Jol. (*Bangia elegans*, Phyc. Brit.). 4! 9! 12.

Bangia Lyngb.

B. fusco-purpurea, Lyngb. 1-14.

f. *crispa*, Holm. et Batt. (*Bangia crispa*, Holm. Fasc. No. 104). 9!

f. *Lejolisii*, Holm. et Batt. 9!

Erythrotrichia Aresch.

E. carnea, J. Ag. (*Bangia ceramicola*, Phyc. Brit.). 1. 2. 4! 9!

Porphyra C. Ag.

P. ciliaris, Crn. (*Bangia ciliaris*, Phyc. Brit.). 1! 7! 9!

P. coccinea, J. Ag. 1! 4!

RHODOPHYCEAE (*continued*).

Porphyra leucosticta, Thur. 1-9!

P. linearis, Grev. (*P. vulgaris*, Phyc. Brit. pro parte).
1-9!

P. laciniata, C. Ag. 1-14.

f. *typica*.

f. *umbilicalis*.

P. amethystea, Kütz. 4!

P. abyssicola, Kjellm. 1!

Diploderma Kjellm.

D. miniatum, Kjellm. 1! 4! 13.

D. amplissimum, Kjellm. 13!

Cohort II.—**NEMALIONINAE.**

Order.—**HELMINTHOCLADIACEAE.**

Tribe I.—**Chantransieae.**

Chantransia Fries.

Ch. Daviesii, Thur. (*Callithamnion Daviesii*, Phyc. Brit.).
1-14.

Ch. corymbifera, Thur. 9!

Ch. virgatula, Thur. (*Callithamnion virgatulum*, Phyc.
Brit.). 1-14.

Ch. secundata, Thur. 1-9!

Ch. luxurians, Thur. 6. 9!

Tribe II.—**Nemalieae.**

Nemalion Targioni-Tozzetti.

N. lubricum, Duby. 6! 9!

N. multifidum, J. Ag. 1. 2. 5. 6! 9! 10. 11!

Helminthocladia J. Ag.

H. purpurea, J. Ag. (*Nemalion purpureum*, Phyc. Brit.).
9! 11.

H. Hudsoni, J. Ag. 9!

Helminthora J. Ag.

H. divaricata, J. Ag. (*Dudresnaya divaricata*, Phyc. Brit.).
1. 9! 13.

RHODOPHYCEAE (*continued*).

Order II.—**CHAETANGIACEAE.**

Tribe.—**Scinaieae.**

Scinaia Bivona.

S. furcellata, Bivona (*Gimmania furcellata*, Phyc. Brit.)

1. 2. 9!

f. *subcostata*, J. Ag. 1!

Order III.—**GELIDIACEAE.**

Tribe I.—**Binderelleae.**

Choreocolax Reinsch.

Ch. Polysiphoniae, Reinsch. 4! 9!

Tribe II.—**Harveyelleae.**

Harveyella Schmitz et Rke.

H. mirabilis, Schmitz et Rke 4! 9!

Tribe III.—**Wrangelieae.**

Atractophora Crn.

A. hypnoides, Crn. 9!

Naccaria Endlicher.

N. Wiggihii, Endlicher. 2. 7. 8! 9! 10. 11. 13.

Tribe IV.—**Gelideae.**

Pterocladia J. Ag.

P. capillacea, Bornet (*Gelidium corneum*, var. *capillaceum*, Phyc. Brit.). 9.

Gelidium Lamx.

G. corneum, Lamx. 1-14.

f. *abnormis*, Grev.

f. *aculeata*, Grev.

f. *clavata*, Grev.

f. *clavifera*, Grev.

f. *conferta*, Grev.

f. *flexuosa*, Harv.

f. *latifolia*, Grev.

f. *pulchella*, Grev.

f. *sesquipedalis*, Grev.

f. *uniformis*, Grev.

G. crinale, J. Ag. (*G. corneum*, var. *crinale*, Phyc. Brit.).

1. 4! 5. 9!

RHODOPHYCEAE (*continued*).

Cohort III.—**GIGARTININAE.**

Order I.—**GIGARTINACEAE.**

Tribe I.—Gigartineae.

Chondrus J. Ag.

Ch. crispus, Stackh. 1-14.

f. virens, Turn.

f. stellata, Turn.

f. aequalis, Turn.

f. filiformis, Turn.

f. patens, Turn.

f. sarniensis, Turn.

Gigartina Stackh.

G. Teedii, Lamx. 9!

G. acicularis, Lamx. 9! 11. 13.

G. pistillata, Stackh. 9!

G. mamillosa, J. Ag. 1-14.

f. linearis, Turn.

f. prolifera, Turn.

f. echinata, Turn.

f. incurvata, Turn.

Tribe II.—Tylocarpeae.

Phyllophora Grev.

Ph. rubens, Grev. 1-4! 9!

Ph. Brodiaei, J. Ag. 1. 4! 5! 7! 12.

f. angustissima, C. Ag. 1!

Ph. Traillii, Holm. et Batt. 4! 5. 9!

Ph. palmettoides, J. Ag. 9!

Ph. membranifolia, J. Ag. 1-14.

Stenogramme Harv.

S. interrupta, Mont. 9! 10. 14!

Gymnogongrus Mart.

G. Griffithsiae, Mart. 1. 2. 9! 10. 12.

G. norvegicus, J. Ag. (*Chondrus norvegicus*, Phyc. Brit.).

1. 2. 6! 7. 9!

Ahnfeltia Fries.

A. plicata, Fries (*Gymnogongrus plicatus*, Phyc. Brit.).

1-14.

RHODOPHYCEAE (*continued*).

Actinococcus Kütz.

A. roseus, Kütz. 1. 4! 5! 6! 7!

Tribe III.—**Callymenieae**.

Callophyllis Kütz.

C. laciniata, Kütz. (*Rhodymenia laciniata*, Phyc. Brit.). 9!

Callymenia J. Ag.

C. reniformis, J. Ag. 1. 2. 9! 10. 11. 13.

C. microphylla, J. Ag. 9!

Order II.—**RHODOPHYLLIDACEAE**.

Tribe I.—**Cystoclonieae**.

Cystoclonium Kütz.

C. purpurascens, Kütz. (*Hypnea purpurascens*, Phyc. Brit.). 1-14.

Catenella Grev.

C. Opuntia, Grev. 1-14.

Euthora J. Ag.

E. cristata, J. Ag. (*Rhodymenia cristata*, Phyc. Brit.). 1. 4! 7!

Tribe II.—**Rhodophyllideae**.

Rhodophyllis Kütz.

Rh. bifida, Kütz. (*Rhodymenia bifida*, Phyc. Brit.). 1. 2. 4. 5. 7! 8. 9! 11. 14.

f. *latifrons*, Holm. et Batt. 9!

Rh. appendiculata, J. Ag. (*Rh. bifida*, var. *ciliata*, Phyc. Brit.). 9!

Cohort IV.—**RHODYMENINAE**.

Order I.—**SPHAEROCOCCACEAE**.

Tribe I.—**Sphaerococceae**.

Sphaerococcus Grev.

Sp. coronopifolius, Grev. 2. 6. 9! 11. 14.

Tribe II.—**Gracilarieae**.

Gracilaria Grev.

G. confervoides, Grev. 1-14.

RHODOPHYCEAE (*continued*).

Gracilaria divergens, J. Ag. 9!

G. compressa, Grev. 9!

G. multipartita, J. Ag. 9.

Calliblepharis Kütz.

C. ciliata, Kütz. (*Rhodymenia ciliata*, Phyc. Brit.). 1. 2. 7!
8! 9! 11. 14.

f. *angusta*, Holm. et Batt. 8!

C. jubata, Kütz. (*Rhodymenia jubata*, Phyc. Brit.). 1. 2. 7.
9! 14.

f. *divaricata*, Holm. et Batt. 9!

f. *dilatata*, Holm. et Batt. 9!

Order II.—**RHODYMENIACEAE.**

Tribe I.—**Rhodymenieae.**

Rhodymenia J. Ag.

Rh. palmetta, Grev. 1. 2. 5. 6. 9! 10. 11. 14.

f. *Elisiae*, Kütz. 9!

f. *bifida*, Turn. 9!

f. *crassiuscula*, Turn. 9!

f. *flabelliformis*, Kütz. 9!

f. *divaricata*, Kütz. 9!

Rh. palmata, Grev. 1-14.

f. *typica*, Kjellm. 4! 9!

f. *marginifera*, Harv. 9!

f. *sarniensis*, Grev. 4! 9!

f. *simplex*, J. Ag. 9!

f. *sobolifera*, J. Ag. 4! 9!

f. *laciniata*, Holm. et Batt. 4! 9!

Rh. nicaeensis, Holm. (*R. palmetta*, var. *nicaeensis*,
Phyc. Brit.). 6. 8. 9!

Cordylecladia J. Ag.

C. erecta, J. Ag. (*Gracilaria erecta*, Phyc. Brit.). 4! 6!
9! 11.

Lomentaria Lyngb.

L. articulata, Lyngb. (*Chylocladia articulata*, Phyc. Brit.).
1-14.

RHODOPHYCEAE (*continued*).

Lomentaria clavellosa, Gaill. (*Chrysymenia clavellosa*, Phyc. Brit.). 1-14.

L. rosea, Thur. (*Chrysymenia rosea*, Phyc. Brit.). 1! 4! 6! 9!

Champia Lamx.

Ch. parvula, Harv. (*Chylocladia parvula*, Phyc. Brit.). 1. 4! 6. 9!

Chylocladia Grev.

Ch. kaliformis, Grev. 1. 2. 6. 9! 10. 11. 14.

f. *patens*, Kütz. 9!

f. *squarrosa*, Harv. 9!

Ch. ovalis, Hook. 1. 2. 3. 6. 9! 10. 11. 14.

Ch. reflexa, Lenorm. 9!

Tribe II.—**Plocamieae**.

Plocamium Lyngb.

Pl. coccineum, Lyngb. 1-14.

f. *angustifrons*, Le Jol. 1-14.

f. *latifrons*, Le Jol. 1-14.

f. *uncinata*, C. Ag. 4! 9!

Order III.—**DELESSERIACEAE**.

Tribe I.—**Nitophylleae**.

Nitophyllum Grev.

N. uncinatum, J. Ag. 1. 9!

N. Gmelini, Harv. 6! 9! 11.

N. laceratum, Grev. 1-14.

f. *uncinata*, Grev. 9!

f. *Smithii*, Kütz. 4! 9!

N. reptans, Crn. 4! 9!

N. punctatum, Grev. 1-14.

f. *ocellata*, J. Ag. 1. 4! 6. 9!

f. *crispata*, Harv. 1. 4! 9.

f. *Pollexfenii*, Harv. 1!

f. *fimbriata*, Harv. 1. 4! 6. 9!

N. venulosum, Zan. 9. (*N. thysanorhizans*, Holm. Grevillea, 1874, p. 2, pl. 12, and 1875, pl. 37, figs. 5-7).

N. Bonnemaisionii, Grev. 1. 3. 4! 5. 6. 9!

f. *crassinervis*, Batt. 4!

N. Hilliae, Grev. 4! 9! 14.

RHODOPHYCEAE (*continued*).

Nitophyllum literatum, J. Ag. 9!

N. versicolor, Harv. 1. 6! 14.

Tribe II.—Delesserieae.

Delesseria Lamx.

D. alata, Lamx. 1-14.

D. angustissima, Griff. 1. 3!

D. Hypoglossum, Lamx. 1. 2. 4! 5. 6. 7! 8. 9! 10. 11.
14.

f. crispa, Crn. 9!

D. ruscifolia, Lamx. 1. 2. 4! 8-9! 10. 11. 14.

D. sinuosa, Lamx. 1-14.

D. sanguinea, Lamx. 1-14.

Order IV.—BONNEMAISONIACEAE.

Bonnemaisonia C. Ag.

B. asparagoides, C. Ag. 1-14.

f. teres, Harv.

Order V.—RHODOMELACEAE.

Tribe I.—Rhodomeleae.

Bostrychia Mont.

B. scorpioides, Mont. 4! 5. 9! 10. 11. 13 (*Helicothamnion
scorpioides*, Phyc. Brit.).

Rhodomela C. Ag.

Rh. subfusca, C. Ag. 1-14.

f. gracilior, J. Ag. 4!

Rh. lycopodioides, C. Ag. 1-14.

f. typica, Kjellm. 1-14.

f. laxa, Kjellm. 1. 4!

Odonthalia Lyngb.

O. dentata, Lyngb. 1. 2. 3. 4! 5. 7! 10.

Tribe II.—Laurenciae.

Laurencia Lamx.

L. obtusa, Lamx. 1. 2. 4! 9! 14.

f. genuina, Hauck. 9!

f. crucifera, Hauck. 9!

L. hybrida, Lenorm. 1-14.

L. pinnatifida, Lamx. 1-14.

RHODOPHYCEAE (*continued*).

Tribe III.—Amansieae.

Halopithys Kütz.

H. pinastroides, Kütz. (*Rytiphloea pinastroides*, Phyc. Brit.). 5. 9!

Tribe IV.—Polysiphonieae.

Chondria Harv.

Ch. tenuissima, C. Ag. (*Laurencia tenuissima*, Phyc. Brit.). 9! 14.

Ch. dasyphylla, C. Ag. (*Laurencia dasyphylla*, Phyc. Brit.). 1-14.

Ch. caerulescens, J. Ag. 9!

Polysiphonia Grev.

a. Oligosiphoniae ecorticatae.

P. sertularioides, J. Ag. 4! 9! (*Polysiphonia pulvinata*, Phyc. Brit.).

P. Rhunensis, Bornet. 6! 9!*

P. foetidissima, Cocks. 9!

P. fibrata, Harv. 1-14.

P. urceolata, Grev. 1-14.

f. typica, J. Ag. 1-14.

f. patens, J. Ag. 4! 9!

f. formosa, J. Ag. (*P. formosa*, Phyc. Brit.). 1. 4! 9!

f. comosa, J. Ag. 4!

P. divaricata, Kütz. 4.

β. Oligosiphoniae corticatae.

P. subulata, J. Ag.

f. Griffithsiana, J. Ag. (*P. Griffithsiana*, Phyc. Brit.). 9.

P. Richardsoni, Hook. 2!

P. spinulosa, Grev. 2!

f. major (*P. Carmichaeliana*, Phyc. Brit.).

P. elongella, Harv. 1. 2. 5. 6. 9! 14.

P. elongata, Grev. 1-9! 11. 14.

f. denudata, J. Ag. 4!

f. rosea, J. Ag. 9!

P. violacea, Wyatt. 1. 2. 4! 5. 9! 14.

P. fibrillosa, Grev. 4! 9!

RHODOPHYCEAE (*continued*).

γ. Polysiphoniae ecorticatae.

- P. variegata*, J. Ag. 9!
- P. furcellata*, Harv. 9!
 - f. *forcipata*, J. Ag. (*P. turgidula*, Holm. Fasc. No. 7). 9!
 - f. *patula*, J. Ag. (*P. furcellata*, Phyc. Brit.). 9!
- P. fastigiata*, Grev. 1-14.
- P. ceramiaeformis*, Crn. 9!
- P. simulans*, Harv. 9!
- P. atro-rubescens*, Grev. 1-14.
- P. subulifera*, Harv. 2. 9! 11! 13.
- P. obscura*, J. Ag. 9!
- P. nigrescens*, Grev. 1-14.
 - f. *affinis*, Harv. (*P. affinis*, Phyc. Brit.).
- P. parasitica*, Grev. 1. 2! 4! 6. 9! 14.
- P. byssoides*, Grev. 9!

δ. Polysiphoniae corticatae.

- P. Brodiaei*, Grev. 1-9! 11. 14.
 - f. *typica*, Holm. et Batt. 9!
 - f. *densa*, Holm. et Batt. 9!
- P. thuyoides*, Harv. (*Rytiphloea thuyoides*, Phyc. Brit.). 4!
 - 5. 6! 9! 11.
- P. fruticulosa*, Spreng. (*Rytiphloea fruticulosa*, Phyc. Brit.).
 - 2. 5. 6! 9! 11. 14.

Pterosiphonia Falk.

- P. complanata*, Schmitz, MS. 9! 11.

Tribe V.—Dasyeae.

Dasya C. Ag.

- D. venusta*, Harv. 9!
- D. arbuscula*, C. Ag. 1. 2. 5. 9! 11. 14.
- D. ocellata*, Harv. 9! 11. 14.
- D. punicea*, C. Ag. 9!
- D. media*, Harv. MS. 1!
- D. coccinea*, C. Ag. 1-14.
 - f. *tenuis*, J. Ag. 1! 9! 14.
 - f. *patens*, J. Ag. (*D. coccinea*, f. *squarrosa*, Phyc. Brit.).
- D. Cattloviae*, Harv. 9.

RHODOPHYCEAE (*continued*).

Order IV.—**CERAMIACEAE.**

Tribe I.—**Spermothamnieae.**

Sphondylothamnion Näg.

S. multifidum, Näg. (*Wrangelia multifida*, Phyc. Brit.).

2. 6. 9! 11. 14.

f. *pilifera*, C. Ag. 9!

Spermothamnion Aresch.

S. Turneri, Aresch. (*Callithamnion Turneri*, Phyc. Brit.).

1-14.

f. *intricata*, Holm. et Batt. (*Callithamnion intricatum*, J. Ag.).

f. *repens*, Le Jol. 2. 6. 4! 9!

S. flabellatum, Bornet. (*Callithamnion strictum*, C. Ag.).

4! 9!

Ptilothamnion Thuret.

P. pluma, Thur. (*Callithamnion pluma*, Phyc. Brit.).

2. 4! 6. 9! 11. 14.

Tribe II.—**Griffithsieae.**

Griffithsia C. Ag.

G. corallina, C. Ag. 1-14.

G. setacea, C. Ag. 1-14.

G. Devoniensis, Harv. 9!

G. barbata, C. Ag. 9!

Halurus Kütz.

H. equisetifolius, Kütz. (*Griffithsia equisetifolia*, Phyc. Brit.). 1-14.

f. *simplicifilum*, Harv. (*Griffithsia simplicifilum*, Phyc. Brit.). 7. 11!

Tribe III.—**Monosporeae.**

Bornetia Thur.

B. secundiflora, Thur. (*Griffithsia secundiflora*, Phyc. Brit.). 9!

Monospora Solier.

M. pedicellata, Solier. (*Callithamnion pedicellatum*, Phyc. Brit.). 1. 2. 5. 6. 9! 11. 14.

f. *comosa*, Holm. et Batt. 9!

M. clavata, J. Ag. 9!

RHODOPHYCEAE (*continued*).

Pleonosporium Näg.

P. Borreri, Näg. (*Callithamnion Borreri*, Phyc. Brit.).

1. 8. 9! 13.

f. fasciculata, Holm. et Batt. (*Call. fasciculatum*, Phyc. Brit.). 8!

Tribe IV.—Callithamnieae.

Rhodochorton Näg¹.

Rh. Rothii, Näg. (*Callithamnion Rothii*, Phyc. Brit.).

1-14.

Rh. floridulum, Näg. (*Callithamnion floridulum*, Phyc. Brit.). 1-14.

Rh. intermedium, Kjellm. 4!

Rh. mesocarpum, Kjellm. (*Callithamnion mesocarpum*, Phyc. Brit.). 2.

Rh. membranaceum, Magn. 4! 9!

Rh. sparsum, Kjellm. 2. 4! 9!

Callithamnion Lyngb.

a. Eucallithamnion.

C. tenuissimum, Kütz. 9!

C. interruptum, C. Ag. 9!

C. polyspermum, C. Ag. 1-14.

C. roseum, Harv. 1-14.

C. tripinnatum, C. Ag. 9. 11.

C. affine, Harv. 2.

β. Phlebothamnion.

C. Hookeri, C. Ag. 1-14.

C. Brodiaei, Harv. 4! 9!

C. fruticosum, J. Ag. 9!

C. arbuscula, Lyngb. 1. 2. 3! 4! 5. 11.

C. tetragonum, C. Ag. 1. 2. 5. 6. 9! 11. 14.

f. brachiata, J. Ag. (*C. brachiatum*, Phyc. Brit.). 1. 2. 5. 6. 9! 11. 14.

C. tetricum, C. Ag. 9! 11. 14.

¹ In the absence of cystocarpic fruit, which is unknown at present, the position of this genus is doubtful; it is placed here only for the sake of convenience.

RHODOPHYCEAE (*continued*).

γ. *Pocillothamnion*.

- C. corymbosum*, Lyngb. 1-14.
C. granulatum, C. Ag. (*C. spongiosum*, Phyc. Brit.). 1-14.

δ. *Seirospora*.

- C. seirospermum*, Griff. 1! 2. 3. 9!
 f. *miniata*. 9!
 f. *versicolor*, Holm. et Batt. 9!
C. byssoides, Arn. 1. 9, 14.
 f. *seirosporifera*, Holm. et Batt. (*C. hormocarpum*, Holm.). 9.

Tribe V.—*Compsothamnieae*.

Compsothamnion Schmitz.

- C. thuyoides*, Schmitz (*Callithamnion thuyoideum*, Phyc. Brit.). 6. 8. 9. 11. 14.
C. gracillimum, Schmitz (*Callithamnion gracillimum*, Phyc. Brit.). 4. 5. 6. 9.

Tribe VI.—*Ptiloteae*.

Plumaria Schmitz.

- P. elegans*, Bonnem. 1-14.

Ptilota C. Ag.

- P. plumosa*, C. Ag. 1! 2. 3. 4! 7! 10. 11.

Tribe VII.—*Crouanieae*.

Antithamnion Näg.

- A. cruciatum*, Näg. (*Callithamnion cruciatum*, Phyc. Brit.).
 2! 5! 6. 9! 14.
 f. *pumila*, Harv. 9!
A. plumula, Thur. (*Callithamnion plumula*, Phyc. Brit.).
 1-14.
 f. *crispa*, J. Ag. 4! 9!
 f. *spinescens*, Strömf. 4!
A. floccosum, Kleen. (*Callithamnion floccosum*, Phyc. Brit.).
 1. 2. 4!
A. barbatum, Holm. et Batt. (*Callithamnion barbatum*,
 Phyc. Brit.). 4! 6! 9!

Crouania J. Ag.

- C. attenuata*, J. Ag. 9!

RHODOPHYCEAE (*continued*).

Tribe VIII.—Spyridieae.

Spyridia Harv.

S. filamentosa, Harv. 6! 9!

Tribe IX.—Ceramieae.

Ceramium Lyngb.

a. Inermes.

C. gracillimum, Harv. 9! 11.

C. fastigiatum, Harv. 4. 9! 11.

C. tenuissimum, J. Ag. (*C. nodosum*, Phyc. Brit.). 5.
6. 9!

f. *arachnoidea*, C. Ag. 9!

C. Deslongchampsii, Chauv. 1. 2. 4! 5. 6. 7. 9! 11. 14.

C. strictum, Harv. 4! 6. 9! 11.

f. *divaricata*, Holm. et Batt. (*C. diaphanum*, Crn.). 9!

C. diaphanum, Roth. 4! 9!

C. circinatum, J. Ag. (*C. decurrens*, Phyc. Brit.). 9!

C. rubrum, C. Ag. 1-14.

f. *pedicellata*, J. Ag. 4! 9!

f. *prolifera*, J. Ag. (*C. botryocarpum*, Phyc. Brit.). 4! 9!

f. *secundata*, J. Ag. 4! 9!

f. *corymbosa*, J. Ag.

f. *microcladioides*, Holm. et Batt. (*C. Microcladia*,
Cocks.). 4! 7! 9!

β. Armatae.

C. echionotum, J. Ag. 1. 9!

C. acanthonotum, Carm. 1-14.

f. *transcurrens*, Holm. et Batt. 9!

C. ciliatum, Ducluz. 9! 10. 11.

C. flabelligerum, J. Ag. 4! 5. 9!

Microcladia Grev.

M. glandulosa, Grev. 9!

Cohort V.—**CRYPTONEMINAE.**

Order I.—**GLOEOSIPHONIACEAE.**

Gloeosiphonia Carm.

G. capillaris, Carm. 1. 2. 3. 4! 5. 9! 11. 14.

RHODOPHYCEAE (*continued*).

Order II.—**GRATELOUPIACEAE.**

Halymenia J. Ag.

H. ligulata, C. Ag. 2. 3. 6. 8! 9! 11. 13. 14.

f. *dichotoma*, Harv. 9!

f. *latifolia*, Harv. 9!

f. *ramentacea*, Harv. 9!

Grateloupia C. Ag.

G. filicina, C. Ag. 9!

f. *intermedia*, Holm. et Batt. 9!

G. dichotoma, J. Ag. 9!

Order III.—**DUMONTIACEAE.**

Dumontia Lamx.

D. filiformis, Grev. 1-14.

f. *crispata*, J. Ag. 4! 9!

Dudresnaya Bonnem.

D. coccinea, Bonnem. 2. 4! 9! 11.

Dilsea Stackh.

D. edulis, Stackh. (*Iridaea edulis*, Phyc. Brit.). 1-14.

Order IV.—**NEMASTOMACEAE.**

Tribe I.—**Schizymeniaceae.**

Calosiphonia Crn.

C. Finisterrae, Crn. 9!

Schizymenia J. Ag.

S. Dubyi, J. Ag. (*Kallymenia Dubyi*, Phyc. Brit.). 1. 9!

11.

Tribe II.—**Halarachnieae.**

Furcellaria Lamx.

F. fastigiata, Lamx. 1-14.

Order V.—**RHIZOPHYLLIDACEAE.**

Polyides C. Ag.

P. rotundus, Grev. 1-14.

Order VI.—**SQUAMARIACEAE.**

Tribe I.—**Cruoriaceae.**

Petrocelis J. Ag.

P. cruenta, J. Ag. (*Cruoria pellita*, Phyc. Brit.). 2. 4! 9!

11.

RHODOPHYCEAE (*continued*).

Petrocelis Henedyi, Batt. (*Actinococcus Henedyi*, Harv.).

2! 4! 7!

Cruoria Fries.

Cr. pellita, Lyngb. 4! 5. 6. 9! 14.

Tribe II.—**Squamariaceae.**

Peyssonnelia Dcne.

P. Dubyi, 1-14.

P. Harveyana, Crn. 4! 9!

GENERA OF DOUBTFUL AFFINITY.

Haematocelis J. Ag.

H. fissurata, Crn. 4!

Haematopflaea Crn.

H. Crouanii, Crn. 4! 9!

Rhododermis Crn.

Rh. elegans, Crn.

f. *polystromatica*, Batt. 4! 9!

Rh. parasitica, Batt. 4!

Order VII.—**HILDENBRANDTIACEAE.**

Hildenbrandtia Nardo.

H. prototypus, Nardo.

f. *rosea*, Kütz. (*H. rubra*, Phyc. Brit.). 1-14.

Order VIII.—**CORALLINACEAE.**

Schmitziella Born. et Batt.

S. endophloea, Born. et Batt. 5! 9!

Choreonema Schmitz.

Ch. Thuretii, Schmitz (*Melobesia Thuretii*, Born.; Holm.

Fasc. No. 14). 9!

Melobesia Lamx.

M. confervoides (*Lithocystis Allmanni*, Phyc. Brit.). 4! 9!

M. corticiformis, Kütz. 4! 9!

M. membranacea, Lamx. 1-14.

M. farinosa, Lamx. 4! 6! 9!

M. verrucata, Lamx. 4! 6. 9!

M. Lejolisii, Rosan. 4! 9!

M. pustulata, Lamx. 1-14.

RHODOPHYCEAE (*continued*).

Melobesia macrocarpa, Rosan. 4! 9!

M. Laminariae, Crn. 4! 9!

M. Corallinae, Crn. 4! 9!

Lithophyllum Phil.

L. lichenoides, Phil. (*Melobesia lichenoides*, Phyc. Brit.).
6! 9! 14.

L. Lenormandi, Rosan. 4! 6! 9!

Lithothamnion Phil.

L. fasciculatum, Aresch. (*Melobesia fasciculata*, Phyc. Brit.). 11.

L. calcareum, Aresch. (*Melobesia calcarea*, Phyc. Brit.).
2. 3. 4! 6. 9! 11. 14.

L. polymorphum, Aresch. (*Melobesia polymorpha*, Phyc. Brit.). 1-14.

L. agariciforme, Aresch. (*Melobesia agariciformis*, Phyc. Brit.). 11.

Corallina Lamx.

C. officinalis, Linn. 1-14.

C. squamata, Ellis. 6! 9! 14.

C. mediterranea, Aresch. 9!

C. rubens, Ellis et Sol. (*Jania rubens*, Phyc. Brit.). 6. 9!
10. 14.

f. *corniculata*, Hauck. (*Jania corniculata*, Phyc. Brit.).
5. 6! 9! 11. 14.

APPENDIX I.

The following species must be excluded from the list of British Marine Algae, since they have not been proved to grow on the shores of Britain, but have only been met with as waifs.

PHAEOPHYCEAE.

Cystoseira barbata, C. Ag.

Laminaria longicuris, De la Pyl.

Sargassum bacciferum, C. Ag.

„ *vulgare*, C. Ag.

RHODOPHYCEAE.

Dasya Mulleri, Sond.

Gelidium cartilagineum, Gaill.

APPENDIX II.

The following species may be expected to occur on the shores of Britain, having been found either on the Atlantic shores of France, or of Norway, or in the Baltic Sea. It is possible that species belonging to the Mediterranean Flora may also occur, as well as *Nitophyllum venulosum*, Zan., but it is not possible to suggest with any degree of certainty the species which may occur on the South-west coasts of England and Ireland. The capital letters N. and S. are employed to indicate that they may occur respectively on the Northern or Southern shores of Britain.

CYANOPHYCEAE.

Brachytrichia Balani, Born. et Flah. S.

Calothrix Contarenii, Born. et Flah. N. S.

C. fusco-violacea, Crn. S.

C. rubra, Born. et Flah. S.

Gloeotrichia punctulata, Thur. S.

Lyngbya gracilis, Menegh. S.

L. membranacea, Kütz. S.

L. persicina, Kütz. S.

CYANOPHYCEAE (*continued*).

- Merismopoedia** glauca, Naeg. S.
Nodularia armorica, Thur. S.
Oscillaria subsalsa, C. Ag. N.
Plectonema terebrans, Born. et Flah. S.
Phormidium incrustatum, Gom. MS. S.
Pleurocapsa fuliginosa, Hauck. N. S.
Spirulina versicolor, Thur. S.

CHLOROPHYCEAE.

- Acrochaete** repens, Pringsh. S.
Blastophysa rhizopus, Rke. N.
Characium marinum, Kjellm. N.
Chaetomorpha Cladophorae, Crn. N.
 " gracilis, Kütz. N. S.
 " Sphacelariae, Fosl. N.
Chlorochytrium dermatocolax, Rke. N. S.
Chlorangium marinum, Cienk. N.
Cladophora pygmaea, Rke. N.
 " sericea, Reinb. N. S.
Enteromorpha fucicola, J. Ag. N. S.
 " radiata, J. Ag. N. S.
 " tubulosa, J. Ag. N. S.
Monostroma balticum, Wittr. N.
 " fuscum, Wittr. N.
 " oxycoccum, Kütz. S.
 " orbiculatum, Thur. S.
 " splendens, Wittr. N.
Ostreobium Queketti, Born. et Flah. S.
Phaeophila Engleri, Rke. N.
 " Floridearum, Hauck. S.
Protoderma marinum, Rke. N.
Schizogonium laetevirens, Kütz. N. f. *crispata*, Reinb.
Ulvela lens, Crn. S.
Vaucheria intermedia, Nordst. N. S.
 " coronata, Nordst. N. S.
 " piloboloides, Thur. N. S.
Zygomitus reticulatus, Born. et Flah. S.

PHAEOPHYCEAE.

- Alaria linearis**, Strömf. N.
Ascocyclus foecundus, Rke. N.
 " **globosus**, Rke. N.
 " **ocellatus**, Rke. N.
Coilodesme bulligera, Strömf. N.
Ectocarpus fulvescens, Born. S.
 " **microscopicus**, Crn. S.
 " **Myriocladiae**, Crn. S.
 " **Stilophorae**, Crn. N. S.
Desmotrichum balticum, Kütz. N.
 " **scopulorum**, Rke. N.
Fucus evanescens, C. Ag. N.
Gobia baltica, Rke. N.
Halorhiza vaga, Kütz. N.
Haplospora globosa, Kjellm. N.
Kjellmania sorifera, Rke. N.
Leptonema fasciculatum, Rke. N.
Liebmannia major, Crn. S.
Lithoderma fatiscens, Aresch. N.
Myriocladia chordariaeformis, Crn. S.
 " **tomentosa**, Crn. S.
Phyllaria lorea, Kjellm. N.
Scaphospora speciosa, Kjellm. N.
Scytosiphon pygmaeus, Rke. N.
Streblonema volubilis, Thur. S.
Symphoricoccus radians, Rke. N. S.

RHODOPHYCEAE.

- Antithamnion boreale**, Kjellm. N.
Callithamnion bipinnatum, Crn. S.
 " **decompositum**, J. Ag. S.
 " **elegans**, C. Ag. S.
 " **fallax**, Crn. S.
 " **Furcellariae**, J. Ag. S.
 " **Gaillonii**, Crn. S.
 " **Hapalidii**, Crn. S.
 " **parvulum**, Crn. S.

RHODOPHYCEAE (*continued*).

- Callithamnion** serpens, Crn. S.
 " sphaericum, Crn. S.
Callophyllis flabellata, Crn. S.
Ceramium pennatum, Crn. S.
Chantransia efflorescens, J. Ag. S.
Contarinia pulcherrima, Crn. S.
Crouania bispora, Crn. S.
Cruoriella armorica, Crn. S.
Cryptonemia seminervis, J. Ag. S.
Delesseria Boerii, Rupr. N.
Dermocorynus Montagnei, Crn. S.
Halosaccion ramentaceum, J. Ag. N.
Haematocelis parasitica, Crn. S.
 " rubens, J. Ag. S.
Liagora viscida, C. Ag. S.
Lithophyllum laeve, Strömf. N.
Lithothamnion circumspectum, Strömf. N.
 " depressum, Crn. N.
 " glaciale, Kjellm. N.
 " intermedium, Kjellm. N.
 " soriferum, Kjellm. N.
Melobesia callithamnioides, Rosan. S.
 " confinis, Crn. S.
 " hapalidioides, Crn. S.
 " myriocarpa, Crn. S.
 " simulans, Crn. S.
Nemastoma marginifera, J. Ag. S.
Nitophyllum alliaceum, Crn. S.
 " Sandrianum, J. Ag. S.
Peyssonnelia atro-purpurea, Crn. S.
 " rupestris, Crn. S.
Phyllophora Bangii, Jensen. N.
 " Herediae, J. Ag. S.
Polysiphonia insignis, Crn. S.
 " intricata, J. Ag. S.
 " opaca, Zan. S.
 " pennata, J. Ag. S.
Ptilota pectinata, Kjellm. N.

RHODOPHYCEAE (*continued*).

- Ptilota serrata**, Kütz. N.
Rhodochorton chantransioides, Rke. N.
Rhodomela virgata, Kjellm. N.
Rhodophyllis dichotoma, Gobi. N.
Solieria chordalis, J. Ag. S.

Is the Eusporangiate or the Leptosporangiate the more primitive type in the Ferns¹?

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With Plate VII.



IN my paper on 'The comparative examination of the Meristems of Ferns as a phylogenetic study,' published in the *Annals of Botany*, vol. III, p. 305, &c., a very considerable number of facts were passed in review, relating to the embryonic tissues of root, stem, leaf, wing, and sporangium; the observations were made upon representatives of various divisions of the Filicineous series, viz. the Hymenophyllaceae, Polypodiaceae, Cyatheaceae (in part), Schizaeaceae, Osmundaceae, and Marattiaceae. The main result was to show that there is a singular parallelism in character of all the meristems in these several divisions; it was demonstrated that, in the divisions first named, the meristems of each of the constituent parts of the plant are relatively simple in construction, and exhibit a definite regularity of segmentation, one initial cell (or in the wings a row of initial cells) of definite form being present in each. Passing onwards through the series, this simplicity and regularity is departed from; the structure be-

¹ This question was discussed by the author at the Royal Horticultural Society's Conference on Ferns, in July, 1890, and a statement of his views then put forward is printed in the *Journal of the Society*, N. S., vol. XII, pp. 496-505.

[*Annals of Botany*, Vol. V. No. XVIII. April, 1891.]

comes more complex, the identity of the single initial is lost, and the regular sequence of segmentations gives place to a less definite arrangement. On these characters therefore, as well as on those of the mature parts to which the meristems give rise, the Ferns may be arranged as a series: at the one end are the typically more delicate Leptosporangiate Ferns, while at the other would be the typically more robust Eusporangiate forms. It was further remarked in the paper above quoted that this parallelism as regards complexity of structure does not appear only in the parts of the sporophyte, but also that it may be traced in the sexual generation: that in the Hymenophyllaceae, which have a peculiarly delicate structure of the sporophyte, the prothallus is frequently filamentous, and the sexual organs freely exposed, while in the more robust Eusporangiate Ferns, such as *Marattia* or *Ophioglossum*, the prothallus is massive, and the sexual organs deeply sunk in its tissue. Accordingly, whether the general character of the sporophyte, or of the gametophyte be considered, the divisions of the Filicineae might be arranged as a series, extending from the typically Leptosporangiate forms on the one hand to the typically Eusporangiate on the other; the Osmundaceae, and in some respects the Schizaeaceae, also taking an intermediate position, and serving as connecting links between the two extremes. The question whether or not this series is to be regarded as a simple linear sequence, will be discussed later on.

The series thus roughly blocked out appears to be a natural one, from the facts that the Filicineae themselves are obviously a natural group, and that the steps from one extreme to the other are gradual and consistent in all the parts. The next question will naturally be, which is the lower and which the upper end of the series; which is the more primitive, and which the more recent, and derivative type? It is to the reconsideration of this very important question that I propose to devote the following pages. The opinion currently held by botanists is that the simpler, Leptosporangiate Ferns are the more primitive, and that the Eusporangiate Ferns occupy

a higher position in the developmental tree: this view I shared when writing, two years ago, the paper above quoted: I there definitely stated, however, that the converse view was capable of defence (p. 374); in fact, that the simpler Ferns might be regarded as forms which had degenerated, and owe their more delicate structure to adaptation to life in moist shade: but this view I did not then accept. Subsequently the question has been taken up by D. H. Campbell¹, who has argued in favour of the Eusporangiate forms as being primitive rather than derivative: yet, though he has brought forward various points of interest and importance, the whole matter has not been by any means exhausted, and I therefore propose to look into the evidence which may be adduced in support of the two views, and to consider first what basis of evidence there actually is in favour of the view now currently held.

Seeing that the broadest lines of progress of evolution have commonly led from the smaller and simpler to the larger and more complex, there has been a general disposition to assume that the simpler terms of any series are the more primitive. This assumption has doubtless affected the views of botanists with regard to the Ferns, and has led to the established opinion that the Hymenophyllaceae, being structurally the simplest, approach the primitive Filicineous type more nearly than other living forms. But a simplification of structure has been recognised in so many cases as following on exposure to certain conditions of life, that the idea of degeneration has become a familiar one. We are therefore no longer justified in making the above assumption unless it be supported by a knowledge of the environment past and present, as well as by comparative evidence. For such evidence recourse must be had in the present case to lower rather than to higher forms, and the comparison has been commonly drawn between the Filmy Ferns and the Mosses: notwithstanding the wide differences between them, it has been generally held that of all Vascular plants the Hymenophyllaceae approach most nearly to the Bryophyta.

¹ Botanical Gazette, Jan. 1890.

It is not my object here to give a complete history of the origin and growth of this opinion: it is however one of long standing. Both Linnæus and Sprengel placed the Hymenophyllaceae at the end of the series of Ferns, while the Mosses immediately followed them: notwithstanding that R. Brown and Sir W. Hooker¹ preferred to make them 'part of the Polypodiaceae, ranking near *Davallia* and *Loxsonia*,' Presl² and Bernhardt separated them as a special family of Ferns, and the former writer concludes that the Hymenophyllaceae are rather far removed from the Filicineae, and must be regarded as a connecting link with the Mosses and Liverworts³. Van den Bosch⁴ went so far as to erect them into an order, which he styled the Bryopterideae, and placed them between Mosses and Ferns. These views were however based chiefly on the external characters of the Sporophyte; when the internal structure of the Sporophyte as well as the characters of the prothallus had been investigated by Mettenius, he concluded⁵ that the views of Van den Bosch were untenable, and that though the Hymenophyllaceae occupy the lowest position among the Ferns, being furthest removed from the Ophioglossaceae, still they are true Ferns. The affinity to the Bryophyta which he also recognised⁶, was accepted by Prantl⁷, but it remained for Goebel⁸ to bring together evidence from the comparative examination of the sexual generation, in support of the Bryophytic affinity. Goebel remarks at the close of his memoir that we are able even now to follow, at least in part, the phylogenetic development of the sexual generation from the Bryophyta to the Pteridophyta, though the neutral generation fails to supply us with any

¹ Genera Filicum, description of Plate XXXI.

² K. B. Presl, Hymenophyllaceae, 1842, pp. 96, 97.

³ l. c., p. 98.

⁴ Versl. en Mededeel. d. k. Akad. Amsterdam, XI, 1861, and Journ. d. Bot. Nederland., I, 1861.

⁵ Ueber die Hymenophyllaceae, Abh. Sächs. Ges. d. Wiss. 1864, p. 500.

⁶ He points out especially the affinity with the Sphagnaceae.

⁷ Hymenophyllaceae, p. 62, 1875.

⁸ Zur Keimungsgeschichte einiger Farne, Ann. d. Jard. Bot. de Buitenzorg, vol. VII.

suggestion as to the origin of the Fern from the Moss-sporogonium. The above brief statement will serve to show how long and how consistently the opinion has been held by special writers upon the Hymenophyllaceae, that they are the most primitive types of living Ferns. We will now consider wherein the points of similarity between them and the Mosses really lie, and try to estimate them at their true value in support of the primitive character of the Filmy Ferns.

Over and above the corresponding facts of alternation in the Mosses and Filmy Ferns, and the homosporous character which they both share, the chief points of similarity are these :—

- (i) The filmy character of the leaf ;
- (ii) The filamentous prothallus ;
- (iii) The projecting sexual organs ;
- (iv) The presence of a single, well-defined apical cell ;
- (v) The reputed absence of roots in some Filmy Ferns.

Each of these will be successively discussed and criticised.

(i) It was perhaps the filmy texture in the leaf more than any other character, which suggested the affinity of the Filmy Ferns to the Bryophyta: long before the phenomena of antithetic alternation¹ were properly apprehended, it was pointed out that a similarity of structure exists between the fronds of the Hymenophyllaceae and the leaves of the Mosses, since in both cases the filmy leaf may consist of only a single layer of cells. But while such a comparison was not unnatural some fifty years ago, it is to be borne in mind that the facts of antithetic alternation are now clearly before us¹: that we are comparing the filmy leaf of these Ferns, which is part of the sporophyte, with the so-called leaf of the Moss, which is part of the gametophyte: the two are not strictly homologous parts, and accordingly their comparison cannot be accepted as convincing: at best we have here only an *analogy*, the leaf of the Fern not being the lineal descendant of the leaf of the

¹ In case this term be unfamiliar, reference may be made to an article 'On antithetic as distinct from homologous alternation of generations in Plants,' *Annals of Botany*, vol. IV, p. 347.

Moss. But there are still further reasons for thinking this comparison unsatisfactory. I have attempted elsewhere to show that the 'filmy' texture of the leaf is not a safe indication of close affinity even among the Ferns¹, by pointing out that within the Filicineous series it occurs at three distinct points, viz. among the Hymenophyllaceae, the Aspleniums, and the Todeas: if within the very natural group of the Ferns themselves it is not a certain index of affinity, but is rather to be viewed as a result of direct adaptation, how can the filmy texture of the leaf be held to strengthen the comparison between the Hymenophyllaceae and the systematically far distant series of the Mosses? If the affinity be a true one, the evidence of it must be based on firmer ground than that of the filmy leaf².

(ii) The existence of a filamentous, protonema-like prothallus in the Hymenophyllaceae, affords what is apparently a better ground for comparison. Various writers have recognised its counterpart in the protonema of the Moss, but none has treated the matter so fully as Goebel, who has made a comparative study of the sexual generation of certain Ferns, and based upon it views as to the phylogeny of Mosses and Ferns, and the relationship between them: he sums up in the following words³: 'We may accordingly regard as the starting-point of the Bryophyta and Pteridophyta, Alga-like forms, consisting of branched filaments, of which the female sexual organs produced on fertilisation the asexual generation. Even now we can partially trace the phylogenetic development of the sexual generation, or at least form for ourselves a connected idea of it. Still it is not to be forgotten that besides the onward progress from the simple condition of

¹ Annals of Botany, vol. III, p. 379.

² Giesenhagen (Flora, Oct. 1890, p. 460) has cited the case of *Selaginella cuspidata* as having at the margins of the leaf a texture similar to that of the Hymenophyllaceae, also *Lycopodium linifolium*, which is a shade-loving species. He concludes (p. 462) that the simplest Hymenophyllaceae were derived from forms of more complex construction, and are the result of progressive simplification of morphological structure: also that the Hymenophyllaceae are as near to the Polypodiaceae as any other family of homosporous Leptosporangiates.

³ l. c., p. 115.

a branched filament, there may have been also a degeneration of the sexual generation, as seems to me probable in the case of the Fern-prothalli even at the present day.' It is further added in a note that 'the degeneration is in many cases brought about by the transfer of the formation of sexual organs to earlier periods of development of the prothallus.'

That there is a similarity between the protonema of the Moss and the prothallus of the Hymenophyllaceae no one can doubt; but before it could be finally accepted that the filamentous form is in both families really a primitive character, and not a result of more direct adaptation to similar external circumstances, which took place independently in the two families, we should require more evidence as to the details of descent than is as yet forthcoming, and the conclusion will need to harmonise with other facts relating to form and development of these and other organisms. I am not prepared at present to concede this point without considering carefully the grounds on which the opinion is founded. To this end we may first take up the question whether the filamentous form was the original one for the sexual generation of the Bryophyta: and secondly, we may inquire whether the similarity of form between the protonema of the Mosses and the filamentous prothallus of the Filmy Ferns is an indication of real affinity.

Having shown that among the Mosses there are forms in which the leafy plant is of very small size, and simple structure as compared with most Mosses, so that the protonema constitutes the greater part of the sexual generation, Goebel states that 'the appearance of a protonema on the germination of spores of the Mosses cannot be regarded as a "phenomenon of adaptation," but as a peculiarity inherited from their ancestors¹.' This conclusion follows from the recapitulation-theory², which, however, is a much less safe guide in the embryology of plants than in that of animals. I have elsewhere expressed at length my doubts of the propriety of basing broad phylogenetic conclusions upon details of external

¹ l. c., p. 112.

² Goebel, *Muscineen*: Schenks Handbuch, II, p. 387.

conformation of the sexual generation, in view of the extent of the direct impress of external circumstances upon it in certain known examples¹: at the same time I am free to admit that a reasonable case (though not a demonstration) can be made out for the relatively primitive character of the Moss-protonema, notwithstanding that the formation of a protonema is not a constant phenomenon in all Mosses².

Passing to the second question, viz., whether the similarity of form between the protonema of the Moss and the filamentous prothallus of the Hymenophyllaceae is an indication of real affinity, we enter on different ground. Between the Mosses and the Ferns there is a very wide gap. Though the general facts of alternation are similar, still as regards the form and structure of the sporophyte the two families have virtually nothing in common; but in the general conformation of the prothallus, and in its propagation by gemmae, they are alike: can this be accepted as an index of affinity in face of so fundamental a difference in the neutral generation? Among the higher plants it is notorious how little attention is paid to similarities of external conformation of the vegetative organs if the other characters indicate strong divergence, and there is no reason why this principle should be neglected in dealing with the Cryptogams. Moreover in the protonematoid growths of the Hymenophyllaceae we see an excessively inconstant character: even within the genus *Trichomanes*, while the prothallus of *T. pyxidiferum* is throughout filamentous, with exception of the archegoniophores, that of *T. alatum* is most diverse in its form³: in *Hymenophyllum* on the other hand the flattened form is prevalent: thus within the Hymenophyllaceae there is great want of constancy in that very character to which, in accordance with current views, so much importance is attached as evidence of relationship to the Mosses. This is in itself sufficient to cast doubt upon it,

¹ Annals of Botany, vol. I, p. 292.

² *Andreæa* is an exception. See Berggren, Studien öfver Mossornas bygnad och Utveckling (Lunds Univ. Arsskrift. T. VII).

³ See Annals of Botany, vol. I, Plates XIV, XV.

a doubt which is strengthened by the absence of other evidence. It is by no means an improbable view that the filamentous form of the Hymenophyllaceous prothallus is the result of adaptation to the very moist situations in which they commonly grow: an extreme case in fact of that lengthening of the germinal filament which may be produced by certain external conditions¹, and that we have here to deal with a phenomenon of analogy with the Mosses rather than with an index of true affinity; to this I shall return later.

(iii) It will doubtless be remarked, however, that in the freely exposed, projecting sexual organs of the Hymenophyllaceae, and especially of *Trichomanes*, there is an obvious character which is shared with the Mosses: that is so, but the correspondence applies rather to the position of the organs, than to details of their structure. The archegonium is a typical Fern-archegonium: it develops as a Fern-archegonium, and has the single neck-cell, common to Leptosporangiate Ferns². The antheridia are borne, it is true, on a narrow pedicel, but their development and mature structure conform approximately to that in other Ferns. It is then their *position* which would provide ground for comparison rather than their structure; but this protruding position is a necessary result of the simple structure of the prothallus, and if that be a result of relatively direct adaptation, as above suggested, so also would be the exposed position of the sexual organs.

(iv) The presence of a single initial cell with definite segmentation at the apex of the young Moss-sporogonium, and also at the apex of the stem, leaf, and root of the Leptosporangiate Ferns, while such are absent or less definite in their segmentation in the Eusporangiate Ferns, is certainly a fact worthy of note. The common presence of a single initial in the lower forms, and the absence of it from most Phanerogams, may be regarded as pointing towards the conclusion that those organisms which show the single initial are lower in the scale. Examples are however known of the

¹ See Goebel, l. c., p. 115: also Dodel-Port, Kosmos, 1880, p. 11.

² Annals of Botany, vol. I, p. 210.

existence of a single initial cell in Phanerogams¹, while in certain Thallophytes and Bryophytes no single initial is present: this point cannot therefore be accepted as having much weight. The presence of a single initial seems frequently to follow a less robust habit and a sharp curvature of surface of the growing-point. Plants of aquatic position are commonly of delicate texture; most of the lower forms are more or less distinctively aquatic; accordingly the presence of a single initial, though common in the lower forms, is not necessarily to be viewed as an indication of a lower affinity.

(v) Again, some may see in the rootless condition of certain of the Hymenophyllaceae, evidence that these are primitive forms, which share this character with the sporophyte of the Mosses. This condition is reputed to occur in certain species of *Trichomanes*, but, as Giesenhagen has observed², we are not yet in a position to state that these Ferns are really rootless in every stage, and in those species in which the seedlings have been seen, a root is present. But even if they were proved to be actually rootless at all stages of their life, the absence of roots might be a result of degeneration, as it undoubtedly is in *Wolffia*, or in the Utricularias described by Goebel³: it is not necessarily to be accepted as a primitive character.

We have now reviewed those characters upon which the Bryophytic affinity of the Filmy Ferns may be based, and the most satisfactory character for purposes of comparison is the protonema. Against this, which as above pointed out, may be viewed as a more directly adaptive rather than as an ancestral character, is to be set the fact that the simpler Ferns are the only Leptosporangiate Vascular Cryptogams, and that living forms afford no clue as to any direct mode of origin of such simple sporangia⁴. Thus the comparison above dis-

¹ The most prominent example is the root of *Heleocharis palustris*.

² Flora, Oct. 1890, p. 460.

³ Ann. d. Jard. Bot. de Buitenzorg, vol. IX, p. 98.

⁴ It is not necessary to dwell upon Prantl's suggestion as to the origin of the Hymenophyllaceous sorus from some form like *Anthoceros*. A view which depends upon the conversion of the internal sporogenous layer into a number of superficial sporangia, without any evidence how such a conversion did or

cussed appears to rest on very slender grounds, and it may well be asked whether some alternative opinion may not be more probable. May we not find a more true affinity to the lower forms in the Eusporangiate Ferns? In discussing this question I propose to take a general survey of the supposed affinity. In view of the wide differences between the Bryophyta and the Pteridophyta, and of the great antiquity of the Ferns, it will not be desirable to compare directly any one living Filicineous type with any one living type of Bryophyte, but rather I would consider the more general question of probability of the Eusporangiate character being primitive and ancestral as compared with the Leptosporangiate. It may be noted, however, that on general comparative grounds the affinity of the Eusporangiate ferns would be to the Liverworts rather than to the Mosses, and the question may therefore resolve itself into this: whether the affinity of the Leptosporangiate Ferns to the Mosses, or of the Eusporangiate Ferns to the Liverworts, be the more true and natural one.

Looking at the question then in its broader aspect, it will be noted that of the three great phyla of Vascular Cryptogams, two are exclusively Eusporangiate. There is no evidence, either from present or fossil forms, that the Lycopodiinae or Equisetineae have had any Leptosporangiate ancestry, and they therefore serve to show that a stock may be Eusporangiate from the first, and make it also the less probable that the Ferns should have originated otherwise. The absence of any intermediate steps leading to the Leptosporangiate type, except from the Eusporangiate Ferns themselves, adds weight to this argument.

In the second place, the more bulky type of sporangium is already foreshadowed by the capsule of the Liverworts; it would be going too far to say that the capsule of a *Fungermannia* or of a *Marchantia* is one Eusporangiate sporangium, for it is probable that in the evolution of the Ferns a sub-

could come about, will hardly commend itself to the reason as in any way probable. Moreover, it is not apparent on other grounds that there is any near affinity between the Anthocerotae, and the Filmy Ferns. See Prantl, Hymenophyllaceae, p. 62.

division of the archesporium took place, not its mere repetition; but the resemblance is undeniable: there is thus in the sporogonium itself an indication of how the Eusporangiate sporangium may have been derived, however vague and uncertain that indication may be thought to be; whereas there is as yet no rational suggestion as to the mode of origin from the Bryophyta of the sporangium as it is seen in the Leptosporangiate Ferns.

Passing on to the apical meristems, the characters of these have been used by me as a basis for disposing the Filicineae in series, as above stated. It is to be remembered that such evidence cannot be expected to apply with equal force in all cases, and that it is of greater weight within narrow circles of affinity, than in the comparison of more remotely related organisms. It is, however, worthy of note that while a single initial is present in the young sporogonium of the Moss, in the Liverworts a single initial is not found, though in certain of the Jungermanniaceae four cells, which hold a central position at the apex of the sporogonium, suggest in some measure that structure which is characteristic of the meristems of the Marattiaceae: it would however be unwise to rest strongly on such a point as this.

In comparing the Hymenophyllaceae with the Mosses the mere vegetative characters of the gametophyte have been brought forward as weighty evidence: if we are to depart so far from the methods of classification applied to the higher plants, and consider vegetative characters in plants widely diverse in other respects, as much might I think be said for the similarity between, for instance, the prothallus of the Marattiaceae or Osmundaceae and the sexual plant of the Anthoceroeteae: the flattened but massive green thallus, which may in either be branched, is not dissimilar in the two cases. The point of distribution of the sexual organs may appear to be an obstacle, they being on the upper surface in the Anthoceroeteae, while in the Marattiaceous prothallus they are commonly on the lower; but Jonkman¹ specially states and

¹ La génération sexuée des Marattiacées, pp. 13-17. Figs. 53-57.

figures the fact that in these plants, both antheridia and archeogonia are found on both surfaces, though they are more numerous on the lower.

As regards the sexual organs themselves there is a nearer correspondence between the Eusporangiate Ferns and the Liverworts than is to be found between the Leptosporangiate Ferns and the Mosses. I have elsewhere pointed out¹ that in the Eusporangiate Ferns the sexual organs are deeply sunk in the tissue of the massive prothallus, a position sufficiently distinct from that of the freely exposed and projecting organs of the Hymenophyllaceae. The same is the case with certain of the Thalloid Liverworts, and especially in the Anthocero-teae. D. Campbell² has drawn attention to the fact, demonstrated by Jonkman, that more than a single canal-cell is present in the archeogonium of the Marattiaceae, a character in which, according to our present knowledge, they alone among the Vascular Cryptogams compare with the Bryophyta: it may also be noted that the embryo of *Marattia* assumes a vertical position of the axis from the first, according to Luerssen³; but this is a point to which too much importance should not be attached. Do what we will by drawing comparisons based on such points as these, the difference between any living Fern and any living Bryophyte is an uncommonly wide one, and it is almost useless to attempt to place any view of relationship upon a sound basis by comparison of mere details in organisms so widely different.

There is however a line of evidence which, though in itself not conclusive, will serve to give greater stability to the suggestion that the Eusporangiate Ferns are the more primitive type: I mean the evidence from Palaeophytology: in approaching the discussion of such a question as the present, too little attention has been paid to this branch. It is hardly necessary to premise that as negative evidence it is not strong: the fact that certain types of plants have not been

¹ Annals of Botany, vol. III, p. 370.

² Botanical Gazette, 1890, p. 4.

³ Handbuch d. Syst. Bot., I, p. 582, and Fig. 154.

found in the earlier rocks does not necessarily prove their absence at the periods when those rocks were formed, though the fact is worthy of note: for our purpose the *prevalence* of certain forms over others in the earlier formations will command greater attention, and we may at once proceed to consider how, in this respect, the facts of palaeophytology bear upon the present question.

Recent writers have repeatedly remarked the preponderance of Ferns of the Eusporangiate type in the primary rocks: though very many Fern-remains are represented only by barren fronds, where the sporangia have been found they are in the overwhelming majority of cases of a character allied to the Marattiaceae: it may further be stated that no drawing from a microscopic section showing internal details of an undoubted leptosporangiate sporangium from the primary rocks has yet been published¹, and it is from these, rather than from mere surface observations of prints, that the most trustworthy evidence is to be gathered. Perhaps the best authenticated example of a print of a Leptosporangiate Fern from the primary rocks is that of *Hymenophyllites delicatulus*, described and figured by Zeille², and referred by him to the Hymenophyllaceae: here the details of the impression were so well preserved that Zeiller was able to recognise and draw the oblique annulus, which corresponds very closely with that of a modern Filmy Fern. The original specimens of this fossil were examined by Graf zu Solms-Laubach, and from them he concluded 'that the fact is correctly stated, and that no other interpretation of the figures is possible³.' The sporangia figured and described by Mr. Carruthers as being found in a section of a nodule from the coal must also be considered⁴. I have had the opportunity, through the kindness

¹ Renault states that he has specimens of sporangia of Gleicheniaceae and of *Trichomanes* in silicified sections from Grand-Croix, but did not publish them because he did not know to what fronds they belonged: Cours de Bot. foss. III, p. 218. The case of sporangia from a coal nodule figured and described by Mr. Carruthers, Geol. Mag., vol. IX, No. 2, 1872 (Plate II, Fig. 5), will be referred to below.

² Ann. d. Sci. Nat., 6 Série Botanique, vol. XVI, 1883.

³ Palaeophytologie, p. 157.

⁴ Geol. Mag. vol. IX, No. 2, Pl. II, Fig. 5.

of Mr. Carruthers, of seeing the original specimen, and there certainly appears to be an oblique annulus, similar to that of the Hymenophyllaceae: it is however to be noted, as indeed Mr. Carruthers himself remarks, that these sporangia are larger than those of present Filmy Ferns, while the stalk appears to be a relatively short and massive one: these points make the further elucidation of the nature of such sporangia very desirable, while in my opinion they raise a doubt as to the near correspondence of this Carboniferous Fern with our present Hymenophyllaceae. The case of *Hymenophyllites Weissii*, Sch., figured by Schimper, from the coal of Saarbrücken is much less satisfactory¹, the reference of this to the Hymenophyllaceae depending chiefly upon the character of the sorus as a whole (if indeed that which is so described be really a sorus), while the sporangia themselves have not been distinguished or described in detail. The large and typical Devonian Fern, *Palaeopteris hibernica*, Schimper, (*Archaeopteris hibernica*, Forbes) has also been referred to the Hymenophyllaceae²: here again it is the character of the sorus as a whole, not of the sporangium, which has led to the conclusion: the sporangia themselves seem not to have yet been seen, and therefore the reference to the Hymenophyllaceae cannot be taken as more than a provisional suggestion³. Mr. Kidston, after a careful re-examination of the specimens of this species in the British Museum, and in Dublin, comes to the very divergent conclusion that 'the true position of *Archaeopteris hibernica* is in the Marattiaceae.' I have also examined specimens in the British Museum, and failed to recognise any distinct evidence of the Hymenophyllaceous affinity.

Stur in speaking of those Carboniferous Ferns which he refers to the Polypodiaceae, regards their position in that

¹ Compare Schimper, *Traité d. Paléophytologie*, Pl. XXVIII.

² Schimper, *Traité*, Pl. XXXVI; Carruthers, *Geol. Mag.*, IX, 1872, p. 3 and Plate II.

³ See also Kidston, on the fructification and affinities of *Archaeopteris hibernica*; Forbes, *Ann. and Mag. of Nat. Hist.* 1888.

family as no more than a provisional suggestion : he is careful to state¹ that in none of these has the sporangium itself been seen, but at most the indusium of the sorus, or the receptacle without sporangia.

Passing on to specimens of the carboniferous period, where the microscopic details can be seen in sections, evidence is found of the structure of the sporangia being more complex than that of the Leptosporangiate Ferns. This is the case in the sporangia figured by Williamson², for in these, traces of a second series of cells are found within the external layer of the wall, a character which is absent in the mature Leptosporangiate sporangium. Prof. Williamson has, with great liberality, shown me those of his sections of coal nodules which exhibit Fern sporangia, and the comparatively small number of these shows how rarely they are preserved. I was struck in looking over these specimens by their great uniformity of type, and have selected a few for detailed drawing (Figs. 1-4). In examining these it is to be borne in mind that the sections pass in irregular directions through the sporangia, but still the similarity is unmistakeable : in each case the superficial layer of cells has thickened and firm cell-walls, but the individual cells are of very irregular size and shape; no definite ring-like annulus can be traced. Within the outer layer are to be found in each case more or less distinct traces of internal cells (*i*, *z*), which do not constitute a regular and continuous layer, but only a partial internal sheath ; at some points a simple line may be seen (as in Fig. 4. *x*), without any distinct layer of cells ; this will be referred to subsequently. The number of spores in the single sporangium is relatively large, as may be judged from the sporangium shown in Fig. 4, where more than seventy are seen in the single section, and the total number in the sporangium must have been much larger. None of the sections show clearly the mode of insertion, and the sporangia

¹ Stur, *Die Carbonflora*, 1885, p. 235.

² *Phil. Trans.*, vol. 167, Part I, on the organization of the Fossil Plants of the Coal Measures, Part VIII, Pl. 7, Figs. 25-30.

are commonly found quite isolated. I think it probable that these sporangia are similar to those represented by Mr. Kidston, and described by him as 'annulate sporangia'¹; though possibly not specifically identical with sporangia represented in my figures, and though the internal cells are not represented in Mr. Kidston's figures, still the correspondence of his sporangia to those examined by myself is certainly closer than to sporangia of Leptosporangiate Ferns. In searching among modern Ferns for sporangia structurally similar to these from the coal, I have found in *Todea barbara* a very remarkable resemblance: the main structural points of the Osmundaceous sporangium are already well known: their large size, and short stalk, the absence of a definite ring-like annulus, and dehiscence by a longitudinal slit. In longitudinal section the structure in *Todea barbara* is as in Fig. 6: the most noteworthy characters for our present purpose are the irregularity of the external layer of cells, which is composed of relatively large, thick-walled cells at (*a*), while elsewhere the cells may be relatively small and thin-walled. Within this, and especially towards the base of the sporangium, will be seen small and compressed cells, limited by oblique walls, which remain till the sporangium is mature, constituting a partial and irregular inner layer (*i*, Figs. 6-8), while, in sporangia not quite mature, a granular film may be traced lining the cavity in which the spores are produced. The stalk of this large sporangium is relatively thin, and appears in the longitudinal section as composed of about four rows of cells. The whole construction of the sporangium is of a more bulky type than that of the typical Leptosporangiate, and I have elsewhere shown that this is its character from the very first stages of its development. In comparing this with the fossil sporangia, it is to be remembered that the

¹ Trans. Geol. Soc. of Glasgow, vol. IX, Part I, Figs. 11-13. In connection with Mr. Kidston's use of the words 'annulate' and 'ex-annulate,' it should be remarked that these terms are not to be taken as substitutes for 'Leptosporangiate' and 'Eusporangiate.' The fact that an annulus is absent from the Hydropterideae, though these are typically Leptosporangiate forms, shows that precision is necessary on this point.

latter are cut through in most irregular directions, and accordingly the comparison should be with irregular and oblique sections from the modern Fern: two such are represented in Figs. 7 and 8, and the similarity, even in details, between these and the sporangia from the coal is very notable: the comparison should specially be made with Fig. 3, and it will be seen that the position and appearance of the 'annulus' (*a*), the line of dehiscence (*d*), and the internal cells (*i*), as well as the relative size and appearance of the rest of the tissues shown, correspond to an extraordinary degree. Perhaps the most striking point is that the granular film (*x*), already noted in the modern sporangium, may be traced in the sporangium from the coal, for the delicate irregular line (*x*) in Fig. 4 is believed to represent that similarly marked in Figs. 6-8. It is thus seen that the correspondence between the structure of these sporangia from the coal nodules, and of the modern *Todea barbara*, is an unusually close one.

In interpreting this extraordinary resemblance it is to be remembered that these sporangia from the coal nodules are isolated from the fronds; there is thus no proof from what type of Fern they were derived, other than that yielded by their form and internal structure: it is not even suggested that they all belong to the same species or genus, and I would be far from urging on the above grounds that *Todea barbara* itself is a plant of very early date: it seems, however, that their Osmundaceous character is probable, and it is to be noted that the Osmundaceae have hitherto been believed to be of post-carboniferous origin. For the purposes of the present argument, these sporangia have an interest: they are clearly not Leptosporangiate, as the word is ordinarily understood, but occupy an intermediate position, connecting these with the Eusporangiateae; their size, their more complex structure, and the number of spores which they produce, all show this; and as this, though itself rare, is the prominent type of Fern sporangium from the coal nodules, of which the microscopic structure is known, we may see in

that fact a measure of farther evidence of the prevalence of Ferns with a more bulky sporangium in the earlier rocks over those of the true Leptosporangiate type.

From the above data the conclusion may be drawn that though it is not possible absolutely to deny the presence of Leptosporangiate Ferns in the primary rocks, still the evidences of their occurrence are at least exceedingly rare, and the question whether they existed at all in those early times is not even yet placed beyond the possibility of doubt by observation of microscopic sections¹. But, as above remarked, it is not the present object to prove their absence, but to fully appreciate their rarity in the primary rocks, as compared with the Eusporangiate forms. On this point Stur² has put forward figures relating to the Carboniferous Ferns; in considering which it is to be remembered that many of the Ferns quoted are classified by their vegetative organs alone, and not by observation of their sporangia: his results may be tabulated as follows:—

	Present Flora.	Carboniferous.
Ophioglossaceae { genera species	3 17	2 19
Marattiaceae { genera species	4 23	15 98
Polypodiaceae (?) { genera species	108 2700	4 or 5 58

In estimating the value of these figures it must be remarked that our knowledge of the present Flora is

¹ Schenk, in his *Handbuch* (vol. IV, p. 37), writes of the Hymenophyllaceae, 'one observation due to Zeiller is the only evidence of the existence of this family in the older formations;' and again, speaking of other Leptosporangiate Ferns, 'they seem to be entirely absent from the older formations, and to appear first in the Mesozoic strata.'

² *Die Carbonflora*, Abh. d. k. k. Geol. Reichsanstalt zu Wien, 1885, p. 411.

infinitely more perfect than of the carboniferous plants, and that of the fossil Ferns here entered among the Polypodiaceae, the details of the sporangia are not known in any one case. Bearing these points in mind, it appears that the Ophioglossaceae stand roughly in the present as in the past, that the Marattiaceae of the coal preponderated greatly over those of the present era, both in genera and species, while the Polypodiaceae, which are the most typical Ferns of the present time, are represented in the coal by relatively few forms which are only doubtfully referred to this family. Stur further states that the Gleicheniaceae, Osmundaceae, and Schizaeaceae were entirely absent from the coal, and suggests for them a post-carboniferous origin; though I do not consider that, in the absence of all knowledge of their vegetative organs, the sporangia above described demonstrate beyond doubt the presence of Osmundaceous Ferns in the coal, I should not be prepared to maintain their absence in view of those facts. Speaking generally, the present Eusporangiate Ferns may be said to be the reduced remnants of a more prevalent race of former times, while the Leptosporangiates were in the main a race of later origin, and are now greatly more prevalent than in earlier periods. In the previous pages I have attempted to show that the comparison of the facts of structure and development of present living forms is not incompatible with the view that the Eusporangiates represent the more primitive type for the Filicineae: the palaeobotanical evidence is clearly in favour of this, though it is not, and cannot be expected to be, absolutely conclusive.

In the memoir already referred to at the opening of this paper¹ I have dwelt at some length upon the adaptive nature of the differences of bulk of the various parts of the sporophyte and gametophyte in the Ferns: having demonstrated that, as regards bulk of the young parts, the Ferns form a series, it was recognised that the more robust Eusporangiate forms are better suited in all their parts to

¹ *Annals of Botany*, vol. III, pp. 366-374.

an exposed habitat, while the more delicate Leptosporangiate Ferns are less fitted to withstand exposure in dry air¹. On grounds of comparison, which I now am disposed to think were insufficient, I then concluded that the series from the Hymenophyllaceae to the Marattiaceae represents an ascending series, illustrating the emergence of one phylum of the Vascular Cryptogams from the semi-aquatic to the aerial habit². But, it may well be asked, have we not in the Leptosporangiate Ferns a peculiarly specialised type? They are found at the present day chiefly, and the Hymenophyllaceae, upon which the comparison with the mosses is specially based, almost exclusively, under the shade of larger growths³. Where in the earlier period would such shade be found? If, as I have elsewhere suggested⁴, the origin and differentiation of the spore-bearing generation may be correlated with the migration from water to the land, it would be contrary to all reason to suppose that the primeval forms were such as we now see specialised to life under dense shade. Moreover, the plants which constituted the chief terrestrial growths of the primary rocks were not distinctively shade-giving plants, such as the more modern Angiosperms, under the shadow of which such plants now grow: there is thus a presumption against specialised, shade-loving forms such as the Hymenophyllaceae being really primitive. I am now disposed, on considering all the evidence, to hold that the Leptosporangiate Ferns are derivative and specialised forms, while the Eusporangiatæ represent the more primitive type: that the similarities of the vegetative organs, such as they are, between the Mosses and the Hymenophyllaceae are the result of specialisation along two distinct, but parallel, developmental lines, in accordance with similar external con-

¹ On the extreme susceptibility of the Hymenophyllaceae to exposure, and their special adaptation to life in wet, densely shady forests, see Giesenhagen, *Flora*, 1890, p. 417.

² *l. c.*, p. 374.

³ Those more exclusively acquainted with the British Flora must bear in mind that *Hymenophyllum tunbridgense*, and *Wilsoni*, are exceptional among Filmy Ferns as regards their exposed habit.

⁴ *Annals of Botany*, vol. IV, p. 347.

ditions: as the Cactaceae and Euphorbiaceae have independently adapted themselves to life in regions of prolonged drought, by reduction of leaf-surface, and succulent development of the axis, so may these two distinct stocks have adjusted their details of construction to a damp and often shaded habitat. The thin texture of the leaf is clearly an adaptive character, since it recurs in three distinct families of Ferns, in species of *Selaginella* and *Lycopodium*, and also in a minor degree in certain of the higher plants, in all cases a concomitant of shady and damp habitat. The same is probably the case with the filamentous prothallus; this seeming especially probable in face of the modifications of which prothalli are susceptible when grown in water: when the gametophyte is thus simplified in structure, the sexual organs must needs project, as they do in the Hymenophyllaceae. Thus the characters which are commonly cited as demonstrating an affinity between Mosses and Hymenophyllaceae may be recognised rather as being of a more directly adaptive nature, such as might be produced in the vegetative system of distinct groups of plants exposed to similar external conditions. Add to this the absence of any support for the affinity in the characters of the sporophyte, and the fact that the Mosses are entirely unrepresented in the earlier rocks, and do not appear until the Tertiaries, and the improbability of a true affinity between the Mosses and Hymenophyllaceae becomes in my opinion very strong indeed.

If this affinity be once given up, then the search for a point of attachment of the Filicineous series is necessarily transferred to the Liverworts, with the further result that the closest similarity to be traced is then with the Eusporangiate Ferns: in the anatomical characters of the sorus and sporangium a measure of support may be found for the suggested affinity, which, however, I would put forward only with that reservation which is necessary where the facts are but scanty. The sporophyte of the Fern corresponds to the sporogonium of the Liverwort, and the isolated archesporial cells of the former to the united archesporium

of the latter. It is probable that in the course of evolution of the Filicineae, the originally united archesporium became partitioned by bands of sterile tissue, each portion, thus isolated, developing together with its superficial covering of cells into a sporangium: if this were so, it follows that we may recognise in the synangia or so-called 'coalescent sporangia' of the Marattiaceae, and also in the 'sporangio-phore' of *Ophioglossum*, instances of the incomplete separation of the individual sporangia, though the archesporium in each is separate from that of its neighbours¹. From a comparative point of view I am disposed to regard these synangia, which are found in more than one series of the Vascular Cryptogams, as primitive in character, and as indicating not a coalescence of sporangia which were distinct in more ancestral forms, but rather an incomplete separation of sporangia, whose distinct archesporial cells were derived by isolation from some such united ancestral archesporium as is seen in the Bryophyta of the present day. If such Eusporangiate forms with synangial sori were the more primitive, it is not difficult to conceive how in plants growing in moist and shaded positions, where the danger of exposure to drought is minimised, the sporangia might have become not only completely separate, but also reduced in bulk, as we see in the progression through the Os-mundaceae to the truly Leptosporangiate Ferns: and parallel with this reduction of the sporangium, as I have shown elsewhere, would have proceeded the reduction in mass of all the other members of the sporophyte.

Again, this view that the Eusporangiate Ferns were the more primitive, and the Leptosporangiate derivative and specialised, may throw light upon what I have hitherto regarded as a perplexing phenomenon, I mean apospory: it was difficult to understand why this obliteration of a marked phase in the alternation should make its appearance in forms which we were accustomed to accept as primitive, seeing that on other grounds it is regarded as a terato-

¹ Compare D. Campbell, l. c.

logical phenomenon, and not as a reversion. If, however, the views as to the origin of the antithetic alternation, which I have elsewhere put forward, be accepted, and also that the Eusporangiate Ferns be really primitive, apospory appears in a new light: as at present recorded it is found to occur in Leptosporangiate Ferns and Mosses; in forms which, under the present hypothesis, are specialised in accordance with a moist and often shaded habitat; in these the circumstances of life on exposed land surfaces, which in my view conducted in the first instance to the antithetic alternation, are mitigated: living, as at least many of the aposporous plants do, in an almost uniformly moist habitat, it is to be expected, rather than wondered at, that the limits of the alternate generations should be obliterated: that the typically terrestrial sporophyte should, on exposure to surroundings more specially favourable to the growth of the gametophyte, grow out directly into the prothallus: and that the spore-formation, which is the distinctively sub-aerial mode of propagation, should be in abeyance: more especially is this to be anticipated in the Hymenophyllaceae when grown in closed cases; and what more pronounced example of apospory, of actual obliteration of the limits of the two generations, could be afforded than that of *Trichomanes alatum*¹? The very existence of apospory in Leptosporangiate Ferns seems to me to support the view that they are derivative and specialised forms rather than primitive, and these remarks will apply equally to the Mosses, in which aposporous development is induced only under conditions of specially damp culture.

In the above pages it will, I think, have been sufficiently shown that the view of the Eusporangiate Ferns as relatively primitive is capable of defence: a comparison of form and development, the palaeontological evidence, and even the facts of apospory, all fall in with this theory, and give it more or less uniform support; but it is impossible at present to do more than put it forward as an hypothesis, and the question must still be held to be an open one. If the new view be

¹ Annals of Botany, vol. I, p. 278.

finally accepted, much of the theoretical writing at the close of my former paper¹ will need to be read in converse. I would, however, remark that whichever opinion be adopted, the *facts* of my former paper remain, and the serial arrangement of the Ferns there based upon the broad area of facts relating to the meristems stands as surely as before. A somewhat modified opinion may, however, be held as regards the families of Leptosporangiate Ferns, and instead of attempting to arrange them all in a linear sequence, it would probably be more in accordance with their characters, as well as with their position as derivative forms, to see in them a number of relatively distinct lines of individual development, which might have radiated, so to speak, from the Eusporangiate centre.

The effect of these opinions upon current views as to the main lines of descent would be as follows: In the first place, the thalloid Liverworts would take a more important place as primitive terrestrial plants, which probably approximate to those forms which gave rise to the Filicineous series: from the latter, as well as from the early Bryophyta, derivative forms sprang, which became specialised to a moist and shaded habitat, as an undergrowth below larger organisms: these parallel lines of development culminated in the Leptosporangiate Ferns and the Mosses of the present day, both of which may be regarded as blind branches. From some forms allied to our modern Marattiaceae and Ophioglossaceae, the Cycads probably sprang, and from some forms of Lycopodiaceous affinity, the Coniferae. Obviously, if this were so, the effect of recognising the Eusporangiate Ferns as relatively primitive is to carry down to a lower point in the whole scale of plants the insertion of the Gymnospermic type: this would coincide well with palaeophytological facts, for it appears that the Gymnosperms date back to as early formations as the three phyla of the Vascular Cryptogams themselves. That questionable organism *Isoetes* would now find a natural, but independent, place between the bases of the Filicineous and

¹ Annals of Botany, vol. III, p. 372, etc.

Lycopodineous series, for, while not distinctly referable to either of them, it shows affinities to both of them as well as to the Cycads. Thus, whatever other strength the view of the Eusporangiate, as the more primitive type for Ferns, may possess, it appears to me to have the effect of making the phylogeny of vascular plants more intelligible, and of harmonising it better with palaeophytology than the converse opinion, which most botanists have hitherto been accustomed to hold.

DESCRIPTION OF FIGURES IN PLATE VII.

Illustrating Professor Bower's paper on Ferns.

Figs. 1-5 represent sporangia found in sections of nodules from the coal of Halifax and Oldham; 1-4. are from slides belonging to Prof. Williamson; 5. from a slide belonging to Mr. Carruthers. The cabinet numbers are those of Prof. Williamson's Catalogue.

a = annulus. *d* = point of dehiscence. *i* = internal cells. *x* = granular film.

Fig. 1. A young sporangium, showing the internal layer very distinctly, and filled with the remains of immature spores. (Cabinet number, 1875.)

Fig. 2. An older sporangium which has probably ruptured at *d* and lost its spores. (Cabinet number, 1020.)

Fig. 3. A mature sporangium showing point of dehiscence (*d*) and internal cells. (Cabinet number, 1292.)

Fig. 4. A mature sporangium with spores still contained in it, the granular film (*x*) may be traced for a considerable distance lining the wall: the number of spores in the section is over 70. (Cabinet number, 1875.)

Fig. 5. Portion of a sporangium from Oldham showing internal cells (*i*): (× 150.)

Fig. 6. Sporangium of *Todea barbara* in longitudinal section: (× 150.)

Figs. 7, 8. Sections of the same in oblique directions, chosen so as to match Fig. 3 as nearly as possible: the position of the figures on the plate, as well as the lettering, correspond to those of Fig. 3: (× 150.)

Fig. 1.

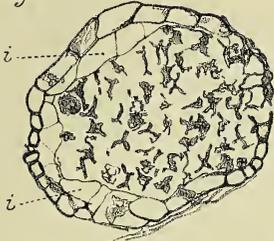


Fig. 2.

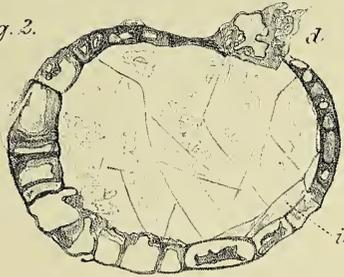


Fig. 6.

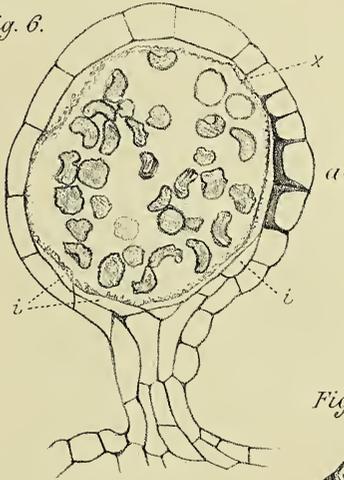


Fig. 3.

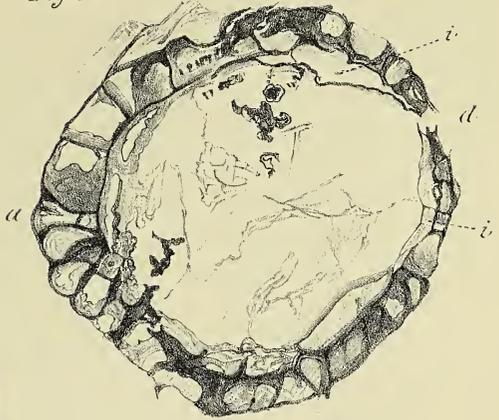


Fig. 4.

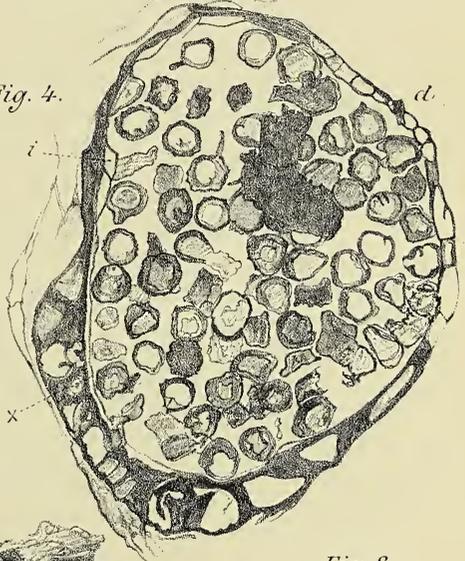


Fig. 5.



Fig. 8.

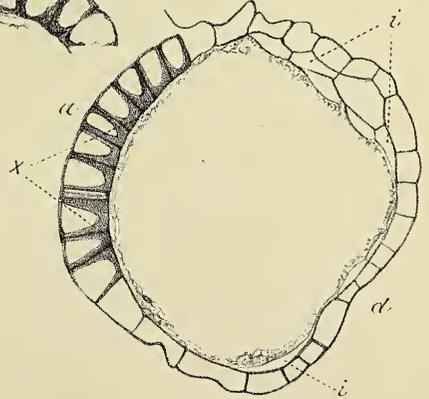
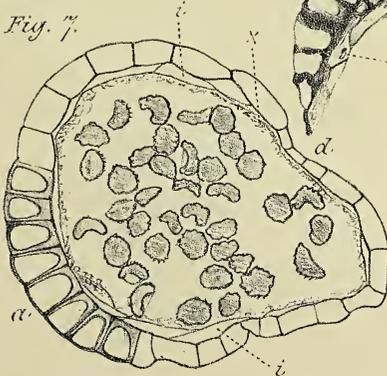


Fig. 7.



Bower del.

University Press, Oxford.

Observations on Phaeozoosporeae.

BY

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With Plate VIII.
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OBSERVATIONS tending to lessen that large number of Phaeozoosporeae of which it can be said that the reproductive organs are unknown or only imperfectly known, must be of use, more especially if such observations help in the formation of a more natural system of classification of this group. In the following pages I propose to give the results of the investigation of several brown sea-weeds which the excellent opportunities for research at Plymouth enabled me to examine in considerable detail.

I. CARPOMITRA CABRERAE Kütz.

This plant, added to the British Flora in 1833 by Miss Ball¹, is one of the rarest of British sea-weeds. In the summer of 1889 I was so fortunate as to obtain, by dredging, a scrap of the plant from which it was possible to make out the mode of growth of the thallus.

Trichothallic growth. The tip of a branch of *C. Cabrerae* is occupied by a tuft of hairs quite visible to the naked eye (Fig. 1). Janczewski says, 'S'il est permis de faire quelque conjecture sur l'accroissement d'une algue d'après des échantillons d'herbier, nous indiquerons que le *Sporochnus pedunculatus* et le *Carpomitra Cabrerae* nous ont paru végéter d'une manière analogue à l'accroissement du *Cutleria multifida*².' Examination of fresh material shows that Janczewski was,

¹ Miss Ball's specimen, with the rest of her herbarium, is in the Herbarium of the Science and Art Museum, Dublin.

² Ed. de Janczewski, Mém. Sc. Nat. Cherbourg, xix. p. 109. 1875.

[Annals of Botany, Vol. V. No. XVIII. April, 1891.]

in the main, right in his conjecture. In *C. Cabrerae*, the branches of which are sub-cylindrical, the hairs at the growing-point (Fig. 2) radiate outwards and, frequently, branch. A thallus-branch with its apical tuft of hairs is roughly comparable to a paint-brush. The hairs are connected through the *punctum vegetationis* with the cells of the thallus, but not so directly in series as in *Cutleria multifida*. Each hair exhibits basal growth; cells are given off, on the distal side to the base of the hair, the terminal cells of which fall off, on the proximal side to the body of the thallus. The hairs are free from one another to the merismatic region, but the cells given off on the proximal side are cemented together, and build up the compact thallus. They undergo intercalary divisions and form the parenchymatous thallus, in the branches of which a midrib is, at a little distance from the apex, well marked. It is of interest to note that the hairs, having chlorophyll in their joint-cells, are capable of considerable assimilative activity, as a result of which the merismatic region, from which new cells are being steadily derived, is well supplied with food¹. It is not difficult to see how, by a grouping together of simple, uniseriate, uncorticate, trichothallic branches, the mode of growth in *C. Cabrerae* can be derived from the well-known mode in *Ectocarpus*.

Reproductive organs. The sessile terminal mitre-like *receptacle* (as the fertile tip is called) gives to *Carpomitra* its name (Fig. 3). The sporangia form, with the paraphyses, a dense covering at the tip of a branch. The paraphyses are simple or, more generally, branched, and, when branched, often dichotomous. The sporangia are sessile or stalked, the stalk being provided by the paraphysis (Fig. 4). The terminal cell of the paraphysis contains chloroplastids, and not, as thought by Harvey², 'probably the remains of spermatozoa.' Each sporangium is unilocular and contains a

¹ The assimilative powers of the tufts of hairs in the Australian genera *Bellotia* and *Encyothalia* must be very great. In these genera the mode of growth is no doubt the same as in *C. Cabrerae*.

² W. H. Harvey, Phyc. Brit. Pl. 14.

large number of spores each of which has a well-marked orange-red pigment granule. I was not able to see either the dehiscence of the sporangium or any movements of the spores. The only fertile plant I had the opportunity of examining was taken in ten fathoms, in August 1890, in Plymouth Sound. The statement, occasionally to be met with, that the tips of the branches in *C. Cabrerae* are naked, is due to the examination of the plant in a fertile state. In this state, however, microscopic examination shows that the tufts of hair are present though the hairs are reduced to their bases. Indeed there is every indication that the receptacles are transformed branch-apices. The superficial cells of the thallus, instead of forming a compact limiting layer to the thallus, grow out into paraphyses and sporangia.

2. SPOROCHNUS PEDUNCULATUS Ag.

S. pedunculatus, though rare, is much commoner than *Carpomitra Cabrerae*, and can be dredged in tolerable plenty in Plymouth waters¹.

Trichothallic growth. The mode of growth of the thallus is essentially the same as in *C. Cabrerae* (Figs. 5, 6). The thallus is filiform, pinnately branched, each branch bearing a number of alternating shortly-stalked receptacles. Occasionally one finds a plant in which the main stem bears the stalked receptacles directly, without the formation of lateral branches. Both main stem, branches, and receptacles have their tips occupied by a tuft of hairs acting as just described in *C. Cabrerae*. Fig. 2 applies almost equally well to *S. pedunculatus*. In a ripe receptacle the hairs are quite short, though still recognisable; the *punctum vegetationis* is present, though no longer active; there is everything in fact to indicate that the receptacle is built up on the same plan as the sterile branch. It is not difficult to see that the stalked receptacle is in reality a modified branch of the thallus, as is, less obviously, the case in *C. Cabrerae*.

¹ T. Johnson, Journal Marine Biol. Assoc., New Series, vol. I, No. 3; Flora of Plymouth Sound, p. 286.

Reproductive organs. The arrangement of the reproductive organs is almost exactly the same as in *C. Cabrerae*. The sporangia and paraphyses are densely crowded together, at right angles to the surface of the stalked receptacle. The paraphysis is simple or branched. The sporangia are sessile or more usually inserted on the paraphyses, one paraphysis having several sporangia on it at different levels. The sporangia rarely reach to the terminal capitate cell of the paraphysis, so that, in nature, the only part of the receptacle visible from the outside is the free ends of the paraphyses.

Each sporangium is unilocular, and contains a large number of zoospores which appear quite like one another. I frequently kept a plant (it is only when it is quite young that it is not fertile) for 12–24 hours in a darkened bottle through which a steady stream of fresh sea-water was running. On examining the plant under the microscope the zoospores were to be seen escaping in large numbers. They have the usual phaeophyceean characters, are motionless at their escape, and collect in groups on the surface of the receptacle. In a few seconds the zoospores of a group separate and move off suddenly in all directions. I kept the zoospores under observation for many hours at a time, at nearly all hours of the day and night, and under various conditions, but saw no indication in them of any tendency to fuse with one another. Apparently each one is capable of independent germination. It should not be forgotten that the conditions under which zoospores of deep-sea plants are examined in a laboratory are very different from those under which they live in nature, 30–40 feet below the surface of the water. A method of observation in which the natural conditions of light, pressure, temperature are carried out, as far as possible, is necessary before negative evidence can be fully relied on. The zoospores are very sensitive to light and quickly arrange themselves in a row, away from the light if at all bright¹.

I was interested to find more than one plant in which the

¹ This is a further illustration of the observations of Strasburger and others on the movements of zoospores of Algae.

receptacles were themselves branched (Fig. 5). This branching was more frequently seen in plants in which the main stem was unbranched, and bore the stalked receptacles directly. This lends support to the view that the receptacles are modified branches, and shows that the paraphyses themselves are apparently capable of trichothallic growth—one of many instances of a want of fixity of function in the various parts of a brown sea-weed.

3. ASPEROCOCCUS Lamour.

I have recently shown¹ that in the genus *Punctaria* Grev. plantlets arise on the old thallus by *trichothallic gemmation*, from the hairs with basal growth, to be found scattered, in tufts, over the surface of the thallus. I find a very similar gemmation in *Asperococcus* Lamour. Here and there, on the surface of *Asperococcus*, solitary hairs with basal growth may be seen². In an old plant a hair may be seen developing into an *Asperococcus* plantlet. Quite recently Buffham has discovered projecting plurilocular sporangia³ in *Asperococcus*. There is much evidence that *Asperococcus* and *Punctaria* are, through *A. compressus*, much more closely related to one another than is at present admitted, *Asperococcus* being placed in the somewhat distant family Sporochneaceae⁴.

4. ARTHROCLADIA VILLOSA (Huds.) Duby.

A. villosa can be dredged in abundance in Plymouth waters. The mode of growth of the thallus has been described and figured by Falkenberg⁵. The thallus is filiform, pinnately branched. The joints of the branches are beset with closely crowded whorls of pinnately branched septate filaments. It is on these filaments, towards their base, that the sporangia are formed. Each sporangium is described as stalked, chain-

¹ T. Johnson, Linnean Soc., Nov. 1890.

² J. Reinke, Atlas d. Meeresalgen, Taf. 4.

³ Buffham's discovery has not yet been announced in print.

⁴ F. Hauck, Meeresalgen, xi.

⁵ Falkenberg, Schenk's Handb. ii. p. 221.

like, plurilocular. Each compartment of the chain is described and figured as containing only one large zoospore¹. I have examined a very large number of plants of *A. villosa* and have never found the state of matters as just described to hold good. I have always found each compartment of the chain, on its stalk of 1–3 cells, to contain 10–20 zoospores which even before their escape are to be seen in very active motion. It was possible to see all stages in the mode of escape of the zoospores. The compartments open independently of one another, not necessarily simultaneously or successively, and the zoospores almost immediately after their escape swim off. The zoospores are all alike and, though more pear-shaped, are very similar to those of *Sporochneus pedunculatus*. They show the same sensitiveness to light. Beyond one or two doubtful cases which could be explained in other ways I saw no signs of any tendency on the part of the zoospores to fuse with one another, though zoospores from different plants were placed together. Each zoospore appears to be capable of independent germination. Not unfrequently the greater part of the whole branchlet falls off, leaving only the base on which the fertile filaments are inserted. Occasionally the sporangia are intercalary, i. e. in addition to the sterile stalk-cells there are several vegetative cells at the apex of the fertile filament (Fig. 10). It seems to me that if these observations are trustworthy, the description of the reproductive organs in *A. villosa* should be altered. We should no longer speak of the sporangiferous filament as a stalked plurilocular sporangium with one zoospore in each compartment, but as a stalked chain-like sorus of unilocular, plurisporous sporangia. Falkenberg² contends, in opposition to Thuret, that the sporangia are plurilocular, basing his opinion on (1) the independent opening of the several compartments of the chain, (2) the origin of the fertile cells from one mother-cell. On the other hand, it should be noted

¹ MM. Crouan figure the compartments plurisporous (Florule du Finistère, 1867, c. 30, 190), without discussing the question of the nature of the sporangia.

² Falkenberg, *op. cit.* p. 226.

(1) that if the individual compartments in the chain are unilocular sporangia, each one will naturally have its own opening; (2) that the form of the sporangiferous filament is such that it must have an unicellular origin; (3) that in the formation of a plurilocular sporangium the division of the nucleus of the mother-cell takes place repeatedly, forming the rudiments of the zoospores, and that it is only after this that the cell-walls forming the compartments of the plurilocular sporangia are laid down. In *A. villosa* the mother-cell of the fertile filament divides, successively not simultaneously, into a number of cells, each of which becomes at once, in the chain, an independent cell with its own cell-wall; each fertile cell then behaves like an unilocular sporangium, the nucleus divides repeatedly, and forms the rudiments of many zoospores in each chamber. Occasionally the apical cells of the filament are vegetative, making the fertile cells intercalary. This is not merely a question of nomenclature, for the correct interpretation is of no small taxonomic importance. Broadly speaking, a plant with unilocular sporangia is of lower position, so far as reproduction is concerned, than one with plurilocular sporangia. Since the zoospores to which they give rise usually germinate independently, the unilocular sporangia may be regarded as asexual organs. Plurilocular sporangia, on the contrary, are known in several cases¹ to be *gametangia*, the contents showing a most interesting gradation in the differentiation of the sexual cells, tending towards the well-known mode of fertilisation in the Fucaceae. I do not overlook the possibility that the plurilocular sporangia which have hitherto been described in *A. villosa* may occur, that I may not have had any plants bearing them, and that if I had I may have overlooked them. When my plants were examined as soon as possible after being dredged, they appeared to have monosporous compartments: but on being kept in a darkened bottle for some hours, the multispore condition revealed itself.

¹ *Ectocarpus siliculosus*, *E. pusillus*, *Giraudia sphacelarioides*. In *Dictyosiphon hippuroides* the unilocular zoosporangia are gametangia.

5. DESMARESTIA Lamour.

Trichothallic growth. In this abundant and widely-distributed genus the mode of growth of the thallus is readily observable (Fig. 12). It has been described in detail by Janczewski¹, and later by Falkenberg². The thallus is pinnately branched, the main stem and all its branches end, when in the growing condition, in an uniseriate septate hair possessed of basal growth. This primary filamentous axis persists as such, and is recognisable in the thickest part ($\frac{1}{2}$ inch or more) of the thallus. The axial hair is itself abundantly branched in a pinnate manner in its uncortexed part. It is from the basal cells of its pinnules, on the thallus side of its merismatic region, that the whole of the extensive cortex is primarily derived. It will be seen how this mode of growth in *Desmarestia*, like that in the Tilopterideae, is but a complication of that in *Ectocarpus* Lyngb.

Reproductive organs. Though the genus *Desmarestia* is so widely distributed and of great systematic importance, the only description of the sporangia is the very brief one by Thuret and Bornet³: 'Je rappellerai que dans le *Desmarestia*, ou du moins dans le *D. viridis*, car dans le *D. Dudresnayi* Lamx.⁴, MM. Crouan (Florule du Finistère, Tab. 30) figurent une forme de fructification très différente, les sporanges se forment également dans les cellules corticales. Mais les cellules fructifères ne présentent aucune modification de forme et de dimension et ne se distinguent des cellules corticales ordinaires que par la nature de leur contenu.' I was successful in finding *D. ligulata* in a fertile state. The sporangia are, as in *D. viridis*, unilocular, and, as in it, are only to be distinguished from ordinary cells by the nature of their contents (Figs. 12, 13). In *D. ligulata*, however, the sporangia are not confined

¹ Janczewski, *op. cit.* p. 106.² Falkenberg, *op. cit.* p. 221, Fig. v.³ Thuret et Bornet, *Et. Phyc.* p. 16.⁴ The figure referred to in MM. Crouan's Florule (Tab. 30. 191, Fig. 3) is 'ramule de *Desm. viridis* avec un sporange disséminant ses sporidies.' It is an incomplete figure representing apparently the escape of numerous spores from a unilocular sporangium.

to the superficial cortical cells, but are formed also from any joint-cell of the primary cellular axis (Fig. 12), and from any joint-cell of the hair-pinnules (Fig. 14). Hence, morphologically, any cell of the thallus is capable of becoming a sporangium. Each sporangium contains one spore only, occasionally two to four. Each spore is of large size, much larger than the ordinary phaeophycean zoospore, and more like the spore of *Pylaiella fulvescens*, or of *P. litoralis*, or of the *Tilopteridae*. Whether the spore is ciliated, like the ovum of *Cutleria*, or non-ciliated, like that of *Tilopteris*, whether it is an ovum, or comparable to the tetrasporangium-like body in *Tilopteris*, I cannot say. It will be seen that, though my observations on the sporangia have, unfortunately, not gone far, they yet throw some light on the relationship of *Desmarestia* to the *Tilopteridae*. Careful microscopic examination of *Desmarestia*, at all seasons of the year, would yield results of great interest.

SUMMARY.

1. In *Carpomitra Cabrerae* Kütz., and *Sporochnus pedunculatus* Ag., the mode of growth of thallus is trichothallic, the apices of the branches being occupied by tufts of innumerable radiating hairs with basal growth. The mode of growth is readily derivable from that in *Ectocarpus*. The sporangia are unilocular, multisporeous. The terminal cell of each paraphysis is assimilative, not reproductive. The receptacle is the modified apex of a thallus-branch, and is, in *S. pedunculatus*, sometimes branched. The zoospores of *S. pedunculatus* are sensitive to light, and apparently capable of independent germination.

2. In *Asperococcus* Lamour, plantlets arise on the thallus by trichothallic germination, from hairs with basal growth, much as in *Punctaria* Grev., to which *Asperococcus* is much more closely related than is at present admitted.

3. In *Arthrocladia villosa*, (Huds.) Duby, the sporangia are unilocular, multisporeous, and form stalked chain-like sori. The zoospores after their escape behave like those of *S. pedunculatus*.

4. In *Desmarestia ligulata*, unilocular sporangia, containing one to four spores, and morphologically equivalent to any cell of the thallus, occur. In mode of growth of thallus, and in contents of sporangia, *Desmarestia* shows a close relationship to the Tilopterideae.

EXPLANATION OF FIGURES IN PLATE VIII.

Illustrating Mr. T. Johnson's paper on Phaeozoosporeae.

Carpomitra Cabrerae Kütz.

Fig. 1. A small portion of thallus showing tufted apices of branches, slightly magnified.

Fig. 2. Longitudinal section of apex of branch showing nature of trichothallic growth. *m*, Merismatic region of tuft. $\times 80$.

Fig. 3. Fertile tip of thallus, slightly magnified. *r*, Receptacle; *t*, remains of apical tuft of hairs.

Fig. 4. Surface of receptacle. $\times 400$. *p*, A branching paraphysis; *s*, *s'*, *s''*, stages in the sporangia; *a*, cells of surface proper of receptacle.

Sporochmus pedunculatus Ag.

Fig. 5. Thallus showing stalked receptacles, *r*; apical tufts of hairs, *t*; *r*, a branching receptacle, slightly magnified.

Fig. 6. A maturing receptacle more highly magnified.

Fig. 7. Surface of receptacle. Letters as before. $\times 400$.

Fig. 8. Zoospore. $\times 900$.

Arthrocladia villosa, (Huds.) Duby.

Fig. 9. Fertile filament. *sc*, Sterile cells. $\times 900$.

Fig. 10. Intercalary sporangia. $\times 320$.

Fig. 11. A zoospore. $\times 900$.

Desmarestia ligulata, (Lightf.) Lamour.

Fig. 12. Apex of a cortixed branch. *pa*, Primary septate axis; *is*, intercalary sporangia; *h*, branching hairs, only a few represented; *m*, merismatic region. $\times 120$.

Fig. 13. Cortical sporangia *cs*; *is*, intercalary sporangia on hair-pinnule. $\times 240$.

Fig. 14. Intercalary sporangia *is*, on branchlet of primary axis, several spores in each. $\times 240$.

Fig. 1.



Fig. 2.

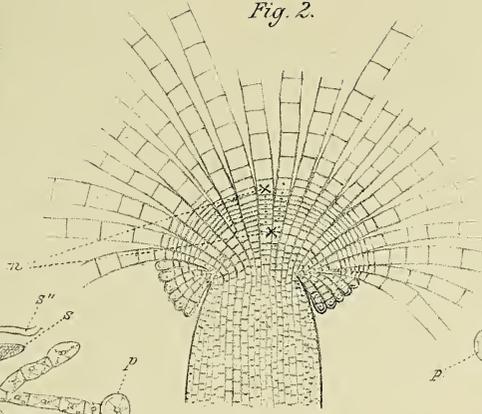


Fig. 5.



Fig. 3.

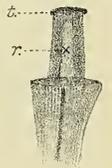


Fig. 4.

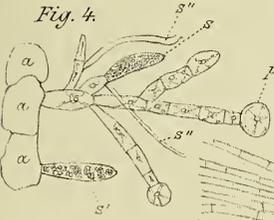


Fig. 7.

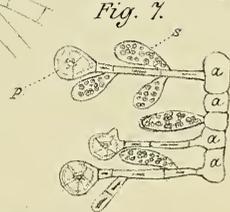


Fig. 6.

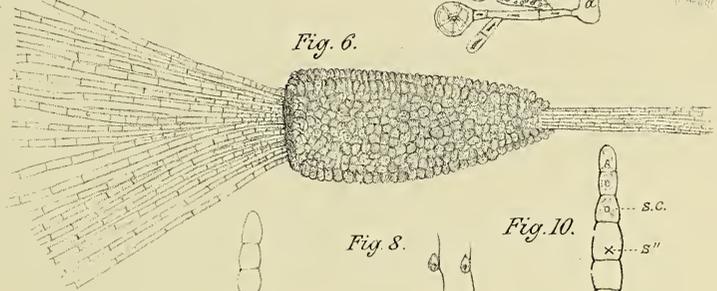


Fig. 8.



Fig. 10.

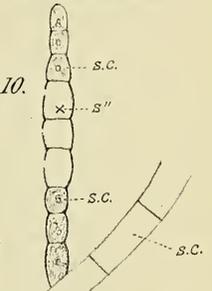


Fig. 14.

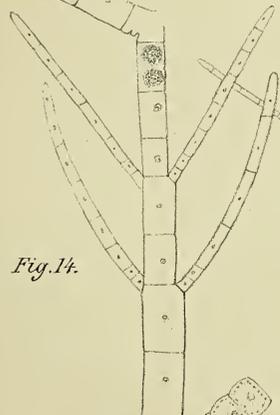


Fig. 12.

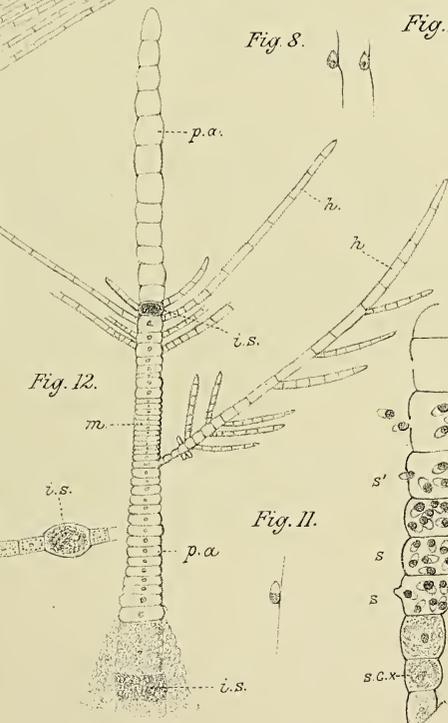


Fig. 11.



Fig. 9.

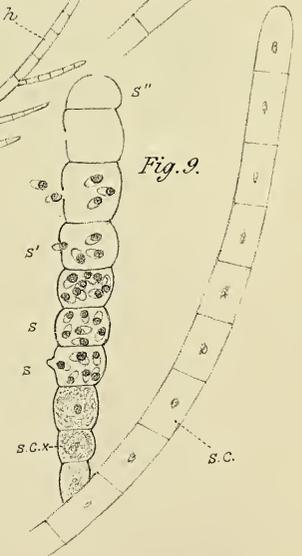
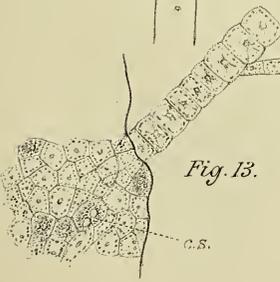


Fig. 13.



Johnson del.

University Press, Oxford.

The Structure of *Pachytheca*. II.

BY

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With Plate IX.



IN a former number of this Journal¹ I made a study of the structure of *Pachytheca* as exhibited by two sections belonging to Sir Joseph Hooker.

As these were the only survivors of the comparatively large number of slides which had from time to time appeared, it was thought advisable, without delay, to describe such anatomical details as could be observed under the microscope. It was pointed out, however, in the course of the paper, that certain difficulties could only be cleared away upon obtaining fresh slides through different parts of the organism, or in a different state of preservation.

For this reason it was decided to restrict the description to matters of fact, and to avoid, as far as possible, theoretical considerations concerning the systematic relations of the plant².

In the paper already referred to it was shown that the plant consisted of the following parts:—(1) a *medullary* portion of filaments passing in all directions, (2) a *cortical* portion in which the cell-rows were disposed radially, and

¹ *Annals of Botany*, III. 141.

² See Hooker, On *Pachytheca*, *Annals of Bot.* III. 135, for a summary of the views of different authors.

[*Annals of Botany*, Vol. V. No. XVIII. April, 1891.]

(3) a zone of dubious nature, uniting the two, called the *zone of oval bodies*.

The relation between the cortical and medullary tubes could not be determined, and the zone of oval bodies was unexplained. It is hoped that in the present paper both of these difficulties will be removed.

Comparatively recently, I have had the good fortune, by the kindness of Mr. John Storrie, Curator of the Cardiff Museum, to come across a valuable series of *Pachytheca* slides; and it is with these that I propose to deal in the present paper.

The specimens, from which the slides were prepared, occur in a small, isolated portion of Silurian rocks in the neighbourhood of Cardiff. These have been determined by Professor Sollas to comprise layers between the Old Red Sandstone and rocks of Lower Wenlock age; and it is in the lower part of the series that *Pachytheca* is found.

The Wenlock beds are well exposed in the Tymawr quarry, a conspicuous object on the right of the road leading to Newport. There are several beds in which *Pachytheca* occurs. In the uppermost one, which I have carefully examined, there are a great number of pieces of *Nematophycus*, and a fair sprinkling of *Pachytheca*: all seeming to be more or less rolled or waterworn.

The specimens of *Pachytheca* are usually perfectly spherical, and sometimes very hard. They seem to consist of an exceedingly fine argillaceous matrix in which many of the structural details have been preserved. Mr. Storrie has collected the specimens of *Pachytheca* and *Nematophycus*¹ for a number of years past, and has himself prepared an exceedingly interesting series of sections. These he has exhibited at various local scientific gatherings, and has now placed them at my disposal for description.

¹ The specimens of *Nematophycus* are, if anything, better preserved than those of *Pachytheca*; and I hope, at some time, to publish a paper on the former, since the plant found at Cardiff appears, in certain particulars, to differ from the Canadian specimens kindly sent me by Sir William Dawson.

One of the most remarkable circumstances connected with these slides is the varying manner in which the structure is preserved. It is not easy, by the examination of any one slide, to make much progress ; but, by the careful comparison of a selected series of specimens, certain of the difficulties, which have hitherto clustered around the study of this plant, may be removed.

For the sake of clearness I shall refer to the slides selected for description under the numbers 1-13. The figures contained in my former paper¹ I shall refer to as B 1-14, and those in Sir Joseph Hooker's paper² as H 1-12.

DESCRIPTION OF SECTIONS.

It is a fortunate matter that Mr. Storrie has succeeded in cutting no less than four sections in different planes through a single specimen of *Pachytheca*. As these slides may throw light upon the question of the *oval bodies*, I shall deal with them first.

Slide 1 (Figs. 1 and 1 a) contains a radial section through one half of the spherical body of the plant. The medullary portion is, to a great extent, absent, being represented by a few small fragments close to the zone of oval bodies. The cortex is well shown, and consists of a series of radiating tubes, sometimes branching, of clear light yellow substance, bordered by well-defined thick walls. These tubes are separated from one another by elongated spaces, usually rather wider than the tubes, terminating towards the medulla in slightly broader rounded ends. The spaces are bridged across by crystals of the light yellow substance, but are not filled by it: the remainder of the spaces being unoccupied, or more or less filled with a darker, brown, granular mass.

It will thus be seen that it is perfectly easy to distinguish the clear radiating tubes from the broken spaces between them ; and it is equally easy, by comparison with the figures

¹ Annals of Botany, III. 141.

² Ibid. III. 135.

B 1, 2, and 6 to determine the correspondence of the rounded inner ends of the spaces with the oval bodies of these figures.

Internally to the zone of oval bodies a clear, yellowish or brownish layer, of some thickness, lines the whole inner surface of the specimen. It will be seen from the figures that the cortical tubes are immediately continuous with this layer, and arise directly from it as so many radiating processes. The inner margin of this medullary portion frequently presents circular or cylindrical forms, such as would be obtained by transverse or longitudinal optical sections of tubular cells; but all, or nearly all, traces of vegetable structure have disappeared, and these portions, and all other parts of the preparation, appear at present in the form of a mineral concretion around a framework of cells whose outlines have disappeared.

Slide 2 (Figs. 2, 2 *a*) bears a tangential section through the other half of the same specimen, in a plane at right angles to that of section 1.

The centre of the preparation is composed of the transverse sections of well-marked circular tubes, with thick walls and broken contents, separated from one another by a clear yellow matrix; in fact, it presents exactly the opposite appearance to what would have been expected from an examination of Slide 1.

As seen in the figure (2), however, as the centre of the preparation is left, and the tubes are cut more and more obliquely, anastomosis of these takes place; while the outer part of the section shows a state of things the reverse of that at the centre, namely, the presence of a series of more or less obliquely cut clear yellow tubes separated by a broken, dark-coloured matrix.

An examination with the high power reveals the following facts (Fig. 2 *a*). Each of the central tubes has a beautifully defined wall of uniform and considerable thickness; and this wall is marked by perfectly regular parallel striae at right angles to its surface. The contents are more or less broken up, either showing holes, or being filled up by clear yellow crystals or a dark-brown granular mass.

Surrounding each tube, and fitting into the interstices between the neighbouring ones, is a set of indistinct sections of much smaller tubes, placed with such regularity that, at the centre of the preparation, each large tube is surrounded by a group of exactly six smaller ones. The smaller tubes have all the appearance of vegetable cells cut transversely, and in size they approach more nearly to the cell-filaments described in the medulla and cortex, and as possibly passing between the oval bodies, in Figs. B 1, 2, 5, 6, &c.

The appearance of smaller tubes in the clear matrix, although frequently very indistinct, is characteristic of all parts of the preparation; in fact, wherever the yellow matrix is well seen, the sections of the smaller tubes may be sought. This clear yellow matrix thus presents the appearance of a mineral concretion, which has collected around, and follows in all its branchings, a framework of algal filaments; and it is only in certain parts of the preparation that the form and size of the original cell-rows can be followed.

Slide 3 (Fig. 3) contains the remaining two sections cut from the same specimen. These appear to be cut obliquely, that is, halfway between radially and tangentially, and parallel to the section on Slide 1. I shall refer to one of these sections only.

A glance at the figures will substantiate the conclusions already arrived at as to the identity of the browner spaces with the oval bodies and their outward prolongations. Indeed, the general resemblance between parts of this section and Figs. B 7 and H 2 is easily recognisable. Further, between the sections of the obliquely cut larger tubes may occasionally be detected the sections of smaller cell-filaments (Fig. 3). From the study of these three slides, it appears probable that the cellular structure, apparent under a low power, is to be considered as a mineral framework, between the parts of which the original plant cells are to be sought. The beauty and regularity of the striated walls of the larger tubes lead one to suggest that they are made up of numerous parallel crystals such as are frequently to be found at the boundaries of crystalline concretions; and such an assumption is con-

firmed by the study of certain other parts of the section, and, more emphatically, by other sections still to be described. Finally, although these tubes are exceedingly regular and quite distinct at the centre of the section, they anastomose in all directions at a short distance from it—a fact irreconcilable with the view that theirs is a typical cell structure.

Section 4 is a tangential one, and presents a number of yellow tubes cut across transversely at the centre of the preparation, more or less obliquely peripherally. The yellow tubes are separated by open spaces, or, more usually, by an opaque, dark brown matrix.

While these tubes are circular at the centre of the section, a considerable amount of anastomosis occurs at a short distance from it—an arrangement discountenancing the idea that they are the sections of cells. Each tube has a well-marked darker thick concretionary wall similar to those already described for Fig. 2 *a*. The interior of each tube has a bright yellow matrix with few granules; and frequently the centre of the tube is occupied by a smaller one, or a sharply defined double circle, exactly resembling the surface view of a bordered pit of *Pinus*. A fusion of the smaller tubes is never seen, but, where anastomosis of the larger tubes occurs, the smaller ones are found in different parts of the yellow matrix at about their normal distance apart.

In this case the smaller tubes are the remains of the cells of the plant, the yellow matrix of the larger tubes being the mineral collected around and infiltrating these. Where the larger tubes are in contact, a fusion of the mineral has taken place, and the result is an apparent anastomosis.

A close comparison between specimens 2 and 4 suggests that the great difference in appearance is due to the relative quantity in the two cases of the yellow matrix in which the smaller tubes are always imbedded. While in section 2 there is a preponderance of this substance in the section, in section 4 there is a preponderance of the dark brown mass. In both cases these two constituents of the section are separated from one another by the well-marked limiting layer.

Returning now to the smaller tubes in section 4, it is noticeable that some are much more distinct than others. There are all transitions between distinct double circles and an indefinite brownish core. This I regard as suggesting that the clear double circles are not merely transverse sections of the cell-tubes, but that they are the *transverse walls* of the cell-rows.

It is frequently found that, where the central portion of a larger tube is indistinct, a double circle is brought into view by focussing deep into the thickness of the section. In the outer obliquely cut part of the preparation there are more of these double circles present, and they frequently present the flattened or oval shape which would be expected in transverse walls of tubular cells viewed obliquely.

Slides 5 and 6 are similar to one another as regards preservation. The sections are rather obliquely cut, but they nevertheless include a considerable portion of the medulla. In No. 5 (Fig. 4) the medulla consists of portions of tubes cut in all directions—transversely, obliquely, longitudinally. Towards the zone of oval bodies these fragments are fused together to form a more or less coherent light yellow mass, which will presently receive a closer attention. From this mass the radiating tubes arise. The latter, however, owing to the slight obliqueness of the section, form a clear anastomosis between numerous oval bodies, instead of being straight radiating tubes (as in Fig. 1). The tubes, in all parts of the section, have a clear, yellow centre, and a darker, brown 'wall' similar to that in section 4. The spaces between the tubes are unoccupied by any mineral, excepting the occasional presence of the dark brown substance hitherto met with (Fig. 2 a).

Upon carefully examining the outer, fused portion of the medulla, two evidences of structure may be detected. There are, in the first place, numerous '*double circles*' similar to those of section 4. There are also short *black lines* of surprising sharpness, equal in length to the greater diameter of the double circles; and, with care, all stages of transition may be

observed from the two circles, through a pair of ellipses, to the black line. It is assumed that the black lines represent the double circles in optical section, and therefore that they are the transverse walls of the cell-filaments (see Fig. 5).

For the observation of these particulars section 6 is better than section 5. I have drawn a small portion of the clear border of the medulla, just inside the zone of oval bodies, and obviously formed by the fusion of the tubes in that region. And I have taken advantage of the use of the micrometer screw to focus all parts of the thickness of the section, so as to include as many of the transverse walls as possible.

In the medulla of section 5 (see Fig. 4), and, better still, in the corresponding part of section 6, the central part is filled up by a number of sections and pieces of tubes; and, if we examine these tubes carefully, we shall find the transverse walls in various positions and at various distances. The course of the cell-rows may be readily traced by following the black lines and the general direction of the outer tubes. It is seen in longitudinal sections of the larger tubes that the short black lines occur at regular intervals, and that they only stretch a short distance across the diameter of the tubes. Occasionally there are more than one set of dark lines in one and the same tube; and this probably represents the condition described as anastomosis of tubes in the transverse sections (Fig. 2). From the occasional regular distance of the black lines from one another, cells of the filaments may be regarded as from ten to twenty times as long as broad. The double circles are only found in transversely cut tubes, of which they occupy the centres.

There are traces, here and there, on each side of a transverse wall, of the adjacent longitudinal walls; but these would probably not be detected had we not a previous suspicion of their existence.

We are therefore entirely dependent, for our knowledge of the exact distribution of the algal filaments, upon their transverse walls, which are, indeed, the only parts preserved.

This is peculiarly interesting because of the attention

drawn, in my former paper, to the thickness of the stopper-like transverse walls (see Figs. B 3 and 4). Although in those sections we had to do with well-preserved longitudinal walls, yet, in cases of difficulty, it is easier to follow the regularly-placed short black lines than the tubes themselves. Thus, upon a careful examination of section 1, with the high power (Fig. 1 *a*), there may be seen such a transverse wall in the branched radiating tube just beneath the point of bifurcation. And the presence of this small black line is sufficient to determine the question so often asked with regard to Sir Joseph Hooker's slides, 'Do the medullary filaments pass between or into the oval bodies?'

Slide 7 is selected from an interesting batch which Mr. Storrie has prepared since my examination of the specimens so far described. It contains an accurately radial section, and the cells of the cortex are in a similar state of preservation to that of Slides 5 and 6. In the present case, however, the cortex is unique, in that everywhere along the radiating tubes, the short *black lines* are marvellously distinct (Fig. 6). On the other hand, I cannot detect one double circle. It is worth while, in passing, to note the curious fact that, here, as in the former cases, the black lines do not stretch right across the tubes. This may indicate that only a median part of the transverse wall is preserved. However this may be, the absence of similar longitudinal walls shows that, in the living plant, the characters of transverse and longitudinal walls differed.

Slide 8 (Fig. 7). This section differs very greatly in appearance from those on the slides so far dealt with. It corresponds in direction with those on Slides 2 and 4, being a tangential section through the cortex.

Under a low power the section appears to consist of numerous tubes with dark brown, granular contents, and very thick clear white walls,—in fact, the resemblance to a transverse section through the stalk of a living seaweed with mucilaginous walls, such as *Polyides* or parts of *Laminaria*, is very striking.

The tubes at the centre are not, however, always united into a tissue, but frequently leave intercellular spaces between them; and these latter are filled up by crystals of the same white substance as that of which the mass of the section is composed. The walls are usually composed of two layers, similar to the 'shells' of thickened cell-walls; and the outer layer is of the same thickness as the striated walls of Slide 2, without, however, their brown-yellow colour, or well-marked striae.

The tubes near the periphery are obliquely cut, and present much the same characters as the central ones. In this part of the section, however, the outer shell, bordering upon the intercellular spaces, is occasionally of a darker colour, and presents numerous parallel striae; it is, in these parts, identical, in appearance and position, with the thick striated walls already referred to.

The brown, granular contents of the tubes in this preparation are evidently, from their disposition and size, the cell-filaments of the plant; and the white substance forming the tubes is the mineral concretion around them. There is no appearance of structure, whether of transverse or longitudinal walls, in the cells.

Slide 9 bears a section cut through the centre of the organism, which presents much the same state of preservation as section 8 just described.

The cell-filaments are represented by granules without any transverse or longitudinal walls. In the medulla there are occasionally well-defined, thick, white tubes around these granular cores; but in the greater part of the section, including the cortex, the region of oval bodies and most of the medulla, the white mineral has fused to form a translucent basis in which the course of the cell-filaments may be determined fairly accurately.

It follows, from what has been said concerning the nature of the oval bodies, that they are not present in the best preserved portions of this section. They have hitherto formed interspaces between the cell-containing tubes, and here there

are no such interspaces, owing to the greater mass of mineral deposited. In some parts of the section the structure is more broken up, and there the region of oval bodies is fairly definitely indicated.

The outer part of the medulla, as would be anticipated from Fig. 5, is characterised by an interweaving of the granular threads; and the region of the cortex is determined by the regularity of the spaced radiating tubes. Further, it is easy, in certain parts of the section, to trace the radiating filaments directly into the network of threads forming the outer part of the medulla (Fig. 8).

In the figure I have drawn such a junction,—leaving out all the cracks and granules of the matrix. I have also used to the full the micrometer screw, in order to trace all connections of the filaments. At the same time this connection has not been exaggerated, for a general view of the preparation gives a better impression of intimate union than the drawing of a few isolated filaments¹. This is, I believe, the first specimen, if not the only one, in which cortical and medullary filaments have been seen to join one another.

With regard to the *branching of the filaments* in *Pachytheca*, a careful search in Sir Joseph Hooker's specimens produced one or two cases in the outer portion of the cortex (Fig. B 4). The absence of well-defined cells in the present specimens has thus far prevented the detection of any cases of branching. In Fig. 8 there is a possible branching of the filaments, but such a case has not been certainly determined.

Slide 10. Here, however, branching is by no means uncommon. The slide contains a radial section, more or less resembling specimens 8 and 9 in the manner of preservation. The only traces of the cell-filaments consist in the granular threads already alluded to. While, however, the greater part of the pith and cortex is very poorly preserved, the section has all the appearance of containing the true periphery of the plant in a good state of preservation.

¹ In this specimen, as in slides 4 and 10, the nature of the section prevents photographic treatment.

In the best parts (Fig. 9), the cells end at a short distance from the periphery, and are bounded externally by a clear yellow layer comparable, in appearance, with the mucilaginous layer bounding many existing Algae.

The branching occurs near the extremity of the filaments, and is common—as many as ten distinct branchings appearing in one-fifth of the circumference. There appears to be a frequent tendency towards anastomosis of the ends of the filaments, but this appearance is probably due to the conditions of fossilisation. The ends of the filaments are frequently dilated (Fig. 9), although this may be due to incipient branching. It seems to me possible that this swelling or branching has some connection with the reproduction of the plant.

Slide 11 (Fig. 10) contains a beautifully cut section in the same condition as 1, 2, and 3. There is, however, *no zone of oval bodies*: that is to say, the spaces separating the radiating filaments do not swell at their medullary ends. This is a matter of importance, as explaining the absence of oval bodies from a number of specimens where we might expect to find them. Thus in all the specimens from the Transition Beds (Figs. B 9–11), it was noted that the inner ends of the radiating black lines were not swollen. This difference from Sir Joseph Hooker's specimens was of so marked a nature, that I hazarded the suggestion that the organisms were possibly belonging to different species. But the present specimen, by the absence of a distinct zone of oval bodies, renders the subdivision of the genus *Pachytheca* at present superfluous.

There are certain other slides of *Pachytheca* which do not admit of such a ready explanation; although the present conclusions, founded upon the examination of something like forty slides and specimens, are in no way affected by these unexplained cases. One of these specimens, on **Slide 12**, has a curious star-like body in its centre much resembling a youthful *Rivularia*. This may have arisen in the following way. A disturbance in the regularity of the radiating processes

may have caused a funnel-shaped divergence of the filaments from one point of the cortex outwards. I have noted several such disturbances and corresponding divergences in radial sections; and it is perfectly reasonable to suppose that a tangential view of such an arrangement might give the star-like appearance described. On the other hand, the idea which most prominently asserts itself is that we have to do with a mode of reproduction by the endogenous formation of new individuals.

Another peculiarity of the same specimen is worthy of note. The part usually occupied by the medulla consists, in this section, of a number of polygonal areas of great regularity. As far as can be judged, this peculiar formation is brought about by the regular arrangement of the filaments in meshes. The Rivularia-like body occupies the centre of the organism, and the peripheral portion, as usual, consists of radiating filaments.

Another specimen, on **Slide 13**, shows, on one side, a large number of more or less parallel, short filament-segments, which pass without interruption far into the medulla. At other parts of the section, the zone of oval bodies, entirely absent at this point of invasion, is found separating medulla and cortex as usual.

PRINCIPAL LOCALITIES OF THE FOSSIL.

Various places are mentioned in Murchison's *Siluria*¹ where *Pachytheca* is to be found. Among these, it is found in the Bone-bed at Ludlow and Hagley Park near Hereford, and in the Old Red Sandstone of Clun Forest. Specimens from the latter locality are figured under the name of *Bufonites* (see Plate XXXV, Fig. 30).

Almost every place that I have visited, where the transition beds between the Old Red Sandstone and the Silurian crop out, has furnished me with traces of the fossil. I may specially mention the Downton Sandstone near Onibury, Norton and Forge Bridge in South Shropshire, and the Perton

¹ l. c. pp. 135, 138, 140, &c.

quarry near Stoke Edith in Herefordshire¹. A small specimen was turned up by my friend Mr. T. Groom at Ledbury.

I am indebted to Mr. Jas. Reid of Blairgowrie, who has forwarded to me specimens of *Pachythecca* from the Old Red Sandstone of Perthshire². The specimens are rare and poorly preserved.

Of Canadian specimens I have had no means of judging excepting from the figures of Sir W. Dawson³. I am inclined to regard the fossils in both countries as identical.

Figures of *Pachythecca*, exhibiting microscopic structure, appear in Rev. J. D. La Touche's descriptions of Shropshire fossils⁴. These figures, I believe, were contributed by Sir J. D. Hooker.

Dr. Grindrod found his specimens in the West Malvern Wenlock Limestone⁵. I have not myself succeeded in obtaining any specimens there. With the permission of Professor A. H. Green, I have examined carefully Dr. Grindrod's collection, now in the possession of Oxford University, but I found no trace of *Pachythecca* from this locality.

Dr. Hicks has noted *Pachythecca* in the Denbighshire Grits of the Pen-y-glog slate quarry near Corwen⁶. One specimen there is, in the Jermyn Street Museum, which exhibits structure. This specimen has been figured by Messrs. Etheridge and Newton in their appendix to Dr. Hicks' paper. The specimens which I succeeded in knocking out at this quarry were small and devoid of structure. My best thanks are due to Dr. Hicks for his care in directing me in the somewhat difficult search for these fossils.

The specimens found by Mr. Storrie at Cardiff, in the Wenlock rocks of Tymawr quarry, form the subject of the present paper.

¹ Annals of Botany, vol. III, p. 145.

² Dawson, Devonian Plants from Scotland, Nature, 10 April, 1890.

³ Dawson, Quart. Journ. Geol. Soc. 1881, XXXVII. 299.

⁴ La Touche, Handbook of the Geology of Shropshire, Adnitt, Shrewsbury.

⁵ Hooker, l. c., p. 135.

⁶ Hicks, Remains of Plants, &c., Quart. Journ. Geol. Soc. 1881, XXXVII. 482.

SUMMARY OF RESULTS.

1. *General Structure.* *Pachytheca* is a *spherical alga* consisting of a mass of cellular filaments. The cells of these filaments appear to resemble, in general shape, those of a living *Cladophora*.

The body of the plant is divisible into a *medullary* portion, in which the cell-rows pass in every direction; and a *cortical* portion, where the cell-rows are accurately radial, and at equal distances from one another. The cells of these two regions are continuous with one another; and the point of junction, formerly known as the *zone of oval bodies*, is characterised by a change in the mode of petrification—probably partly dependent upon the alteration in the arrangement of the tubes at this point.

The *cortex* may be divided into three zones:—an inner zone, in which the cell-rows are usually separated widely by lacunae in the infiltrating mineral; a middle zone, consisting of radiating, for the most part unbranched filaments; and an outer zone, near or at the periphery, where branching is frequent.

2. The *zone of oval bodies* (B 1, 2, &c.), the ‘cellular’ structure seen in Figs. 2 and 3, as well as the radiating dark-coloured tubes of Fig. 1, are spaces between the concretions collected around and incrusting the cell-filaments.

3. The ‘cellular’ structure of sections 4 and 8, the network of tubes in the medulla and cortex of sections 5 and 6, and the system of white crystalline tubes seen in specimens viewed under low power by reflected light, are concretionary deposits around the original living cellular framework.

4. This *cellular framework* of the plant has, with few exceptions, entirely disappeared; and the tubes left behind are usually four or five times larger than the original cells. In a few cases the longitudinal walls may be traced (see Figs. B 3 and 5, and perhaps specimen 7). More frequently the transverse walls alone are preserved.

5. The *transverse walls* appear in surface view as a pair of sharply defined concentric circles, remarkably like the

bordered pits of *Pinus* (Fig. 5). In profile they appear as short black lines (Figs. 5 and 6). In the best specimens (Fig. 6) these appear to consist of two parts—a black line, and a distinct lens-shaped swelling at its centre: the lens-shaped mass probably appearing as the inner circle in surface view.

The transverse walls do not completely bridge the spaces between the longitudinal walls in Fig. 6—suggesting that only part of the transverse wall is preserved, or that the longitudinal wall itself has disappeared.

6. The lacunae in the inner cortex, known as *oval bodies*, need not be present (specimens 9 and 11). This may explain the constant absence of such bodies in all the specimens examined from the transition beds between Silurian and Old Red Sandstone (Figs. B 8–14). In these specimens the dark lines are evidently comparable with the spaces between the radiating tubes of specimen 11. This similarity does away, at present, with the necessity for subdividing the genus *Pachytheca*.

7. The specimen figured in Sir Joseph Hooker's paper (*Annals of Bot.*, III, Pl. VIII, Figs. 3–7) I regard as indicating a condition of petrification not unmet with in the Cardiff specimens. In fact, certain parts of section 7 remind me strongly of it. The tubes, in these parts, are made up of elongated concretionary masses, separated by spaces of broken material (see Fig. 6); and the increase in number of these spaces gives the section the appearance of being composed of elongated parenchymatous cells.

8. The *branching* in the cell-rows of the medulla is quite possible, although it is difficult to demonstrate (Fig. 8). The branching outside the region of oval bodies seems probable, seeing that the cell-rows are much nearer together in the middle zone than in the inner zone of the cortex.

Undoubted branching has only been detected in the outer zone of the cortex, where it is characteristically present (Figs. 9 and B 4).

9. As regards the reproduction of *Pachytheca* nothing is known. Two suggestions have occurred:—

(a) Possibly the branchings and swellings at the ends of the cortical filaments may have something to do with spore-formation (Fig. 9).

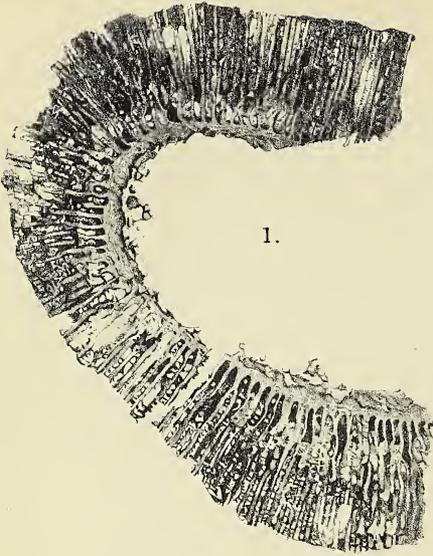
(b) It is suggested by specimen 12 that a new formation of a daughter sphere may take place within the body of the parent.

10. The *principal localities* of the fossil are collected at the end of the paper. *Pachytheca* is found as low in the Silurian as the Denbighshire Grits, and its range extends upwards into the Old Red Sandstone.

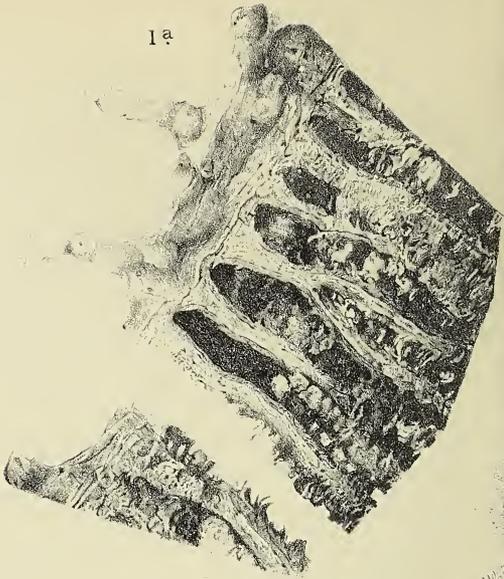
EXPLANATION OF FIGURES IN PLATE IX.

Illustrating Mr. C. A. Barber's paper on *Pachythecca*.

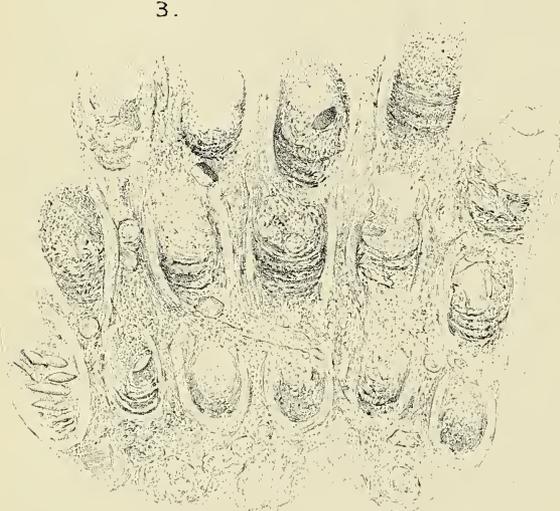
- Fig. 1. Radial section of one half of *Pachythecca*, from a photograph. $\times 32$.
Fig. 1 a. A small portion of the same section, from a photograph. $\times 160$.
Fig. 2. Tangential section through the other half of the same specimen, from a photograph. $\times 32$.
Fig. 2 a. A few cells of the same section (drawn). $\times 270$.
Fig. 3. A small portion of an oblique section through the same half as in Fig. 2 (drawn). $\times 320$.
Fig. 4. A slightly oblique section of *Pachythecca* on Slide 5, from a photograph. $\times 32$.
Fig. 5. A small portion of section 6 (drawn). This corresponds in position with the clear fused zone bordering the medulla externally in Fig. 5. $\times 320$.
Fig. 6. A portion of the cortex of specimen 7 (drawn). $\times 320$.
Fig. 7. Tangential section through specimen 8, from a photograph. $\times 37$.
Fig. 8. A few granular cell-filaments from Slide 9 at the junction of cortex and medulla, showing the continuity of the cortical and medullary filaments. $\times 320$.
Fig. 9. A small portion of the periphery of specimen 10, showing what appears to be the external boundary of the plant. The branching and swelling is pronounced (drawn). $\times 270$.
Fig. 10. Section of specimen 11 showing the absence of any zone of oval bodies. (From a photograph.) $\times 32$.



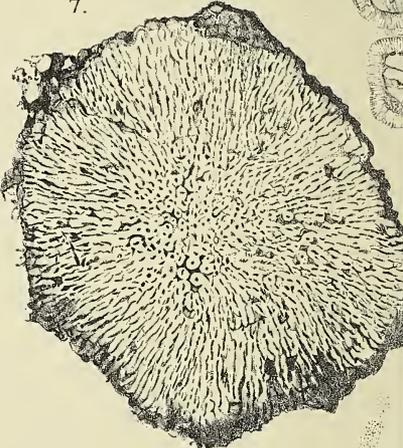
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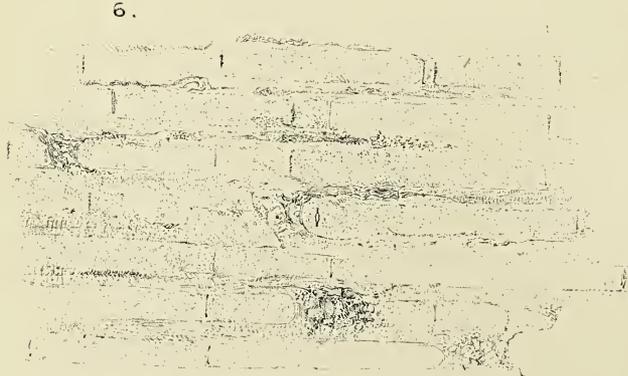
1a



3.



7.



6.



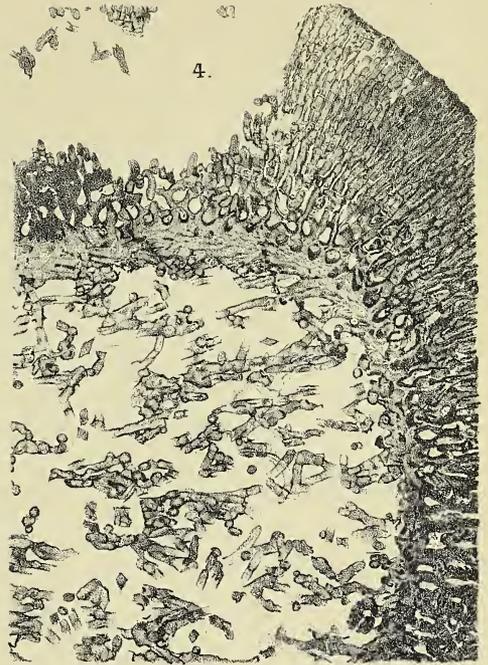
8.

From Photo. & Draw. by C.A. Barber.

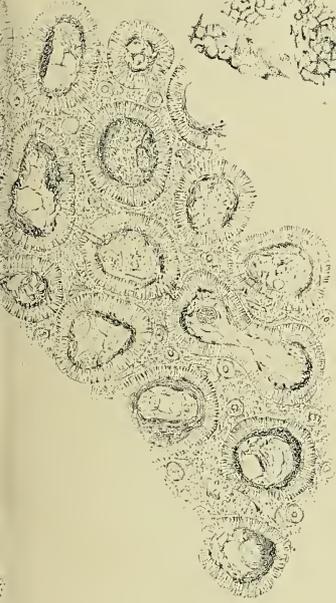
2.



4.



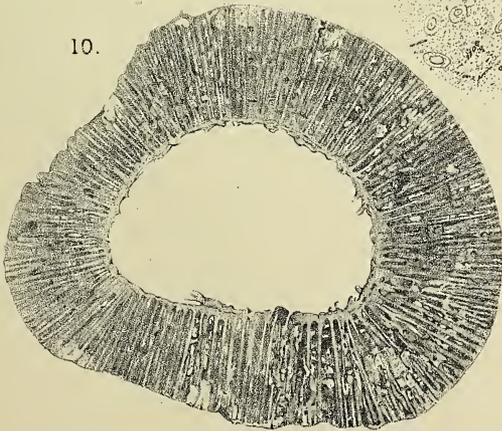
2a



5.

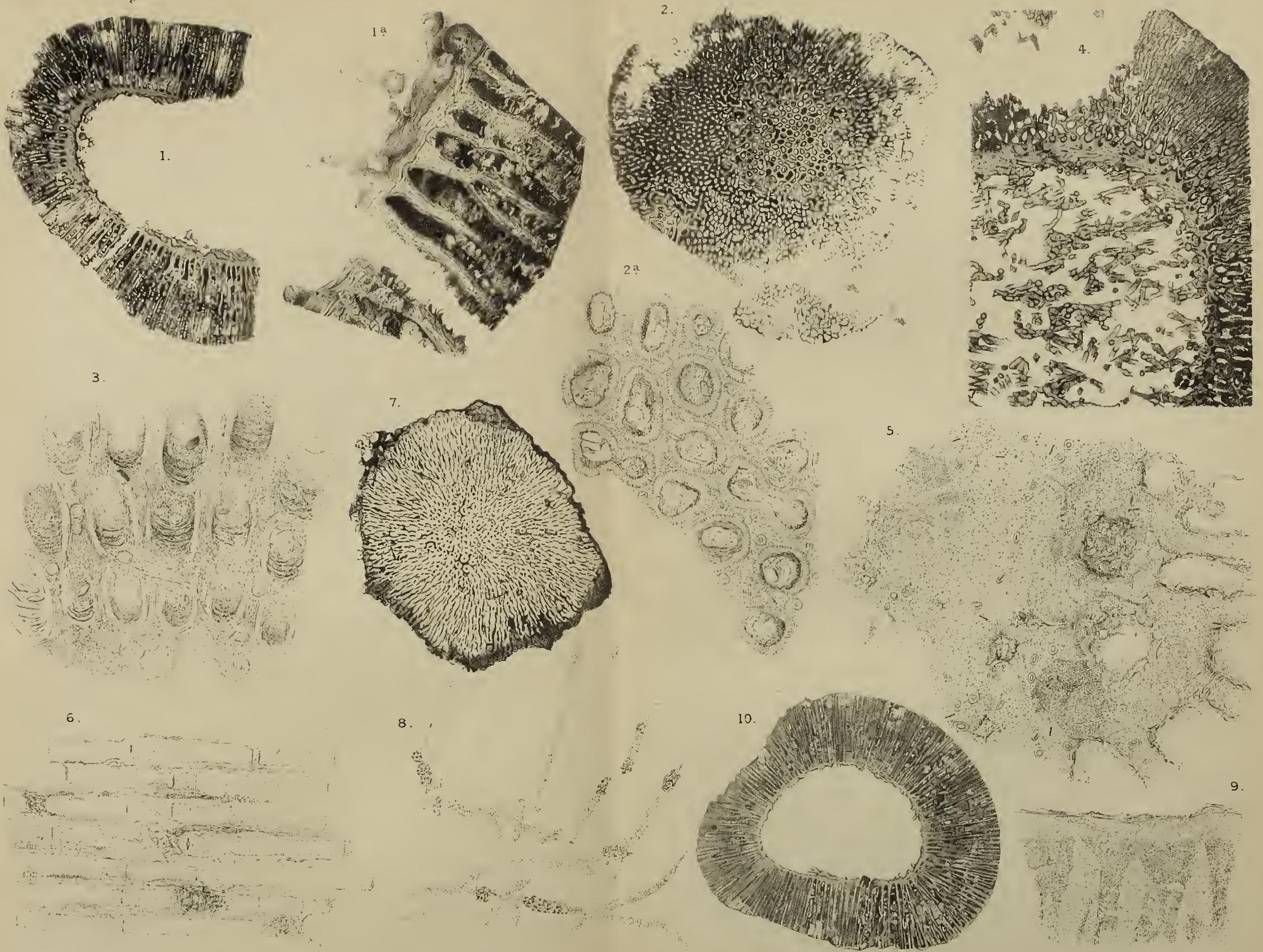


10.



9.





From Photo. & Draw by C.A.Barber.

University Press, Oxford.

On the Vascular Cryptogamia of the Island of St. Vincent.

BY

J. G. BAKER, F.R.S.

Keeper of the Herbarium, Royal Gardens, Kew.

—♦—
With Plates X, XI.

THROUGH the liberality of Mr. F. Ducane Godman, F.R.S., a very complete collection of the plants of St. Vincent has lately been made by Messrs. H. H. & G. W. Smith, working in connection with the general committee for the biological exploration of the West Indies, appointed by the British Association for the Advancement of Science. Four collections have been sent to Kew during 1889 and 1890, of which the Vascular Cryptogamia have fallen to my lot to work out. The following is a complete enumeration of the species, with a description of the novelties.

The island is situated in about 13 degrees north latitude and 61 degrees west longitude. It is eighteen miles long by eleven miles broad, with an area of 140 square miles. The extinct volcano called the Souffriere rises to a height of 3,700 feet, and another peak overtops it by 300 feet. The whole flora of the island is strictly tropical, and the general vegetation is luxuriant and perhaps more diversified than in any of the chain of islands from Tobago to Antigua, unless it be in Dominica.

As the number of specimens is large enough to allow of several sets being made up for distribution, I cite under each species the collectors' numbers.

GLEICHENIACEAE.

- 149, 907, 1361. *Gleichenia pubescens*, H. B. K.
864. *G. pectinata*, Presl.

CYATHEACEAE.

- 156, 196, 947, 986, 1014, 1131, 1349. *Cyathea arborea*, Smith.
962, 1018. *C. Tussacii*, Desv.
801, 849, 854. *Hemitelia horrida*, R. Br.
696, 863, 886, 1012, 1013. *Alsophila aspera*, R. Br.
196, 987. *A. ferox*, Presl.
292, 1717. *A. infesta*, Kunze, var.

HYMENOPHYLLACEAE.

- 604, 1067. *Hymenophyllum vincentinum*, n. sp. (see Plate X).
Rhizome very slender, wide-creeping. Stipe glabrous, slender, erect, about an inch long, winged in the upper half. Frond oblong-lanceolate, bipinnatifid, glabrous, $1\frac{1}{2}$ –10 in. long, about an inch broad; main rachis winged throughout; pinnae lax, rhomboid, erecto-patent, much cut away on the lower side at the base, cut down to a narrow wing into lax entire linear segments $\frac{1}{8}$ – $\frac{1}{6}$ in. long. Sori few, terminal. Valves of the indusium ovate-oblong, entire. Mountain forests of the Morne à Garou mountain, &c., alt. 2500–3200 feet. Allied to *H. rarum*, R. Br.
1066. *H. vincentinum*, var. *latifolium*, Baker. Fronds shorter and broader than in the type, in the extreme form tripinnatifid. Damp forest in a mountain glen at 1500 feet, observed only upon the trunk of a single tree.
365, 611, 1062, 1063. *H. polyanthos*, Sw.
364, 1070, 2071. *H. hirsutum*, Sw.
1072. *H. latifrons*, V. D. B. Rare, in damp cavities of rocks and on tree trunks on the mountains, at 3000–3300 feet.
1069. *H. lineare*, Sw.
254, 480, 965, 1074, 1075, 1076, 1077, 1365. *H. ciliatum*, Sw.
A fine series of forms.
1065, 1067. *H. valvatum*, H. & G.
851. *H. fucoides*, Sw.

1068. *H. Catherinae*, Hook. Very rare, in the highest mountains at about 3000 feet, on the lower side of overhanging tree trunks. This is a very rare species, gathered previously only in Guadeloupe by L'Herminier and in Jamaica, on St. Catherine's peak, at an elevation of 5000 feet.
278. *Trichomanes spicatum*, Hedw.
367. *T. membranaceum*, L.
412. *T. punctatum*, Poir.
- 711, 1072. *T. muscoides*, Sw.
425. *T. pusillum*, Sw.
573. *T. quercifolium*, H. & G.
952. *T. Krausii*, H. & G.
- 665, 1078. *T. sinuosum*, Rich.
580. *T. Bancroftii*, H. & G.
327. *T. Kaulfussii*, H. & G.
533. *T. lucens*, Sw.
141. *T. alatum*, Sw.
- 61, 322, 507, 628, 1081, 1724. *T. pyxidiferum*, L., a series of forms.
485. *T. rigidum*, Sw., a small beautiful finely dissected variety, on rocks of the central ridge of mountains, at 3000 feet.
- 91, 892. *T. crispum*, Sw.

POLYPODIACEAE.

1723. *Dicksonia cicutaria*, Sw.
1722. *Davallia aculeata*, Sw.
- 1027, 1093. *Lindsaya guianensis*, Dryand.
- 194, 644, 957. *Adiantum tetraphyllum*, Willd.
969. *A. concinnum*, H. B. K.
1895. *A. Capillus-veneris*, L.
- 540, 958. *A. villosum*, L.
1721. *Cheilanthes radiata*, R. Br.
1896. *C. microphylla*, Sw.
1974. *Pellaea geraniaefolia*, Fée.
- 260, 272, 960. *Pteris laciniata*, Willd.
186. *P. aculeata*, Sw.
589. *P. longibrachiata*, Ag. Messrs. Smith report this as tolerably common in the high mountain glens. Agardh founded his species partly upon a specimen in the Kew herbarium gathered in St. Vincent by Guilding. Messrs. Smith's specimens

and notes give a much better idea of the plant than we had before, and I feel little doubt now that it is a good species, and give therefore a revised description. Caudex erect, reaching sometimes a foot in length, 6–8 in. diam. Stipe sometimes 6 ft. long, $2\frac{1}{2}$ in diam. at the base. Frond deltoid, 5–6 ft. long and broad, composed of five primary bipinnate divisions, an end one and two side ones forked low down; final pinnae lanceolate nearly a foot long, 3–4 in. broad, cut down to a narrowly winged rachis into contiguous lanceolate entire final segments $\frac{1}{3}$ – $\frac{1}{2}$ in. broad; texture moderately firm; both surfaces glabrous; veins anastomosing copiously. Sorus narrow; indusium narrow, glabrous. It is mentioned as a doubtful species under *P. Kunzeana* in our Synopsis Filicum, and the name is misprinted *longibracteata*.

282. *Lomaria attenuata*, Willd.
 1025. *L. Plumieri*, Desv.
 838, 1023. *L. procera*, Spreng.
 302, 966. *Blechnum occidentale*, L.
 666. *Asplenium serratum*, L.
 710. *A. obtusifolium*, L.
 188. *A. auriculatum*, Sw.
 207. *A. Serra*, L. & F.
 1900. *A. pumilum*, Sw.
 358, 961, 1119, 1121. *A. laetum*, Sw.
 453, 1118. *A. cuneatum*, Sw.
 682, 1018, 1898. *A. rhizophyllum*, Kunze. I fail to draw any clear line between this and *cicutarium*.
 875, 1897. *A. cicutarium*, Sw.
 1346. *A. arboreum*, Willd.
 712, 890, 1122, 1123, 1719. *A. Shepherdi*, Kunze.
 373. *A. crenulatum*, Baker.
 24, 36, 129, 386, 416, 926, 959, 960, 1124, 1125, 1126, 1127, 1128, 1344, 1345, 1363, 1899. *A. radicans*, Schk. A very fine series of forms and varieties of this large bipinnate species, which is spread throughout tropical America. It is very difficult to form an idea of the specific limits of these huge tropical types from herbarium specimens, and perhaps more than one species is covered by the set of numbers.
 1019. *Asplenium (Anisogonium) Godmani*, n. sp. (see Plate XI).

Rootstock not seen. Whole plant 4 ft. high. Frond oblong-lanceolate, membranous, glabrous except on the main ribs, green on both surfaces, 2-3 ft. long, pinnatifid at the apex, simply pinnate at the base. Pinnæ sessile, oblong-lanceolate, entire, the largest 8-9 in. long, $2\frac{1}{2}$ - $2\frac{3}{4}$ in. broad, rounded at the base, narrowed gradually to the tip. Veins in pinnate groups, a few in each group anastomosing towards the margin of the pinnæ. Sori slender, long; indusium very narrow, glabrous. Damp forest at the extreme top of the Morne à Garou mountain, on the ground, alt. 3100 feet. A very distinct novelty, allied to *A. heterophlebium* and *decussatum*.

326. *A. marginatum*, L.
 791, 944, 956. *Aspidium semicordatum*, Sw.
 171. *A. plantagineum*, Griseb.
 140, 865, 867. *A. trifoliatum*, Sw.
 829. *A. trifoliatum*, var. *A. Plumieri*, Presl.
 964, 1130, 1360. *Nephrodium conterminum*, Desv.
 151. *N. Sprengelii*, Hook.
 789. *N. patens*, Desv.
 705. *N. trichophorum*, Baker.
 855. *N. Jenmani*, Baker; only about the head-waters of a few mountain streams on the leeward side of the island, alt. 1500-2000 ft. Known before only in Jamaica.
 963. A single frond, not identified, possibly a new species, near *N. Jenmani* and *tomentosum*.
 221, 451, 946. *N. brachyodon*, Hook.
 862. *N. effusum*, Baker.
 292, 1021. *N. villosum*, Presl.
 138, 861. *N. amplum*, Baker.
 860. *N. furcatum*, Hook.
 891. *N. molle*, Desv.
 238. *Nephrolepis exaltata*, Schott.
 417. *Oleandra nodosa*, Presl.
 659. *Polypodium flavo-punctatum*, Kaulf.
 43. *P. decussatum*, L.
 317, 697, 754. *P. crenatum*, Sw.
 89, 451, 785, 946, 1347, 1348. *P. tetragonum*, Sw.
 858, 1716. *P. tetragonum*, Sw., var. *P. megalodus*, Schk.
 170. *P. marginellum*, Sw.

840. *P. serrulatum*, Mett.
 29. *P. trifurcatum*, L. Rare, on high mountains, 2500–3500 feet.
 269, 933. *P. trichomanoides*, Sw.
 142, 932. *P. jubaeforme*, Kaulf.
 514, 937. *P. suspensum*, L.
 943. *P. cultratum*, Willd.
 919. *P. taxifolium*, L.
 249. *P. pectinatum*, L.
 406. *P. sororium*, H. B. K. The type and a monster with deeply pinnatifid pinnae after the fashion of *P. cambricum*, L.
 255, 658. *P. piloselloides*, L.
 144, 291, 293, 837, 945. *P. loriceum*, L.
 775. *P. incanum*, Sw.
 688, 798, 1718, 1901. *P. aureum*, L. Type and varieties.
 85, 745, 1364. *P. lycopodioides*, L.
 968. *P. repens*, L.
 173, 479. *P. Phyllitidis*, L.
 1022. *P. crassifolium*, L.
 143. *Monogramme seminuda*, Baker.
 83, 1114, 1115, 1117, 1720. *Gymnogramme calomelanos*, Kaulf.
 A series of forms.
 1116. *G. calomelanos*, Kaulf., var. *G. chrysophylla*, Kaulf.
 325. *G. calomelanos*, Kaulf. A handsome decomposed finely cut variety, almost denuded of white powder, allied to *G. decomposita*, Baker, of which the native country is unknown; well known in cultivation.
 413. *G. elongata*, Hook.
 191, 315. *Meniscium reticulatum*, Sw.
 161. *Vittaria lineata*, Sw.
 109. *V. remota*, Fée.
 389. *Antrophyum lanceolatum*, Kaulf.
 1017. *A. subsessile*, Kaulf.
 1028. *Taenitis lanceolata*, R. Br.
 973. *Hemionitis palmata*, L.
 438. *H. citrifolia*, Hook.
 967. *Acrostichum conforme*, Sw., var. *A. alatum*, Fée.
 379, 1138. *A. latifolium*, Sw.
 1139. *A. Herminieri*, Bory.
 380, 1137. *A. apodum*, Kaulf.

1135. *Acrostichum (Elaphoglossum) Smithii*, n. sp. Densely tufted. Basal paleae dense, subulate, ferruginous. Stipe of barren frond very slender, pale straw-coloured, naked above the base, 3-4 in. long. Barren frond lanceolate, membranous, 8-9 in. long, an inch broad at the middle, narrowed gradually to both ends, furnished with a few small lanceolate brown scales on both surfaces, not ciliated on the edges. Veins fine, distant, distinct, erecto-patent. Fertile fronds much smaller, lanceolate, with a stipe 5-6 in. long. Rare on trees in the mountain forests, alt. 2500-3000 feet. Allied to *A. lineare* and *Aubertii*.
376. *A. viscosum*, Sw.
1134. *A. villosum*, Sw.
1136. *A. undulatum*, Willd. Very fine specimens. Rather common locally on trees in the mountain forests, alt. 1500-2500 feet.
608. *A. sorbifolium*, L.
281. *A. cervinum*, Sw. The type and pectinate-pinnatifid form mentioned in *Synopsis Filicum*.
593. *A. aureum*, L.
1039. *A. praestantissimum*, Bory. The taenitoid form.
1133. *A. crinitum*, L.

MARATTIACEAE.

279. *Danaea alata*, Smith. Exactly matching the plant gathered by Guilding, which is a little different from our other specimens.
- 307, 692, 1024, 1027, 1029. *D. nodosa*, Sm. I cannot distinguish *D. elliptica*, Sm.

LYCOPODIACEAE.

630. *Psilotum triquetrum*, Sw.
1333. *Lycopodium reflexum*, Lam.
1339. *L. dichotomum*, Jacq.
- 301, 735, 1337. *L. taxifolium*, L.
1335. *L. linifolium*, L.
1334. *L. funiforme*, Cham.
- 52, 1332. *L. cernuum*, L.
1338. *L. aqualupianum*, Spring.

SELAGINELLACEAE.

1377. *Selaginella portoricensis*, A. Br.
1375. *S. rotundifolia*, Spring.
1376. *S. apus*, Spring.
54, 119, 235, 1010. *S. flabellata*, Spring.

The whole collection consists of 145 species or well-marked varieties, represented by 271 numbers.

The following species, not collected by the Messrs. Smith, are reported from the island in Grisebach's Flora of the British West Indies, principally on the authority of the Rev. Lansdowne Guilding.

Cyathea Serra, Willd.

C. tenera, Griseb. An endemic species, gathered by Caley, represented in the Kew herbarium by a single pinna, labelled in the handwriting of John Smith.

Hemitelia grandifolia, Spring.

Hymenophyllum hirtellum, Sw.

Trichomanes reptans, Sw.

T. brachypus, Kunze.

Adiantum macrophyllum, Sw.

A. Kaulfussii, Kunze.

A. intermedium, Sw.

A. obtusum, Desv.

A. trapeziforme, L., var. *cultratum*.

A. tenerum, Sw.

Pteris podophylla, Sw.

Ceratopteris thalictroides, Brong.

Blechnum longifolium, H. B. K.

Asplenium alatum, H. B. K.

A. marinum, L.

A. lunulatum, Sw.

A. furcatum, Thunb.

Nephrodium limbatum, Desv.

Polypodium flabelliforme, Lam.

P. gramineum, Sw.

Monogramme graminea, Schk.

Taenitis angustifolia, R. Br.

Marattia alata, Sm.

Equisetum palustre, L.

Out of this list of 26 species I have no hesitation in striking out three as mistakes, the *Equisetum*, the *Monogramme*, and *Asplenium marinum*. There remain the endemic *Cyathia tenera* and 22 species all likely to occur in any West Indian Island. This leaves, as our census for St. Vincent, 168 species, which is a large number for an island only 140 square miles in area. Most of the species are widely spread through Tropical America, and it will be noticed that only four of them are endemic.

EXPLANATION OF FIGURES IN PLATES
X AND XI.

Illustrating Mr. Baker's paper on the Vascular Cryptogamia of the Island
of St. Vincent.

PLATE X.

Hymenophyllum vincentinum, Baker.

Fig. 1. A pinna.

Fig. 2. A sorus exposed by removal of the valve of the indusium.

(Both figures enlarged.)

PLATE XI.

Asplenium Godmani, Baker.

Fig. 1. Portion of fertile frond (enlarged).

Fig. 2. Pinna from lower part of frond.

Fig. 3. Apical portion of frond.

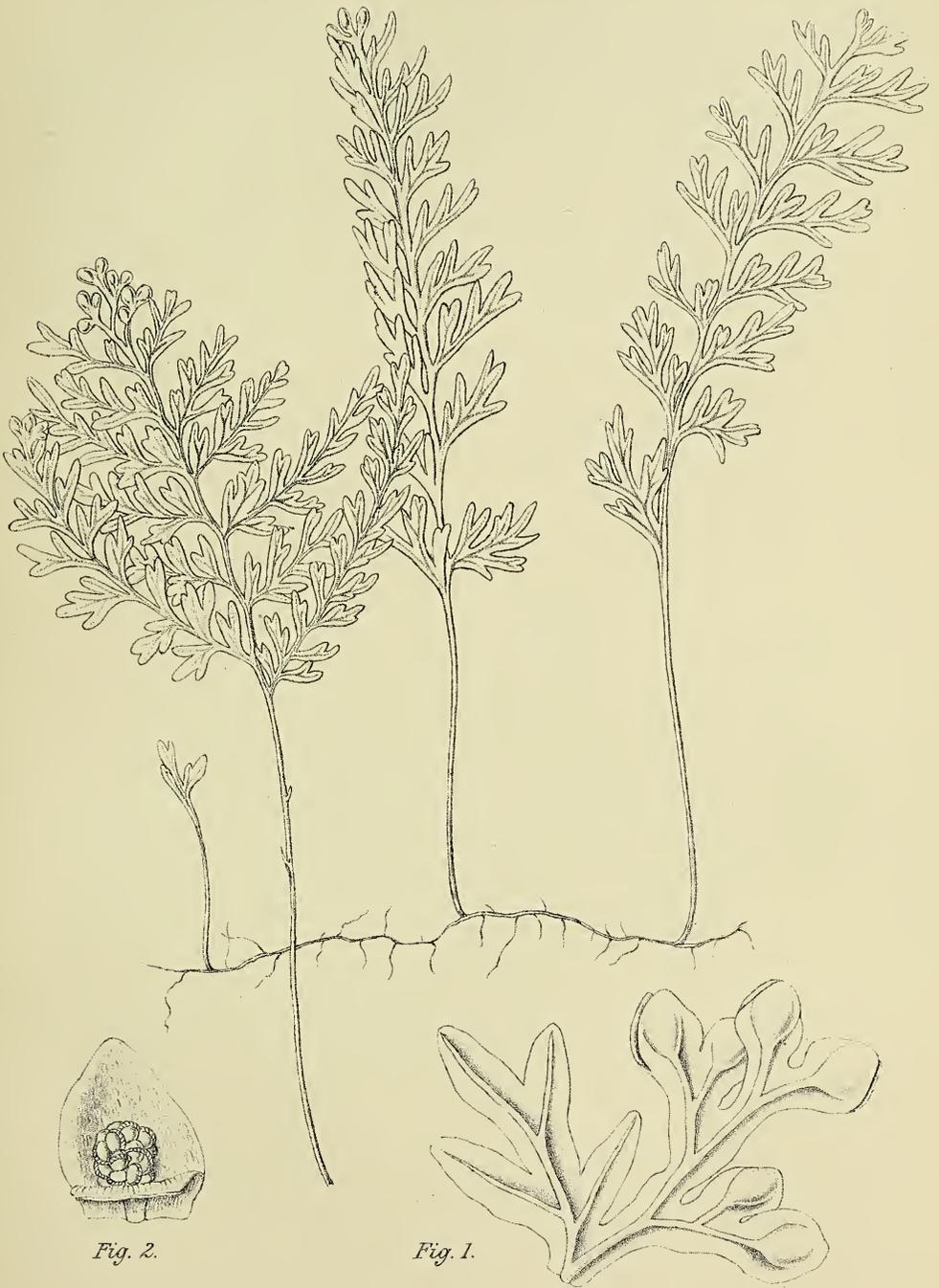


Fig. 2.

Fig. 1.

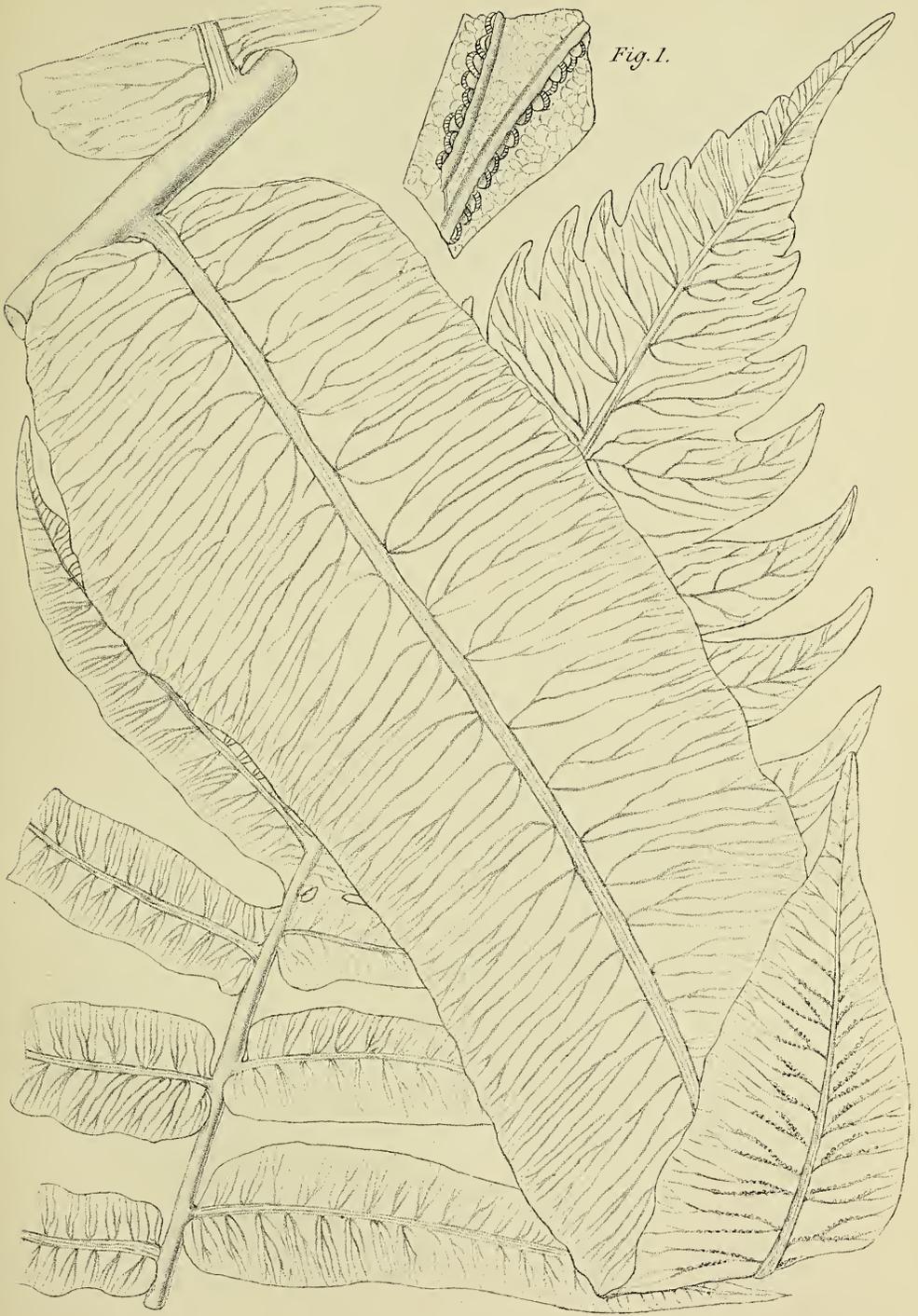


Fig. 1.

M. Smith del.

University Press, Oxford.

BAKER.— FERNS OF ST. VINCENT.
ASPLENium GODMANI, Baker.

On some points in the Anatomy of *Ipomoea versicolor*, Meissn.

BY

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—+—
With Plates XII and XIII.
—+—

IPOMOEA *versicolor*, Meissn., a native of Mexico, is frequently grown in greenhouses under its older name of *Mina lobata*, Cerv., and has also been described as *Quamoclit Mina*, George Don. Like so many of its genus and order it is a twining plant, and, though an annual, attains a considerable height during its single season of growth. In one of the specimens examined, which was grown in a cool greenhouse, the length of the main stem exceeded 17 ft. (above 5 m.), but no doubt larger dimensions are often reached.

For about the first three internodes above the cotyledons the stem is straight. Twining begins in full vigour in or about the fourth internode. (See Fig. 1.)

The younger part of the stem is cylindrical and contains a normal ring of bicollateral leaf-trace bundles, the xylem-groups of which soon become united by the cambium to form a continuous zone of wood. The bicollateral structure, which is nearly constant throughout the order, is very characteristic

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here¹. Each group of internal phloëm belongs definitely to one of the leaf-trace bundles, and accompanies the latter on its exit into the leaf.

Before considering the modifications of structure which subsequently arise in certain parts of the stem we will trace the relation between the bundle-systems of stem and root, for this plant illustrates with diagrammatic clearness the changes through which bicollateral bundles pass in the transitional region.

The two² obcordate cotyledons each contain four vascular bundles in the petiole, all of which, like those of the leaves generally, are bicollateral. The two median bundles are of large size, and lie close together. The two small lateral bundles are widely separated from them. On entering the axis the bundles of each median pair at once turn their protoxylem-groups towards each other, and pass down through the long hypocotyl to the root. The *lateral* bundles of the cotyledons on entering the hypocotyl approach each other so as to form two other pairs, at right angles to the former, each lateral pair being thus made up of one bundle from each cotyledon. These bundles also turn their protoxylem-groups towards each other and can only be distinguished from the median pairs by their position. The median pairs are further from the centre, the major axis of the elliptical pith passing through them, while the minor axis coincides with the position of the lateral pairs. The opposite median pairs are separated by about 14, the lateral pairs by about 9 pith cells. Lower down the pith of the hypocotyl becomes circular, and here all the four pairs of bundles are in all respects similar. The diagrammatic section (Fig. 2) is taken at a point where the pith is still somewhat elliptical, C-C being the median plane of the cotyledons.

The bundles of the plumular leaves fuse with the lateral

¹ Cf. Solereder, Ueber den systematischen Werth der Holzstruktur bei den Dicotyledonen, 1885.

² Occasionally three cotyledons are developed, but I did not investigate these exceptional seedlings.

cotyledonary bundles as soon as the latter enter the stem, so that the hypocotyl is traversed by the cotyledonary traces only.

Each pair of bundles in the hypocotyl has a common strand of internal phloëm lying just within the two converging protoxylem-groups. As we trace the bundles down towards the root we find that in each pair the protoxylem-groups slowly approach each other, and as this goes on the internal phloëm-strand passes out between them. Three stages of their course are shown in Figs. 3, 4, and 5, taken respectively at the levels *a*, *b*, and *c* shown in the sketch of the seedling (Fig. 1). As the root is approached the two xylem-groups of each pair meet and fuse, turning their protoxylem outwards. At this point the internal phloëm is seen forming two strands, one on each side of the xylem plate (Fig. 4. *pl*²). Lower down still the internal phloëm passes completely to the outside of the xylem (Fig. 5) and ultimately joins the external phloëm. The later stages of the transition are passed through within a very short space, as is shown by the relative positions of the sections as marked in Fig. 1. The main root is tetrarch, and its four xylem plates, corresponding to the four pairs of cotyledonary traces, eventually meet in the centre, the pith dying out. It will be seen that the course of the bundles agrees with the well-known type of *Phaseolus*. Its regularity is very favourable to tracing the passage of the internal phloëm.

The transitional region between stem and root shows remarkable peculiarities when secondary growth begins, and these are now to be described.

The upper and younger part of the stem is cylindrical and typical in structure, as already stated. The lower part of the stem, however, has a flattened form; its greater diameter may be as much as double the lesser, the latter being equal to the diameter of the cylindrical portion. The region showing this flattened form may be many feet in length in well-grown specimens, but the peculiarity is most marked in the neighbourhood of the cotyledons. The flattened appearance

is due to the presence of two great masses of secondary tissue, chiefly xylem, which have been added one on each side of the stem. The original ring of xylem can be traced all round; at the flat sides it has received little or no increment, while on the prominent faces the additional masses of wood and bast have been superposed upon it. The xylem of these masses is characterized by the presence of many enormous pitted vessels, attaining .25 mm. in diameter, while those of the ordinary ring scarcely measure .05 mm. The phloëm is decidedly more developed on the prominent faces than elsewhere, but the difference is not so marked as in the xylem.

The flattened region extends to the hypocotyl, in which the median line of the prominences is at right angles to the plane of the cotyledons. Towards the root, however, the thickening becomes more uniformly distributed until the transverse section is once more circular (Fig. 2).

In the upper part of the flattened region there is nothing anomalous except the unequal distribution of the secondary tissues, which also occurs in some other Convolvulaceae. A little thin-walled parenchyma is present in the secondary xylem.

In the lower internodes, however, the structure is much less regular and in the hypocotyl is extremely anomalous (cf. Fig. 2). The secondary masses of wood are broken up in all directions by bands and patches of thin-walled parenchyma containing isolated strands of phloëm, in which the sieve-tubes and companion-cells are of normal structure, and perfectly similar to those of the external and medullary phloëm. The diagrammatic section in Fig. 2 is taken from the lower part of the hypocotyl where the secondary thickening is nearly uniform all round. The parenchyma of the wood, whether forming rays or isolated groups, is everywhere traversed by strands of phloëm. In these transitional regions a large proportion of the whole phloëm is interxylary.

The investigation of developmental stages leaves no doubt that these masses of parenchyma, together with the phloëm

which they enclose, are produced centrifugally on the inner side of the normal cambium (see Fig. 6). The same cambium subsequently adds lignified tissue outside them, and they thus become enclosed in the wood (cf. Figs. 6 and 7). The phloëm-groups themselves may either be formed directly from the cambium or by the subsequent division of the parenchymatous cells. Both processes occur side by side, as is also the case in *Asclepias* and *Thladiantha*, to be described elsewhere.

The parenchymatous islands with their strands of phloëm extend up into the first internodes above the cotyledons and gradually disappear. They seem never to end blindly in the wood, but ultimately to abut on the cambium. Above the cotyledons they can only communicate with the *medullary* phloëm at the nodes.

The main root in its lower portion is normal. Here, as in the stem, the interxylary phloëm ends in contact with the cambium.

Ipomoea versicolor then presents the curious case of a plant in which the greater part of both stem and root is normal, while the region for some distance on both sides of the transition possesses a complicated system of interxylary phloëm. The anomalous transitional region, with its abundant conducting tissue, serves no doubt as a temporary store-house of food-material, reserved perhaps in part for the period of flowering.

A word must be said on the relation of the *medullary* phloëm to the phloëm-systems of the mature root. As already explained, the former is continuous, at the lower end of the hypocotyl, with the normal external phloëm. Then secondary growth begins; at the points where the medullary phloëm passes out the cambium necessarily cuts through it. Its continuity, however, is not altogether interrupted, for opposite each bundle-pair, through which the out-going phloëm passes, the cambium forms a parenchymatous xylem-ray containing, as already stated, strands of interxylary phloëm (see Fig. 5; the diagram, Fig. 2, is taken *above* the exit of the medullary

phloëm). With these strands the medullary phloëm remains in permanent continuity. Thus the interxylary phloëm of the transitional region is in communication both with the medullary and the external phloëm-systems of stem and root.

A further complication of structure appears in the older hypocotyl, for an internal cambium arises by the divisions of the outer cells of the pith, starting from the internal phloëm-groups, and sometimes extending nearly round the whole circumference. It produces some additional medullary phloëm internally, and also gives rise occasionally to a few lignified elements on the side towards the wood.

The chief points then to be noted are the following:—

1. The internal phloëm extends downwards into the hypocotyl and passes out between the converging protoxylem groups of each cotyledonary pair of bundles, thus joining the external phloëm of the root.

2. The hypocotyl and the adjacent parts of stem and root have a complex secondary wood containing numerous strands of interxylary phloëm, imbedded in parenchyma. These 'phloëm-islands' are produced centrifugally by the cambium.

As regards the course of the internal phloëm in the transition from stem to root, *Ipomoea versicolor* may be taken as typical of plants with bicollateral bundles generally. A full discussion of this subject, with references to the literature, will be found in a forthcoming paper by Mr. Brebner and myself.

I am not aware that the existence of phloëm-islands in the wood has previously been observed in any Convolvulaceae. The very remarkable anomalies described by Schmitz¹ and Dutailly² in the roots of certain perennial members of the

¹ Über die Anat. Structur der perennirenden Convolvulaceen-Wurzeln, Bot. Zeitung, 1875, p. 677. His results are summarized by de Bary, Comp. Anat., Eng. ed. p. 606. Tschirch, Angewandte Pflanzenanatomie, 1889, figures a transverse section of the root of *Ipomoea Purga*.

² Sur quelques phénomènes . . . dans le tige et la racine des Dicotylédones, Paris, 1879.

order are of quite a different kind, depending on the appearance of new cambial regions in the secondary parenchyma of xylem and phloëm.

Both the preparations and drawings for this investigation have been made by Mrs. D. H. Scott. The plants were raised from seed under glass.

EXPLANATION OF THE FIGURES IN PLATES XII AND XIII.

Illustrating Dr. D. H. Scott's paper on *Ipomoea versicolor*, Meissn.

The following lettering is used throughout the microscopical figures :—

- c^1 = normal cambium.
- ph^1 = normal external phloëm.
- ph^2 = medullary phloëm.
- ph^3 = interxylary phloëm.
- px = protoxylem.
- x^1 = primary xylem.
- x^2 = secondary xylem.
- p = pith.
- e = endodermis.

Fig. 1. Seedling, showing the whole plant, with the cotyledons and the first few leaves. $G-G$ level of the ground. The upper internodes are already twining round a support. a , b , and c , positions at which the sections shown in Figs. 3, 4, and 5 were taken. Two-thirds of natural size.

Fig. 2. Semi-diagrammatic transverse section of the hypocotyl. $C-C$ median plane of the cotyledons. *red* = primary xylem of the cotyledonary traces. *yellow* = secondary xylem. *blue* = phloëm, medullary, interxylary, and external. *brown* = periderm. The parenchyma is left white.

Fig. 3. Part of a transverse section taken at a (Fig. 1). A pair of cotyledonary bundles is shown, with converging protoxylem, and a common group of medullary phloëm just within them.

Fig. 4. Corresponding section much lower down, at b (Fig. 1). The xylem-groups are now united with outwardly-directed protoxylem. The medullary phloëm is passing to the exterior, forming two strands, one on either side of the xylem-plate. The whole has been enclosed by secondary wood.

Fig. 5. Corresponding section somewhat lower, at c (Fig. 1). The medullary phloëm now lies to the outside of the xylem-plate. Observe that the cambium is here beginning to form a medullary ray.

Fig. 6. From a much older hypocotyl, showing a parenchymatous 'island' with interxylary phloëm, in course of development. The cambium is beginning to form new wood and thus complete the formation of the island.

Fig. 7. From the same hypocotyl as Fig. 6, showing a similar island completely imbedded in the wood, and containing much interxylary phloëm. The arrow c^1 points towards the cambium.

Figs. 3-7 are $\times 330$ diam.

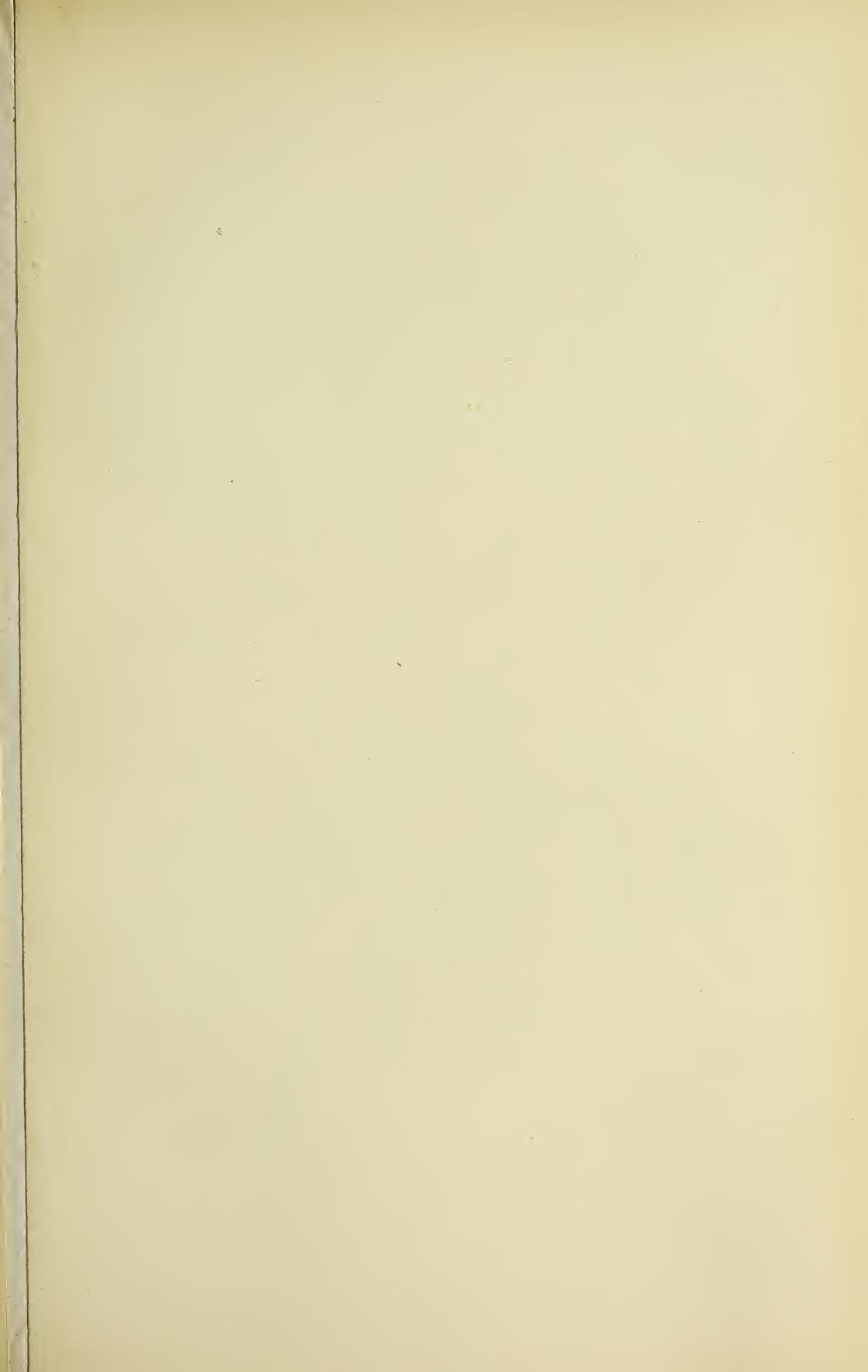




Fig. 1.

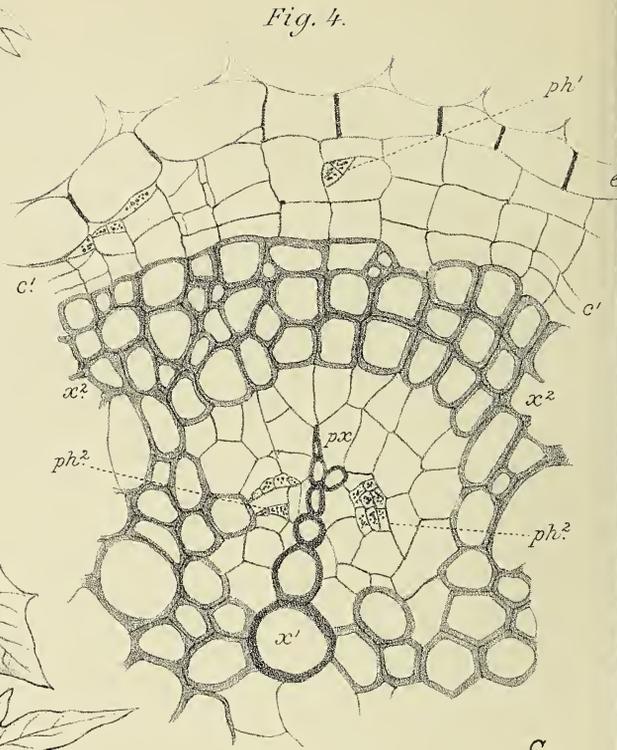


Fig. 4.

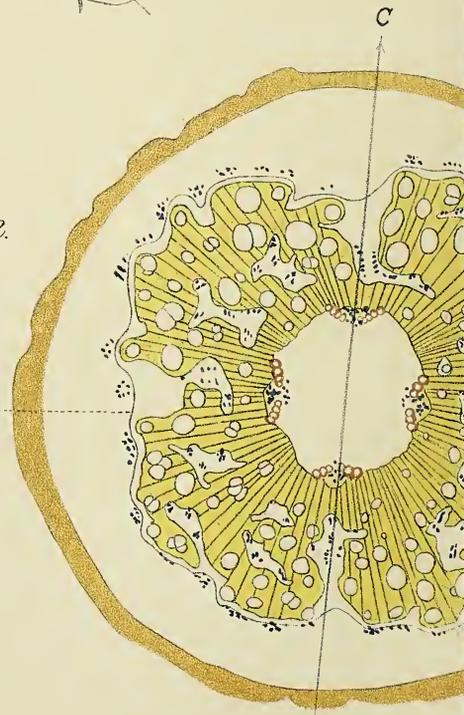


Fig. 2.

R. Scott del.

Fig. 3.

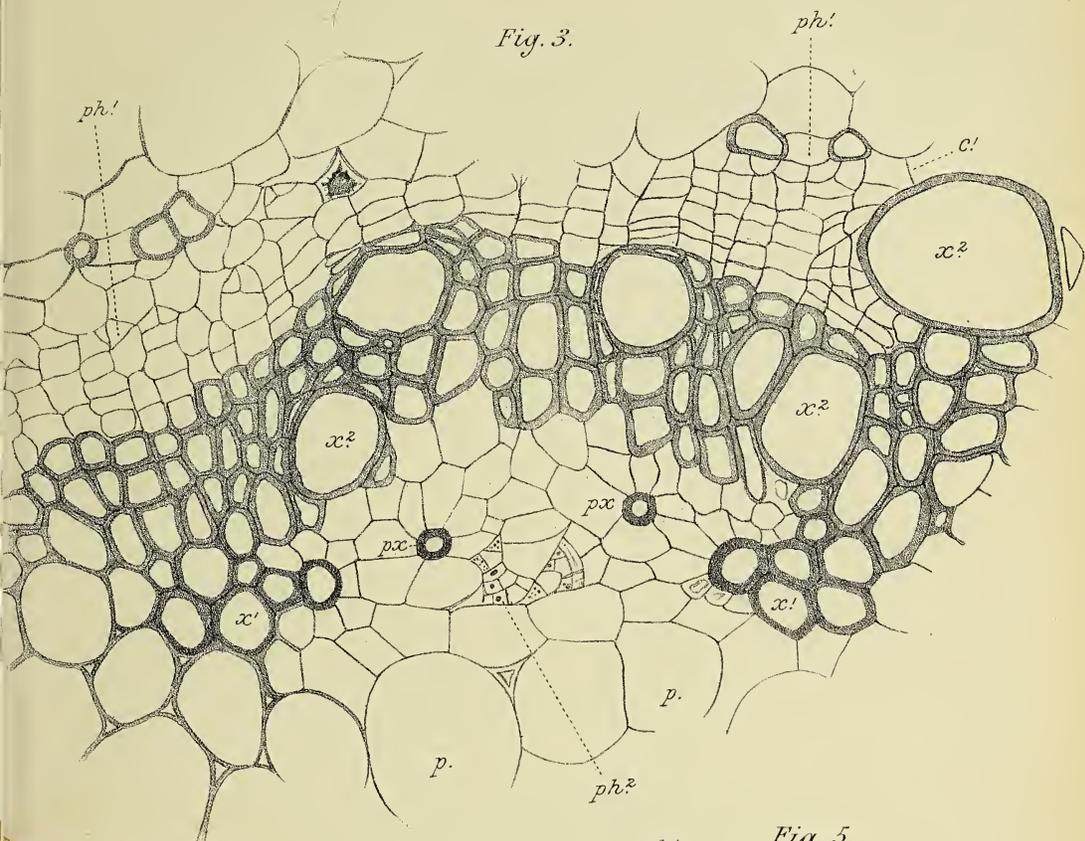


Fig. 5.

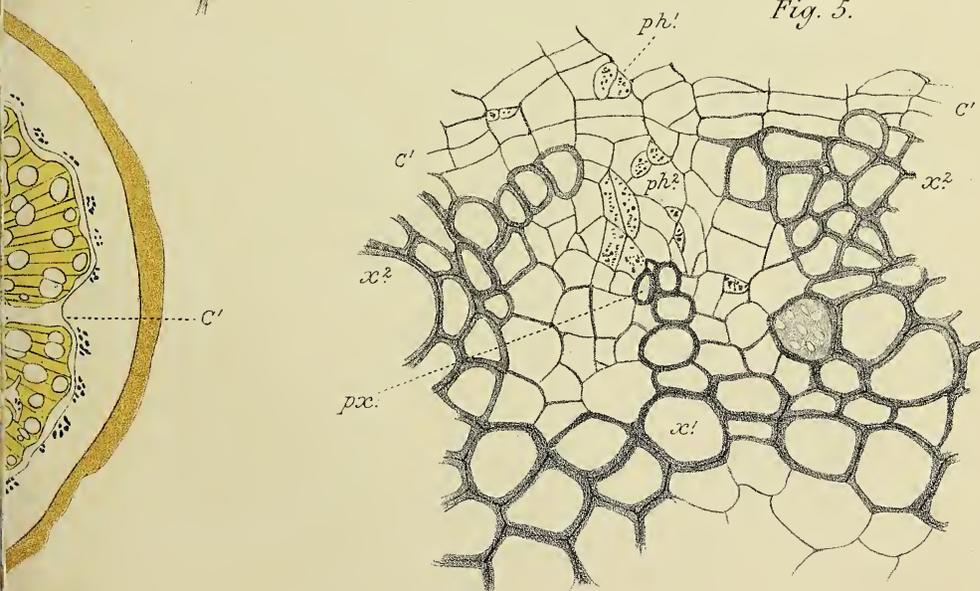


Fig. 1.

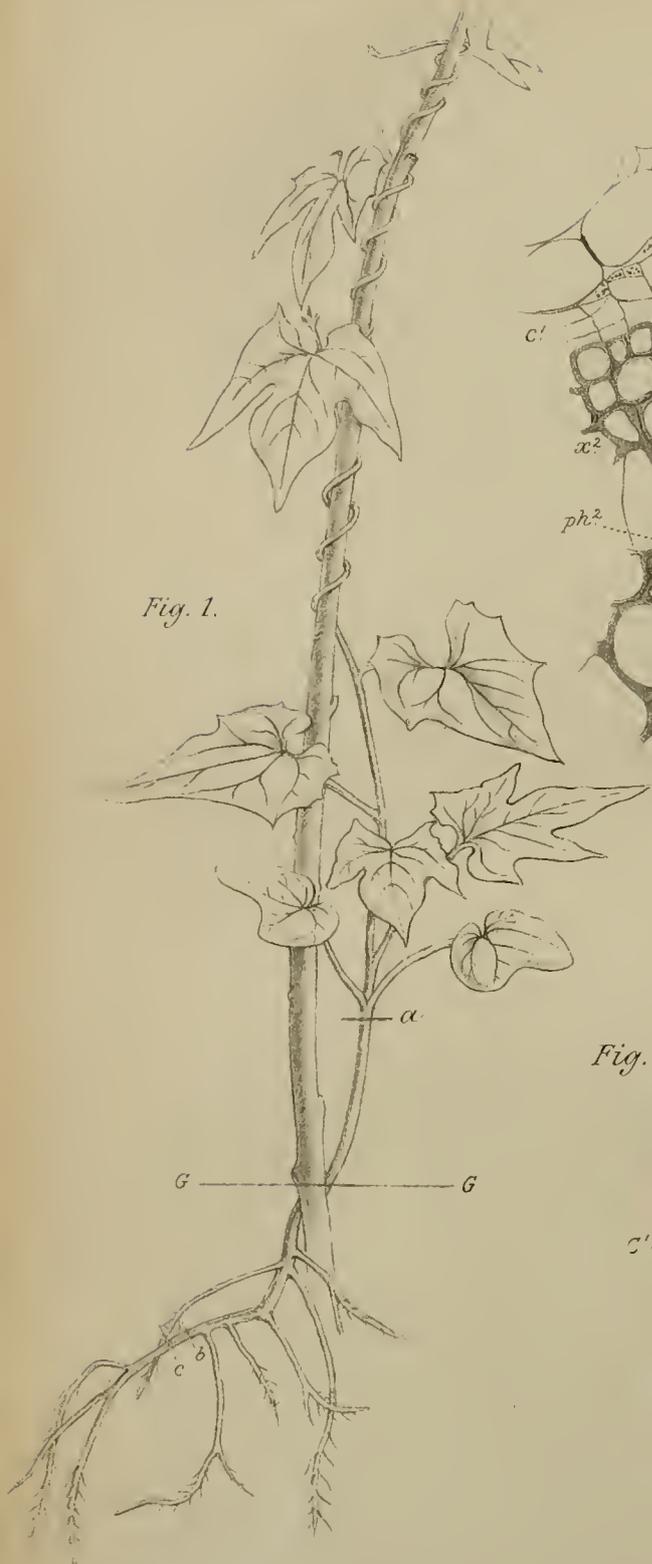


Fig. 4.

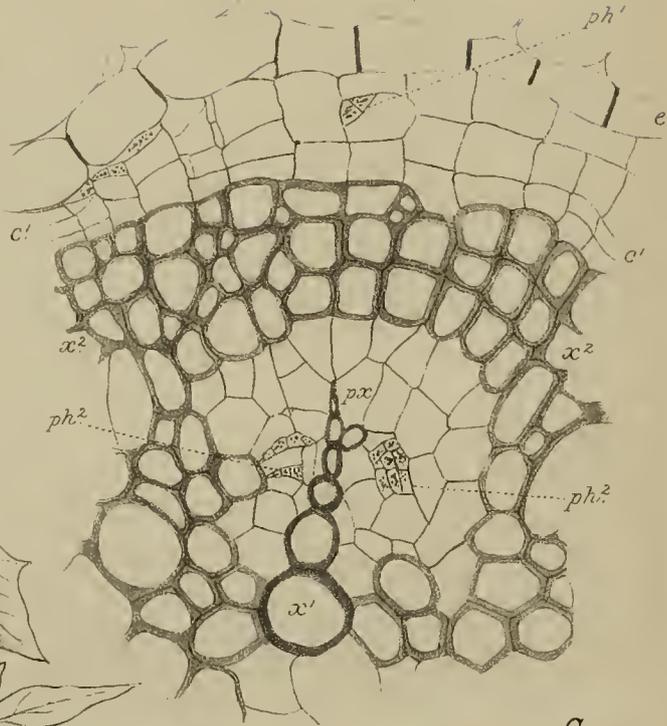


Fig. 3.

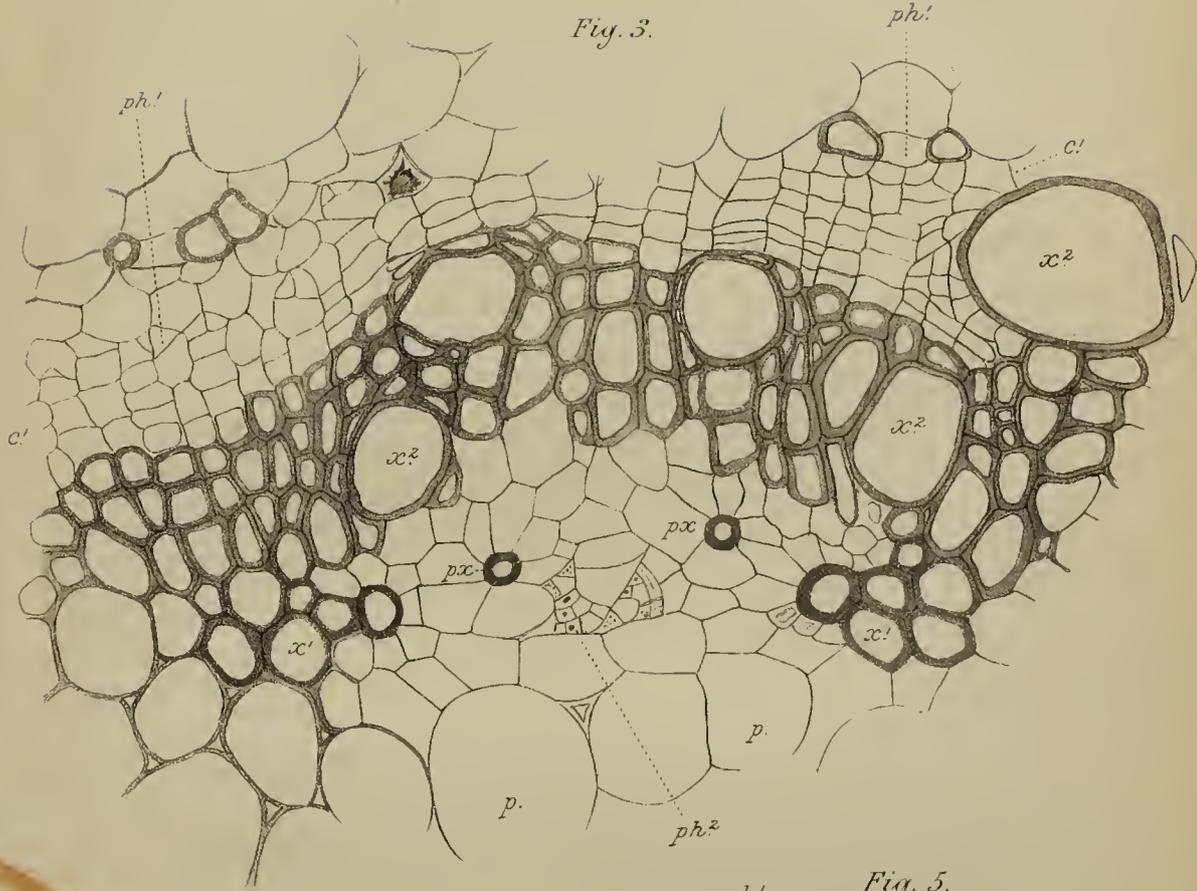


Fig. 2.

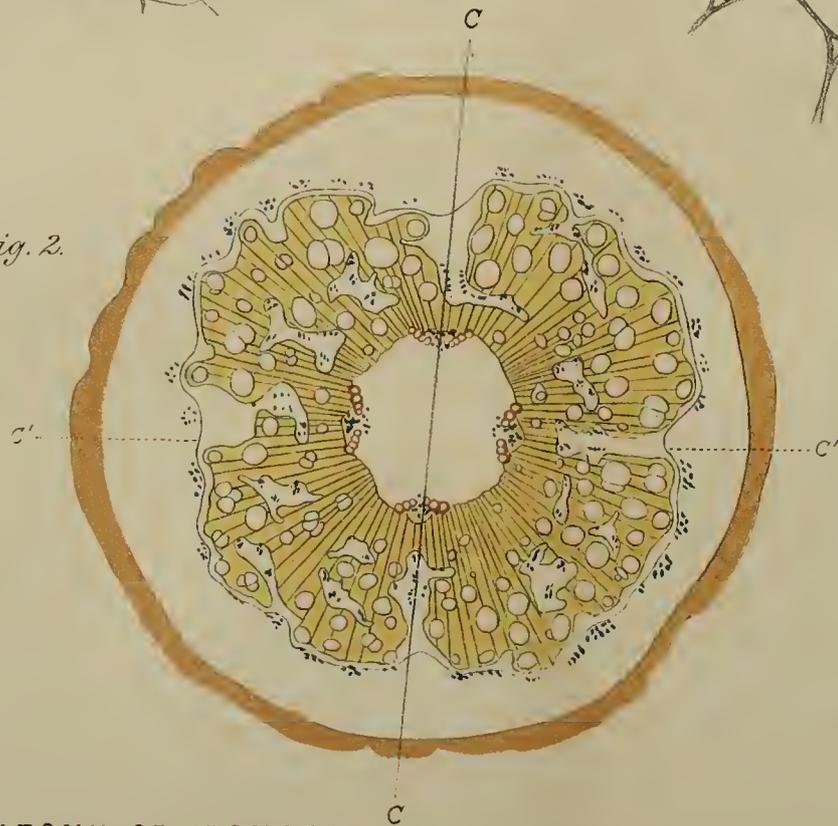
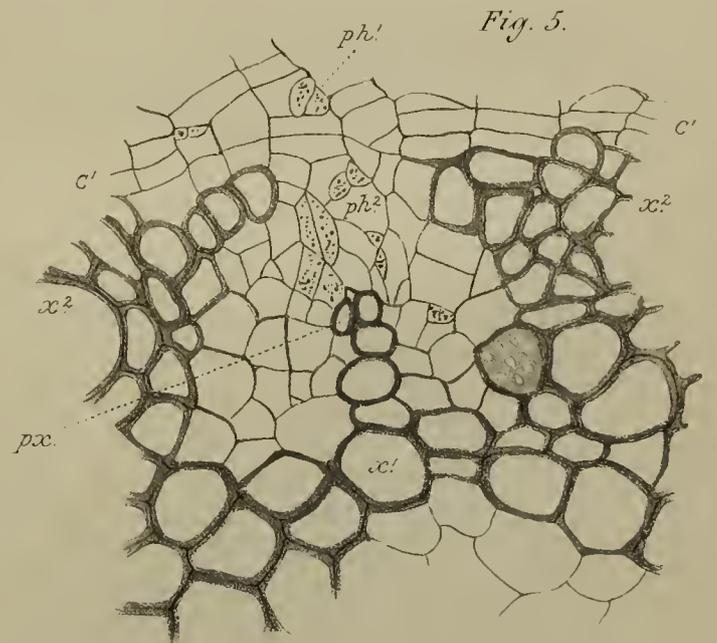


Fig. 5.



R. Scott del.

Fig. 6.

ph'

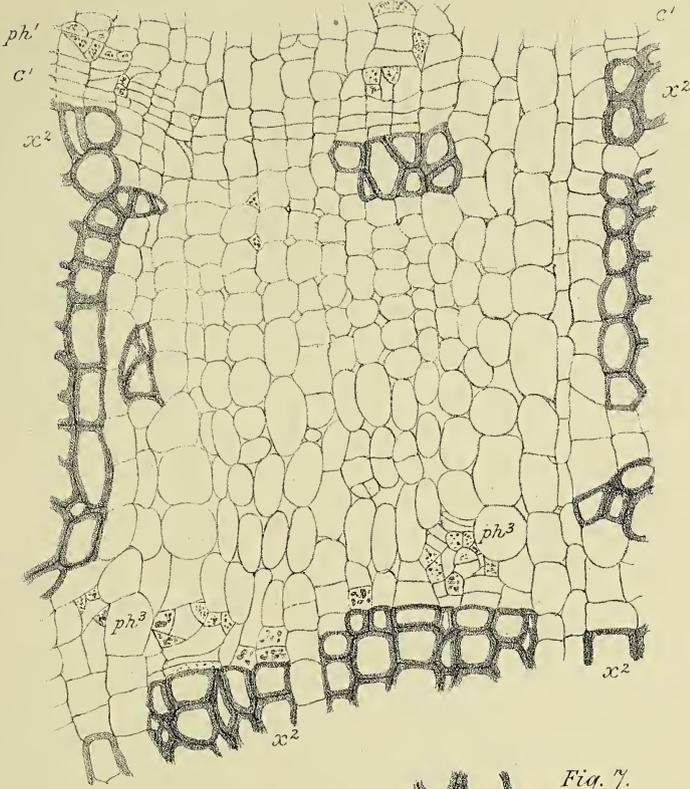
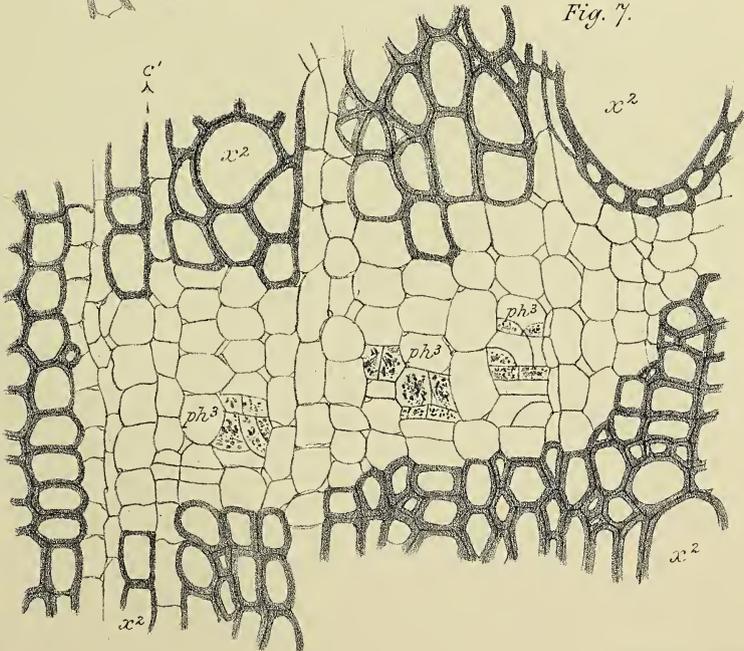


Fig. 7.



A Summary of the new Ferns which have been discovered or described since 1874.

BY

J. G. BAKER, F.R.S.

Keeper of the Herbarium, Royal Gardens, Kew.

—♦—
With Plate XIV.
—♦—

THE second edition of Hooker and Baker's *Synopsis Filicum* (now out of print) brings the enumeration of genera and species up to the year 1874. Since that date a large number of novelties have been discovered and described and so much fresh light has been thrown by morphological investigation on the taxonomic relations of the different groups of plants included under FILICES that it is time for a new handbook. As there is not any chance of this being produced at present, I propose in this paper to attempt a general summary of what has been added to our knowledge in respect to species during the last sixteen years. I do not intend to describe again the plants that have been described already; but merely to indicate their position in the sequence followed in the *Synopsis*, in the same way as in the supplement published in the second edition. Most of the larger collections that have been received at Kew have been already published in Britten's *Journal of Botany* and in the *Transactions and Journal of the Linnean Society*, but a considerable number of new species which have been received from time to time are still unnoticed. Of many of the plants which have been described by other authors we possess authentic specimens. Some of these I can only place as synonyms, and others, measured by the standard of

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specific difference adopted in *Synopsis Filicum*, as forms or varieties. Of the distinctness of published novelties of which I have not been able to see specimens, it is almost impossible to judge, but I have indicated the position they would occupy in the *Synopsis* as well as I could from the published descriptions. In a few cases fresh material that has been received shows that species that are passed over in the book for want of knowledge ought to be maintained, or that species kept up as distinct in the book ought to be combined.

Besides innumerable papers in journals, in the proceedings and transactions of societies and in local floras that include ferns (which I need not attempt to enumerate, as they will appear in the citations), the two principal books that concern our subject that have appeared since 1874 are Beddome's most useful Handbook of the Ferns of British India, published at Calcutta in 1881, and Father Sodiro's '*Recensio Cryptogamarum Vascularium Provinciae Quitensis*' published at Quito in 1883. The sixteenth century of Hooker's *Icones* is devoted entirely to Ferns. The principal collections which contain new species have been made in Madagascar by Pool, Miss Gilpin, Kitching, Baron, Humblot, Hildebrandt and Last; in China by Henry, Faber, Ford, Hancock, Maries and Delavay; in Perak by Scortechini; in Tonquin by Balansa; in the Malay archipelago by Beccari, Burbidge and Dr. Hose (Bishop of Singapore and Sarawak); in New Guinea by Beccari and Sir William Macgregor; in New Caledonia by Vieillard and Balansa; in Polynesia by Moseley (Challenger expedition), Horne, Sir J. B. Thurston and the Rev. R. B. Comins; in the Western United States by various collectors; in Mexico by Pringle, Parry and Palmer; in Costa Rica by Harrison and Cooper; in the West Indies by Jenman, Hart, Nock, Sherring and Fendler; on the Roraima expedition by im Thurn; in New Granada by Kalbreyer; in Ecuador by Father Sodiro; and in Brazil by Glaziou. In this enumeration the species are numbered as in the *Synopsis Filicum*. Novelties are indicated by an asterisk attached to the numbers of the species to which they are most nearly allied.

GLEICHENIACEAE.

Genus 2. GLEICHENIA Sm.

3. *G. circinata*, Sw. I cannot separate specifically *G. patens*, Colenso in Trans. New Zeal. Instit. 1888, 212.
4. *G. rupestris*, R. Br., must evidently be placed as a mere variety of *G. circinata*.
8. *G. littoralis*, Colenso, in Trans. N. Zeal. Inst. 1883, 334, I cannot separate from *G. flabellata*.
- 12*. *Mertensia littoralis*, Philippi, Descr. Nuev. Plant. 1873, 104. Chili. Not seen.
15. *G. subandina*, Sodiro, Recens. 5, and *G. hypoleuca*, Sodiro, Recens. 8, Andes of Ecuador, I should place as varieties of *G. revoluta*.
17. *G. seminuda*, Moore, Ind. Fil. 383, Columbia, *G. blepharilepis*, Sodiro, Recens. 6, and *G. leucocarpa*, Sodiro, Recens. 8, Andes of Ecuador, I should place as varieties of *G. pubescens*.
- 17*. *G. intermedia*, Baker, in Journ. Bot. 1887, 24. Costa Rica, Cooper. Intermediate between *pubescens* and *dichotoma*. There are two varieties, *flexuosa* and *dissitifolia*.
19. *G. Brackenridgei*, Fourn. in Ann. Sc. Nat. sér. 5, XVIII, 269, New Caledonia and Fiji, and *G. oceanica*, Kuhn, Hook. and Baker, Syn. Fil. edit. 2, 449, should probably be classed as varieties of *G. flagellaris*.
23. *G. linearis*, Clarke, in Trans. Linn. Soc. ser. 2, I 428, (*Polypodium lineare*, Burm.), is a synonym of *G. dichotoma*, Hook.

CYATHEACEAE.

Genus 4. CYATHEA Sm.

Bommer proposes to divide *Cyathea* into three genera, viz. 1, *Cyathea*, indusium of one single indehiscent piece; 2, *Eatoniopteris*, indusium of one piece, membranous, breaking up into fragments; 3, *Fourniera*, indusium formed of a number of narrow hyaline imbricated scales. For my own part, I feel more inclined to unite *Hemitelia* to *Cyathea* than to divide *Cyathea* as it now stands.

NEW WORLD SPECIES.

- 3*. *C. Nockii*, Jenm., in Journ. Bot. 1879, 257. Jamaica, Nock. Indusium of *C. arborea*, but frond bipinnate.

- 3*. *Cyathea Boni*, Christ, in Journ. de Bot. 1890, p. 410. French Tonquin, *Bon*. Near *C. Hookeri*, of Ceylon.
- 4*. *C. jamaicensis*, Jenm., in Journ. Bot. 1882, 323. = *C. arborea* var. *concinna*, Baker, in Journ. Bot. 1881, 52. Jamaica.
- 4*. *C. monstrabilis*, Jenm., in Journ. Bot. 1881, 273. Jamaica. Probably an abnormal form.
- 4*. *C. conquistita*, Jenm., in Journ. Bot. 1882, 324. Jamaica, *Wilson*, 134.
- 4*. *C. pendula*, Jenm., in Journ. Bot. 1882, 324. Jamaica, *Wilson*, 16. This and the last are known only from specimens sent long ago by Wilson to John Smith, whose fern-herbarium is now at the British Museum.
- 4*. *C. crassipes*, Sodiro, Recens. 10. Andes of Ecuador. May be a variety of *C. insignis*, Eaton.
- 10*. *C. ocanensis*, Baker, n. sp. Trunk 8–15 feet long. Frond ample, bipinnatifid, subrigid, glabrous. Pinnae oblong-lanceolate, 1–1½ ft. long. Pinnules lanceolate caudate, 2½–3 in. long, ½–⅝ in. broad, cut down by a broad wing into oblong tertiary segments ⅙ in. broad. Veins 10–12-jugate, indistinct, forked. Sori crowded, costular; indusium very fragile. New Granada; province of Ocana, *Kalbreyer*, 608.
- 10*. *C. corallifera*, Sodiro, Recens. 11. Andes of Ecuador, *Sodiro*.
- 10*. *C. fulva*, Sodiro, Recens. 11. Andes of Ecuador, *Sodiro*.
- 10*. *C. aspidioides*, Sodiro, Recens. 14. Andes of Ecuador, *Sodiro*. This and the last two are closely allied to *C. divergens*, Griseb. = *C. petiolulata*, Karst.
- 11*. *C. dissoluta*, Baker; Jenman, in Journ. Bot. 1881, 52. Jamaica, *Jenman*. Between *C. gracilis* and *Schanschin*.
- 14*. *C. puberula*, Sodiro, Recens. 16. Andes of Ecuador, *Sodiro*. Not seen. 'Near *C. straminea*, Karst.'
- 20*. *C. Copelandii*, Kuhn & Luerss. in Abhandl. Nat. Bremen, VII, 278. Island of Trinidad, South Atlantic, *Copeland*. I cannot from the dried pinnae distinguish this clearly from the widely-spread continental *C. Schanschin*, Mart.
- 20*. *C. ruiziana*, Klotzsch, in Linnaea, XX, 439. Fronds ample, bipinnatifid, glabrous, moderately firm; main rachis densely furfuraceous and muricated. Pinnae oblong-lanceolate, 1½ ft. long, 8 in. broad; rachis densely furfuraceous with many ovate-lanceolate glossy black paleae with a pale edge. Pin-

nules lanceolate, 4 in. long, $\frac{5}{8}$ in. broad, with many ovate and ovate-lanceolate paleae on the ribs beneath: tertiary segments oblong. Veins 8-10-jugate, deeply forked. Indusium very fragile, Peru, *Pavon*. Described from a type specimen lent by Mr. H. C. Levinge, in 1885.

12. **C. mexicana**, Schlecht. So far as I can judge from sterile fronds, the plants which have been widely spread in gardens under the names of *Alsophila Malzinei* and *A. Vangeertii*, are forms of this species.

OLD WORLD SPECIES.

In no group of Ferns have the additions made since 1874 been more numerous than in the Cyatheas and Alsophilas of the Old World.

- 26*. **C. Thomsoni**, Baker, in Journ. Bot. 1881, 180. Plateau north of Lake Nyassa, *Joseph Thomson*. Very near *C. Dregei* of the Cape.
- 29*. **C. mossambicensis**, Baker, n. sp. Frond ample, bipinnate, moderately firm, green and glabrous on both surfaces; rachis pale brown, naked, unarmed. Pinnae lanceolate, a foot or more long, 2 in. broad; pinnules linear-oblong, obtuse, distinct, crenate, $\frac{1}{8}$ - $\frac{1}{4}$ in. broad. Central veins of the pinnules twice forked. Sori placed nearer the midrib than the margin. Indusium a firm persistent cup with a truncate mouth. Namuli Makua country, *Last*, collected in 1887. Near *C. camerooniana*, Hook.
- 33*. **C. Lastii**, Baker, in Journ. Bot. 1891, 13. North-West Madagascar, *Last*.
- 33*. **C. regularis**, Baker, in Journ. Linn. Soc. XXV, 349. Madagascar, *Baron*.
- 33*. **C. discolor**, Baker, in Journ. Linn. Soc. XV, 412. Madagascar, *Pool*.
- 33*. **C. serratifolia**, Baker, in Journ. Bot. 1884, 139. North-West Madagascar, *Humboldt*, 278. Very distinct; cutting of *Alsophila Taenitis*.
- 33*. **C. polyphlebia**, Baker, in Journ. Linn. Soc. XX, 303. Madagascar, *Baron*.
- 33*. **C. segregata**, Baker, in Journ. Linn. Soc. XX, 303. Madagascar, *Baron*.

- 33*. *Cyathea rigidula*, Baker, in Journ. Linn. Soc. XXII, 534. Madagascar, *Baron*.
- 34*. *C. ligulata*, Baker, in Journ. Bot. 1884, 140. North-West Madagascar, *Humboldt*, 299.
- 33*. *C. hirsuta*, Baker, in Journ. Bot. 1884, 140. North-West Madagascar, *Humboldt*, 262.
- 33*. *C. Humboldtii*, Baker, in Journ. Bot. 1884, 140. North-West Madagascar, *Humboldt*, 264.
- 33*. *C. Hildebrandtii*, Kuhn, in Ind. Sem. Hort. Berol. 1875, 20. Johanna Island, *Hildebrandt*, 1747.
- 34*. *C. leptochlamys*, Baker, in Journ. Linn. Soc. XXII, 535. Madagascar, *Baron*.
- 34*. *C. quadrata*, Baker, in Journ. Linn. Soc. XV, 411. Madagascar, *Pool*.
- 34*. *C. appendiculata*, Baker, in Journ. Linn. Soc. XV, 411. Madagascar, *Meller*.
- 36*. *C. sumatrana*, Baker, in Journ. Bot. 1880, 209. Sumatra, *Beccari*, 438.
- 38*. *C. suluensis*, Baker, in Journ. Bot. 1879, 65. Sulu archipelago, *Burbidge*.
39. *C. sarawakensis*, Hook. The Bishop of Singapore and Sarawak has sent a series of specimens demonstrating that *C. lobbiana*, Hook. and *Alsophila alternans*, Hook. are forms of this species.
40. *C. assimilis*, Hook. *C. beccariana*, Cesati, in Becc. Fil. Born. 3, belongs here.
- 41*. *C. philippinensis*, Baker; *Alsophila philippinensis*, Hort. Veitch. Trunk short, slender; paleae large, linear, pale brown. Frond bipinnate, oblong-rhomboid, 3 ft. long, 1 ft. broad, narrowed from the middle to the base; rachises of frond and pinnae densely paleaceous. Pinnae lanceolate, central largest, 6-7 in. long, $1\frac{1}{2}$ in. broad; pinnules ligulate, crowded, sessile, $\frac{1}{4}$ in. broad, entire or crenate, with forked veins and a single row of sori between the midrib and edge; indusium moderately firm, but breaking up into pieces. Philippines, introduced into cultivation by Messrs. Veitch. Described from a plant that produced fruit at Kew in Feb. 1878.
- 44*. *C. schizochlamys*, Baker, in Journ. Bot. 1880, 209. Sumatra, *Beccari*, 439.

- 47*. *C. brevipinna*, Baker, in Benth. Fl. Austral. VII, 709. Lord Howe's Island.
47. *C. medullaris*, Sw. I cannot separate *C. polyneuron*, Colenso, in Trans. New Zeal. Instit. 1878, 429.
- 48*. *C. Macgregori*, F. M. & Baker, in Journ. Bot. 1890, 104. Highlands of New Guinea, *Sir W. Macgregor*.
49. *C. dealbata*, Sw. I cannot separate *C. tricolor*, Colenso, in Trans. New Zeal. Instit. XV, 304.
- 50*. *C. Muelleri*, Baker, in Journ. Bot. 1890, 104. Highlands of New Guinea, *Sir W. Macgregor*.
- 52*. *C. Moseleyi*, Baker, in Journ. Linn. Soc. XV, 104. Admiralty Isles, *Moseley* (Challenger expedition).
- 52*. *C. fusca*, Baker, in Malesia, III, 31. Fly river, New Guinea, *D'Albertis*.
52. *C. Whitmeei*, Baker, in Journ. Bot. 1876, 343. Samoa, *Whitmee*.
53. *C. Moorei*, Baker, = *C. Macarthurii*, F. M., Benth. Fl. Austral. VIII, 708; the latter being the earliest specific name.
- 53*. *C. scabra*, Baker, in Journ. Bot. 1876, 343. Samoa, *Whitmee*.
- 54*. *C. Thurstoni*, Baker, in Journ. Bot. 1884, 182. Fiji, *Sir J. Thurston*.
- 54*. *C. samoensis*, Baker, in Journ. Bot. 1876, 9. Samoa, *Whitmee*.
- 55*. *C. funebris*, Hort. Linden; *Fourniera funebris*, Fourn. in Linden, Ill. Hort. XXIII, 99. New Caledonia; not seen.

Genus 5. HEMITELIA, *R. Br.*

NEW WORLD SPECIES.

- 11*. *H. Hartii*, Baker, in Journ. Bot. 1886, 243. Chiriqui, *Hart*.
- 15*. *H. cystolepis*, Baker; *Cyathea cystolepis*, Sodiro, Recens. 8. Andes of Ecuador. Indusium present, but very small.
- 15*. *H. firma*, Baker, in Journ. Bot. 1877, 161. Andes of Ecuador, *Sodiro*.
- 15*. *H. crenata*, Sodiro, Recens. 18. Andes of Ecuador, *Sodiro*.
- 15*. *H. Joadii*, Baker, n. sp. Frond ample, bipinnatifid, moderately firm, green and glabrous on both surfaces, with a few small white membranous paleae on the midribs of the pinnules beneath; rachis unarmed, glabrous. Pinnae oblong-lanceolate,

1-1½ ft. long, 5-6 in. broad; pinnules lanceolate, sessile, $\frac{3}{4}$ - $\frac{7}{8}$ in. broad, cut down to a broad wing into oblong, distinctly-toothed tertiary segments $\frac{1}{6}$ in. broad. Veins simple, distinct, 6-7-jugate. Sori marginal; indusium firm, $\frac{1}{2}$ -cupshaped. Santa Marta, *Joad*, (1863).

- 15*. **Hemitelia Traillii**, Baker, n. sp. Fronds ample, bipinnatifid, moderately firm, green and glabrous on both surfaces, slightly scaly on the ribs beneath; rachis unarmed, furnished with a few large lanceolate brown scales. Pinnae oblong-lanceolate, 2 ft. long, 8-9 in. broad; pinnules lanceolate petioled, above an inch broad, cut down to a narrow wing into oblong-lanceolate inciso-crenate tertiary segments $\frac{1}{4}$ in. broad. Veins forked, 8-9-jugate. Sori medial, placed at the fork of the veins; indusium minute. Amazon valley, North Brazil, collected by Professor *Traill* of Aberdeen in 1874.
- 15*. **H. Sherringii**, Jenm., in Journ. Bot. 1886, 266. Rose-hill, Jamaica, *Sherring*; only one plant seen.
- 15*. **H. parvula**, Baker. First published as *Alsophila parvula*, Jenm., in Journ. Bot. 1879, 258; afterwards as *Hemitelia microsepala*, Jenm., in Journ. Bot. 1886, 266. Jamaica.

OLD WORLD SPECIES.

- 16*. **H. brunoniana**, Clarke, in Trans. Linn. Soc. ser 2, Bot. I, 430, = *Amphicosmia brunoniana*, Beddome. India orientalis. Included under *Alsophila contaminans*, in Syn. Fil. p. 41.
- 16*. **H. decipiens**, J. Scott, East Himalayas = *Cyathea decipiens*, Clarke & Baker, in Journ. Linn. Soc. XXIV, 409, and the South Indian **H. Beddomei**, Clarke, in Trans. Linn. Soc. n. ser. I, 429, is very nearly allied to it. Both of them only differ from *Cyathea spinulosa* in the indusium.
18. **H. Smithii**, Hook. I cannot separate **H. stellulata**, Colenso, in Trans. New Zeal. Instit. 1885, 222.
- 19*. **H. glandulosa**, Kuhn, in Hildeb. Pl. Madag. Exsic. No. 4176. Frond ample, bipinnate, moderately firm, green and glabrous on both surfaces; rachis unarmed, naked beneath. Pinnae oblong-lanceolate, 1½-2 ft. long, 8-10 in. broad; pinnules sessile, lanceolate, $\frac{3}{4}$ - $\frac{7}{8}$ in. broad, cut down to the rachis into distinct linear-oblong crenulate tertiary segments $\frac{1}{8}$ in. broad.

Veins 10-12-jugate, forked. Sori subcostular; indusium minute. Central Madagascar, *Hildebrandt*. Very near *H. Melleri*, Baker.

- 19*. **H. Godeffroyi**, Luerss., in Mus. Godef. II, 4. Queensland, *Mrs. Dietrich*. Not seen. See Benth. Fl. Austral. VII, 709.

Genus 6. ALSOPHILA, *R.Br.*

NEW WORLD SPECIES.

- 11*. **A. Sodiroi**, Baker; *A. alata*, Sodiro, Recens. 19, non Fournier. Andes of Ecuador, *Sodiro*. Near *A. leucolepis* and *paleolata*.
- 12*. **A. sessilifolia**, Jenm. in Journ. Bot. 1882, 325. Jamaica, *Wilson* (Herb. J. Smith only).
12. **A. aspera**, R. Br. I cannot clearly separate the Trinidad **A. echinata**, Moore, Ind. Fil. 49 = *A. Eatonii*, Jenm., in Journ. Bot. 1887, 98 (Fendler, 32).
- 12*. **A. podophylla**, Baker, in Journ. Bot. 1881, 202. New Granada, *Kalbreyer*; habit and texture of *Cyathea divergens*.
- 16*. **A. macrosora**, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 288. Roraima, *in Thurn*.
- 16*. **A. trichophlebia**, Baker, n. sp. Frond ample, deltoid, tripinnatifid, moderately firm, green on both surfaces, glabrous above, furnished beneath with copious ovate bullate scales on the midrib of the pinnules, and all the veins beneath ciliated with large hairs; rachises of pinnae pilose on both sides, especially above. Pinnae oblong-lanceolate, the largest 9-10 in. long, $2\frac{1}{2}$ -3 in. broad. Pinnules sessile, lanceolate, 4-5 lines broad, cut half-way down to the midrib into oblong tertiary segments $\frac{1}{12}$ in. broad. Veins simple, 2-3-jugate. Sori medial. Paraguay, *Balansa*, 306 (Herb. De Candolle). Allied to *A. atrovirens* and *floribunda*.
- 20*. **A. pallescens**, Sodiro, Recens. 20. Andes of Ecuador, *Sodiro*. Allied to *A. paleolata*, Mart.
- 37*. **A. latevagans**, Baker, in Journ. Bot. 1881, 203. New Granada, province of Antioquia, *Kalbreyer*, 1327. Very distinct and curious.
- 37*. **A. hispida**, Baker, in Journ. Bot. 1881, 202. New Granada, province of Antioquia, *Kalbreyer*, 1561.

OLD WORLD SPECIES.

- 38*. *Alsophila alata*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 349. New Caledonia, *Balansa*, 1589. Not seen.
- 40*. *A. dissitifolia*, Baker, in Journ. Bot. 1886, 182. Fiji, *Sir J. B. Thurston*.
41. *A. Novae-Caledoniae*, Mett. Fournier, in Ann. Sc. Nat. sér. 5, XVIII, 349, refers this to *Fourniera*, but neither Mr. Wright nor I can find any trace of an indusium. *Fourniera lepidotricha*, Fournier, loc. cit. New Caledonia, *Balansa*, 1592, not seen, is said to be extremely near to *F. Novae-Caledoniae*.
- 43*. *A. woolsiana*, F. Mull. Fragm. VIII, 179. Queensland. Near *A. Leichardiana*.
- 47*. *A. Hornei*, Baker, in Journ. Bot. 1879, 293. Fiji, *Horne*.
- 47*. *A. polyphlebia*, Baker, in Journ. Linn. Soc. XV, 104. Arru Islands, *Moseley* (Challenger expedition).
- 48*. *A. denticulata*, Baker, in Journ. Bot. 1885, 102. Formosa, *Hancock*, 55.
- 56*. *A. dubia*, Beddome, in Journ. Bot. 1881, 1 t. 279 A. Perak and Borneo. Very near *A. podophylla*, Hook.
- 58*. *A. rheosora*, Baker, in Journ. Bot. 1890, 292. Tonquin, *Balansa*, 1803, 1861.
- 58*. *A. formosana*, Baker, n. sp. Frond ample, tripinnatifid, moderately firm, glabrous, green on both surfaces, rachis of pinnae naked, castaneous. Pinnae oblong-lanceolate, 1-1½ ft. long, 5-6 in. broad. Pinnules sessile, lanceolate, nearly an inch broad, cut down to a broad wing into oblong lobes ½ in. broad. Veins 6-8-jugate. Sori medial. Formosa, *Hancock*, 113. Near *A. glabra*, Hook.
58. *A. glabra*, Hook. I cannot separate *A. vexans*, Cesati, Fil. Recens. Born. 4.
- 59*. *A. albo-setacea*, Beddome, Handb. 16. Nicobar Isles, *Kurz*.
- 59*. *A. Kingii*, Clarke; Beddome, Handb. 473. Perak. *A. Bakeri*, Zeiller, in Bull. Bot. Soc. France, XXXII, 71, is probably the same species.
- 59*. *A. modesta*, Baker, in Journ. Bot. 1880, 210. Sumatra, *Becconi*, 434.

- 59*. **A. sikkimensis**, Clarke & Baker, in Journ. Linn. Soc. XXIV. 409. Sikkim, *Clarke*. Probably a variety of *A. ornata*, with which links connecting it have just been found by Mr. Gamie, jun.
- 59*. **A. obscura**, Scortech.; Beddome, in Journ. Bot. 1887, 321, tab. 278, fig. 2. Perak, *Scortechini*. Near *A. comosa*, Hook.
- 59*. **A. trichodesma**, Scortech.; Beddome, in Journ. Bot. 1887, 321. Perak, *Scortechini*.
- 59*. **A. Burbidgei**, Baker, in Journ. Bot. 1879, 38. Borneo, *Burbidge*.
- 64*. **A. castanea**, Baker, in Journ. Bot. 1891, 3. North-west Madagascar, *Last*.
- 64*. **A. simulans**, Baker, in Journ. Bot. 1891, 3. North-west Madagascar, *Last*.
- 64*. **A. vestita**, Baker, in Journ. Linn. Soc. XV. 412. Madagascar, *Pool*.
- 64*. **A. bullata**, Baker, in Journ. Linn. Soc. XV, 412. Madagascar, *Pool*.
64. **A. Baroni**, Baker, in Journ. Linn. Soc. XXI, 455. Madagascar, *Baron*.

In the second edition of the 'Synopsis Filicum,' in 1874, about 200 tree-ferns are described as distinct species. Since that date upwards of eighty new ones have been found.

Genus 8. MATONIA *R.Br.*

M. sarmentosa, Baker, in Journ. Linn. Soc. XXIV, 256 (see Plate XIV). Rachis slender, terete, with long internodes. Segments 3-4 from each internode, linear, rigid, glabrous, simple or forked, 4-5 in. long, $\frac{1}{8}$ in. broad. Veins indistinct, simple, or forked. Indusium globose, rigid, superior, attached by a short central stipe, splitting by circumscissile dehiscence, so as to leave a patelliform persistent base. Sporangia 8-10 in a cluster, with a short stipe and incomplete vertical ring. Niah, Sarawak, Borneo, collected by Mr. Charles Hose in 1887, sent to Kew by the Bishop of Singapore and Sarawak.

This is the most interesting novelty that has been found during the period which this paper covers. It has entirely the indusium and sporangia of the old well-known *Matonia pectinata*, on which this genus was established by Robert Brown,

but the habit of the plant is entirely different. *Matonia* ought clearly to form a tribe by itself, not to be united with the Cyatheaceae.

HYMENOPHYLLACEAE.

Genus 16. HYMENOPHYLLUM *Smith*.

- 3*. **H. Armstrongii**, Kirk; Baker, in Hook. Ic., tab. 1614 = *H. melanocheilos*, Colenso, in Trans. New Zeal. Instit. XVII, 255, is the same as *Trichomanes Armstrongii*, Baker, Syn. Fil. edit. 2, 465.
- 5*. **H. Balfourii**, Baker, n. sp. Rhizome filiform, wide-creeping. Stipe filiform, very short. Frond deltoid, glabrous, $\frac{1}{4}$ – $\frac{1}{2}$ in. long, cut down to a narrow wing into 3–6 erecto-patent lobes, the upper simple, the lower forked. Sorus one to a frond, immersed in the end of a lobe; indusium with a cuneate tube and orbicular lips. Bourbon, *Balfour*. Near the American *H. abruptum*, Hook.
- 8*. **H. vincentinum**, Baker, Ann. Bot. V, p. 164, Plate X. St. Vincent, *H. H.* and *G. W. Smith*, communicated by F. Ducane Godman, F.R.S.
- 8*. **H. terminale**, Philippi, in Linnaea, XXXIII, 306. Chili. Near *H. rarum*.
- 10*. **H. paniculiflorum**, Presl; V. D. B. Hymen. Jav. tab. 39. Japan. Appears to be a distinct species, intermediate between *gracile* and *polyanthos*.
- 14*. **H. Thuidium**, Harringt., in Journ. Linn. Soc. XVI, 25. Panay, Philippines, *Steere*.
- 15*. **H. ooides**, F. M. & Baker, in Journ. Bot. 1890, 105. Highlands of New Guinea, *Sir W. Macgregor*.
- 16*. **H. dejectum**, Baker, in Trans. Linn. Soc. N. S. Bot. II, 289. Summit of Mount Roraima, *in Thurn*.
18. **H. polyanthos**, Sw. I cannot separate **H. lophocarpum**, Colenso, in Trans. New Zeal. Instit. 1884, 255.
- 18*. **H. villosum**, Colenso; Kirk, in Trans. New Zeal. Instit. X, 395. Midway between *polyanthos* and *demissum*, more deltoid in outline than the former, with narrower segments and smaller sori. New Zealand.
- 18*. **H. trichomanoides**, Bailey, in Queensl. Flora, Suppl. 3, p. 90,

- Summit of Bellenden Ker range. Not seen. Said to be like *H. polyanthos* in habit, with fruit between the types of *Hymenophyllum* and *Trichomanes*.
- 21*. *H. australe*, Willd., Sp. Plant. V. 527 (1810), is an older name for this species than *H. javanicum*, Spreng.
- 21*. *H. montanum*, Kirk, in Trans. New Zeal. Instit. X, 394, tab. 21, fig. B. Lake Wakatipu, New Zealand. Like dwarf *australe*, with very jagged indusia.
- 21*. *H. samoense*, Baker, in Journ. Bot. 1876, 10. Samoa, *Whitmee*.
- 21*. *H. streptophyllum*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 266. New Caledonia, *Balansa*, 2708. Not seen.
22. *H. demissum*, Sw. I cannot separate *H. megalocarpum*, Colenso, in Trans. New Zeal. Instit. XV, 308.
- 22*. *H. Baldwinii*, Eaton; Baker, in Hook. Ic. tab. 1611. Sandwich Islands, *Miss E. S. Boyd*.
- 27*. *H. erecto-alatum*, Colenso, in Trans. New Zeal. Instit. 1878, 431. New Zealand. Not seen. Said to come in between *dilatatum* and *pulcherrimum*.
- 31*. *H. pedicularifolium*, Cesati, Fil. Polyn. Becc. 6. Rhizome filiform, wide-creeping. Frond oblong-rhomboid, nearly sessile, glabrous on the upper surface, densely ferrugineo-pilose beneath, an inch long, cut down to a broadly-winged rachis into 5-6 pairs of pinnae, the upper simple, linear, the lower 2-3-lobed. Sori one each from the upper side of the upper pinnae near the base; indusium oblong; valves as long as the tube. Mountains of New Guinea, *Beccari*.
- 32*. *H. Levingei*, Clarke, in Trans. Linn. Soc. Bot. ser. 2, I, 439, tab. 49, fig. 3. Sikkim, alt. 7000 ft., *Levinge*. Very distinct.
- 32*. *H. Boutoni*, Baker, Fl. Maurit. 462. Mauritius, *Bouton*.
- 34*. *H. Poolii*, Baker, in Hook. Ic. tab. 1619. Central Madagascar, *Pool*.
- 34*. *H. Balansae*, and *humboldtianum*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 265. New Caledonia, *Balansa*. Not seen. To be compared with *H. ciliatum*, Sw.
- 34*. *H. pachydermicum*, Cesati, Fil. Becc. Born. 8. Borneo, *Beccari*. Near *ciliatum*.
- 38*. *H. rufescens*, Kirk, in Trans. New Zeal. Instit. 1878, 457, tab. 19, fig. A. New Zealand, *Field, Kirk*. I am not sure that this is specifically distinct from *H. subtilissimum*, Kunze.

46. *Hymenophyllum sericeum*, Sw. I cannot separate *H. refrondescens*, Sodiro, Recens. 2.
- 52*. *H. tunbridgense*, Sm. I cannot clearly separate *H. pusillum*, *revolutum*, or *pygmaeum*, Colenso, New Zealand Ferns described in the Transactions of the New Zealand Institute for 1879–1880.
- 52*. *H. brachyglossum*, Cesati, Fil. Becc. Born. 7. Borneo, *Beccari*. Habit of a slender form of *H. tunbridgense*, but with round sori placed at the end of the segments.
- 52*. *H. Henryi*, Baker, in Journ. Bot. 1889, 176. West China; province of Hupeh, *Dr. Henry*, 5457.
- 52*. *H. subflabellatum*, Cesati, Fil. Becc. Born. 8. Sarawak, Borneo, *Beccari*. Fronds $\frac{1}{5}$ – $\frac{2}{5}$ in. long, broad ovate, almost flabellately bisect, the primary segments pinnatifid, with sori terminal or lateral on the lobes of the upper segments.
- 56*. *H. oxyodon*, Baker, in Journ. Bot. 1890, 262. Tonquin, *Balansa*, 1905.
- 63*. *H. polyodon*, Baker, in Journ. Linn. Soc. XX, 104. Admiralty Isles, *Moseley* (Challenger expedition).
- 67*. *H. Houstonii*, Jenm., in Journ. Bot. 1886, 42. Jamaica, *Herb. Sloane*.
- 67*. *H. fraternum*, Harringt., in Journ. Linn. Soc. XVI, 26. Panay, Philippines, *Steere*.
- 68*. *H. Reinwardtii*, Blume, V. D. B., Hymen. Jav. tab. 42. Appears to be a distinct species, near *H. bivalve*, Sw. Mount Singalan, Sumatra, *Beccari*.

Genus 17. TRICHOMANES *Linn.*

- 7*. *T. Hildebrandtii*, Kuhn, in Reise Deck. Bot. 70. Johanna Island, *Hildebrandt*, 1856.
- 10*. *T. Motleyi*, V. D. B. I cannot separate *T. beccarianum*, Cesati, Fil. Becc. Born. 8, tab. 1, fig. 2, nor *T. cognatum*, Cesati, Fil. Becc. Polyn. 6.
- 10*. *T. cultratum*, Baker, in Journ. Bot. 1879, 293. Fiji, *Horne*.
- 10*. *T. Wallii*, Thwaites. Rhizome filiform, wide-creeping. Frond ovate or orbicular, ciliated, entire, $\frac{1}{8}$ – $\frac{1}{6}$ in. long. Veins distinct, simple; spurious venules 0. Sorus solitary at the end of the distinct midrib. Indusium funnel-shaped, immersed, with a

- broad entire collar-like border. Southern forests of Ceylon, *Wall.*
- 15*. **T. Sayeri**, F. M. & Baker. Rhizome wide-creeping. Stipe very short. Frond orbicular, or obovate-cuneate, $\frac{1}{5}$ – $\frac{1}{6}$ in. long, deeply emarginate, with rounded apical lobes. Midrib distinct from base to apex; veins flabellate. Indusium solitary, terminal, stipitate; lips orbicular. Trinity Bay, Queensland, *Sayer.*
- 12*. **T. labiatum**, Jenm., in Gard. Chron. N. S. XXIV. 7. British Guiana, *Jenman.*
- 14*. **T. setiferum**, Jenm., in Journ. Bot. 1881, 52. Mountains of Jamaica, near Cinchona plantation, *Nock.*
20. **T. muscoides**, Sw. I cannot separate **T. yandimense**, Bailey, Queensland Flora, 686.
- 20*. **T. pinnatinervium**, Jenm., in Gard. Chron. 1886, II, 787. British Guiana, *Jenman.*
- 23*. **T. trinerve**, Baker, Fl. Maurit. 463. Mauritius, *Lady Barkly.*
- 27*. **T. dichotomum**, Philippi, in Bot. Zeit. 1856, 650. Chili, *Philippi.*
- 41*. **T. ignobile**, Cesati, Fil. Becc. Born. 9. Sarawak, Borneo, *Beccari.* Midway between *bicorne* and *intramarginale*.
- 44*. **T. apicale**, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 257. New Caledonia, *Vieillard.* Not seen.
- 44*. **T. spinulosum**, Philippi, in Linnaea, XXX, 208. Chili, *Philippi.*
- 48*. **T. Filicula**, Bory. I cannot, from the description, separate **T. johnstoniense**, Bailey, Synops. Queensl. Plants, Suppl. 63.
49. **T. pyxidiferum**, L. I cannot separate **T. barnardianum**, Bailey, Synops. Queensl. Plants, Suppl. 3, 89, with figure.
- 49*. **T. jungermannioides**, Fourn. in Ann. Sc. Nat. sér. 5, XVIII, 258. New Caledonia, *Balansa*, 1632. Not seen.
- 52*. **T. Macgillivrayi**, Baker, n. sp. Rhizome filiform, wide-creeping. Stipe slender, filiform, under an inch long. Frond oblong-lanceolate, bipinnatifid, glabrous, $1\frac{1}{2}$ –2 in. long; rachis winged down to the base; pinnae crowded, oblong-lanceolate, sharply serrated; secondary segments small, oblong. Sori one to a pinna, placed near the base on the upper side; indusium with a campanulate tube, and sub-orbicular entire lips. Fiji, *Macgillivray.* Near the Bornean *T. denticulatum*, Baker.

- 53*. **Trichomanes venosum**, R. Br. I cannot separate **T. venustum**, Colenso, in Trans. New Zeal. Instit. XII, 366.
54. **T. crispum**, L. I can only separate as a variety **T. digitatum**, Sodiro, Recens. 4, non Swartz. It differs from the type by having the indusium protruded entirely from the lamina.
- 61*. **T. Hosei**, Baker, in Journ. Linn. Soc. XXII. 223, tab. 12. Sarawak, Borneo, *Bishop Hose*.
- 61*. **T. Beckeri**, Krause; Philippi, in Linnaea, XXXIII. 305. Chili. Habit of *Hymenophyllum dichotomum*.
- 63*. **T. Luersseni**, F. M.; Luerss., in Bot. Centralblatt, 1882, 440. Mountains of Aneiteum, *G. Braithwaite*.
70. **T. rigidum**, Sw. Surg. Halcro Johnston sends specimens connecting with this species *T. Hartii*, Baker, in Gard. Chron. 1882, II. 680, collected at Sierra Leone by the late Dr. W. Hart.
71. **T. apiifolium**, Presl. *Hymenophyllum*? **puellum**, Cesati, Fil. Polyn. Becc. 6, collected by Beccari on the mountains of New Guinea, is probably a form of this species.

POLYPODIACEAE.

I should like to separate Hymenophyllaceae from Polypodiaceae as a distinct sub-order, and divide the latter into four tribes as follows: viz. (1) Indusium none (e. g. *Acrostichum*, *Polypodium*); (2) Indusium formed only from the altered margin of the frond (e. g. *Adiantum*, *Pteris*); (3) Indusium formed in part from the altered margin of the frond, with an inner valve in addition (e. g. *Dicksonia*, *Lindsaya*); and (4) Indusium truly dorsal (e. g. *Aspidium*, *Asplenium*).

Genus 11. WOODSIA *R.Br.*

4. **W. lanosa**, Hook., must be omitted. It is identical with *Gymnogramme Andersoni*, Beddome, Fil. Brit. Ind. tab. 100.
6. **W. insularis**, Hance, must also be omitted. It is made up of a mixture of *W. ilvensis* and *manchuriensis*, as is shown by the type specimens, now at the British Museum.
- 6*. **W. Hancockii**, Baker, n. sp. Stipes densely tufted, 1-1½ in. long; paleae ovate or lanceolate, pale brown. Frond lanceolate, bipinnatifid, 2-3 in. long, ½ in. broad; rachis slender, stramineous, naked; pinnae deltoid, ¼ in. long, cuneate at the base, toothed on the outer edge; lower lobes cuneate. Veins few,

- distinct. Sori 2 to the lower pinnae; indusium small, with a fimbriate edge. Siao-wu-tai, Pekin, *Hancock* (Herb. Hance). Habit of dwarf forms of *polystichoïdes*; sori of *glabella*; stipe and rachis stramineous, not castaneous.
12. **W. obtusa**, Torrey. I cannot separate as a species **W. Plummerae**, Lemmon, in Coulter, Bot. Gazette, VII. 6, from Southern Arizona.
- 12*. **W. pusilla**, Fourn., in Bull. Soc. Bot. France, 1880, 329. Mexico, *Schaffner*. Not seen.

Genus 13. *DICKSONIA* L'Hérit.

- 7*. **D. fibrosa**, Colenso. I cannot separate specifically **D. sparmaniana**, Colenso, in Trans. New Zeal. Instit. 1879, 363, nor **D. microcarpa**, Colenso, in Trans. New Zeal. Instit. 1888, 214. The Chatham Island *Dicksonia* is said to be intermediate between the Australian *antarctica* and New Zealand *fibrosa*.
- 7*. **D. Lathamii**, Moore, in Gard. Chron. 1885, vol. II, 584. A plant raised by Mr. W. G. Latham, in the Birmingham Botanic Garden. Intermediate between *arborescens* and *antarctica*.
10. **D. squarrosa**, Sw. I cannot separate specifically **D. gracilis**, Colenso, in Trans. New Zeal. Instit. 1882, 306.
- 11*. **D. Baudouini**, Fourn., in Ann. Sc. Nat. sér. 5, t. 18, p. 347. New Caledonia, *Baudouin*. Allied to *D. berteroaana* and *Deplanchei*. Not seen.
- 18*. **D. ampla**, Baker, in Journ. Linn. Soc. XXII. 223. Sarawak, Borneo, *Bishop Hose*.
- 18*. **D. Pearcei**, Baker, n. sp. Rootstock not seen. Stipe long, naked, castaneous. Frond oblong-deltoid, tripinnate, a foot long, moderately firm, glabrous above, hairy on the ribs beneath; lower pinnae the largest, subdeltoid; pinnules sessile, lanceolate, cut down to the rachis into oblong obtuse entire tertiary segments, $\frac{1}{3}$ – $\frac{1}{6}$ in. broad. Veins of tertiary segments few, distinct; lower veinlets forked. Sori not more than one to each tertiary segment; indusium campanulate, coriaceous, with a truncate mouth. Eastern Andes of Ecuador, alt. 8000–9000 feet, *Pearce*, 251. Very distinct.
- 18*. **D. pubescens**, Baker, in Journ. Bot. 1881, 203. New Granada, province of Antioquia, alt. 6500 feet, *Kalbreyer*.

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- 18*. *Dicksonia Sprucei*, Baker, in Journ. Bot. 1877, 162. Andes of Ecuador, *Spruce*.
- 18*. *D. vagans*, Baker, in Journ. Bot. 1877, 162. Andes of Quito, *Sodiro*; Andes of Peru, *Barclay*.
- 19*. *D. incurvata*, Baker, in Journ. Bot. 1879, 294. Fiji Islands, *Horne*, 971.
- 20*. *D. antillensis*, Jenman, in Journ. Bot. 1886, 267. Mountains of Jamaica, *Morris*, *Sherring*. Allied to the divided forms of *D. cicularia*.
- 20*. *D. glabrata*, Cesati, Fil. Polyn. Becc. 6. Rootstock wide-creeping. Stipe 3-4 ft. long, stout, glossy, castaneous, naked, muricated. Fronds oblong-deltoid, 3-4 ft. long, glabrous, decomposed; many lower pinnae lanceolate-deltoid, a foot long; pinnules lanceolate-acuminate, tertiary segments free, lanceolate-deltoid, produced on the upper side, obtusely toothed. Veinlets distant, erecto-patent. Indusium cup-shaped. New Guinea, *Beccari*.
- 21*. *D. lambertiana*, Remy, in C. Gay, Fl. Chil. VI. 523. Rootstock not seen. Stipe long, stout, naked, stramineous. Frond lanceolate-deltoid, decomposed, 1½-2 ft. long, glabrous on both surfaces; rachis stramineous, without any hairs or scales; pinnae crowded, lanceolate, lowest the largest, a foot long; pinnules deltoid, cuneate-truncate on the lower side at the base, produced on the upper side; tertiary segments lanceolate, deeply pinnatifid, in the largest pinnules ¼-½ in. long. Sori small, only one to each lobe; indusium 2-lobed; valves broader than long. Andes of Chili, *Bonpland*, *Philippi*, *Ball*. Most resembles *D. davallioides* in the cutting of the final divisions.
- 23*. *D. gomphophylla*, Baker, in Journ. Linn. Soc. XXII. 223. Borneo, mountains of Sarawak, alt. 2000 feet, *Bishop Hose*.
24. *D. davallioides*, var. *Youngii*, Moore. Rootstock epigeaeous, stipes contiguous, an inch thick at the base. Australia. Has been cultivated at Kew for many years.
27. *D. Elwesii*, Baker. Better specimens, received from Mr. H. C. Levinge in 1885, show that this is not more than a marked variety of *D. appendiculata*, Wall.
- 29*. *D. rhombifolia*, Baker, in Journ. Bot. 1890, 105. New Guinea, near the summit of the Owen Stanley range, *Sir W. Macgregor*.

Genus 14. *DEPARIA* Hook. et Grev.

1. **D. prolifera**, Hook. A plant lent to us by Sir F. Mueller, from Illawarra, New South Wales, will probably prove to be specifically distinct from the Hawaiian type. It has narrow segments, and smaller less exerted sori. I believe that only a single specimen has been seen.
3. **D. Godefroyi**, Lueres., in Fil. Graef. 222, T. 19 (under *Dennstaedtia*). Fiji Isles, *Graeffe*, 54. Habit and cutting of *Nephrodium cicutarium*; veins forming copious areolae with branched free included veinlets.

Genus 14*. *LECANOPTERIS* Blume.

I now think this will have to stand as a distinct genus in the neighbourhood of *Dicksonia*, from which it differs by having the indusium formed from a single valve, and curious tuberous rootstock, with species as follows, viz. :—

1. **L. carnosa**, Blume, Fil. Jav. tab. 94 A. Perak and Philippine and Malay Isles.
2. **L. pumila**, Blume, Fil. Jav. tab. 94 B. Malay Isles.
3. **L. Macleayii**, Baker, n. sp. Rootstock not seen. Stipe short, naked. Frond lanceolate, glabrous, moderately firm, above a foot long, 4–5 in. broad, cut down to a narrowly-winged rachis with many linear obtuse crenate pinnae, $\frac{1}{4}$ – $\frac{1}{3}$ in. broad. Sori distant, many to a pinnae; indusium very small, orbicular, convex. Java, *Macleay*.
4. **L. Curtisii**, Baker, in Hook. Icones, tab. 1607. Sumatra, *Curtis*.
5. **L. deparioides**, Baker, in Journ. Bot. 1881, 366. *Davallia deparioides*, Cesati, Fil. Becc. Born. 13, tab. 4, fig. 8. Rootstock tuberous, as in the other species, produced into short phyllo-podes articulated at the top. Stipe naked, substramineous, 6–8 in. long. Frond lanceolate, membranous, glabrous, simply pinnate, 1½–2 ft. long, 3–4 in. broad; rachis winged only at the top; pinnae sessile, linear, obtuse, $\frac{1}{3}$ in. broad, narrowed towards the base; barren entire; fertile crenate, with a sorus at the tip of each lobe. Venation of *Phymatodes*. Indusium as in the other species, consisting of a cup, formed from the edge of the frond, holding a small globose sorus. Borneo, Sarawak, *Beccari*.

Genus 18. *DAVALLIA* Smith.

Subgenus *Humata*.

- 4* *D. pinnatifida*, Baker, in Journ. Bot. 1886, 257. Sarawak and Borneo, *Bishop Hose*. Intermediate between *pectinata* and *pedata*.
6. *D. pedata*, Smith. Further material appears to indicate that 7 *D. alpina*, Blume, 9 *D. vestita*, Blume, and 10 *D. Cumingii*, Hook. (*D. lepida*, Presl) are not more than varieties of *pedata*.
- 9* *D. Tyermanni*, Baker, in Hook. Ic. tab. 1620. Locality not West tropical Africa, as was supposed when the plant was first described by Moore from garden specimens, but Central China, where it has been collected by *Maries*, *Everard*, and *Hancock*.

Subgenus *Leucostegia*.

- 13* *D. oligophlebia*, Baker, in Journ. Bot. 1888, 323. Sarawak, Borneo, *Bishop Hose*.
- 16* *D. Kingii*, Baker, in Hook. Ic. tab. 1622. Mountains of Java, *H. O. Forbes*, 657.
- 16* *D. nephrodioides*, Baker, in Journ. Bot. 1886, 257. Sarawak, Borneo, *Bishop Hose*.
17. *D. Clarkei*, Baker, in Hook. Ic. tab. 1625. I cannot separate specifically the Yunnan *D. Delavayi*, Beddome MSS.; Clarke and Baker, in Journ. Linn. Soc. XXIV, 410.
- 17* *D. Hosei*, Baker, in Journ. Bot. 1888, 323. Sarawak, Borneo, *Bishop Hose*.
- 22* *D. bipinnata*, F. M., in Benth., Fl. Austral. VII. 717 = *Leptolepia bipinnata*, Kuhn, Choetop. 28. Queensland, *Walter Hill*, and regathered lately at a height of 5000 feet by *Sayer* and *Davidson*.
- 22* *D. aspidioides*, Baker; *Leptolepia aspidioides*, Mett.; Kuhn, Choetop. 28, tab. 2, figs. 1-3. New Caledonia, *Vieillard*, 1612.
- 22* *D. Andersonii*, Baker; *Leptolepia Andersonii*, Mett.; Kuhn, Choetop. 28, tab. 2, figs. 12-14. Honolulu, *Anderson*.
- 23* *D. athyriifolia*, Baker, n. sp. Rootstock not seen; stipe 2 ft. long, with a few lanceolate membranous dull brown paleae at the base. Frond oblong-deltoid, decomposed, glabrous, 1½-2

- ft. long; lower pinnae oblong-lanceolate, 6-8 in. long; pinnules oblong-lanceolate, cut down to the rachis into oblong obtuse deeply pinnatifid tertiary segments, with oblong lobes. Veins of ultimate segments simple or forked. Sori generally solitary at the base of each final lobe; indusium minute, membranous. Yunnan, *Delavay*. Near *D. nodosa*, Hook.
- 23*. **D. Macgillivrayi**, Baker; *Leucostegia Macgillivrayi*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 344. New Caledonia, *Macgillivray*. Not seen.
- 23*. **D. maxima**, Baker; *Leucostegia maxima*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 344. New Caledonia, *Balansa*, 1593. Not seen.
- 24*. **D. cicutarioides**, Baker, in Journ. Bot. 1890, 106. Mount Musgrave, New Guinea, *Sir W. Macgregor*.

Subgenus **Odontoloma**.

- 28*. **D. Hornei**, Baker, Fl. Maurit. 470. Seychelles, *Horne*.

Subgenus **Eudavallia**.

- 34*. **D. plumosa**, Baker, in Journ. Bot. 1876, 10. Samoa, *Whitmee*.
- 36*. **D. Graeffei**, Luers. Fil. Graef. 211, tab. 18. Samoa, *Powell*, 168, *Graeffe*, 227.
- 37*. **D. stenoloba**, Baker, in Becc. Malesia, III. 35. Amboyna, *Beccari*.
- 39*. **D. aretotheca**, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 339. New Caledonia, *Balansa*, 852. Not seen.
40. **D. pallida**, Mett.; Baker, in Hook. Ic. tab. 1624. I cannot separate specifically **D. beccariana**, Cesati, Becc. Fil. Born. 14, tab. 3, fig. 6.
- 45*. **D. Tasmani**, Cheeseman; Field, Ferns New Zeal. 75, tab. 24, fig. 5. Kermadec Isles, *Cheeseman*. Near *pyxidata* and *canariensis*. One of the very few endemic plants of this small group of islands.
- 47*. **D. Mariesii**, Moore herb. Rootstock stout, wide-creeping; paleae brownish, lanceolate from a dilated base. Stipe naked, shorter than the frond. Fronds deltoid, decompose, evergreen, moderately firm, glabrous, 4-6 in. long and broad; pinnae cut away on the lower side at the base; lower much the largest, deltoid, produced on the lower side; pinnules

deltoid, cut away on the lower side at the base; final segments short, linear, 1-nerved. Sori distinctly intramarginal; indusium small, campanulate. Mountains of Japan, *Maries*, in Hort. Veitch, 1878. To be compared with the varieties of *bullata*.

- 49*. *Davallia Veitchii*, Baker, in Journ. Bot. 1879, 39. Kina-balu, Borneo, alt. 6000-7000 ft. *Burbridge*.

Subgenus *Microlepia*.

- 50*. *D. phanerophlebia*, Baker, in Journ. Bot. 1890, 292. Tonquin, *Balansa*, 118.
- 51*. *D. Sloanei*, Jenm., in Journ. Bot. 1886, 37. Jamaica, *Herb. Sloane*. Cutting of *Dicksonia adiantoides*, fructification of *Davallia*.
52. *D. pinnata*, Cav. I cannot separate specifically *D. longipinnula* and *D. intramarginalis*, Cesati, Fil. Bec. New Guin. 7, gathered by Beccari on the mountains of New Guinea.
- 53*. *D. triangularis*, Baker, n. sp. Rootstock not seen. Stipe slender, fragile, naked, 6-8 in. long, brown towards the base, stramineous upwards. Frond deltoid, tripinnate, membranous, glabrous, 4-5 in. long and broad; lowest pinnae much the largest, oblong-deltoid; pinnules cut away on the lower side at the base; final segments oblong, $\frac{1}{2}$ - $\frac{1}{3}$ in. broad. Veins pinnate in the final segments; veinlets erecto-patent. Indusium campanulate, moderately firm, persistent. Yunnan, *Delavay*. Near *D. Wilfordii*, Baker, which has now been found in Korea and Northern China.
54. *D. hirsuta*, Sw., has been found by *Maries* in Kiu Kiang and by Hancock at Chefoo and Ningpo.
- 57*. *D. madagascariensis*, Baker = *Microlepia madagascariensis*, Moore, Ind. Fil. 318 = *Davallia calobodon*, Mett. = *Dicksonia hypolepidoides*, Baker, in Journ. Linn. Soc. XVI, 197. Has been gathered in Madagascar recently by Miss Helen Gilpin and Mr. J. T. Last. As regards fructification it stands on the boundary line between *Dicksonia* and *Davallia*. In cutting it closely resembles the common Indian *D. rhomboidea*, Wall.
- 58*. *D. Kurzii*, Clarke, in Trans. Linn. Soc. Bot. ser. 2, I, 446. Pegu, *Kurz*, 3236. Near *D. platyphylla*, Don.
- 62*. *D. moluccana*, Blume. I place as a variety, marked by its stout

muricated stipe, **D. asperrima**, Cesati, in Becc. Prosp. 6, gathered by *Beccari* in Amboina.

- 63*. **D. philippinensis**, Harringt., in Journ. Linn. Soc. XVI, 27. Mount Mahahuy, Philippines, *Steere*.

Subgenus **Stenoloma**.

- 70*. **D. odontolabia**, Baker, in Journ. Bot. 1884, 140. North-east Madagascar, *Humboldt*, 430. Near *D. goudotiana*, Kunze.
71*. **D. decomposita**, Baker, in Journ. Bot. 1884, 141. North-east Madagascar, *Humboldt*, 259.
71*. **D. flabellifolia**, Baker, in Journ. Linn. Soc. XV, 414. Central Madagascar, *Pool*.

Genus 19. **CYSTOPTERIS** *Bernh.*

1. **C. fragilis**, Bernh. I can only separate as geographical varieties **C. Novae Zealandiae**, Armstrong, in Trans. New Zeal. Instit. 1880, 360, and the Australian **Woodsia laetevirens**, Prentice.
1*. **C. japonica**, Luers., in Engl. Jahrb. 1883, 363. Kiu-siu Archipelago, *Tachiro*. Not seen.
4*. **C. moupinensis**, Franch., Pl. David. 149. Moupine, Tibet, *David*. Not seen. Perhaps identical with a plant collected twice by *Mr. H. E. James*, in his recent journey between Mukden and Kirin, which comes near the very rare European *C. sudetica*, A. Br. & Milde.

Genus 20. **LINDSAYA** *Dryand.*

Subgenus **Eulindsaya**.

1. **L. linearis**, Sw. I can only separate as a slight variety **L. trilobata**, Colenso, in Trans. New Zeal. Instit. 1883, 345.
1*. **L. incisa**, Prentice, in Journ. Bot. 1873, 295. Queensland, *Prentice, Bailey*.
1*. **L. dimorpha**, Bailey, Queensland Ferns, 19. **L. heterophylla**, Prentice, in Journ. Bot. 1873, 295, non Dryand. Queensland, *Prentice, Bailey*. This and the last are very near to *L. linearis*.
4*. **L. plicata**, Baker, in Journ. Linn. Soc. XXV, 350. North-east Madagascar, *Baron*, 5887, *Last*.

5. *Lindsaya concinna*, J. Sm. Not distinct specifically from *L. cultrata*, Sw.
- 5*. *L. jamesonioides*, Baker, in Journ. Bot. 1879, 39; Hook. Ic. tab. 1626. Kina-balu, Borneo, *Burbridge*.
- 7*. *L. oxyphylla*, Baker, in Journ. Bot. 1891, 3. North-east Madagascar, *Last*.
- 7*. *L. crispa*, Baker, in Journ. Bot. 1879, 39; Hook. Ic. tab. 1627. Borneo, *Burbridge*.
- 13*. *L. leptophylla*, Baker, in Journ. Bot. 1884, 141; Hook. Ic. tab. 1628. North-east Madagascar, *Humboldt*, 495.
- 16*. *L. madagascariensis*, Baker, in Journ. Linn. Soc. XVI, 198; Hook. Ic. tab. 1629. Madagascar. This runs down into a curious odontolomoid form, which bears the same relation to the type that *Davallia schizophylla* (Synopsis, edit. 2, p. 468) bears to *Lindsaya tenera*.
- 16*. *L. gomphophylla*, Baker, n. sp. Rootstock not seen. Stipe produced, naked, castaneous. Frond deltoid, rigid, glabrous, $\frac{1}{2}$ -ft. long, simply pinnate in the upper, bipinnate in the lower half; lower pinnae much the largest. Final segments orbicular-cuneate, $\frac{1}{2}$ -in. broad, deeply crenate round the outer edge, cuneate in the lower half. Veins simple, flabellate. Sori interrupted. Indusium narrow, rigid, persistent. Borneo, *Sir Hugh Low*. Allied to the New Caledonian *L. nervosa*, Mett.
- 17*. *L. prolongata*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 334. New Caledonia, *Balansa*, 1602. Not seen.
- 24*. *L. tricrenata*, Baker, in Journ. Bot. 1890, 106. Mount Musgrave, New Guinea, *Sir W. Macgregor*.

Subgenus *Isoloma*.

- 28*. *L. indurata*, Baker, in Journ. Bot. 1888, 324. Sarawak, Borneo, *Bishop Hose*.
- 31*. *L. flavicans*, Mett.; Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 334. New Caledonia. Not seen.
- 31*. *L. exilis*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 335. New Caledonia, *Vieillard*, *Balansa*. Not seen.
- 31*. *L. campylophylla*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 335. New Caledonia, *Balansa*, 854. Not seen.
- 31*. *L. Balansae*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 335. New Caledonia, *Balansa*, 1652. Not seen.

- 31*. **L. mediocris**, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 336.
New Caledonia, *Balansa*. Not seen.
- 32*. **L. viridis**, Colenso, Fil. Nov. New Zeal. 14. New Zealand.
Allied to *L. microphylla*, Sw., from which it differs by much
closer regularly cuneate final segments, and sub-davallioid sori.

Subgenus **Synaphlebium**.

37. **L. lobata**, Poir. I cannot separate specifically **L. ambigens**,
Cesati, Fil. Becc. Polyn.

Subgenus **Diellia**.

The late Dr. Hillebrand, in his recently-published Flora of the Hawaiian Islands, has fully re-described the species and varieties of this curious subgenus, which is peculiar to the Sandwich Islands. To the species in our *Synopsis Filicum* he adds the following, viz :—

- L. centifolia**, Hillebr. p. 621.
L. laciniata, Hillebr. p. 621, with 2 varieties.
L. Alexandri, Hillebr. p. 622, with 3 varieties.
L. Knudsenii, Hillebr. p. 623, with a variety.

Genus 21. **ADIANTUM** *Linn.*

Kuhn, in Jahrb. Berlin. Bot. Gart. vol. I. p. 337, has published a valuable monograph of this genus. He characterises briefly 113 species, many of which are dealt with as varieties in the *Synopsis Filicum*. He proposes two subgenera, viz.—(1) *Euadiantum*, sporangia confined to the veins; and (2) *Adiantellum*, sporangia occupying the intervening parenchyma as well as the veins.

1. **A. reniforme**, L. Besides the type, which inhabits Madeira and the Canaries, and var. *asarifolium*, Willd., which inhabits Mauritius and Bourbon, a third subspecies, *crenatum*, Baker, has lately been found by Mr. J. T. Last in the North-East of Madagascar. It differs from the others by its more distant sori and crenate edge of the frond.
- 3*. **A. Balfourii**, Baker, in Hook. Ic. tab. 1630. Socotra, *Balfour*.
Differs from all the forms of *lunulatum* by its equilateral shortly-petiolate pinnae.
- 3*. **A. Balansae**, Baker, in Journ. Bot. 1890, 262. Tonquin, *Balansa*, 134. Near the African *A. Mettenii*, Kuhn.

- 3*. ***Adiantum Pearcei***, Philippi, in *Linnaea*, XXXIII, 304. Andes of Chili, *Pearce*. Near *A. pumilum*, Sw. Not seen.
- 3*. ***A. Gravesii***, Hance, in *Journ. Bot.* 1875, 197 = ***A. Mariesii***, Baker, in *Gard. Chron.*, N. S. XIV, 494. Central China, *Lamont*, *Maries*. Simply pinnate frond like dwarf *lumulatum*; segments like those of *monochlamys*.
- 3*. ***A. ruizianum***, Klotzsch.; Hook. *Sp. Fil.* II, 10. Stipe naked, castaneous, 6-9 in. long. Frond lanceolate, simply pinnate, 6-8 in. long, 2-2½ in. broad, firm, glabrous. Pinnae 1-1½ in. broad; end one deltoid; side ones suborbicular, broader than long; lower margin straight; all the rest crenate; petiole of lower pinnae ½-1 in. long. Sori orbicular, placed all round the pinnae except the base. Peru, *Pavon*. Near *A. grossum*, Mett., but pinnae smaller, with longer stalks, and sori and indusia orbicular. Described from a type specimen kindly lent by Mr. H. C. Levinge.
- 5*. ***A. amelianum***, Glaziou; Baker, in *Journ. Bot.* 1882, 309. South Brazil, *Glaziou*, 12,280. Doubtfully distinct from *A. rhizophyllum*, Schrad.
- 7*. ***A. Kaulfussii***, Willd. and 8, ***A. obliquum***, Willd. are best considered as two varieties of *A. platyphyllum*, Sw.
- 12*. ***A. Glaziovii***, Baker, in *Journ. Bot.* 1882, 309. South Brazil, *Glaziou*, 13,345. Intermediate between *intermedium* and *obtusum*.
- 13*. ***A. Steerei***, Harringt., in *Journ. Linn. Soc.* XVI, 34. Pona Cocha, Andes of Peru, *Steere*.
15. ***A. diaphanum***, Blume. ***A. heteromorphum***, Colenso; Field, *Ferns New Zeal.* 80, is a variety, and I cannot separate specifically ***A. polymorphum*** and ***A. tuberosum***, Colenso, in *Trans. New Zeal. Instit.* 1888, 215-217.
- 15*. ***A. monosorum***, Baker, in Hook. *Ic. tab.* 1633. Solomon Isles, *Herb. Macleay*.
- 16*. ***A. Hosei***, Baker, in *Journ. Bot.* 1888, 324. Borneo; pendulous on limestone cliffs, Sarawak, *Bishop Hose*. Near *affine*.
16. ***A. affine***, Willd., var. *intermedium*, Benth., *Fl. Austral.* VII, 725, Queensland and N. S. Wales, differs from the New Zealand type by its transversely oblong sori; var. *chathamicum*, Field, *Ferns New Zeal.* 81, Chatham Island, is less compound than

- the type with longer final segments. See also var. *heterophyllum*, Colenso, in Trans. New Zeal. Instit. 1888, p. 218.
- 16*. **A. Hornei**, Baker, in Journ. Bot. 1879, 294. Fiji, *Horne*, 560. Near *affine*.
- 22*. **A. dioganum**, Glaziou; Baker, in Journ. Bot. 1882, 310. South Brazil, *Glaziou*. Between *crisatum* and *villosum*.
- 27*. **A. Novae-Caledoniae**, Keyserl. Monogr. Adiant. 4. New Caledonia. Introduced into cultivation in 1883, by Messrs. W. and J. Birkenhead. Near *A. fulvum*.
- 31*. **A. pilosum**, Baker, n. sp. Stipe 2 ft. long, black, glossy, and naked below the top. Frond deltoid, bipinnate, a foot long and broad; rachises densely pilose. Segments crowded, rhomboid, entire on the lower and inner, toothed on the upper and outer edges, the central an inch long, $\frac{1}{2}$ in. broad. Sori round, one placed at the tip of each lobe on the upper margin of the segments. Indusia round, persistent, $\frac{3}{4}$ in. diam. New Granada, *Kalbreyer*, 956. Near *A. tetraphyllum*, Willd.
41. **A. Capillus-veneris**, L. **A. Fergusonii**, Moore, in Gard. Chron. 1884, II, 360; and **A. Mairisii**, Moore, in Gard. Chron. 1885, II, 294 (*A. Roperi*, Hort.), are forms of garden origin, probably derived from this species.
- 41*. **A. Levingei**, Baker, n. sp. Stipe slender, castaneous, $\frac{1}{2}$ ft. long. Frond deltoid, 2-3-pinnate, glabrous, 8-12 in. long; lower pinnae much the largest. Final segments: terminal cuneate, $\frac{1}{3}$ - $\frac{1}{2}$ in. broad, deeply 2-3-lobed on the upper margin, with a sorus at the base of a sinus in the centre of each lobe; lateral segments subrhomboid, distinctly petioled. Indusium firm, glabrous, orbicular-reniform, $\frac{1}{12}$ in. diam. Sikkim, Chintang, alt. 3000 ft., *Levinge*. Cutting of *Capillus-veneris*; sori and indusium of *venustum*.
- 41*. **A. Schaffneri**, Fourn., in Bull. Soc. Bot. France, 1880, 328. Mexico, *Schaffner*. Not seen.
- 42*. **A. hians**, Moore, in Gard. Chron. 1887, I, 41. Stipe elongate, slender, castaneous. Frond membranous, deltoid, tripinnate, glabrous, a foot long. End segments cuneate; lateral rhomboid, $\frac{1}{3}$ - $\frac{1}{2}$ in. broad, deeply lobed on the outer edge. Sori only 1-2 to a segment. Sinus deep. Indusium large, reniform. New Caledonia and Fiji, *Herbert*.
- 42*. **A. Williamsii**, Moore, in Gard. Chron. 1878, II, 44, fig. 4.

Habit slightly sarmentose. Rachises brown-black, quite glabrous. Frond deltoid, tripinnate, $1\frac{1}{2}$ –2 ft. long, tinged with sulphur when young. Pinnæ deltoid, the lowest the longest. Rachis flexuose upwards. Final segments $\frac{1}{2}$ – $\frac{3}{4}$ in. broad, all distinctly stalked, the end one cuneate, the lower side ones rounded or nearly truncate at the base. Sori 3–5 to a segment, roundish or broader than deep. Andes of Peru, alt. 12,000 ft. Near *aethiopicum*.

- 42*. **Adiantum neo-guineense**, Moore, in Gard. Chron. 1887, I, 12. Stipe naked, castaneous, 6–8 in. long. Frond deltoid, tripinnate, glabrous, above a foot long and broad. Rachises very slender, glabrous, nearly black. End segments cuneate; lateral trapezoid, $\frac{1}{2}$ in. long, cuneate. Sori orbicular, 3–4 to a segment, placed in deep sinuses. New Guinea, *Goldie*. Recedes from *aethiopicum* in the direction of *tenerum*.
43. **A. excisum**, Kunze. **A. Pacotti**, Hort. and **A. Weigandii**, Moore, in Gard. Chron. 1883, II, 748, are forms of garden origin, probably derived from this species.
- 45*. **A. Wagneri**, Mett. (*A. decorum*, Moore). **A. elegans**, Moore, in Gard. Chron. 1886, I, 200; **A. cyclosorum**, Moore, in Gard. Chron. 1887, I, 547; and **A. Oweni**, Moore, in Gard. Chron. 1887, I, 110, are forms of garden origin nearly allied to this species.
46. **A. tenerum**, Sw. **A. Lathomi**, **Gheisbreghtii**, **Scutum**, **Farleyense**, **Victoriae**, **Bausei**, **rhodophyllum**, and **Princeps**, of gardens, are probably all of them derived from this species.
- 46*. **A. Collisii**, Moore, in Gard. Chron. 1886, I, 681. A form of garden origin which appears to be intermediate between *tenerum* and *cuneatum*.
47. **A. cuneatum**, L. & F. **A. festum**, **fragrantissimum**, **Waltoni**, **Dadsii**, **aemulum**, **gracillimum**, and **mundulum**, of Moore, appear to be varieties of this species.
- 47*. **A. bellum**, Moore, in Gard. Chron. 1879, I, 172, Fig. 24. Bermuda, *Lefroy*, *Moseley*. Intermediate between *cuneatum* and *aethiopicum*.
- 47*. **A. Paradiseæ**, Baker, in Gard. Chron. 1889, II, 558. Bedford, Cape Colony, *Miss Paradise*.
- 48*. **A. Cooperi**, Baker, in Journ. Bot. 1887, 25. Costa Rica, *Cooper*. Near *glaucophyllum*, Hook.

- 50*. **A. Wattii**, Baker, in Journ. Linn. Soc. XVIII, 381, tab. 14a, Figs. 1-2. Chumba, *Watt*.
- 50*. **A. Davidi**, Franchet, Pl. David. II, 150. Moupine, Tibet, *Père David*.
- 51*. **A. Faberi**, Baker, in Journ. Bot. 1888, 225. Mt. Omei, West China, alt. 3000 ft., *Faber*, 1033.
- 51*. **A. Senae**, Baker, in Journ. Bot. 1885, 217. South Brazil, *Glaziou*, 15,723. Intermediate between *tremulum* and the small forms of *cuneatum*.
- 51*. **A. Roborowskii**, Maxim. Mel. Biol. XI, 867. West China; Kansu, *Przewalski*. Allied to *monochlamys* and *Gravesii*.
- 56*. **A. Oatesii**, Baker, in Oates, Matebeleland, App. with Figure. Matebeleland, *Oates*. Very near *pedatum*.
57. **A. hispidulum**, Sw. *A. Birkenheadii*, Moore, in Gard. Chron. 1886, I, 648. appears to be a variety of this species.
- 58*. **A. rigidum**, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 329. New Caledonia, *Balansa*, 50, 2689. Not seen.
- 58*. **A. stenochlamys**, Baker, n. sp. Stipe long, naked, wiry, nearly black. Frond pedate, tripinnate, deltoid, firm, glabrous, 6-9 in. long and broad. Final segments: terminal cuneate, $\frac{1}{2}$ - $\frac{3}{4}$ in. broad, shallowly lobed, and crenate round the upper half; lateral subrhomboid, shortly petioled, little longer than broad, with the inner edge inflexed so that it is imbricated over the rachis; upper and outer edge shallowly lobed and crenate. Sori 6-8 to a fully-developed segment, $\frac{1}{8}$ in. long. Indusium firm, narrow. British North Borneo; Kudat, *Dr. Fraser*. Pulo Gaya, *Sir H. Low*.

Genus 23. LONCHITIS *Linn.*

- 1*. **L. Polypus**, Baker, in Journ. Linn. Soc. XV, 414. Madagascar, *Pool, Hildebrandt*.

Genus 24. HYPOLEPIS *Bernh.*

- 13*. **H. meifolia**, Baker; *Cheilanthes meifolia*, Eaton, in Proc. Amer. Acad. XVII, 185. Mexico, *Parry & Palmer*. Closely allied to *H. californica*.

Genus 25. CHEILANTHES Sw.

Subgenus **Adiantopsis**.

- 1*. **C. Fordii**, Baker, in Journ. Bot. 1879, 304. Canton, *Ford*.
- 6*. **C. Duthiei**, Baker, n. sp. Stipes densely tufted, castaneous, glabrous, 1-1½ in. long, with a few paleae towards the base. Frond oblong-deltoid, membranous, glabrous, 2 in. long, green on both surfaces. Pinnæ oblong-deltoid, sessile: lowest the largest, produced on the lower side. Pinnules oblong, ¼-⅓ in. broad. Sori placed all round the edge of the pinnules, usually orbicular, rarely confluent. Indusium grey, glabrous, orbicular-reniform, persistent. British Garwhal, *Duthie*, 5144. Cutting of *C. subvillosa*, but indusium of this subgenus.
11. **C. Schimperii**, Kunze. Has been gathered in the Usugura Mountains by the late *Bishop Hannington* and in the Shiré Highlands by *Mr. J. T. Last*. Known before only in Abyssinia.
- 12*. **C. Reesii**, Jenm., in Journ. Bot. 1886, 267. Jamaica, *Rev. J. L. Rees*. Cutting of *C. microphylla*; sori and indusium of this subgenus.
- 13*. **C. madagascariensis**, Baker, in Journ. Linn. Soc. XVI, 198. Madagascar, *Miss Helen Gilpin*.

Subgenus **Eucheilanthos**.

- 15*. **C. depauperata**, Baker, n. sp. Stipes densely tufted, wiry, castaneous, naked, 3-4 in. long. Frond lanceolate, bipinnate, rigid, 4-6 in. long, ¼-⅓ in. broad, green and glabrous on the upper surface; rachis castaneous, scabrous, viscose. Pinnæ numerous, small, deltoid, with many linear lobes with strongly recurved edges. Sori hidden by the recurved margin. Cape Colony; Central Karroo region, *Sir H. Barkly, Bolus*.
- 16*. **C. monocloviensis**, Baker, n. sp. Stipes naked, tufted, castaneous, 3-4 in. long. Frond deltoid, tripinnate, glabrous, 2-3 in. long, moderately firm, green and naked on both sides. Lower pinnæ the largest, deltoid; rachises castaneous, furnished with many ovate or lanceolate pale membranous paleae. Final segments obovate-cuneate, ⅙-⅓ in. broad. Indusium broad, rigid, glabrous. North Mexico; Coahuila

- and Nuevo Leon, 1880, *Palmer*, 1378. Near *C. fragrans*, Sw.
17. **C. arabica**, Decaisne. Somali-land, *Hildebrandt*, 1489.
- 18*. **C. Cooperae**, Eaton, Ferns North Amer. 7, tab. 2, fig. 1. California and North Mexico.
- 18*. **C. Streetiae**, Baker; *Notochlaena Streetiae*, Baker, in Journ. Linn. Soc. XVI, 204. Madagascar, *Mrs. Street*. Habit and texture of the small forms of *Hypolepis bergiana*.
- 19*. **C. heterotricha**, Anders., in Eugen. Reise, 40. Charles Island, Galapagos group. Near *C. Macleanii*, Hook. Not seen.
- 22*. **C. Delavayi**, Baker, n. sp. Stipes tufted, hairy, castaneous, 5-6 in. long. Frond deltoid or oblong-deltoid, tripinnatifid, $\frac{1}{2}$ ft. long, 2-3 in. broad, moderately firm, green on both surfaces, finely pubescent. Lower pinnae the largest, deltoid, petioled. Pinnules deltoid, $\frac{1}{2}$ - $\frac{3}{4}$ in. broad, cut down nearly to the rachis into contiguous oblong lobes. Indusium continuous, rigid, drab-brown, crenate. Yunnan, *Delavay*.
- 23*. **C. trichophylla**, Baker, n. sp. Stipes tufted, pubescent, brown, 4-5 in. long. Frond oblong-lanceolate, tripinnate, moderately firm, densely pilose, a foot long, 3-4 in. broad; main rachis flexuose. Pinnae deltoid or oblong-deltoid, the longest 2 in. long, mostly patent or even rather deflexed; final segments linear-oblong, $\frac{1}{8}$ - $\frac{1}{6}$ in. long. Indusium broad, pale, persistent. Yunnan, *Delavay*.
- 24*. **C. Pringlei**, Davenport, in Bull. Torrey Club, 1883, 61, tab. 34. Mountains of South-East Arizona, *Pringle*.
- 24*. **C. longipila**, Baker, n. sp. Stipes tufted, wiry, brown, 1-4 in. long, densely clothed with long soft white hairs, as are the rachis and lamina. Fronds oblong-lanceolate, tripinnate, 3-4 in. long. Pinnae lanceolate-deltoid, rather ascending, more produced on the lower side. Ultimate segments oblong, crenate-pinnatifid, subbullate, under $\frac{1}{2}$ line broad. Sori round, very minute, finally confluent. Central Mexico, 6000-8000 ft., *Parry & Palmer*, 989. Near *C. viscosa*, Kaulf., but hairs longer, not glandular, and fronds oblong-lanceolate, not deltoid.
- 26*. **C. Clelandi**, F. M. & Tate, in Trans. Roy. Soc. South Austral. 1887. South Australia: west of Spencer gulf. Habit of *Pellaea pilosa* and *Bojeri*. Not seen.

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- 27*. **Cheilanthes Thwaitesii**, Mett. An earlier name is *C. laxa*, Moore, Ind. Fil. 245.
- 28*. **C. patula**, Baker, in Journ. Bot. 1888, 225. Western China, *Dr. A. Henry*, 3998. Near *C. subvillosa*, Hook.
- 28*. **C. Kramerii**, Franch. et Savat., Enum. Jap. III, 619. Japan. Near *C. subvillosa*. Not seen.
- 29*. **C. albomarginata**, Clarke, in Trans. Linn. Soc. Bot. ser. 2, I, 456, tab. 52. Eastern Himalayas. Cutting of *C. farinosa*, but denuded, with white-edged paleae. Beddome now places *C. Dalhousiae*, Hook. as a variety of *farinosa*.
34. **C. tenuifolia**, Sw. It seems impossible to draw any definite line of demarcation between *tenuifolia* and *Sieberi*. I cannot separate specifically **C. Kirkii**, Armst., in Trans. New Zeal. Instit. 1880, 36, non Hook.; **C. javensis**, Moore, Ind. Fil. 244; **Pteris alpina**, Field, Ferns New Zeal. 97, tab. 98, fig. 3; nor **C. exilis**, Moore & Houlston.
- 34*. **C. viscida**, Davenport, in Bull. Torrey Club, VI, 192. Sierra Nevada, California.

Subgenus **Physapteris**.

- 35*. **C. flexuosissima**, Baker, n. sp. Stipes densely tufted, castaneous, naked, $\frac{1}{2}$ ft. long. Frond deltoid, decomposed, 3-4 in. long, fragile, membranous, glandulose-puberulent on both surfaces. Segments round or obovate, bullate, $\frac{1}{2}$ line broad, flabellately toothed in the upper half. Sori placed all round the segments except the base. Indusium continuous, scariose. South Brazil, *Glaziou*, 7482.
- 36*. **C. recurvata**, Baker, in Journ. Bot. 1878, 299. Paraguay, *Balansa*, 35. Near *C. regnelliana*, Mett.
- 37*. **C. Bolusii**, Baker, in Hook. Ic. tab. 1636. Cape Colony: South Western province, *Bolus*, 2801. Near *C. induta*, but 4-pinnatifid, with a black rachis and stipe and small round bullate segments.
- 38*. **C. Parishii**, Davenport, in Bull. Torrey Club, VIII (1881), 61, tab. 8. California, *W. P. Parish*.
- 43*. **C. albida**, Baker, n. sp. Stipes tufted, wiry, slender, slightly scaly, 2-5 in. long. Frond oblong-lanceolate or oblong-deltoid, tripinnate, 2-3 in. long, densely white-hairy on both surfaces, with densely imbricated bright brown paleae on the midribs of

- the pinnae and pinnules beneath. Pinnae lanceolate-deltoid, the central $\frac{1}{2}$ - $\frac{3}{4}$ in. long; tertiary segments small, round, bullate. Central Mexico, *Parry & Palmer*, 999.
- 43*. *C. Clevelandii*, Eaton, *Ferns North Amer.* 89, tab. 12, fig. 2. California.
- 43*. *C. cinnamomea*, Eaton, in *Proc. Amer. Acad.* XVII, 186. *Myriopteris rufa*, Fée. Mexico, *Schaffner*, 91.
- 47*. *C. intermedia*, Baker; *Myriopteris intermedia*, Fourn., in *Bull. Soc. Bot. France*, 1880, 328. Mexico, *Schaffner*.
- 48*. *C. peruviana*, Baker; *Plecosorus peruvianus*, Fée, *Gen. Fil.* 195. Stipes brown, tufted, nearly naked, 6-8 in. long. Frond oblong-lanceolate, bipinnate, a foot long, subrigid, green and glabrous on the upper surface, densely paleaceous beneath. Pinnae many, lanceolate, $1\frac{1}{2}$ -2 in. long, cut down to the midrib into oblong crenate pinnules with much inflexed edges. Sori filling up nearly the whole under surface of pinnules. Peru, *Pavon*. Very distinct.
53. *C. farinosa*, Kaulf. For an account of the Indian forms see Mr. H. F. Blanford's paper on the Silver Ferns of Simla, read before the Simla Natural History Society, June 25, 1886. I cannot separate specifically *C. anceps* and *C. grisea*, there described, nor from the descriptions, the Mexican *Aleuritopteris Schaffneri*, Fourn. in *Bull. Soc. Bot. France*, 1888, 328; nor the Japanese *C. Brandtii*, Franch. et Savat. *Enum. Jap.* II, 620.
- 53*. *C. Palmeri*, Eaton, in *Proc. Amer. Acad.* XXII, 464. Jalisco, Mexico, *Palmer*, 223.

Genus 30. PELLAEA *Link.*

- 12*. *P. cambodiensis*, Baker, n. sp. Stipes densely tufted, slender, castaneous, naked. Frond glabrous, chartaceous, lanceolate-deltoid, 2-3 in. long, an inch broad, bipinnatifid or bipinnate. Pinnae 5-6-jugate below the pinnatifid apex, the lowest the longest, produced on the lower side, subdeltoid, broadly obtusely lobed. Veins free, branched. Indusium pale, glabrous. Cambodia, *Godefroy-Lebeuf*, 860. Habit of *P. nitidula*, much less compound.
- 13*. *P. Riedelii*, Baker, n. sp. Habit of *P. burkeana*. Frond rigid, bipinnate. Segments linear, with enrolled margins. Central Brazil, *Riedel*.

15. **Pellaea ternifolia**, Fée. West Indies, St. Domingo, *Baron Eggers*. I cannot separate specifically **Cheilanthes weddelliana**, Moore, Ind. Fil. 257.
- 16*. **P. Pringlei**, Davenport, in Herb. Pringle Jalisco, 2591. Frond simply pinnate; lower pinnae petioled, hastate. North Mexico.
- 17*. **P. lancifolia**, Baker, n. sp. Stipes densely tufted, castaneous, 2-3 in. long, with a few minute linear paleae near the base. Frond lanceolate, bipinnate, membranous, glabrous, 4-5 in. long, narrowed from the middle both ways. Rachis naked, castaneous. Central pinnae the largest, sessile, lanceolate, cut down nearly or quite to the rachis into 2-3-jugate, adnate, ovate-deltoid patent lobes, 1-1½ lin. broad; lower pinnae distant, dwarfed. Indusium very broad, green, glabrous. Namaqualand, *Sir H. Barkly*. Differs from *profusa* by its naked rachis and very broad indusium.
- 22*. **P. Kitchingii**, Baker, in Journ. Bot. 1880, 327; Hook. Ic. tab. 1639. Central Madagascar, *Kitching*.
- 24*. **P. fumariaefolia**, Philippi. Stipes tufted, slender, naked, 3-4 in. long, green above the castaneous base. Frond oblong, decomposed, thick, green, glabrous, 2-3 in. long; sterile more compound than the fertile. Lower pinnae the largest, petioled, deltoid. Final segments short, linear, 1-nerved. Fertile frond less compound; final segments linear-oblong, ¼-⅓ in. long. Sori filling the whole under surface of the segments. Indusium broad, continuous, rigid, glabrous. Araucania, *Philippi*. Habit of *Cryptogramme crispa*.
- 28*. **P. namaquensis**, Baker, n. sp. Stipes densely tufted, castaneous, 2-3 in. long, clothed with distinct spreading linear paleae. Frond deltoid, tripinnatifid, bright green, glabrous, 2-3 in. long; rachis castaneous, with a few minute paleae. Lowest pinnae much the largest, deltoid, stalked, ½ in. broad, its pinnules cut down nearly to the rachis into a few oblong lobes. Indusium narrow, green, membranous, glabrous. Namaqualand, *Sir H. Barkly*. Between *involuta* and *conso-brina*.
- 35*. **P. integricuspis**, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 324. New Caledonia, *Balansa*, 824. Not seen. To be compared with *P. falcata*.

- 38*. *P. tripinnata*, Baker, in Journ. Linn. Soc. XXV, 350. Madagascar, *Baron*, 5674.
- 40*. *P. crispatula*, Baker, n. sp. Stipes very slender, densely tufted, castaneous, fragile, naked, 1-2 in. long. Basal paleae lanceolate, bright brown, minute. Fronds simple, lanceolate, glabrous, 2-2½ in. long, ¼-½ in. broad, narrowed gradually to the point, generally cordate at the base, with small rounded contiguous lobes. Veins very distinct, forming 2-3 rows of areolae between the midrib and edge, without any included veinlets. Sori placed all round the margin of the frond, at first globose, finally confluent. Indusium very narrow, obscure. South Brazil, *Glaziou*, 14,405. Habit of *Pteris sagittifolia*. Sori and indusium very different.

Genus 31. PTERIS *Linn.*Subgenus **Eupteris**.

- 1*. *P. phanerophlebia*, Baker, in Journ. Bot. 1881, 367; Hook. Ic. tab. 1610. Madagascar, *Curtis*, *Baron*, *Humboldt*, *Last*. Habit of *P. sagittifolia*, Raddi, but veins free.
- 1*. *P. quinquelobata*, Baker; *Pellaea quinquelobata*, Fée; Prantl, in Engler's Jahrb. 1882, 422. South Brazil, *Glaziou*, 7011. Habit of less divided forms of *P. palmata*. Frond thick, deltoid, 3-5-lobed.
- 1*. *P. platysora*, Baker, in Journ. Bot. 1880, 211. Sumatra, *Beccari*.
- 3*. *P. vitiensis*, Baker, in Journ. Bot. 1879, 295. Fiji, *Horne*, 718.
4. *P. cretica*, L. *P. Mayi*, Hort. is a crested variegated form. I cannot separate specifically the New Zealand *P. lomarioides*, Colenso, in Trans. New Zeal. Instit. 1880, 380; Field, Ferns New Zeal. 91, tab. 25, Fig. 4. *P. treacheriana*, Baker, in Journ. Bot. 1879, T. 5, is identical with *P. melanocaulon*, Fée.
5. *P. pellucida*, Presl. *P. commutata*, Kuhn, in Reise Decken Bot. 20, is apparently a variety of *pellucida*, with veins casually anastomosing.
- 5*. *P. papuana*, Cesati, Fil. Bec. Polyn. 3, 7. Rhizome repent, as thick as a man's thumb, tomentose, with minute brown subulate paleae. Stipe a foot long, naked, dark purplish brown.

Fronds oblong-lanceolate, simply pinnate, glossy, glabrous, coriaceous, 2-3 ft. long. Pinnæ linear, 6-7 in. long, $\frac{1}{4}$ in. broad, very acuminate, obscurely serrulate at the tip, the upper single, the lower 3-4-jugate. Veins subpatent, very fine, and close. Mountains of New Guinea, *Beccari*. *P. pellucida*, Cesati, loc. cit., is a more luxuriant form of the same species.

- 6*. *Pteris sumatrana*, Baker, in Journ. Bot. 1881, 367. Sumatra, *Curtis*. Near *P. hookeriana* and *serrulata*.
7. *P. dactylina*, Hook., has been found recently in Szechwan by *Faber*, and Yunnan by *Delavay*.
9. *P. serrulata*, L. fil. Has been found lately in Alabama and Guadeloupe. Can it be a mere variety of *cretica*?
10. *P. ensiformis*, Burm. *P. Victoriae*, Hort. Bull., is a beautiful variety of this species, with fronds variegated with white.
- 10*. *P. Balansae*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 320. New Caledonia, *Balansa*, 797. Not seen.
- 10*. *P. polymorpha*, Fourn., in Ann. Sc. Nat. sér. 5, XVIII, 320. New Caledonia, *Balansa*, 831, 2686. Not seen.
- 12*. *P. inaequalis*, Baker, in Journ. Bot. 1875, 199. China and Japan. Between *P. semipinnata* and *longipinnula*.
- 13*. *P. appendiculata*, Baker, in Journ. Bot. 1881, 366. Madagascar, *Curtis*. Like *P. triplicata* in texture and general habit.
- 14*. *P. remotifolia*, Baker, in Journ. Linn. Soc. XVI, 199. Madagascar, *Miss Helen Gilpin*.
- 16*. *P. dissitifolia*, Baker, in Journ. Bot. 1890, 262. Tonquin, *Balansa*, 1970. Near *inaequalis* and *semipinnata*.
- 16*. *P. formosana*, Baker, in Journ. Bot. 1885, 103. Formosa, *Hancock*, 83. Near *semipinnata*.
22. *P. quadriaurita*, Retz. *P. subindivisa*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 467, tab. 56, fig. 1, Himalayas, and *P. reducta*, Baker, in Journ. Bot. 1880, 211, Sumatra, are probably forms of *quadriaurita* with a simply pinnatifid frond. Clarke and Beddome agree in separating as a species *P. grevilleana*, Wall. See Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 466.
- 22*. *P. furcans*, Baker, in Journ. Bot. 1888, 324. Borneo, *Bishop Hose*.

- 22*. *P. concinna*, Baker, in *Malesia*, III, 37. Mountains of New Guinea, *Beccari*. Near *P. Griffithii*, Hook.
- 22*. *P. Walkeri*, Baker, in *Journ. Bot.* 1888, 324. Borneo, *Walker*. Sent by *Bishop Hose*, 224, from Banggi Island, also off the coast of Borneo.
29. *P. heterophylla*, L. *P. internata*, Moore, is probably a garden variety of this species.
- 29*. *P. macrodon*, Baker, in *Journ. Linn. Soc.* XV, 414. Central Madagascar, *Pool*.
34. *P. tremula*, R. Br. Var. *foliosa*, Moore, in *Gard. Chron.* 1886, I, 787, is a curious monstrous garden form.
36. *P. longipes*, D. Don. Further material shows *P. brevisora*, Baker, No. 39, which has now been found in Zambesia, to be only a variety of this species, with shorter sori.

Subgenus *Poesia*.

- 42*. *P. Radula*, Baker, in *Journ. Bot.* 1880, 211. Mountains of Borneo, *Beccari*. Near *P. scaberula*, A. Rich.

Subgenus *Campteria*.

46. *P. biaurita*, L. *P. dubia*, Kuhn, in *Reise Decken Bot.* 71. Johanna Island, *Hildebrandt*, 1763, differs from the type by the want of spinules on the face and by the segments being sharply serrulate at their barren tips.
48. *P. triplicata*, Agardh. Further material shows *P. Melleri*, Baker, No. 49, to be a form of this species.
- 50*. *P. oligodictyon*, Baker, in *Journ. Bot.* 1889, 328. Central Madagascar. Habit of *P. flabellata*, Thurnb. with campterioid veining.

Subgenus *Doryopteris*.

- 52*. *P. cordifolia*, Baker, in *Journ. Bot.* 1891-4. North-West Madagascar, *Last*. Near *P. sagittifolia*, Raddi.

Subgenus *Litobrochia*.

- 61*. *P. acuminata*, Baker, in *Journ. Bot.* 1891, 5. North-West Madagascar, *Last*. Near *P. lanceaefolia*, Agardh.

- 62*. **Pteris Burtoni**, Baker, n. sp. Stipe naked, castaneous, 2-4 in. long, winged in the upper half. Frond deltoid, simply pinnate, $\frac{1}{2}$ ft. long, moderately firm, glabrous; rachis winged. Pinnae 3-7, lanceolate, entire, sessile, the largest 3-4 in. long, $\frac{3}{4}$ -1 in. broad. Veins forming 2-3 rows of areolae between the midrib and margin. Fruit not seen. Gold Coast, *Burton & Cameron*. Near *P. splendens*, Kaulf.
62. **P. splendens**, Kaulf. var. *Miersii*, Baker. Pinnae only $\frac{1}{2}$ in. broad, more numerous than in the type; veins much less conspicuous than in the type; areolae fewer. Rio Janeiro, *Miers*.
- 62*. **P. dominicensis**, Baker, in Hook. Ic. tab. 1642. Dominica, *Baron Eggers*, 960.
- 63*. **P. platyodon**, Baker, in Journ. Linn. Soc. XV, 415. Central Madagascar, *Pool*.
66. **P. denticulata**, Sw. I place **P. Enderi**, Regel, as a variety of this species.
- 66*. **P. Pearcei**, Baker, n. sp. Stipe long, naked. Frond lanceolate-deltoid, simply pinnate, $1\frac{1}{2}$ ft. long, moderately firm: rachis stramineous. Pinnae distant, ascending, linear: lowest the largest, 8-9 in. long, with 1-4 irregular lanceolate lobes on the lower side. Veins very distinct, forming 2-3 rows of hexagonal areolae between the midrib and edge. Indusium narrow, glabrous. South America, probably South Brazil, *Pearce*, 271. Near *P. splendens*.
- 66*. **P. Johnstoni**, Baker, n. sp. Stipe naked, slender, castaneous, nearly a foot long. Frond deltoid-caudate, simply pinnate, bright green, glabrous, 6-8 in. long, chartaceous. Lower pinnae sessile, forked at the base; upper lanceolate, entire, $2\frac{1}{2}$ -3 in. long, $\frac{3}{4}$ in. broad, decurrent in a narrow wing to the rachis. Veins fine, distinct, forming 2-3 rows of areolae between the midrib and edge. Fruit not seen. Sierra Leone, *Dr. Halcro Johnston*. Habit of *P. cretica*.
- 73*. **P. similis**, Kuhn, in Reise Decken Bot. 21. Niam-niam land, *Schweinfurth*, 3311. Much larger than *P. atrovirens*: final segments 2 in. long. Rachis very spinulose.
- 74*. **P. villosa**, Hort. Linden. Stipe long, naked. Frond deltoid, 2-3-pinnatifid, $1-1\frac{1}{2}$ ft. long, membranous, very hairy. Lower pinnae largest, forked at the base, lanceolate, $\frac{1}{2}$ ft. long, $1\frac{1}{2}$

- in. broad, cut down nearly to the rachis into oblong segments $\frac{1}{4}$ in. broad. Veins anastomosing copiously. Fruit not seen. Hort. Linden. 1859, 1861, said to come from Assam. Near *P. woodwardioides*, Bory.
77. **P. macilenta**, A. Cunn. I cannot separate specifically **P. pendula**, Colenso, in Trans. New Zeal. Instit. 1888, 218.
- 77*. **P. Nevillei**, Baker, n. sp. Frond ample, tripinnate, membranous, glabrous: rachis weak, stramineous, naked. Lowest pinnae a foot or more long, its lowest pinnules copiously compound, with deeply pinnatifid lanceolate tertiary segments; final segments contiguous, oblong, deeply toothed, $\frac{1}{8}$ – $\frac{1}{6}$ in. broad. Veins forming 1–2 rows of areolae between the midrib and margin. Fruit not seen. Bourbon, *Neville*. Near *P. macilenta*.
- 79*. **P. platypteris**, Sodiro, Recens Crypt. Vasc. Prov. Quit. 28. Andes of Ecuador, *Sodiro*. Near *P. macroptera*, Link.
82. **P. tripartita**, Sw. This dates from 1800 and is an older name than *P. marginata*, Bory. Further material shows that **P. milneana**, Baker, is probably a mere variety of this species.
- 85*. **P. longibrachiata**, Agardh. The full material recently sent home from St. Vincent by Messrs. H. H. & G. W. Smith shows that this is probably a distinct species.

Genus 33. LOMARIA Willd.

- 6*. **L. acuminata**, Baker. Also Samoa, *Whitmee*. An earlier name is *L. norfolkiana*, Heward, in Lond. Journ. Bot. I, 122.
- 6*. **L. deflexa**, Baker, in Journ. Bot. 1888, 226. West China on Mount Omei, alt. 7000 ft., *Faber*. Near *L. norfolkiana*.
- 8*. **L. simillima**, Baker, in Journ. Bot. 1884, 141. North-East Madagascar, *Humblot*, 307. Very near the American *L. Plumieri*, Desv.
9. **L. vulcanica**, Blume. I cannot separate specifically **L. paucijuga**, Colenso, in Trans. New Zeal. Instit. 1888, 222.
11. **L. lanceolata**, Spreng. I cannot separate specifically **L. aggregata**, Colenso, in Trans. New Zeal. Instit. 1888, 223; Field, Ferns New Zeal. 103, tab. 29, fig. 7.

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- 11*. *Lomaria pubescens*, Baker, in Journ. Linn. Soc. XV, 415. Central Madagascar, *Pool*.
- 14*. *L. leyboldtiana*, Philippi, in Linnæa, XXXIII, 303. Chili, shore at Lota, *Pearce*. Not seen.
- 14*. *L. Hancockii*, Baker; *L. apodophylla*, Baker, in Journ. Bot. 1885, 104; *Blechnum Hancockii*, Hance, in Journ. Bot. 1883, 267. Formosa, *Hancock*.
- 18*. *L. stenophylla*, Baker, in Journ. Bot. 1884, 142. North-East Madagascar, *Humboldt*, 305.
- 20*. *L. parvifolia*, Colenso, in Trans. New Zeal. Instit. 1888, 224. Exactly matches our type specimen of *L. pumila*, Raoul, which can scarcely be regarded as more than a variety of *L. alpina*. See Field, Ferns New Zeal. 106.
22. *L. procera*, Spreng. Under this I place *Blechnum sociale*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 31. Andes of Ecuador.
- 22*. *L. areolaris*, Harringt., in Journ. Linn. Soc. XVI. Philippines, *Steere*.
24. *L. boryana*, Willd. Under this I place *L. stipitellata*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 29. Andes of Ecuador.
- 24*. *L. microbasis*, Baker, in Journ. Bot. 1880, 328. Madagascar, *Kitching*.
- 25*. *L. xiphophylla*, Baker, in Journ. Bot. 1884, 142. North-East Madagascar, *Humboldt*.
30. *L. membranacea*, Colenso. I cannot separate specifically *L. oligoneuron*, Colenso, in Trans. New Zeal. Instit. 1883, 346.
- 31*. *L. biformis*, Baker, in Journ. Linn. Soc. XV, 415; Hook. Ic. tab. 1643. Madagascar. Fronds curiously heteromorphic.

Subgenus *Plagiogyria*.

- 35*. *L. stenoptera*, Baker; *L. concinna*, Baker, in Journ. Bot. 1885, 103; *Blechnum stenopterum*, Hance, in Journ. Bot. 1883, 268. Formosa, *Hancock*.

Genus 34. *BLECHNUM* Linn.

- 2*. *B. parvulum*, Philippi, Descr. Nuev. Plant. 1873, 104. Juan Fernandez. Not seen.
- 9*. *B. rugosum*, Moore, in Gard. Chron. 1884, I, 408. Garden. Not seen.

- 14*. **B. Whelani**, Bailey, Queensl. Flora, Suppl. III, 92. Mountains of Queensland. Near *B. serrulatum*. Not seen.

Genus 37. DOODIA *R.Br.*

- 4*. **D. polysora**, Terracino, in Rend. R. Acad. Sc. Fisc., Nap., April, 1886. New Caledonia. Not seen.
5. **D. caudata**, R. Br. I cannot separate specifically **D. squarrosa**, Colenso, in Trans. New Zeal. Inst. 1880, 382, and **D. harryana**, Moore, in Gard. Chron. 1884, 408.

(*To be continued.*)

EXPLANATION OF FIGURES IN PLATE XIV.

Illustrating Mr. Baker's Summary of the New Ferns discovered or described since 1874.

Matonia sarmentosa, Baker.

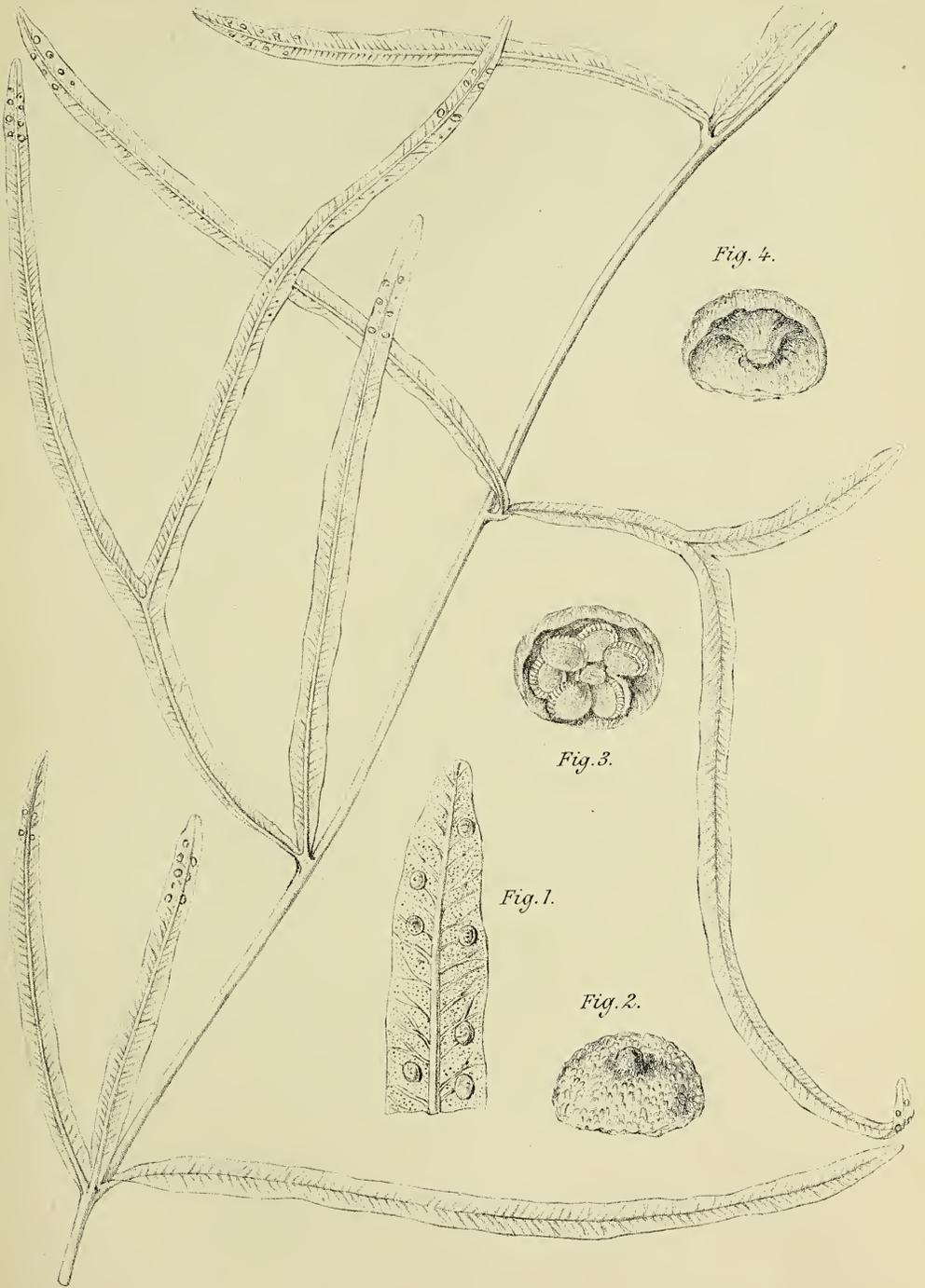
Fig. 1. Summit of fertile segment of frond.

Fig. 2. Indusium.

Fig. 3. Indusium lifted up so as to show the sporangia.

Fig. 4. Indusium lifted up so as to show the central stipe.

(All enlarged.)



M. Smith del.

University Press, Oxford.

NOTES.

NOTE ON MR. BARBER'S PAPER ON PACHYTHECA.—

Few fossils have been the subject of more varied explanation than *Pachytheca*. This has arisen from the fact that any positive indications as to its structure have been so meagre. The careful investigations of Mr. Barber tell us pretty well all that we are ever likely to know, and at any rate supply us with definite grounds for rejecting the greater part of the hypotheses which have been put forward with regard to it.

More than ten years ago I carefully investigated the specimens of *Pachytheca* belonging to Sir Joseph Hooker at his request. I arrived at these conclusions:—(i) That the cortical cells branched, (ii) that the cortical cells and the medullary filaments were continuous, and (iii) that the structure of the whole organism was comparable with that of known Algal types. On the occasion of Sir W. Dawson's paper on *Prototaxites* being read at the Geological Society, on Nov. 16, 1881, my friend, Prof. Judd, asked me to make some statement about *Pachytheca*. It will be convenient to reprint from the Proceedings what took place.

‘Prof. Judd stated that he exhibited, on behalf of Mr. Thiselton-Dyer, two sections of *Pachytheca*. Mr. Thiselton-Dyer regretted that he was unable to be present at the Meeting, but had sent Prof. Judd a letter, from which he read the following extract:—

“Kew, Nov. 15, 1881.

“Some time ago Sir Joseph Hooker received from Mr. Grindrod a number of specimens of *Pachytheca in situ* on pieces of rock. As these examples of the fossils were apparently well preserved, two or three were detached and intrusted to Mr. Norman, who made the sections which are now in your hands. Sir Joseph Hooker did not see his way to any definite conclusion as regards the structure which they exhibited. He, however, allowed me to examine them, and they have since remained in my possession. The conclusion which I arrived at was that

[Annals of Botany, Vol. V. No. XVIII. April, 1891.]

their structure agreed in general plan with that of *Codium*, as shown in Kützing, 'Phycologia Generalis,' Pl. 42, Fig. 1.

"As a possible algal nature has been suggested for *Pachytheca* by Mr. Etheridge, I think it may not be considered presumptuous on my part to now state that I have been of opinion ever since I studied the sections, that *Prototaxites* and *Pachytheca* are both referable to the same morphological type of structure. The radiating cells in the latter terminate internally in loosely interlacing slender filaments, with which the central cavity has been apparently filled. *Pachytheca* does not resemble any type of sporangium with which I am acquainted; the structure, as displayed in the specimens, has a certain resemblance to that of the sporocarp of *Pilularia*; but I cannot reconcile what I have seen of it with the supposition that it was a reproductive structure belonging to any type of vascular cryptogam.

'According to the view which I take of *Pachytheca*, it was an algal organism closely resembling in essential structure a diminutive *Codium*, but with the peripheral cells branched instead of simple. I do not see any evidence to lead me to suppose that it was related to *Prototaxites* as a sporangial organ. The existence of *Prototaxites* on modern biological views necessarily implies the existence, at some time or other, of allied forms, and I do not see why *Pachytheca* should not have been a contemporaneous one.'

I should not recall the past history of an observation, which to me is not of very great importance, were it not that in his paper Sir Joseph Hooker pointed out that I stood alone in asserting that the cells of the cortical and peripheral tissue were continuous. 'This organic connection,' he says, 'between the tissue of the cavity and walls is, if confirmed, a fact of very great importance. It has escaped my own notice and that of several excellent observers, who had devoted much time to the study of my specimens.'¹ I think it is not without interest to point out that it *has* been confirmed. Mr. Barber has obtained independent evidence of the fact in one of the sections, which I myself have not seen, described in his present paper. He remarks, however, 'this is, I believe, the first specimen, if not the only one, in which cortical and medullary filaments have been seen to join one another.' I can only say that I determined the fact of their

¹ Annals of Botany, III, pp. 138, 139.

continuity in one of Sir Joseph Hooker's sections, or I should not have placed it on record. But I am not prepared to say that I saw it with anything like the precision which is exhibited in the section examined by Mr. Barber.

I make these remarks in justice to myself. But I do not wish to detract in any way from the excellence of Mr. Barber's papers. He has placed our knowledge of *Pachytheca* on solid ground which it had never before attained, and has added to that knowledge a number of new facts of great importance, which he has interpreted in a very skilful and convincing manner.

I may take the opportunity of saying that there is, I think, some little misapprehension on Mr. Barber's part with regard to the curious round calcareous pebbles which occur in such profusion at the bottom of Lough Belvedere, near Mullingar¹. I never found time to give these pebbles a more than superficial examination. They certainly deserve, however, a more minute study than I think they have yet received. An accumulation of them might easily form a rock, and the interpretation of its structure would not be easy.

When the pebbles, which are of all sizes up to that of a filbert, are digested in a weak acid, the lime is removed and an algal mass remains of the same size and form. The bulk of this consists of a *Rivularia*: but if I remember rightly, my friend Mr. Archer, F.R.S., told me that he had detected other algae casually interwoven in the mass. But I have no recollection of observing anything confirming Mr. Barber's statement that there is any symbiosis of *Rivularia* and *Cladophora*, or penetration of the former by the latter.

The analogy which suggested itself to my mind between these curious pebbles and *Pachytheca* rested on a different point. The Mullingar *Rivularia* evidently has the power of incrusting itself with calcium carbonate, and I cannot help thinking that *Pachytheca* when a living organism must have had a similar propensity. If so, the incrusting material would undergo considerable change in the process of fossilization: but this would account for the manner in which its filamentous structure, which otherwise one would have expected to be very perishable, is so considerably preserved.

W. T. THISELTON-DYER, Kew.

¹ Annals of Botany, III, p. 144.

ON THE ANTHERIDIA OF LOMENTARIA.—At Woods Holl, Mass., this summer (July 26, 1890), while examining material of *Lomentaria uncinata*, Menegh., collected in Vineyard Sound, tips

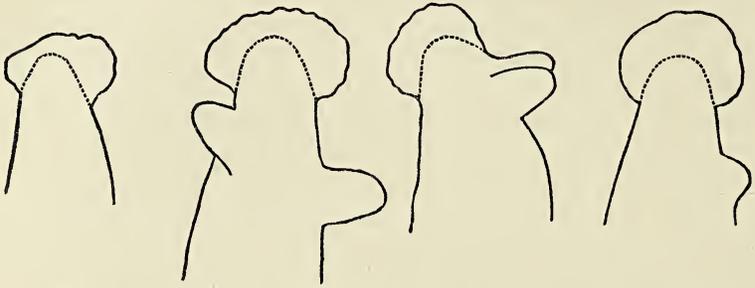


Fig. 2. Several camera lucida outline sketches of antheridia-bearing tips.

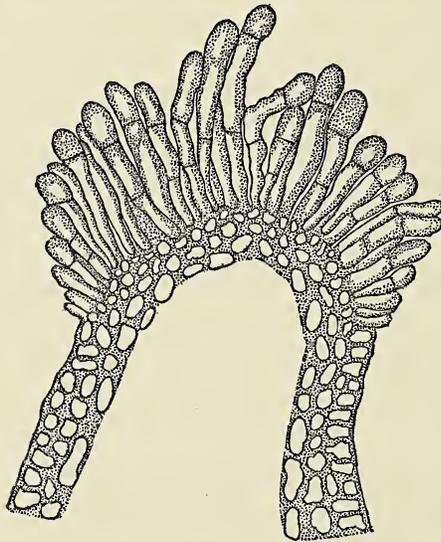


Fig. 3. Central longitudinal section through an antheridia-bearing tip.

bearing antheridia were discovered. From the literature at my command and from inquiry, it would appear that the antheridia of *Lomentaria* have seldom been seen, consequently a brief note on their position and structure may not be without interest.

They are found usually at the ends of the branches of the frond,

forming little spherical heads much resembling in position the antheridia of *Griffithsia Bornetiana*, Farlow, in which, however, they are spread out over the apex forming a hood-like covering, and do not, as in *Lomentaria*, form an enlarged head (Fig. 2).

While the position is usually directly apical, several tips were found where, by the partial branching or merely deflexed onward growth, the position had become somewhat lateral.

Several of the antheridial plants were found, one of which bore also numerous tetraspores. In general appearance and manner of growth I cannot distinguish the male plant from the common tetrasporic and sterile plants.

Serial sections through an antheridial tip show the head to be a tuft of short (30–35 μ long), radiating, clavate, 2-3 or 4-celled filaments originating from the apical cells of the tip and bearing at their extremity the antheridial mother-cells (Fig. 3).

Dr. W. A. Setchell, who examined my material at the time, informs me that he shortly after discovered undoubted antheridia of *Champia parvula* (Ag.) Harv., a closely related plant. It was merely a fragmentary specimen and unfortunately was destroyed. Their position and appearance, he reports, accord entirely with those of *Lomentaria uncinata*, Menegh.

H. J. WEBBER, St. Louis, Mo.

ECTOCARPUS FENESTRATUS.—Messrs. Holmes and Batters include this species in their 'Revised List of British Marine Algæ¹.'

As far as I know, the single type-specimen exists in the Kew Herbarium, to which it came from that of the Rev. M. J. Berkeley. The herbarium of Mrs. Griffiths does not appear to contain any example.

With some reluctance, and as a wholly exceptional case, I entrusted this unique specimen to Dr. Bornet for examination. It will be interesting to quote the following extract from a letter which I have received from him, dated February 24 :—

“ Je vous retourne le précieux échantillon que vous m'avez confié. Sa fragilité est telle qu'il est fort difficile d'en détacher des filaments ; j'ai pourtant réussi, sans lui causer aucun dommage perceptible, à en prendre une idée suffisante pour que sa détermination soit à peu près

¹ Annals of Botany, V, p. 79.

assurée. Afin qu'on n'a plus à y toucher, je joins à l'exemplaire un croquis exact des sporanges, dont la forme est fort différente de celle que Harvey a représentée. Autant qu'il est permis d'en juger, d'après un échantillon incomplet et qu'on ne veut pas risquer de détruire, je rapporte l'*Ectocarpus fenestratus* à l'espèce qu'on nomme aujourd'hui *E. Lebelii*; selon toute apparence, l'échantillon est un exemplaire à anthéridies, beaucoup plus développé que d'habitude. Quelques espèces voisines, telles que les *E. pusillus* et *insignis*, présentent parfois un développement semblable. Donc, grâce à vous, voici une question éclaircie.'

W. T. THISELTON-DYER, Kew.

TYPE-SPECIMENS OF MRS. GRIFFITHS.—In the introduction to 'A Revised List of the British Marine Algæ,' by Messrs. Holmes and Batters, the authors remark¹: 'It may be useful to state that in the course of our investigations we have found that the type-specimens of the following authors are deposited in the herein-stated herbaria':—

Then follows a list, in which I find 'Mrs. Griffiths, Linnean Society, London.' This seems to me to need a word of comment.

In the 'Report on the Progress and Condition of the Royal Gardens at Kew' for the year 1862 I find, amongst the additions to the Herbarium:—

'The unrivalled collection of *British Seaweeds*, formed during a long life devoted to that order of Plants, by Mrs. Griffiths, of Torquay. Presented by Miss Burdett-Coutts.'

I believe that this herbarium was very extensive, and that there were vast series of specimens representing each species. Mrs. J. E. Gray was about this time in the habit of residing at Kew during part of every summer. Sir William Hooker entrusted to her the task of selecting a series of specimens which would represent Mrs. Griffiths' types; these at the present moment are undoubtedly preserved in the Kew Herbarium. And the fact is well known to critical algologists, for Dr. Bornet, writing to me recently, mentions incidentally:— 'L'herbier de M^{me} Griffiths et celui de Berkeley sont conservés au Musée de Kew.'

As I have said, the herbarium was extensive, and there were vast quantities of duplicates, such as a private collector might preserve for some purpose or other, but which would be of little use in a public

¹ Annals of Botany, V, p. 66.

collection. A large proportion of these were distributed, and it is only recently that the last remains have been disposed of. A considerable proportion were placed at the disposal of Mrs. J. E. Gray, in recompense for her pains and trouble in arranging the type-collection. These (I believe with duplicates from her own herbarium) she made up into sets and, bound in handsome volumes, distributed to various public institutions. One such set may be in the possession of the Linnean Society. But the type-collection is certainly not there, for the simple reason that it is where it has always been since Mrs. Griffiths' death—at Kew.

The same authors state that Mrs. J. E. Gray's own type-specimens are at 'Cambridge University.' I strongly suspect that what Cambridge possesses is one of the collections referred to above. I can hardly doubt that Mrs. J. E. Gray enriched the Kew Herbarium of Algæ, which was practically for some years under her charge, with any specimens of her own which would be of value to it.

W. T. THISELTON-DYER, Kew.

Contributions to the Life-History of Isoetes.

BY

DOUGLAS HOUGHTON CAMPBELL,

Professor of Botany in the Indiana State University.

—+—
With Plates XV, XVI, XVII.
—+—

SINCE Hofmeister first called attention to the homologies existing between the heterosporous pteridophytes and the spermaphytes, the genus *Isoetes* has always been an object of special interest to botanists, and the subject of numerous investigations, as it is, in some respects, undoubtedly the nearest to the spermaphytes among all known living pteridophytes. For this reason a thorough study of the life-history of some species, as compared with other pteridophytes, has long been a desideratum, both as a means of determining to which class of the pteridophytes *Isoetes* is most nearly allied, as well as, if possible, to throw some light upon the origin of the spermaphytes.

The mature sporophyte¹ has been thoroughly studied, and the development of the sporangia and spores² has been carefully investigated. Since Hofmeister's³ work, however, but little has been done upon the female prothallium; but Millardet⁴, and later Belajeff⁵, have described in detail the germination of the microspores and the development of the

¹ Hofmeister, De Bary, Bruchmann, &c.

² See especially Goebel, Beiträge zur vergleichenden Entwicklungsgeschichte der Sporangien, Bot. Zeit. 1880-1881.

³ Hofmeister, Higher Cryptogamia, pp. 336 ff.

⁴ Le prothallium mâle des crypt. vasc.

⁵ Belajeff, Bot. Zeit. 1885, pp. 793-809.

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male prothallium, and Kienitz-Gerloff¹ has corrected some of Hofmeister's errors in regard to the embryo.

There are serious difficulties in the study of the germinating macrospore and young embryo; indeed, so great are these that without the aid of the modern histological methods, they are quite insurmountable. Free-hand sections of the fresh macrospore and young embryo are impossible, and even in the later stages very difficult. Having successfully imbedded in paraffine and sectioned the macrospores of *Pilularia*² and *Marsilia*³, the study of the development of the female prothallium of *Isoetes* was taken up, in the hope that by the same methods the early stages might be successfully made out. Although it proved a difficult task, it was at last possible to trace out the whole development of both the prothallium and the embryo. A brief summary of the most important points in the development of the former has already appeared⁴.

Owing to the thick and impervious exospore, great care is necessary in imbedding to prevent shrinkage, and even with every precaution, many preparations proved perfectly worthless. This was especially true with young prothallia after the formation of the cell-walls, but before the exospore was ruptured.

On the whole, material fixed with one per cent. aqueous solution of chromic acid proved most satisfactory. After washing thoroughly and dehydrating, the specimens were gradually brought into turpentine, and after remaining several hours in a saturated solution of paraffine in turpentine, were placed in melted paraffine for from six to eight hours, and then imbedded for sectioning. At first chloroform was used instead of turpentine, but it almost invariably caused shrinkage, and so was finally abandoned. When chloroform is used, a much shorter time (two to three hours) is usually sufficient for a thorough saturation by the melted paraffine.

¹ Kienitz-Gerloff, Entwicklung des Embryos v. *Isoetes lacustris*; Bot. Zeit. 1881.

² Campbell, on *Pilularia globulifera*; Annals of Botany, vol. II., no. VII.

³ Campbell, on *Marsilia Aegyptiaca*; Ber. der Deutschen Bot. Gesellschaft, 1888, VIII.

⁴ Berichte der Deutschen Bot. Gesellschaft, 1890, No. III.

After the specimens were imbedded they were sectioned with a Minot-microtome, stained on the slide, and mounted in Canada-balsam. While safranine and gentian-violet, in water, give a good nuclear stain, the young cell-walls colour but little, and often do not show as clearly as could be wished. Bismarck-brown, however, particularly when dissolved in 70 per cent. alcohol, stains the young cell-walls especially well, and is by far the best stain for this purpose that I have yet found. Extremely beautiful preparations of the older prothallia and embryos were made by staining *in toto* with alum-cochineal or Kleinenberg's haematoxylin, for a nuclear stain, and then staining on the slide with the Bismarck-brown. In the younger stages, however, nearly all attempts at staining *in toto* were ineffectual. Bismarck-brown is especially satisfactory also, in that it does not overstain, and is not readily extracted by alcohol, so that there is not the danger of too much decoloration in dehydrating the specimens that is met with when using other aniline colours.

I am especially indebted to Mr. F. V. Coville of Washington, through whose kindness a very abundant supply of fruiting specimens of *Isoetes echinospora*, var. *Braunii*, Durieu, was sent me. The plants were collected in the vicinity of Washington in September, 1889, and at this time the spores were ripe, or nearly so. The plants were kept in an aquarium with about an inch of sand at the bottom, and remained in good condition through the winter, resuming growth vigorously the following spring. The spores are ordinarily set free by the decay of the sporangium-wall, and this does not occur, probably, until late in the autumn or winter, when the plants are growing under normal conditions; so that probably the spores do not germinate naturally until spring. If, however, they are set free artificially, they will begin to germinate very soon, but the process is slower than when set free spontaneously.

The first sowings were made by me Sept. 27, and from that time on, at intervals, through the autumn and winter. There was much difference shown in the promptness of germination, even in the same lot; and as the absolute opacity

of the exospore renders it quite impossible to judge of the stage of development in the living spore, we can only judge of the time necessary for the different stages of growth, by a comparison of sections, and this, of course, can give only an approximate idea. Of the first lot, sown Sept. 27, the youngest spore, in which the first division of the primary nucleus was observed, was nineteen days old; but in one case, at least, a spore of the same age had advanced beyond this point, and to judge by comparison with others, was probably two or three days in advance of those in which the first division of the primary nucleus was seen. The youngest full-grown prothallia observed were from a week to ten days older, and the first young plants broke through the prothallium almost exactly one month from the time the spores were placed in water. The germination of the microspores is more rapid, but the exact time was not noted. Owing to the transparency of the exospore the time required can be determined with much greater exactness than is the case with the macrospores. Spores sown later germinate more rapidly. Sowings were made Dec. 13, and just three weeks later (Jan. 2) the first young plants were noted, the leaf being already green and about one centimetre in length. Microspores sown about the same time produced the first ripe spermatozoids in two weeks.

THE MALE PROTHALLIUM.

The microspores are borne in the sporangia at the bases of the inner leaves, and are of the bilateral type of spores, i. e. each is in form the quadrant of a sphere. The exospore is nearly colourless in the species under consideration, smooth, and sufficiently transparent to allow a plain view of the interior of the spore. Owing to this the development of the antheridium is easily followed in the living spores. As the germination of the microspores of *I. lacustris* has already been exhaustively treated by Millardet¹ and Belajeff², and *I. echinospora* does not differ in any respect from that species,

¹ Loc. cit.

² Loc. cit.

no detailed account will be given here. The vegetative part of the prothallium is reduced to a single small cell cut off from one end of the spore; the remainder of the spore forms the antheridium, as in *Marsilia*¹. In the antheridium two walls are formed so inclined to each other as to include two upper cells and one lower. This latter next divides into two by a vertical wall, and subsequently by a periclinal wall is further divided into two peripheral and two central cells. Each of the latter divides once more, and each of the four central cells thus formed is the mother-cell of a spermatozoid. The full-grown antheridium thus consists of four peripheral and four central cells, and is therefore the most reduced among the pteridophytes.

In many instances the microspores were imbedded with the macrospores, and as the nuclei could then be stained, the number of the peripheral cells, as well as the origin of the spermatozoids, was readily made out. The latter are too small in this species to be a good subject for the study of their development; but there is no doubt that, as in other cases, the body of the spermatozoid is derived mainly from the nucleus of the sperm-cell. At all stages it colours very intensely with gentian-violet, while the surrounding protoplasm remains entirely colourless. Like the spermatozoids of the Filicineae, the body of the spermatozoid is spirally coiled, and multi-ciliate. Belajeff², in a recent paper, opposes the generally accepted view that the body of the spermatozoid is of nuclear origin, and claims that only a small portion of it is derived from the nucleus. His views, however, are not supported by the recent work of Guignard on this subject, nor have I been able to find any confirmation of his statements from a careful study of a number of forms.

¹ Campbell, loc. cit., p. 341.

² Ueber Bau und Entwickl. d. Spermatozoiden bei den Gefässcryptogamen; Ber. der Deutschen Bot. Gesellschaft, 1889, p. 122.

THE MACROSPORE AND FEMALE PROTHALLIUM.

The macrospores are formed in the sporangia of the outer leaves, and are very much larger than the microspores, from which they differ in form, being of the tetrahedral type. They are nearly globular in form, and, like most tetrahedral spores, the three ridges where the spore is in contact with the others of the tetrad, are very conspicuous, and may be seen with a hand-lens. If the fresh spore is crushed in water, its contents appear milky, and microscopic examination reveals oil-drops and some starch-granules mingled with roundish bodies of albuminous nature. The latter absorb water more or less, and look almost like free cells. While, as we have already stated, it is quite impossible to section the fresh spores, by hardening with alcohol or chromic acid, it is not difficult to imbed them, and then sections may be easily made; and when stained with some aniline colour (gentian-violet or safranine), the structure is readily made out.

The wall of the spore is composed of several layers of which the outer one (Epispore) is thick and glassy in texture, and in our species provided with short recurved spinules (Fig. 40, *sp*). The interior is filled with coarsely granular protoplasm that often appears spongy, owing probably to the dissolving out of the oil in the process of imbedding (Fig. 1). Scattered through the spore are round starch-grains (Fig. 1, *s*), having a central hilum. Besides the starch-grains are numerous somewhat irregular bodies (Fig. 1, *Al*) that stain strongly with gentian-violet or safranine, and seem to be albuminous reserve-materials. The nucleus is large and readily seen. It lies in the basal part of the spore—that is the part opposite the point of contact with the other spores of the tetrad. The nucleus is broadly elliptical in form, and a small space about it is usually nearly free from the larger starch-grains and albuminous granules. Not infrequently, between the nucleus and the wall of the spore, a close layer of small starch-granules was observed that was very conspicuous (Fig. 1, *s'*). The nucleus (Figs. 2, 3) has a delicate,

but evident membrane, and usually one large nucleolus. This stains somewhat with gentian-violet and safranin, but not very deeply: and while a faint reticulate structure may be seen, it does not stain. The nucleus of the resting spore, it will thus be seen, is very poor in chromatin.

In my preliminary paper¹, the statement was made that the nucleolus, even in the ungerminated spore, stains strongly, but a further examination of the preparations showed that this was only true in spores that had been free for some time, and indicated, presumably, the first stage in their germinations. A number of spores taken directly from the sporangium and sectioned, showed but very slight coloration of the nucleolus.

After the spores have lain a few days in water, the nucleus increases somewhat in size, and then the nucleolus colours very intensely. At the same time several smaller bodies, likewise strongly coloured, and resembling the nucleolus except in size, are usually to be seen (Figs. 4, 5). In these nuclei, too, there is a central area that colours faintly, and later (Figs. 4 and 5), in this area the nuclear filaments can be seen, and small chromatin-corpules become visible.

Although a large number of sections were made, the further changes in the nucleus, preliminary to its division, were not seen, and only twice was the primary nucleus of the spore found in actual division, in both cases nineteen days after the spores were sown. In the younger of the two the chromatin-masses were distinct and in the form of nearly round granules. The outlines of the daughter-nuclei could be faintly traced, but no membrane had yet formed. Very numerous connecting threads were seen between the young nuclei, and a very evident cell-plate occupied the equator of the nuclear figure.

The older stage (Fig. 6) had the membrane of the daughter-nuclei better defined, and the chromatin-masses had apparently partially coalesced. No cell-wall is formed, and the result of the first division is two free nuclei. The first division takes place while the nucleus is in its original position, but whether

¹ Loc. cit., p. 99.

the secondary nuclei also divide before moving to the apex of the spore I cannot say, as the next youngest stage observed had four free nuclei, and these lay in the apical part of the spore, with no indication whether they had assumed this position before or after the division of the secondary nuclei. These nuclei were much smaller than the primary one which, however, they resemble in structure, except that they have relatively more chromatin than the nucleus of the resting spore. They lie close to the periphery of the spore, and the surrounding cytoplasm is much more finely granular than that of the interior of the spore, and colours much less strongly with gentian-violet.

The nuclei now divide rapidly, becoming at the same time much smaller, until a considerable number (usually from thirty to fifty) of free nuclei are formed; but as yet there is no trace of division-walls between them. By far the larger number of the nuclei lie in the upper part of the spore, but sometimes an occasional one may be detected in the basal part or centre; but these portions are usually destitute of nuclei at the time when cell-formation begins. For the demonstration of the nuclei at this time, the sections should be overstained with gentian-violet, and the superfluous colour removed with alcohol. In this way the nuclei remain strongly coloured after the cytoplasm is entirely decoloured.

The first trace of cell-formation is at the apex of the spore. At this time the cytoplasm colours more deeply than before, and sometimes very delicate threads may be detected, radiating in all directions from the nuclei and connecting the adjacent ones (Fig. 8). Shortly after, the first traces of the division-walls appear simultaneously between the nuclei, in the form of cell-plates composed of minute granules (microsomes), presumably of cellulose. The separate microsomes quickly coalesce and form the continuous membrane of the young cell-wall. In this way the upper part of the spore becomes transformed into a solid tissue (Figs. 9, 10).

The cell-formation proceeds quickly toward the base of the spore, following the spore-wall, so that for a time the central

part remains undivided. The whole process recalls most vividly the endosperm-formation in most angiosperms. Owing to the dense contents, and the extremely thin cell-walls, it is not easy to determine exactly when the whole cavity of the spore becomes filled with the cellular tissue. On account of the preponderance of the free nuclei in the upper part of the spore, and their consequent proximity to each other, the cells of the prothallium in this region are smaller than those in the lower and central part of the prothallium (see Figs. 10-12). The divisions in these upper cells, too, are more frequent, and sometimes the transition from the upper small-celled tissue to the lower large-celled is quite abrupt, and all the more noticeable as the upper cells are comparatively free from the coarse granular contents of the lower cells. After the first cell-walls are complete, the subsequent nuclear division is accompanied regularly by the formation of division-walls between the daughter-nuclei.

The process here described it will be seen is very similar to that found in the usual endosperm-formation of the spermatophytes, and differs very much from Hofmeister's account¹, according to which free cells are first formed that afterwards coalesce to form the prothallium. Only in a very few instances, and these mostly later stages, was any appearance noted that had the appearance of a splitting of the protoplasm, as Farmer² describes, and this was readily shown to be due to shrinkage caused by the action of reagents, and with a little care it was evident that in all such cases cell-walls were present, and that the apparent cracks simply marked their position (Fig. 40).

The first archegonium is very early evident, generally before the cell-division is completed in the lower part of the spore. The mother-cell (Fig. 10, *a*) occupies the apex, and is early recognisable on account of its larger size and denser contents. It is simply one of the first-formed cells that ceases to divide after it is complete; and as the neighbouring cells divide rapidly, the contrast in size between it and those adjoining becomes very marked. Whether seen from above or in profile, it usually

¹ Loc. cit., p. 339. ² Proceedings of the Royal Society, vol. 45, p. 307, 1889.

appears triangular, or nearly so, in outline, the walls bounding it meeting so as to enclose a nearly regular tetrahedron. The nucleus is also evidently larger than those of the surrounding cells. A notable point connected with the archegonium, and also true of the later ones, is the large size of the mother-cell as compared with that of the archegonium of most pteridophytes. Of the other pteridophytes, the Marattiaceae¹ approach most nearly to *Isoetes*, as they do in the structure of the mature archegonium.

The development of the first as well as the later archegonia is the same, and follows closely that of the Filicineae, showing especially close resemblances to the Marattiaceae. The mother-cell (Fig. 13, *a*) first divides by a transverse wall into two cells, of which the outer smaller one gives rise to the neck of the archegonium, the inner larger one to the central cell and the neck-canal-cell. The first division in the inner cell is parallel to the first wall in the archegonium mother-cell, which thus becomes divided into three cells placed one above another (Fig. 14). The contents of these cells are quite similar and the nuclei large and distinct. The next divisions occur in the neck-cell, which is divided by vertical walls, at right-angles to each other, into four nearly equal cells. These mark the four rows of cells composing the neck. Each of the neck cells next undergoes division by a transverse wall into two, and each of the latter in the same way into two more, so that the mature archegonium has a neck composed of four rows, each composed of four cells (Figs. 16, 17).

Almost simultaneously with the first transverse divisions of the neck-cells, the central cell has cut off from its upper part the ventral canal-cell (Figs. 15, 16, *b*), which is larger than is common, being the whole breadth of the central cell. In the meantime the neck-canal-cell (*c*) has pushed up between the neck-cells, but while very broad, is relatively much shorter than usual.

The neck-canal-cell has at first a single nucleus, but this,

¹ Jonkman, La génération sexuée des Marattiacées, Figs. 99-105.

at least in some instances, divides as in most ferns, but there is no division-wall formed (Fig. 17).

As the archegonium approaches maturity, the neck-cells elongate somewhat, and the two upper tiers project above the surface of the prothallium (Fig. 16). Shortly before opening, the walls of the canal-cells, as usual, become disorganised, and with their contents form a mucilaginous mass which is expelled when the archegonium opens. At the same time the contents of the mother-cell of the egg-cell contract and become nearly globular. The act of opening of the archegonium was not observed, but stages shortly before and after were met with.

The egg-cell (Fig. 18, *o*) is a large round or oval naked cell with a large and clearly marked nucleus, having a very large nucleolus that stains with great intensity; but besides the nucleolus there seems to be but little chromatin. The upper part (about one-third) of the egg is composed of hyaline protoplasm, exhibiting a faintly reticulate structure, and forms the 'receptive spot.' The lower part, surrounding the nucleus, is filled with granules, and stains strongly with gentian-violet.

Owing to the small size of the spermatozoids and the great difficulty of getting satisfactory sections of ripe archegonia, the actual process of fertilization was not seen, and I am not prepared to state positively what the first results of the process are. In one or two cases noted, where the egg had apparently been recently fertilized, the receptive spot had disappeared and the protoplasm had become uniformly granular throughout.

The ripe archegonium closely resembles that of the Marattiaceae. It is sunk in the prothallium except the two upper tiers of neck-cells, and both in this respect, as well as the very broad canal-cells, resembles closely Jonkman's figures¹ of *Angiopteris* and *Marattia*. The egg-cell, however, is relatively much larger. Owing to the small increase in size, during its growth, there is very little displacement of the cells of the archegonium and its limits are very definite.

In *Isoetes lacustris*, according to Hofmeister², only one archegonium is formed at first, and if this is fertilized no

¹ Loc. cit.

² Loc. cit., p. 340.

others are produced ; but in *I. echinospora* (and it is not unlikely that further investigation will show that it is true for *I. lacustris* as well), even before the first archegonium is complete, two others begin to develop, and reach maturity shortly after the first, whether it is fertilized or not. In case these all fail to be fecundated a small number (probably never more than five or six) may be formed subsequently; but so far as my observations go, the production of archegonia on the old, unfecundated prothallium, is very limited, as is the growth of the prothallium itself. In no instance was the formation of chlorophyll noticed, and only in the rarest instances were root-hairs developed from the superficial cells, so that the prothallium is entirely dependent upon the food-materials contained in the spore for its growth, and when these are exhausted must necessarily perish. As the prothallium becomes older, the cell-walls become firmer, and more evident on account of the absorption of the food-materials in the cells, which for this reason become more transparent.

In regard to the development of the female prothallium, *Isoetes* stands alone among pteridophytes so far as we know at present, although it is possible that an investigation of the earlier stages of the prothallium of *Selaginella* may show analogies ; but the fact that the true prothallium of the latter is separated by a membrane from the lower part of the spore would point rather to a formation by true cell-division, as in *Marsilia*¹ and *Pilularia*². The oophyte of all other heterosporous pteridophytes is capable to some extent of independent growth, and this is especially true of the Filicineae, in which it develops chlorophyll, and may increase very considerably in size, provided the archegonia are not fertilized. Indeed the development of the oophyte of *Isoetes* resembles much more nearly that of the gymnosperms, or the endosperm of the angiosperms, than it does the prothallium of any pteridophyte, and in this respect must be regarded as the nearest approach to the former among the pteridophytes.

¹ Loc. cit.

² Loc. cit.

THE EMBRYO.

The youngest embryos observed had the first division-wall already complete (Fig. 19). This is transverse, but more or less inclined to the axis of the archegonium. The nuclei of the two cells are large, and contain several chromatin-masses. The second divisions in the two halves of the embryo do not always occur simultaneously, the lower half dividing sometimes before the upper, and at times the first walls in the two parts are at right-angles to each other instead of in the same plane, as is usual. Of the quadrants resulting from these divisions, the two lower form the foot, which is here large, and of the upper one forms the first leaf, and the other the primary root. The apex of the stem, which always is very inconspicuous, arises between the bases of the leaf and root, and probably belongs to the same quadrant as the latter; but as it does not project at all, and is not certainly recognisable until after the boundary between the quadrants is no longer evident, this cannot be asserted positively.

Sometimes (see Fig. 21) the quadrants divide by vertical walls into nearly equal octants, but in several young embryos observed (see Fig. 25) no regular octant-wall was formed, at least in the upper quadrants, but whether such irregularities were normal it is difficult to say, and it is certain that sometimes, at any rate, and probably in most cases, the embryo is divided into regular octants as in the ferns.

The next divisions also follow much the same plan as in the fern-embryo, and for a short time the young members may be said to grow from an apical cell, inasmuch as the tetrahedral octants at first have segments cut off parallel with the basal, quadrant, and octant walls, leaving an outer cell (Fig. 24, *a*) that still retains the original form; but very soon periclinal walls are formed in this cell in each quadrant, and it is no longer recognisable as an apical cell. Unfortunately, on account of the great difficulty of making successful sections of the very young embryos, it was not possible to get a sufficient

number of satisfactory preparations to determine positively, or for how long this regularity of growth persists.

Up to this time the embryo has increased but little in size, and has the form of a globular or oval cellular mass in which the organs are not differentiated. In proportion as the basal-wall diverges more or less from the horizontal, so does the axis of the first leaf which is parallel with it. Occasionally the basal-wall is so nearly vertical that the young leaf grows upright, penetrating the neck of the archegonium at right-angles to its usual course. The embryo now rapidly elongates in the direction of the basal-wall, and very soon there may be distinguished in the upper portion a division into leaf and root (Figs. 27, 28). The original quadrant-wall remains distinct for some time, and is especially evident in transverse sections (Fig. 29, *II II*). At the base of the leaf, at this stage, a single cell (Fig. 27, *x*), larger than its neighbours, may sometimes be seen. This is the mother-cell of the ligule, which is so conspicuous a feature of all the leaves.

If we compare the young embryo at this stage with that of other pteridophytes, we find that it does not agree exactly with any, but on the whole resembles that of the various Filicineae that have been examined. The greatest difference, apart from the absence of a single apical-cell in the young members, is the different position of the stem. This in all the true ferns examined arises from one of the lower quadrants, which here takes part in the formation of the foot, while the stem-apex in *Isoetes*, as already stated, arises between the leaf and root that is from one of the *upper* quadrants.

Longitudinal sections of the embryo at a time when root and leaf become first clearly recognisable, show that the foot is not clearly limited (Fig. 28, *f*), as the basal-wall of the embryo early becomes indistinguishable on account of the displacement due to the rapid cell-multiplication in the axis of the embryo; nor is it as conspicuous as in the later stages (Figs. 39-41), projecting but little, and not having its cells noticeably larger than those of the root and leaf. These now (Figs. 28, 30) have the form of a blunt cone, the latter some-

what longer and more pointed, but in neither is there any longer any trace of a single apical-cell. At the base of the leaf, which is now separated from the root by an evident depression, the ligule is usually (Fig. 28, *x*) visible, as a short row of cells lying close to the base of the leaf. A vertical transverse section of an embryo of about the same age (Fig. 31) shows that the ligule is already divided by walls in two planes, these walls being arranged with great regularity. Hofmeister¹ compares the divisions to those in the young gemmae of *Marchantia*, and the resemblance is quite striking. The ligule later divides further by both longitudinal and transverse walls until it may reach a breadth of from ten to twelve cells, with a length of about the same (Figs. 46, 49).

Very soon after the ligule becomes visible, the base of the root, which lies close to it, begins to project in the form of a semicircular ridge (Fig. 30, *v*) that grows rapidly and forms a sheath enclosing the ligule, together with the base of the leaf. The sheath increases by the division of the marginal cells, from whose bases cells are cut off which divide further and thus add to the sheath, and increase the depth of the space inclosed by it. A number of cells at the bottom of the furrow, between the sheath and the base of the leaf, constitute the apex of the future stem of the plant. As they differ in no wise from the neighbouring cells, it is quite impossible to say how many of them belong properly to the stem-apex.

The Leaf.—The first leaf, as we have seen, arises from one of the two upper quadrants, and may for a very short time be said to have a single apical-cell; but very early all trace of a definite apical growth is lost, and the lengthening is soon due to rapid division of the cells at the base. At first nearly cylindrical, it soon becomes slightly flattened and the primary tissue-systems are plainly evident. The first periclinal walls in the embryo probably separate the dermatogen from the inner tissues, which do not show a further division into plerome and periblem until a much later stage. At any rate, in

¹ Loc. cit., p, 346.

all but the very youngest embryos, the dermatogen in the leaf is very plain.

About the time that the first divisions in the ligule are formed, a few cells near the centre of the embryo cease to divide by transverse walls, but elongate in the direction of the longer axis of the embryo, and dividing longitudinally, form a bundle of narrow cells, the first trace of the fibro-vascular system of the young plant. This first group of cells lies so near the centre of the embryo that it is not possible to assign it certainly to either root or leaf; indeed in some cases it seems to belong to one quadrant, and again to the other. From it, in both directions, the development of the single axial bundle of both leaf and root proceeds, and by it they are both directly connected. A cross-section of these cells shows them to be of nearly equal diameter (Fig. 31). The section of the plerome-cylinder is somewhat elliptical, corresponding to the flattening of the leaf, and the appearance of the longitudinal sections differs as the section is made parallel to the flattened surface of the leaf, or at right-angles to it. In the former case, the diameter of the plerome is uniform, and it ends abruptly (Fig. 43). In the latter, it is narrower and tapers gradually to a point (Fig. 39). In both views its limits are clearly defined, as are those of dermatogen and periblem. The plerome-cylinder never extends entirely to the apex of the leaf, but is separated from it by several rows of cells. In the periblem, the divisions are mainly transverse, and the cells are therefore arranged in quite regular rows; this is especially marked in horizontal sections (Fig. 43).

Now begins a rapid growth in length, due partly to an increase in length of the cells at the tip of the leaf, and partly to the rapid transverse divisions and growth of the basal cells. The cells of the prothallium grow for a time, following the growth of the embryo, but soon the cells are ruptured and the young leaf protrudes, and having now developed abundant chlorophyll, appears to the naked eye as a bright green point attached to the spore.

At first the leaf is composed of a compact tissue without

intercellular spaces, but as it begins to elongate, the cells increase rapidly in size, and separating at the corners, numerous intercellular spaces result. There are usually two rows of very large ones (Fig. 49, *i*) that form broad air-channels extending the whole length of the leaf, but interrupted at intervals by layers of cells that form imperfect partitions across them.

The primary xylem consists of small spiral and annular tracheids at the base of the leaf, and from these the formation of similar ones proceeds toward the tip. Their number is small, even in the full-grown leaf, and they are the only differentiated elements of the bundle, which for the rest is composed of elongated parenchyma-cells, differing in no essential particular from the original procambium-cells.

The Root.—The first root arises from the posterior upper quadrant of the embryo. Ordinarily its axis of growth is in the same plane as that of the leaf, so that a vertical longitudinal division of the embryo through the centre bisects both root and leaf (Fig. 39). Not infrequently, however, the root diverges more or less from the median line, and when the leaf is nearly vertical, as sometimes happens, it makes almost a right-angle with it. In the root, as in the leaf, the primary tissues become early differentiated, but here the growth is due exclusively to the activity of cells near the apex.

In the very young root (Fig. 27) the end is covered with a single layer of large cells, the dermatogen, continuous with that of the rest of the embryo. Beneath are two layers, concentric with the cells of the dermatogen (Figs. 27, 28). Of these, the inner is the initial layer of the plerome, which soon becomes well defined and connected with the bundle of procambium-cells in the centre of the embryo. The layer of cells below the primary epidermis is the initial meristem for all of the tissues of the root except the plerome, and the outermost layer of cells (primary epidermis) splits into two layers (Fig. 38, *R*), that take no further part in the growth of the root.

At a somewhat later stage (Fig. 44) the primary tissue-systems are plainly seen, and are arranged as follows. Occupying the axis of the root is a blunt cylinder whose terminal cells ($\times \times$) are somewhat larger. This is the plerome-cylinder. At the apex the cells are nearly iso-diametric, but lower down become longer and narrower by the formation of longitudinal walls and increase in length due to growth.

Covering the apex of the plerome is a single layer of cells, which is the initial for all the other tissues, and this arrangement, when established, continues as long as the root grows. From this layer additions are made to the root-cap at regular intervals, and the layers of cells so cut off do not undergo any further division by periclinals, but remain one cell in thickness, so that a regular stratification of the root-cap is always noticeable. At the apex of the root there is no distinction between dermatogen and periblem, but these first become separated back of the apex.

The primary xylem consists of very delicate spiral tracheids which are formed at the base of the root at the same time that the first ones appear in the leaf.

The root grows rapidly in length and bends downward so as to attach the young plant to the ground. It increases but little in diameter, and has fewer and much smaller air-spaces than are found in the leaf.

If we compare the structure of the roots with that of other plants, it is found to correspond most nearly with that of certain monocotyledons. Bruchmann¹ gives for the roots of the older plant a structure corresponding to De Bary's² third type of angiospermous roots, which differs from the account given here in that there is a special initial layer for dermatogen and calyptrogen. I have not examined the older roots, and so cannot state whether this is true in the species under consideration or not.

The Foot. The foot, which at first projects but little, enlarges as the embryo grows, by the rapid growth of its

¹ Jenaische Zeitschr. für Naturw. VIII. p. 522.

² De Bary, Comparative Anatomy.

cells, and encroaches upon the lower cells of the prothallium, which are destroyed by its growth and their contents absorbed to supply nourishment to the rapidly growing embryo; and by the time that the young plant breaks through the prothallium, and the root reaches the ground, the foot has grown so as to nearly fill the cavity of the spore, and nothing is left of the prothallium except a layer of cells surrounding the central part of the young plant. These cells have now lost their dense contents, and contain little else than a watery cell-sap.

SUBSEQUENT GROWTH OF THE YOUNG PLANT.

About the time that the young plant breaks through the prothallium, the second leaf begins to develop. The growing-point of the stem (Fig. 45, *st*) lies in the groove between the base of the root and leaf, and is a nearly flat area, whose surface is nearly at right-angles to the axis of the leaf. The second leaf (L^2) arises as a slight elevation on the side opposite the first leaf. From the first it consists of several cells, and its growth is entirely similar to that of the first leaf, which it resembles in all respects. The ligule begins to develop while the leaf is still very small. Almost as soon as the leaf can be made out, a line of procambium cells is formed, running from the junction of the first leaf and root and continued into the second leaf as its plerome. As in the first leaf, the apical growth is of short duration, and the subsequent increase in length is mainly due to the rapid multiplication of the cells near the base of the leaf.

The growth is slow for a time, but after reaching a certain length it elongates very rapidly, and about this time the first trace of the second root appears. It arises at the base of second leaf in the immediate vicinity of the common fibrovascular bundle of the stem. A group of cells (Fig. 47, r^2) here begins to multiply actively, and very soon shows a division into the initials of the tissue-systems of the young root. As the growing cells of the young root stain more deeply than those of the surrounding tissues, it is distinguishable at a

very early stage. Very soon the tissue-systems become differentiated, and the root elongates rapidly and breaks through the overlying tissues. In its structure and growth it does not differ in any way from the first one.

The stem has no fibro-vascular bundle apart from the common bundle formed by the coalescence of the bases of the bundles of the leaves and roots. In both leaves and roots there is but a single bundle. This in the leaves is very decidedly collateral in the arrangement of its tissues, with the xylem upon the inner (upper) side. Except for their larger size, and somewhat better developed fibro-vascular bundle, as well as having usually four rows of large air-spaces, instead of two, the full-grown leaves resemble in structure those first formed.

The histology of the mature sporophyte was not investigated further, as this has already received full attention from other investigators.

Owing to the large air-spaces in the leaves, they are much lighter than the water in which the plant grows, so that they finally stand upright, whether their first position was horizontal or vertical. In the former case, the apex then appears to be attached laterally, and the apex of the stem is horizontal. Longitudinal sections of young plants with two or three leaves (see Fig. 50) show that the stem has a flat, or slightly concave apex which lies at the bottom of a deep cavity formed by the bases of the leaves. The third leaf arises in the same way as the second, and at a point distinctly opposite, i. e. immediately above the first.

The development of the young plant was not followed beyond this point, but probably agrees with Hofmeister's account of *I. lacustris*¹, in which the $\frac{1}{2}$ arrangement of the leaves continues up to about the eighth, when it is replaced successively by the $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, and $\frac{8}{21}$ arrangements.

¹ The Higher Cryptogamia, pp. 354-356.

SUMMARY.

The results of the foregoing statements may be briefly summed up as follows :

1. The spores of *Isoetes echinospora*, var. *Braunii*, Durieu, will germinate as soon as ripe, provided the sporangium is artificially opened, but germinate more promptly after a rest of several months.

2. The microspores in germinating produce a single prothallial cell, and an antheridium composed of four peripheral and four central cells, each of the latter giving rise to a single multi-ciliate spermatozoid, the body of which is derived from the nucleus of the sperm-cell.

3. The ripe macrospore contains a large elliptical nucleus lying in the basal portion. This undergoes division while in its original position, but no division-wall is formed. The secondary nuclei, by repeated divisions, give rise to a number of free nuclei, which lie in the apical region of the future prothallium, and not until the number is quite large (about 30-50) does the process of cell-formation begin.

4. The process of cell-formation is entirely similar to that in the embryo-sac of most spermaphytes. It begins at the apex of the spore and proceeds toward the base, following the wall, and finally proceeding centripetally, the whole spore becomes filled with a continuous tissue.

5. The first archegonium arises from one of the first formed cells, at the centre of the apical region. Its development corresponds closely with that of the Marattiaceae.

6. Other archegonia (usually two) begin to form before the first one is mature, quite independently of its being fertilized or not.

7. A small number of secondary archegonia may be formed in case the primary ones all fail to be fecundated, but the total number is small, not exceeding eight in any cases observed.

8. The prothallium is incapable of independent growth, and dies after the supply of food in the spore is exhausted.

9. The first wall in the embryo is transverse, but may be inclined to the axis of the archegonium. The lower cell forms the foot; the upper, stem, leaf, and root.

10. There is usually, but not invariably, a regular division into octants, as in the ferns, and the first divisions in the octants correspond also to the fern-type; but very early all trace of growth from an apical cell is lost in all the members.

11. The leaf arises from two of the upper octants, the root from the others, the stem arising between them at a later stage.

12. The growth of the root corresponds to that of certain monocotyledons.

13. More than one archegonium may be fertilized, but so far as observed only one embryo develops completely.

CONCLUSIONS.

On reviewing the statements here given, it is evident that *Isoetes* must still be regarded as holding a very isolated position among plants; for while showing evident affinities with several forms, they are in widely separated groups.

Vines¹ has given a number of reasons for placing *Isoetes* with the Filicineae rather than with the lycopods with which it is generally associated, and calls attention to several points, i. e. the anatomy and histology of the stem, the multi-locular sporangia, &c., but admits that there are certain difficulties in the way. In certain respects, notably the dichotomy of the older roots, there is a strong resemblance to the lycopods.

The secondary thickening of the stem is peculiar among living pteridophytes, with the exception of certain species of *Botrychium*, but it is of quite a different type from that of gymnosperms and dicotyledons, and approaches more nearly that found in a few monocotyledons.

One point overlooked by Vines, and one it seems to me of great importance, is the structure of the spermatozoids. These closely resemble those of the ferns, both in their form

¹ Annals of Botany, II. pp. 117-223.

and in having numerous cilia. All lycopods yet examined have bi-ciliate spermatozoids like those of the bryophytes.

The embryo, too, in the absence of a suspensor common to many, at any rate, of the Lycopodineae, as well as to the arrangement of its members, points to a genetic connection with the ferns rather than the lycopods. Unfortunately we have no account of the young embryo of any of the eusporangiate ferns, with which *Isoetes* ought to have a closer connection than with the leptosporangiate forms.

Taking into consideration, then, the data at our disposal, the weight of evidence seems to be in favour of regarding *Isoetes* as belonging rather to the Filicineae than to the Lycopodineae.

As to the affinities of *Isoetes* with the spermaphytes, in regard to the formation of the female prothallium, it more nearly resembles them than it does any pteridophyte with the possible exception of *Selaginella*; and in the absence of any distinction between the prothallium proper and endosperm, is certainly nearer the spermaphytes than is the former. The reduction, too, of the antheridium, producing but four spermatozoids, is greater than in any other pteridophyte.

The embryo, in the absence of a suspensor, differs very widely from that of the gymnosperms, even the cycads with which Bower¹ suggests there may be a relationship, and among the spermaphytes the monocotyledons offer the nearest approach to it in structure. The lateral formation of the stem-apex, as for instance in *Alisma* (see Goebel, 'Outlines,' Fig. 332), is extraordinarily similar to its formation in *Isoetes*, as well as the relative positions of the single cotyledon and root; and this together with the histology of the grown sporophyte, the leaves with their sheathing bases surrounding the short, bulb-like stem, and the structure of the roots, all suggest a possible relationship to the monocotyledons directly rather than with the gymnosperms. Certainly the development of the prothallium would hardly be an argument against

¹ Annals of Botany, vol. III. No. XI. p. 387.

such a view, as the prothallium of the gymnosperms is quite as highly developed, and in the cycads, at least, capable of independent growth.

There is, however, an immense interval between the flower of the simplest angiosperm and the sporophylls of *Isoetes*, and it would be rash to assume a relationship unless more evidence can be produced on the side of the angiosperms to warrant this. The possibility of an independent origin of the angiosperms from the pteridophytes has, however, been broached more than once, and further investigations with a view to settling the matter are very much to be desired.

EXPLANATION OF FIGURES IN PLATES
XV, XVI, XVII.

Illustrating Prof. Campbell's paper on *Isoetes*.

All the figures were drawn with a Zeiss camera from microtome-sections mounted in Canada-balsam.

PLATE XV.

Fig. 1. Cross-section of an ungerminated spore, between the nucleus and the wall. *s*^s, starch granules; *Al*, Albuminous granules. Chromic acid, safranin preparation. $\times 650$.

Figs. 2 and 3. Two sections through the nucleus of the same spore as Fig. 1. *n*, nucleolus.

Figs. 4 and 5. Nuclei of spores that have lain in water, showing the first changes in the nucleus. Chromic acid, gentian-violet. $\times 650$.

Fig 6. The primary nucleus undergoing division. *P*, the cell-plate. Chromic acid, gentian-violet. $\times 650$.

Fig. 7. Oblique section through the apical region of a spore having 48 free nuclei. $\times 300$.

Fig. 8. Cross-section of the apical region of a spore at the beginning of cell-formation. Chromic acid, gentian-violet. $\times 650$.

Fig. 9. A somewhat older stage, in vertical sections. \times about 300.

Fig. 10. Vertical section through the apex of the young prothallium, showing the mother-cell of the first archegonium (*a*). $\times 300$.

Fig. 11. A few cells from the base of the same.

Fig. 12. Vertical section of a prothallium, showing one of the first archegonia, which has failed to be fertilized. $\times 275$ (about).

Figs. 13-17. Successive stages in the development of the archegonium. $\times 600$. *a*, mother-cell; *n*, neck-cell; *c*, neck-canal-cell (Fig. 14); *h*, neck-canal-cell (Figs. 15 and 16); *b*, ventral canal-cell; *o*, central cell in Fig. 14, mother-cell of egg-cell in Figs. 15 and 16.

PLATE XVI.

(The arrow corresponds to the axis of the archegonium.)

Fig. 18. Open archegonium showing the egg-cell (*o*); *r*, the receptive spot. $\times 650$.

Fig. 19. Two-celled embryo *in situ*. $\times 300$.

Fig. 20. Three-celled embryo. $\times 650$.

Fig. 21. Eight-celled embryo, median longitudinal section. $\times 600$.

Fig. 22. An older embryo *in situ*. $\times 300$.

Fig. 23. Transverse section of young embryo. $\times 600$.

Fig. 24. Median section of the embryo shown in Fig. 22.

Fig. 25. Vertical section of an embryo of about the same age, but showing irregularities in the arrangement of the cells. $\times 300$.

Fig. 26. Two vertical sections of an older embryo. $\times 300$.

Figs. 27 and 28. Longitudinal sections of embryos in which the ligule (x) is beginning to form. L , leaf; r , root. $\times 300$.

Fig. 29. Four transverse sections of a young embryo. a , nearest the archegonium; d , furthest from it; $IIII$, the quadrant wall. $\times 300$.

Fig. 30. A median section of a somewhat older embryo than 28. b , section of the root of the same. $\times 300$.

Figs. 31–35. Five vertical sections (at right angles to the longer axis) of an embryo of about the same age as Fig. 30. Fig. 31 is a median section, the others through the root. x , the ligule. $\times 300$.

Figs. 36–38. Three horizontal sections of a somewhat older embryo; letters as in the other figures. $\times 300$.

Fig. 39. Median longitudinal section of an older embryo. $\times 300$. r , root; L , leaf; p , foot; x , ligule; v , sheath.

PLATE XVII.

Fig. 40. Section of the prothallium, with the contained embryo (em). $\times 125$. ar , archegonia; sp , spore-membrane.

Fig. 41. Outline of an embryo at the time of formation of the second leaf (L^2). $\times 125$.

Figs. 42, 43. Two longitudinal sections of the first leaf of an advanced embryo. $\times 300$.

Fig. 44. Longitudinal section of the root of a similar embryo. $\times 300$.

Fig. 45. Apical region of the stem (st) of the embryo shown in Fig. 41. L^1 , L^2 , first and second leaves; r , root; x^1 , ligule of first leaf; v , sheath. $\times 300$.

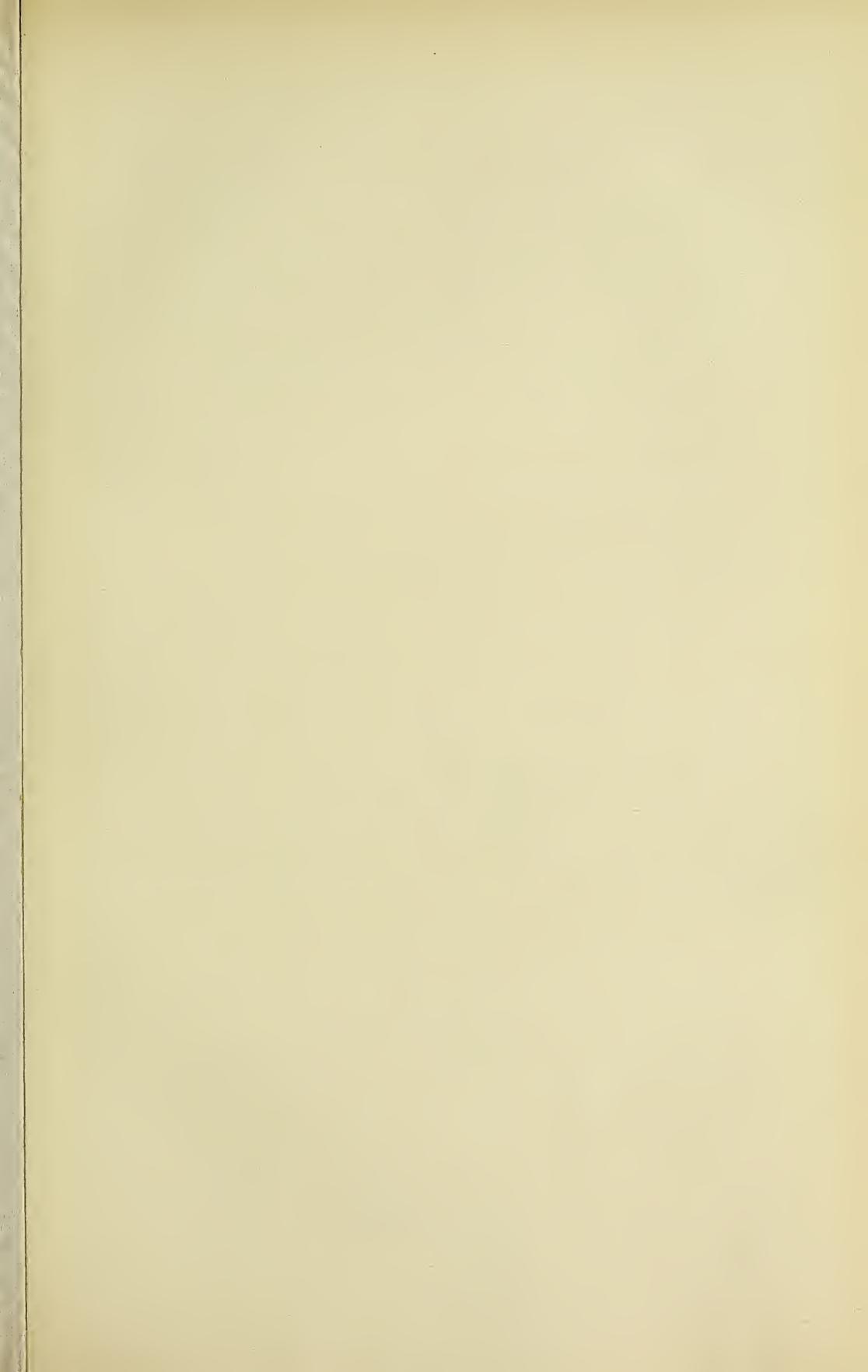
Fig. 46. Similar section of a young plant in which the first leaf was nearly full-grown. Letters as before. $\times 300$. r^2 , rudiment of the second root.

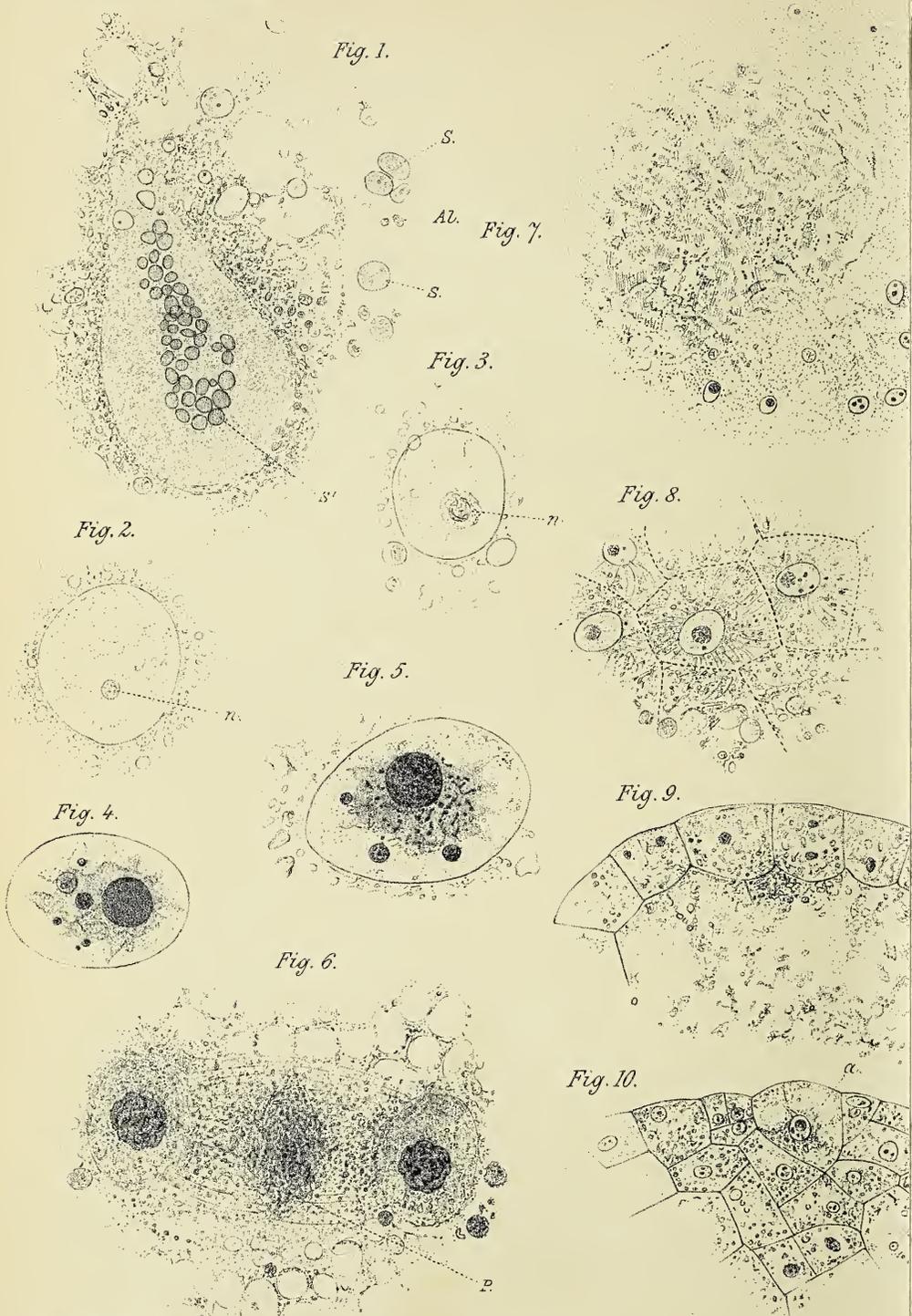
Fig. 47. Section of a somewhat younger plant than that shown in Fig. 46, showing the first rudiment of the second root (r^2). L^2 , the second leaf. $\times 300$.

Fig. 48. Longitudinal section of the young second leaf (L^2) cutting through the second root (r^2). The tracheides have already formed at the base of the first root. $\times 300$.

Fig. 49. Cross-section near the base of the first leaf of the young plant, showing the intercellular spaces (i) and the second leaf (L^2) and ligule (x) surrounded by the sheath (v) at the base of the leaf. $\times 300$.

Fig. 50. Median longitudinal section of a young plant with two full-grown leaves. $\times 125$. Pr , Prothallium; r^1 , r^2 , roots; L^1 , L^2 , L^3 , leaves; st , stem; sp , spore-membrane; ar , archegonium neck.





D.H. Campbell del.

Fig. 11.

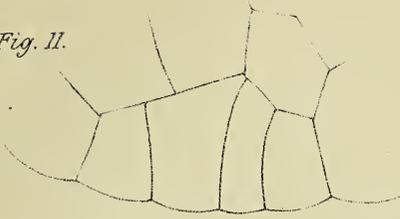


Fig. 13.

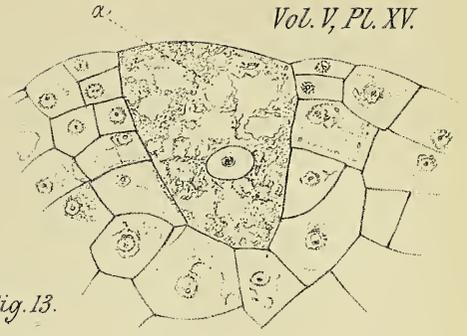


Fig. 12.

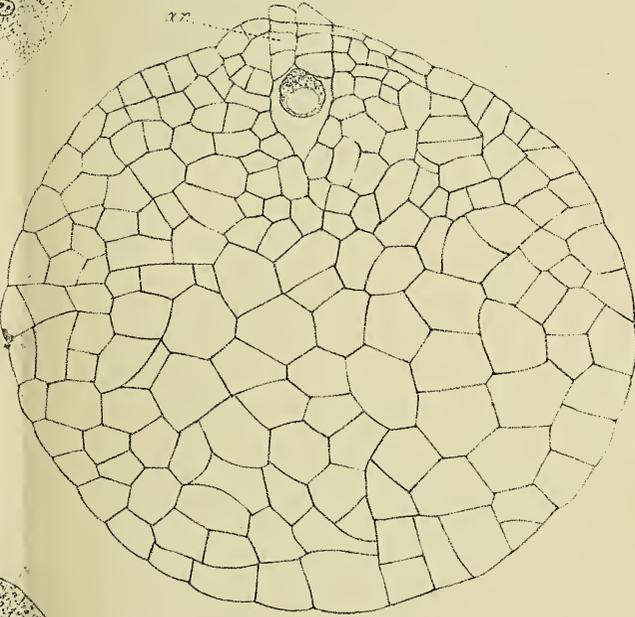


Fig. 14.

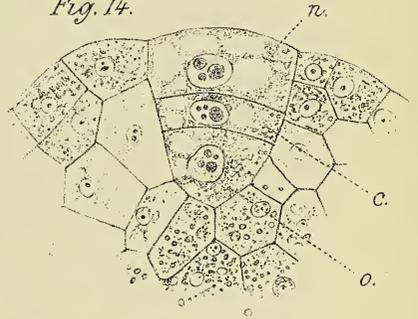


Fig. 15.

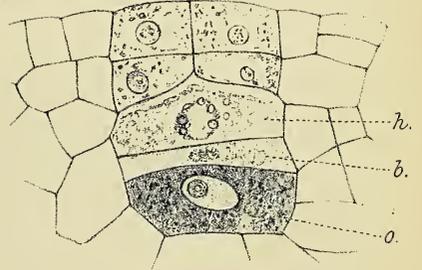


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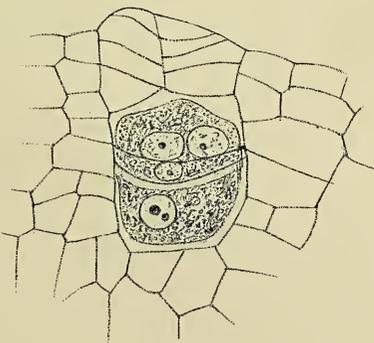


Fig. 16.

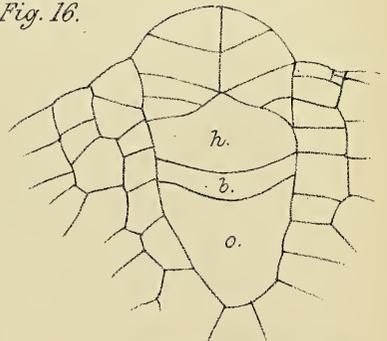
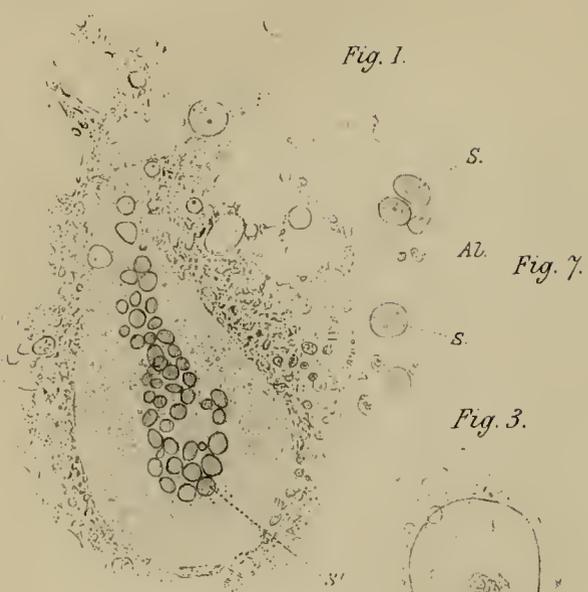


Fig. 1.



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Fig. 7.

S.

Fig. 3.

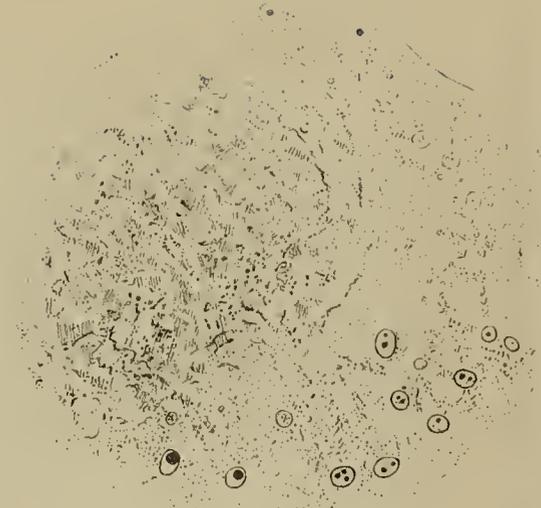


Fig. 8.

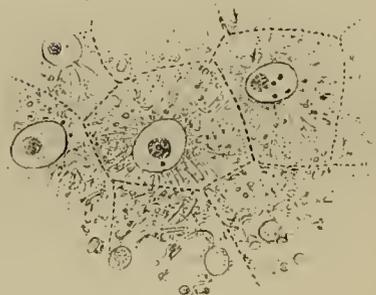


Fig. 9.

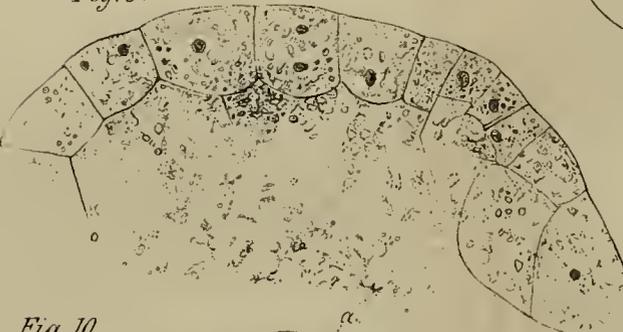


Fig. 10.



Fig. 11.

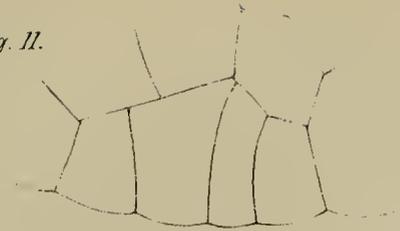


Fig. 12.

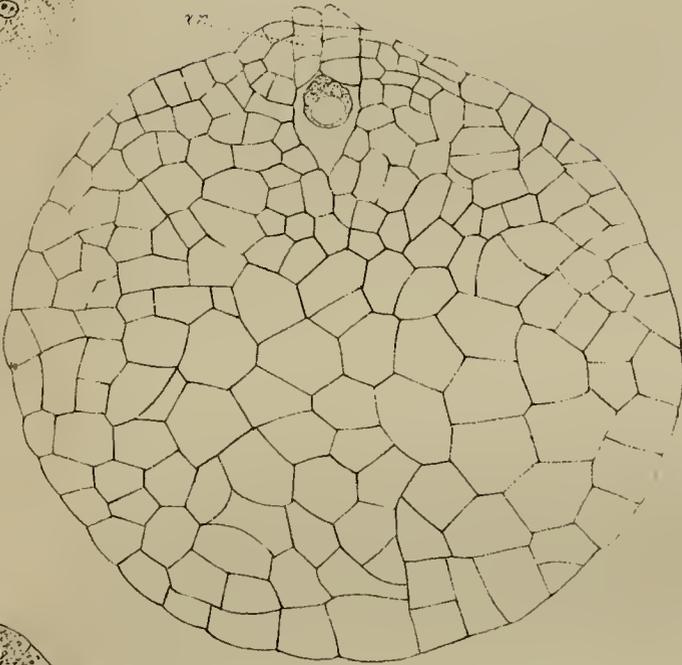
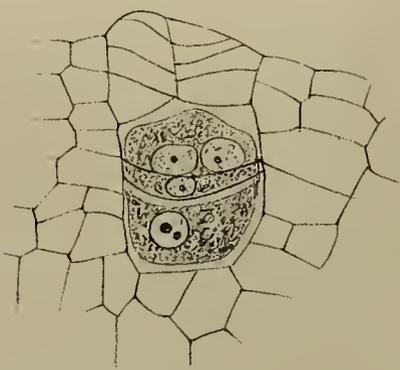


Fig. 17.



α.

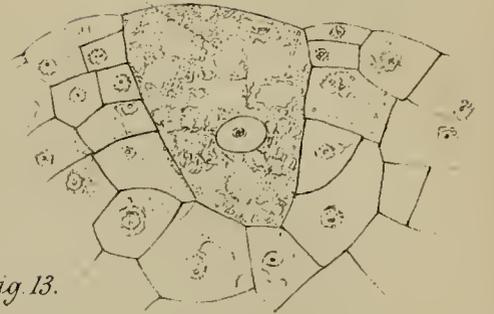


Fig. 13.

Fig. 14.

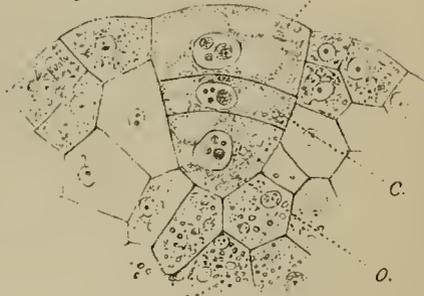


Fig. 15.

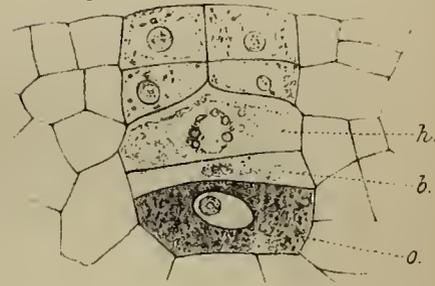


Fig. 16.

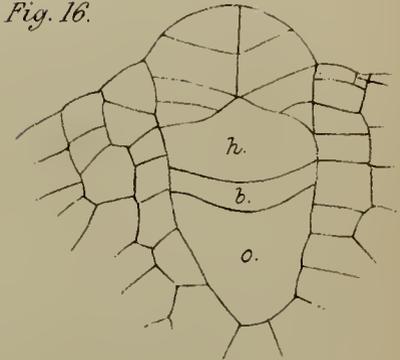


Fig. 2.



Fig. 5.

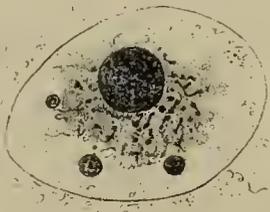
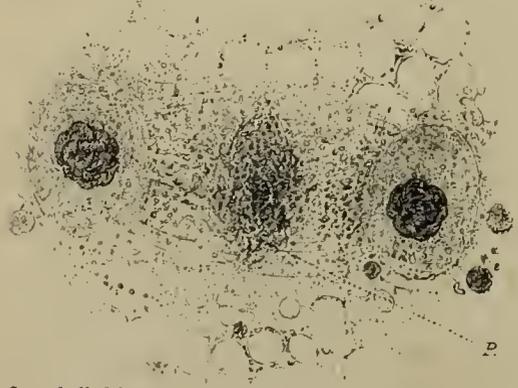


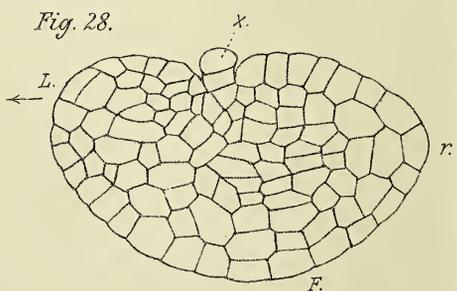
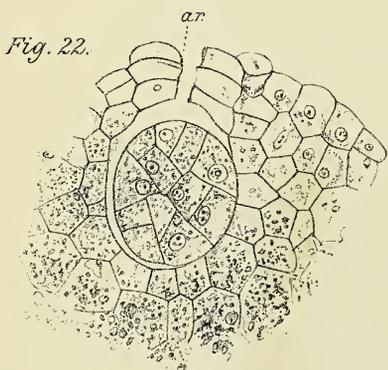
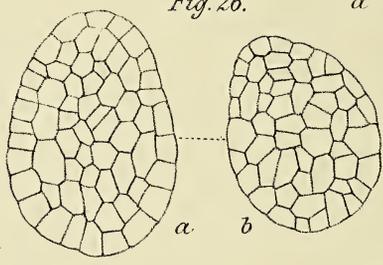
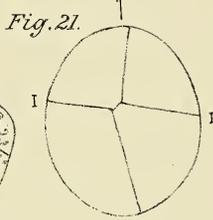
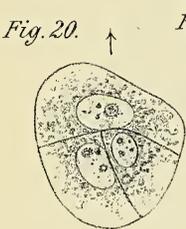
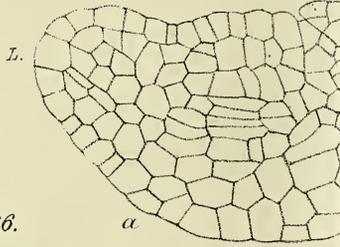
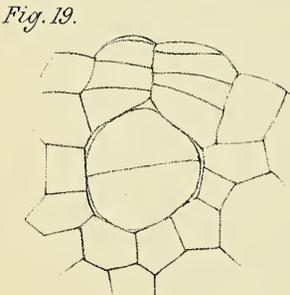
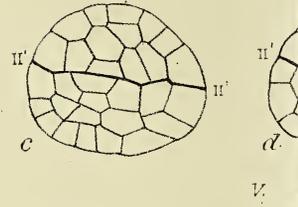
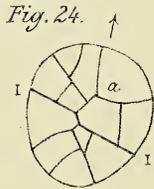
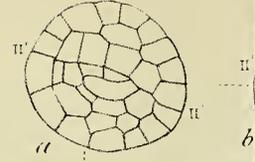
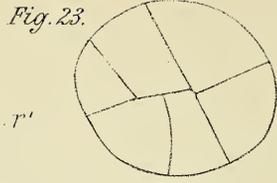
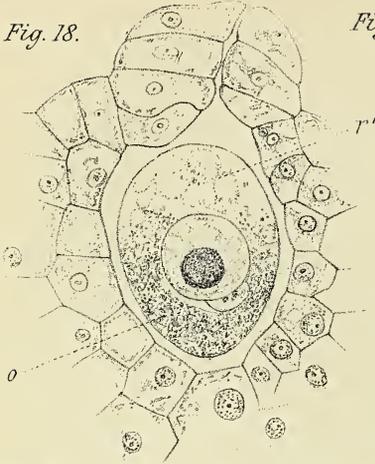
Fig. 4.



Fig. 6.



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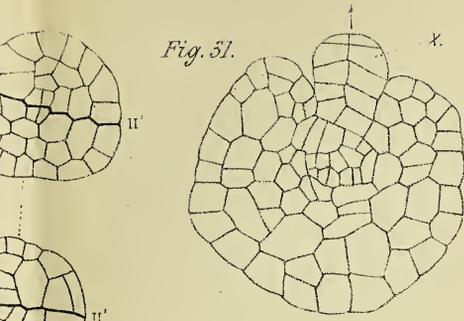


Fig. 31.

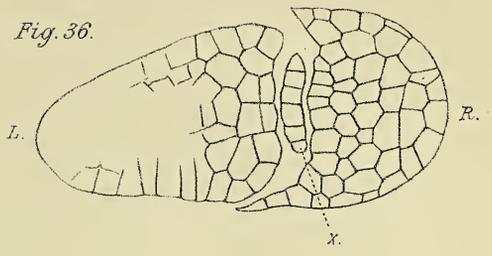


Fig. 36.

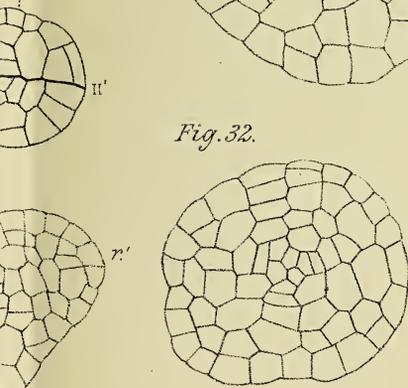


Fig. 32.

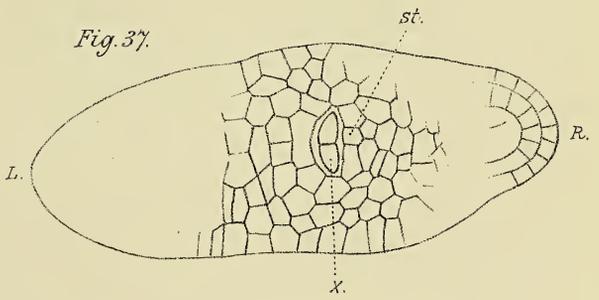


Fig. 37.

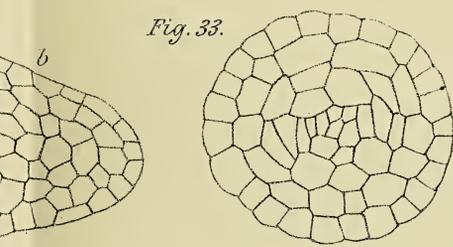


Fig. 33.

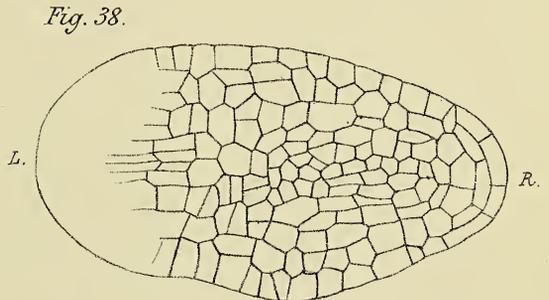


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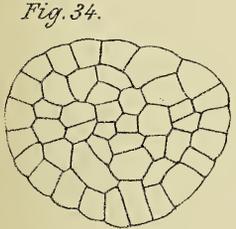


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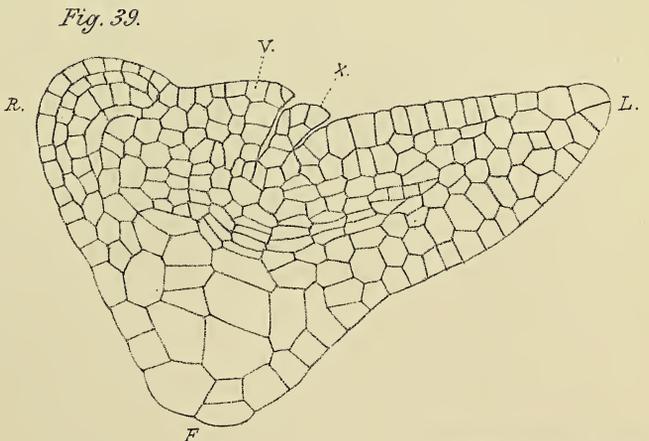


Fig. 39.

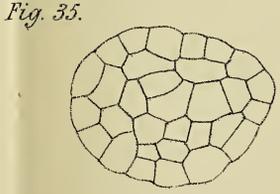
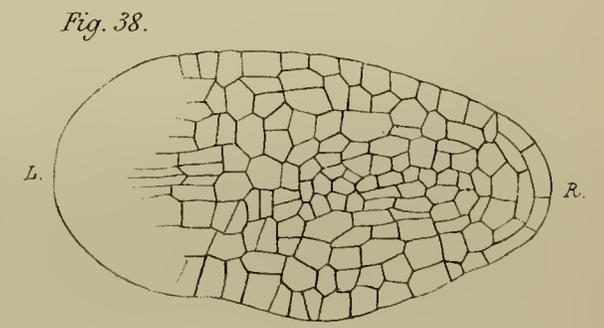
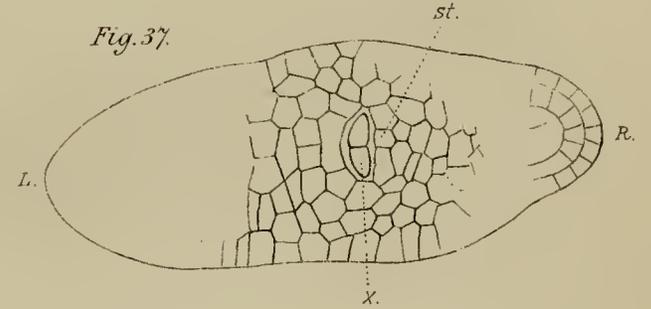
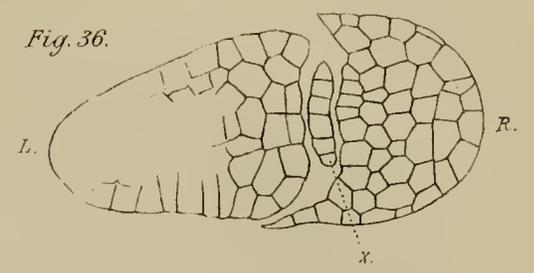
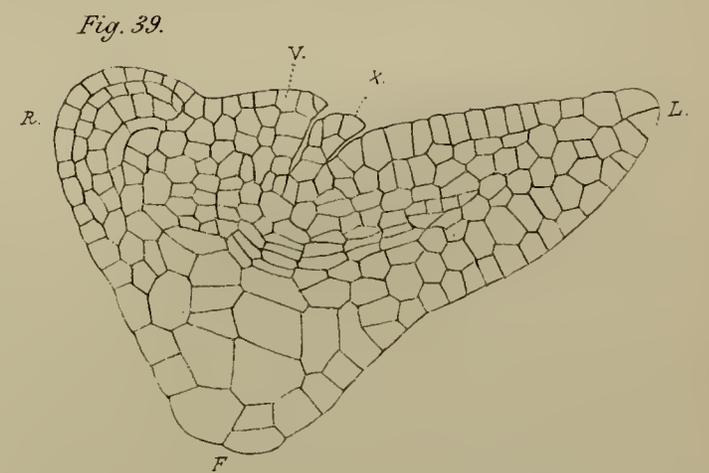
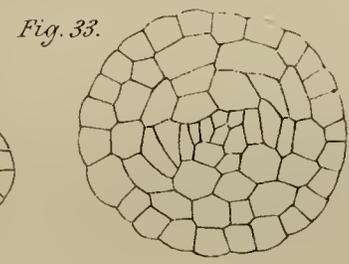
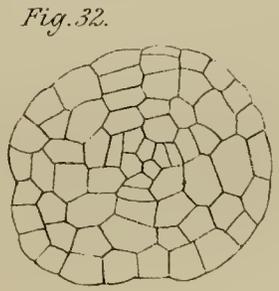
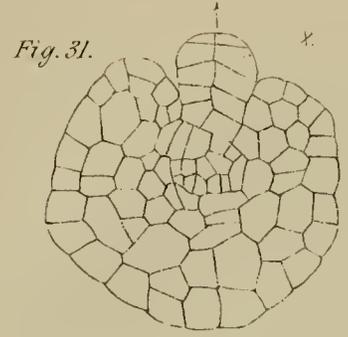
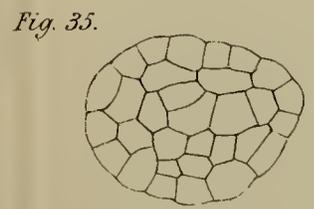
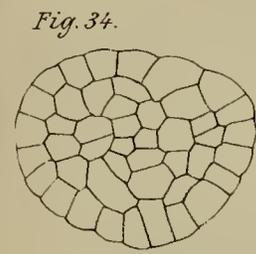
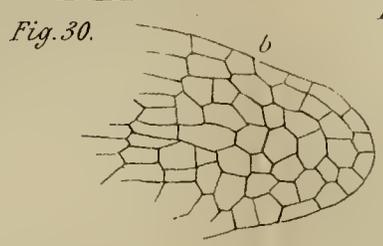
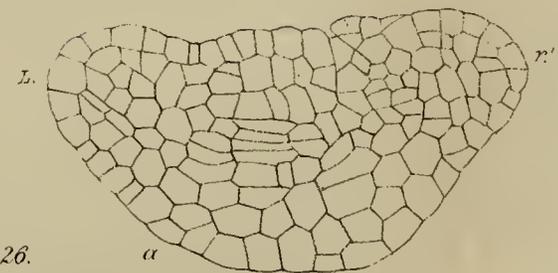
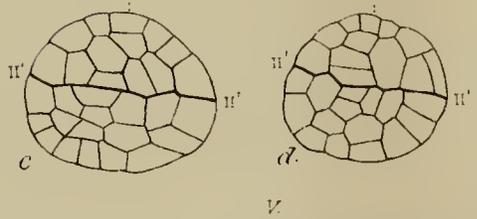
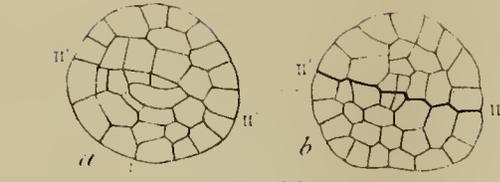
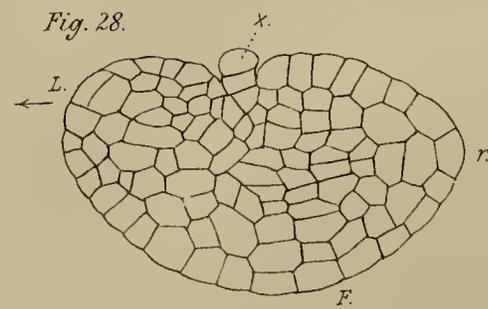
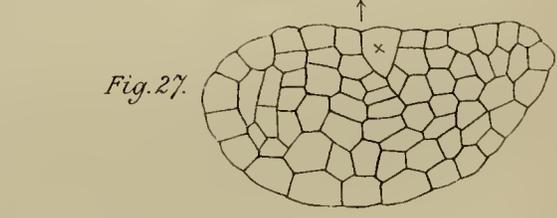
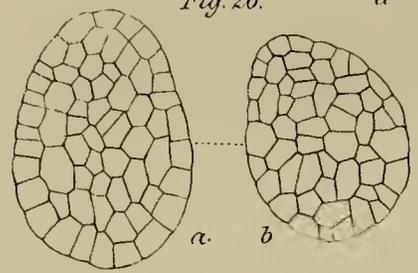
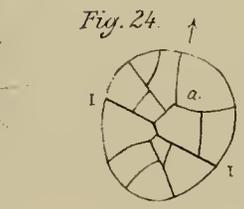
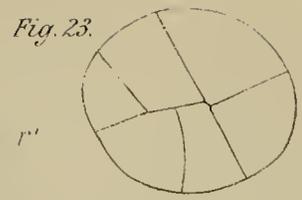
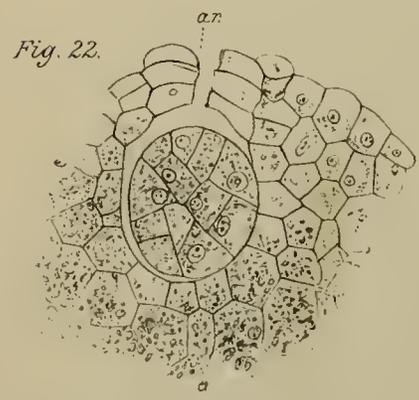
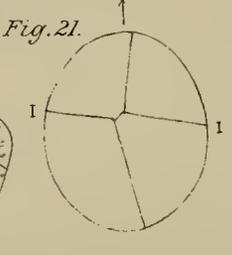
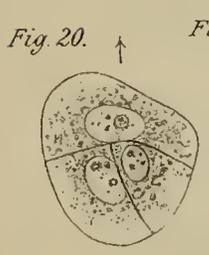
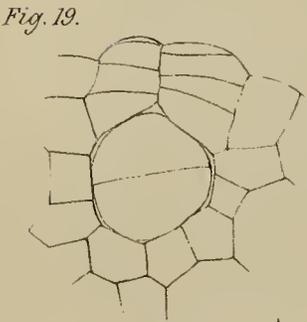
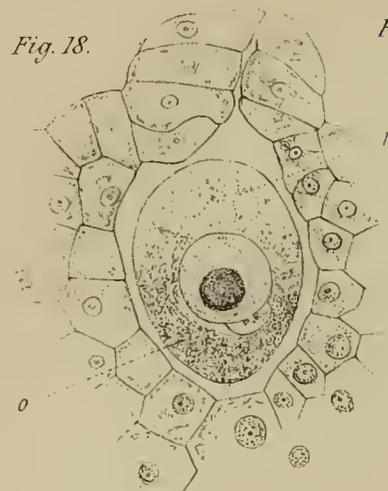
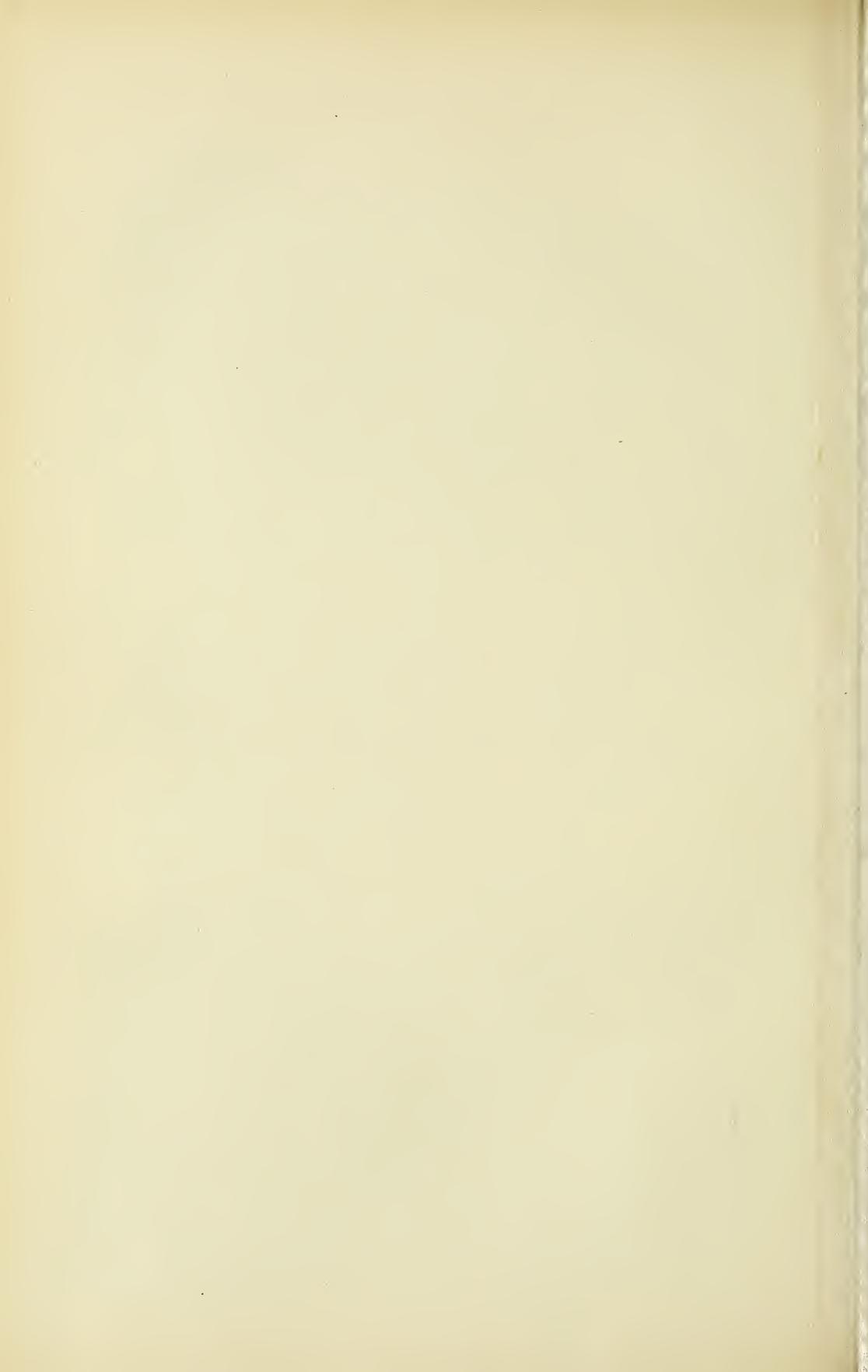


Fig. 35.



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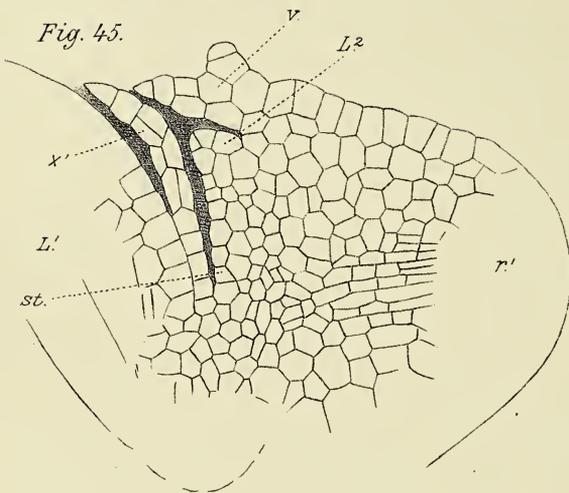
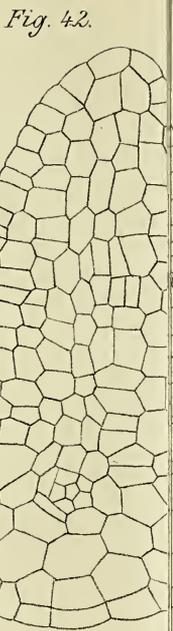
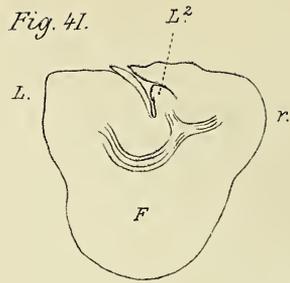
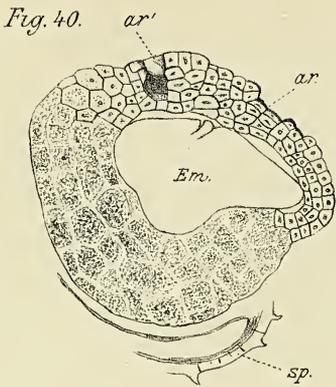


Fig. 48

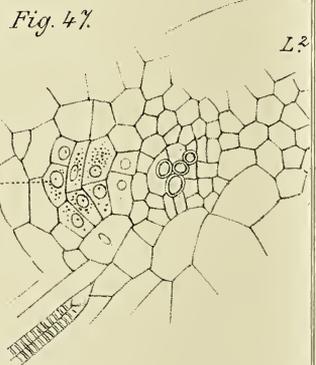
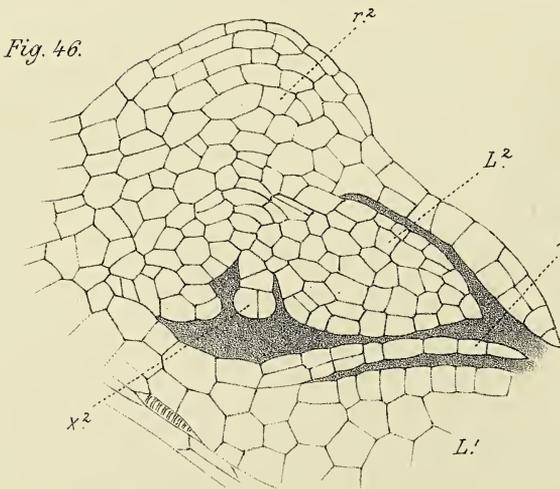


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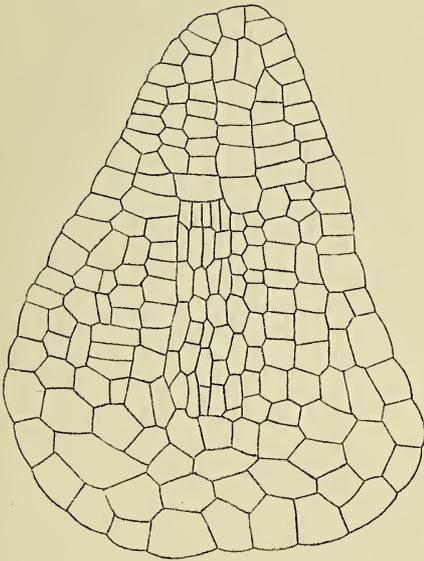


Fig. 44.

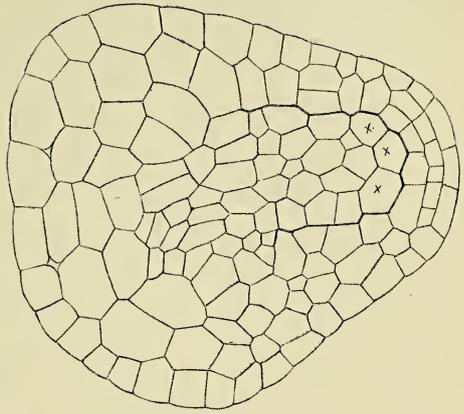


Fig. 49.

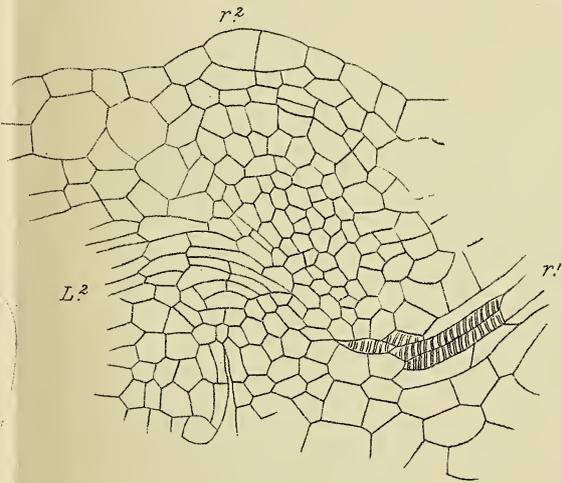
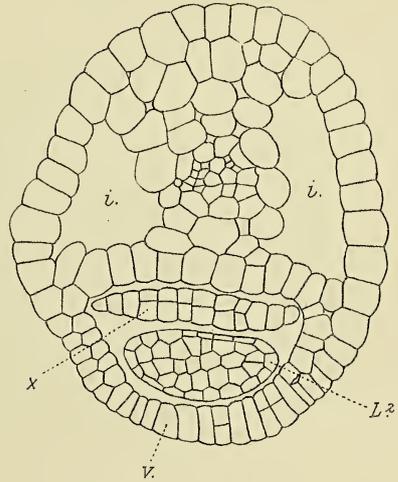
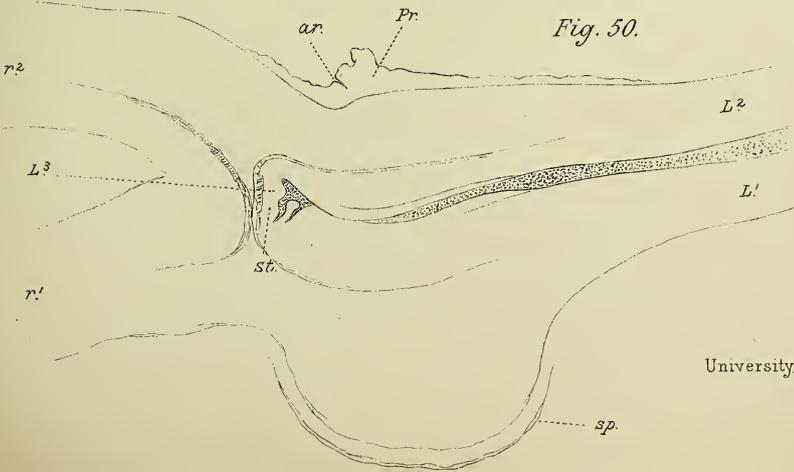


Fig. 50.



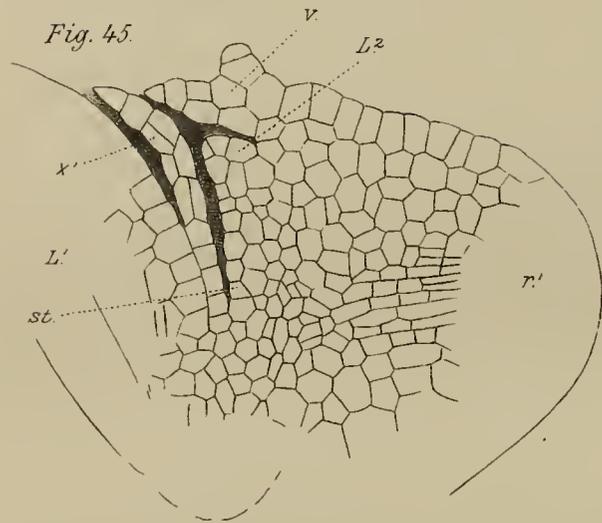
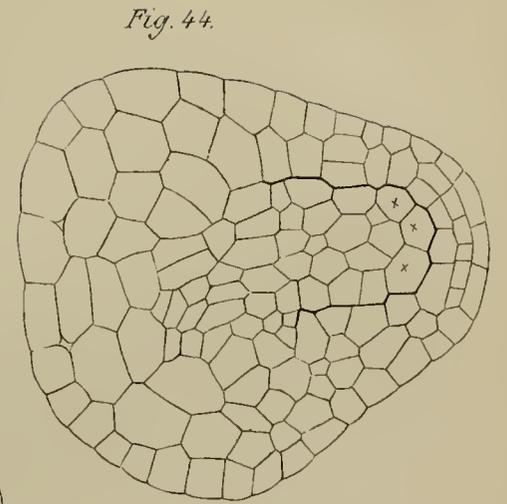
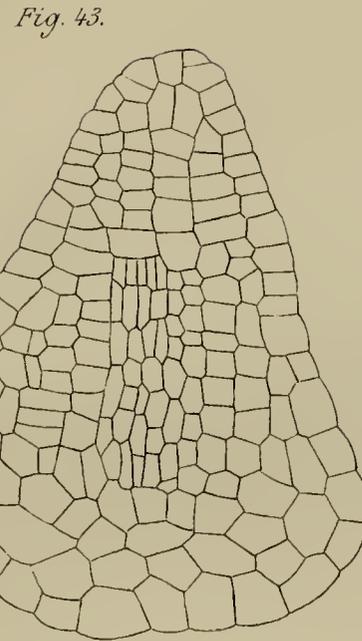
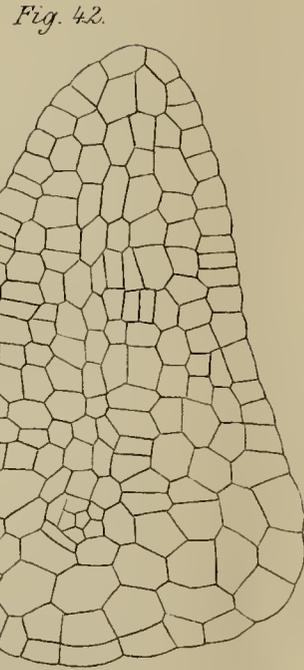
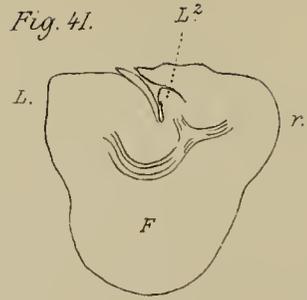
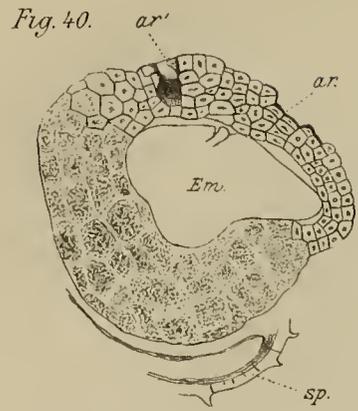


Fig. 48.

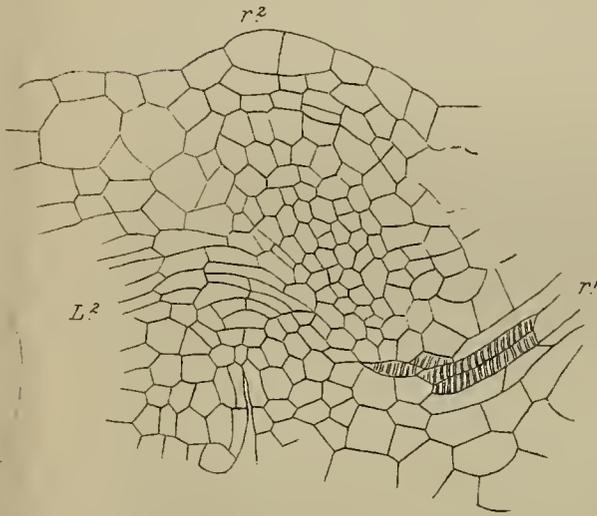


Fig. 49.

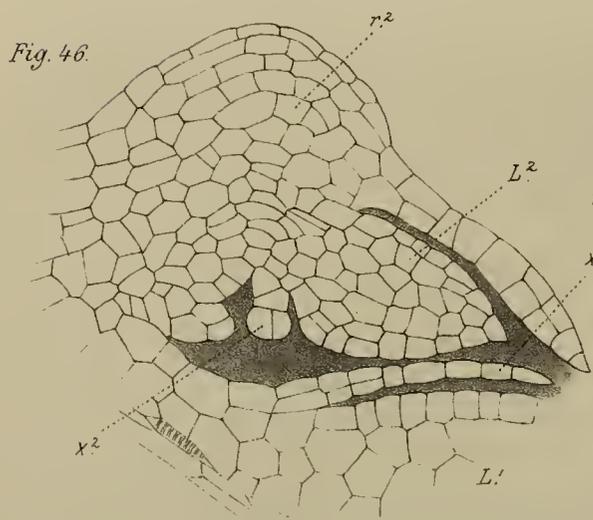
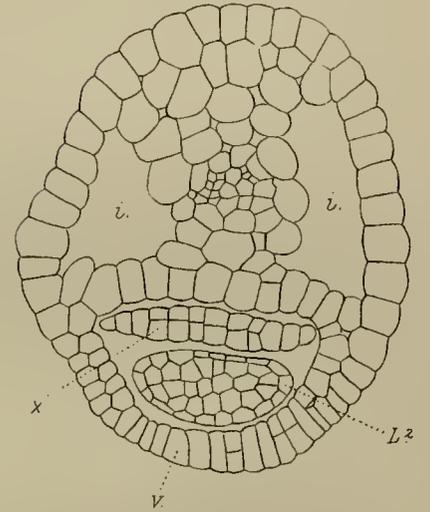


Fig. 47.

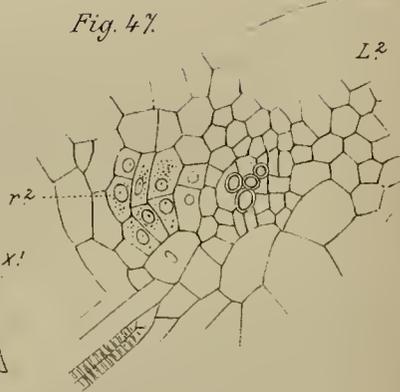
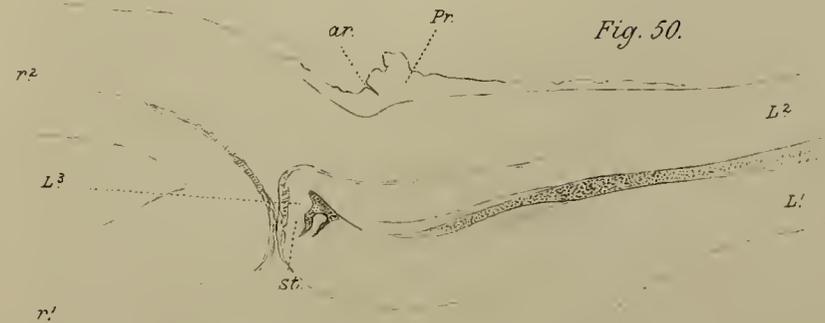
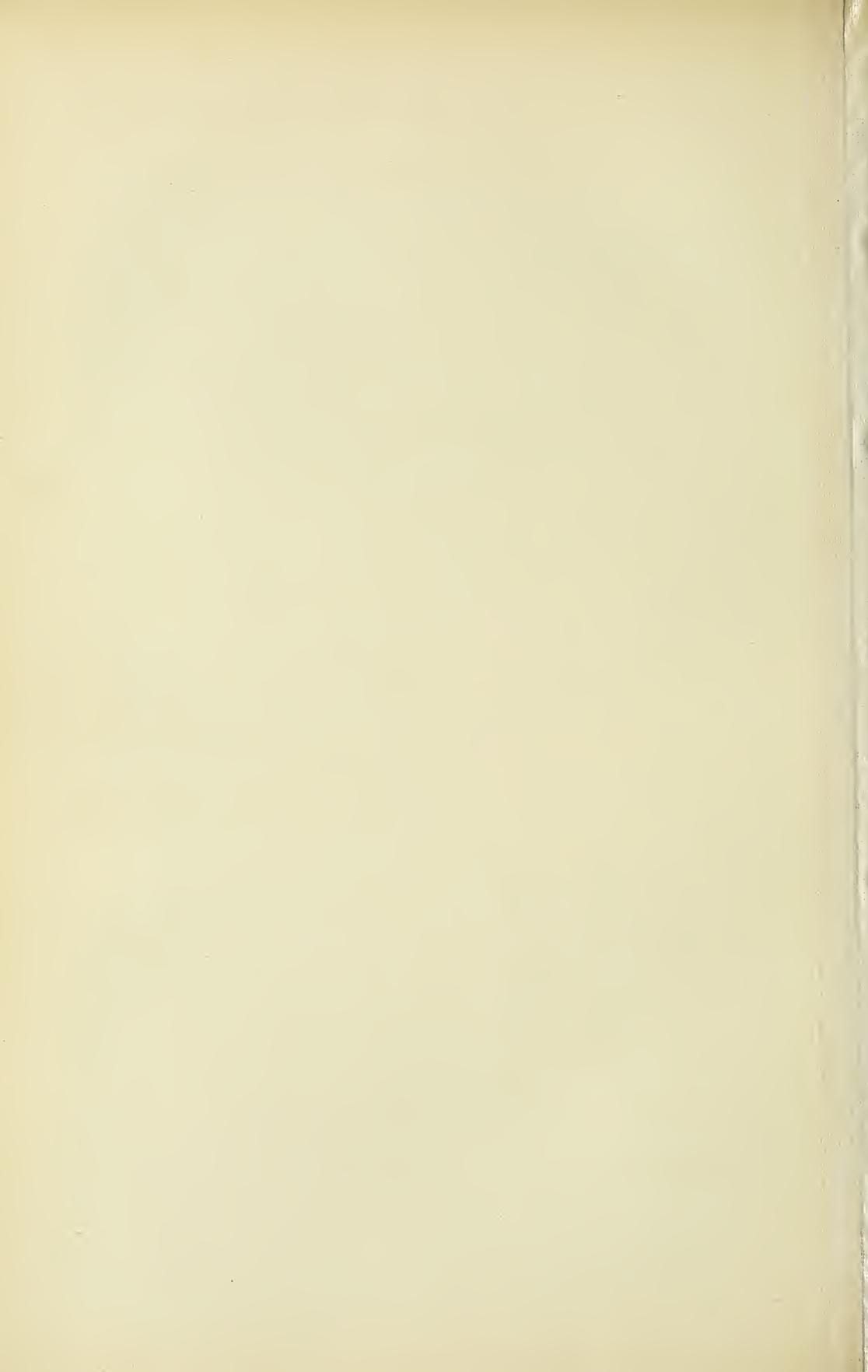


Fig. 50.





POSTSCRIPT.

Since the foregoing was written, an article¹ appeared in the December number of the *Annals of Botany*, in which some points considered in my paper were treated, although the major part of the article was concerned with a study of the development of the organs of the mature sporophyte. As I have only considered the development of the oophyte and the embryo, I will only call attention here to that part of Mr. Farmer's paper that had to do with these.

In regard to the sporophyte the only point to be noted is the development of the root. My observations agree with Mr. Farmer's, except that I am inclined to attribute more than one initial cell to the plerome, and regard the first root decidedly as a primary organ of the embryo, and not as an adventitious one.

Concerning the oophyte, there are a number of important particulars in which our results disagree. First: In *I. echinospora* the nucleus of the ungerminated spore *invariably* occupies the *basal* part of the spore, and not the apex as described by Mr. Farmer for *I. lacustris*.

Second: It was possible, by overstaining with gentian-violet and then withdrawing the surplus stain, to demonstrate the nuclei at all stages of germination.

Third: The first stages of germination consist of a division of the nuclei alone. No signs of any formation of cracks in the protoplasm were observed; division walls first appear after the number of nuclei reaches 30-50.

Fourth: The number of archegonia is limited, and the mother-cells are very early differentiated. All the cells of the upper part of the prothallium are *not* potentially archegonium mother-cells.

Fifth: There is not necessarily the sharp separation of the vegetative and reproductive portions of the prothallium that

¹ On *Isoetes lacustris*, L.; J. Bretland Farmer, *Annals of Botany*, vol. V. No. XVII. Dec. 1890.

Mr. Farmer asserts for *I. lacustris*, and this is certainly not determined by the first division of the primary nucleus. This being the case, the comparison he draws (p. 59) between *Isoetes* and the angiosperms can hardly be maintained.

The conclusions as to the affinities of *Isoetes* are the same, regarding it as belonging rather to the Filicineae than the Lycopodineae.

DOUGLAS H. CAMPBELL.

BLOOMINGTON, INDIANA,
February, 1891.

On Internal Phloëm in the Root and Stem of Dicotyledons.

BY

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Assistant Professor of Biology (Botany) Royal College of Science, London,

AND

GEORGE BREBNER.

With Plates XVIII, XIX, XX.

MODERN botanical research, especially during the last fifteen years, has sufficiently demonstrated the importance of that modification of the more ordinary type of dicotyledonous structure, which consists in the presence of phloëm on the medullary as well as on the cortical side of the vascular bundles. The term *bicollateral*, now generally used to express this arrangement of the vascular tissues, was first introduced by De Bary¹.

The structure itself was discovered in *Cucurbita* by Th. Hartig² in 1854, and by von Mohl³ in the Asclepiadeae and other plants in the following year. From that time onwards internal phloëm has been observed in a constantly increasing number of natural orders. Owing chiefly to the investigations

¹ Comp. Anatomy of Phanerogams and Ferns; Eng. ed. p. 338.

² Botanische Zeitung, 1854, p. 51.

³ Bot. Zeitung, 1855, p. 890.

of Russow¹, Vesque², Petersen³, and Solereder⁴, we are now able to form a fair estimate of the distribution of this character among the dicotyledonous orders, though it is almost certain that additions will still be made to the number of those which possess it. Taking Solereder's summary⁵ as the latest available, we find bicollateral bundles in the following orders: *Polypetalae*: Vochysiaceae, Melastomaceae, Myrtaceae, Lythraceae, Onagraceae, Cucurbitaceae; also in some Combretaceae. *Gamopetalae*: Asclepiadaceae, Apocynaceae, Solanaceae, Gentianeae, Loganiaceae; also in most Convolvulaceae, and in some Acanthaceae. *Apetalae*: Thymelaeaceae, Penaeaceae, Euphorbiaceae (sub. tribe Eu-crotoneae, &c.), and in one genus of Polygonaceae. In the great majority of these eighteen orders, the character is constant throughout, with the occasional exception of a divergent tribe. For the systematic details Solereder's work must be consulted. We have not included the Cichoriaceae and Campanulaceae, in which the nature of the medullary vascular tissues is open to some doubt.

Enough has been said to show that bicollaterality is a character widely prevalent among the most highly organized dicotyledonous families and of great systematic value. It may fairly be maintained, that these orders represent, in certain directions, the most advanced types of dicotyledonous structure.

¹ Betrachtungen über das Leitbündel- und Grundgewebe; Dorpat, 1875.

² Anatomie comparée de l'écorce; Annales des Sciences Nat., Bot. Sér. 6, T. II. 1875.

³ Ueber das Auftreten bicollateraler Gefäßbündel; Engler's Jahrbuch für Systematik, Bd. III. 1882.

⁴ Ueber den systematischen Werth der Holzstructur bei den Dicotyledonen; München. 1885.

⁵ Loc. cit., p. 28. We are not aware of any additions to the list since, unless it be the Basellaceae, a family of climbers allied to the Chenopodiaceae, investigated by Morot and not mentioned by Solereder; see Morot: Note sur l'Anatomie des Basellacées, Bulletin de la Soc. Bot. de France, vol. 31, 1884. Medullary phloëm, accompanied by xylem, has further been found by Dangeard in *Acanthophyllum* (Caryophyllaceae); by Robinson in *Iodes* (Phytocreneae), and by ourselves in *Acantholimon* (Plumbagineae); but these formations are allied rather to those in the pith of *Tecoma* than to the internal phloëm of bicollateral bundles: see Dangeard, Monographie anatomique des Acanthophyllum, Le Botaniste, 1889, p. 194; Robinson, on the stem-structure of *Iodes tomentella*, &c., Annales du Jardin botanique de Buitenzorg, vol. VIII. p. 95, 1890.

The physiological importance of bicollaterality cannot be fully estimated until the general question of the functions of the phloëm has been finally determined, but it is undoubtedly great. The sheltering of a portion, often the larger portion, of the delicate phloëm within the woody cylinder is an obvious advantage, as is also the fuller utilization of the pith-area and consequent concentration of the tissues generally. It is probable also, that the pith-cells themselves may be able to discharge both storing and conducting functions more efficiently when brought into direct relation with the phloëm and its proteid contents.

All such speculations are of necessity premature, but in the mean time the due consideration of these modified arrangements may guard us against erroneous views of the functions of the phloëm, which might be entertained, if we limited our attention to so-called normal structure. To this point we shall return.

The primary object of our work was to investigate the structure of the root in plants, which have bicollateral bundles in the stem and its appendages. Our observation of medullary phloëm in the root of *Strychnos*¹ rendered it probable, that in other plants a similar continuity of structure between root and shoot might be traced. In order to estimate the significance of any anatomical character it is evidently necessary to know, whether it extends throughout the plant or is limited to special regions. As regards the more modified dicotyledons, however, our knowledge of their characteristic structure is often confined to the subaërial organs. And if, as we fully expected to find, medullary phloëm as such, proved in many cases to be absent from the root, it was still desirable to trace its course in the transitional region, and to see whether it ended blindly or became in any way continuous with the normal phloëm of the root.

This point has been very little attended to by anatomists. Gérard traced the course of the bundles from root to stem in two Solanaceous plants and in *Cucurbita*. He found that the

¹ On the Anatomy and Histogeny of *Strychnos*, Annals of Botany, vol. III. p. 291, 1889.

normal phloëm-strands of the root give off branches, some of which pass into the pith and are continuous with the internal phloëm of the stem. He figures the transitional region in *Datura*¹. Fischer described very fully the transition from stem to root in *Cucurbita*. He shows clearly how the internal phloëm of the stem passes to the outside of the primary xylem and for some distance forms a ring between the latter and the secondary wood, gradually disappearing lower down, but long remaining traceable in the medullary rays. His statement that the transitional phloëm-ring between primary and secondary xylem ends blindly below, gives, we think, a wrong impression. He purposely limited his investigation to a much thickened axis, and this fact somewhat impairs the clearness of his results². Lastly Dangeard, who has most recently investigated the mode of union of root and stem, merely states that in the Convolvulaceae the internal phloëm accompanies the cotyledonary traces as far as their lower extremity in the hypocotyl, a statement which throws little light on our subject³.

Our most interesting information on the roots of plants with bicollateral stem-structure is due to Weiss⁴, who has shown that in many of these plants, and especially those with fleshy roots, the parenchymatous xylem of the latter contains strands of phloëm, produced internally by the cambium. This interxylary phloëm in the root was found by him in various Onagraceae, Gentianeae and Solanaceae, and he considers it a characteristic peculiarity of plants with medullary phloëm in the stem.

Our observations extend those of Weiss, and may perhaps throw some further light on the relations between the two

¹ R. Gérard, Passage de la racine à la tige; Ann. des Sci. Nat. Bot. Sér. 6, T. XI. 1881, pp. 358, 376, Pl. 18, Fig. 54.

² Fischer, Siebröhrensyst. der Cucurbitaceen; Berlin, 1884, p. 53, Pl. VI. Fig. 14.

³ Dangeard, Recherche sur la mode d'union de la tige et de la racine; Le Botaniste, vol. I. 1889, p. 110.

⁴ J. E. Weiss, Anat. und Physiol. d. fleischig verdickten Wurzeln; Flora, 1880; Markständiges Gefässbündelsystem und Blattspuren; Bot. Centralblatt, vol. 15, 1883, pp. 397, 409.

structures. Weiss in his second work lays stress on the distinction between *medullary phloëm* and *medullary bundles*. The former is simply the internal part of the phloëm in the bicollateral bundles. The *medullary bundles* (which possess or may possess xylem as well as phloëm) are an independent system and usually represent the lower ends of the leaf-traces, which have already passed down one or more internodes as part of the normal ring. The distinction, plain enough in the extreme cases, is by no means obvious in all, for on the one hand the *medullary phloëm* of bicollateral bundles may be widely separated from its xylem, while on the other hand the *medullary bundles* often consist of phloëm-strands only. Weiss states that the *medullary phloëm* as distinguished from the independent *medullary bundles* may be recognized by the following characters:—

1. The medullary phloëm-strands in Solanaceae, Asclepiadeae, Apocynaceae, Gentianeae, Convolvulaceae, Vochysiaceae, Cucurbitaceae, &c., in every case accompany the leaf-traces, within which they lie, on their exit into the leaf.

2. They arise almost at the same time with, or only a little later than, the parts of the phloëm outside the xylem.

3. Where a cambium forms in connection with them, it never produces wood also, as it does in the *medullary bundles* of some of the Cichoreaceae and Campanulaceae, and in *Tecoma*, *Acanthus*, &c.¹

This last distinction (3) was originally due to Vesque². It is a merely empirical generalization and, as might have been expected, has proved not to hold good. The other differences are of value, though their application is not always easy.

Plants with *medullary bundles* in the stem may also have interxylary phloëm in the root, as in various Cruciferae (e. g. *Cochlearia*). In the typical cases each phloëm-strand in the root is surrounded by xylem-elements, forming a tertiary concentric bundle. These structures arise at a distance from the normal

¹ Markständiges Gefässbündelsystem, loc. cit., p. 396.

² Loc. cit. Vesque speaks of *false cambium* in these cases. See our subsequent observations on *Apocynum* and *Willughbeia*.

cambium in the older secondary xylem. Weiss regards them as the direct downward prolongation of the medullary leaf-trace bundles of the stem¹.

In the course of our work various facts of interest connected with bicollateral structure were observed in the stem as well as in the root, and beyond this, we were led to examine one plant (*Acantholimon*), which does not possess bicollateral bundles in the strict sense at all, though it has analogous peculiarities. Hence, our field of work is not very strictly defined. The present paper is only a beginning of the subject. Many important orders are entirely untouched, and there is clearly room for much further investigation, for which we have already some materials.

The following observations then may be grouped under two heads:—

1. The relation between stem and root-structure in plants with bicollateral bundles.

2. Special modifications of the stem-structure in plants, which belong to this category or present a similar arrangement of tissues. Observations closely connected with the subject before us will be found in the preceding paper on *Ipomoea versicolor*², which for reasons of convenience has been dealt with separately.

We adhere to the term *bicollateral bundles* in spite of the strong objections to its use which have been urged by Hérail. This author rejects De Bary's terminology on the ground that it is only really appropriate to a single family, the Cucurbitaceae. In the majority of the plants in question, he finds that the medullary phloëm does not appear at the same time as the rest of the bundle and does not proceed from the same meristem. It is especially on this second point, the independent *position* of the internal phloëm, that he insists. His contention is supported by observations on the Solanaceae, Asclepiadeae, Apocynaceae, Myrtaceae, &c.³ Without entering

¹ Markständiges Gefässbündelsystem, loc. cit., p. 406.

² See p. 173 of the present volume of the *Annals of Botany*.

³ Hérail, Étude de la tige des Dicotylédones; *Ann. des Sci. Nat. Bot. Sér. 7*, vol. II. 1885, p. 267.

into a detailed criticism of his statements we may admit at once that his view is so far justified, that in many cases the medullary phloëm groups show no clear relation, as seen in transverse section, to individual vascular bundles. But their longitudinal course shows sufficiently to which bundle or system of bundles they belong. The term *vascular bundle* itself does not always or even generally represent a well-defined unit. The idea is taken from certain plants, especially Monocotyledons, in which the strands of associated tracheae and sieve-tubes are really distinct. Botanists have found it convenient to extend the idea to vascular tissue generally, although in a large number of the higher dicotyledons, so far at least as the stem is concerned, the limits between the bundles may be impossible to trace. And so it is with the special case of bicollaterality. So long as an internal phloëm-strand has the same longitudinal course as the neighbouring bundles of the leaf-trace there is no serious objection to regarding them as parts of the same formation. We do so, however, rather as a matter of convenience than of principle and without expressing any general opinion as to the order of development, which certainly varies in different cases.

I. RELATION BETWEEN STEM AND ROOT-STRUCTURE IN PLANTS WITH BICOLLATERAL BUNDLES.

1. *Browallia viscosa*, H. B. and Kth. (Salpiglossideae). The bicollateral structure of the vascular bundles in many Salpiglossideae has been demonstrated by Vesque, Petersen, and Solereder. The two last-named authors have pointed out that this anatomical character, which appears to be constant for the tribe, seems to confirm the opinion of Bentham and Hooker, that these plants belong to the Solanaceae rather than to the Scrophulariaceae. *Browallia* itself was among the genera investigated by Petersen¹.

In the above species, the transverse section of a young

¹ Loc. cit., p. 382.

stem (in which the secondary wood averages six elements in radial thickness) shows a ring of numerous small groups of internal phloëm, each group of about the size of one of the smaller cells of the pith. All the groups lie at some distance within the protoxylem of the bundles, from which they are separated by at least two parenchymatous cells, usually more. The phloëm in the pith is collectively greater in amount than that in the normal position. The medullary groups are entirely confined to the outer small-celled zone of pith. In an older stem, with wood about thirty cells thick, the medullary phloëm-groups have increased somewhat in bulk, divisions taking place in the adjacent cells so as to add new elements to the phloëm. There is, however, no regular internal cambium in this plant and the groups remain isolated. The external phloëm receives slight additions from the normal cambium, but its proportion to the internal phloëm is little affected. It is worth pointing out incidentally, that the stem has a beautifully clear endodermis with the characteristic dots on the radial walls. This is continuous, through the hypocotyl, with the endodermis of the root.

The main root is diarch and shows perfectly typical structure, without any pith (see Fig. 5). Sections of older roots show that secondary thickening goes on in the usual manner. This, then, is a plant in which the medullary phloëm of the stem has completely disappeared in the root. It remains to trace its downward course and to determine its relation to the normal phloëm-groups of the vascular cylinder of the root. The transverse section of the hypocotyl shows six bundles. Of these, two opposite pairs are the cotyledonary traces (see Fig. 1). The bundles of each pair have their protoxylem-groups turned towards each other. The two remaining bundles, lying between the two cotyledonary pairs, proceed from the leaves above the cotyledons. They disappear lower down, anastomosing with the cotyledonary traces. It is the latter only which are directly continuous with the xylem of the root. The pith is small compared to that of the epicotyledonary stem. It contains a number

(10-12) of phloëm groups. Some of these are placed opposite the primary xylem of the bundles, but on the whole there is little regularity. Their distance from the protoxylem-elements also varies, some of the groups lying near the centre of the pith. It is noticeable, that in the hypocotyl the number of internal still exceeds that of external phloëm-groups, the dimensions of each group being about equal.

On tracing the hypocotyl downwards to the tap-root, the changes which we find in the position of the tissues are as follows¹:—The pith gradually thins out; the two lateral bundles disappear, becoming confluent with those of the cotyledons. The primary xylem-groups of each cotyledonary pair approach each other and ultimately unite, turning their protoxylem outwards. In the transitional region the strands of internal phloëm successively pass out between the converging xylem-bundles and one by one reach the strands of external phloëm, with which they fuse. The external phloëm-strands concentrate themselves on the two sides of the vascular cylinder, between the two centripetal xylem-groups, which now represent the cotyledonary pairs. Finally, these two groups themselves unite at the centre of the root, forming the diarch xylem-plate, and at this point the last of the internal phloëm-strands passes out and joins the normal phloëm.

So far we have considered the course of the primary bundles without reference to the occurrence of secondary growth. In the upper part of the hypocotyl, the cambium, being formed immediately outside the primary xylem, lies necessarily far outside the internal phloëm-groups. Lower down, where some of these groups on their outward course are already level with the xylem, the cambium forms in contact with their outer surface. Then we come to the critical region of transition, where the internal approaches the external phloëm, and here it is plain, that for a certain distance the cambium must actually cut through the outgoing strand. Lower down

¹ It can hardly be necessary to explain that the succeeding description relates simply to the *course* of the bundles and has no reference to *developmental* changes.

still, where the fusion with the external phloëm is complete the cambium appears in its typical position entirely within the phloëm.

The figures 1 to 5 are selected from a series of 140 successive transverse sections. Fig. 1 shows the structure of the hypocotyl above the point where the internal phloëm has begun to pass out, or at least before any of it has passed beyond the primary xylem. In Fig. 2 the pith is already much smaller, and three of the internal phloëm-strands are shown on their outward course, having already passed the primary xylem-groups¹. In Fig. 3 the pith is still smaller, much of the internal phloëm has passed out, and one large group is seen imbedded in the secondary wood outside one of the cotyledonary traces. Fig. 4 is from a region, where the minute pith is almost entirely occupied by such internal phloëm, as has not yet made its exit. The xylem of each pair of cotyledonary bundles is here united into a single group, and beyond one of the two groups thus formed, a phloëm-strand is shown, on its way to join its neighbours outside. Lastly, Fig. 5 shows the typical root-structure. The two cotyledonary xylem-groups here form a single diarch plate. There is no pith, and all the phloëm has become external.

It will be seen that the sections were taken from a plant, which, though young, already showed some secondary thickening. We have stated above, that at certain points of the transitional region the cambium crosses the outgoing phloëm-strand. The question arises: does the cambium at these points form lignified secondary wood, so as completely to interrupt the continuity of the internal and external phloëm, or does it keep up this continuity by the interposition of secondary phloëm-elements? We have no doubt that the latter is the truth. In the sections drawn, some of the elements of the outgoing strand are most probably of secondary

¹ It would be just as correct to speak of the xylem passing inwards as of the internal phloëm passing outwards, the question being simply one of relative position. The description given in the text is, however, preferable, for the point to be emphasized is the ultimate junction of the internal with the external phloëm.

origin (see for example Fig. 3), and in other cases the imbedded phloëm-group is connected with the cambium by thin-walled tissue, as is shown clearly in Fig. 4.

Other sections through the transitional region of an older plant, with a thick zone of secondary wood, showed phloëm-groups imbedded in the latter, at a distance from the primary tissues which left no doubt as to their origin from the cambium. We conclude, therefore, that the phloëm of the root-system remains in permanent, and not merely in transitory, connection with the medullary, as well as with the external phloëm of the sub-aërial organs.

As regards the main points *Browallia* may be taken as a type of those plants which have medullary phloëm in the stem, but have normal roots. Further information on the points discussed will be found in the paper on *Ipomoea versicolor*. Our observations agree essentially with those of Gérard, above cited. He traced the transition in the opposite direction, namely from root to stem.

2. *Asclepias obtusifolia*, Mx. The Asclepiadeae are among the plants in which the bicollateral structure is best known. So far as the stem is concerned the above species presents nothing remarkable. The internal phloëm is in the form of a ring of very numerous groups, which remain isolated from one another. They are not localized exclusively opposite the protoxylem-groups, but also border on the interfascicular tissue. They are generally separated by two or three parenchymatous cells from the xylem-elements. The internal phloëm, although not so great in amount as in some other plants, is extremely well developed, the sieve-tubes and the companion-cells being large and characteristic. There are occasional divisions in the cells bordering on the groups externally, but no considerable cambial increase takes place. Petersen's¹ Fig. 26 (from *A. princeps*) gives a fair idea of the structure of one of these groups, but in our plant there are more sieve-tubes in each. The diameter of a sieve-tube is often as much as 0.3 mm.

¹ Loc. cit., Pl. VII.

The external phloëm is considerable in amount, but is largely parenchymatous; the sieve-tubes are similar in size to those of the interior, and in a stem 1 cm. in diameter are scarcely more numerous.

As regards the root, the early stages are normal, with a diarch or triarch vascular cylinder. But all roots, which attain a diameter of much more than 1 mm. have groups of phloëm in the wood. In a root about 3 mm. in thickness, such as that from which Fig. 6 is drawn, much the greater part of the phloëm is situated in the wood. In roots of this size periderm has not yet formed, though the external cortex is withering away, and the vascular cylinder forms the bulk of the root. The secondary tissues are extremely parenchymatous and the cells crowded with starch; xylem- and phloëm-parenchyma are quite similar, and the isolated phloëm-groups in each arise in the same way by the sub-division of cells cut off respectively on the inner and outer side of the cambium. On the xylem-side the parenchyma consists, partly of the medullary rays, partly of xylem-parenchyma in the narrower sense. Except in the form of the cells, there is no difference between the two, but the phloëm-islands appear to be limited to the latter. As regards the distribution of the interxylary phloëm, some of the groups are in contact with the protoxylem-elements. These groups have arisen, at any rate in part, from primary parenchyma. Otherwise the phloëm-islands are all secondary. Some of them lie at the sides of the groups of tracheae, which are scattered about among the parenchyma. In this case cambial divisions take place on the side towards the tracheae, and we have the same structure which Weiss figured in *Bryonia*¹. Other phloëm-groups are isolated in the secondary parenchyma remote from the tracheae. No considerable cambial growth of the phloëm-islands takes place. The neighbouring cells divide and add a few more sieve-tubes to the strand, but there is no obliteration of the older elements. The long-continuing divisions show that the development of the phloëm-island is a

¹ Loc. cit., Flora, 1880, Fig. 6.

gradual one, and is not completed until the group has been left far behind by the main cambium (Fig. 6).

The elements of the phloëm of the root resemble those of the stem, but the joints of the sieve-tubes are often very short. The transverse walls both of the external and of the interxylary sieve-tubes may be horizontal, bearing a single sieve-plate, or inclined, in which case they show a series of plates. In size the interxylary are quite equal to the external sieve-tubes, both often exceeding .03 mm. in diameter.

Roots 1 cm. thick show essentially the same structure. By this time a pericyclic periderm has been formed. The xylem is more parenchymatous than ever. Not only has an immense amount of fresh parenchyma been added by the cambium, but the older parts have undergone dilatation, which starts from several centres and leads to the obliteration of some of the elements. This process is accompanied by the formation of new strands of phloëm by the subdivision of cells in the dilated xylem-parenchyma.

The interxylary phloëm-groups of the root then may arise in three different ways:—

1. By the division of cells of the primary conjunctive parenchyma.
2. By direct centrifugal development from the cambium.
3. By late division of cells of the older secondary xylem-parenchyma long after its origin from the cambium.

We might for convenience distinguish the three varieties as primary, secondary, and tertiary phloëm-islands. From what has already been said, it will be clear that the distinction between them is not always quite a sharp one.

In the thicker roots horizontal or oblique anastomoses of the interxylary phloëm-strands are often found.

The transition from stem to root could only be examined in an old plant, as no seedlings were available. For one or two internodes above the hypocotyl the wood of the stem contains minute phloëm-islands. They extend up as far as the wood remains parenchymatous, generally occurring near the groups of tracheae. Careful study of successive sections led to the

conclusion that these interxylary phloëm-strands end blindly above, and are not continuous in that direction with any of the phloëm-systems of the stem. The lower part of the stem is in fact to be regarded as an extension of the storing-tissues of the root, and the phloëm-strands may serve for the conduction of proteid food-materials from one part to the other.

Starting from one of the lowest internodes and tracing the tissues downwards the following changes are observed: The wood becomes more and more parenchymatous, i. e. nearly all its elements except the scattered vessels come to have cellulose walls and starchy contents. The interxylary phloëm-strands become larger and more numerous. The medullary phloëm-strands ramify and at a certain stage are found crowded all over the pith, which gradually becomes smaller, some of them reaching its centre. In the mean time the primary xylem-groups approach the middle of the axis ultimately fusing to form the diarch xylem-plate of the root. Thus some of the medullary phloëm-groups, and ultimately all of them, pass to the outside of the primary xylem. There is no doubt, that the more central phloëm-groups of the main root are the direct downward continuation of the medullary phloëm of the stem¹. The process is so far essentially the same as in *Browallia*. But in *Asclepias* the medullary phloëm does not pass entirely to the outside of the cambium. It passes, in part at least, straight down the root, adjacent to the primary xylem, and thus forms the first ring of phloëm-islands. The rest of the interxylary phloëm is of secondary or tertiary origin as described above. Some light is thus thrown on the frequency of phloëm-islands in the roots of plants with bicollateral bundles in the stem. The medullary phloëm of the stem becomes the interxylary phloëm of the root. The formation of interxylary phloëm by the cambium is not a new departure, but an extension of the primary structure. The phloëm-strands, whatever their origin, are connected by anastomoses.

Our results agree in many points with those obtained by

¹ Just as Weiss found in *Oenothera*, loc. cit.; Bot. Centralblatt, XV. p. 409.

Weiss in various Onagraceae, Gentianeae, and Solanaceae¹. He, however, found that the interxylary phloëm was always formed directly from the cambium, and that the groups never increased subsequently by a special cambium of their own. In *Asclepias*, as we have seen, phloëm-islands may be formed in tissues far removed from the cambium, while the groups constantly show cambial growth themselves, though not on a great scale. The sharp distinction, which Weiss endeavours to draw between his *interxylary bundles* and *interxylary phloëm* so far falls to the ground.

3. *Thladiantha dubia*, Bunge (Cucurbitaceae). We take this plant next, because, though systematically so remote from *Asclepias*, it presents certain analogies with that genus as regards the points under consideration. The bundle-system of the stem is of the usual Cucurbitaceous type and is shortly described by De Bary². The internal phloëm, which is not very greatly developed, is connected with the external mass by sieve-tubes in the medullary rays, as happens in other Cucurbitaceae³. There is a distinct interfascicular cambium⁴.

Some of the *roots*⁵ have very curious tuberous swellings, to the structure of which we will return. But first the more ordinary root-structure must be described. The bundle-cylinder is most often tetrarch, but this is not constant, and indeed the same root may pass from hexarch to tetrarch structure in various parts of its course. The roots have no pith, the primary xylem-bundles often meeting in one or two large central vessels. A group of bast-fibres lies outside each of the primary phloëm-masses, as in the Leguminosae. As the root grows in thickness the bast-groups break up into a

¹ Loc. cit. Flora, 1880, p. 97, and Bot. Centralblatt, XV. p. 408.

² Loc. cit., p. 248.

³ De Bary, loc. cit., p. 338. We have occasionally found a few small sieve-tubes in the secondary rays also.

⁴ Cf. M. C. Potter, On the increase of the thickness of the stem of the Cucurbitaceae; Proc. Cambridge Phil. Soc. vol. VII. p. 4.

⁵ Some of the peculiarities of these roots have already been described by Dutailly, Sur quelques phénomènes déterminés par l'apparition tardive d'éléments nouveaux dans les tiges et les racines des Dicotylédones. Paris, 1879, pp. 37 and 39.

number of separate strands, as indicated in the diagrammatic Fig. 7. The periderm is pericyclic.

When secondary thickening begins, the cambium, as so often happens, forms secondary parenchyma opposite the protoxylem and true wood only opposite the phloëm. The parenchyma may either be continued indefinitely by the cambium as a ray, or woody elements may be formed closing it in. As growth in thickness goes on, this process is repeated. New rays originate at the middle of each prominent xylem-mass and these also may be discontinuous, the wood closing in over them. Fig. 7 shows a typical case with the secondary rays only just beginning. In Fig. 8, the secondary ray shown is partly closed in. Considering the position of the parenchyma, analogy has led us to speak of it as forming rays, but when it becomes enclosed in wood the expression xylem-parenchyma would be more appropriate. The normal phloëm is well developed, the sieve-tubes attaining the large diameter of 0.45 mm. But phloëm is also formed on the inside of the cambium. In the earlier stages it is limited to the ray-parenchyma. Some of the interxylary sieve-tubes are always situated at the beginning of the principal rays. Some of these are perhaps of primary origin. Others are scattered about near the sides of the ray. As soon as the secondary rays are started, phloëm is formed in them also (see Figs. 7 and 8). Sometimes a nascent ray becomes almost at once enclosed in wood and in these cases the whole of the little parenchymatous group may be used up to form a phloëm-strand. Some of the interxylary sieve-tubes are formed directly from the cambium; others are differentiated later on in tissue which is already remote from it, so that here again the two processes distinguished by Weiss occur in the same root. The interxylary groups are small, in fact a single sieve-tube with its companion-cells is often isolated. The cells surrounding the phloëm show a few divisions, but no considerable growth takes place in this way in the non-tuberous part of the root. The interxylary sieve-tubes are not so large as the external ones, but reach 0.3 mm. in diameter.

The root-tubers grow to an enormous size. They form huge irregularly rounded swellings, which are often between two and three inches (5 to 7.5 cm.) in diameter. The root above and below them is cylindrical and not more than about 5 mm. thick. The root-tubers are deeply furrowed in the longitudinal direction. The furrows, which are usually four in number, correspond in position to the four primary xylem-groups of the root, the ridges between them to the primary phloëm. As compared with the ordinary root, the tubers show most interesting changes of structure consisting (1) in increased centrifugal activity of the normal cambium, with production of an excessive amount of parenchyma, the rays bearing a large proportion to the wood; (2) in enormous dilatation of the pre-existing parenchyma, especially in the region immediately surrounding the primary xylem. This dilatation results in the breaking up of the inner lignified portions of the secondary wood into isolated strands imbedded in parenchyma. Often the dilatation of the tissues bordering on the primary xylem nips off, as it were, the outer ends of the xylem-plates. Where this happens the protoxylem may be carried by the continuous extension of the tissues behind it, far out into the surrounding parenchyma. The result is very curious. In one case two out of the four xylem-plates were unaffected and remained in their original position. In a third xylem-plate the dilatation had separated off the outer part at a rather late stage, so that the protoxylem was only carried a little way out. The fourth protoxylem-group however had been nipped off quite early, and was now stranded in the parenchyma at a distance from the rest of the primary xylem equal to many times the diameter of the original vascular cylinder. During the dilatation every isolated group of lignified tissue forms a centre around which active cell-division goes on, and owing to these local meristematic regions the dilated parenchyma loses all trace of its former regular radial arrangement. The growth of the tuber is accompanied by a great increase in the amount of its interxylary phloëm. The tertiary phloëm-bundles are especially

crowded around the middle of the root in the region where dilatation has chiefly taken place. They are also massed along the margins of the isolated strands of secondary lignified tissue, but are by no means limited to the neighbourhood of woody elements.

As the dilatation of parenchyma goes on chiefly in the inner part of the root, the outer region of the xylem is the more woody. Here we find, immediately within the cambium, a series of woody wedges (containing the tracheae), separated from each other by broad parenchymatous rays. They are arranged usually in four groups, corresponding in position to the primary phloëm-bundles. As the root-tubers increase in thickness the course of both xylem- and phloëm-strands becomes very oblique, with frequent anastomoses. The development has been traced in detail up to a diameter of about half-an-inch (1.25 cm.). The further growth of the root-tuber appears to be chiefly due to dilatation. Almost the whole tissue in the old specimens is parenchymatous, the wood being almost limited to a narrow zone just inside the cambium.

This root shows with remarkable clearness the characteristic changes involved in the assumption of this type of *fleshy* structure. Complicated as the final condition is, it is easy to refer it to its origin from a comparatively normal dicotyledonous root-structure.

We have not, in this plant, specially investigated the transition from root to stem, but we have no doubt that here, as in *Asclepias*, the innermost interxylary phloëm of the root is continuous with the medullary phloëm of the stem.

Altogether this root has much in common with that of *Asclepias*, the most essential distinction lying in the different relation of the interxylary phloëm to the 'medullary' rays.

Sieve-tubes in the xylem have been observed in the root of *Cucurbita* by Van Tieghem¹ and Fischer². From the description of the latter they seem to be limited to the transitional region. He regards them as forming the downward continuation of the sieve-tubes found in the medullary

¹ Ann. des Sc. Nat. Bot. Sér. 5, vol. XIII, p. 215.

² Loc. cit., p. 53.

rays of the hypocotyl. The interxylary phloëm-system of *Thladiantha* is beyond comparison more highly developed a fact correlated no doubt with the presence of the root-tubers.

The interxylary phloëm in our plant differs from that in *Bryonia*¹, (1) in the fact that it is in part formed directly from the cambium, (2) in having no constant relation to the tracheae.

4. *Chironia peduncularis*, Lindl. (Gentianeae). In this genus the existence not only of the medullary phloëm, which is usual in the order, but also of phloëm-strands imbedded in the wood, was discovered by Vesque² in 1875. The species observed by him was *C. linoïdes*. His observations were extended by Solereder to *C. baccifera* and to *Orphium frutescens*³. We have been able fully to confirm the statements of these authors in the species examined by us. The medullary phloëm forms a ring of scattered strands separated by a few cells (1-3) from the inner margin of the wood. Opposite the larger bundles the phloëm-strands may form a double row. The external phloëm is not much developed. In a stem, where the secondary wood was quite thirty elements in radial thickness, the normal phloëm had received scarcely any increase from the cambium. The groups of sieve-tubes are both smaller and less numerous than those in the pith, and the individual sieve-tubes are also smaller. In the external phloëm .015 mm. is a maximum diameter for the sieve-tubes, while in the internal strands .022 mm. is commonly attained.

The examination of sections from near the apex proves that the medullary phloëm is formed somewhat later than the external. The first medullary strands to be formed are those just within the large bundles, and here they reach their greatest development. Later on, phloëm-strands are also differentiated on the inner side of the smaller bundles and the interfascicular tissue. As a rule it is not until two or three xylem-elements have been fully formed in each bundle, that

¹ Weiss, loc. cit., Flora, 1880, p. 109.

² Loc. cit., p. 146, Pl. 10, Figs. 3 and 4.

³ Loc. cit., p. 182.

the corresponding medullary phloëm-groups arise. Each group is formed by the subdivision of an elongated cell of the young pith, or more than one such cell may take part in the process. *Chironia* then is a plant to which Hérail's objection to the term *bicollateral* would be especially applicable. The internal phloëm arises late compared with the rest of the bundle and not, strictly speaking, from the same procambial strand¹. But to these differences we are not disposed to attach great importance. The medullary phloëm accompanies the bundles on their exit to the leaf and only disappears in the finer branches².

The interxylary phloëm-strands begin to be formed when the secondary wood is about fifteen elements thick. They are similar to those in the pith, only more regular owing to their cambial origin. We have satisfied ourselves that Vesque is right in stating that they are developed on the inner side of the cambium, so here we have a case of centrifugal interxylary phloëm as contrasted with the centripetal development in *Strychnos*. These phloëm-islands are formed in great numbers. In a thickened stem the normal phloëm is quite insignificant in amount compared to the medullary and interxylary systems jointly.

Before we leave the stem it may be pointed out that here also there is a typical endodermis and uniseriate pericycle, both of which are easily recognised even in the thick stems.

So far as we know no observations have previously been made on the *root* of *Chironia*. A thickened root has the structure represented in Fig. 9. The cortex, which is not thrown off by periderm, is very lacunar; it shows a distinct exodermis. Its innermost layer, the endodermis, undergoes radial cell-division, enabling it to keep pace with the growth of the vascular cylinder within. The pericycle is one or two layers in thickness. The external phloëm is only moderately developed. The xylem-cylinder is dotted over in all parts

¹ Our observations on the development of *Strychnos* may be contrasted with this. See *Annals of Botany*, vol. III. p. 281, Pl. XVIII. Fig. 1.

² Cf. Weiss, *loc. cit.*, *Bot. Centralblatt*, XV. p. 401.

with phloëm-islands, which collectively far exceed in area the normal phloëm. Of these interxylary strands the more external lie entirely in the secondary wood. Others, however, occur on a level with the primary xylem, and in many roots, though not in all, there is a central phloëm-strand occupying the small pith-area. When this is absent the xylem-groups meet in the middle.

Tracing the development, we find that the bundle-system is polyarch, the number of xylem- and phloëm-bundles variable, often as many as ten of each.

For a time the protoxylem-groups alone represent the wood, often with one vessel only to each bundle, the protophloëm appearing between them as usual. Later on the centripetal development of the primary xylem goes on, but its inner and later-formed portion is as a rule separated from the protoxylem by a few cells, which remain parenchymatous. The further development of the primary xylem is accompanied by the formation of phloëm-strands among the lignified cells, so that the more internal phloëm is of primary origin. The strands situated on the margin of the primary xylem may subsequently receive additional elements from the cambium (Fig. 10, *ph*³). The root shown in Fig. 9 has an approximately central phloëm-group (*ph*²), the origin of which is evidently altogether primary.

The secondary thickening of the root presents a striking peculiarity, which has not, so far as we are aware, been noticed elsewhere. In ordinary dicotyledonous roots, as has long been known, the cambium first arises within the primary phloëm, by divisions of the cells of the conjunctive parenchyma. It then extends round the exterior of the xylem-plates, the pericyclic cells dividing to complete the cambium outside the protoxylem. In *Chironia* however, the cambium is, as a rule, formed *inside* the protoxylem-groups, which are thus for a time completely cut off from the rest of the wood. This, then, is the function of the parenchyma, which remains un-lignified between the protoxylem and the more internal wood. It divides to complete the cambial ring (see Fig. 10, *px*).

As the activity of the cambium goes on, the isolated protoxylem-elements are pushed further and further outwards, accompanying the external phloëm¹. Often this proceeds until a large amount of secondary wood has been formed, as in the root shown in Fig. 9, where two protoxylem-elements are seen outside the cambium. Sooner or later, however, the protoxylem is restored to the main body of the wood, from which the cambium had severed it. Sometimes this happens very soon (Fig. 11), sometimes very late (Fig. 9), and it takes place very irregularly. Thus in Fig. 9, between the two isolated protoxylem-elements is a third, which has long been enclosed in secondary wood. It is difficult to distinguish, but is probably the element marked with letter *a*. The enclosure of the protoxylem in the wood happens as follows: the cambial divisions within it cease, the cells lying just to the outside begin to divide and complete the cambial ring; new wood is formed and the protoxylem-element is now left behind, imbedded in secondary wood (cf. Fig. 11). Ultimately all these elements are thus regained by the wood. As is often the case in roots, the protoxylem-vessels are not spiral but reticulate. Their thickening is sufficiently different from that of the pitted vessels of the secondary xylem for them to be recognised long after their enclosure in the latter. Since we made these observations we have found the same mode of development in the root of an *Impatiens*, in which the protoxylem is also cut off by the cambium from the wood.

We traced carefully the development of the secondary phloëm-islands of the root. Here, as in the stem, they are formed centrifugally, on the inner side of the cambium. A cell cut off from the latter divides two or three times by tangential or inclined walls. The products of division are the mother-cells of sieve-tubes. They then divide again to form their companion-cells and the phloëm-strand is complete (see Fig. 12). The development can be studied with advantage in radial longitudinal sections, which also leave no

¹ It is a curious coincidence, though certainly nothing more, that the same root should show phloëm-strands in the xylem and xylem-strands in the phloëm.

doubt that the cambium lies to the outside of the sieve-tubes all through.

Chironia and *Strychnos* are the only genera in which we have at present found strictly medullary phloëm in the root, phloëm, that is, which lies altogether within the primary xylem. In both cases its presence is somewhat inconstant. On the whole the agreement in structure between root and stem is exceptionally manifest in *Chironia*. The material at our disposal did not permit of our tracing the actual transition from the one to the other, for all the roots available were adventitious. As regards the connection of these roots with the stem, we found that the interxylary and medullary phloëm-strands of the adventitious root are continuous with the interxylary phloëm of the stem, but there is no direct communication with the medullary phloëm of the latter.

In *Gentiana acaulis*, L., which we also examined, the root, though very parenchymatous, showed no internal or interxylary phloëm. In other Gentianeae, however, peculiarities resembling those of *Chironia* and *Orphium* have been observed. Thus Arthur Meyer in his admirable monograph of *Gentiana lutea*¹ describes sieve-tubes in the secondary wood of both stem and root of that species². He states that *G. punctata*, *pannonica*, and *purpurea* agree anatomically with *G. lutea*.

In *G. cruciata*, Jost³ found phloëm-strands in the secondary wood of the stem, but not of the root. Weiss also found interxylary phloëm in the fleshy roots of some Gentianeae⁴. It is evident that the anatomy of the order will repay further investigation, especially as regards the relation between stem- and root-structure.

We examined a considerable number of other roots of plants with bicollateral bundles, but the results do not call for

¹ A. Meyer, Beiträge zur Kenntniss pharmaceutisch wichtiger Gewächse, V. Ueber *Gentiana lutea*, &c. Archiv für Pharmacie, 3te Reihe, Bd. XXI. 1883.

² Loc. cit., pp. 502, 569.

³ L. Jost, Die Zerklüftungen einiger Rhizome und Wurzeln; Bot. Zeitung, 1890, p. 442.

⁴ Loc. cit., Bot. Centralblatt, XV. p. 410. No details are given.

detailed description. In *Oenothera longiflora*, Jacq. we were able to confirm Weiss's observations as to the presence of centrifugally formed interxylary phloëm in the root of this genus¹. A large amount of secondary phloëm-parenchyma is formed here, but the groups of sieve-tubes are small on both sides of the cambium.

In the following bicollateral plants the roots investigated showed external phloëm only:—

Myrtus mucronatus, Cambess. *Lythrum Graefferi*, Ten.
*Calystegia sepium*², R. Br. *Apocynum cannabinum*, L.
Willughbeia flavescens, Dyer. *Willughbeia firma*, Bl.
Cryptostegia grandiflora, R. Br. *Dischidia nummularia*, R. Br.
Hoya pendula, Wight et Arn. *Periploca graeca*, L.
Daphne Mezereum, L.

In all these cases it is probable that the transition from stem to root takes place as in *Ipomoea* and *Browallia*, and that the medullary phloëm of the stem is continuous with the external phloëm of the root.

Our conclusions as regards the roots may be summed up as follows:—

1. The majority of the plants examined with bicollateral bundles in the stem showed normal structure of the root, the medullary phloëm (to judge from the cases specially investigated) turning outwards in the hypocotyl with the protoxylem-groups. It is thus continuous with the external phloëm of the root-system.

2. A certain number of roots among the plants in question have interxylary strands of phloëm. These may be (a) *primary*, (b) *secondary*, or (c) *tertiary*. The first, as regards the main root, form the direct downward prolongation of the medullary phloëm of the stem, the phloëm-strands running down through the wood, instead of turning outwards to join the external phloëm. The *secondary* interxylary phloëm, which may be limited to the root or extend also into the stem, is in the plants here described formed centrifugally, on

¹ Loc. cit., Flora, 1880.

² Cf. however the paper on *Ipomoea versicolor*, Scott, Ann. of Bot. No. XVIII.

the inner side of the cambium. The *tertiary* strands are differentiated from the older secondary woody parenchyma, when already remote from the cambium, and are especially characteristic of fleshy roots. *Intraxylary* (medullary) phloëm has so far only been found in the roots of *Strychnos* and *Chironia*.

II. SPECIAL MODIFICATIONS IN THE STRUCTURE OF THE STEM.

We are not aware that any cases have hitherto been recorded of the formation of medullary *wood* by an internal cambium in plants with undoubtedly bicollateral structure of the bundles. As was pointed out in the introduction, Weiss, in agreement with Vesque, has made the constant absence of medullary wood a criterion by which the internal phloëm of bicollateral bundles can be distinguished from that which belongs to an independent bundle-system in the pith (e. g. *Tecoma*). On this ground, among others, Weiss has removed the internal phloëm of certain Cichoriaceae, Campanulaceae, and Acanthaceae, from the former to the latter category¹. We have found, however, that in some plants with typical bicollateral structure a true internal cambium is active, producing new wood as well as new phloëm, the orientation of the two being inverted as compared with the normal parts of the bundle.

1. *Apocynum cannabinum*, L. The Apocynaceae are enumerated by Vesque, De Bary, Weiss, Solereder, &c. among plants characterized by bicollateral structure of the bundles, and the character is here of ordinal value. The above species (the so-called 'Indian Hemp') is thoroughly typical in this respect. The internal phloëm is developed from the procambium simultaneously with the xylem and external phloëm, and from the first exceeds the latter in extent. It lies close to the protoxylem-groups of the bundles, only one or two

¹ Loc. cit., Bot. Centralblatt, XV. pp. 321, 396, &c.

parenchymatous cells intervening between the primitive tracheae and the nearest internal sieve-tubes. It is not until the stem has attained a considerable thickness that any departure from ordinary bicollateral structure begins. At the stage shown in Fig. 13, the normal wood has a radial thickness of from seventy to ninety elements. The very characteristic internal phloëm forms a ring, which is not however continuous but is broken up into groups by narrow radial strands of parenchyma from one to three cells wide. Often, but not always, these rays correspond to the primary medullary rays of the normal wood. Not only is the internal greater in amount than the external phloëm, but its individual elements are also larger. The internal sieve-tubes often reach .03 mm. in diameter, while the normal ones scarcely exceed .02 mm. In some places an internal cambium has appeared, which at one or two points, opposite the protoxylem of the larger bundles, has begun to form tissue on its outer side. This tissue is the *internal centripetal wood*. The cambial divisions begin in the parenchymatous cells immediately bordering on the outer edge of the phloëm. Thus the internal is separated from the normal wood by one or two layers of thin-walled cells. The first xylem-elements formed are lignified parenchyma.

The internal cambium soon extends all round the pith, but its production of wood is for a long time limited to the regions where it first started. Elsewhere its activity is limited to the formation of additional phloëm on its inner face. When the normal wood is from 130 to 150 cells in radial thickness the internal woody masses are about fifteen cells thick (Fig. 14).

At a still later stage the internal wood becomes much more extensive. In the oldest stem at our disposal, about 1.4 cm. in diameter, it forms eight masses, which together occupy the greater part of the circumference of the pith. These masses lie opposite those parts of the normal wood which are richest in vessels, or, in other words, the internal wood still shows a relation to the primary bundles. Its maximum thickness now

amounts to twenty-five elements, equal to about one-eighth of the normal wood. The internal cambium forms most phloëm where it does not produce any wood. Opposite the woody groups the number of phloëm-elements is smaller and they also undergo greater compression (see Fig. 14).

The internal centripetal wood, where it is well developed, consists of elements of three kinds: (1) fibrous cells with pointed ends which form the small lumina seen between the larger elements in transverse sections (Fig. 14); (2) xylem-parenchyma, and (3) ray-parenchyma. The internal xylem-rays resemble those of the normal wood, but their cells are less elongated radially. All the elements have lignified walls, and simple elliptical pits, which in the fibrous cells are spirally arranged. The internal wood chiefly differs from the external in the absence of vessels.

It may be added that the internal sieve-tubes are of perfectly typical structure, with lateral sieve-fields as well as transverse plates, which form callus in autumn.

The pith is very lacunar and offers comparatively little resistance to the growth of the internal vascular tissues.

2. *Willughbeia firma*, Bl. (Apocynaceae). This climbing representative of the order shows the same structure as *Apocynum cannabinum*, namely centripetal internal wood, but in a still more striking form, for in *Willughbeia* the internal wood contains large vessels. Its development begins here even later than in *Apocynum*. When the normal wood is on the average about eighty cells in radial thickness there is still no sign of internal xylem. The inner phloëm-groups form a ring, and are only separated from one another by narrow rays of parenchyma. There is already an active internal cambium which has arisen by division of about the third layer of parenchymatous cells within the protoxylem, and has added largely to the phloëm, so that the older phloëm-elements and some of the pith-cells also are becoming crushed and obliterated. The pith contains very large thick-walled sclerenchymatous fibres, and also large laticiferous cells. As the inward growth of the internal phloëm continues, the rays keep pace

with it, chiefly by extension of their cells without division. The internal sieve-tubes are usually about $\cdot 025$ mm. in diameter, and have very abundant proteid contents. Besides the typical phloëm-elements, the internal groups, like the pith, contain septate crystal-sacs, such as are also found in the normal external phloëm. The two phloëm-systems are about equal in extent. The internal ring has the advantage in radial thickness (which amounts to ten elements), but this is balanced by the greater periphery of the external phloëm.

In an older stem, in which the normal wood has about 140 elements on the radius, the centripetal xylem has appeared. It is formed in irregular groups, one of which is shown in Fig. 15. The elements of this internal wood are (1) vessels with bordered pits, composed of long joints, and reaching $\cdot 04$ mm. in diameter (about half that of the largest vessels of the normal wood); (2) xylem-parenchyma, and (3) radially elongated cells which may be regarded as forming xylem-rays. The centripetal wood, which is entirely produced by the internal cambium, is therefore of perfectly typical structure. The parenchyma, lying between the outer margin of the centripetal wood and the protoxylem, becomes partially lignified. In one case we found reticulated elements, probably vessels, in this position.

In the older stems the greater development of the internal vascular tissues has necessarily produced increased obliteration towards the pith. Many of the older sieve-tubes have very callous plates.

3. *Periploca graeca*, L. (Asclepiadeae). In this plant there is a very distinct internal cambium, which produces a large amount of secondary phloëm towards the pith. It also occasionally forms a few lignified elements in centripetal direction, but in the stems investigated the amount of internal wood was insignificant.

The cases of *Apocynum* and *Willughbeia* are sufficient to invalidate the generalization of Vesque and Weiss that the inner cambium of bicollateral bundles is a 'false' cambium

capable of producing phloëm only without wood. All such arbitrary limitations of the possibilities of dicotyledonous structure are rash. Until Sanio's discovery in *Tecoma*, no one would have suspected the existence of medullary cambium at all. Now we know that it is of common occurrence, and that whether it be connected with bicollateral or with independent medullary bundles, it is alike able to form xylem or phloëm or both, according to the special requirements of the plant. The only safe generalization as to cambium is that it may arise in any living tissue, to whatever 'system' this may belong, and that it is capable of producing any form of tissue for which at the moment the plant has an increased demand.

4. *Gentiana acaulis*, L. Our observations on this plant, to which reference has already been made, may be described very shortly, for they are in close agreement with those of Meyer and Jost, above cited, on other species of the genus. In the stem of this species the bulk of the phloëm is internal. Its arrangement is unusually complex. In the older internodes we find two concentric rings of internal phloëm-groups, in addition to which there is often a third set lying quite in the middle of the pith. At first sight one is disposed to regard these strands as forming an independent medullary system, but investigation of their longitudinal course shows that this is not so, but that all the internal strands are branches from the inner phloëm of the bicollateral bundles, so even in this extreme case we see no sufficient ground for departing from De Bary's terminology.

The main bundles of the leaf are bicollateral. The leaves themselves are opposite, decussate, and sheathing. Three bundles enter the stem from each leaf, but fuse into one broad bundle before turning down into the internode. The fused bundle runs down through two internodes, its elements spreading themselves out tangentially¹, and ultimately joins the outgoing bundles of the leaf vertically beneath, i. e. at the

¹ As Meyer says of *G. lutea*, the elements separate so widely that one can no longer speak of the course of the bundles, but only of the connection of the elements; loc. cit., p. 501.

second node below. The internal phloëm accompanies the leaf-trace bundles into the stem, and runs straight down through two internodes, where it joins that of the next bundle vertically beneath. It is usually at this point that branches arise which penetrate somewhat more deeply into the pith, while those which reach the middle of the stem are given off lower down still. Hence as a rule the transverse section of the youngest internodes shows a single ring of internal phloëm-groups, a rather older part has a double ring, while the more central groups arise by the division of pith-cells at a comparatively late stage. But there is no great constancy about this and occasionally the more internal branches arise much earlier. The different strands are further connected by anastomoses¹. We may add that sometimes phloëm-groups are formed *outside* the protoxylem elements, between these and the rest of the wood. This is an approach to the formation of interxylary phloëm-islands, as in some other Gentians, *Chironia*, &c.

We have described the distribution of the phloëm in this plant because it shows an extreme modification of ordinary bicollateral structure, and yet is readily referable to the type. It may be added that the external phloëm-groups are also very scattered and widely separated from the xylem, so that there is a certain analogy between the two systems as regards distribution. We pass over our other observations on plants with strictly bicollateral bundles, as they present no new points of importance, and go on to a plant the remarkable structure of which is only indirectly connected with our main subject.

5. *Acantholimon glumaceum*, Boiss. (Plumbagineae). The anatomy of this genus has already been the subject of several investigations, the earliest of which is due to Prof. Oliver², who especially insists upon the absence of typical medullary rays. He also observed and figured among other peculiarities the

¹ Cf. Meyer, loc. cit., p. 502; and Jost, loc. cit., p. 439.

² D. Oliver, On the structure of the stem in certain species of Caryophylleae and Plumbagineae; Trans. Linnæan Soc. vol. XXII, 1859.

occurrence of concentric belts of parenchyma in the wood. Krüger¹ confirmed Prof. Oliver's results as to the medullary rays and was the first to discover concentric bands of typical phloëm in the wood. This remarkable anomaly he was inclined to refer to the action of successively renewed cambial layers. Lastly, Solereder² confirmed Krüger's discovery, and found, in the occurrence of tangential divisions between the xylem and interxylary phloëm-zones, a clear proof that the wood as a whole (Holzkörper) owes its origin to the appearance of successive cambial layers. Both he and Krüger, however, recognise the possibility that the interxylary phloëm might arise as in *Strychnos*, i. e. as De Bary erroneously supposed to be the case in *Strychnos*. On this view the interxylary phloëm would be formed centrifugally on the inner side of the cambium. We proved in our former paper³ that the phloëm in the wood of *Strychnos* is developed centripetally, and it was the apparent analogy of structure between that genus and *Acantholimon*, which led us to examine the latter. Some divergences in detail, between our observations and those of previous writers, may well be due to specific differences.

Acantholimon glumaceum is well known in gardens as a rock-plant. Its habit is not unlike that of its British relation, *Armeria vulgaris*. The latter, however, does not share its anomalies of structure.

The diagrammatic transverse section (Fig. 16) will give a sufficient idea of the extraordinary structure of a thick stem. In order to understand the complicated conditions at maturity, it will be necessary to trace the development.

The young stem has a perfectly normal structure. The bundle-ring is interrupted by several (usually 3-5) broad radial strands of parenchyma. The tangential section shows that each of these rays occurs immediately above the exit of a leaf-trace bundle. We do not see that they differ essentially from the primary medullary rays of other stems, which in all cases are

¹ Otto Krüger, Beitrag zur Kenntniss der sogenannten anomalen Holzbildungen. Dissertation. Leipzig, 1884.

² Loc. cit., Holzstruktur, p. 164.

³ Annals of Botany, vol. III.

the spaces (filled with parenchyma) between the bundles, and must therefore have a definite relation to the bundle-system. In this plant, and in many others, the outgoing bundle leaves, as it were, a parenchymatous space above its exit, which is only closed over further up by the converging bundles on either side. This space is the primary ray. In *Acantholimon* there is no interfascicular cambium, the ray following the growth in thickness by extension of its cells, perhaps accompanied by a few irregular divisions. No secondary rays are formed at any stage which has come under our observation.

A normal fascicular cambium is formed between xylem and phloëm and for some time the thickening goes on in a perfectly typical way. The annular and spiral vessels of the primary wood are succeeded by a secondary xylem, which is especially rich in vessels. These are of two kinds: large vessels with bordered pits, and much smaller ones with a conspicuous spiral thickening and small pits between the coils. The closely packed elements with lignified thickened walls, which in a transverse section might easily be taken for woody parenchyma, are in reality these small vessels. The parenchyma, which is scattered among them, is entirely thin-walled and usually unligified. In addition to these elements, the secondary wood contains scattered strands of fibres thickened so that the cavity has all but disappeared. The larger vessels occur in rather regular concentric layers. The phloëm is very thick. It consists of elongated cells equivalent to phloëm-parenchyma, but prosenchymatous in shape, of sieve-tubes, with inclined terminal sieve-plates, and their companion-cells. The first anomalous formations generally appear in stems about 2 mm. in diameter, where there is a wide zone of secondary wood and the outer cortex has been already cast off by periderm. The first departure from normal structure consists in the appearance of an internal cambium. This has not hitherto been observed. The cambial divisions may occur immediately within the protoxylem of the bundles in the outermost small-celled tissues of the pith, but in other

cases they occur in the parenchyma of the bundles themselves *outside* the protoxylem, so that the latter is cut off from the body of the wood¹. The internal cambium at once begins to form centripetal wood on its outer surface and internal phloëm towards the pith. If the cambium has cut off the protoxylem the latter is necessarily carried inwards towards the centre of the pith in front of the advancing phloëm. Figs. 17 and 18 show the more normal type, where the cambium arises within the protoxylem. The difference is of no importance whatever, as regards the final result. The medullary formations are localized opposite the bundles; sometimes there is one internal strand to each bundle, sometimes there are two. Both internal wood and phloëm agree exactly in structure with the normal tissues. In the former, the relatively large vessels are conspicuous. The secondary formations encroach very seriously on the pith. We have found the internal wood as much as twenty-five elements in radial thickness; the phloëm is generally less extensive. It is quite possible that the internal cambium may at first be continuous with the normal cambium at the nodes, as Robinson found to be the case in *Iodes tomentella*², but we have no proof of this. The formations in *Acantholimon* bear a close resemblance to those observed by Robinson. The similarity with *Tecoma* is more superficial, for in this latter plant a medullary phloëm-strand is present before the cambium appears, which is not the case here. In *Acantholimon* the internal wood and phloëm are entirely secondary, and it would be a forced view to regard them as forming part of the leaf-trace system. The curious structure described by Dangeard (*l.c.*) in *Acanthophyllum* has some analogy, but differs in the fact that the cambium completely surrounds the wedges of wood, which we have never found in *Acantholimon*. We suspect that the anomaly discovered by Morot in the Basellaceae is more nearly related to the present case than to ordinary bicollateral structure.

¹ This process is comparable *mutatis mutandis* to the mode of origin of the normal cambium in the root of *Chironia*.

² *Loc. cit.*

In the mean time other anomalies have made their appearance. At a certain point in the development, in some cases, when the normal wood has only twelve cells on the radius, in others, when it has formed from thirty to forty layers, interxylary phloëm appears. In one specially instructive case the thickening was very eccentric: on one side the wood and bast were normal, on the other side the wood was much thicker and traversed by two tangential bands of interxylary phloëm, each of which had a cambium on its inner side (cf. Fig. 19). In this stem, the first interxylary cambium of the anomalous part exactly fitted on to the external cambium of the normal portion. We call attention to this exceptional case, because it throws light on the origin of the concentric zones. As a rule, the thickening is approximately uniform round the whole circumference. The bands of interxylary cambium and phloëm sometimes run completely round the stem interrupted only by the parenchymatous rays. But more often their arrangement is less regular, the number of concentric bands varying not only in the different woody wedges, but also within the same wedge. The general arrangement of the tissues is such, that the inner layer of each concentric zone of xylem contains the larger vessels. Its outer portion is formed of the densely packed smaller vessels with thin-walled parenchyma interspersed (Fig. 19). The wider phloëm-zones have precisely the same structure as the normal external phloëm (Fig. 20). The sieve-plates in autumn are often callous. The narrower zones of thin-walled tissue are occasionally destitute of sieve-tubes, consisting only of cambium on the inner and thin-walled phloëm-parenchyma on the outer side. But this is exceptional and, as a rule, the interxylary zones consist of typical phloëm. The interxylary cambium which always lies on the inner side of the phloëm band, does not appear to be very active, for no crushing to speak of takes place. The radial rows of the interxylary phloëm are continuous inwards (through the cambium), but not outwards, with those of the wood. There can be no doubt that the development of these phloëm-bands is centri-

petal (cf. Figs. 19 and 20). The only satisfactory explanation of the whole structure is that we have here to do with successive layers of extrafascicular cambium. For a time the normal cambium continues its activity as in ordinary Dicotyledons. Then a new cambial layer is formed by division of the cells of the pericycle or of the outer phloëm-parenchyma. This layer may be continuous (except in the rays) all round the stem, or it may be partial, abutting at either end on the normal cambium. The new layer forms wood internally and phloëm externally, so that the original cambium and phloëm become enclosed, and so the first interxylary zone is formed. After an interval the process is repeated. The first extrafascicular cambium is replaced by a more external layer, and so another complete or partial phloëm zone is left behind and becomes imbedded in the wood. This process may take place over and over again, until we have the complicated structure of an old stem, as shown in the diagram (Fig. 16). As we have already seen, each enclosed cambium retains something of its activity and does not itself pass over into permanent tissue.

These are conclusions, which we have drawn from the careful comparison of many stems, but we have not yet been so fortunate as to observe the first origin of a new cambial layer. Possibly the first extrafascicular cambium may arise in the pericycle, certainly the later ones are formed from the phloëm-parenchyma. In the exceptional cases, when the interxylary zones have no sieve-tubes, we may assume that this new cambium arose very near the old, so that the differentiation of the products of the latter remained incomplete.

Occasionally small round bundles are seen in transverse sections imbedded in the wood, just outside an interxylary zone. These are leaf-trace bundles on their very oblique outward course, which have become enclosed by extrafascicular cambium.

The adventitious roots have a normal structure.

Our conclusions as to *Acantholimon* are as follows:—

1. An internal cambium is formed at a late stage, either

just inside or just outside the protoxylem. It produces a large amount of medullary wood and phloëm, with inverted orientation.

2. The concentric bands of phloëm and xylem, of which the secondary tissues are composed, are due to the activity of successive cambial layers, as was conjectured by Krüger and Solereder.

CONCLUSION.

In concluding we wish to point out the bearing of our subject on a theory which has been recently put forward as to the function of the phloëm in general.

In opposition to the prevailing view that the phloëm is primarily the conducting tissue for the nitrogenous, and especially for the proteid, food-substances of the plant, Prof. Frank¹ and Dr. Blass² maintain that the phloëm is essentially a store-tissue for the benefit of the wood. Prof. Frank says³: 'The position which this tissue invariably occupies speaks most clearly for its function as a store-chamber of those substances which the cambial layer requires for the formation of the wood; for in all fibrovascular strands it is a faithful companion of the woody bundles, and it increases and diminishes in amount with the bulk of the woody bundle which is to be formed; it is constantly situated immediately outside the cambial layer; it forms an annular zone around the cambial ring where the latter surrounds a closed cylinder of wood, as in most dicotyledonous stems and trunks; it forms an isolated strand, placed exactly in front of the woody bundle with its cambium, when we have to do with isolated fibrovascular-strands, as is especially the case in the petioles and ribs of the leaf.' Dr. Blass, who worked in conjunction with Prof. Frank, expresses his views as follows: 'Just as the contents of the starch-sheath serve to build up the bast-cells,

¹ Lehrbuch der Pflanzenphysiologie, 1890.

² Untersuchungen über die physiologische Bedeutung des Siebtheils der Gefässbündel; Pringsheim's Jahrbücher, Bd. XXII, 1890.

³ Loc. cit., p. 162.

so the contents of the phloëm are chiefly conveyed to the cambium in order to be employed in the activity of this meristematic zone and in the building up of the xylem¹. As evidence for this view, Dr. Blass, who has worked out the theory in detail, brings forward the facts that in trees the sieve-tubes nearest the cambium are richest in proteid contents; that in some cases the contents of the phloëm accumulate in autumn and are diminished when growth is renewed in the spring; that in some plants with reduced xylem (*Drosera* and certain aquatics) the sieve-tubes are rudimentary, containing nuclei and even chlorophyll-granules; and lastly that in the ringing experiments so often quoted in support of the prevailing views, the excessive growth above the incision is due simply to the formation of 'wound-parenchyma,' and not to the interruption of the downward current of food-material. In support of this contention, Dr. Blass states that the phloëm below the wound shows no diminution of its contents.

We purposely avoid criticising Dr. Blass's arguments, though it appears to us that his results are not inconsistent with the theory of conduction and in some points even lend it additional support. We willingly admit that in all plants with cambial growth the supply of food-materials for such growth must be an important function of the phloëm. Nor are we aware that this has ever been denied. But we wish to point out that the anatomical relations of the phloëm are often quite inconsistent with the supposition that its exclusive or principal function is connected with the formation of wood.

In all the numerous plants which have bicollateral bundles or an analogous arrangement of tissues, a great part of the phloëm, often the greater part and sometimes nearly the whole, is placed in that region of the stem where no formation of wood is going on, in a position as remote as possible from the wood-producing cambium, for the rare exceptions in which some internal wood is also formed may here be left out of consideration. Yet this internal phloëm is absolutely

¹ Loc. cit., p. 258.

typical in structure and contents. Nor is it a merely transitory tissue. Long after it is cut off from the normal cambium by a broad zone of secondary wood, it goes on increasing, often to a much greater extent than the normal external phloëm. In many of these plants it is the latter, the phloëm in contact with the wood-producing cambium, which is tending to become rudimentary, while the internal phloëm, remote from the cambium, is abundantly developed and retains all its typical characters.

That the internal, like any other phloëm, *indirectly* supplies the cambium as well as other growing regions, we do not for a moment doubt, but this is simply to say that it is a conducting tissue.

So too with the 'phloëm-islands.' In plants like *Strychnos* or *Salvadora* these are no sooner formed than they become imbedded in the dense wood, and are cut off from all direct communication with the cambium. It would be easy to cite other examples, as the stem of the Chenopodiaceae and many allied orders, in which almost all the phloëm is deeply imbedded in the fully formed wood, or the Monocotyledons generally, where the closed bundles retain a typical and active phloëm for months or years after all formation of wood has been completed.

In the light of facts such as these we cannot but think that the view of Prof. Frank and Dr. Blass depends on too one-sided a consideration of typical dicotyledonous anatomy. The passage quoted above from the former author, as well as Dr. Blass's concluding statement that 'a typical condition of the sieve-tubes is only to be found where wood-elements are to be formed¹,' seem to us not to be justified by facts. Our results as to the continuity of the various phloëm-systems in root and stem tend to give further anatomical support to the theory of the conducting functions of this tissue, a theory which, as we need hardly point out, is fully consistent with the view of Prof. Sachs that the phloëm may also be the seat of proteid-formation.

¹ Loc. cit., p. 290.

We are indebted for our material partly to the Director of the Royal Gardens, Kew, partly to Mr. H. N. Ridley, of the Botanic Gardens, Singapore, who has been so kind as to send us a number of specimens carefully preserved in spirit.

We have further to thank the officers of the botanical department of the British Museum, and also Mr. B. Daydon Jackson, Sec. L. S., for their kind help in the nomenclature of species.

POSTSCRIPT.

When this paper was completed in December, 1890, we had not seen the work of M. Lamounette, 'Recherches sur l'origine morphologique du liber interne,' which appeared in November, in the *Annales des Sci. Nat., Bot. Sér. 7. T. XI.*

M. Lamounette has made a number of valuable observations on the origin of internal phloëm in the hypocotyl, the cotyledons, the terminal bud of the stem, and the leaves. He strongly supports the views of M. Hérail, and rejects the term 'bicolaterality' in all cases, even in the Cucurbitaceae (p. 264). He regards the internal phloëm as being due to an ulterior evolution of the medullary cells, analogous to the formation of periderm in the cortex (p. 235), and considers that it was primarily independent of the normal bundles, its close association with them in the Cucurbitaceae not having been attained at a later phylogenetic stage. His view of the internal phloëm as an 'acquired character' which has become hereditary (p. 278) is evidently beyond criticism in the present state of our knowledge.

As regards the transition from stem to root, M. Lamounette says that the internal phloëm, when present in the hypocotyl, is altogether formed in the medullary parenchyma, and not in any degree at the expense of the phloëm of the root (p. 277). He appears to attribute the opposite view to Gérard. Surely there is some confusion between *course* and *development* here. In the cases investigated by Gérard and by ourselves there is no doubt as to the *continuity* between the internal phloëm of the hypocotyl and the external phloëm of the root, but no one has ever supposed that the one is developed from the other. M. Lamounette appears to have overlooked this continuity in all cases, a fact which is probably explained by his having worked chiefly with very young seedlings. He rightly points out that the development of the internal phloëm in the hypocotyl often takes place very late as is especially the case in *Ipomoea* (p. 243). In the Onagraceae he finds that internal phloëm is entirely absent from the hypocotyl, the cotyledons, and even the earlier-formed leaves (pp. 245 and 274). So far as the hypocotyl is concerned this can only be true of very young plants, for we know from Weiss's observations above cited that the internal phloëm is here continued into the root, when it forms the innermost interxylary phloëm-strands (see above, p. 272). We suspect that in all cases continuity between the internal phloëm of the stem and the phloëm of the root exists, though the connection may no doubt be established relatively late in some cases.

M. Lamounette's careful observations on the origin of the internal phloëm in the growing point of the stem are of great interest. He finds that it always arises later than the normal tissues of the bundle, and that it is of medullary, not of procambial origin. The distinction in some cases is certainly a very fine one, and we have not always been able to detect it, but we willingly accept M. Lamounette's results. We hope that our further investigations may throw additional light on this author's interesting hypothesis that the phylogenetic origin of all internal phloëm is to be traced to independent medullary strands, unconnected with the normal bundle-system.

Two other papers have lately appeared, bearing on our subject. Leonhard's Beiträge zur Anatomie der Apocynen (Bot. Centralblatt, Bd. XLV, 1891) confirms the general occurrence of internal phloëm throughout this order (with one doubtful exception). The author appears to have found phloëm embedded in the wood in *Lyonsia*, though his description is not perfectly clear, as he does not distinguish between *interxylary* and *intraxylary* phloëm.

Quite recently M. Hérail has published a preliminary note on medullary phloëm in the root (Comptes Rendus, April 13, 1891). He has discovered this structure in the adventitious roots of *Vinca major* and *V. media*, but not of *V. minor*, in which the pith soon becomes sclerotic. He points out the necessary condition on which the occurrence of medullary phloëm in the root manifestly depends; namely the presence of a permanently parenchymatous pith. He cites Van Tieghem's observation of internal phloëm in the root of *Cucurbita*, but is not acquainted with our description of this tissue in the root of *Strychnos*, published in 1889. M. Hérail's observations are a welcome addition to our own.

D. H. S. & G. B.

May 1, 1891.

EXPLANATION OF FIGURES IN PLATES XVIII,
XIX, XX.

Illustrating Messrs. Scott and Brebner's paper on Internal Phloëm.

The following lettering is used throughout :—

- cb^1 = normal cambium.
- cb^2 = medullary cambium.
- cb^3 = extrafascicular cambium.
- ph^1 = normal external phloëm.
- ph^2 = medullary phloëm.
- ph^3 = phloëm-islands, imbedded in the xylem.
- x^1 = primary xylem.
- x^2 = secondary xylem.
- x^3 = centripetal xylem, formed by medullary cambium.
- px = protoxylem.
- pc = pericycle.
- e = endodermis.

Figs. 1-5, *Browallia viscosa*.

The line C-C¹ is the plane of the cotyledons.

Fig. 1. Transverse section of hypocotyl. Numerous groups of medullary phloëm. In this and the following figures the xylem of the cotyledonary traces is shaded dark. $\times 300$.

Fig. 2. Do. lower down. Three internal phloëm-groups are passing out. $\times 300$.

Fig. 3. Do. still lower. Another phloëm-group is seen in the xylem on its way out. $\times 300$.

Fig. 4. Do. near root. Little medullary phloëm is left. One group is seen passing out. $\times 300$.

Fig. 5. Transverse section of tap-root, showing typical diarch structure. All the phloëm is now united in the normal position. $\times 300$.

Fig. 6. *Asclepias obtusifolia*. Part of a transverse section from a thickened root. Two phloëm-islands shown imbedded in the xylem-parenchyma, near a group of vessels. $\times 150$.

Figs. 7 and 8. *Thladiantha dubia*.

Fig. 7. Semi-diagrammatic transverse section of a root to show the distribution of the tissues. The protoxylem-groups coloured *red*, the xylem generally *yellow*, the sieve-tubes *blue*, and the bast-fibres *brown*.

Fig. 8. Part of a transverse section from a similar root, showing a secondary ray in which interxylary phloëm has been formed. $\times 150$.

Figs. 9-12. *Chironia peduncularis*.

Fig. 9. Part of a transverse section of an octarch root, moderately thickened, to show general structure. ph^2 is here the approximately central group of medullary phloëm. Two protoxylem-elements are seen to the outside of the cambium. An intermediate one has become imbedded in the secondary wood. $\times 150$.

300 *Scott and Brebner.—On Internal Phloëm, &c.*

Fig. 10. Part of a transverse section of a young octarch root at the commencement of secondary thickening. The cambium is forming *inside* the isolated protoxylem-elements. Primary interxylary phloëm-groups are in course of development. $\times 300$.

Fig. 11. Do. do. from a decarch root, at a stage very slightly later than Fig. 10. Four protoxylem-groups shown. To the left the cambial divisions take place *inside* the protoxylem. The cambium passes *outside* the next two groups, and on the right divisions are seen on both sides of the protoxylem-element. This root had a considerable pith containing a large group of internal phloëm. $\times 300$.

Fig. 12. Do. do. from a root at nearly the same stage as Fig. 9, showing the centrifugal development of the phloëm-islands on the inner side of the cambium. $\times 300$.

Figs. 13 and 14. *Apocynum cannabinum*.

Fig. 13. Part of a transverse section of a stem in which the normal wood is 70–90 cells thick. The development of centripetal wood from the internal cambium has just begun. It is separated from the protoxylem of one of the primary bundles by one or two layers of parenchyma. $\times 170$.

Fig. 14. Similar section from an older stem. The internal wood is now about 15 cells thick. The internal phloëm projects far into the pith. $\times 170$.

Fig. 15. *Willughbeia firma*.

Part of a transverse section from a thick stem, showing the centripetal wood and internal cambium and phloëm, and their relation to the protoxylem of the normal wood. $\times 300$.

Figs. 16–20. *Acantholimon glumaceum*.

Fig. 16. Semi-diagrammatic transverse section of an old stem, to show the distribution of the tissues. *Red* = protoxylem. *Yellow* = xylem generally. *Blue* = phloëm. The cortex, rays, and pith are left *white*.

Fig. 17. Part of a transverse section showing the inner part of the normal wood, the centripetal wood, and the internal cambium and phloëm. The centripetal wood is alone shaded. $\times 300$.

Fig. 18. Longitudinal section of the same. Notice specially the loosely coiled spirals of the protoxylem-vessels, on the inner side of which the centripetal wood is forming. Some of the internal sieve-tubes have callous plates. $\times 300$.

Fig. 19. Transverse section showing part of an interxylary band of cambium and phloëm. The cambium lies on the *inner* side of the phloëm. $\times 300$. The external zone of wood (x^2a) begins with large vessels.

Fig. 20. Longitudinal section of the same. The callous plates of the older interxylary sieve-tubes are shown. The outer part of the inner zone of wood (x^2) consists chiefly of narrow spirally thickened vessels, while the inner part of the outer zone (x^2a) has large pitted vessels. $\times 300$.

All the figures were drawn under the camera lucida. Those $\times 300$ were drawn with a power of 450 diam. and subsequently reduced to two-thirds.

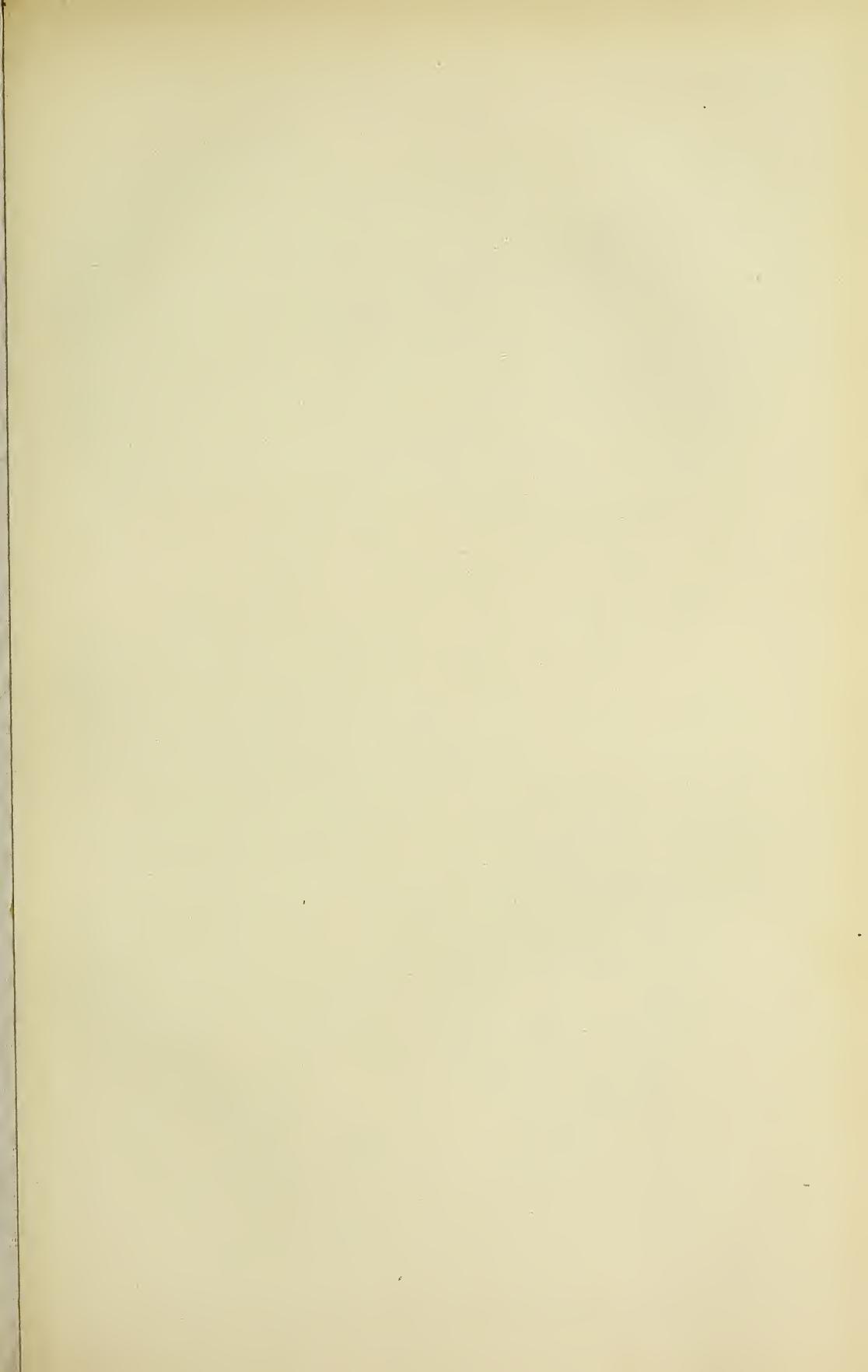


Fig. 1.

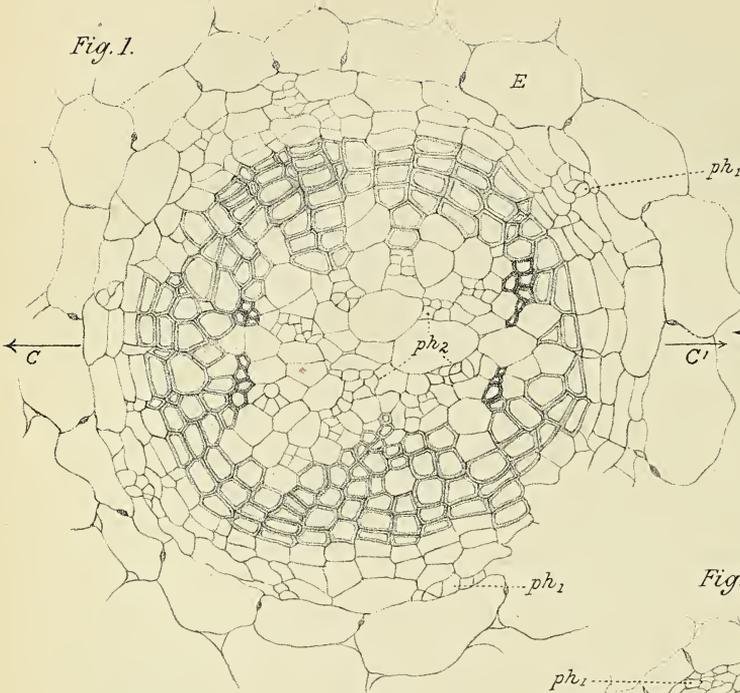


Fig. 2.

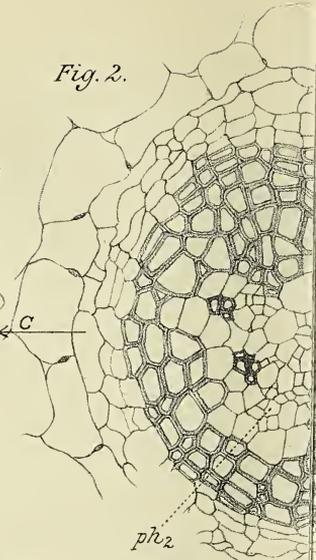


Fig. 5.

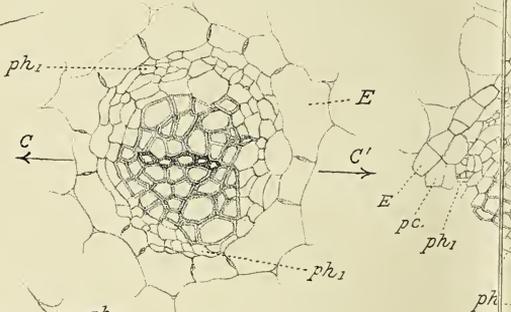


Fig. 3.

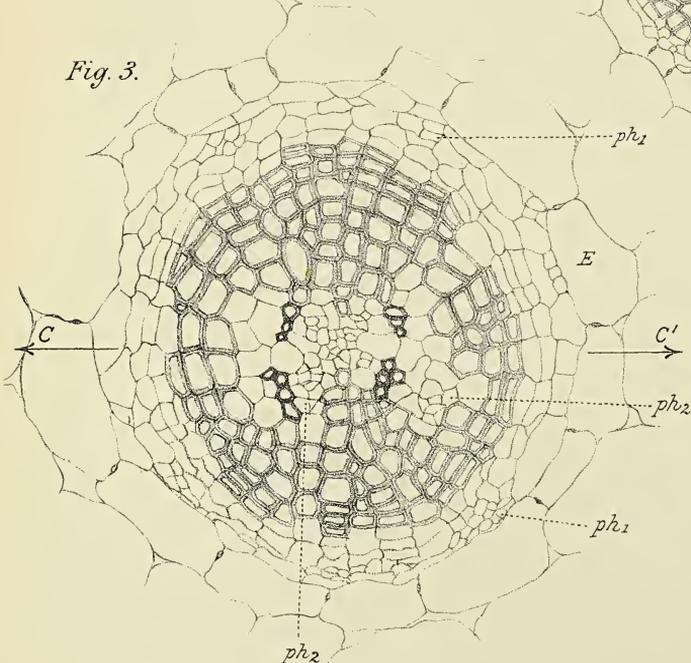
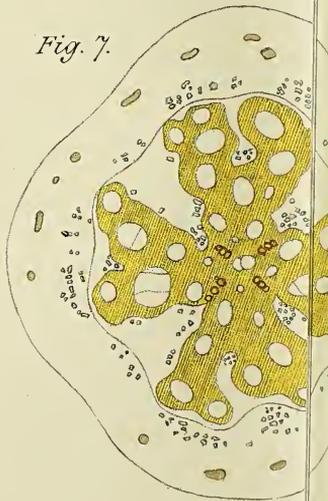


Fig. 7.



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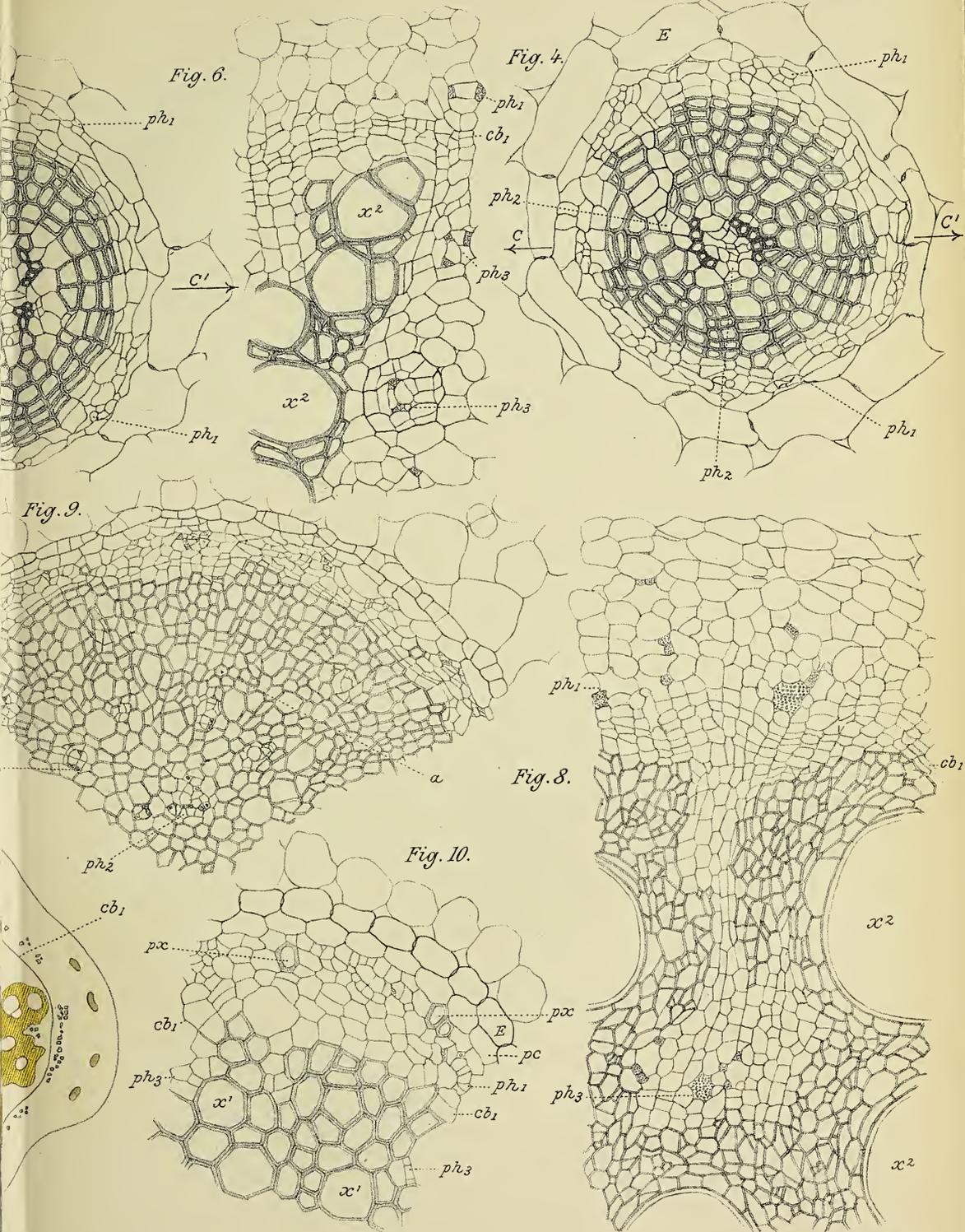


Fig. 1.

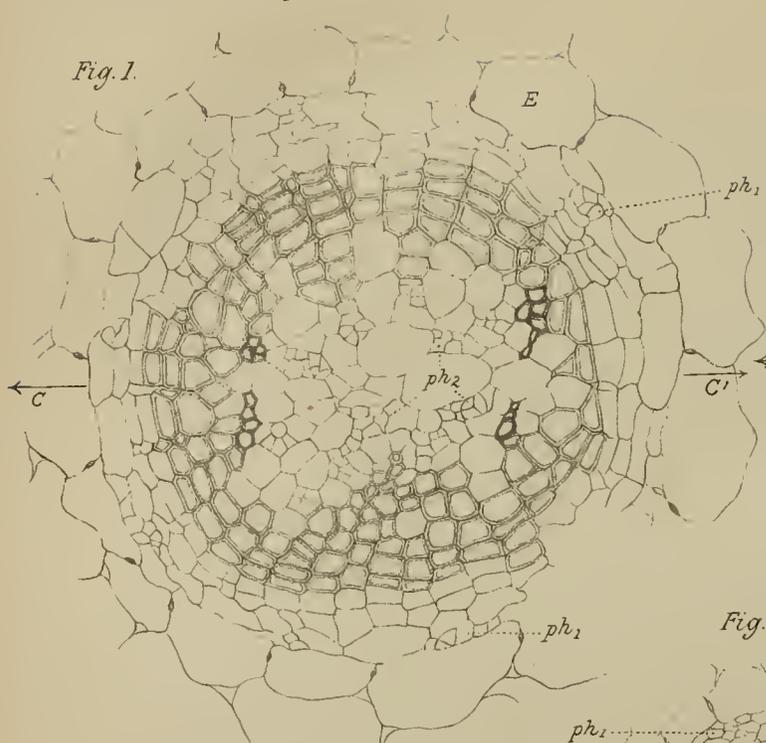


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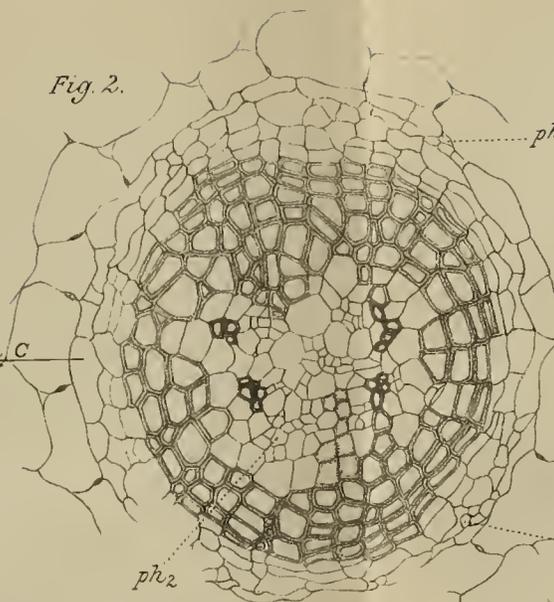


Fig. 6.

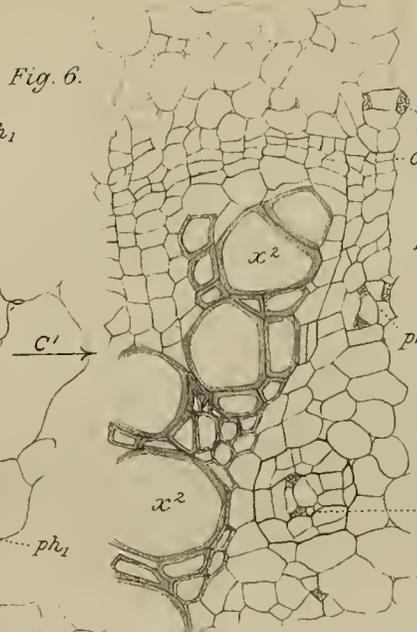


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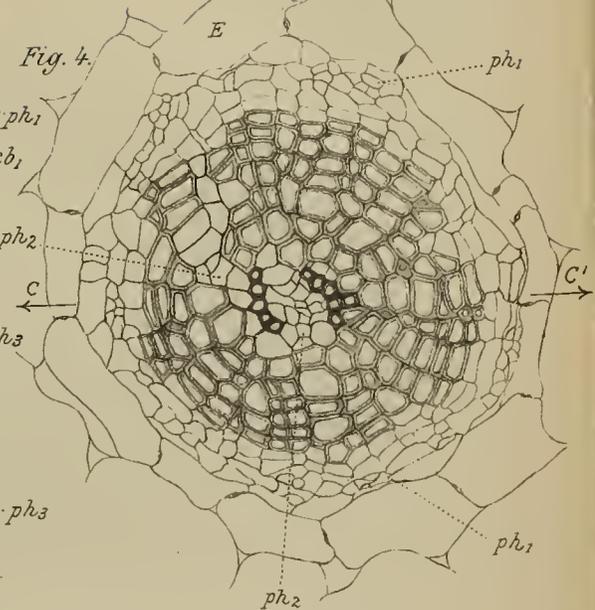


Fig. 5.



Fig. 9.

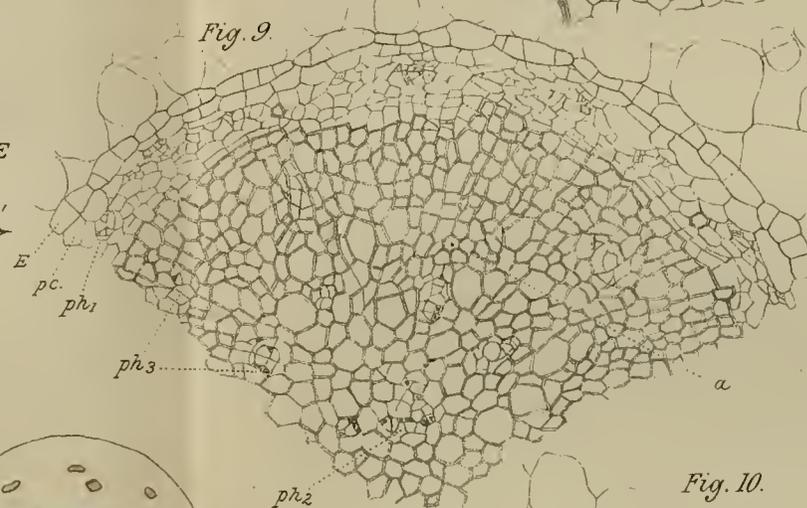


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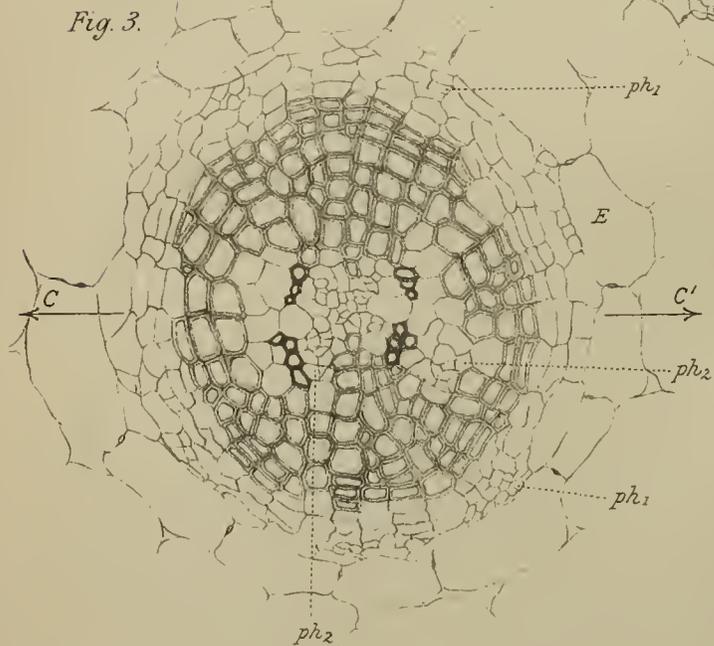


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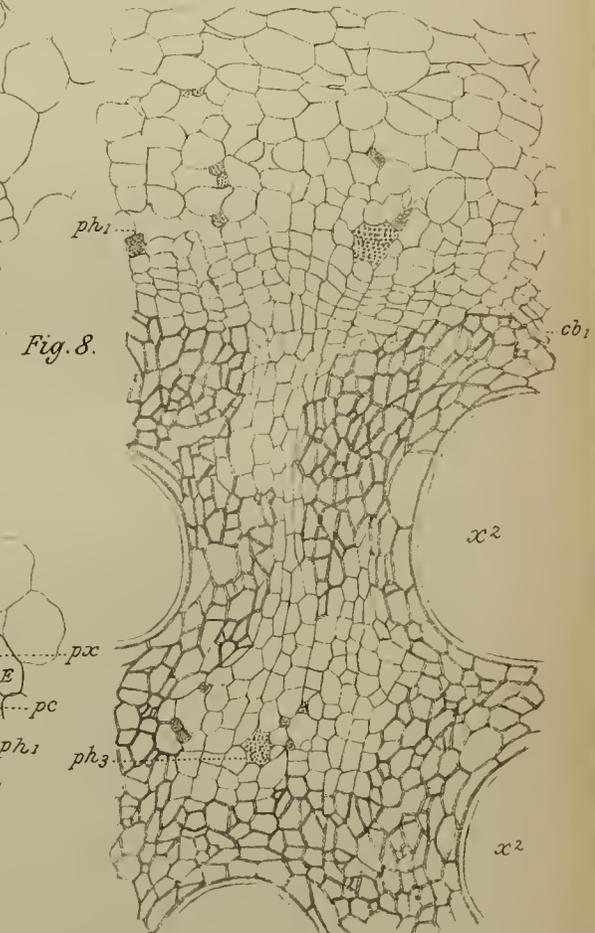


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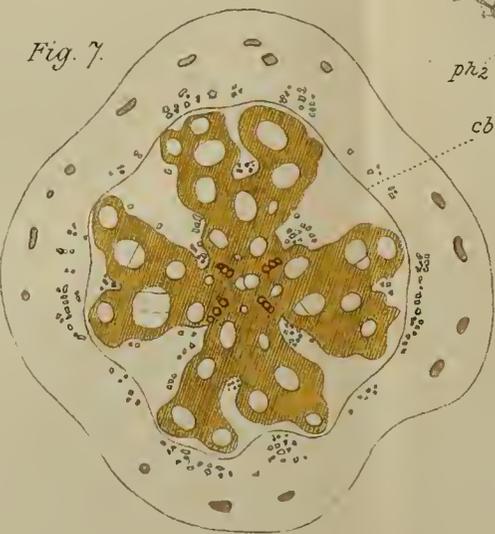
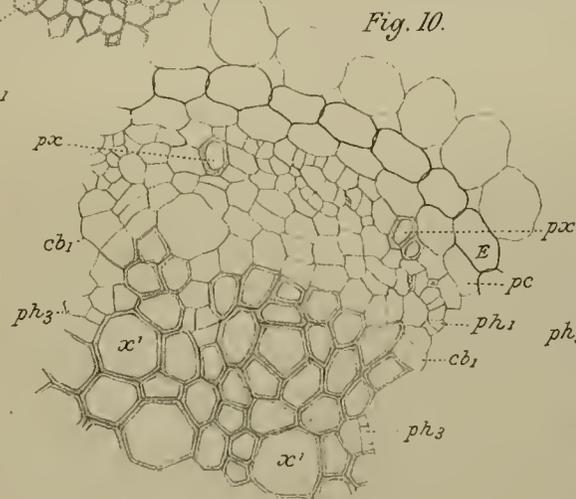


Fig. 10.



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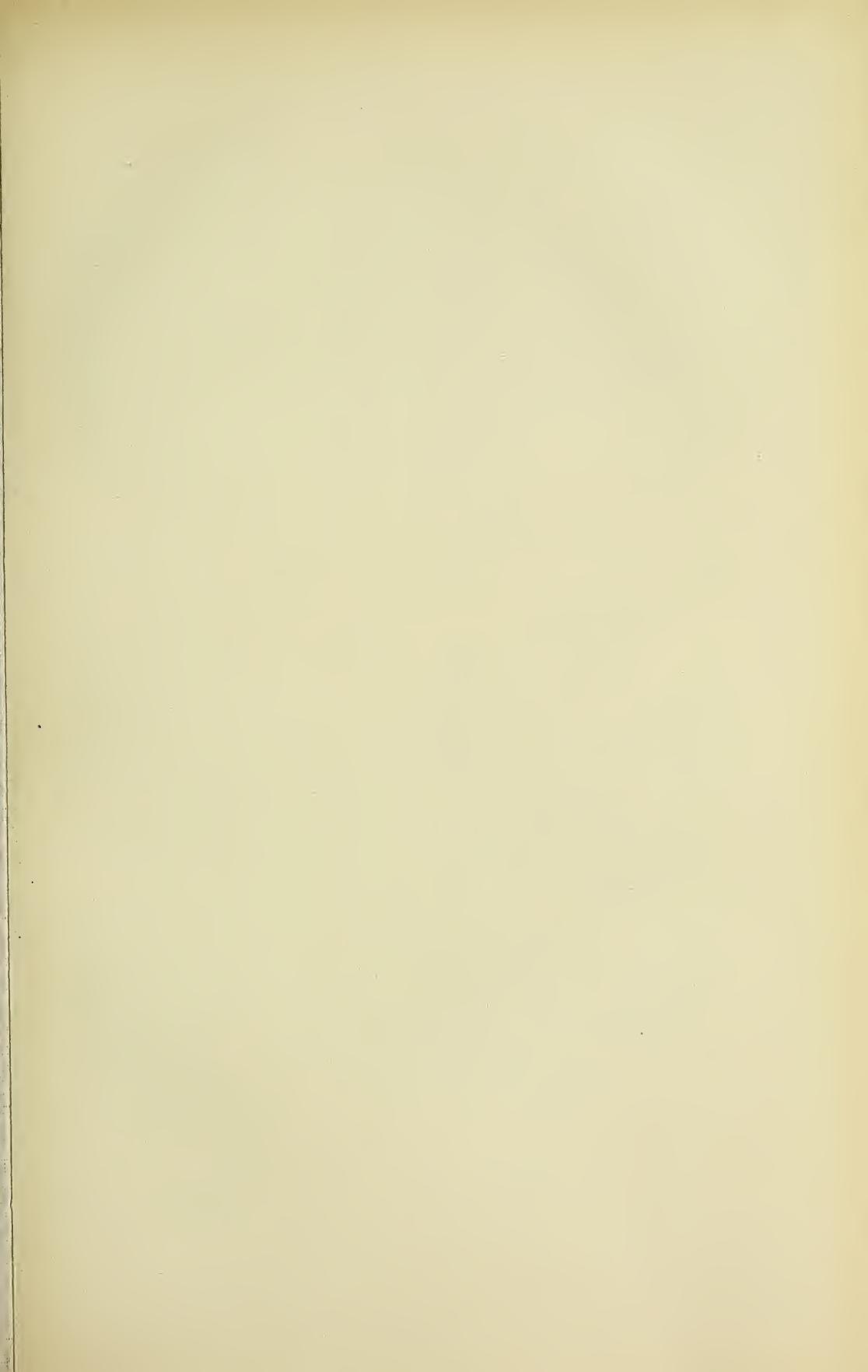


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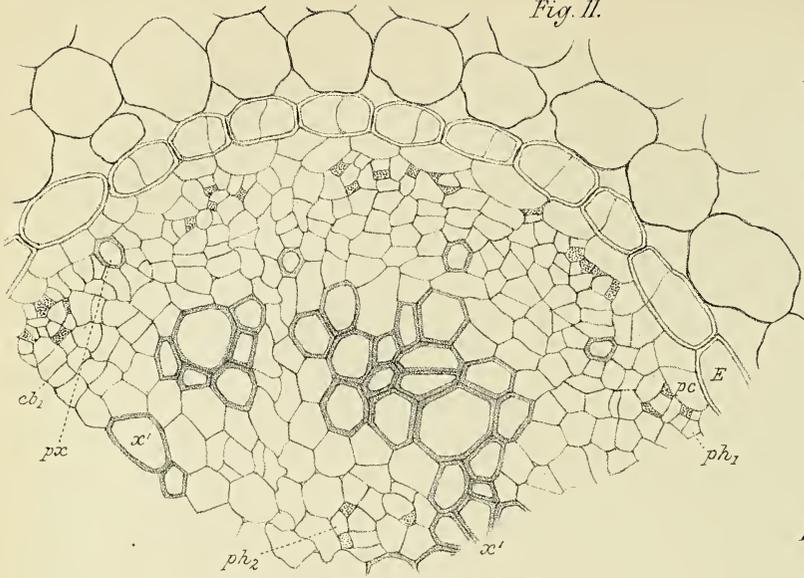


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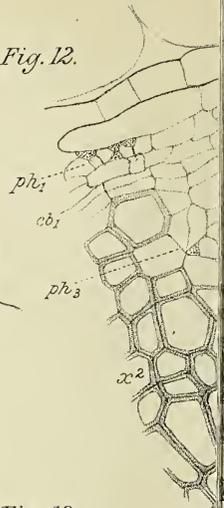


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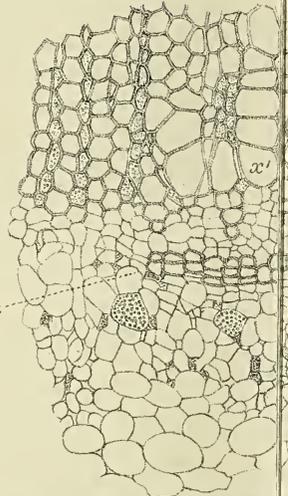


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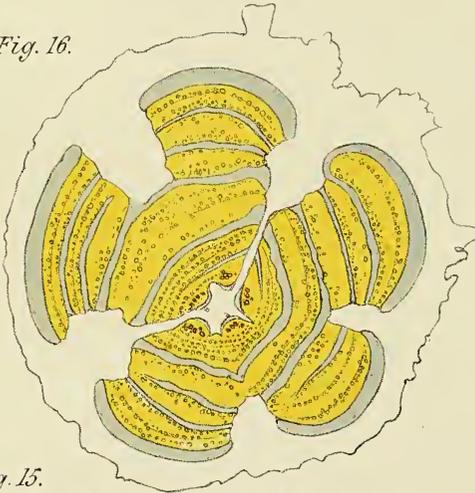


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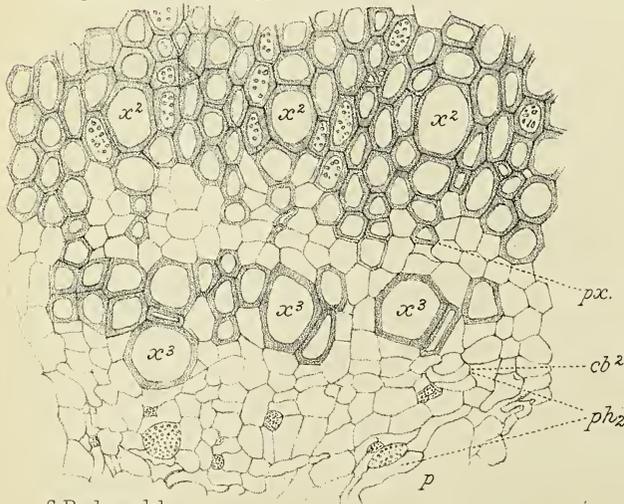
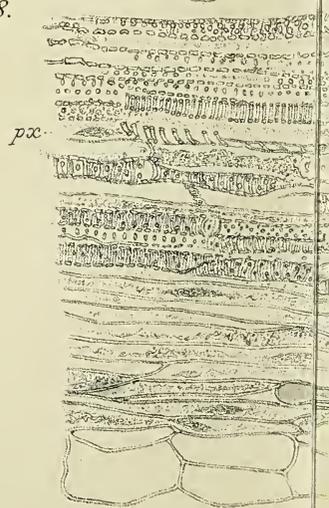


Fig. 18.



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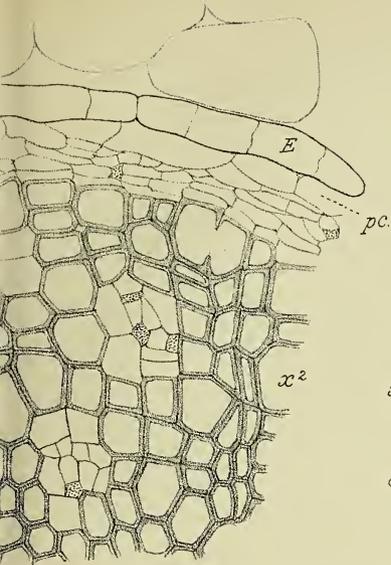


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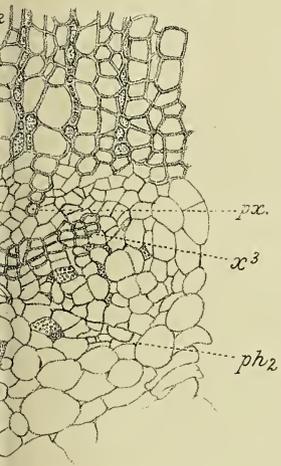
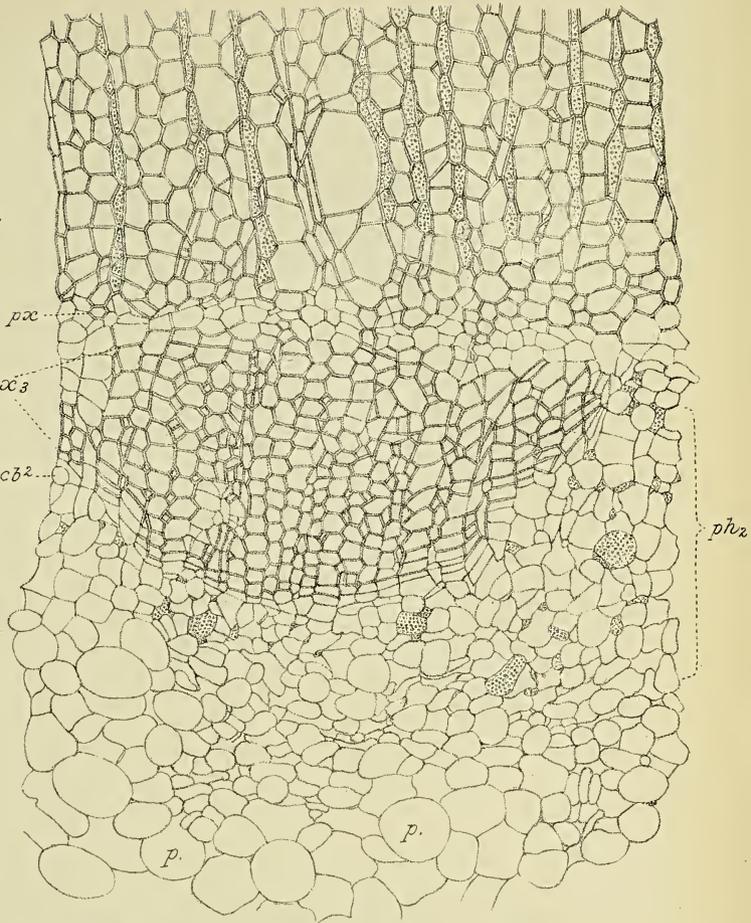


Fig. 17.

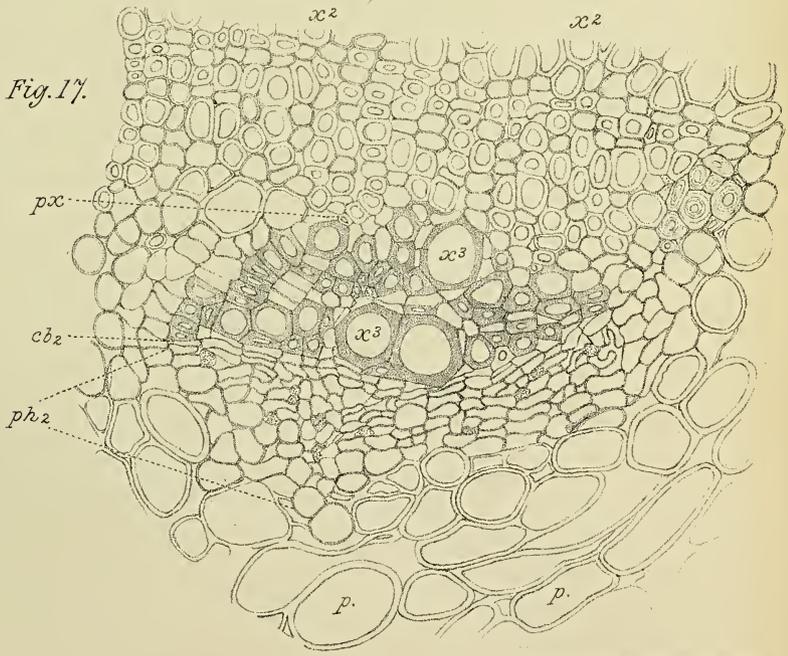
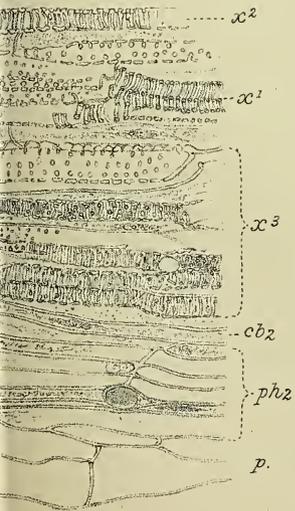


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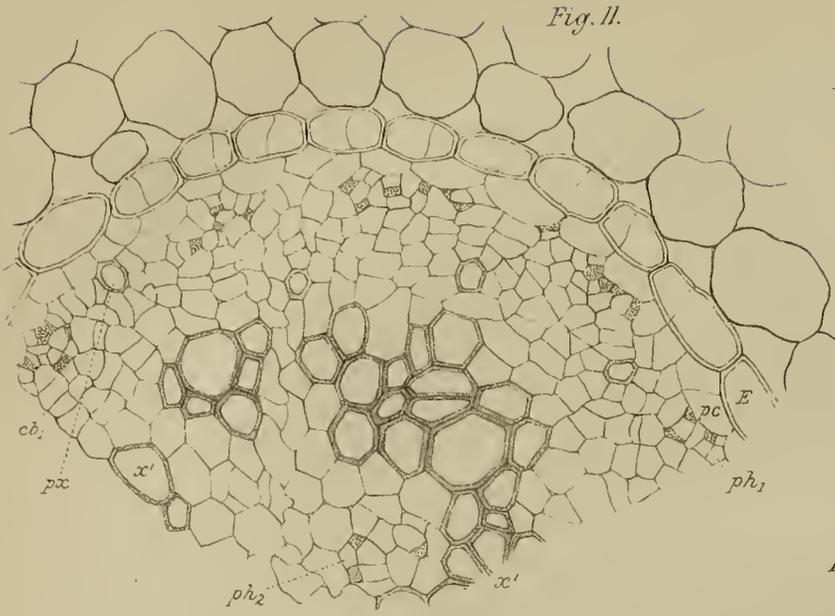


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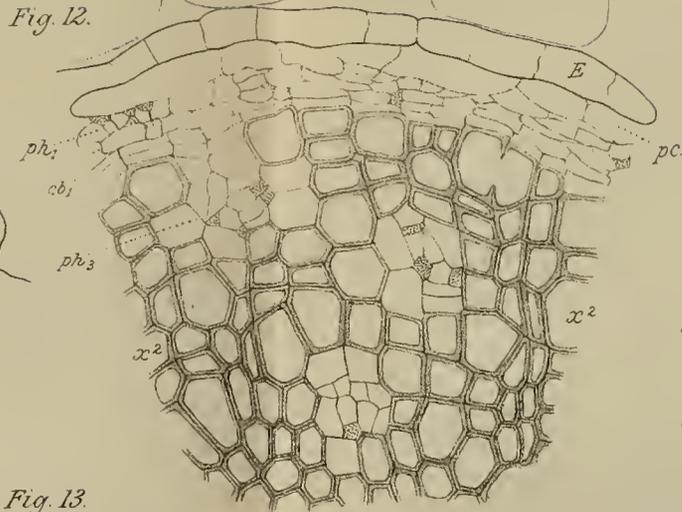


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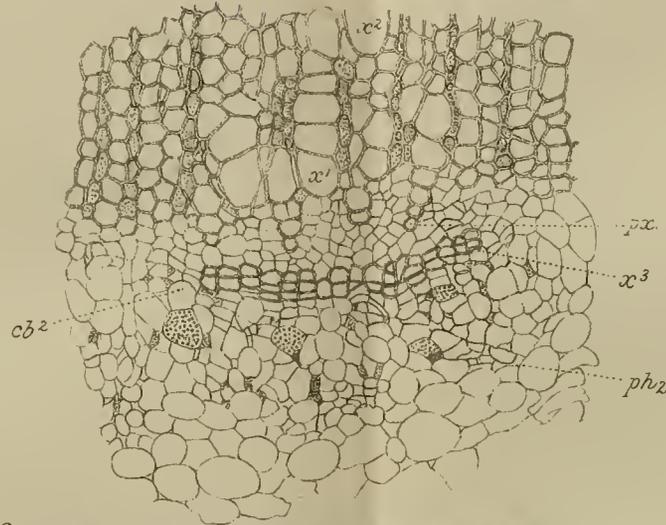


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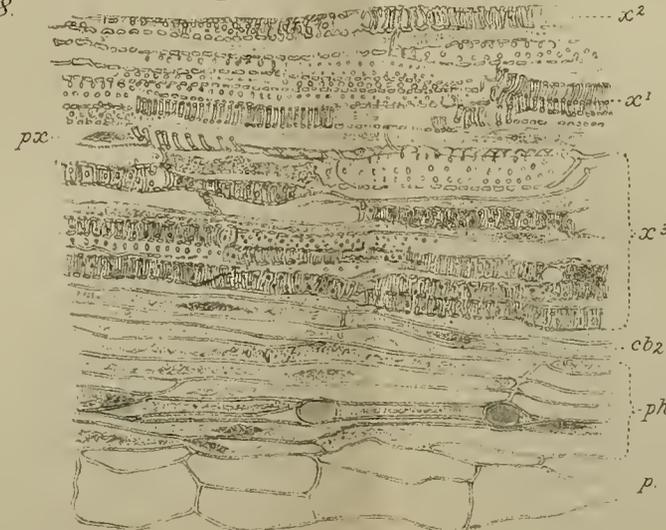


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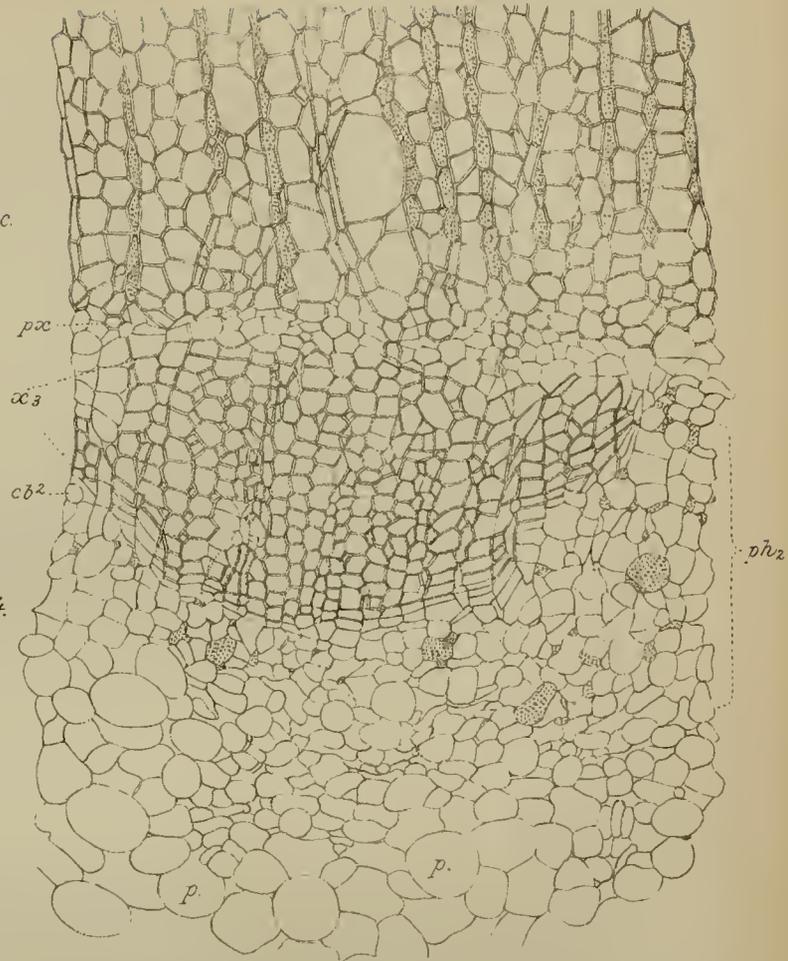


Fig. 17.

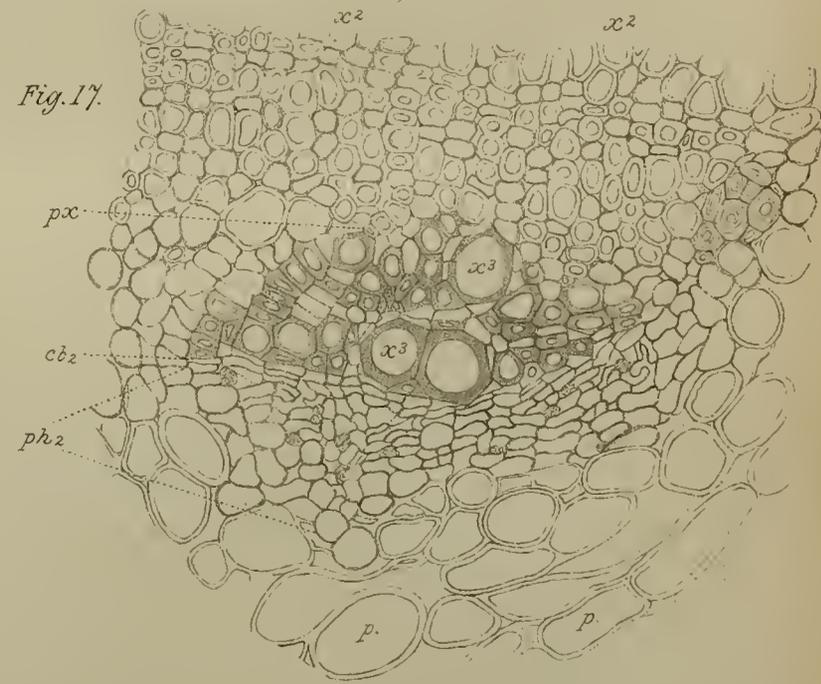


Fig. 16.

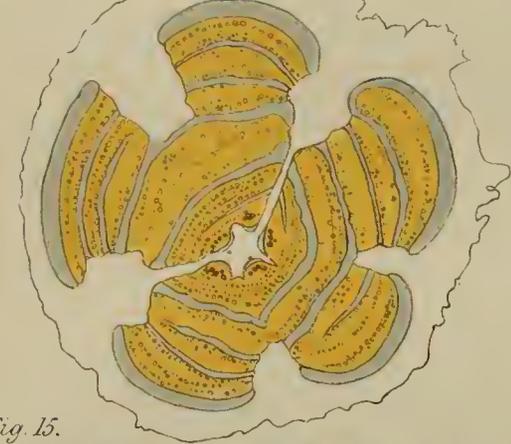
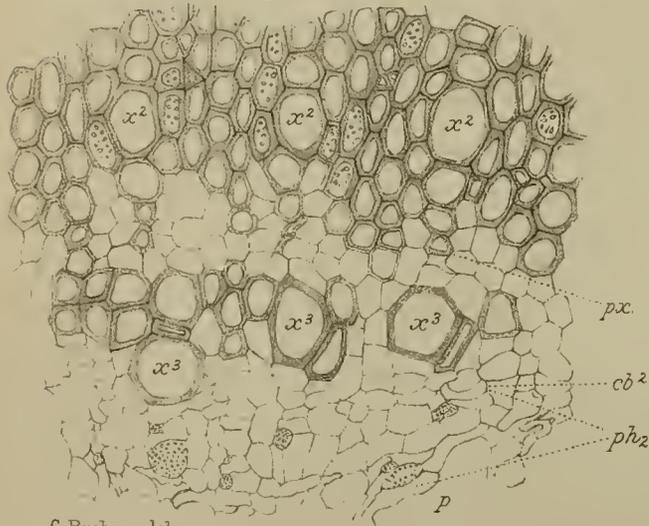


Fig. 15.



G. Brebner del.

University Press, Oxford.

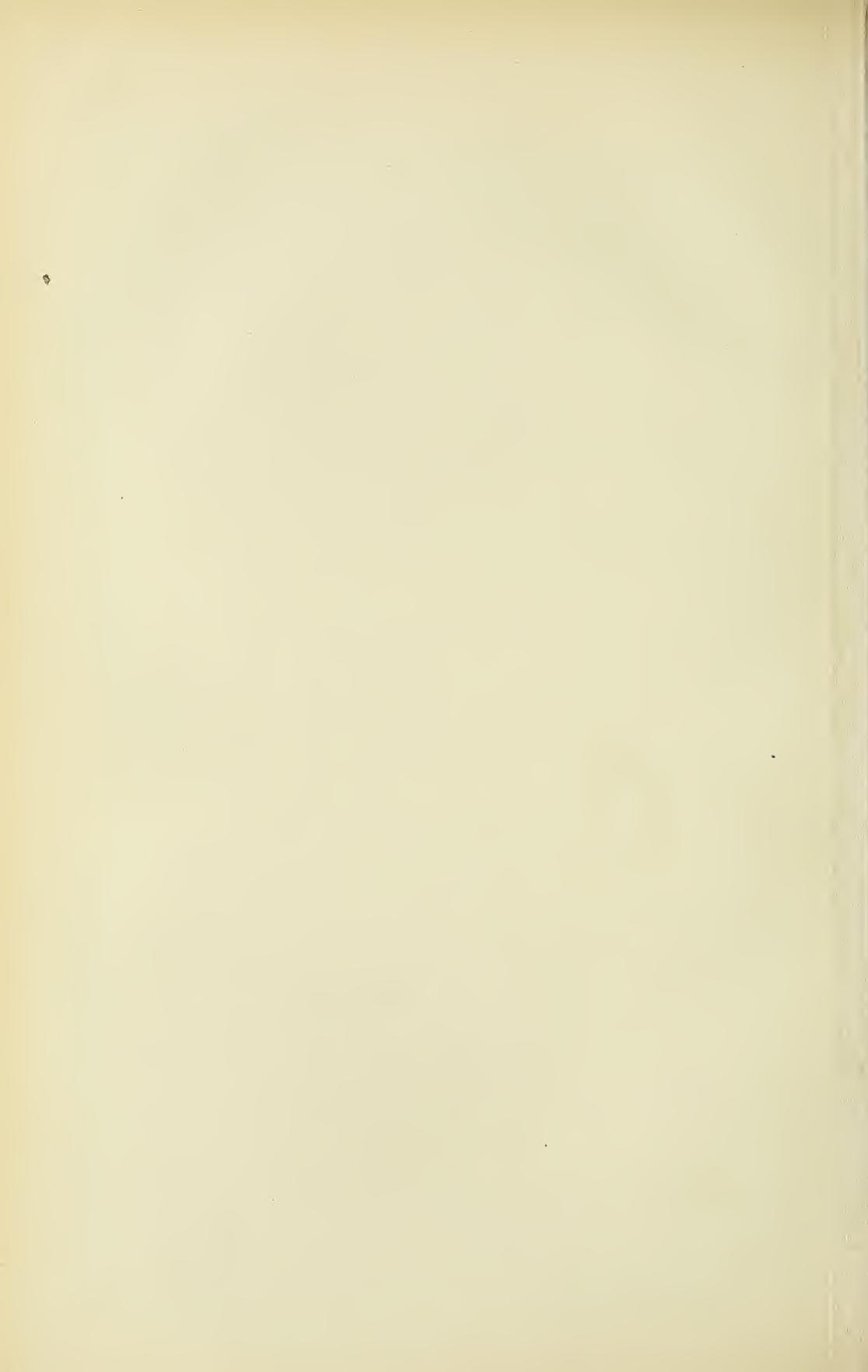


Fig. 19.

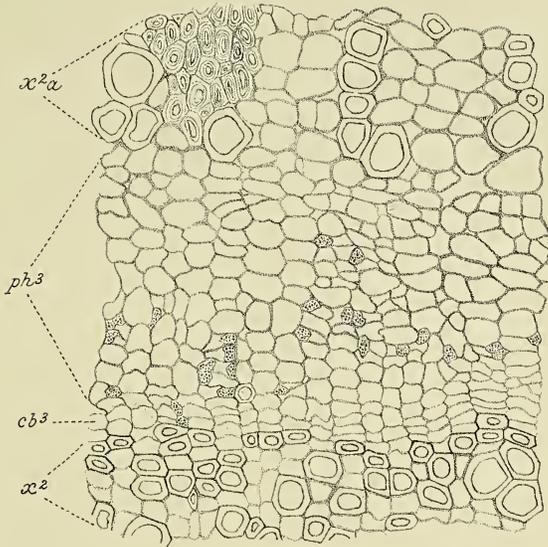
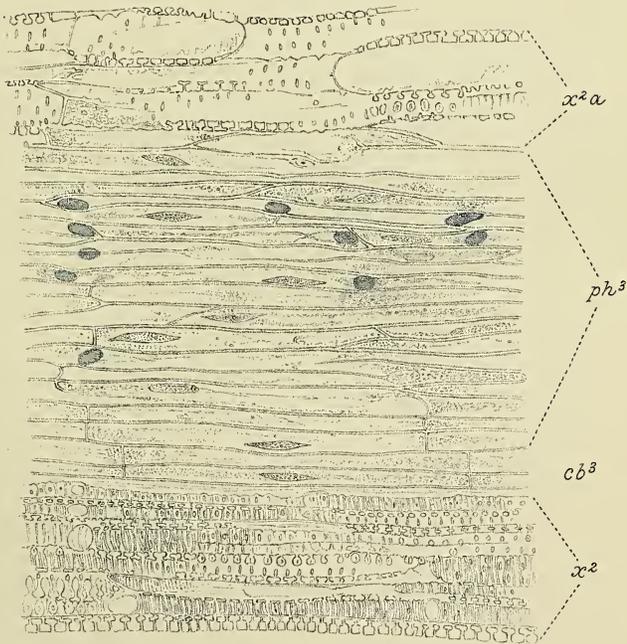


Fig. 20.



A Summary of the new Ferns which have been discovered or described since 1874.

BY

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(Continuation.)

Genus 38. ASPLENIUM, *Linn.*

Subgenus **Euasplenium.**

- 13*. **A. Robinsoni**, F. M., in Journ. Bot. 1884, 289. Norfolk Island, *Robinson*. I believe this to be identical with *A. squamulatum*, var.? *Smithii*, Hook., a garden plant of unknown origin.
- 15*. **A. Maetierii**, Beddome, in Journ. Bot. 1888, 3. Malay Peninsula.
- 15*. **A. Scortechinii**, Beddome, in Journ. Bot. 1887, 322. Perak, *Scortechini*.
- 15*. **A. holophyllum**, Baker, n. sp. Frond simple, lanceolate, subcoriaceous, glabrous, 3-4 in. long, $\frac{1}{2}$ - $\frac{5}{8}$ in. broad at the middle, narrowed gradually to the apex and a very short stipe. Veins immersed, erecto-patent, simple or forked. Sori short, ceasing a space from the edge, not above $\frac{1}{8}$ in. long. Indusium simple, broad, firm, glabrous, persistent. Formosa; Tamsui Mountains, *Hancock*, 101.
- 17*. **A. melanolepis**, Baker, in Journ. Bot. 1890, 264. Tonquin, *Balansa*, 1919.
- 20*. **A. longissimum**, Baker, in Journ. Bot. 1891, 4. North-West Madagascar, *Last*.
- 25*. **A. filicaule**, Baker, in Journ. Bot. 1881, 204. New Granada; province of Antioquia, *Kalbreyer*.
- 25*. **A. holophlebium**, Baker, in Journ. Bot. 1877, 163. Andes of Ecuador, *Sodiro*.
- 26*. **A. Delislei**, Baker, n. sp. Tuft with long stolons rooting at the end. Basal paleae minute, lanceolate, clathrate, nearly

- black. Stipes 1-2 in. long, slender, green, naked. Frond linear-lanceolate, simply pinnate, green, glabrous, 3-4 in. long, $\frac{1}{2}$ in. broad. Pinnae rhomboid, sessile, truncate on the lower and inner side, crenate on the upper and outer; lowest pinnae distant and dwarfed. Veins distinct, flabellate, 5-6 to a pinnae. Sori short, broad. Indusium glabrous, persistent. Bourbon, *Delisle*, 592. Near *A. viride* and *Kraussii*.
33. **A. Sandersoni**, Hook. Further material shows that **A. Hanningtoni**, Baker, in Journ. Bot. 1883, 245, from the Usagura Mountains, is a form of this species, and that **A. brachypterum** and **Dregeanum**, Kunze, are dareoid varieties.
34. **A. dentatum**, L. I can only separate as a variety **A. jamaicense**, Jenm. in Journ. Bot. 1886, 208, from the Mountains of Jamaica.
37. **A. Trichomanes**, L. I cannot separate specifically the New Zealand **A. melanolepis**, Colenso, in Trans. New Zeal. Instit. 1888, 227, and the Portuguese **A. Caput-serpentis**, Henriquez.
- 37*. **A. Reuteri**, Milde, Fil. Eur. 62. Cilicia, *Balansa*. Not seen.
42. **A. normale**, Don. Received lately from Japan, China, Siam, Sumatra, and Madagascar.
- 42*. **A. leucostegioides**, Baker, n. sp. Stipes very short, tufted, castaneous, with a few minute crisped linear-subulate paleae. Fronds lanceolate, membranous, simply pinnate, 2-3 in. long, $\frac{3}{4}$ -1 in. broad, with a few minute paleae on both surfaces. Pinnae sessile, rhomboid-oblong, $\frac{1}{4}$ in. broad, very oblique at the base. Veins few, distant, erecto-patent, lower forked. Sori oblong or orbicular, not more than 2-3 to a pinna. Indusium membranous, green, glabrous. East Maui, Sandwich Isles, *F. L. Clarke*. Received from Mr. G. E. Davenport.
- 44*. **A. parvulum**, Mart. et Gal. Stipes densely tufted, short, black, wiry. Fronds lanceolate, simply pinnate, 4-6 in. long, $\frac{1}{2}$ - $\frac{3}{4}$ in. broad. Pinnae sessile, oblique oblong, auricled on the upper side at the base, cuneate-truncate on the lower side; lower pinnae gradually smaller. Sori medial, oblong, 5-6-jugate in the central pinnae. Mexico and Southern United States.
- 48*. **A. iudens**, Baker, in Journ. Linn. Soc. XIX, 294. Solomon Isles, Rev. *R. B. Comins*. Near *A. multilineatum*, Hook.

- 50*. **A. Poolii**, Baker, in Journ. Linn. Soc. XV, 416. Central Madagascar, *Pool*.
53. **A. Vieillardii**, Mett. New Caledonia. Very variable in cutting. I place as varieties **A. schizodon**, Moore, in Gard. Chron. 1871, 1004; **A. apicidens**, Moore, in Gard. Chron. 1881, I, 267; and **A. Baptistii**, Moore, in Gard. Chron. 1881, I, 235. See also var. *facile*, Moore.
- 54*. **A. Moorei**, Baker, n. sp. Stipe long, green, naked. Fronds oblong-deltoid, simply pinnate, moderately firm, glabrous, a foot long and broad. Pinnae multijugate, lanceolate, distinctly petioled, serrated, the lowest $\frac{1}{2}$ ft. long, an inch broad at the base, cuneate on the lower side. Veins distinct, forked, very ascending. Sori $\frac{1}{2}$ – $\frac{3}{4}$ in. long. Indusium narrow, firm, persistent, glabrous. Solomon Isles, *Chas. Moore*. Between *A. Vieillardii* and *lucidum*.
- 56*. **A. pachysorum**, Baker, in Journ. Bot. 1891, 4. North-West Madagascar, *Last*. Very near the West African *A. longicauda*, Hook., of which Kalbreyer has found a bipinnate variety.
- 64*. **A. Hancockii**, Maxim. Mel. Biol. XI, 868. Formosa, *Hancock*. Differs from *A. lunulatum* by vestiture, entire pinnae, and sori reaching from midrib to margin.
- 65*. **A. Mannii**, Hilleb. Fl. Hawaii, 594. Sandwich Isles, *Seemann*, 2240, *Hillebrand*. Near *A. persicifolium*, J. Sm.
- 65*. **A. Steerei**, Harringt. in Journ. Linn. Soc. XVI, 28. Mount Mahayhay, Philippines, *Steere*.
70. **A. cultrifolium**, L. I cannot separate specifically **A. pululahuae**, Sodiro, Recens. Crypt. Vasc. Quit. 33, from the Andes of Ecuador.
77. **A. contiguum**, Kaulf, var. *fissum*, Moore, in Gard. Chron. 1881, 267, is a subbipinnate variety, and **Paralleloneuron Neitneri**, Hort., a still more deeply cut form of this species. I have not seen **A. Knudsenii** and **nitidulum**, Hilleb. Fl. Hawaii 601.
- 81*. **A. Balfourii**, Baker, n. sp. Stipes 6–9 in. long, clothed throughout with lanceolate, brown paleae, with a pale margin. Fronds oblong-lanceolate, simply pinnate, 2–3 ft. long, 8–9 in. broad, moderately firm, glabrous: rachis scaly throughout. Pinnae lanceolate, serrated especially towards the tip, 4–4 $\frac{1}{2}$ in. long, an inch broad, cuneate on the lower side at the base; lower gradually smaller. Veins distant, erecto-patent, forked.

- Sori reaching from the midrib nearly to the edge, $\frac{1}{4}$ – $\frac{1}{3}$ in. long. Bourbon, *Balfour*. Near *A. compressum*, Sw. of St. Helena.
- 87*. *A. Schweinfurthii*, Baker, in Balf. Bot. Socot. 328, t. 100. Socotra, *Schweinfurth*. *Balfour*.
88. *A. obtusatum*, Forst. Under this, as defined in Synopsis Filicum, range the Sandwich Island *A. Kaulfussii*, Schlecht., Hilleb. Fl. Hawaii, 592, and the New Zealand *A. anomodum*, Colenso, in Trans. New Zeal. Instit. 1882, 309.
- 88*. *A. cesatianum*, Baker, in Malesia, III, 39. New Guinea, on Mount Arfak, *Beccari*.
- 92*. *A. sherburgense*, Baker, n. sp. Stipes tufted, 3–4 in. long, clothed with deciduous subulate paleae. Fronds oblong-lanceolate, simply pinnate, moderately firm, glabrous, a foot long, $1\frac{1}{2}$ –2 in. broad, rooting at the tip. Pinnae 20–25-jugate, sessile, oblong, crenate, $\frac{3}{4}$ – $\frac{7}{8}$ in. long, $\frac{3}{8}$ in. broad, cuneate on the lower side at the base, slightly auricled on the upper; rachis thinly clothed with bristly paleae like those of *A. crinicaule*. Veins erecto-patent, simple except the lowest. Sori regular, simple, parallel, remote from the edge. Indusium glabrous, persistent. Sherburg Island, Upper Guinea, *Mrs. Mair*. Near *A. crinicaule*, Hance.
94. *A. falcatum*, Lam. I have not seen the Sandwich Island *A. pseudo-falcatum*, Hilleb. Fl. Hawaii, 597, nor the New Caledonian *A. fastigiatum* and *dentato-serratum*, Fourn. in Ann. Sc. Nat. sér. 5, XVIII, 305.
95. *A. caudatum*, Forst. *A. decipiens*, Kuhn, in Reise Decken. Bot. 71, Johanna Island, *Hillebrand*, 1773, differs from the type by its more deeply cut pinnae and frond dwarfed gradually at the base.
- 100*. *A. oligophlebium*, Baker, in Gard. Chron. n. s. XIV, 494. Japan, *Maries*. Near *A. formosum*, Willd.
102. *A. resectum*, Smith. *A. unilaterale*, Lam. Ency. II, 305 (1786), is an older name for this species.
- 105*. *A. centrifugale*, Baker, in Journ. Linn. Soc. XXV, 360. Christmas Island, *J. J. Lister*. Very near the Indian *A. planicaule*, Wall.
- 105*. *A. castaneo-viride*, Baker, n. sp. Stipes tufted, castaneous below, green above, 2–3 in. long. Frond lanceolate, pinnate,

- subrigid, green, glabrous, $\frac{1}{2}$ ft. long, 1-1 $\frac{1}{2}$ in. broad at the middle, narrowed gradually to the base. Pinnae sessile, unequal-sided, laciniate-pinnatifid. Veins indistinct, erectopatent. Sori finally forming a continuous mass, covering the whole pinna, except the tip and outer edge. China; Chefoo, *Hancock*, 14.
- 106*. **A. formosanum**, Baker; *A. Hancockii*, Baker, in Journ. Bot. 1885, 104, non Maxim. Formosa, *Hancock*, 134. Allied to *A. laciniatum* and the small forms of *A. affine*.
- 107*. **A. subaquatile**, Cesati, Fil. Born. Beccar. 20, tab. 3, fig. 5. Borneo, first gathered by Beccari, later by Curtis and Bishop Hose.
- 114*. **A. Lydgatei**, Hilleb. Fl. Hawaii, 596. Sandwich Islands. "Allied to *A. difforme*, R. Br." Not seen.
119. **A. pekinense**, Hance. Further material shows that 132, **A. Saulii**, Hook., in Blakistone's Yangtze, 303 (1862), is a larger, more compound form of the same species, and the latter is the older name. It has lately been found by Levinge in the Himalayas (Chumba and Jhelum Valley).
- 124*. **A. sphenotomum**, Hilleb. Fl. Hawaii, 529. Sandwich Islands. Not seen.
125. **A. furcatum**, Thunb. An earlier name for this cosmopolitan species is *A. praemorsum*, Swartz, Prodr. Fl. Ind. Occ. 130 (1788).
126. **A. affine**, Swartz. In Madagascar this proves to be excessively variable in cutting. I now refer here **A. simillimum**, Kuhn, in Hildeb. Madag. Exsic. No. 3773; **A. Gilpiniae**, Baker, in Journ. Linn. Soc. XVI, 200; **A. herpetopteris**, Baker, in Journ. Linn. Soc. XVI, 20; and **A. viviparoides**, Kuhn, in Hildeb. Pl. Madag. Exsic. No. 4148. See also vars. *Pecten* and *tanalense*, Baker.
133. **A. fontanum**, Bernh. I place as a variety very near *exiguum*, **A. yunnanense**, Franchet, in Bull. Bot. Soc. France, XXXII, 28, gathered in Yunnan by Father Delavay.
- 133*. **A. chihuahuense**, Baker, n. sp. Stipes densely tufted, castaneous, green upwards, $\frac{1}{2}$ -1 in. long. Frond oblong-deltoid, bipinnate, moderately firm, glabrous, an inch long. Lower pinnae the largest, sessile, ovate, lobed down to the base on the upper side (lobe obovate-cuneate), cuneate-truncate on the

lower side. Veins flabellate. Sori medial, linear or oblong. Indusium pale, persistent, glabrous. Mexico; province of Chihuahua, *Pringle*, 144, in collection of 1887. Allied to *A. fontanum*.

- 134*. *A. coenobiale*, Hance, in Journ. Bot. 1874, 142 = *A. fuscipes*, Baker, in Journ. Bot. 1879, 304. Canton, *Ford*.
 134*. *A. moupinense*, Franchet, Pl. David. II, 152, Tibet; province of Moupine, *David*. Near *A. varians* and *incisum*.
 144. *A. bulbiferum*, Forst. I cannot from the descriptions separate *A. canterburiense*, Armstrong, in Trans. New Zeal. Instit. 1881, 361, New Zealand, and *A. meiotomum*, Hilleb. Fl. Hawaii, 596, Sandwich Islands.

Subgenus **Darea**.

- 156*. *A. beccarianum*, Cesati, Prosp. 7. New Guinea, *Beccari*. Between *A. Mannii* and *obtusilobum*.
 165*. *A. loxoscaphoides*, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 354. Mount Kilimanjaro, alt. 8000 ft., *Johnston*, 43.
 168*. *A. sertularioides*, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 354. Mount Kilimanjaro, alt. 9000-13,000 ft., *Johnston*, 26.
 174*. *A. Solmsii*, Baker, in Hemsl. Biol. Cent. Amer. Bot. III, 639. Guatemala, *Bernoulli* and *Cario*, 317. Like the dareoid forms of *bulbiferum*.

Subgenus **Athyrium**.

178. *A. spinulosum*, Baker. Has lately been found in Japan by *Maries*, and in Yunnan by *Delavay*. Further material shows the East Himalayan *A. subtriangulare*, *Hook.*, cannot be separated as a species.
 180*. *A. Atkinsoni*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 487 = *Athyrium Atkinsoni*, *Bedd.* Ferns Brit. Ind. Suppl. 11, t. 359. Himalayas; and var. *Andersoni*, Clarke, loc. cit. t. 57.
 184*. *A. mongolicum*, Franch. Pl. David. I, 351. China. Habit of *A. thelypteroides*, with indusium almost of a *Lastrea*.
 184*. *A. Henryi*, Baker, n. sp. Stipes long, naked, tufted, stramineous. Fronds oblong-lanceolate, bipinnate, moderately firm, glabrous, 1-2 ft. long. Pinnae sessile, lanceolate, the largest

- 6-8 in. long, $1\frac{1}{2}$ in. broad, cut down nearly to the rachis into oblong crenate secondary lobes $\frac{1}{8}$ in. broad. Veins 9-10-jugate in secondary lobes; veinlets forked. Sori medial, much curved. Indusium glabrous, persistent. West China; Hupeh and Patung, *Dr. A. Henry*. Near *A. thelypteroides*.
- 185*. **A. nephrodioides**, Baker, in Journ. Bot. 1887, 170. West China; Patung, *Dr. A. Henry*. Frond narrowed gradually from the middle to both ends. Indusium like that of a *Lastrea*.
- 189*. **A. Newtoni**, Baker, n. sp. Stipes long, tufted, stramineous or castaneous, with a few lanceolate paleae. Fronds oblong-lanceolate or subdeltoid, 2-3-pinnate, moderately firm, glabrous, 1- $1\frac{1}{2}$ ft. long, 8-12 in. broad. Many lower pinnae, subequal, oblong-lanceolate, 4-5 in. long, $1\frac{1}{2}$ -2 in. broad. Pinnules oblong-lanceolate; tertiary segments deeply crenate, $\frac{1}{8}$ - $\frac{1}{6}$ in. broad, with a cuneate base. Upper veins simple; lower forked. Sori round, medial. Indusium much curved, glabrous. Island of St. Thomas, West Tropical Africa, *Newton*. Very near the Indian *A. macrocarpum*, Blume.
190. **A. nigripes**, Blume. Beddome places as a variety **A. Clarkei**, Atkinson; Clarke, in Trans. Linn. Soc. ser. 2, I, 489. Eastern Himalayas.
- 192*. **A. Duthiei**, Beddome, in Journ. Bot. 1889, 72. Garwhal and Kumaon, *Duthie*.
193. **A. oxyphyllum**, Hook., var. *kulhaitense*, Atkins.; Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 494, is a form with the indusium obsolete.
- 194*. **A. Baldwinii**, Hilleb. Fl. Hawaii, 618. Sandwich Isles. Near *A. aspidioides*.
- 197*. **A. lastreoides**, Baker, in Journ. Bot. 1888, 227. China, Mount Omei, alt. 3500 feet, *Faber*, 1064.
- 198*. **A. umbrosum**, J. Sm., var. *crisovalense*, Baker, in Journ. Linn. Soc. XIV, 294, is a very compound variety allied to *assimile*. Beddome places as a variety of *australe* the Himalayan *A. bellum*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 496, plate 63, fig. 2.
- 199*. **A. oosorum**, Baker, in Journ. Bot. 1876, 343. Samoa, *Whitmee*. Near *A. woodwardioides* in sori, but frond much larger and more compound.

Subgenus **Diplazium**.

- 203*. **A. porphyrorachis**, Baker, in Journ. Bot. 1879, 40. Borneo, *Beccari, Burbidge*. **Polypodium subserratum**, Hook. Syn. Fil. 325, gathered by Wallace, is this plant in an immature sterile condition.
205. **A. pallidum**, Blume. I cannot separate **A. Prenticei**, Bailey, in Trans. Linn. Soc., N. S. Wales, IV, 37. Queensland.
- 205*. **A. chlorophyllum**, Baker, in Journ. Bot. 1885, 104. Formosa, *Hancock*, 97.
- 205*. **A. Harrisoni**, Baker, in Journ. Bot. 1884, 362. Costa Rica, *Harrison*.
- 205*. **A. aequibasale**, Baker, in Journ. Linn. Soc. XXII, 225. Sarawak, Borneo, *Bishop Hose*.
- 206*. **A. macrotis**, Baker, in Journ. Bot. 1884, 362. Costa Rica, *Harrison*.
- 208*. **A. verapax**, Donnell Smith, in Bot. Gaz. 1888, 77, t. 2. Guatemala. Very near *A. Riedelianum*, Bongard, of Brazil.
- 207*. **A. xiphophyllum**, Baker, in Journ. Bot. 1879, 40. Borneo, *Burbidge*.
- 209*. **A. leptorachis**, Baker, in Journ. Bot. 1890, 264. Tonquin, *Balansa*, 1833. Near *A. Seemannii*, Baker.
- 209*. **A. Pullingeri**, Baker, in Gard. Chron. 1874, 484. Hong-Kong, *Pullinger*. Cultivated at Kew. Near *A. Seemannii*.
- 210*. **A. Campbelli**, Jenman. Stipes tufted, naked, $\frac{1}{2}$ ft. long. Frond simply pinnate, deltoid, moderately firm, glabrous, $\frac{1}{2}$ ft. long and broad. Pinnae 3-5, lanceolate, 3-5 in. long, $1-1\frac{1}{4}$ in. broad at the middle, crenate, deltoid at the base, narrowed to the point. Veins ascending, forked. Sori $\frac{1}{2}-\frac{3}{4}$ in. long. Indusium narrow, glabrous. British and Dutch Guiana, *Jenman*. Near *A. bantamense*, Baker.
- 210*. **A. longisorum**, Baker, in Journ. Bot. 1881, 204. Antioquia, *Kalbreyer*, 1876. Near *A. bantamense*.
- 216*. **A. megaphyllum**, Baker, in Journ. Bot. 1890, 264. Tonquin, *Balansa*, 1836. Near *A. celtidifolium*.
- 216*. **A. mocennianum**, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 37. Andes of Ecuador, *Sodiro*. Between *A. celtidifolium* and *sylvaticum*.
- 217*. **A. Sammadii**, Kuhn, Reise Decken. Bot. 34. Niam-Niam Land, Central Africa, *Schweinfurth*, 3117. Near *A. syl-*

- vaticum*. Pinnae $1\frac{1}{2}$ -2 in. broad, shallowly lobed. Lobes sharply toothed. Veins few in a group.
- 219*. **A. sandwichense**, Hilleb. Fl. Hawaii, 610. Sandwich Islands. Near *A. arboreum*.
- 220*. **A. brevipes**, Baker, in Journ. Linn. Soc. XVI, 201. Central Madagascar, *Miss Helen Gilpin*. Near *A. Shepherdi*.
221. **A. semihastatum**, Kunze. Has lately been found in Porto Rico by Sintenis.
- 221*. **A. monticulum**, Jenm. in Journ. Bot. 1882, 326. Jamaica, *Sherring, Morris*, 250. Near *A. Mildei*.
- 226*. **A. fenzlianum**, Luers., in Flora 1875, 434. Sandwich Isles, *Wawra*. Near *A. sylvaticum* and *japonicum*.
- 226*. **A. marginale**, Hilleb. Fl. Hawaii, 613. Sandwich Isles. Near *A. fenzlianum*.
- 229*. **A. crenato-lobatum**, Baker, n. sp. Stipe brownish, naked, $\frac{1}{2}$ ft. long. Fronds lanceolate-deltoid, bipinnatifid, bright green, glabrous, $1\frac{1}{2}$ ft. long. Pinnae lanceolate, sessile, the largest $\frac{1}{2}$ ft. long, $\frac{3}{4}$ -1 in. broad, cut down to a narrow wing into oblong obtuse conspicuously, crenate lobes $\frac{1}{4}$ in. broad. Veins pinnate in the secondary lobes: veinlets simple, distant, ascending. Sori medial, the lowest diplazioid. Indusium glabrous. Sandwich Islands. Cultivated at Kew in 1879. Near *A. speciosum* and *sorzogonense*.
233. **A. sorzogonense**, Presl. I place as a variety **A. Stoliczkae**, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 500=*Diplazium Stoliczkae*, Beddome, Ferns Brit. Ind. Suppl. 13, t. 361. Himalayas.
- 233*. **A. crinitum**, Baker, in Journ. Linn. Soc. XXIV, 258=*A. sorzogonense*, var. *majus*, Hook. Further material received from the Bishop of Singapore and Sarawak shows that this is a distinct species.
- 235*. **A. laffianum**, Baker, in Gard. Chron. 1882, I, 73; Bot. Challenger, I, 84, t. 12. Bermuda. Near *A. crenulatum*. Cultivated at Kew in 1880.
- 235*. **A. diminutum**, Jenman, in Journ. Bot. 1881, 53. Jamaica. Like *A. Franconis* on a small scale.
- 236*. **A. Wheeleri**, Baker, n. sp. Stipe long. Frond membranous, deltoid, nearly tripinnate, $1\frac{1}{2}$ ft. long. Pinnae and pinnules lanceolate, the latter sessile, reaching $1\frac{1}{2}$ -2 in. long, $\frac{1}{2}$ - $\frac{5}{8}$ in.

- broad, cut away on the lower side at the base, cut down to a narrow wing into oblong tertiary segments $\frac{1}{8}$ – $\frac{1}{6}$ in. broad. Veins pinnate in the tertiary segments, the lowest veinlet forked, the rest simple. Sori oblong, medial, often diplazioid. Japan, *Wheeler*. Habit of *A. deltoideum*, Presl.
- 240*. **A. caryaefolium**, Baker, n. sp. Fronds ample, firm, bipinnate; rachises scaly. Lower pinnae oblong-lanceolate, above a foot long, 4–5 in. broad, with many free lanceolate nearly entire pinnules $\frac{1}{2}$ – $\frac{5}{8}$ in. broad. Veins usually forked. Sori linear, touching the midrib, not reaching the edge. New Granada, *Kalbreyer*, 985. Near *A. nervosum*, Mett.
- 243*. **A. Doderleinii**, Luers., in Engler Jahrb. 1883, 355. Liu-kiu Archipelago, Japan, *Doderlein*. Near *A. vestitum*, Presl.
- 243*. **A. polypodioides**, Mett. I place as a variety **A. sikkimense**, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 500, tab. 65, fig. 1. Sikkim.
249. **A. latifolium**, D. Don. Beddome places under this variable species **A. succulentum**, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 502, tab. 64, fig. 4, and **A. torrentium**, Clarke, loc. cit. p. 500, tab. 64, fig. 3 (excl. fig. 2, which is typical *latifolium*). *A. maximum*, Don, appears to be merely a form of the same species.
- 249*. **A. travancoricum**, Beddome, Ferns, Brit. Ind. 188, under *Diplazium*. Travancore Hills. Very large, with pinnae 2 ft. long.
251. **A. arborescens**, Mett. Much fresh material has been received. It has been sent from the Usagura Mountains by Sir John Kirk, and from the Island of St. Thomas, off the Guinea coast, by Professor Henriquez, and it now seems the Madagascar **A. madagascariense** and **A. nemorale**, Baker, in Journ. Linn. Soc. XV, 417, had better not be separated specifically.
- 253*. **A. amplissimum**, Baker, n. sp. Frond ample, tripinnatifid, moderately firm, bright green, glabrous; rachises brown-stramineous, naked, or sparsely fibrillose. Pinnae oblong-lanceolate, 1–1½ ft. long. Pinnules lanceolate, lower shortly petioled, 3–4 in. long, 1–1¼ in. broad, cut down to a narrow wing into oblong-lanceolate crenate tertiary segments. Veinlets 6–7-jugate, mostly forked. Sori oblong, reaching from the midrib

- half-way to the edge. Amboyna, *Challenger expedition*. Received from Professor Balfour. Near *A. Arnotti*, Baker, of the Sandwich Isles.
259. *A. radicans*, Schk. From this variable species I cannot clearly separate *A. hartianum*, Jenm. in Journ. Bot. 1886, 268, *A. altissimum*, Jenm. in Journ. Bot. 1879, 259, and *A. taylorianum*, Jenm. in Journ. Bot. 1886, 269, all three Jamaican.
- 261*. *A. zanzibaricum*, Baker, n. sp. Frond ample, membranous, glabrous, deltoid, 4-pinnatifid. Pinnae oblong-lanceolate, 2 ft. long, 9-10 in. broad. Pinnules oblong-lanceolate, cut down to the rachis into lanceolate deeply pinnatifid tertiary segments with oblong erecto-patent lobes. Veins pinnate in lower quaternary segments. Sori sausage-shaped, not more than $\frac{1}{16}$ - $\frac{1}{12}$ in. long, lower diplazioid. Indusium narrow, membranous. Zanzibar, *Last*.
- 261*. *A. brunneo-viride*, Jenm. in Journ. Bot. 1886, 269. Jamaica, *Morris*, 264, *Sherring*. Near *A. sandwichianum*. Mett.
- 261*. *A. Huttoni*, Baker, n. sp. Fronds ample, deltoid, decom-
pound, moderately firm, glabrous. Pinnae oblong-lanceolate, a foot or more long. Pinnules lanceolate; tertiary segments oblong, obtuse, $\frac{1}{6}$ in. broad, deeply pinnatifid; quaternary lobes oblong, obtuse. Veins pinnate in the quaternary lobes; veinlets ascending, simple. Sori medial, reach $\frac{1}{12}$ in. long. Indusium firm, glabrous, persistent. Malay Isles, *Hutton*. Received from Messrs. Veitch. Near *A. sandwichianum*, Mett.

Subgenus *Anisogonium*.

- 264*. *A. Virchowii*, Kuhn, in Hildeb. Pl. Madag. Exsic. No. 4168. South Betsileo Land, Madagascar, *Hildebrand*. Frond simple, lanceolate.
- 264*. *A. Corderoi*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 39. Andes of Ecuador, *Sodiro*. Frond lanceolate, simple or simply pinnate. Pinnae oblong.
- 266*. *A. cardiophyllum*, Baker; *Micropodium cardiophyllum*, Hance, in Journ. Bot. 1883, 268. Rhizome slender, wide-creeping, naked. Stipe slender, naked, castaneous, 7-8 in. long, arti-

- culated at the base. Frond simple, cordate-ovate, membranous, 4-5 in. long; basal lobes orbicular, an inch broad; costa ebeneous. Veins immersed, anastomosing towards the margin of the frond. Sori ascending, medial, irregular, at most an inch long, all single. Hainan, Formosa, *B. C. Henry*.
- 268*. *A. Forbesii*, Baker, n. sp. Rootstock not seen. Stipe naked, 5-6 in. long. Frond deltoid, simply pinnate, a foot long, glabrous, moderately firm. Pinnæ 3-jugate, lanceolate-acuminate, entire, sessile, $\frac{1}{2}$ ft. long, 2-2 $\frac{1}{2}$ in. broad, cordate at the base. Veins 3-5-jugate, anastomosing towards the margin of the frond. Sori linear. Java: Province of Bantam, *H. O. Forbes*, 459. Near *A. lineolatum*, Mett.
- 271*. *A. macrodictyon*, Baker, in Journ. Bot. 1877, 193. Andes of Quito, *Sodi*ro.
- 271*. *A. hemionitideum*, Baker, in Journ. Bot. 1877, 163. Andes of Ecuador, *Sodi*ro.
- 273*. *A. fuscum*, Baker; *A. fuliginosum*, *Sodi*ro, Recens. Crypt. Vasc. Prov. Quit. 40, non Hook. Andes of Ecuador, *Sodi*ro.
- 274*. *A. esculentum*, Presl. Further material shows that *A. vitiense*, Baker, is a form of this species, and I cannot from the description separate *A. dietrichianum*, Luer, in Mus. Godef. V, 16. Queensland.
- 275*. *A. platyphyllum*, Baker, in Journ. Bot. 1890, 264. Tonquin, *Balansa*, 1847.

Genus 41. SCOLOPENDRIUM, *Smith*.

- 1*. *S. Delavayi*, Franchet, in Bull. Soc. Bot. France, XXXII, 29; Clarke, in Journ. Linn. Soc. XXV, t. 41. Yunnan, *Delavay*. Manipur, *Watt, Clarke*. Frond small, orbicular; midrib none; veins free.
- 5*. *S. Balansae*, Baker, in Hook. Ic. t. 1653. Paraguay, *Balansa*, 2885.

Genus 41*. DIPLORA, *Baker*.

- D. integrifolia*, Baker, Solomon Isles, is figured Hook. Ic. t. 1651.

Genus 41*. TRIPHLEBIA, Baker.

Differs from *Scolopendrium* and agrees with *Diplora* in having a prominent receptacle running down the centre of the sorus. Here it arises from a sort of adventitious vein, not always produced beyond the sorus, but in *Diplora* the receptacle runs along the proper vein, and the two valves of the indusium do not spring from veins.

Four species are known, as follows:—

1. **T. pinnata**, Baker, in Malesia, III, 41: Hook. Ic. t. 1652 = *Scolopendrium pinnatum*, J. Sm. Philippines, *Cuming*, 137, 311.
2. **T. longifolia**, Baker, l. c. = *Scolopendrium longifolium*, Presl. Rel. Haenk. I, 48, t. 9, fig. 1. Philippines, *Haenke*. Sarawak, Borneo, *Dr. Hose*.
3. **T. Linza**, Baker, in Malesia, III, 42, t. 5 = *Asplenium Linza* Cesati, Fil. Bec. Polyn. 4. New Guinea, *Beccari*.
4. **T. dimorphophylla**, Baker, in Malesia, III, 42, t. 4 = *Asplenium subserratum*, Cesati, non Blume. Island of Andai, North of New Guinea, *Beccari*.

Asplenium scolopendropsis, F. M. Notes, Papuan plants III, 49, gathered in New Guinea by D'Albertis, probably also belongs to *Triphlebia* and may be identical with *T. Linza*.

Genus 43. ASPIDIUM, Sw.

Subgenus Polystichum.

- 3*. **A. basipinnatum**, Baker, in Journ. Bot. 1889, 176. China; Kwantung Province, *Ford*, 103.
- 5*. **A. xiphophyllum**, Baker, in Journ. Bot. 1888, 227. China; Mount Omei, alt. 5000 feet, *Faber*, 1040. Near *A. munitum* and *falcinellum*.
- 5*. **A. auritum**, Baker; *Phanerophlebia aurita*, Fée. Fil. Bras. Suppl. 70, tab. 100, fig. 1. Rio Janeiro, *Glaziou*, 4431.
- 6*. **A. Macleaii**, Baker, in Hook. Ic. tab. 1654. Drakensbergen, Transvaal, *McLea*, *Ayres*.
- 9*. **A. otophorum**, Franchet, Pl. David. II, 154. Moupine, Tibet, *Father David*. Between *A. Lonchitis* and *auriculatum*.
- 11*. **A. Atkinsoni**, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 506; *Polystichum Atkinsoni*, Beddome, Ferns Brit. Ind. tab. 362. Bhotan and Sikkim.

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12. *A. triangulum*, Sw. I place as a variety *A. caudatum*, Jenm. in Journ. Bot. 1879, 260. Jamaica, *Jenman*.
13. *A. auriculatum*, Sw., vars. *submarginale* and *stenophyllum*, Baker, in Journ. Bot. 1888, 227. China, *Faber* and *Ford*.
- 13*. *A. deltodon*, Baker, in Gard. Chron., n. s., XIV, 494. Ichang gorge, Central China, *Maries*.
- 13*. *A. lanceolatum*, Baker, in Gard. Chron., n. s., XIV, 494. China. This and the last are nearly allied to *A. auriculatum*.
- 14*. *A. acanthophyllum*, Franchet, in Bull. Soc. Bot. France, 1885, 28. Yunnan, *Delavay*. Nearly allied to *A. ilicifolium*.
- 14*. *A. phaeostigma*, Cesati, Fil. Becc. Polyn. 7. New Guinea, *Beccari*. Habit and texture of *Nephrodium crassifolium*, but indusium distinctly peltate.
18. *A. aculeatum*, Sw. I should now reduce as varieties of this species 21. *A. obtusum*, Mett., and 22. *A. californicum*, Eaton.
20. *A. mohrioides*, Bory. Has been found in California by Lemmon and Pringle, and in the Falkland and Auckland Isles, and also in the Antarctic Island of Amsterdam.
23. *A. Richardi*, Hook. *A. oculatum*, Hook, is evidently a mere variety.
- 26*. *A. moupinense*, Franchet, Pl. David. 153. Moupine, Tibet, *Father David*. Near *A. prescottianum*, Hook.
- 26*. *A. bakerianum*, Atkinson; Baker, in Hook. Ic. tab. 1656. Himalayas. Placed by Beddome as a variety of *A. prescottianum*.
- 26*. *A. capillipes*, Baker, in Journ. Bot. 1888, 228. West China, Mount Omei, *Faber*, 1086.
- 29*. *A. Hancockii*, Baker; *A. reductum*, Baker, in Journ. Bot. 1888, 105; *Philopteris Hancockii*, Hance, in Journ. Bot. 1884, 139. Tamsui, Formosa, *Hancock*, 41. Very near *A. tripterum*, Kunze.
30. *A. laserpitiiifolium*, Mett. I cannot separate *A. festinum*, Hance, in Journ. Bot. 1883, 269, found near Canton by *Faber*. This species has also been found in Tonquin by *Balansa*.
31. *A. maximowiczianum*, Miquel, Prolus. 343. Japan, *Maximowicz*, *Dickins*. Intermediate between *aculeatum* and *aristatum*.

35. *A. ascendens*, Sw. Here belongs *Nephrodium duale*, Donnell Smith, in Amer. Bot. Gaz. 1890, 29, tab. 4, gathered in Guatemala by Baron von Turckheim.
37. *A. aristatum*, Sw. I place as a variety *A. exile*, Hance, in Journ. Bot. 1883, 268, gathered in Che-Kiang, by Stonach.
40. *A. multifidum*, Mett. I cannot separate specifically *Polystichum Pearcei*, Philippi, in Linnaea, XXXIII, 805, gathered in Chili by Pearce.
41. *A. sikkimense*, Baker = *Nephrodium sikkimense*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 52. Distributed also as *Lastrea bella*, Clarke. Like *A. varium*, this stands on the line between *Aspidium* and *Nephrodium*, which I should not in a new book keep up as genera.
- 42*. *A. caruifolium*, Baker, in Journ. Bot. 1888, 228. Mount Omei, China, alt. 3000-3500 ft., *Faber*, 1027.
- 42*. *A. Wattii*, Beddome, in Journ. Bot. 1888, 231. Manipur, *Watt*, 6715.

Subgenus *Cyrtomium*.

- 46*. *A. Boydiae*, Eaton, in Bullet. Torrey Club, 1879, 359. Hawaii, *Baldwin*.

Subgenus *Euaspidium*.

- 51*. *A. Murrayi*, Baker, n. sp. Stipe naked, stramineous. Fronds deltoid, membranous, glabrous, a foot long, with a shallowly pinnatifid oblong-cuneate end-segment and two pairs of sessile pinnae, the lowest produced on the lower side and deeply lobed towards the base. Main veins parallel, arcuate, $\frac{1}{2}$ in. apart, with copious hexagonal areolae between them, with free included veinlets. Sori small, copious, scattered irregularly. Indusium peltate, persistent, glabrous. St. Lucia, *H. B. Murray*.
- 52*. *A. trilobum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 41. Andes of Ecuador.
- 53*. *A. beccarianum*, Baker, in Malesia, III, 43; *A. calcareum*, Cesati, Fil. Polyn. Becc. 4, non Presl. Island of Andai, off the coast of New Guinea, *Beccari*.
- 53*. *A. subrepandum*, Baker, n. sp. *A. repandum*, Sodiro, Recens. 42, non Willd. Stipes tufted, naked, above a foot long. Fronds oblong-lanceolate, membranous, glabrous, simply pinnate, above a foot long; apex pinnatifid. Pinnae 3-4-jugate,

lowest the largest, produced on the lower side, the others lanceolate acuminate, sessile, 6–8 in. long, an inch broad at the middle. Main veins fine, erecto-patent, under $\frac{1}{4}$ in. apart, with copious hexagonal areolae between them. Sori in two rows near the main veins, 3–4 in a row. Indusium large, peltate, persistent. Andes of Ecuador, *Sodiro*.

Genus 44. NEPHRODIUM, *Rich.*Subgenus *Lastrea*.

- 4*. **N. brachypodium**, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 290. Roraima, *in Thurn*.
- 4*. **N. longicaule**, Baker, in Journ. Bot. 1881, 204; Hook. Ic. tab. 1658. Antioquia, New Granada, *Kalbreyer*, 1454.
- 6*. **N. Dickinsii**, Baker; *Aspidium Dickinsii*, Franch. et Savat. Enum. Jap. II, 236, 639. Japan and China.
- 6*. **N. Faberi**, Baker, n. sp. Stipe stramineous, 6–8 in. long, clothed up to the top with ovate brown membranous paleae. Frond oblong-lanceolate, simply pinnate, moderately firm, $\frac{1}{2}$ ft. long, 3 in. broad, scattered over with scales beneath; rachis paleaceous. Lower pinnae longest, lanceolate, sessile, $\frac{1}{4}$ – $\frac{1}{3}$ in. broad, auricled on the upper side at the base, rounded on the lower side. Veins obscure. Sori principally in two rows near the midribs of the pinnae. Indusium small, evanescent. Ningpo, China, *Faber*, 205. Near *N. decipiens* and *Dickinsii*.
- 6*. **N. parallelum**, Baker, in Journ. Linn. Soc. XV, 417. Central Madagascar, *Pool, Kitching*.
- 7*. **N. Sheareri**, Baker, in Journ. Bot. 1875, 200; *N. isolatum*, Baker, in Gard. Chron., n. s., XIV, 494. Kiu-Kiang, China, *Shearer, Mariès*; Ningpo, *Hancock*.
- 8*. **N. enneaphyllum**, Baker, n. sp. Stipe 8–9 in. long, densely scaly at the base; paleae lanceolate, bright brown. Frond deltoid, simply pinnate, moderately firm, glabrous, 8–9 in. long and broad. Pinnae about 9, lanceolate, petioled, truncate at the base, crenate, the lowest the largest, 4 in. long, an inch broad. Veins in pinnate groups, free; veinlets 3–4-jugate, ascending. Sori small, almost restricted to the central half of the pinnae. Ichang, China, *Henry*, 3217. Between *N. podophyllum* and *Sieboldii*.

10. **N. hirtipes**, Hook. Found in China by Hancock, and Samoa by Whitmee. **Polypodium Scottii**, Beddome, Ferns Brit. Ind. t. 345, appears to be a form without indusium.
- 10*. **N. trichophlebium**, Baker, in Journ. Linn. Soc. XVI, 201. Central Madagascar, *Mrs. Pool*.
- 10*. **N. fibrillosum**, Baker, in Journ. Linn. Soc. XV, 418. Central Madagascar, *Pool*.
- 15*. **N. semilunatum**, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 46. Andes of Ecuador. Near *N. insigne*, Baker.
16. **N. gracilescens**, Hook. Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 514, describes three Himalayan varieties, *decipiens*, *hirsutipes*, *didymochlenoides*. I have not seen **Aspidium laxum**, Franch. et Savat. Enum. Jap. II, 237.
- 16*. **N. Humblotii**, Baker, in Bull. Linn. Soc. Paris, 534. Comoro Isles, *Humblot*, 274. Allied to *N. albo-punctatum* and *subbiauratum*.
- 16*. **N. mongolicum**, Baker. *Aspidium mongolicum*, Franchet, in David, Exsic. No. 2273. South Mongolia, *Father David*.
- 16*. **N. ochrorachis**, Baker, in Journ. Bot. 1854, 142. North-east Madagascar, *Humblot*, 272.
- 17*. **N. Fournieri**, Baker. *Aspidium flaccidum*, Fourn. in Bull. Soc. Bot. France, 1880, 328. Mexico.
- 17*. **N. pubirachis**, Baker, in Journ. Bot. 1876, 344. Samoa, *Whitmee*.
- 17*. **N. Holmei**, Baker, n. sp. Rootstock not seen. Stipe $\frac{1}{2}$ ft. long, substramineous, glabrous, naked. Frond oblong-lanceolate, bipinnatifid, membranous, a foot long, densely pilose on the rachis, and main ribs; rachis not scaly. Pinnae lanceolate, sessile, the largest 3 in. long, $\frac{3}{4}$ in. broad, cut down nearly to the rachis into entire oblong segments $\frac{1}{8}$ – $\frac{1}{6}$ in. broad; lower pinnae reduced at the base. Veins very distinct, 8–9-jugate, simple. Sori few, medial. Indusium minute hispid, fugacious. Montserrat, *Rev. H. R. Holme*.
- 17*. **N. borbonicum**, Baker, n. sp. Rootstock not seen. Pinnae naked, 4–5 in. long, brown at the base, stramineous above it. Frond oblong-deltoid, bipinnate, $\frac{1}{2}$ ft. long, thick, with a few small bullate scales on the under surface. Pinnae lanceolate, sessile or shortly petioled, the lowest not reduced, $1\frac{1}{2}$ –2 in. long, $\frac{5}{8}$ – $\frac{3}{4}$ in. broad; segments entire, $\frac{1}{12}$ in. broad; lowest

- sometimes slightly compound. Veinlets simple, erecto-patent, 8-10-jugate. Sori small, supramedial. Indusium minute, fugacious. Bourbon, *Delisle*, 331.
- 17*. **N. savaiense**, Baker, n. sp. Rootstock rather creeping; paleae linear, brown. Stipe 6-9 in. long, naked, pilose. Frond oblong-lanceolate, bipinnatifid, subcoriaceous, 12-15 in. long, 8-9 in. broad, pilose on the rachis and under surface. Pinnae lanceolate, sessile, cut down to the rachis into oblong lobes $\frac{1}{8}$ in. broad. Veinlets simple, 10-12-jugate. Sori basal, minute. Indusium fugacious, densely bristly. Samoa, *Powell*, 183.
- 19*. **N. tibeticum**, Baker. *Aspidium tibeticum*, Franch. Pl. David. II, 156. Moupine, Tibet, *Father David*. Near *N. patens*.
- 19*. **N. Turckheimii**, Donnell Smith, in Bot. Gaz. 1887, 133, tab. 11. Guatemala, *Baron von Turckheim*, 714.
- 22*. **N. paucijugum**, Jenm. in Journ. Bot. 1886, 270. Jamaica, *Sherring*. Near *N. Sloanei*.
- 26*. **N. japonicum**, Baker, n. sp. Stipe subcastaneous, $\frac{1}{2}$ -ft. long. Frond lanceolate, deltoid, bipinnatifid, membranous, finely downy, 12-15 in. long, 9-10 in. broad; rachis castaneo-stramineous, downy, not scaly. Pinnae lanceolate, sessile, acuminate, the lowest the largest, 4-5 in. long, $\frac{3}{4}$ in. broad, cut down to a narrow wing into obtuse subentire lobes 1-1 $\frac{1}{2}$ in. broad. Veinlets simple, 8-9-jugate. Sori supra-medial. Indusium large, membranous. Nagasaki, Japan, *Capt. Blomfield*.
28. **N. albo-punctatum**, Desv. Oldest name is *Polypodium pectinatum*, Forsk.
- 28*. **N. zambesiacum**, Baker, n. sp. Stipe not seen complete. Frond large, bipinnate, slightly hairy. Lower pinnae lanceolate, a foot long, 1 $\frac{1}{4}$ in. broad, cut down to the rachis into entire acute lanceolate segments $\frac{1}{2}$ in. broad. Veinlets simple, 14-15-jugate. Sori medial. Indusium fugacious, membranous, glabrous. Zambesi Highlands, *Buchanan*.
- 29*. **N. lepidum**, Baker. *Lastrea lepida*, Moore, in Gard. Chron., n. s. XXVI, 681. Polynesia, *Hort. Henderson*. Very near the Vitian *N. Prenticei*.
- 29*. **N. Sangnellii**, Herb. Moore. Stipe long, naked, with a few

- brown basal paleae. Frond oblong-deltoid, moderately firm, hairy on the main ribs beneath, above a foot long, a foot broad; rachis naked, stramineous. Pinnae lanceolate, 5-6 in. long, $\frac{1}{2}$ - $\frac{5}{8}$ in. broad, cut down to a narrow wing into obtuse segments $\frac{1}{2}$ in. broad; lower pinnae rather reduced. Veinlets 8-9-jugate, simple. Sori medial. Indusium small, membranous. New Caledonia, *Hort. Birkenhead*. Near *N. calcaratum*, Hook.
- 35*. *N. valdepilosum*, Baker, in Journ. Bot. 1888, 204. New Granada, Antioquia, *Kalbreyer*, 1347, 1871.
33. *N. crinitum*, Desv., var. *exaggeratum*, Baker. Fronds deltoid, free lanceolate pinnules reach an inch long, obtusely lobed. Veins subpinnate in the lower lobes. Sori 2-4 to a lobe. Central Madagascar, *Pool*. Bears same relation to type that *elongatum* bears to *Filix-mas*.
- 36*. *N. regulare*, Baker, in Journ. Bot. 1875, 200. China, Province of Kiu-Kiang, *Dr. Shearer*.
- 40*. *N. Buckholzii*, Baker; *Aspidium Buckholzii*, Kuhn, Reise Decken. Bot. 47. Cameroon Mountains, *Buckholz*. Habit of *Polypodium cyatheaefolium*.
- 40*. *N. beccarianum*, Cesati, Fil. Bec. Born. 23. Sarawak, Borneo, *Beccari*.
- 40*. *N. Luersseni*, Harringt. in Journ. Linn. Soc. XVI, 29. Buluku Island, Philippines, *Steere*.
- 41*. *N. polytrichum*, Baker, in Journ. Bot. 1891, 107. West Borneo, Sarawak, *Dr. Hose*. A fine large plant, near *N. crassifolium* and *Leprieurei*.
44. *N. sanctum*, Baker, Andes of Quito, *Sodiro*. Var. *magnum*, Jenm., in Journ. Bot. 1886, 290, connects the type with *N. conterminum*.
- 45*. *N. Sewellii*, Baker, in Journ. Linn. Soc. XV, 418. Central Madagascar, *Pool*.
- 45*. *N. anateinophlebium*, Baker, in Journ. Linn. Soc. XVI, 202. Central Madagascar, *Miss Helen Gilpin*.
47. *N. Beddomei*, Baker. Lately found in the Philippines by Micholitz, in China by Dr. Henry, and in Moupin, Tibet, by Father David.
- 47*. *N. perakense*, Beddome, in Journ. Bot. 1888, 4. Perak, *Day*. Near *N. Beddomei*.

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- 48*. *N. nevadense*, Baker; *Aspidium nevadense*, Eaton, Ferns North Amer. 73, tab. 10. California, on the Sierra Nevada.
49. *N. conterminum*, Desv. Under this very variable species fall *N. brachypus*, *amphoxypteris*, *lasiopteris*, *stenophyllum*, and *stramineum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. p. 43-51, from the Andes of Ecuador and the Jamaican *N. caribaeum* and *nockianum*, Jenm. in Journ. Bot. 1886, 270.
- 49*. *N. simulans*, Baker, in Journ. Bot. 1890, 106. Mount Knutsford, New Guinea, *Sir W. Macgregor*. Very near *N. conterminum*.
- 49*. *N. fasciculatum*, Baker; *Aspidium fasciculatum*, Fourn. in Ann. Sc. Nat. ser. 5, XVIII, 295. New Caledonia, *Balansa*, 1611, 3568. Not seen.
- 49*. *N. Seemanni*, Baker, n. sp. Rootstock not seen. Stipe short, naked. Frond oblong-lanceolate, bipinnatifid, 2-2½ ft. long, 8-9 in. broad, moderately firm, slightly hairy; rachis naked. Pinnae very numerous, sessile, lanceolate, acuminate, ½ in. broad, cut down nearly or quite to the rachis into entire segments, ⅓ in. broad; lower pinnae reduced. Veinlets, 5-6-jugate, simple, erecto-patent. Sori supra-medial. Indusium firm, glabrous, persistent. Oahu, *Seemann*. Very near *N. conterminum*.
- 49*. *N. firmum*, Baker; Jenm. in Journ. Bot. 1879, 260. Jamaica, *Jenman*.
52. *N. Sprengelii*, Hook. *N. Sherringii*, Jenm. in Journ. Bot. 1879, 261, is, I think, a variety of this species.
- 52*. *N. conforme*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 45. Andes of Ecuador, *Sodiro*, type and var. *strigillosum*. Near *N. Sprengelii*.
- 53*. *N. polylepis*, Baker; *Aspidium polylepis*, Franch. et Savat. Enum. Jap. II, 236, 631. Japan, *Savatier*, *Dickins*. Allied to *N. conterminum* and *prolixum*. Distinguished by its few veins and scaly rachis and lamina.
- 53*. *N. longicuspe*, Baker, in Journ. Linn. Soc. XVI, 202. Central Madagascar, *Miss Helen Gilpin*. Near *N. prolixum*.
- 55*. *N. retrorsum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 51. Andes of Ecuador, *Sodiro*.

- 55*. *N. atomiferum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 48. Andes of Ecuador, *Sodiro*.
- 55*. *N. Canadasii*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 48. Andes of Ecuador, *Sodiro*.
- 55*. *N. macradenium*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 48. Andes of Ecuador, *Sodiro*. This and the three last are allied to *N. resinofetidum* and *Sprucei*.
- 57*. *N. subjunctum*, Baker, n. sp. Rootstock decumbent. Stipe naked, 5-6 in. long. Frond membranous, oblong-lanceolate, bipinnate, 2½-3 ft. long, 8-12 in. broad at the middle, narrowed to the base, finely pilose beneath, principally on the midrib of the pinnae; rachis pilose. Pinnae lanceolate, sessile, the largest 6-8 in. long, ½-⅝ in. broad, cut down nearly to the midrib into linear-oblong entire lobes ½-⅓ in. broad. Veinlets simple, 8-10-jugate. Sori sub-marginal. Samoa, *Powell*, 248. Habit of *N. sophoroides*, but veins free.
- 62*. *N. carazunense*, Baker, in Journ. Bot. 1877, 163. Andes of Ecuador, *Sodiro*.
- 63*. *N. Jenmani*, Baker, in Journ. Bot. 1877, 263. Jamaica, alt. 4000-5000 ft., and found lately in St. Vincent, by Messrs. H. H. and G. W. Smith, whilst collecting for Mr. F. D. Godman.
- 66*. *N. Wilsoni*, Baker, n. sp. Rootstock not seen. Frond oblong-lanceolate, nearly bipinnate, 1½ ft. long, ½ ft. broad, pubescent beneath; rachis nearly black, finely pubescent. Pinnae lanceolate, sessile, 3 in. long, cut down nearly to the midrib, with entire or crenate segments ⅓ in. broad; lower pinnae not reduced. Veins 8-9-jugate, often forked. Sori sub-marginal. Indusium large, reniform, persistent. Uganda, Tropical Africa, *Rev. C. T. Wilson*. Habit of least compound forms of *Polypodium distans*.
- 66*. *N. Macarthyi*, Baker; *N. puberulum*, Baker, in Journ. Bot. 1875, 201, non Syn. Fil. edit. 2, 495. Central China, *Dr. Shearer, Macarthy*.
68. *N. apiciflorum*, Hook., is now placed by Beddome as a variety of *Filix-mas*, with which it is connected by var. *Nidus*, Clarke: Hook. et Baker, Syn. Fil. edit. 2, 498.
- 70*. *N. unifurcatum*, Baker, in Journ. Bot. 1888, 228. Mount Omci, China, alt. 3500 ft., *Faber*, 1051.

- 70*. *N. singalanense*, Baker, in Journ. Bot. 1880, 212. Mount Singalan, Sumatra, alt. 5000–6000 ft., *Beccari*, 471.
- 71*. *N. Dayi*, Beddome, in Journ. Bot. 1887, 323. Perak, *Scortechini*, *Day*.
- 73*. *N. chontalense*, Baker, *Aspidium chontalense*, Fourn. in Bull. Soc. Bot. Paris, XIX, 254. Chontales, *Levy*, 516. Not seen.
73. *N. Filix-mas*, Rich. *N. cochleatum*, D. Don, which is kept up as a species by Clarke in Trans. Linn. Soc. ser. 2, Bot. I, 521, is placed again under *Filix-mas* by Beddome. I cannot separate specifically the Chinese *Aspidium oxyodon*, Franch. Pl. David. I, 353, the Hawaiian *A. hawaiense*, Hilleb. Fl. Hawaii, p. 575, and now think *N. antarcticum*, Baker, in Journ. Linn. Soc. XIV, 479, from Amsterdam Island, had better be placed here.
- 73*. *N. Mannii*, Hope, in Journ. Bot. 1890, 145. Assam, *Mann*. Allied to the compound forms of *N. Filix-mas*, but rachis densely paleaceous.
- 73*. *N. subtriangulare*, Hope, in Journ. Bot. 1890, 327. Assam, *Mann*. Not seen.
77. *N. lacerum*, Baker. Chefoo, *Hancock*. Both *lacerum* and *erythrosorum* are, in a broad sense, only varieties of *Filix-mas*.
78. *N. erythrosorum*, Hook. *Aspidium prolificum*, Maxim., which has been introduced into cultivation, is a monstrous form of this species.
- 83*. *N. fragile*, Baker; *Polypodium fragile*, Baker, in Journ. Linn. Soc. XVI, 203. Central Madagascar, *Miss Helen Gilpin*. Further material shows that this has a reniform indusium.
- 83*. *N. assamense*, Hope, in Journ. Bot. 1890, 326. Assam, *Mann*. Habit of *Asplenium (Athyrium) nigripes*. Not seen.
89. *N. fragrans*, Rich., has been found by Maries in Japan.
- 91*. *N. coriaceum*, Hope, in Journ. Bot. 1890, 328. Assam, *Mann*. Texture and cutting of a small form of *Pteris aquilina*. Not seen.
- 92*. *N. bissetianum*, Baker, in Journ. Bot. 1877, 366. Japan, *Bisset*. Cutting of *N. spinulosum*. Remarkable for its copious peculiar paleae.
- 93*. *N. xanthotrichium*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 52. Andes of Ecuador, *Sodiro*.

- 93*. *N. tricholepis*, Baker, in Hemsl. Biol. Cent. Amer. Bot. III, 651. Guatemala.
94. *N. sparsum*, Don. I cannot separate specifically *Aspidium pellucidum*, Franchet, Pl. David, II, 157. Moupine, Tibet, *David*.
101. *N. Falconeri*, Hook. Further material shows this is a more compound variety of *N. barbigerum*.
- 103*. *N. Layardi*, Baker, n. sp. Caudex erect. Stipes densely tufted, naked, a foot long. Frond deltoid, tripinnate, a foot long, membranous, glabrous; rachis naked. Lower pinnae the largest, deltoid, unequal-sided, all cuneate-truncate on the lower side at the base. Largest pinnules oblong, sessile, obtuse, crenate, $\frac{1}{4}$ - $\frac{1}{3}$ in. broad. Upper veinlets of tertiary segments simple; lower forked. Sori small, medial. Indusium minute. Polynesia, probably Fiji, *Layard*. Near *N. hirtum* and *chinense*.
105. *N. chinense*, Baker; *Aspidium Forbesii*, Hance, in Journ. Bot. 1875, 198, cannot be separated.
- 105*. *N. gymnophyllum*, Baker, in Journ. Bot. 1887, 170. Nanto, China, *Dr. Henry*. Between *N. chinense* and *sparsum*.
117. *N. odoratum*, Baker = *N. crenatum*, Baker, Fl. Maurit. 497, its oldest name being *Polypodium crenatum*, Forsk.
- 117*. *N. Fordii*, Baker, in Journ. Bot. 1889, 177. Kwantung, China, *Ford*, 104. Very near *N. crenatum*.
- 118*. *N. Hendersoni*, Baker, n. sp. Stipe pubescent, 4-5 in. long. Frond deltoid, tripinnate, 5-6 in. long, very hairy, especially on the rachis and midrib of the pinnae beneath. Lowest pinnae the largest, much produced on the lower side, the rest lanceolate and simply pinnate, their pinnules oblong-rhomboid, obtuse, $\frac{1}{4}$ in. broad, the lower inciso-crenate. Veinlets distant, distinct, erecto-patent. Sori small, medial. Indusium minute, fugacious. Fernando Po, *Henderson*. Near *pubescens* and the small forms of *subquinquefidum*.
123. *N. decompositum*, R. Br. Kirk wishes to separate as a species the New Zealand *N. pentangularum*, Colenso, which has a creeping rhizome. It is figured and described under the name of *decompositum* by Field, Ferns New Zeal. 131, tab. 5, fig. 7.
126. *N. dissectum*, Desv. Clarke separates as a species in Trans.

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- Linn. Soc. ser. 2, Bot. I, 526, tab. 73, *N. ingens* of Atkinson, which Beddome still regards as a variety of *dissectum*.
128. *N. splendens*, Hook. West China, *Dr. Henry*.
131. *N. scabrosum*, Baker. A plant gathered by Mann, in Assam, is close to this, but evidently distinct specifically.
- 131*. *N. Lastii*, Baker. Rootstock and stipe not seen. Frond ample, deltoid, decompound, glabrous; rachis naked, stramineous. Lower pinnae oblong-lanceolate, a foot long; pinnules lanceolate; tertiary segments oblong, obtuse, $\frac{1}{6}$ – $\frac{1}{4}$ in. broad, cut down to the rachis into contiguous oblong quaternary lobes, toothed on the outer edge. Veins pinnate in the quaternary lobes. Sori costular. Indusium firm, glabrous, persistent. Namuli Mukua Country, South-east Tropical Africa, *J. T. Last*. Near *N. scabrosum*.
- 131*. *N. sarawakense*, Baker, in Journ. Linn. Soc. XXII, 225. Sarawak, Borneo, *Bishop Hose*.
- 131*. *N. aciculatum*, Baker, in Journ. Linn. Soc. XXII, 226. Sarawak, Borneo, *Bishop Hose*.
- 131*. *N. spectabile*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 526, non Hook. = *Lastrea Hendersoni*, Bedd. Ferns Brit. Ind. t. 377. Khasia and Nepal.
- 134*. *N. intermedium*, Baker. I cannot separate specifically *N. rhodolepis*. Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 526. Himalayas.
- 134*. *N. leucostipes*, Baker, in Journ. Bot. 1885, 105. Formosa, *Hancock*.
- 137*. *N. oligophlebium*, Baker, n. sp. Stipe slender, naked, stramineous. Frond lanceolate-deltoid, tripinnatifid, $1\frac{1}{2}$ ft. long, membranous, glabrous. Several lower pinnae opposite, subequal, oblong-lanceolate, 4–5 in. long; pinnules sessile, lanceolate, the lower cut down to a narrow wing into contiguous lobes $\frac{1}{2}$ in. broad. Veins pinnate in the ultimate segments, with simple distant 3-jugate veinlets. Sori submarginal, very small. Indusium glabrous, fugacious. Kiangsu, China, *Quekett*. Near *N. setigerum*.
- 138*. *N. obovatum*, Baker, in Journ. Bot. 1890, 265. Tonquin, *Balansa*, 1815.
- 139*. *N. multisetosum*, Baker, in Journ. Linn. Soc. XXII, 226. Sarawak, Borneo, *Bishop Hose*. Habit of *Polypodium ornatum*, Wall.

- 141*. *N. megaphyllum*, Baker, in Journ. Linn. Soc. XXII, 227. Sarawak, Borneo, *Bishop Hose*.
- 142*. *N. myriolepis*, Baker, in Journ. Bot. 1888, 34. St. Domingo, *Baron Eggers*, 1575. Near *N. amplum*.
- 145*. *N. setulosum*, Baker, in Journ. Bot. 1890, 265. Tonquin, *Balansa*, 1856. Habit of *N. villosum*.
146. *N. arborescens*, Baker. I had much correspondence with the late Rev. T. Powell about this plant, and finally he came to the conclusion that he had made a mistake in reporting it as arborescent. I propose therefore to drop the name and keep up two nearly-allied Samoan species, as follows.
- 146*. *N. Powellii*, Baker, n. sp. Caudex erect. Stipes tufted, densely clothed with linear paleae, of which the lower are $1\frac{1}{2}$ in. long. Frond deltoid, decomposed, firm, glabrous, $2\frac{1}{2}$ -3 ft. long. Lower pinnae the largest, deltoid, a foot long. Pinnales oblong-lanceolate; tertiary segments lanceolate, deeply pinnatifid, cuneate-truncate on the lower side at the base; lobes obtuse. Veins pinnate in the quaternary lobes; veinlets simple, erecto-patent. Sori medial. Indusium firm, glabrous, persistent. Samoa, *Powell*, 245.
- 146*. *N. ludens*, Baker, n. sp. Rootstock decumbent. Stipes 1-2 ft. long: basal paleae linear, the lowest $1-1\frac{1}{4}$ in. long. Fronds oblong-deltoid, decomposed, moderately firm, glabrous, 4-4 $\frac{1}{2}$ ft. long. Pinnae deltoid; quaternary segments oblong, crenate. Veins pinnate in the quaternary lobes. Sori medial. Indusium firm, glabrous, persistent. Samoa, *Powell*, 87, 167.
- 146*. *N. maximum*, Baker, in Journ. Bot. 1884, 162. Fiji, *Sir J. B. Thurston*.
- 151*. *N. ochropteroides*, Baker, n. sp. Stipe stramineous, a foot long, furnished towards the base with copious spreading lanceolate brown paleae. Frond deltoid, subcoriaceous, glabrous, tripinnate, a foot long. Pinnae cut away on the lower side at the base; lowest the largest, deltoid, unequal-sided; final segments ovate or lanceolate, contiguous, acute, at most $\frac{1}{4}$ in. long. Veins pinnate; veinlets obscure, erecto-patent. Sori medial. Indusium firm, reniform, persistent. Fox's gap, Jamaica, *Hart*.
- 153*. *N. magnum*, Baker, in Hook. Icones, tab. 1663. North-east Madagascar, *Humboldt*, 265.

- 153*. *N. granulatum*, Baker, in Journ. Bot. 1891, 4. North-west Madagascar, *Last*. Near *N. effusum*.

Subgenus *Eunephrodium*.

- 154*. *N. Bakeri*, Harrington, in Journ. Linn. Soc. XVI, 29; Hook. *Icones*, tab. 1664. Panay, Philippines, *Steere*.
- 157*. *N. subintegrum*, Sodiro, *Recens. Crypt. Vasc. Prov. Quit.* 54; *Polypodium subintegrum*, Baker, in Journ. Bot., n. s., VI, 164. Andes of Ecuador, *Sodiro*.
- 158*. *N. Harrisoni*, Baker; *N. stenophyllum*, Baker, in Journ. Bot. 1884, 363, non Sodiro. Costa Rica, *Harrison*. Near *N. incisum* and *Skinneri*.
- 159*. *N. debile*, Baker, in Journ. Bot. 1880, 212. Mount Singalan, Sumatra, *Beccari*, 433. Habit of *Polypodium reptans*, Sw.
- 161*. *N. calcareum*, Jenm. in Journ. Bot. 1886, 271, and *N. usitatum*, Jenman, Jamaica, *Sherring* and *Jenman*, are, I think, indusiate forms of *Polypodium tetragonum*, Sw.
- 161*. *N. hastatum*, Jenman, in Journ. Bot. 1879, 261, Jamaica, *Jenman*, is, I believe, an indusiate form of *Polypodium oblitteratum*, Sw.
- 162*. *N. unitum*, R. Br. I cannot distinguish specifically the New Zealand *N. inaequilaterum*, Colenso, in *Trans. New Zeal. Instit.* 1888, 229.
- 163*. *N. lucidum*, Baker, in *Gard. Chron.* 1887, II, 456. Central Madagascar, *Pool*. Cultivated at Kew, Oct. 1877.
- 165*. *N. Hopei*, Baker=*N. microsorum*, Clarke; *Beddome*, *Ferns Brit. Ind.* 270, non Hook. Sikkim.
- 165*. *N. Wakefieldii*, Baker, n. sp. Rootstock and stipe not seen. Frond oblong-lanceolate, bipinnate, 3-4 ft. long, 1½ ft. broad, moderately firm, pubescent on the ribs beneath; rachis naked. Pinnae lanceolate, 8-9 in. long, ¾ in. broad, cut down to a narrow wing, with linear-oblong lobes ½ in. broad; lowest pinnae not dwarfed. Veins 9-10, simple, only the lowest joined. Sori near the margin. Indusium firm, persistent. Mombasa, *Rev. T. Wakefield*. Near *N. extensum*.
- 168*. *N. aneitense*, Baker. *Aspidium aneitense*, Fourn. in *Ann. Sc. Nat. sér. 5, XVIII*, 297. Aneiteum and New Caledonia. Not seen.
169. *N. procurrens*, Baker. Doubtfully distinct from *N. molle*.

- 169*. **N. rampans**, Baker, in Journ. Bot. 1889, 177. Hupeh, China, *Dr. A. Henry*, 7814.
- 176*. **N. Peripae**, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 54. Andes of Ecuador, *Sodiro*.
- 176*. **N. eminens**, Baker, in Journ. Bot. 1880, 213. Mount Singalan, Sumatra, alt. 5000–6000 ft., *Beccari*, 455.
- 179*. **N. philippinense**, Baker. *N. caudiculatum*, J. Smith, non Sieber. Rootstock and complete stipe not seen. Frond oblong-lanceolate, bipinnatifid, 2–3 ft. long, 1–1½ ft. broad, moderately firm, glabrous; rachis naked. Pinnae lanceolate-acuminate, 8–9 in. long, ½ in. broad, cut down less than half way to the rachis into oblong erecto-patent lobes ¼ in. broad; lower pinnae not dwarfed. Veins simple, 8–9-jugate. Sori medial. Indusium firm, glabrous, persistent. Philippines, *Cuming*, 10, 84, 338. Near *N. arbuscula*, but lower pinnae not gradually dwarfed.
- 179*. **N. tenebricum**, Jenman, in Journ. Bot. 1882, 326. Jamaica. Nearly allied to *N. arbuscula*.
- 182*. **N. simulans**, Baker, in Journ. Bot. 1888, 325. Borneo, *Bishop Hose*, 231. Near *N. latipinna*, Hook.
- 183*. **N. eurostotrichum**, Baker, in Journ. Bot. 1880, 329. Tanala, Madagascar, *Kitching*. Near *N. pennigerum*.
- 183*. **N. costulare**, Baker, in Journ. Linn. Soc. XVI, 203. Central Madagascar, *Miss Helen Gilpin*.
- 185*. **N. jamaicense**, Baker, in Journ. Bot. 1877, 264. Jamaica, *Jenman*.
- 185*. **N. bermudianum**, Baker, in Voyage Challenger, Bot. I, 86, tab. 13. Bermuda. Cultivated at Kew in 1879 from plants sent by Sir R. Laffan.
- 186*. **N. decadens**, Baker, in Journ. Bot. 1884, 183. Viti Levu, alt. 2000 ft., *Sir J. Thurston*.
- 187*. **N. Sintenesii**, Baker = *Aspidium Sintenesii*, Kuhn, in Sintenis, Pl. Portorico Exsic. No. 2136. Porto Rico, *Sintenis*. Near *N. molle*.
- 187*. **N. devolvens**, Baker, in Journ. Bot. 1885, 217. Rio Janeiro, *Glaziou*, 15,766. Midway between *N. molle* and *refractum*.
- 194*. **N. Rodigasianum**, E. Morren, in Linden Ill. Hort. n. ser. t. 442. Samoa. Differs from *N. truncatum* by having the frond narrowed gradually to the base. Cultivated at Kew, 1883.

- 194*. *N. sakayense*, Zeiller, in Bull. Bot. Soc. France, XXXII, 74. Perak, *Morgan*. Near *N. truncatum*.

Subgenus *Pleocnemia*.

- 197*. *N. microchlamys*, Baker, in Journ. Linn. Soc. XV, 107. Little Kei Island, Polynesia, *Moseley* (Challenger Expedition).
- 199*. *N. fuscipes*, Clarke, in Trans. Linn. Soc. ser. 2. Bot. I, 536, tab. 75 = *Pleocnemia membranifolia*, Bedd. Ferns Brit. Ind. 225, t. 115. Tropical Asia. Habit of *N. dissectum*, but venation pleocnemoid.
- 199*. *N. oligodictyon*, Baker, n. sp. Rootstock and stipe not seen. Frond oblong-deltoid, bipinnatifid, moderately firm, glabrous; rachis without scales. Lower pinnae largest, equilateral, 9–10 in. long, 2 in. broad, cut down to a broad wing into entire linear-oblong segments $\frac{1}{4}$ in. broad. Veins copiously pinnate in the secondary lobes, forming areolae only in the wing. Sori medial, 10–12-jugate in the lobes. Indusium membranous, fugacious. Malay Isles, *Hutton*, in Herb. Veitch. Near *N. giganteum*.
- 199*. *N. Fournieri*, Baker. *Aspidium Vieillardii*, Fourn. in Ann. Sc. Nat. sér. 5, XVIII, 299. New Caledonia, *Vieillard*, 1602. Near *N. giganteum*. Not seen.
- 200*. *N. chrysotrichum*, Baker, n. sp. Frond ample, decompose, moderately firm, furnished on the rachises and ribs beneath with short bright yellow hairs. Lower pinnae oblong-lanceolate, 1–1½ ft. long, 6–8 in. broad; pinnules lanceolate, sessile, $\frac{1}{2}$ – $\frac{3}{4}$ in. broad, cut down to a broad wing into pinnatifid tertiary segments with oblong lobes. Upper veins forked, lower forming an arch. Sori small, one in each final lobe. Indusium persistent, glabrous. Samoa, *Whitmee*.
- 200*. *N. artinexum*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 536. *Pleocnemia Clarkei*, Beddome, Ferns Brit. Ind. Suppl. 15, tab. 368. Khasia, *Clarke*.

Subgenus *Sagenia*.

- 201*. *N. pleiopodum*, Baker, in Journ. Bot. 1888, 325. West Borneo, *Bishop Hose*, 232. Near *N. singaporeanum*. Stipe winged.

- 202*. *N. nebulosum*, Baker, in Journ. Bot. 1880, 213. Sumatra, *Beccari*, 575.
- 202*. *N. domingense*, Baker, n. sp. Stipes tufted, castaneous and slightly scaly towards the base, green and naked upwards. Basal paleae small, lanceolate, dark brown. Frond deltoid, glabrous, 6-9 in. long, imperfectly or perfectly tripartite. Pinnæ oblong-lanceolate, slightly lobed on the lower side at the base; end segment deltoid-cuneate. Main veins distinct nearly to edge; intermediate areolae copious, with free included veinlets. Sori small, scattered irregularly, sometimes confluent. Indusium small, glabrous. St. Domingo, *Imray*. Cultivated at Kew, 1881. Allied to *N. ternatum*.
- 203*. *N. quinquefidum*, Baker, in Journ. Bot. 1890, 265. Tonquin, *Balansa*, 1948.
- 203*. *N. subpedatum*, Harringt. in Journ. Linn. Soc. XVI, 30. Formosa, *Steere*.
- 205*. *N. antioquianum*, Baker, in Journ. Bot. 1881, 205. Antioquia, New Granada, alt. 3000-4000 ft., *Kalbreyer*, 1806. Near *N. subtriphylum*.
- 205*. *N. subconfluens*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 536; *Aspidium subconfluens*, Bedd. Ferns Brit. Ind. t. 364. Khasia.
- 207*. *N. subdigitatum*, Baker, in Journ. Linn. Soc. XXIV, 259. West Borneo, *Bishop Hose*, 196. Allied to *N. Lobbiai* and *subbipinnatum*.
- 211*. *N. Sodiroi*, Baker, in Journ. Bot. 1877, 164. Andes of Ecuador, *Sodiro*. Near *N. polymorphum*.
- 212*. *N. stenopteron*, Baker, in Journ. Bot. 1890, 265. Tonquin, *Balansa*, 1857.
- 212*. *N. Sherringiae*, Jenman, in Journ. Bot. 1887, 99. Trinidad, *Sherring*. Habit of *N. macrophyllum*, but sori numerous and scattered.
- 213*. *N. Endresi*, Baker, n. sp. Stipe long, slender, naked, castaneous. Frond oblong-lanceolate entire, glabrous, cordate at the base, 6-8 in. long, 1½-2 in. broad, the fertile smaller than the sterile. Main veins erecto-patent, parallel, distinct nearly to the edge, ¼-½ in. apart, with copious areolae between them with free included veinlets. Sori in rows near the main veins. Indusium glabrous, subpersistent. Costa Rica, *Endres* (Herb. Veitch).

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- 213*. *N. hederæfolium*, Baker, in Journ. Linn. Soc. XIX, 295; Hook., Icones, tab. 1665. Solomon Isles, *Rev. R. B. Comins*. Near *N. Pica*.
- 213*. *N. tripartitum*, Baker, in Journ. Bot. 1879, 296; Hook. Icones, tab. 1666. Fiji, *Horne*, 562. Near *N. Pica*.
- 213*. *N. lawrenceanum*, Baker; *Sagenia lawrenceana*, Moore, in Gard. Chron. 1881, I, 8. Mountains of Madagascar, alt. 3000 feet. *Humboldt*. Like *N. Pica* on a very large scale. Named in compliment to Sir Trevor Lawrence, M.P., President of the Royal Horticultural Society.
- 216*. *N. Keckii*, Baker; *Aspidium Keckii*, Luerss. in Bot. Centrablatt, 1882, 76. Near *N. latifolium*, Baker. Sumatra, *Keck*.
- 217*. *N. macrosorum*, Baker, in Journ. Linn. Soc. XIX, 295. Solomon Isles, *Rev. R. B. Comins*. Near *N. decurrens*.
- 217*. *N. Gardneri*, Baker, n. sp. Stipes castaneous. Fronds oblong-lanceolate, simply pinnate, moderately firm, glabrous, 1-1½ ft. long. Pinnae including the lowest, very decurrent on the main rachis. Pinnae 2-jugate below the pinnatifid apex; lowest the largest, oblong-lanceolate, 8-9 in. long, 2-2½ in. broad at the middle. Main veins very arcuate, parallel, distinct nearly to the edge, $\frac{1}{3}$ - $\frac{1}{2}$ in. apart. Sori mainly in rows nearly the main veins. Indusium glabrous, subpersistent. Brazil, Organ Mountains, *Gardner*, 5947. Gongo Soco, *Gardner*, 5315. Very near *N. decurrens*.
- 217*. *N. mamillosum*, Baker; *Sagenia mamillosa*, Moore, in Ill. Hort., ser. 4, VI, t. 598. Malay Isles, Introduced into cultivation about 1886. Near *N. decurrens*.
- 218*. *N. Wightii*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 538, tab. 76; *N. siifolium*, Baker, Syn. Fil. 299, ex parte. Courtallum, *Wight*.
- 219*. *N. juglandifolium*, Baker, in Journ. Bot. 1879, 296. Samoa, *Horne*. Near *N. Barteri* and *pachyphyllum*.
- 219*. *N. Hosei*, Baker; *N. stenophyllum*, Baker, in Journ. Linn. Soc. XXII, 227, tab. 11, non Journ. Bot. 1884, 363. Sarawak, *Bishop Hose*.
- 219*. *N. nudum*, Baker, in Journ. Bot. 1879, 41. Lawas River, Borneo, *Burbidge*.
- 219*. *N. grande*, Baker; *Aspidium grande*, J. Sm.; Hook. Sp. Fil.

- IV, 55. Philippines, *Cuming*, 356. Appears to be specifically distinct from *N. pachyphyllum*.
- 219*. *N. amblyotis*, Baker, n. sp. *Sagenia amblyotis*, Moore, herb. Stipe long, naked, castaneous. Frond oblong-lanceolate, simply pinnate, moderately firm, glabrous, a foot long, $\frac{1}{2}$ ft. broad; rachis naked, castaneous. Pinnae 4-jugate below the pinnatifid apex, lanceolate, 4-5 in. long, $\frac{3}{4}$ -1 in. broad at the middle, the lowest with a large oblong lobe on the lower side at the base. Main veins faint, with copious intermediate areolae. Sori in two rows near the main veins. Indusium firm, glabrous. Polynesia, *Hort. Veitch*, 1879. Near *N. pachyphyllum*.
- 219*. *N. Lazarzaburii*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 55. Andes of Ecuador, *Sodiro*. Near *N. pachyphyllum*.
- 221*. *N. athyrioides*, Baker, in Journ. Bot. 1884, 363. Costa Rica, *Harrison*. Habit of *Aspidium trifoliatum*.
- 221*. *N. melanorachis*, Baker, in Journ. Bot. 1888, 325. Sarawak, Borneo, *Bishop Hose*.
- 221*. *N. multicaudatum*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 540, tab. 77; *Aspidium multicaudatum*, Wall. Base of Khasia Hills and Chappedong.
- 221*. *N. kanakorum*, Baker; *Bathmium kanakorum*, Fourn. in Ann. Sc. Nat., sér. 4, XVIII, 301. New Caledonia, *Balansa*, 823. Not seen.
- 224*. *N. andinum*, Baker, n. sp. Stipe naked, stramineous. Frond oblong-deltoid, simply pinnate, membranous, glabrous, $1\frac{1}{2}$ ft. long; rachis naked, stramineous. Pinnae 4-jugate, oblong-lanceolate, 8-9 in. long, the side ones 2-3 in. broad at the middle, the end one broader. Veins arcuate, parallel, $\frac{1}{3}$ - $\frac{1}{2}$ in. apart. Sori in regular rows near the main veins. Indusium firm, glabrous. Eastern Andes, *Pearce*, 307.

Genus 45. NEPHROLEPIS *Schott*.

- 1*. *N. cordifolia*, Presl. I cannot separate specifically the New Zealand *N. flexuosa*, Colenso, in Trans. New Zeal. Instit. 1888, 231. *N. Duffii*, Moore, in Gard. Chron. 1878, tab. 113, from North Australia, is apparently a monstrous form of this species, and *N. Pluma*, Moore, in

332 *Baker.*—*A Summary of the new Ferns, &c.*

Gard. Chron. 1878, I, 588, fig. 68, from Madagascar, a marked variety.

- 2*. *N. exaltata*, Schott. Clarke and Beddome both agree that *N. volubilis*, J. Sm., should be kept up as a distinct species. I cannot separate specifically the Andine *N. intermedia*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 57.
3. *N. acuta*, Presl. I cannot draw any definite line between this and *N. exaltata*. *N. Bausei*, Hort. Veitch, is a fine garden form, with deeply pinnatifid pinnae. *N. rufescens tripinnatifida*, Hort. Veitch; Gard. Chron. 1887, I, figs. 90, 91, is another handsome garden form.

(*To be continued.*)

Notes on the Fertilisation of South African and Madagascar Flowering Plants.

BY

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—♦—
With Plates XXI, XXII, and XXIII.
—♦—

THE following are the somewhat scattered and miscellaneous notes which I was able to make during a two years' botanical trip. I found it quite impossible whilst travelling to make as thorough and complete observations as are really required to properly understand all the adaptations of a flower to insect-visitors; but as most of the forms have not hitherto been studied in their native haunts, the following may be of some interest. I endeavoured to collect every insect which I saw visiting the flowers, and brought home with me a numbered collection. I have to thank M. Henri de Saussure for his extreme kindness in naming for me all my Hymenoptera from Madagascar (about 60 species), many of which were new to science. Mr. L. Péringuey, Assistant Curator of the South African Museum, Cape Town, gave me also about 76 names most of which were specific as well as generic. These were chiefly Coleoptera from South Africa, and my thanks are due to him for his very valuable assistance with these difficult forms. I have also to thank Mr. Waterhouse, of the British Museum (Natural History), for about ten of the commonest generic names; I have not, however, been able to obtain any other assistance at home from the magnificent collection of South African and Madagascar insects in that institution, and many of my insects are therefore still unnamed.

The literature of this part of botany is so well recorded in Müller's 'Fertilisation of Plants,' edited by D'Arcy Thompson (London, 1883), and in the further list given by Professor Macleod in the 'Botanisch Jaarboek,' Tweede Jaargang, 1890, Gent (Vuylsteke), that I have in the text simply quoted their numbers for the different papers consulted. I have ventured to do this as these two books should certainly be in the hands of any one who is studying this branch of botany; both are so full and complete that their assistance is invaluable.

Anemone capensis, L.

Visited abundantly by the hive bee c.p., and also by numerous small Diptera.—Cape Town.

Carica Papaya, L. (Figs. 1, 2.)

The flowers have been described by Müller (Macleod, No. 421). They are remarkable for the extraordinary difference between the male and female. In the male there is a long thin corolla tube with the anthers arranged round the entrance, while an abundance of honey is secreted by the rudimentary ovary. The female flower, on the other hand, has perfectly free petals, and is much larger and of quite a different shape (see Fig. 1).

I saw a sugar bird (*Nectarinia souimanga*) carefully sucking the male flowers. These are also scented at night and are then much frequented by a hawk-moth (No. 464), which I thought also visited the female flowers.—Fort Dauphin.

Nymphaea stellata, Willd.

The bright blue flowers are busily visited by bees. While the stamens are dehiscing, no pollen can be shed upon the stigma as the younger stamens are bent forward over them; afterwards, however, as the anthers ripen, they turn outwards exposing the stigmata. Mr. Watson has already pointed this out for *Nymphaea* (Macleod, No. 581). The opinion of Schultz that self-fertilisation is unavoidable and the only method (Macleod, No. 516a) is therefore without *any foundation* particularly as Williams has shown that in the closely related *Victoria regia* only 60 seeds were produced

by self-fertilisation, while 300 were formed by cross-fertilisation. (Müller, No. 775, also see Macleod, No. 244.)—Near Uitenhage.

Viola decumbens, L. (Fig. 3.)

The stigma is simple in this species and bends downwards so as almost to touch the concave lower lip. On entering an insect will probably carry the extremity inwards and so shake the circle of stamens. The stigma is thus even more primitive than that of *Viola tricolor* (cf. Macleod, No. 337).—Houwhoek, Cape Colony.

Polygala bracteolata, L. (Figs. 4-6.)

The one-sided development of this flower is far more marked than in *P. myrtifolia*. Looking at the petals from above (Fig. 5), one sees that the whole carina is bent laterally to the left, while the alighting brush *v* is only developed on the right side: both the style and the lip of the carina are slightly bent over to the right so that the style emerges in a direction pointing towards the body of an insect which would be standing on the alighting brush. The upper petals are almost entirely free from the three lower (which form the carina), and the right has a rounded projection, or peg, which overlaps the left (*t*, Fig. 5). The style ends in a peculiar hammer-shaped head, the upper part *b* being the pollen-cup, while the stigma is on the inferior inner concavity *st*. So far as I could see, the pollen is originally shed into the hollow or bay *h* below the stigma, but when the flower is ready for insect-visits, almost all of it is found on the cup or upper part *b*. The pollen appears to be forced round into this cup by the growth of the style-extremity over to the right, and this also produces a twisting of the tip of the carina in the same direction.

When a bee alights on the brush, the carina yields at the hinge *x*, and the insect's right side is touched by the stigma and also receives the pollen. Small insects are kept out by the overlapping of the upper petals and the hairs developed at the hinge *h*₁, and upper edges of the carina *h*₂. Self-fertilisa-

tion is not entirely excluded, for some of the pollen remains in $\frac{1}{2}$ (compare Schulz, Macleod No. 516 a). In the great excentricity, only approached by *P. myrtifolia* (Müller, Nos. 178 and 360), and in the greater relative length and depth of the carina, this species departs widely from those hitherto described (*P. Chamaebuxus, comosa, myrtifolia, vulgaris, alpestris*, etc. Müller, p. 122, Nos. 609, 352, 360; Macleod, Nos. 217, 516 a).—Near Cape Town.

Polygala myrtifolia, L.

The flowers are not so excentric, but otherwise similar to those of the preceding species. The stamens dehisce early and the pollen is heaped up on the upper hollow part of the style which is turned very slightly to the right side. When an insect alights upon the brush, the style catches on the edges of the carinal pouch, and is carried back a little way; then, being set free, it springs back elastically and the pollen is jerked out with some force. Even in the resting position it has a slight tension, and when carefully removed from the carina springs upwards. Visitors:—*Xylocopa violacea*, ab.—Near Capetown.

(***Muraltia Heisteria, DC.*** (Figs. 7, 8.)

The genus *Muraltia* carries even further the curious similarity of Polygalaceæ to Leguminosæ pointed out by Delpino (Müller, No. 178), for in this genus there is an explosive mechanism quite as well marked as in *Genista*.

The rigid sepals overlap one another and are ciliate at the margin to prevent the entrance of unnecessary insects. The superior lateral petals have extremely thick rigid claws (*cl*, see Figs.), and lie in close contact with one another above the carina. The latter is formed of the anterior and the two inferior lateral petals which are united to form a tubular sheath enclosing the staminal cylinder and style. Their ends, however, are free and form a broad attractive surface about one-third of an inch in diameter. The upper margins of the tubular petal-sheath above mentioned are extremely thick, and form ledge-like protuberances on its inner side,

and (as will be seen from the figure of a transverse section of the flower in this part) these ledges are held together over the style by the rigid claws of the uppermost petals and the sepals.

Now the carina has a distinct tension leading it to spring downwards while the style (and in a less degree the staminal sheath) have a very strong tendency to fly upwards. Hence, when the carinal ledges are made to slip over the style by an insect forcing its way under the claws of the upper petals, an explosion takes place, and the style springs up to a right angle with its former position while the carinal sheath turns down: an insect must then be struck by the inner vertical stigmatic part of the style, *sz*, and also be touched on the abdomen by the pollen from the seven anthers which emerges in a globular mass. Honey seems to be secreted by four finger-like projections from the top of the ovary or possibly by the bases of the sepals. Visitors:—Hymenoptera: a large bee *Xylocopa violacea*? *Apis mellifica* sucking (from exploded flowers chiefly). Diptera: *Syrphus capensis*. Coleoptera: *Anisonyx ursus*.—Cape Town.

***Muraltia serpylloides*, DC. (Fig. 9.)**

In this species there is the same union of the three lower petals to form a carina enclosing the stamens and style, but the upper edges of this sheath are held together over the style by a deep depression on its upper surface which is fitted by a basal projection of the upper petals, thus forming an even closer similarity to Leguminosae than the preceding species. There is the same explosive emergence.

***Muraltia diffusa*, Burch.**

Similar to *M. Heisteria*, but in this species the ovary is hairy in its exposed upper portion between the superior petals.

***M. phyllicoides*, Thunb.**

Also similar to *M. Heisteria*.

***Mundtia spinosa*, DC.**

The three lower petals are united as in *Muraltia*, but on

depression the style and stamens emerge without any explosion; the petals return to their original position by elasticity. Visitors:—*Apis mellifica* very abundant and effecting fertilisation, also Diptera.—Muizenberg.

***Sida carpinifolia*, DC.**

The styles are at first erect and well above the anthers, so that cross-fertilisation is probable; subsequently they curve downwards so that in the final state they *may* touch the pollen and effect self-fertilisation. Honey appears to be secreted by the thickened bases of the petals and staminal sheath. The carpels separate into two short, sharp, diverging horns, adapted to catch in the fur or feathers of animals and so disperse the seeds. Visitors:—*Apis mellifica*, ab.—Fort Dauphin.

***Hibiscus Trionum*, L.**

Visitors:—*Apis mellifica* and two kinds of Diptera, all sucking (see Macleod, No. 337).

***Abutilon albidum*, L. (Fig. 10.)**

The corolla tube is narrower at the throat than lower down, so that the distance between the anthers (when dehiscing) and the nearest petal is usually about one or two lines; in older flowers the stigmas take up a position exactly the same distance from the petals. Honey is secreted by the cupular base of the sepals, and fills the cavity below the petals and inside the calyx tube; entrance to it is obtained by oval apertures between the claws of the petals. Visitors:—*Apis mellifica* abundant, usually crawling down the corolla and so effecting cross-fertilisation, but sometimes crawling over the mass of stamens in which it may effect either cross or self-fertilisation (cf. Fritz Müller on *Abutilon*, 'Embira branca,' Müller, No. 557).

***Dombeya dregeana*, Sond.**

The five staminodes are curved outwards, and form a sort of arcade between themselves and the petals, round which an insect must crawl to obtain the honey secreted by the petaline

claws; whilst doing so it must be covered with pollen from the extrorse stamens. Visitors:—Hymenoptera: *Apis mellifica*, ab., also a small bee.—King William's Town.

***Pelargonium Eckloni*, Harv.**

The white or flesh-coloured flowers of this species are very conspicuous, as they are placed on a leafless peduncle nearly two feet high! There are seven stamens gradually increasing in length from above downwards; the lateral and inferior stamens are also twisted in such a way that their anthers dehisce upwards, forming a flat pollen-covered surface which must be touched by the abdomen of an insect visiting the flowers. The stamens are protandrous, and when the anthers have fallen off, the five stigmas ripen and spread out in a starlike manner, the three upper style-branches being more curved back than the two lower, so that the stigmata occupy exactly the place formerly taken by the dehiscent anthers. The honey-canal is $1\frac{1}{2}$ inch long. Visitors:—Probably night-flying moths. I found one Hymenopterous insect (No. 334) stealing honey by biting a hole above the canal.—Pretoria.

***Pelargonium betulinum*, Ait.**

Agrees generally with above species, but the filaments of the five upper stamens are connate for one to two lines. Honey canal about $\frac{1}{4}$ of an inch long.

***Pelargonium hirtum*, Jacq.**

Similar to preceding species, but with a honey-canal fully fifteen lines long. (On *Pelargonium* cf. Müller No. 198, which I have not seen.)

***Oxalis*.**

All the species which I gathered at the Cape were trimorphic, and displayed a very peculiar difference in the relative number of the different forms. For instance, in *Oxalis variabilis*, Lindl., I found twenty-three long-styled, twenty-seven intermediate, and fifty short-styled forms as the usual proportion in one locality. In *Oxalis versicolor*, L., on the other hand, the long-styled forms were the most common, the

proportion being forty, twenty-nine, and thirty. Probably a sufficiently large series would make these differences vanish, at least in part.

***Impatiens capense*, Thunb.**

The flowers are protandrous, and the inclination of the spur is such that an insect must touch the anthers while its proboscis is in the spur (see Müller, p. 160).—Perie bush.

***Adenandra obtusata*, Soud.**

This agrees in most respects with *A. fragrans*, R. & Sch., thoroughly described by Urban (Macleod, No. 557). It is markedly protandrous, and in young flowers the style is bent down amongst the peculiar stalked glandules which cover the ovary. The stamens are at first bent inwards, but as they mature they successively rise so that they dehisce between the staminodes. Each anther bears a little glandular stalked knob, which is at first directed inwards, but becomes reflex during dehiscence (probably this secretes a substance which makes the insect's proboscis sticky, as Urban suggests). The staminodes are longer than the stamens, and their inner surfaces are covered with white hairs; they are at first bent in, but subsequently become erect. The style eventually rises and becomes upright in the centre of the flower. I found numerous small Diptera and Coleoptera in the flowers.

***Agathosma elegans*, Cham.**

Abundantly visited by large Diptera, which, wandering through the umbellate flowers, become dusted with pollen. The flowers are protandrous, and the stamens ripen successively just as in *A. glabrata*, Bart & Wendl., thoroughly described by Urban (Macleod, No. 557).

***Diosma ericoides*, L.**

As described by Trelease (Macleod, No. 546) this seems to have exactly the same arrangement as *Agathosma*.

***Quivisia grandifolia*, Scott Elliot, Ined. (Fig. 84.)**

In this genus the petals are united at the tip in the bud, and so enclose the tubular sheath formed by the united staminal

filaments and style. As the flower ripens, however, the staminal sheath and style elongate more than the petals, and (forcing their way between two petals) become greatly curved while still held by the tip of the petals; eventually they become quite straight by the separation of the latter. The staminal tube, in its final state, is two and a half inches long, while the petals are only one and three quarters of an inch in length. Cross-fertilisation is rendered probable by the globular stigma (which almost blocks the entrance to the staminal tube), being above the polliferous part of the anthers. Still self-fertilisation is not wholly excluded, as in older flowers the staminal sheath falls downwards over the bent style, and may thus bring its anthers in contact with the stigma. Honey seems to be secreted by hairs which cover the ovary. The peculiar elongation of the staminal sheath and the barren tips of the anthers, are curiously like *Proteaceae*.

Cyclopia genistoides, *Vent.* (Figs. 11-16.)

This flower belongs to the piston-type. The vexillum is very large, and its thick dome-shaped claw fits closely down over the honey entrance; it is, moreover, the sides of the broad part of the vexillum which hold the two alae together above the carina. There is also a vertical plait in the alae which fits on to a triangular peglike projection of the carina (*af. pc.*); both alae and carina are in their anterior part bent upwards, almost at a right angle to the axis of the flower; their horizontal part rests on the lowest calyx-segment, which is expanded and lengthened to support them. The style lies close to the outer edge of the carina in a well-defined tubular sheath; the pollen is pushed forward by the anthers of the short-anthered stamens (whose filaments do not seem to be thickened). The stigma emerges before the anthers, and is protected to a certain extent from its own pollen by a small ring of hairs. I thought, however, that the stigma had the same peculiarity as that of *Anthyllis* (cf. Müller, 'Fertilisation of Plants,' p. 172).

***Podalyria sericea*, R. Br. (Figs. 17-20.)**

The vexillum is, as is usual in the genus, excessively large, and so broad that the basal lobes of the wing reach to the lower edges of the carina. The alae have an almost vertical claw, and are very broad; they are bent under the carina below, and as at the same time they are held together by the vexillum *above* it, and also overlap one another laterally in front, the union is as close as possible, and the alae and carina must move together. The honey entrance is covered by the vexillum-claw; the bases of the two highest lateral stamens are, moreover, expanded in a triangular manner, and their insertion is overlapped by that of the vexillum, so that entrance to the honey is rendered very difficult, and is only possible for large insects.

***Podalyria calyptrata*, Willd. (Figs. 21-24.)**

This species has a similar though more specialised mechanism. The claws of the alae are entirely vertical. The upper margins of the alae are held together by the grooved midrib of the vexillum, while the lower margins pass below the carina. On depression, bending takes place at the junction of alar limb and claw (which is horizontal). The stamens and style lie along the outer border of the carina in a sort of tubular cavity, and the younger anthers push up the pollen of both whorls as in *Cyclopia*. A gentle depression causes a thin ribbon of pollen to emerge, but a violent one produces emergence of the style and anthers. Although the filaments are free they are rigid and expanded, and also possess hairy interstices, so that they are equivalent functionally to a sheath. The bases of the two superior lateral filaments are united a little way with the vexillum-claw. Visitors:—*Xylocopa caffra*, very ab., *Apis mellifica*, and another Hymenopterous insect, all efficient.

***Podalyria canescens*, E. Mey. (Fig. 26.)**

Very similar to *P. calyptrata*, but the superior backward margins of the alar limb are brought back behind and below

the basal lobes of the vexillum, and also thickened so that the union of the two is still more close.

Podalyria cuneifolia, Vent. (Fig. 25.)

Similar to the other species, but with the edges of the carina in front folded one within the other so as to form a more perfect tubular cavity for the style and pollen. This species (as probably all the others) is visited abundantly by *Xylocopa caffra*, which is very common near Cape Town.

Liparia sphaerica, L. (Figs. 27-30.)

This flower is the most modified of any of the South African *Leguminosae*. The lowest calyx segment is very large (13 lines long and 7 lines broad); the four lateral calyx teeth are tucked under the revolute edges of the standard (see Fig. 27). The vexillum also is very rigid and has a strong arched claw. The alae are rather narrow with their superior surface spread out horizontally, while at their ends they are rolled together round the tip of the carina through half a turn, so as to form a conical bag, out of which the tip of the carina protrudes. An insect standing *on the vexillum* can effect cross-fertilisation just as well or possibly better than when entering by the carina; *first*, because the vexillum being rigid and supported by the upper calyx-segments cannot yield to its weight, and, *secondly*, because the carina and alae, being supported by the lowest expanded calyx-segment, cannot give bodily but simply allow the tip of the carina to slip a little further through the alae; the carina, being thus squeezed by the latter, will at first allow the pollen to emerge as a thin thread, and finally permit the stigma to appear. I devoted many afternoons to the discovery of the insect which fertilises this rare flower, but I was unable to find it. *Xylocopa* could, however, do this.

Priestleya villosa, Thunb.

The basal lobes of the vexillum come well down over the sides of the flower. The alae and carina are connected by, *first*, a shallow depression of the former fitting on to a similar

groove in the latter, and, *secondly*, by the auricles of alae and carina which fit over one another behind. (The carinal edges are also swollen where they meet above the staminal sheath.) On depression the stamens and style emerge and cannot return within the carina.—Cape Town.

***Amphithalea ericaefolia*, E. & Z. (Figs. 31-34.)**

The sides of the vexillum are revolute and the lateral sepals are tucked in behind them, as in *Liparia*, while the anterior sepal steadies and supports the carina. There is a large triangular peg on each side of the carina which fits into a deep socket-like groove of the alae; the margins of the alae above this socket are thickened, while their lower margins turn inwards below those of the carina. Hence the alae and carina are quite inseparable. On depression the stamens and style emerge. The hairs on the ovary keep off small insects.

***Borbonia cordata*, L. (Figs. 35-37.)**

This flower is perhaps nearest in all essential points to *Lotus* (cf. Müller, p. 167). There are, however, some very marked differences in which it approaches very closely to some of the *Aspalathi*. The vexillum, e.g., has a long and arched claw, and the basal lobes of the limb are so turned down that they press upon the superior surfaces of the alae. The latter have rather deep longitudinal grooves corresponding to these points of depression (i.e. of the vexillum), and their lower surfaces are also bent inwards along their whole length and to such an extent that, at the junction of the alar claw and limb, the surfaces of the alae are entirely horizontal, and are in contact below the carina. The latter has a marked lateral bulging on either side, with a groove above and below, and this is closely embraced by the alae on both sides. Hence, on depression, alae and carina move together (the alae bending at the horizontal surface near the junction of limb and claw). The five outer anthers push up the pollen as in *Lotus*, and the odd stamen grows with them (sometimes showing an intermediate form of anther). The stigma and then the pollen (as a conical mass round the style) emerge on depression. The

alae have a slight tendency to spring upwards when loosened from the carina, and this must tend to bring the carina back to its original position after depression.

Rafnia angulata, *Thunb.*

The outer whorl of stamens with the odd filament push up the pollen as in *Borbonia*, but the connection of alae and carina is much looser than in that genus. The upper edges of the alae are held together by the median groove of the vexillum and the upper edges of the carina form a flat triangular surface, fully 2 lines broad in front of the vexillum. The alae, however, embrace the carina below, as in *Borbonia*.

Lotononis involucrata, *Bth.* (Figs. 42-46.)

The effect of the elongated inferior calyx-tooth, characteristic of the genus, is to strengthen the carina which rests on it. The alae and carina are connected in three ways: *first*, by a deep groove in the carina, fitted by a depression of the alae; *secondly*, by the overlapping of the superior backward projections or auricles of both alae and carina; and, *thirdly*, by the inferior backward projections of the alar wings which are in contact below the carina. The alae are kept in contact with the carina by the downward prolongation of the vexillum-wings, which are almost as deep as the carina itself; they also overlap vertically in front. On depression the alae are separated from one another, as well as bent down, and the carina opens very widely to allow the style and stamens to emerge.

Lotononis prostrata, *Bth.* (Figs. 38-41.)

Very similar to preceding species.

Viborgia obcordata, *Thunb.*

The structure is almost identical with the last species.

Aspalathus aemula, *E. Mey* (Figs. 47-50.)

The vexillum has a long arched claw, and its two basal lobes fit into a deep groove on the superior surface of the alae, as in *Borbonia*: the lower edges of the alae are also slightly bent inwards below the carina at junction of the limb and claw. The carinal halves have a rather deep longitudinal

depression along their upper surfaces, into which the alar depression fits. The style and stamens emerge by a rather oblique slit at the end of the carina.

Aspalathus sarcantha, *Vog.* (Fig. 55.)

The basal lobe of the vexillum on each side fits into a deep superior hollow of the ala, which again works on a lateral projection of the carina. The lower edges of the alar claw (just before the limb) are turned inwards, and touch one another below the carina. On depression the alae rotate on this horizontal portion, which is just inside the calyx. The stigma and anthers emerge as in *A. aemula*. The alae have a marked tendency to curl upwards, so that when set free from the carina their tips come in contact with the vexillum; this tendency will assist in bringing back the carina to its original position after depression.

Aspalathus Chenopoda, *Thumb.* (Figs. 51-54.)

This form shows a further advance in structure, as the claws both of alae and carina are firmly *adherent to the staminal tube*, and bending is entirely confined to the junction of alar limb and claw. The inner edges of the vexillar basal lobes are extremely hairy, and their lower extremities fit into the hollow between alar limb and claw, so keeping out all useless insects and also keeping in the honey which is very abundantly secreted. Moreover, at first the pollen merely emerges as a ribbon-like mass (just as in *Lotus*), though after repeated depressions the stigma and anthers also emerge just as in *A. aemula*. Visitors:—Hymenoptera: (No. 192, an undescribed species). Diptera: a Bombylid, *Pangonia angulata*.

Crotalaria capensis, *Jacq.* (Fig. 56-60.)

The flowers are of the same general type as those of *Lupinus*, but are marked by the extraordinary depth of the carina as seen from the side. The upper surfaces of the carina, moreover, are bulged out horizontally, and the alae having the same shape, embrace it very closely (Fig. 60): their vertical superior margins are held together by the deep

groove in the vexillum. The stamens are differentiated into two distinct whorls, of which those with the shorter anthers push up the pollen as in the Lupine. The style is protected from its own pollen by hairs on its inner surface. On depression a thin streak of pollen exudes from the drawn out conical end of the carina, and subsequently the stigma appears. The honey is protected by the thick, flat, and rigid vexillum-claw which fits over the entrance. Visitors:—*Xylocopa caffra* and *Apis mellifica*, both ab.

Crotalaria retusa, L. (Figs. 61, 62.)

Very similar to the preceding, but with the vexillum-claw even more specialised to cover the honey entrance. I also found that in the buds the vexillum completely covers the carina, the sides being wrapped together in front, and in consequence of this the style, which is at first directed obliquely upward from the end of the ovary, is unable to develop, and therefore takes the peculiar downward curve (see Figs. 58, 64), and which is characteristic of the genus. After the vexillum has been freed from the carina, no further elongation of the style takes place. Visitors:—Hymenoptera: (probably *Xylocopa violacea*), *Allodape Elliotii*, De Sauss., standing on vexillum and sucking head downwards. Diptera: *Philanthes diadema*. Lepidoptera: two spp. sucking (Nos. 630, 634).—Fort Dauphin.

Crotalaria humilis, E. & Z. (Figs. 63-65.)

In this species the tip of the carina and enclosed style are spirally twisted together, a further specialisation rendering the piston-action more complete. In other respects it agrees with *C. capensis*. Visitors:—*Apis mellifica*, ab.

Psoralea decumbens, Ait.

The flower has an explosive mechanism: the staminal sheath having a distinct tendency to fly upwards, though the alae and carina have very little, if any, downward tension. Equilibrium is maintained by the vexillum which holds the alae together above the carina. The alae and carina are also united by, *first*, a groove in the alae lying upon a slight

bulging of the carina, and, *secondly*, by the swollen basal auricles of the alae which project backwards covering similar though smaller lobes of the carina.

An insect raising the vexillum causes explosion. (Cf. Sprengel, loc. cit. p. 362 on *P. bituminosa*.) Visitors:—*Apis mellifica*, very ab.—Cape Town, Oct.

***Psoralea pinnata*, L.**

Visitors:—Hymenoptera: Large bee (? *Xylocopa*), *Apis mellifica*, etc. Lepidoptera: spp.—East London.

***Indigofera filiformis*, Thunb.**

That the carina of this genus has an elastic tendency to spring downwards was pointed out so long ago as 1837 by Don, 'General History of Dichlamydeous Plants.' The flowers of *Indigofera macrostachya*, Vent. have been excellently described by Delpino (No. 178, Müller); those of *I. speciosa* by Henslow (No. 323, Müller), and those of *I. Dosua* by Meehan (No. 385, Macleod). In this species I found exactly the same general structure. The carina has a very strong tendency to spring downwards (residing chiefly in the thickened claw), while the staminal sheath and claw have a distinct tendency to spring upwards. The inner edges of the carina are strongly thickened and fit over the staminal sheath, thus keeping the carina from descending; the alae form a perfectly horizontal platform, being supported on conical projections of the sides of the carina (cf. 'Bollazione od ernie' of the carina of *I. macrostachya*, Delpino, l. c.); their inner edges, moreover, are grooved and fit over the thickened upper borders of the carina. This horizontal position seems to me to assist in keeping the flower from explosion in two ways, *first*, because the alae, if they are to allow the carinal edges to move outwards, must be twisted outwards in a plane which is the one in which they are expanded instead of being simply bent in a plane at right angles to their own surface, as would be the case if they were in the ordinary alar position, and, *secondly*, because the resultant of their weight (and that of a small insect standing on them) is made to be directly downwards without any

outward component, and is therefore counteracted by the staminal tube.

In fact, in order to produce explosion, an insect must insert its proboscis between the thickened carinal edges, and so, by separating them, allow them to slip over the sides of the staminal sheath. If this is done by a needle an explosion occurs and pollen is scattered in all directions. This necessity of separating the carinal edges explains the fact that Meehan saw bumble-bees, hive-bees, and sand-wasps visiting the flowers without causing explosion. The *Bombus* at Philadelphia however could not have understood the flowers, as Delpino saw *Bombus italicus* causing explosion of *I. macrostachya* and being much alarmed thereby. (See also No. 346 Müller.)

Sutherlandia frutescens, R. Br.

See Annals of Botany, vol. iv, 1890, p. 268.

Lessertia pulchra, Sims (Figs. 66–68).

The calyx-tube in this flower keeps the alae and carina together. The shape of the latter is peculiar; its lower margin follows exactly the shape of the ovary and style, while its two upper margins are in contact above forming a vertical narrow edge (*a—b*, Fig. 68). On depression pollen emerges as a ribbon-like streak all along this edge (*a—b*). The stigma is protected by a circle of long stiff almost upright hairs which are depressed by the weight of the insect.

Clitoria heterophylla, Lam. (Fig. 69.)

The flowers are blue and, like those of *C. mariana*, inverted. (Trelease, 'American Naturalist,' vol. XIII, Nov. 1879.)

The vexillum is large and forms a broad alighting place for insects: pollen is very early shed on a brush of hairs which covers the inner face of the style; the alae and carina are united and move together so that when they are forced upwards by the insect, the pollen-covered style protrudes. The nectary is peculiar, in fact so far as I know unique in the order; it consists of a reflexed collar-like ridge rising from the staminal tube and lying like a saddle upon the ovary.—

Fort Dauphin. Visitors:—*Apis mellifica* and other Hymenoptera.

Erythrina caffra, DC., and *E. indica*, L.

See Annals of Botany, l. c. p. 267.

Canavalia ensiformis, DC. (Figs. 70–71.)

The large reddish purple flowers are very conspicuous. The vexillum is strongly reflex and the basal ends of the limbs are produced downwards into thickened pegs which occupy the space between the auricles and claws of the alae. There is a longitudinal bulging along each side of the carina, which is fitted above and below by the alae; the auricles of the latter are also carried back below the vexillum and thickened in such a way that they fill up the entrance so that no honey can escape. On depression both style and stamens emerge, and in young flowers some of the pollen is thrown a considerable distance as the edges of the carina catch the stamens. Honey is abundantly secreted. Visitors:—*Xylocopa violacea*, also Lepidoptera.—Fort Dauphin.

Phaseolus lunatus, L.

The carina in this form is bent into a spiral forming one complete turn and a half. The flower is fertilized exactly as in e. g. *P. Caracalla* (see Delpino, Müller, No. 178). It differs from *P. coccineus* described by Farrer (Müller, No. 242) in the appendage to the odd stamen being perfectly symmetrical (cf. Darwin, Müller, No. 169). Visitors:—*Apis mellifica* and several Lepidoptera.

Phaseolus adenanthus, Mey (Figs. 72–75).

In this flower there is a very close similarity to *Canavalia*. The lower basal ends of the wings of the vexillum are similarly thickened, but there is also a pulley-like thickening at its point of curvature; the auricles of the alae lie between these two thickened parts of the vexillum and rotate round the lower one on depression, but as each ala has also a small horizontal spur from its lower margin which passes below the carina, and as the calyx is strong and leathery, the effect of

depression is to cause the vertical section of the alae to become circular instead of elliptical, and this causes the carina to separate widely above leaving free egress to the pollen-covered style which is only slightly curved. Visitors:—*Apis mellifica*, ab., also Lepidoptera (cf. *P. diversifolius*, described by Foerste, Macleod, No. 151).

Vigna triloba, Walp.

This form shows a further advance in structure on *Phaseolus adenanthus*, as the vexillum is connected with the alae in three ways: *first*, by the thickened basal lobes of its wing, which fit in between the alar claw and auricle; *secondly*, by a pulley-like thickening in the middle line of the vexillum (just where the broad part of its blade begins), and which holds the superior edges of the alar blades together; and, *thirdly*, by another pair of thickened pegs which are developed between the other thickenings and run forwards and inwards, fitting upon the outside of the auricles of the alae. On comparison with *P. adenanthus*, it is easily seen that in this species the single pulley-like thickening in the front of the vexillum has become double, so that the auricle of the alae is still made to work in a groove between the basal and medial thickenings of the vexillum. The vexillum-claw has on its lower sides two raised edges, which clasp the odd stamen (this is similar to that of *Phaseolus*) in its broad part very firmly. The style emerges in this species through a small orifice at the end of the carina.

Vigna angustifolia, Bth.

The flowers are very unsymmetrical. The vexillum has the usual turned-in edges on its claw to clasp the odd stamen, and on its expanded limb there is a conical peg to the right of the midrib, about 4 lines from the base. The peculiar want of symmetry in the alae and carina seems due to the style, which begins (after the horizontal ovary) by a vertical portion, and is then suddenly bent over to the left at right angles to its course, being at the same time twisted, so that the upper surface becomes wholly inferior: a slight lip on its

flattened extremity is the stigma. The right carina forms at the tip a spoon-shaped covering to the horizontal terminal part of the style: it has at the basal end an auricle which is covered by the auricle of the right ala, whose edges are turned over to clasp it firmly: on depression the right carinal half simply slips down and outwards over the style. The left carinal half on the other hand is pushed under the style at its extremity, so as to form a sort of pocket enclosing the anthers, and on its side about half-way down is a conical protuberance; on depression the edge of the left ala catches on this protuberance, and causes the left carinal half to rotate about a horizontal axis, the tip turning directly outwards.

Hence, when an insect alights on the alae and is struggling to pass round and under the peg on the vexillum, it causes the right carina to slip down and the left to rotate, fully exposing the style and anthers, and in passing out (probably under the style) will produce fertilisation. I have often examined this flower, and never seen an insect or a ripe pod upon it, so that it is doubtful what insect visits it, but *Xylocopa* would certainly be able to produce fertilisation.—Pretoria.

Dolichos Lablab, L. (Figs. 76-83.)

A glance at the figures will show the fundamental similarity of the vexillum in this species to that of *Canavalia*, *Phaseolus*, and *Vigna*. The frontal pegs are very large, semi-circular in shape, and hold the upper edges of the alae closely together in the middle line.

The sides of the thickened vexillum-claw have a cavity hollowed out in their thickness, and in this cavity lies the odd stamen: as may be seen from Fig. 78, it is impossible for an insect's proboscis to enter above the odd stamen, so that in this case at any rate the odd stamen must be levered up as described by Farrer (loc. cit.) for *Phaseolus coccineus*, and not as suggested by Francis Darwin (loc. cit.); there is a conical peg on each side of the carina which fits into a very deep socket on the ala.

The stigma (with the pollen-covered hairs below) emerges

from a vertical slit facing the vexillum, and I find that after fertilisation it grows forward till it takes a position inclined at 180° to its original angle. The nectary is in the form of a band embracing the stipitate ovary (Fig. 83).

Rhynchosia crassifolia, Bth.

This has a general similarity to *Vigna* and the rest of the Phaseoleae. The odd stamen is similarly expanded and clasped by the arching claw of the vexillum. The carina has longitudinal bulgings on the side, which are fitted by depressions of the alae above, and a short tooth developed from the inferior margin of the alae below. The carina is distinctly turned to the left towards the tip (cf. *Vigna* and *Phaseolus*), and the style emerges with the pollen borne on a mass of hairs below it.—Durban.

Virgilia capensis, L.

In this flower the stamens and style emerge simply. The alae overlap one another below the carina, and their auricles also fit over those of the carina above, while there are slight swellings on the carinal upper margins which are fitted by grooves on the alae. Hence on depression the carina opens out, leaving free passage for the style. Although the stamens are not united for more than one-tenth of an inch, they form practically a sheath, as the edges of the alternate stamens are expanded (overlapping the others), and hairs are developed along these edges. Visitors:—*Xylocopa violacea?* and another large bee very abundant.—Near Cape Town.

Cotyledon ramosissima, Salm.

The scales of the disc are in this species flat and membranous and stretch across the spaces between the projecting backs of the five carpels so as to form pockets which are usually full of nectar. The filaments of the stamens, at about 3 lines from the base, become suddenly much thickened and hairy, and as these thickenings fit closely together, they form a kind of roof completely covering the honey-pockets.—Somerset East.

Kalanchoe verticillata, *Scott Elliot*, ined.

The flowers are bright scarlet and appear to be pro-androus.

Brexia madagascariensis, *Lindl.* (Figs. 85, 86.)

The midribs of the petals are much thickened and between them lie the rather deep hollows formed by the concave sepals. Honey is secreted by a yellow thickened patch on the lower sides of the filaments near their base and drops into these hollows or pockets between the midribs of the petals. The filaments and the four-lobed staminodial discs between them conceal these pockets, so that they are not visible from above. These four-radiate discs or rudimentary stamens are yellow and appear to secrete a little honey on their upper surfaces near the ovary, so that small insects coming to the flower would never suspect the quantity below but fly away contented. The stamens twist downwards as shown in the figure, but only gradually as they ripen, so that the dehiscing face of the anthers is towards the entrance to the inferior honey-pockets. The short style ends in a flat stigma. Visitors:—The sugarbird *Nectarinia souimanga* sucking honey! Also by a species of clear-winged moth in great abundance and other insects.—Fort Dauphin, also Ambahy.

Montinia acris, *L.*

Honey is secreted in the male flowers by a well-developed disc which is accessible to most insects. Visitor:—*Allodape*, sp. (apparently undescribed, No. 139).

Mesembryanthemum reptans, *Ait.* (Fig. 87a.)

The petals are red and the expanded flower measures fully an inch in diameter: the stamens are united at the base and form a sort of circular palisade arching inwards over the dark-green circular nectary. Insects cannot pass through this barrier from the outside, so that they will usually alight either on the styles or on the disc, and will probably cause cross-fertilisation, though self-fertilisation is quite possible. Visitors:

Hymenoptera: *Apis mellifica* sucking between the stamens. Diptera: a small sp. and *Syrphus capensis*. Coleoptera: *Peritrichia capicola*, *Pachycnema crassipes*, and others.

M. aristulatum, Sond.

Similar to preceding species. Visitors:—Diptera: *Lucilia argyrocephala*, *Lophonotis* sp. Coleoptera: *Anisonyx ursus*, *A. longipes*.

Hydrocotyle Solandra, L. f.

This flower is very markedly protandrous. There is no vestige of the styles while the anthers are dehiscing, and when the former are ripe the anthers have usually fallen off. Nectary dark purple and very large. Visitors:—*Lucilia argyrocephala*, and other Diptera.

Electronia ventosa, L.

The style projects well above the stamens; the corolla has a ring of short woolly hairs just above a basal constricted portion which forms a cavity to hold the honey secreted by the top of the ovary. Visitors:—*Apis mellifica*, very ab., also a Bombylid.—Durban.

Kraussia floribunda, Harv.

The corolla has a narrow tube with spreading reflex lobes. The style ends in a thickened clavate extremity which is marked by longitudinal furrows; whilst in the bud the anthers closely surround this thickened portion and shed their pollen on the grooves, so that when the flower opens the end of the style is thickly covered with pollen. Subsequently the stigmatic lamellae unclose. The arrangement is therefore the same as in Campanulaceae. Visitors:—Lepidoptera: four species (373, 378, 380, 381), very ab., and also *Planema protea*. Hymenoptera: *Apis mellifica*. Coleoptera: two species.

Pavetta obovata, E. Mey, and **Canthium obovatum, Klot.,** have practically an identical arrangement.

Pentanisia variabilis, Harv.

The flowers are arranged in capitula and those towards the exterior open first. They are also distinctly dimorphic! In the first form the style is exserted and the stigma stands

about two lines above the corolla, while the anthers are perfectly sessile and included within a small dilatation of the corolla-tube just inside the throat: in the *second* form the filaments of the stamens are not quite 2 lines long, and during dehiscence their anthers are almost horizontal with their inner pollen-covered face directed upwards, while the style is slightly shorter than the corolla-tube, so that the stigma is included. The narrowness and length of the tube (6–7 lines) shows an adaptation to Lepidoptera, and near Pretoria I have seen various species sucking the flowers. Honey is secreted by a small ring round the base of the style.

Diplopappus fruticulosus, Less.

In the florets of the disc the *ends* of the style-branches are covered with short rough hairs which brush out the pollen: the branches remain in contact at their extremities but curve apart so as to form an arch. The stigmatic papillae are on the *sides of the outer edges* of the branches. It is hence very similar to *Agathaea coelestis*, Cass., described by Hildebrandt (Müller, No. 357), and not very unlike *Chrysocoma* (Müller, 'Fert. of Plants,' p. 323). The rayflorets have no hairs. Visitors:—A peculiar little fly with a very elongate head, very ab., also other Diptera.

Aster tenellus, L.

Similar to *Agathaea coelestis* and *Chrysocoma Linosyris* (see Müller, l. c.) Visitors:—Small Hymenoptera: *Halictus vittatus*, Sm. very ab. Diptera: *Systocheilus mixtus*, *Dischistus heteroceras*, Macg. Coleoptera: *Peritrichia capicola*.

Relhania genistaefolia, L'Her. and **R. ericoides, Cass.** The branches of the style (in the disc-florets) end in hairy *flat* tops which push up the pollen in the usual way.

Osmitopsis asteriscoides, Cass.

I found that in this species there was a differentiation in the disc-florets. The outer circle of disc-florets being alone fertile and having larger nectaries and less pollen than the others. Their styles were open moreover, long before those of the inner florets were ready.—Cape Town.

Bidens pilosa, *L.* Visited by *Pieris hellica*.

Cenia turbinata, *L.*

The fertile florets alternate with the rays, and the branches of their styles are directed inwards. Visitors:—Hymenoptera: small species (No. 189). Lepidoptera: one sucking. Coleoptera: 3 species. Diptera: *Syrphus capensis*.

Cineraria geifolia, *L.* Visitors:—Diptera: *Syrphus cognatus*, sp. nov., *Systocheilus mixtus*. Coleoptera: *Dicranocnemis sallicollis*.

Euryops abrotanifolius, *DC.*

Visitors:—Hymenoptera: *Allodape*, sp. nov., *Halictus albofasciatus*. Diptera: *Lucilia argyrocephala* and small kinds very abundant, *Scatophaga hottentota*, *Spilogaster*, sp. Coleoptera: several species.

Gymnodiscus capillaris, *Less.* (Fig. 87 *b.*)

The style of the disc-florets ends in a thick conical head, at the base of which is a pretty long circle of hairs to hold the echinulate pollen-grains. The surface of this cone is also roughened (really covered with small hairs) for the same reason. Visitors:—*Syrphus capensis*, also small Diptera, ab.

Othonna dentata, *L.* and **O. arborescens**, *L.* similar to preceding.

Dimorphotheca annua, *Less.*

Visitors:—Hymenoptera: *Cosila* sp. Diptera: very ab. a minute species with elongate head, *Lasioprosopa Bigoti*, *Bombylius lateralis*, *Lucilia argyrocephala*, and many other species. Coleoptera: *Anisonyx ursus*, *A. longipes*, *Dichilus dentipes*, *D. simplicipes*, and others.

Tripteris dentata, *Harv.* and **T. amplexens**, *Harv.* (Fig. 88).

The styles of the disc-florets end in short blunt conical extremities covered all over by little rigid teeth and bounded at the base by a circle of much longer hairs. (Hildebrand, loc. cit. p. 31, describes and figures *Calendula arvensis*, in which hairs seem to cover the whole of the style-extremity in the central florets.)

Osteospermum moniliferum, L.

Visitors :—Hymenoptera : species of *Halictus*? Diptera : small species ab. Coleoptera : *Mylabris capensis*, *Tromeces linearis*.

Ursinia, sp.

Visitors :—Coleoptera : *Dichilus dentipes*, very ab., *Anisonyx ursus*, *A. longipes*, etc.

Cryptostemma calendulaceum, R. Br.

The arrangement of the hairs on the style, and its shape, is very similar to *C. hypochondriacum*, Br. described by Hildebrand (Müller, No. 357). The styles rise and fall as in *Gazania pinnata*, Less. (vide infra). Visitors :—Hymenoptera : *Halictus deceptus*, *H. vittatus*, and another. Diptera : *Bombylius stylicornis*, *Lucilia argyrocephala*, *Systocheilus mixtus*, *Dischistus heteroceras*, and another. Coleoptera : *Dichilus simplicipes*, and others.

Arctotis aspera, L.

A. acaulis has been described and figured by Hildebrand (Müller, No. 357). This species possesses the same cylindrical thickening at the end of the style and this cylinder has a basal circle of hairs, besides being covered all over by short rigid teeth. The style below the thickened part is highly elastic and can be stretched half its length without breaking (see *Gazania*). Visitors :—Coleoptera : *Dichilus acanthopus*, *Hedybius*, etc.

Gorteria diffusa, Th. (Fig. 89.)

The style ends in a thickened part similar to other *Arctotidae*, but there is a peculiar constriction at point *c* below which the hairs are larger (see Fig.). The hairs are a bright purple and the pollen-grains yellow through the occurrence of oil-globules in their outer coats.

Gazania pinnata, Less. (Figs. 90 *a*, 90 *b*.)

The terminal part of the style is thickened as in *Arctotis*; the thickening begins with a rim-like projection which bears a circle of rather long hairs; the rest of the thickened part is covered with short curved upward-pointing hairs. The style-branches are papillose over their whole inner surfaces (cf.

Hildebrand; it seems not to be so in *G. ringens*). The most marked peculiarity however is the delicate elastic portion of the style below the thickened extremity. One may on a sunny morning almost see the pollen being pushed up through the anther-sheath by the style, and when the latter has finished extending, it stands fully three lines above the anthers. However, after the pollen has been removed, it sinks till the open stigmatic lips are just above the anther-sheath. This sinking, moreover, seems to be due to a contraction of the style (not to withering), as in the younger styles the cells are longer than they are in the older state. Visitors:—Hymenoptera: *Halictus vittatus*. Diptera: *Systocheilus mixtus*, *Dischistus heteroceras*. Coleoptera: *Peritrichia capicola*.

***Cullumia setosa*, R. Br.**

The pollen is echinulate. The style terminates in a thickened portion as in *Arctotis*. Visitors:—Coleoptera: *Pa-chynema crassipes*, *Dicranocnemis sallicollis*, *Dichilus dentipes*.

***Berkheya carlinoides*, Wild.**

In the shape of the style-extremities and the matter of retraction, this is exactly similar to *Gazania pinnata*. Visitors:—Coleoptera: *Peritrichia capicola*, and others.

***Wahlenbergia procumbens*, A. DC.**

In this species pollen is shed on the hairy outer surface of the stigma just as in *Campanula*. Visitors:—Lepidoptera, ab.—Also ants stealing honey.

***Wahlenbergia capensis*, A. DC.**

This species differs from the preceding in the peculiarly-shaped thickened extremity of the style. This is hemispherical with the broad surface uppermost, and it is upon it that insects usually alight. The bases of the filaments are flattened and triangular in shape, and their edges being turned up and hairy probably prevent the entrance of small insects.

***Microcodon glomeratum*, A. DC.**

The anthers shed their pollen upon rather long hairs which cover the style. The bases of the filaments are tri-

angular and very ciliate at the edges. Self-fertilisation is possible, however, as the five stigmatic branches eventually coil over so much that if any pollen is left on the style they must come in contact with it. Visitors:—Lepidoptera: *Erebia cassius* sucking. Ants also visit the flowers.

***Scaevola Thunbergii*, E. Z.**

The corolla has somewhat the appearance of that of a *Lobelia*. The tube is about 7 inches long, and covered internally with long hairs which are all directed backward; it is slit along the upper surface (just as in *Lobelia*) and through the slit projects the style which, however, is bent forwards and downwards in its upper portion. The stamens dehisce some time before the flower opens. The style in this condition of the flower is shorter than the stamens, and terminates in a membranous cup about $1\frac{1}{2}$ lines in diameter and a line deep. The anthers are bent inwards over the edge of this cup, and their pollen falls into its cavity (at the bottom of which is the quite undeveloped stigma); after dehiscence, however, the style grows past the anthers, and the edges of the indusium are flattened together in such a way that the entrance to the indusial cup is now a narrow transverse (i. e. horizontal) slit. The way in which insect-fertilisation is effected can be clearly seen by gently pushing one's finger under the style into the corolla-tube; while pushing inwards the style simply becomes more and more curved back, but on gently drawing the finger back a ribbon-like mass of pollen is left on the finger. This is because the upper margin of the slit is longer than the lower, and is pressed against it when it is being pushed inwards. If any pollen is left in the cup, it is subsequently forced out by the developing stigma which when fully ripe separates the edges of the slit, and forms a broad surface (indistinctly bi-lobed), $1\frac{1}{2}$ line long and a line broad. The flower is thus protandrous, and exhibits a strong affinity with *Lobelia*; the indusium is exactly comparable to the circle of hairs in *Lobelia*, and as Urban (Müller, No. 751) states that its microscopical structure looks very much like a circle of

hairs united side by side, we have no difficulty in understanding how it arose. (See also Fritz Müller in Müller, No. 353, Bentham in Müller, No. 84.) Visitors:—Near Durban, Hymenoptera: Nos. 385, 365, 367, 366, 368, all large bees about the size of a *Bombus*, and sucking legitimately. Also Nos. 366, 369, and 370 all attempting to obtain the honey by inserting their proboscis in the upper slit of the corolla. I found the basal part of the style very hairy, probably an attempt to prevent this robbery. At Fort Dauphin, Madagascar, *Xylocopa olivacea*, *Elis Romendi*, *Apis mellifica*, and another (No. 617). Lepidoptera: *Thorania*, Durban, Nos. 372, 380, and another sp. Fort Dauphin, a large moth, No. 615. Coleoptera: Durban, No. 371.

Goodenia.

I have been much struck by the exact similarity of the description of this genus, as given by Mr. Hamilton (Macleod, Nos. 180 and 186), with the preceding; but neither Mr. Hamilton nor Mr. Haviland seem to have observed the fertilisation by insects.

Lobelia.

The fertilisation of *Lobelia Erinus*, L., has been very thoroughly described by Farrer (Müller, No. 240). *Lobelia decipiens* agrees closely with it. I found on the lower lip two ridges ending in a slot or groove, which affords a firm foothold for the bee. (Cf. Trelease, Müller, No. 727.) *Apis mellifica* was busily visiting the flowers (near East London); it pushes its head half-way down the tube, and, on retiring, its head and thorax are covered with a broad band of pollen; in so doing it seemed to me that it pushed the bases of the lower filaments aside and so caused a thrusting down of the anther-cylinder on the circle of style-hairs. (Cf. Delpino, Müller No. 360; and Urban, Müller No. 751.)

Lobelia coronopifolia, L.

Also visited by a Hymenopteron at East London.

Erica leeana, Ait.

The corolla is of an unusual length, viz. about 9 lines.

The anthers are united in a ring round the style just as in *Erica Wilmorei* (?) described by Trelease (Macleod, No. 546).

***Erica baccans*, L.**

The corolla is practically urceolate, but the closely appressed sepals are so folded inwards that they divide the interior into four tubular canals. The processes of the anthers (both of one anther and one from each of its neighbours) project into these cavities, and, as they are remarkably broad and long, occupy almost the whole space; when these are touched by an insect's head and proboscis, they cause a rotation of the anther on its filament, and the insect will thus receive a shower of pollen from three of the anthers. This is a further development of the simple type of *E. carnea* (Müller, No. 592) and *E. tetralix* (Müller, No. 633).

***Erica purpurea*, Andr., *E. Plunkenetii*, L., and *E. fascicularis*, L.**

See Annals of Botany, Vol. IV. p. 270.

***Blaeria purpurea*, L.**

The stamens and style protrude from the mouth of the corolla, but the style being longest must first touch an insect's head. I saw a large fly busily visiting this flower, and plunging head and thorax into the corolla; also numerous small Diptera and Coleoptera.

***Orchipeda Dregei*, Scott Elliot (Figs. 90 c-94).**

The flowers are white with a slight yellowish tinge, and are almost three inches in diameter. The corolla-tube (about one inch long) is peculiarly twisted, just as if it had been made to turn through 90° round its own axis; in consequence of this twisting (which occurs pretty late in development, for there is no torsion in young buds) the inside of the corolla-tube is hollowed out into five spirally running grooves, each of which opens to the outside above by a circular aperture between the thickened insertions of the stamens. The anthers are almost sessile and very horny in texture; they are all in contact at their upper extremity, and form a small cone which projects out of the throat of the corolla; each pair of

anthers is also in contact by their basal lobes; a slit is, however, left between the tip and their basal ends as their sides are not quite straight; pollen is produced chiefly by the upper part of the anther (above its insertio), but a slight amount is also found in the basal lobes. The style ends in a thickened extremity of which the uppermost part seemed to be barren; below the level of the polliniferous portion of the anthers, however, it bears a membranous ring, which is formed of ten coherent scales with free triangular tips; these triangular tips are alternately opposite the thickened insertion of the filaments and the entrances to the above-mentioned spiral hollows; those which are opposite the hollows are horizontal, and occupy most of the entrance whilst the others are reflex on the style. The true stigma appears to be underneath this ring, and is therefore protected by it from most of the flower's own pollen. It secretes a sticky matter. We are now in a position to understand the mechanism of the flower. If a bristle is introduced into one of the circular openings, its tip follows the line of the corresponding spiral groove until it reaches the base of the flower and nectary; during the insertion, moreover, it is in contact with the corolla-tube through its whole length. Immediately, however, one withdraws the bristle, it straightens and slips between the horny basal lobes of two anthers so that on withdrawal, being rendered sticky by the secretion of the style above mentioned, it removes the pollen heaped up on the top of the style. The triangular tip of the stylar membranous ring will scrape off any pollen which may be on the proboscis on entering the corolla-tube of another flower. Cross-fertilisation would be therefore effected by, for instance, the proboscis of a moth. Self-fertilisation, however, is not wholly excluded, as the pollen of the basal lobes of the anthers might easily come in contact with the stigma. Visitors:—Probably night-flying moths. Beetles (No. 467) are often on the flowers gnawing the corolla.

Vinca rosea, L. (Figs. 95–97).

The flowers are red and have a long corolla-tube, which is enlarged at the insertion of the stamens, but only half a line

in diameter at the actual throat (*t* in figure). The anthers are inserted just below the entrance and their tips converge or arch together. Behind and above each anther is a small brush of hairs (developed on the corolla), and these hairs form a sort of roof protecting the pollen from rain. The style ends in a flat top (*sz*) upon which the pollen is shed. The stigma is below this, and in its lower part secretes a sticky substance. When a butterfly stands on the spreading limb and inserts its proboscis, the latter slips down the tube along *and against* the inside of the corolla-tube *without touching* the pollen-mass, but on withdrawing its proboscis the latter is straightened and passes over the viscid convex stigma, and as this involves effort it is forced to slip between two anthers, and so catches and brings out a good deal of pollen. This can be clearly proved by introducing a bristle in the flowers. Abundantly visited by numerous (at least eight) species of butterflies.—Fort Dauphin. I could not see any motion of the staminal filaments as found by Wilson (Müller, No. 781) for *V. minor*, which has also been beautifully described by Charles Darwin (Müller, No. 153).

Gomphocarpus arborescens, R. Br.

Visited by small mosquito-like Diptera in great abundance.—Table Mountain, June.

Camptocarpus crassifolius, Dcne., No. 2871, Herb. Scott Elliot (Fig. 98).

The corona is in the form of a cup-like ring about a line high, but opposite the stamens it is prolonged upwards into conical teeth about one and a quarter of a line in length. The filaments of the stamens are united to the coronal cup and as their anthers, as usual, lie upon the mushroom-like head of the style, a narrow passage only is left underneath the overhanging head of the latter *c, c* (see Fig. 98).

The retinaculum consists of a rather long sticky disc which is placed horizontally on the flat lower surface of the style-head, and is therefore inclined at an angle of 60° with the appendices of the anthers to which it is attached (see Fig. *d*).

On looking down on the flower from above, five circular apertures are seen between the stamens which lead down to the base of the flower. In consequence of the fusion of the staminal filaments and corona there is therefore a circular gallery running round the base of the flower under the overhanging style and the base of this gallery appears to be fleshy and secrete honey. Introducing a bristle into one of these circular apertures and bending it about as an insect would its proboscis, the disc becomes usually attached and on withdrawal brings out the pollen. When one does this there is a sudden motion of the pollen-masses which immediately spring forward so that they are in a line with the disc and bristle to which it is attached (whereas formerly they were inclined at 60° to it). Hence on entering another flower the pollen-mass will enter the circular aperture and be in the right position to touch the stigma. Visitors:—Numerous Lepidoptera: *Junonia Rhadama*, *Closterus flabellicornus*, *Limnas chrysippus*, sp., *Acraea Zitya*, and three other species. Hymenoptera: *Apis unicolor* and a sand-wasp form. Diptera: No. 502. Coleoptera: No. 520.

***Belmontia cordata*, E. Mey (Fig. 99).**

The tube of the corolla is 6 to 7 lines long, while the limb measures nearly 10 lines in diameter. The anthers are lodged in a slight swelling just below the throat of the corolla. The greatest peculiarity lies in the occurrence of two stigmata quite separate and distinct from one another. The first is on the extremity of the style and projects out of the throat: so far as I could see, it had normal, well-developed stigmatic papillae; the second is about 2 or 3 lines below this and consists of two longitudinal ridges on the style about a line long: I thought I distinguished germinating pollen-grains upon it. There are peculiar round knobs on the tips of the anthers; in young flowers these are erect and surround the style, while in older flowers they are reflexed and hang downwards; they may secrete a sticky substance rendering the pollen adhesive. The second stigma seems to me

a contrivance to produce self-fertilisation in case the first stigma adapted to cross-fertilisation should receive no pollen. Visitors:—*Apis mellifica*? also a Bombylid, *Pangonia angulata*?—Muizenberg, Cape Town.

Tachiadenus.

In this genus the stigma is well above the anthers. Honey is secreted by a minute ring round the ovary. Visitors:—Lepidoptera abundant.—Imerina and Fort Dauphin.

***Ipomoea palmata*, Forsk.**

The stamens are united to the corolla for about 3 lines and by bending forward towards the style leave a sort of chamber below in which honey is secreted. The nectary is in the form of a ring round the ovary. The staminal filaments are very hairy and the pollen appears to drop on to these hairs. Insects creeping down the corolla will receive pollen on their back from the anthers in young flowers and touch the style in older ones. Visitors:—*Apis mellifica* and Coleoptera.—Fort Dauphin.

***Ipomoea Pescaprae*, Roth.**

The filaments are not united to the corolla. Cf. Burgerstein (Macleod, No. 64 a).

***Lobostemon fruticosum*, Buek. (Fig. 100.)**

The flower is distinctly protandrous. The stamens are of different lengths varying from 5 lines (superior) to 9 lines (inferior). A honey chamber is formed by the hairy projecting bases of the filaments (*h* in figure). Subsequently the style elongates growing beyond the anthers. Visitors:—Hymenoptera: *Xylocopa caffra*, *Apis mellifica*, *Ceratina subquadrata*, *Tetratonia longicornis*. Coleoptera: *Anisonyx ursus*, *A. longipes*, *Dichilus dentipes*, *D. simplicipes*, *Peritrichia capicola*.

For *L. montanum*, see Ann. of Bot. l. c. p. 271.

***Lycium capense*, Mill. non Thunb. (Fig. 101.)**

This is extremely similar to *Lycium barbarum* described by Müller. The nectary is a small ring round the ovary. Visitors:—*Apis mellifica*, ab. also various butterflies.—Fort Dauphin.

On *Lycium* see Müller, p. 426 and No. 590 III ; also No. 702 ; also *L. tubulosum*, Ann. of Bot. l. c. p. 271.

Craterostigma nanum, *Bth.*

There is a short corolla-tube and a well-marked lower lip more than half an inch long. At its highest point, about two lines before the entrance to the tube, the lower lip is furnished with two yellow solid tubercles about a line high and half a line thick. The outer filaments are attached to the lower lip near the origin of these tubercles: the filaments themselves have a basal *horizontal* portion and then suddenly bend at right angles and converge together just under the relatively short upper lip. The inner filaments are short and also converge to a point 2 lines below the outer anthers. The two pairs of anthers are united severally and are somewhat hairy. On depressing the lower lip by pushing the tubercles gently downwards, the upper pair of anthers is brought forwards so as to lie in the line of entrance to the corolla-tube. Such a motion of the stamens is as far as I know unique in Scrophulariaceae. Subsequently when the anthers have finished dehiscing, the stigma elongates and its two lips unclose in a position between the two pairs of anthers. Visitors:—a Hymenopteron, No. 342.

Nemesia floribunda, *Lehm.*

Visited by *Apis mellifica* which inserts its head in the spur and sucks the honey. In so doing, it must remove the pollen from the four anthers arranged above and below the stigma. The flower is probably protandrous.

Nemesia barbata, *Bth.* (Fig. 102.)

The calyx and pedicels are covered with stalked glandular hairs on which one finds the bodies of unnecessary insects. I was not able to satisfy myself whether honey is wholly secreted by the base of the ovary in this genus (so as to drop into the spur), but I could not make out clearly any secretion by the spur itself.

Zaluzianskya coriacea, *Walp.* (Fig. 103.)

In this genus the stigma projects out of the corolla-throat and must first come in contact with an insect standing on the limb. The two anterior stamens are exerted and their anthers are transverse or horizontal during dehiscence, while the posterior anthers are wholly included and their anthers dehisce parallel to the corolla-tube, lying close to its lower surface. The nectary is chiefly developed on the *upper part* of the ovary at the base of the flower. The length (14 lines) of the corolla-tube would lead one to suppose Lepidoptera to be the chief fertilisers of this flower. The limb appears to be closed over the corolla-entrance in dark or cloudy weather.

Phyllopodium diffusum, *Bth.*

The stigma stands well in front of the anthers and of the entrance to the corolla-tube. The longer stamens are exerted and dehisce outwards with anthers inclined at 45° to the horizon: the shorter stamens are almost wholly included and dehisce upwards. Visited by a long-tongued Dipteron remarkable for the extremely hairy yellowish brown abdomen.—Near Cape Town.

Chaenostoma polyanthum, *Bth.*

The style and anthers are both exerted in this species. One insect (? *Odynerus*, sp.), which I was able to watch, was standing *upon the style* and inserting its head *between* the reniform anthers. Also visited by Diptera.—Somerset East.

Manulea Cheiranthus, *L.* (Figs. 104, 105.)

In this genus there is a very short style which only reaches about half-way up the corolla-tube. The anthers are both included in a slight dilatation just below the throat of the corolla. On looking at the corolla from in front, it will be seen (see Fig. 105) that the transverse section of the tube is not circular, but that, owing to a folding inwards of the lines of union of the petals, two canals are formed opposite the two upper petals down which an insect's proboscis must pass *c, c* (see Figs.). The ridges between these canals and the canals themselves are continued inwards for about one line

(that is past the insertion of the stamens). Each of the ridges bears three longitudinal rows of yellow clavate hairs. This arrangement is very complicated at first sight, but is really a simple and beautiful adaptation to cross-fertilisation. When an insect is inserting its proboscis, the curve in the latter will cause it to travel along these canals and quite out of the way of the stamens: moreover the hairs on the internal ridges, *r*, will also prevent any of the plant's own pollen being shaken down the tube. On withdrawing the proboscis, however, it will slip downwards (while straightening) amongst the hairs and stamens and cannot fail to be covered with pollen. The anthers of the two pairs of stamens have the same difference in shape which occurs in *Zaluzianskya* (see above). A long watch did not enable me to find any insects on this plant. *Manulea rubra*, L. seems identical with the above species.

Ilysanthes capensis, *Bth.* (Figs. 106-108.)

The corolla is much like that of *Mimulus* but the arrangement of the stamens is very peculiar. The two upper are erect and arch together so as to dehisce downwards on the back of an insect entering the flower, while the two lower have longer perfectly horizontal and straight filaments lying flat on the lower surface of the corolla. These latter are scabrous and have an appendage or seta usually pointing backwards at an angle of 45° to the filament, and which affords apparently a foothold for insects while entering. The flat triangular stigma lies above the upper anthers. Self-fertilisation is however possible.

The capsules when ripe become bent downwards at an angle of 45° to the stem. This appears to be due to growth taking place at the inner (stem) side of the base of the pedicel, where a small tubercle is formed. *If, however, ripe capsules are not produced no growth takes place* (cf. *Hemimeris sabulosa*).

Utricularia spartioides, *E. Mey.*

The lower lip of the corolla forms an enormous spur with

the lateral margins slightly bulged and these margins are completely fitted and covered by the upper lip. The stamens lie close together against the upper lip, and the stigma is above them. A bee entering must touch the stigma before it reaches the anthers. The irritability of the stigma pointed out for *U. vulgaris* by Hildebrand (Müller, No. 356) and Beal (Müller, No. 44) is scarcely distinguishable in this species. Visited by a small Hymenopteron, *Odynerus*, sp.? sucking and gathering pollen.

Colea decora, *Boj.* (Figs. 109–111.)

The flowers are an inch long and the corolla is at the throat 5 lines broad and only 3 lines deep. The style is well in front of the stamens and is additionally protected from its own pollen by a distinct upward curvature which in the young condition keeps it in contact with the upper part of the corolla-tube: if loosened from the corolla in this state, it bends back, as shown in the figure, proving that it has a distinct tension. The stamens have their filaments slightly curved and dehisce upwards. The corolla is white but dark red inside except the two longitudinal ridges, seen in section, Fig. 110, which are bright yellow and are covered with hairs. These ridges are due to the arrangement of the petals in bud (see Fig. 111). Visitors:—Birds, *Nectarinia souimanga* is very fond of this flower. Also various butterflies and moths (one species of clear-winged moth is a very regular visitor) as well as *Apis mellifca* collecting pollen.—Fort Dauphin.

Rhytiglossa eckloniana, *Nees*.

The peculiar twisting of the corolla-tube so that the anterior and posterior lips are reversed in position ensures that insects will enter above the stamens and style. The method of fertilisation is similar to that of *Plectranthus*.

The two stamens are at first straight and dehisce upwards: after dehiscence they move sideways, and curl themselves round the lower lip of the corolla. The style then elongates till it occupies their former position and the stigmatic surfaces unclose. Visited by numerous Diptera and Hymenoptera.—Bedford.

Asystasia gangetica, *T. And.*

The corolla is rather like that of *Digitalis* but much smaller and somewhat contracted at the base so as to form a sort of honey-pouch. There is marked protandry: *in the first stage* the stamens are arranged in pairs close to the upper lip of the corolla, and dehisce downwards while the immature style lies behind and above them; *in the second stage* first the two anterior stamens and then after an interval the two posterior bend sideways while the end of the style curves downwards and the stigmatic lips are open and ready for the pollen (cf. *Stachys*, see below). Visitors:—Hymenoptera: 8 spp. (Nos. 388–395). Lepidoptera: 1 sp. (384). Coleoptera: 1 sp. (378).—Durban.

Rhinacanthus oblongus, *Nees.*

This is markedly protandrous. The style in the second stage bends forward between the anthers and in so doing may effect self-fertilisation if all the pollen has not been removed by insects (cf. Delpino, Müller, No. 177). Visitors:—Lepidoptera.—East London.

Brachystephanus cuspidatus, *Scott Elliot* (Fig. 112).

The flowers are mauve in colour and there is marked protandry; the final condition being that shown in the figure. Visitors:—*Nectarinia souimanga* not uncommon! Lepidoptera: at least seven species including two species of *Papilio*. Hymenoptera: *Apis mellifica*, *Icaria Rhodorae*, and another, all stealing honey from holes bitten at the base of the flower.

Oftia africana, *Bocq.* (Fig. 113.)

The flowers are small and white and are strongly scented. There is a short and curved corolla-tube with a small spreading limb. The style is included and the stigma faces the upper side of the corolla-tube just behind the anthers, and yet, in spite of its apparent certainty, self-fertilisation is probably quite impossible; first, because the curve of the corolla-tube is such that the anthers are not *above* the stigma but *in front of it*, and pollen cannot therefore naturally fall upon it: secondly, because the inside of the tube is largely covered by hairs, all

of which point upwards, and by using a bristle, I came to the conclusion that the pollen (which seems to come out bodily from the four anthers) cannot be forced down the tube but is only removed on withdrawal. It is difficult to see how pollen can be introduced to the stigma as these hairs would tend to prevent it, but probably they eventually wither. Visitors :— Coleoptera : gathering pollen. Diptera ; a Bombylid? Probably the main fertilisers are night-flying moths.

***Dischisma ciliatum*, Chois.** (Fig. 114.)

The flowers are marked with red and fairly conspicuous from their aggregation in a pretty long raceme. The corolla has a delicate tube about 4 lines long which is split half-way to the base. Probably this apparent splitting is due to the non-development of one petal which is represented as a small tongue at the end of the slit. There is a difference in the shape of the anthers ; the two upper anthers being horizontal and the two lower vertical (cf. *Zaluzianskya*, *Phyllopodium*, *Manulea*). The style projects a long distance out of the corolla, and is curved with the concavity of the curve appressed to the rudimentary petal. The flowers are visited by *Apis mellifica* which, as I saw clearly, plunged its head between the anthers and touched the stigma with its abdomen. The method of fertilisation is therefore identical with that of *Chaenostoma* (p. 368).

***Ocimum hians*, Bth.**

The stamens and style are both widely exerted in this flower, but the latter lies well in front of and above the anthers. The essential organs are not in contact with the lower lip because the staminal filaments curve upwards in a slanting direction. There is a hairy enlargement of the filaments in the throat of the corolla which probably completely excludes small insects from the honey. (Cf. Sprengel, who pointed this out in 1793, Müller, No. 702.)

***Synclostemon densiflorus*, E. Mey.**

The mechanism and shape of this flower is very similar to that of *Plectranthus Eckloni*. The outer stamens roll

forward and dehisce whilst the filaments are straight, then by a continuation of the rolling motion become bent back over the lower lip: the inner stamens follow suit and finally the style elongates and the stigma occupies the position taken by the anthers during dehiscence. The calyx is extremely viscid and hairy, but in spite of this ants are able to enter the flowers and steal honey. The nectaries consist of two short tongue-like projections behind and in front of the ovary. Visitors:—a *Bombylius* with a proboscis $\frac{9}{10}$ th of an inch long, very abundant; a large yellow butterfly, a small *Odynerus*? gathering pollen but effecting fertilisation accidentally.—Perie Mountains.

Synclostemon dissitiflorus, *Bth.*

This is very similar to the preceding species. The nectary is in the form of four tongue-like pieces surrounding the ovary. Visitors:—*Syrphus*? *capensis*.

Plectranthus Eckloni, *Bth.*

The flowers are blue, and as the plant is sometimes eight feet high, it forms a very beautiful part of the undershrub in the Perie Bush. In the young state all the anthers are rolled backwards and included in the corolla-tube, but as the flowers ripen, the outer stamens uncoil and roll forwards dehiscing while the filaments are in a line with the corolla-tube: then by a continuance of the rolling motion they coil themselves round the lower lip. The second pair of stamens follow them and dehisce almost in the same position and then like the first roll themselves round the lower lip. Lastly the style rises and occupies nearly the same position as the stamens, while its stigmatic lips unclose and are ready for fertilisation. Visitors:—*Apis mellifica* collecting pollen; a Bombylid sucking and effecting cross-fertilisation. Two Lepidoptera.

P. fruticosus, *Herit.*

A near ally of the above species has been described and figured by Hildebrand (Müller, No. 360).—Perie Bush.

***Plectranthus Melleri*, Bkr.**

The flowers are small and mauve with dark spots (honey-guides) on the upper lip. The four stamens in this species roll forward and dehisce together at a point opposite the entrance to the corolla-tube. Subsequently they continue the unrolling process and bend down on each side of the lower lip. The stigma then elongates and rises slightly. The nectary consists of both an anterior and a posterior ridge.

***Plectranthus calycinus*, Bth.**

The corolla is covered externally with woolly hairs and has a very peculiar shape; the tube is extremely deep and its axis is inclined to that of the pedicel. The lower lip has the two sides bent up so as to have a boat-shaped appearance, something like the carina of a leguminous flower: when at rest the two edges of this carina fit between the lateral petals which form cushion-like ridges on either side of the broad opening of the corolla-tube and so completely close it. The essential organs are contained in this carinoid lower lip. An insect must alight on this carina or lower lip and force it down, and whilst doing so the stamens emerge and dust its sides with pollen, whilst in older flowers it must also be touched by the stigma. The lower lip flies back elastically after depression and it requires considerable force to press it down. The nectary is chiefly developed on the front of the ovary and a small pinching-in of the corolla just before it forms a sort of cup in which honey accumulates. The woolliness of the corolla is to prevent insects biting an entrance to the tube. I found many flowers with a small hole at a point just above the nectary, and caught a small fly with a proboscis $\frac{3}{10}$ of an inch long sucking through these holes.

***Plectranthus laxiflorus*, Bth.**

This species is remarkable for the sudden bend at right angles in the corolla-tube. The lower lip has the same boat-shaped appearance as in *P. calycinus* and also the same tension which makes depression hard to produce. I watched a bee enter and could see that it required considerable force to

press the carina down. The stigmatic lips do not appear to unclosetill the anthers have dehisced.

Plectranthus tomentosus, *E. Mey.*

Agrees with preceding species.

P. glaucocalyx, *Maxim.* has been described by Loew (Macleod, No. 294) and appears to belong to the type of the three last-described species. The genus contains therefore two quite distinct modifications leading to different ways of fertilisation. The first marked by the very strong protandry and coiling of the stamens round the lower lip, and the second by the elastic boat-shaped lower lip including both stamens and style.

Stachys Lyallii, *Benth.*

This has practically the same arrangement as *S. palustris*, L. (cf. Müller, Nos. 178, 702). In the first (male) condition the lateral outer stamens have their anthers in front of those of the median stamens and dehisce in that position: they afterwards twist sideways so that their anthers are carried out of the way and drop off outside the flower. The median anthers then bend a little forward and dehisce, afterwards turning sideways like the outer lateral ones. Last of all the style bends considerably forward and the stigmatic lips open. Visitors:—*Apis mellifica*, probably *Odynerus* spp. Lepidoptera: 1 sp. (No. 284)—Hebron and Klerksdorp.

Stachys caffra, *E. Mey.* and *S. aethiopica*, L. (Figs. 115–117.)

Seem to have exactly the same arrangement as the preceding species.

S. annua, L. as described by Schulz (Macleod, No. 516) is quite similar, but as he makes the extraordinary statement that spontaneous self-fertilisation is easily possible, I cannot understand his description. Surely this observer cannot have failed to notice protandry in this species. At any rate in no other species of *Stachys* is self-fertilisation possible so far as published observations go.

***Salvia africana*, L. (Fig. 118.)**

The style stands in front of, or a little above, the extremity of the lower lip, and does not, so far as I could see, alter its position during the flowering. The lever-apparatus is of the ordinary type. Visitors:—*Xylocopa caffra*, also *Peritrichia capicola*.—Wynberg.

***Salvia stenophylla*, Bth.**

There is a lever-motion of the stamens but it is not of a high type. The inner anther-lobes apparently even produce a little pollen, and the rotation is very slight, only sufficient to bring the outer anther-lobes in the direction of the straight line passing from the stigma down the corolla-tube. Visitors:—*Pieris hellica* and two other species of Lepidoptera.—Pretoria.

***Teucrium africanum*, Thunb.**

Visited by Lepidoptera.—King William's Town.

***Vitex Bojeri*, Schauer (Fig. 119).**

The corolla is pink and covered externally with short hairs. The four anthers lying close together project considerably out of the corolla-tube while the stigma always lies behind them. The nectary is a small rim round the base of the ovary.—Fort Dauphin.

***Nepenthes madagascariensis*, Poir.**

I found the pitchers in this species to be usually from a third to half full of the decomposing remains of insects. In almost every pitcher there are live maggots or worms, which I could not manage to preserve, apparently living on the remains. Amongst the insects I selected at least thirteen species of Coleoptera (a species of *Hoplia* being very abundant); ten species of Lepidoptera; seven kinds of Hemiptera; four species of Hymenoptera, of which one was a sand-wasp nearly an inch long; twelve species of Diptera, including specially Tipulæ, green flies, and house-flies; two Grasshoppers; two Dragon-flies; and one spider.—Fort Dauphin.

Leucadendron adscendens R. Br. (Figs. 120-121).

The flowers are unisexual and dioecious. In the male flower, the pollen is shed upon the barren style which is marked by eight faint longitudinal grooves corresponding to the anther-loculi, and which are homologous to the deep ones on the style of *Protea*: it appears to be held upon the style, however, mainly by a yellow, sticky secretion in the epidermal cells of the latter. The female flowers have the stigmatic surface always inclined outwards, usually at about 45° to the style. For *Protea* and *Leucospermum*, see Ann. of Bot. Vol. IV, No. xiv, p. 274.

Serruria congesta, R. Br. (Fig. 122.)

The sepals in the bud are closely united over the tip of the style. If they are touched when the flower is ripe, they spring sharply back and immediately become strongly reflexed, showing that their outer surface has a stronger tension than the inner. A certain amount of pollen is scattered by this sudden separation, but most is held on the thickened style-extremity, which is faintly ribbed and seems also sticky. The stigma lies in a minute depression at the summit of the style, and does not ripen till after the pollen has been in large part removed. The anthers end in barren tips, *t.* Visitors:—*Apis mellifica* and other Hymenoptera.

Pterygodium alatum, Sw. (Figs. 123-126.)

In this species the posterior sepal and petals are connate into a helmet-like hood, the 'galea': the labellum and column are adnate, and form what is called the 'lamina,' the shape of which will be clear from Fig. 123 (the view in front) and Fig. 124, a longitudinal mesial section. It consists of an upright column blocking the entrance to the galea, and in the lower part of a broad membranous bilobed wing, which on both sides turns slightly sideways so as to be visible in the longitudinal section. The anther and stigmata occupy the cavity of the galea behind the upright part of the lamina, and a deep groove which is lowest in the middle (i. e. at insertion of lamina) separates them from it. The two lobes of the anther

and stigmata are widely separated from one another and as seen from in front appear as two little projections above the lateral wings of the lamina (see Fig. 126, *a, c*). Honey appears to be secreted at the point *n*, which is a most unusual position, corresponding, as it apparently does, to the missing stigma, and being exactly behind the middle point of the lamina; the groove already noticed leads down to this point *n*, over the lateral wings of the labellum, and obviously is the path by which an insect's proboscis much reach the honey. This explains the position of the disc which is exactly at the entrance to the groove (see Figs.), and, as may easily be shown by making a slender bristle travel down the groove, an insect's proboscis must on withdrawal bring away the disc and attached pollinium: when this happens there is a slight curvature of the caudicle, bringing the base of the pollinium closer to the disc. The pollen-masses are transversely fringed and broad at the base, so that they will readily enter the galea cavity, but must on withdrawal catch on the stigmatic surfaces. What the use of the two pit-like cavities (*n, h*) at the top of the lamina can be, I was unable to make out. Probably visited by some Dipterous insect.

Angraecum superbum, *Pet. Th.* (Figs. 127-129.)

The structure of this flower can be readily understood from the figures. The labellum is hood-shaped, and possesses a thickened crest (*cr*) seen in section (Fig. 128) on its inner face. There is a pit or ditch excavated in the column between the spur entrance and the anther. The latter is raised on a round 'boss,' as seen from the outside (really the top of the column); the disc lies in a narrow groove at the highest point of this 'boss,' just in front of the pit and entrance to the spur. The method of fertilisation is very simple. An insect must stand on the sepals and petals, and insert its proboscis into the spur. As the crest, however, projects so much forwards, the proboscis (being also naturally curved) must be made to slip over the groove *o*, and on retraction must take off the disc and pollinia. This can easily be verified by means

of a bent bristle. On entering another flower the pollinia will be left in the ditch or pit, the sides of which are stigmatic. Visitors:—I found a male *Nectarinia souimanga* sucking the flowers, and certified that it removed at least one pollinium, but as the flowers are scented at night it is probably chiefly fertilised by night-flying moths, such as the Sphingidae (of whom some have proboscides eighteen inches long or more). Cf. Moore (Müller, No. 537), Darwin (Müller, No. 165).

Disperis villosa, Swartz (Figs. 130-132).

In this form the posterior sepal and the lateral petals are connate into a galea which has almost exactly the shape of a poke-bonnet (Salvation Army type). The anterior sepals spread out diagonally in front. The labellum has a narrow thread-like basal portion, and ends in a slightly thickened boat-shaped extremity which appears to secrete a sweet substance. It is bent upwards and then folded back at a right angle so that this thickened extremity lies inside the galea and upon the top of the column. The column ends in the large anther-case, which is horizontal and reniform in shape. The end of the labellum lies in the groove of this reniform anther. The most striking peculiarity of the flower is the manner in which the anther-case terminates at both ends in front. The membrane of the anther-case at each anterior point is drawn out into a spiral ribbon which projects out of the opening to the galea, and is about two lines long: these two little coils stand further forward than the labellum which lies between them, and are close to one another. The caudicle of the pollinium lies along the inner side of their coils, and its disc is on the under surface of the extremity at *d* (Fig. 131). In consequence of this arrangement, the readiest way for an insect to reach the honey secreted on the upper surface of the thickened end of the labellum (point *n*, Fig. 132) is by passing its proboscis *under the arching extremity of the coil*, i.e. below the disc. In doing this, it must search for the nectary by bending its proboscis about, and cannot fail to touch the disc, which immediately clasps it firmly. On

withdrawing the pollinium by a bristle in the way an insect would do, the pollen-mass immediately drops through 60° , or even 90° , and if one now introduces the bristle with the attached pollinium below the coil of another flower, it is seen that this inclination brings it in contact with the stigmata which lie on either side and just below the labellum. I found that in a hundred flowers examined, six had one, and two both pollinia removed. Some of the numerous long-tongued Diptera would be quite able to fertilise this flower (cf. Bolus, 'Orchids of the Cape Peninsula'). Mr. Weale has described a species of *Disperis* from the Kagaberg, but unless I misunderstand his description, the structure is very different from this species (Müller, No. 765).

Moraea.

The different species of this genus show a great deal of variation in some important characters. Thus in *Moraea tristis*, Ker (No. 1148!)¹, there is no very obvious difference between the external and internal perianth-segments, which together form a campanulate tube down which insects may crawl in any direction: moreover, the style-branches are short (though broad) and supported on a column fully 3 lines long. In *Moraea tripetala*, Ker (No. 1081!) the internal perianth-segments have almost disappeared, while the style-branches are separate almost to their bases and each is so closely applied to its corresponding external perianth-segment as to form a complete tube down which the insects are obliged to crawl. All the species which I studied may be grouped between these two, and form a gradual series of transitions (Figs. 133 and 142).

Moraea tristis, Ker (No. 1148!) (Figs. 133, 134).

Honey is secreted at the base of the external perianth-segment. Visitors very rare.

Moraea edulis, Ker (No. 1199!).

The flowers are purple and the external perianth-segments

¹ The species are so hard to distinguish that I have quoted my collecting numbers throughout. The originals are at Edinburgh or Kew.

have a white dot at the tube-entrance; there are three distinct longitudinal rows of hairs along the claw. This is a dimorphic species (cf. Müller, p. 545). One form is exactly like another species, No. 1095! while in the other the arrangement is much like that of *Moraea tristis*, No. 1148! Visitors:—*Anisonyx ursus* and other Coleoptera.

***Moraea tricuspis*, Ker** (No. 1096! Figs. 135–137).

The style-branches are supported on a very distinct column in this species. The internal perianth-segments end in a peculiar three-lobed tip (see Fig. 135), while the external perianth-segments are distinctly concave and possess at the base a small square scale which forms a pouch for the honey. Visitors:—Coleoptera: *Anisonyx ursus*, which I saw crawling down the external perianth-segment and sucking the honey.—Sea Point, Cape Town.

***Moraea angusta*, Ker** (Nos. 1095! 1150! 1198! Figs. 138–140).

The flower is large and in this species each style-branch and its corresponding external perianth-segment are closely approximated to form a complete tube as in *Iris*. The inner perianth-segments prevent the entrance of small insects at the base. In some cases however this tube was not complete (cf. Müller, l. c. p. 545.) Visitors:—Hymenoptera: *Ceratina* sp., ants stealing honey. Diptera: *Pangonia angulata*, *Lucilia argyrocephala*, and others. Coleoptera: *Anisonyx ursus*, *Dichilus simplicipes*, and another sp. (No. 186.)—Devils Mtn. and Washhouses.—Cape Town.

***Moraea papilionacea*, Ker** (Fig. 141).

Except for the presence of large internal perianth-segments, this scarcely differs from the preceding. Visitors:—*Apis mellifica*, very ab. covering its back with pollen, visiting each segment of the flower and crawling backwards out of each (cf. Sprengel, l. c. No. 702 and Müller, l. c. p. 545), also ants stealing honey and *Empis bivittata*, sucking.

Moraea tripetala, *Ker* (No. 1081 ! Fig. 142).

In this form the style-branch and external perianth-segment form a perfect tube, while the internal perianth-segment has vanished. Visitors :—Hymenoptera.

Homeria elegans, *Sweet*.

The flower is of a very simple type, similar to that of a *Crocus* but without the elongate perianth-tube which characterises that genus. The anthers are longer than the style-branches, which however being broad, project sideways between them ; the bifid teeth on the dorsal side of the style-branches are at first erect as in *H. collina*, but subsequently become reflex and pendulous (cf. *Crocus*, Henslow, Gard. Chron. Vol. V. p. 504, and Müller, 'Alpen-Blumen,' p. 56). Visitors :—*Apis mellifica*, very ab., also Coleoptera.—Cape Town.

Homeria collina, *Sweet*.

In the typical form the stigmata are at first lower than the anthers, but eventually elongate till they are about a tenth of an inch above them. The segments of the perianth are reflexed at the apex, and it is chiefly on the reflexed part that insects alight. In the variety *miniata*, Bkr. the segments are erect, and insects usually alight upon the stigmata and then crawl down over the anthers. Visitors :—Typical form. Hymenoptera : a large ? *Xylocopa* (possibly accidental), three kinds of ants. Diptera : *Syrphus*, a form very like the house-fly, both efficient and two small sp. Coleoptera : *Anisonyx ursus*, *Dichilus simplicipes*.—Twelve Apostles, Cape Town.

Var. *miniata*. Visitors :—Hymenoptera : *Apis* stealing honey from base of perianth. Diptera : 2 sp. unnamed. Coleoptera : *Anisonyx ursus*, *A. longipes*, *Chilomene lunata*, and another.—Muizenberg and Cape Town.

Ferraria undulata, *L.* (Figs. 143, 144.)

The perianth forms a capanulate tube about 6 lines deep and the horizontally spreading limbs are about 8 lines long with crisped wavy margins. Honey appears to be secreted by the very thick bases of the segments, and collects in longi-

tudinal hollows on either side of the midrib. The anthers lie well below the style-branches, which are cut up into laciniae forming a sort of bush of papillae above the pollen. The colour is a sort of lurid purple with yellow blotches and appears very attractive to saprophytic flies, e.g. *Scatophaga hottentota*, *Chrysomia regalis*, *Lucilia*, sp., and others. Sometimes these alight on the laciniae of the style and sometimes on the perianth-segments.—Botanic Garden, Cape Town.

Romulea.

The general method of fertilisation in this genus is almost exactly similar to *Crocus* (cf. Müller, 'Alpen-Blumen,' p. 56); but the style-branches are divided and the neighbouring stigmata project in pairs between the anthers and not (in those I saw) above them (cf. Benth. and Hook., Gen. Plant. p. 694). Honey is secreted by the base of the filaments and is usually protected from rain by hairs on the filaments, or perianth-segments. A tube similar to that of *Crocus* is found in all stages of development in the various species.

Romulea rosea, Eckl. (Fig. 145.)

There is a short tube in this form; the throat of the perianth is yellow with black honey-guides, while the general colour is a deep scarlet. Visitors:—*Allodape pictifrons*.—Near Cape Town.

Romulea hirsuta, Eckl.

The flowers are pink, but in most points very similar to the preceding species. The sepals have strongly marked black lines on their lower surfaces which may be honey-guides for insects creeping up the flowers. Visitor:—*Halictus*, sp.

Romulea bulbocodioides, Eckl.

Flowers white, very similar to the preceding. I never saw any flowers with the style twice as long as the anthers such as those found by Battandier (Bull. Soc. Bot. de la France, t. XXX. p. 238).

Galaxia graminea, Thunb. (Fig. 146.)

In this form the stigmata are well above the anthers.

The very long perianth-tube distinguishes this genus from *Homeria* and *Romulea*. Honey is secreted (so far as I could see) by the base of the perianth-segments and it is hard to see of what possible use the long tube can be to the plant (cf. Sprengel, on *Crocus*, Müller, No. 702). Visitors:—*Anisonyx ursus* and two species of small Diptera.

Aristea pusilla, *Ker.*

The flowers are extremely small and fugacious. They are rendered unsymmetrical by the excentricity of the style, which being relatively very long falls over to one side. The flower-axis is almost vertical. Francke (Macleod, No. 156) has described and figured this species correctly in his Inaugural Dissertation. Visitors:—Hymenoptera: *Halictus*, sp. Diptera: *Lucilia*, sp. Coleoptera: *Anisonyx ursus* (all of which are under five lines long).

Aristea spiralis, *Vahl.* (Fig. 147.)

The flowers are almost one and three quarters of an inch in diameter. They are markedly zygomorphic and compared with *Gladiolus* and *Antholyza* show exactly the same difference that one finds between *Plectranthus* and *Stachys*. The style is almost straight and lies on the lower part of the perianth; it is much longer than the stamens whose dehiscing face is directed upwards. Insects enter the flower by passing above and over the anthers and style. In consequence of the rigid and broadly inserted spathe, the flowers are obliged to come out on the other side of the stem, viz. at 180° inclination to their natural position. In young buds, the stamens are quite regular, and the twisting by which the lateral stamens are made to dehisce upwards and not outwards, takes place very late; in some buds, in fact, which opened in my room, it did not take place at all. Visitors:—probably *Xylocopa caffra*.—Wynberg.

Hesperantha falcata, *Ker.*

There is a narrow cylindrical tube, fully 5 lines long in mature flowers, which is full of honey. As the flowers open and are scented in the evening, they are probably visited by night-flying moths.

Ixia graminifolia (Fig. 148).

There are only two or three flowers at the extremity of the long pendulous stalk. The perianth has a very narrow tube, 2-3 lines long, ending in a campanulate limb about half an inch in diameter. The filaments are only one line long, and the subulate style-branches project between the anthers and rest upon the perianth-segments.

Ixia excisa, *Thumb.* (Fig. 149.)

In this species the perianth-tube is 7 lines long. The style is well above the stamens, and as the perianth-limb is only about 3 lines in diameter, insects probably alight *on the style* and not on the perianth as in the preceding species. I found one Dipterous insect acting in this way. I have, however, found the flowers fully expanded so as to be nearly 8 lines in diameter, and in such a case, the fertilisation is probably the same as in the preceding.

Ixia columellaris, *Ker.*

The perianth-tube is long (5 lines), and rather slender; the limb is campanulate or almost stellate and measures 13-14 lines across. The style-branches appear between and about half-way up the anthers. The filaments are fairly long and united both to one another and the perianth, so that entrance to the honey in the tube can only be obtained by passing the proboscis between the anthers and inside the tube formed by the filaments.

Geissorhiza secunda, *Gawl.* (Fig. 150.)

The perianth-tube is extremely short. There is also a distinct tendency to zygomorphy; thus the anterior external perianth-segment is distinctly longer than the other two and the two anterior-lateral inner perianth-segments are broader than the others. The style moreover is longer than the anthers and bent upwards, lying above them as in *Gladiolus*. The anthers, however, dehisce extrorsely, and are quite regular. Visitors:—*Apis mellifica*, *Halictus*, sp., and another (No. 194), also *Bombylius lateralis*.—Wynberg.

***Freesia xanthospila*, Klatt.**

The style is longer than the anthers before the latter begin to dehisce. Hence a bee beginning, as it usually does, on the oldest flower, will first touch its stigmata producing cross-fertilisation, and as it goes along the spike, will become well covered by the pollen of the younger. It can scarcely avoid fertilising the second and third flowers with pollen from the first however.—Visitors :—*Apis mellifica*, c. p., ab.—Cape Town Gardens.

***Lapeyrousia corymbosa*, Ker.**

The flowers are arranged in a dense corymb and are usually mauve with a white star in the centre, bordered by dark purple lines. The flowers are markedly protandrous ; in the first stage the style with closed branches rests on the perianth, while the stamens are erect in the centre of the flower and their anthers dehisce upwards. In the second stage the style straightens, becomes upright and stands in the centre of the flower with its branches very widely open. Self-fertilisation is possible, but only during the straightening process. Visitors :—Hymenoptera : small species of *Ceratina*. Diptera : *Pangonia angulata*, Forsk., another fly (much like the blue-bottle). Coleoptera : *Anisonyx ursus*, abund. (*Pangonia*, a large Bombylid, particularly abundant and visiting the flowers in a very thorough and conscientious way.)

***Melasphaerula graminea*, Ker (Fig. 151).**

The flowers are small, and the perianth is distinctly zygomorphic. The three inferior perianth-segments form the alighting surface for insects, and their edges are peculiarly turned upwards and undulate : the three upper segments are almost erect : there is a very minute perianth-tube usually full of honey, and entrance to it is obtained by two minute openings on either side of the anterior stamen. Visitors :—*Allodape* sp. nov. (a very small Hymenopteron). *Syrphus capensis*.

***Sparaxis grandiflora*, Ker (Fig. 152).**

This flower really belongs to the *Gladiolus*-type, but there are some interesting peculiarities. First, the flowers are not pendulous, but *inclined backwards* towards the axis on which

they are supported. The style is long (about one inch) and its branches when open are on the same level as the tips of the perianth-segments, and afford a convenient point for the insects (usually beetles) to alight upon. The wide infundibular perianth ends in a short tube about $3\frac{1}{2}$ lines long, which is full of honey. The stamens, however, have a special arrangement; for while the odd stamen is turned back towards the style and curved so as to have its dehiscing face directed forwards, the two lateral stamens are so twisted (through 180°) that they dehisce introrsely, so that the entrance to the honey-tube at *a* (see Fig.) is surrounded by three dehiscing anthers. This is, in the case of the lateral stamens, an advance on *Gladiolus* in which these anthers are only turned through 90° . Visitors:—*Anisonyx ursus* and *A. longipes*, both very ab. (Usually this beetle seizes hold of the two lateral stamens by its hind claws and swings itself down into the centre of the flower, and in doing so its hairy back becomes covered with pollen. Self-fertilisation occurs when two are in the same flower and chasing one another round it.)

***Tritonia squalida*, Ker.**

This form is rather like *Sparaxis*, but the lateral stamens are not so much twisted and the style usually lies against the lower part of the perianth.

***Babiana spathacea*, Ker (Fig. 153).**

The arrangement is in this species quite similar to *Gladiolus*. The perianth-tube is only about $3\frac{1}{2}$ lines long. The two inferior perianth-segments are turned up along the edges, and these edges are crinkled and wavy (cf. *Gladiolus pilosus*). The stigmatic lips hang in front of the anthers and are also below them. It is visited by *Anisonyx ursus*, which lays hold of the upturned edges of the perianth by its hind claws. The length of its hind legs will then bring the extremity of its back (which is covered with hairs) first against the bifid extremity of the style-branches, and then against the anthers. Self-fertilisation, however, is not excluded.—Kloof Road, Cape Town.

Babiana plicata, *Ker* (Figs. 154-155).

The perianth-tube is in this flower nearly eleven lines long. The stigma is at first well above the anthers, but self-fertilisation may be produced by the way in which the anthers curl upwards when withering (see Fig.) and by a slight sinking of the style. Visitors:—*Anisonyx ursus* also visits this flower, but it probably is not the most important visitor.—Sea Point, Cape Town.

Babiana ringens, *Ker*.

See *Annals of Botany*, Vol. IV. p. 278.

Gladiolus.

In this genus there appears to be great variation in the relative position of the style-branches and anthers which has led Treviranus (*Bot. Zeit.* Bd. XXI. p. 1) and Musset (*Comptes Rendus*, T. CVIII. No. 17) to consider the flowers as self-fertilised.

There is no doubt, however, that the flowers are distinctly protandrous, as shown by Delpino (see Hildebrand, *Bot. Zeit.* Bd. XXVIII. p. 670), and this clearly appears from Musset's own account of the same species (*G. segetum*). My own observations (on *G. pilosus*, *gracilis*, and *inflatus*) led me to conclude, *first*, that the anthers always begin to dehisce before the style-branches have unclosed; *secondly*, that there is in most flowers a second stage in which the open mature stigmata lie *quite in front*, though sometimes below the level of the anthers (Fig. 157); and *thirdly*, that self-fertilisation can only take place in such conditions as those drawn (see Figs. 158, 159), where the style-branches have finally been brought against the anthers either by themselves curling back or by the gradual sinking of the style itself.

Gladiolus gracilis, *Jacq.* (Figs. 160, 161.)

The mauve-coloured flowers of this species have the edges of the inferior lateral perianth-segments turned upwards so as to form four crinkled ribs running into the base of flower; *Anisonyx ursus* makes use of these edges to haul itself laboriously inwards. Its hairy body is adapted to

convey the pollen, and I have often found its back covered by it.—North West Side Lion's Head, Cape Town.

Gladiolus pilosus (Figs. 156–159).

Very similar to above and probably fertilised by the same insect.—Houwhoek.

Gladiolus inflatus, *Thunb.* (Fig. 162.)

The perianth has a remarkable similarity in shape to that of the Foxglove, and probably is visited by large bees.—Houwhoek.

Gladiolus longicollis, *Baker.*

The perianth ends in a tube 3.5 inches long and the flowers are visited by the Spurge Hawkmoth (on the authority of Mr. Medley Wood).—Natal.

Antholyza.

See *Annals of Botany*, Vol. IV. p. 277.

Iridaceae (*general remarks*)¹.

From the preceding it follows that there is really a very strong similarity in *Homeria*, *Ixia*, and *Romulea*, and if we were to take a sort of generalised *Romulea* as ancestor, the other genera would naturally group themselves into main lines of development, which are represented by *Moraea* and *Gladiolus* respectively. In the first line of development the species of *Moraea* afford a nearly perfect series of transitions from a form not very far removed from *Homeria* to one almost as highly specialised as *Iris* itself.

The two main features in this evolution of *Moraceae* are, first, the gradual disappearance of the internal perianth-segments. Now Heinricher (*Sitz. d. Kön. Acad. der Wiss. Wien*, Bd. LXXXVII. 1883, p. 114,) points out that this inner perianth-circle does not appear till very late in the development of the flower (after that of the stamens); hence we can perhaps see how

¹ One can scarcely regard Weismannism as anything but a theory unsupported by facts. I therefore maintain the following suggestions, based on undoubted facts, which may to a certain extent explain the origin of variations.

a form being early visited by insects might begin to form its seeds before this inner circle was complete.

It would have in this way an advantage, and the inner perianth-segments would become permanently more and more checked in development till they disappeared altogether.

The second great distinction is the enormous development of the style-branches, and here one may get a little nearer to the solution of the question. In almost all Iridaceae the stamens are fully formed before the style has finished growing; and this late growth of the style is one of the most striking features of the order. In *Sparaxis*, e. g., the young style lies feebly on the sides of the perianth, but as it becomes mature rises up, and stands eventually quite upright. Hence in flowers with a perfectly vertical axis we see how, if this excessive growth of the style late in life is any advantage, there would always be favourable variations arising. Moreover the separation or splitting of the style-branches down to their very base which characterises some Moraceae, is not entirely inexplicable, for their weight must tend to produce this result.

In the zygomorphic or *Gladiolus*-line of development there are also transitional forms. *Geissorhiza secunda*, Ker, tends in that direction and in a (possibly abnormal) form of *Babiana* (*B. stricta* var. *villosa* fide Prof. Macowan) I found the stamens quite straight and the style-branches appearing between the anthers just as in *Romulea*! The greater development of the lower perianth-parts is of course a common feature of zygomorphic flowers, but I thought I found that in those where this was most marked the upper perianth-segments were in the direction of the incident light and the lower transversely inclined to it. Of course the action of gravity would equally afford an explanation. At any rate in *Babiana ringens*, where the upper perianth-segments are much larger than the lower, the inclination of the flower is such that the lower are in the direction of the incident light and the upper transverse to it. In *Aristea spiralis* there is the same zygomorphy of the perianth, but the parts are morphologically different. The twisting of the filaments in *Gladiolus*, by which the anthers are made to

dehisce downwards, might be explained by the weight of the latter, which would tend to pull them into the position they assume. I append a list of the literature dealing with the family.

Crocus.—Henslow, Müller No. 327: Sprengel, Müller No. 702: Reid Macleod, No. 476. **Iris.**—Müller, l. c. p. 543: Sprengel, Müller No. 702: Kickx, Macleod No. 387(not seen): Focke, Macleod No. 131 (not seen): Heinricher, Macleod No. 193: Ludwig, Macleod No. 324: Licopoli, on pollen-grains only, Macleod 282, 283, 284. **Cypella.**—Müller No. 597: Müller, F., Macleod No. 419. **Romulea.**—Battandier, Macleod No. 42. **Aristea.**—Francke, Macleod No. 156. **Gladiolus.**—Müller, l. c. p. 548: Sprengel, Müller No. 702: Treviranus, Müller No. 742: Delpino, Müller Nos. 178 and 360: Arnaud, Müller No. 9: Focke, Macleod No. 131 (not seen): Meehan, Macleod No. 380: Musset, Macleod No. 435: Urban, Macleod No. 560.

Wachendorfia hirsuta, Thunb.

The structure of this species is almost the same as that of *W. paniculata* described and figured by Mr. Wilson (Trans. and Proc. Bot. Soc. Edin. Vol. XVII). I found it abundantly visited, on the Cape Flats near Kenilworth, by *Apis mellifica*, which however usually misses both stamens and style. Also *Xylocopa caffra* which was effecting fertilisation.

Myrsiphyllum asparagoides, Willd.

The filaments are triangularly flattened at the base, and thus form a sort of pouch in which a great deal of honey is secreted. Visitors:—*Apis mellifica*, very ab., s. and c. p.—Near Cape Town.

Kniphofia aloides, Moench.

This has been so thoroughly described by Stadler ('Beiträge zur Kenntniss d. Nectararien,' Berlin, 1886) that there is little further to give. I found the colour to be in younger flowers a deep red with the base and midribs darker, while in the older flowers as they fade and become closely appressed to

the peduncle it changes through pink to a light orange-yellow or almost white, so that if, as I think, it is fertilised by Nectarinae, this is of advantage as showing the birds which to avoid; I never found bees in South Africa entombed in the perianth (Macleod, No. 274 *a*).—Somerset East.

Lachenalia tricolor, *Thunb.*

Bees frequently bite holes in the perianth of this species and so steal the honey.—Cape Town Gardens.

Albuca major, *L.* (Fig. 163.)

The three inner perianth-segments are closely appressed to the style which projects a little beyond them; their extremities are abruptly bent inwards and this incurved portion (one line long, two lines broad, and about half a line thick) is movable at the bend (pt. *a* Fig. 163). The lower part of the inner filaments (f_1) is flattened and about a line and a half broad, and this flat basal portion stretches across the groove formed by the projecting lobes of the ovary, so as to form a pouch for the honey which is secreted by the base of the ovary; at a distance of one and a half lines from the base, however, the edges of the flat filament are brought inwards so as to form a narrow canal (f_2) which is the entrance to the above honey-pouch, while the uppermost part of the filament again flattens out and supports the freely movable anther, whose extremity lies beneath the incurved end of the inner perianth-segment. On pushing the inner perianth-segment gently away from the ovary, the tip of the anther is held by this incurved piece and the anther rotates on its filament till it forms an angle of 45° with it. At the Washhouses, Cape Town, I saw *Xylocopa violacea* and another large black bee hanging on to the pendulous flowers and inserting their heads within the inner perianth-segments; in so doing they will produce this rotation of the anther and their heads will remove most of the pollen, while they are inserting their proboscis in the filamentary groove and sucking the honey. This arrangement seems to me to *prevent* their backs being (except to a small extent) dusted with pollen as it is only the head that can

come in contact with the projecting stigma. The outer stamens are barren, and fit over the ridges of the ovary. Mr. Wilson has described and figured *Albuca corymbosa*, Bkr. (Macleod, No. 592), which seems extremely near this species. *A. juncifolia*, Bkr., also described by him, appears to have an almost identical arrangement. *A. major* was described and figured by Sprengel (Müller, No. 702) in 1793.

***Androcymbium leucanthum*, Willd. (Figs. 164-166.)**

The flowers are completely enclosed by the dome-shaped floral leaves β , and within the cavity so formed many insects appear to take refuge. Each perianth-segment is wrapped round and (in the lower part) united to its filament in such a way that it forms a small pouch into which honey is secreted by a dark red swelling at the base of the free portion of the filament at n . The versatile anthers are perfectly horizontal and dehisce upwards. They are usually considerably *above* the level of the stigma so that it is hard to see how self-fertilisation can be avoided. The insects most common in the cavity are *Forficaria*, always very abundant, a species of *Anthicus*, two other ants, and *Heteroodeus pulchilus*. These probably usually creep into the flowers by the base and may leave by the upper opening after crawling over stigma and anthers.—Rose-Bank, Cape Town.

***Baeometra columellaris*, Salisb.**

The anthers end in a flat sterile top which probably tends to prevent self-fertilisation. Insects probably alight on the broad three-cornered summit of the ovary, and then collect pollen or crawl down to the base of the perianth. I could not find a distinct nectary, but the base of the perianth and filaments are of a brownish purple colour and appear secretive. Visitor:—*Dichilus simplicipes*.—Cape Town.

***Commelina nudiflora*, L.**

The flowers are either male or hermaphrodite and are of a bright blue colour. The median inferior stamen is curved upwards and stands exactly in front of the rudimentary ovary;

the two lateral inferior stamens have longer filaments which are also less curved upwards and hence their anthers, which are also fertile (though shorter than that of the preceding), lie below and more in advance of it.

The two superior lateral stamens have short straight filaments and four-lobed barren connectives (though sometimes bearing a little pollen). The sixth stamen is always absent, though I fancied honey was secreted at the point where it should exist. In the female flower the stamens are as in the male and the style originally lies below them, subsequently curving upwards so as to lie in the path of the insect. Visitors:—*Apis mellifica*, very ab.—Fort Dauphin, Madagascar.

Commelina tuberosa, *L.*, *C. Karawinskii*, *Mart.*, and *C. communis*, *L.* have been excellently described and figured by Macleod (*Botanisch Jaarboek*, 2nd Jaargang, 1890, p. 143; English abstract). Except by the constant hermaphroditism and presence of the sixth stamen, they do not differ much from this species. *C. coelestis*, Willd. has been described by Müller (Macleod, No. 416): also by Macleod, No. 343, and by Breitenbach (Macleod, No. 57). The male flowers being those that appear first from the spathe leads to the fertilisation of older flowers by the pollen of younger ones, and hence induces cross-fertilisation.

EXPLANATION OF THE FIGURES IN PLATES
XXI, XXII, AND XXIII.

Illustrating Mr. Scott Elliot's paper on the Fertilisation of South African and Madagascar Flowering Plants.

PLATE XXI.

Carica Papaya.

Fig. 1. Female flower.

Fig. 2. Male flower. *st.* stigma, *sta.* stamens, *n.* nectary; both reduced greatly.

Viola decumbens.

Fig. 3. Flower after removal of sepals and petals but with outline of spur and lower lip. *ap.* outline of anterior petal and *sp.* of its spur, *s.* spurs of anterior filaments, *sti.* stigma.

Polygala bracteolata.

Fig. 4. Flower from side with the lateral sepals removed.

Fig. 5. Flower from above.

Fig. 6. Style. *s.* sepal, *p₂* carina formed of fused anterior petals, with alighting brush *v.* and hairs *h₁* at hinge or joint *x*, and along upper margin *h₂*, *p₃* posterior petals with over-lapping projection *t.* on right posterior petal, *o.* opening through which style appears, *b.* upper hollow on surface of style, *h.* lateral hollow, *st.* stigmatic surface.

Muraltia Heisteria.

Fig. 7. Longitudinal mesial section of an exploded flower.

Fig. 8. Section in line *x-y* (Fig. 7) before explosion. *se.* sepals, *ap.* anterior, and *pp.* posterior petals, *a.l.* thickened ledge on inside of carina, *cl.* thickened claws of posterior petal, *c.* cavity of anterior petals enclosing essential organs, *b.* anterior vertical ridge on front of anterior petal, *l₁* limb of anterior lateral petal, *l₂* half of limb of anterior median petal. *s. sh. st.* staminal sheath, *s.* style, *si.* stigma, *f.* fingerlike projections on the ovary, *n.* nectary.

Muraltia serpylloides.

Fig. 9. Flower after sepals have been removed, lettering as above except *x.* hinge.

Abutilon albidum.

Fig. 10. Flower in longitudinal mesial section. *h.c.* honey cup of sepals, *n.* nectar tissue, *sty.* styles.

Cyclopia genistoides.

Fig. 11. Flower from the side with half the calyx and part of the vexillum-wing cut off.

Fig. 12. and Fig. 13. Left ala from within and without respectively.

Fig. 14. Flower with vexillum, calyx, and left ala removed.

Fig. 15. Extremity of carina enlarged.

Fig. 16. Staminal column towards the base viewed from above.

s. sepals, *ve.* vexillum-claw, *a.* curved claw of ala, *ad.* alar depression fitting on corresponding depression *cd.* of carina, *af.* fold in ala fitting over *pc.* projecting lateral peg of carina, *c.* carina, *ct.* tubular cavity of carina in which style and stamens lie, *x.* opening through which style protrudes, *n.* opening to honey.

Podalyria sericea.

- Fig. 17. Flower with calyx removed.
 Fig. 18 and Fig. 19. Alae from inside and outside respectively.
 Fig. 20. Carina and stamens.

Podalyria calyptrata.

- Fig. 21. Flower viewed laterally, part of vexillum being cut away.
 Fig. 22. After removal of vexillum and right ala.
 Fig. 23. Left carina with essential organs *in situ*.
 Fig. 24. Transverse section along line *a-b* (Fig. 21). *vc.* vexillum-claw, *al.* ala, *gr.* groove on vexillum, *se.* reflex sepals, *sti.* style.

Podalyria cuneifolia.

- Fig. 25. End of carina showing over-lapping or rolling together of alae and carina; *tu.* tubular cavity.

Podalyria canescens.

- Fig. 26. Part of flower from above with vexillum almost entirely removed. *al.* backward extremity of alar limb.

Liparia sphaerica.

- Fig. 27. To show relative arrangement of calyx and vexillum seen from above (the latter being cut across).

- Fig. 28. Right ala from above.
 Fig. 29. Flower from the side with calyx and right half of vexillum removed.
 Fig. 30. Extremity of carina seen from in front: letters as above, except *vr.* rolled-in edges of vexillum, *as.* expanded anterior sepal, *ac.* alar claw, *cc.* carinal claw.

Amphithalea ericaefolia.

- Fig. 31. Flower from the side.
 Fig. 32. Right ala from inside.
 Fig. 33. Left carinal half from outside.
 Fig. 34. Left ala and carinal half *in situ* from inside. *cp.* lateral peg of carina fitted by *ag.* deep socket on ala, *ca.* auricle of carina.

Borbonia cordata.

- Fig. 35. Flower from side with calyx removed.
 Fig. 36. Right ala from inside.
 Fig. 37. Right carinal half from outside. *ag₁*. depression of ala fitting on upper groove, *cg₁* of carinal half, *ag₂* lower margin of ala bent inwards so as to fit into *cg₂* lower groove of carinal half, *b.* the point to which the calyx extends.

Lotononis prostrata.

- Fig. 38. Flower from the side with half the calyx removed.
 Fig. 39. Alae seen from above.
 Fig. 40. Left ala from outside.
 Fig. 41. Left carina from outside, *ac.* alar claw, *a.*, *a¹*. groove on upper surfaces of left and right alae fitting on *cg.* deep groove on carina, *a₃* extremity of left ala wrapped sideways over right ala, *cc.* claws of carina.

Lotononis involucreta.

- Fig. 42. Whole flower from the side.
 Fig. 43. Left ala from outside.
 Fig. 44. Left ala from inside.

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Fig. 45. Left carina from outside.

Fig. 46. Alae and carina from below. Letters as above except *au*₂ auricular connection of ala and carina; *au*₃ inferior bent-in edges of alae.

Aspalathus aemula.

Fig. 47. Flower with calyx removed.

Fig. 48. Left carinal half from outside.

Fig. 49. Left ala from inside.

Fig. 50. Stigma enlarged; *h.* hairs.

Aspalathus Chenopoda.

Fig. 51. Longitudinal section of vexillum from inside.

Fig. 52. Vexillum claw and basal lobes from behind.

Fig. 53. Right ala and carinal half from outside.

Fig. 54. Right carina from outside, *j.* joint or hinge of ala, *cp.* peg on carina.

Aspalathus sarcantha.

Fig. 55. Flower from side with half calyx removed; letters see above.

Crotalaria capensis.

Fig. 56. Alae and carina from above (left ala bent sideways).

Fig. 57. Alae and carina from below.

Fig. 58. Carina and ala from the side.

Fig. 59. Vexillum-claw from below.

Fig. 60. Cross section of ala and carina in line *x-y*, *n.* entrance to nectary.

Crotalaria retusa.

Fig. 61. Vexillum-claw seen from below.

Fig. 62. Carina from above. *tt.* transverse thickened ridge, *t*₂ thickened anterior pegs, *h.* honey-canal.

Crotalaria humilis.

Fig. 63. Flower from side with calyx removed.

Fig. 64. The carina *in situ.*

Fig. 65. Left carinal half separated from within. Letters as above.

Lessertia pulchra.

Fig. 66. Vexillum, calyx, and right ala removed.

Fig. 67. Left ala from inside.

Fig. 68. Outline of carina from above (line *a-b*).

Clitoria heterophylla.

Fig. 69. Longitudinal basal portion of flower in section to show peculiar saddle-like nectary *n.*

Canavalia ensiformis.

Fig. 70. Flower from the side with calyx removed.

Fig. 71. Section along line *a-b*.

Phaseolus adenanthus.

Fig. 72. Longitudinal section of vexillum.

Fig. 73. Right carinal half.

Fig. 74. Left ala from the inside.

Fig. 75. Style. *c.* anterior callosity of vexillum, *s.* spur of ala fitting in groove *g.* of vexillum, *r.* spur of vexillum, *st.* stigma, *b.* brush of hairs.

Dolichos Lablab.

Fig. 76. Flower in longitudinal section.

Fig. 77. Vexillum in longitudinal mesial section.

Fig. 78. Section along line *a-b*.

Fig. 79. Left ala from without.

Fig. 80. „ from inside.

Fig. 81. Carinal half.

Fig. 82. Odd stamen from above and below.

Fig. 83. Style. *s.* odd stamen, *p*¹ groove in ala, *h.* style-hairs, *b.* vexillum-limb, *n.* nectary, *a.* projecting corner of carina fitted by *a*¹ of ala, *ph.* hairs on lower part of style; other letters see above.

Quivisia grandifolia.

Fig. 84. Longitudinal section of flower. *s.* sepals, *p.* petals, *st.* staminal tube, *a.* anthers, *si.* stigma, *t.* barren tips of anthers.

PLATE XXII.

Brexia madagascariensis.

Fig. 85. Longitudinal section through the flower.

Fig. 86. Stamens and staminodes seen from above. *s.* sepals, *p.* petals, *st.* stamens, *a.* anthers, *r.* starlike staminodes, *n.* nectary, *h.* honey-pouch, *m.* midrib of petal in section.

Mesembryanthemum reptans.

Fig. 87 *a.* Flower in longitudinal section. *s.* sepals, *p.* petals, *a.* anthers, *n.* nectary, *si.* stigmata, *ov.* ovules.

Gymnodiscus capillaris.

Fig. 87 *b.* Extremity of style enlarged. *r.* roughening of small hairs. *h.* lower circle of large hairs, *p.* pollen-grains.

Tripteris amplexens.

Fig. 88. End of style enlarged.

Gorteria diffusa.

Fig. 89. End of style. *g.* hairs with which it is covered, *c.* constriction near the base, *y.* yellow globules on pollen-grain, *s.* stigmatic papillae.

Gazania pinnata.

Fig. 90. Position of style in *a* ♂ and *b* ♀ condition.

Orchipeda Dregei.

Fig. 90 *c.* Flower from above.

Fig. 91. Anther-cone enlarged.

Fig. 92. Corolla-tube (with limb removed) from the outside.

Fig. 93. Same in longitudinal section.

Fig. 94. Style-extremity. *b* opening into canals *c.* running spirally round inside of corolla-tube, *a.* anther, *p.* pollen, *s.* flat top of style, *s.c.* ring of membrane ending in *g* horizontal and *v*¹ reflex teeth, *n.* nectar ring, *si.* stigma.

Vinca rosea.

Fig. 95. Longitudinal section of flower.

Fig. 96. Thickened end of style (enlarged).

Fig. 97. Anther-pouch (enlarged). *t.* entrance to corolla, *c.* circle of hairs, *a.* anther, *p.* mass of pollen on top of style, *si.* stigma, *r.* membrane ring, *n.* nectarial ring.

Camptocarpus? crassifolius.

Fig. 98. Flower in longitudinal mesial section. *p.* petals, *t.* tube or cup and *l.* lobes of the corona, *c.* Canal running round below the thickened mushroom-like head *s.* of the style, *n.* nectary, *f.* filament, *d.* disc or retinaculum, *p.* pollen-mass, *a.* anther, *si.* stigma.

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Belmontia cordata.

Fig. 99. Flower in longitudinal section. *st*₁, first, *st*₂, second stigma, *a*, anther with knob, *k*.

Lobostemon fruticosum.

Fig. 100. Longitudinal mesial section of flower. *h*, honey-pouch.

Lycium capense.

Fig. 101. Longitudinal section of flower. *h*, hairs on filaments.

Nemesia barbata.

Fig. 102. Longitudinal mesial section of flower.

Zaluzianskya coriacea.

Fig. 103. Longitudinal mesial section of flower. *s*, sepal, *an*₁, first and *an*₂ second pair of anthers, *n*, nectary, *ov*, ovary, *sty*, style.

Manulea Cheiranthus.

Fig. 104. Longitudinal mesial section of the flower.

Fig. 105. View of entrance to corolla from in front. *c*, canals or grooves on inside of corolla-tube separated by ridges *r*; *a*₁ first and *a*₂ second pair of anthers, *si*, stigma, *gl*, glandular hairs of calyx.

Ilysanthes capensis.

Fig. 106. End of flowering plant.

Fig. 107. Base of pedicel, *p*, commencing to drop, *t*, tubercle, *l*, leaf.

Fig. 108. Two lower filaments with setae *s*.

Colca decora.

Fig. 109. Longitudinal section of flower.

Fig. 110. Cross-section of corolla-tube at pt. *p*.

Fig. 111. Arrangement of free ends of petals in bud to explain ridges on corolla, *se*, sepals, *p*, corolla, *a*, anther, *s*, style, *si*, stigma, *n*, nectary, *m*, midribs of petals.

Brachystephanus cuspidatus.

Fig. 112. Flower in longitudinal section (reduced). *a*, anther, *si*, stigma.

Oftia africana.

Fig. 113. Flower in longitudinal section (letters see above).

Dischisma ciliata.

Fig. 114. Flower (calyx removed) seen from above and slightly diminished in size.

Stachys aethiopica.

Fig. 115. Flower from side in first condition.

Fig. 116. From in front during second stage.

Fig. 117. From side during last ϱ stage. *a*₁ first and *a*₂ second pair of anthers.

Salvia africana.

Fig. 118. Flower from the side: the dotted lines show the position of the anthers. *Stam*, connective-lobe.

Vitex Bojeri.

Fig. 119. Flower in longitudinal section (letters as above).

Leucadendron adscendens.

Fig. 120. Female flower in section.

Fig. 121. Male flower from side. *si*, stigma, *a*, anthers, *p*, pollen.

Serruria congesta.

Fig. 122. Flower from the side. Letters as above, *t.* barren tips of anthers, *f.* their filaments, *b.* bract, *s.* sepals.

Pterygodium alatum.

Fig. 123. Whole flower from in front.

Fig. 124. Longitudinal mesial section of flower (enlarged).

Fig. 125. Left half of lamina and anther seen from behind (enlarged).

Fig. 126. Disc, anther-case, and stigma from in front (Part of Fig. 123 enlarged). *gal.* Galea, *se.* anterior sepals, *lam.* upright part of lamina ending in nectar-holes *nh*; *w.* wing or membranous part of labellum, *ac.* anther-case, *d.* disc, *si.* stigmatic surface, *n.* nectary, *gr.* groove leading to nectary.

Angraccium superbum.

Fig. 127. Whole flower from in front, clinandrium removed.

Fig. 128. Same flower in longitudinal section.

Fig. 129. Rostellum from exactly in front: flower in same position as last. *se.* sepals, *lab.* labellum, *h.* hood in which it ends, *sp.* spur, *cr.* crest or mesial expansion of labellum, *a.* pollinium, *pit.* pit in which pollinia fall, *o.* groove in which disc *d* lies, *ov.* ovary.

Disperis villosa.

Fig. 130. Flower from in front, natural size.

Fig. 131. Flower in longitudinal median section (lateral sepals removed).

Fig. 132. Anther and labellum from above. *s₁.* posterior sepal or galea, *sl.* lateral sepal, *p.* petals united to galea, *l.* basal part of labellum, *n.* nectary on upper part of its thickened extremity, *cl.* case of anther ending in front in spiral ribbons, *d.* attachment of disc at extremity of those ribbons, *cau.* caudicle, *c.* anther.

Iridaceae.

PE. external and *pi.* internal perianth-segment, *pt.* perianth-tube, *co.* column of filaments, *a.* anther, *si.* stigmatic lip, *n.* scale covering nectar-cup.

Moraea tristis.

Fig. 133. Whole flower.

Fig. 134. Staminal column and style with perianth removed.

PLATE XXIII.

Moraea tricuspis.

Fig. 135. Flower with external perianth-segments removed.

Figs. 136 and 137. External perianth-segment seen from within and in longitudinal section.

Moraea angusta.

Fig. 138. Perianth removed.

Figs. 139 and 140. External perianth-segment from within and in section.

Moraea papilionacea.

Fig. 141. Flower in longitudinal vertical section.

Moraea tripetala.

Fig. 142. Flower with one external perianth-segment and style-branch removed.

Ferraria undulata.

Fig. 143. Flower in median vertical section.

Fig. 144. A style-papilla enlarged. *Pa.* papillae.

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Romulea rosea.

Fig. 145. Flower in longitudinal mesial section. *Hp.* hairs on petals, *is.* inner and *os.* outer spathes, *HF.* hairs on filaments.

Galaxia graminea.

Fig. 146. Flower in vertical section.

Aristea spiralis.

Fig. 147. Longitudinal mesial section of flower.

Ixia graminifolia.

Fig. 148. Longitudinal mesial section of flower.

Ixia excisa.

Fig. 149. Longitudinal mesial section of flower.

Geissorhiza secunda.

Fig. 150. Flower with part of perianth cut away.

Melasmaerula graminea.

Fig. 151. Flower seen obliquely from the side.

Sparaxis grandiflora.

Fig. 152. Flower in longitudinal mesial section. *po.* pollen-covered faces of anthers, *a.* entrance to honey.

Babiana spathacea.

Fig. 153. Flower in longitudinal mesial section. *cr.* up-turned edges of lower perianth-segments, the natural position is as in Fig. 154.

Babiana plicata.

Fig. 154. Flower in longitudinal mesial section: first or male condition.

Fig. 155. Relative position of anthers and style-branches in second or female condition.

Gladiolus pilosus.

Fig. 156. Flower seen obliquely from in front.

Figs. 157, 158, and 159. Successive positions relatively of anthers and style-branches.

Gladiolus gracilis.

Fig. 160. Flower in longitudinal section (male stage), natural position as in Fig. 154.

Fig. 161. Second or female condition.

Gladiolus inflatus.

Fig. 162. Corolla from the side.

Albuca major.

Fig. 163. Internal perianth-segment from within. *ip.* incurved terminal part of inner perianth-segment. *f*₁. basal pouching part of inner stamen, *f*₂ groove formed by bending inwards of filaments, *f*₃ upper flat portion, *a.* anther, *sti.* stigma.

Androcymbium leucanthum.

Fig. 164. Flower half natural size.

Fig. 165. Flower with floral leaves removed.

Fig. 166. Perianth-segment with attached filament in longitudinal section, *l.* leaves (cut off), *fl.* dome-shaped floral leaves, *c.* pouch for honey secreted by *n.* nectary, *a.* anther.

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Wahlenbergia (2 sp.), p. 359.
Zaluzianskya, Fig. 103, p. 368.

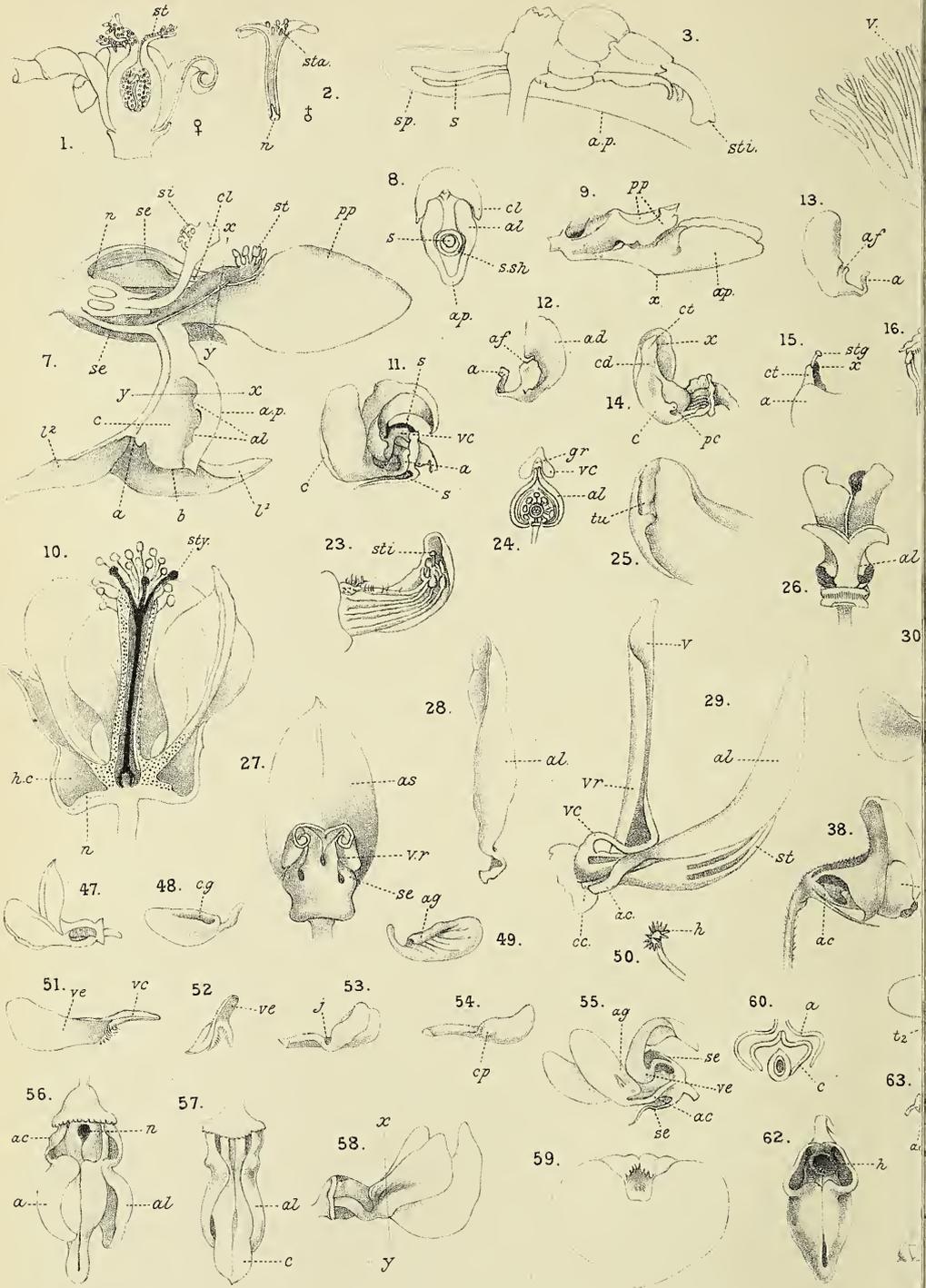
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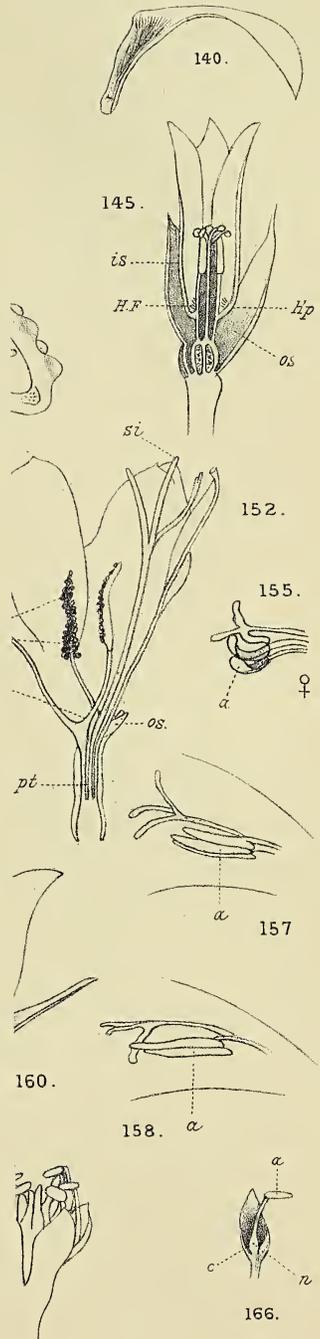
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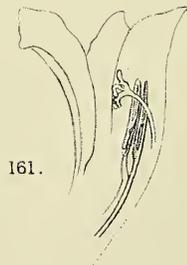
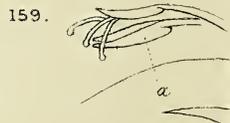
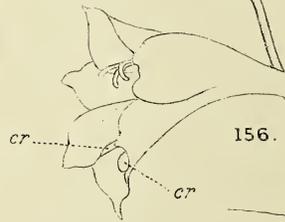
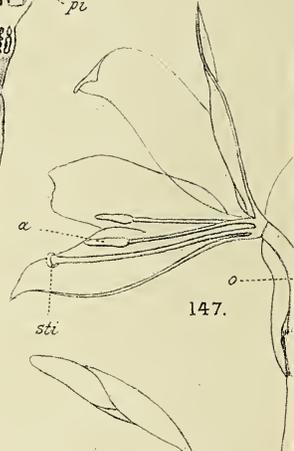
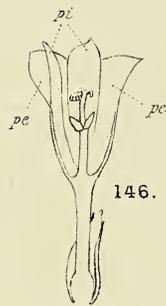
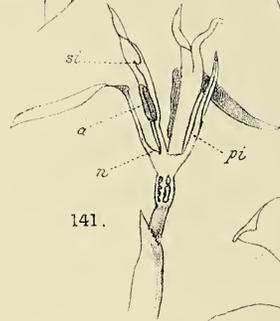
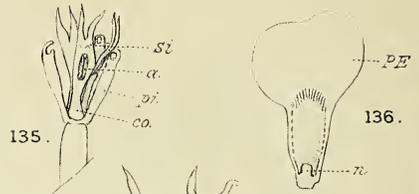


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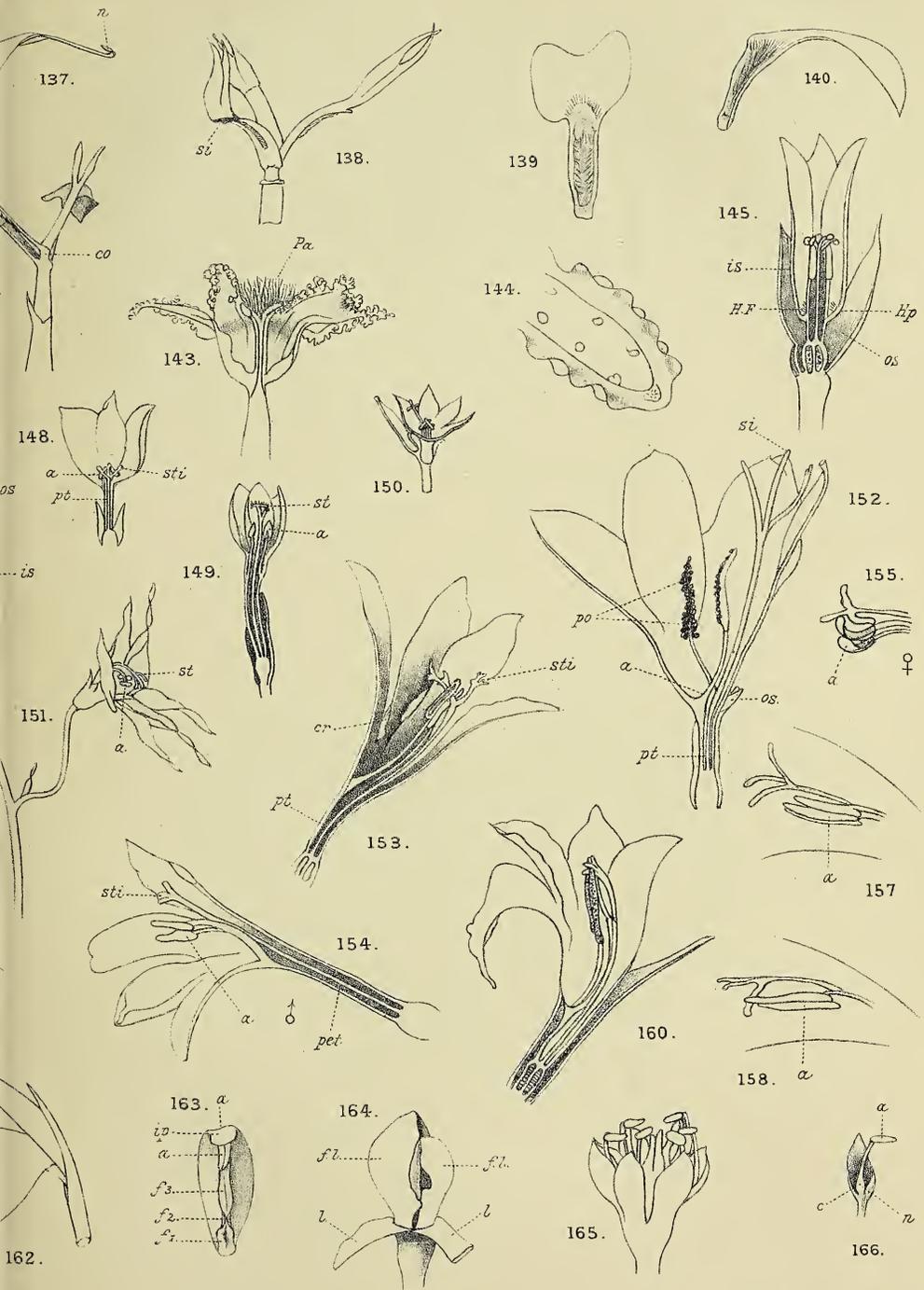


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NOTES.

PROLONGED VITALITY OF THE SEEDS OF SEA-SHORE PLANTS.—Although it has long been well known that the seeds of many sea-shore plants retain their germinating power after long immersion in sea-water, there are few exact observations on record. Dr. H. B. Guppy, who spent some months in the Keeling Islands (the scene of some of Darwin's earliest work), and specially investigated the flora with reference to the germination and growth of seeds cast ashore by the waves, brought home seeds of many of the plants for further experiment. Some interesting results have been obtained. About the middle of last June he sent to Kew a germinating seed of *Thespesia populnea*. This was collected fresh in the Keeling Islands in October, 1888, and kept dry until June 8th, 1890, when it was placed in sea-water, where it remained floating until June 8th, 1891. It was then subjected to conditions favourable to germination, and in less than a fortnight it began to sprout, and it is now growing at Kew. On the 15th of July Dr. Guppy sent a germinating seed of *Ipomoea grandiflora*, collected in the same islands in November, 1888, and subjected to the same treatment subsequently as the seed of *Thespesia*, with the only difference that it was five weeks before it germinated.

Of course these two instances merely confirm what was assumed before, namely, that the seeds of many of the plants found in remote islands must be able to endure long immersion in sea-water without injury; yet they are none the less interesting.

Both are ornamental plants—the *Thespesia* being a small tree and the *Ipomoea* a climber or trailer. Both have densely hairy seeds. The trigonous seeds of the latter are about a third of an inch long, and are furnished with an additional fringe of long hairs around the longer circumference, so that when they float, in still water at least, this fringe rests on the surface. Both have an exceedingly wide range of distribution, partly due, doubtless, to human agency on account of their ornamental character; but also largely due to their capacity for colonisation from seeds cast ashore by the sea. Both occur on remote

uninhabited islands of the Pacific and Indian Oceans, whither it is highly improbable that they have been carried by man.

W. BOTTING HEMSLEY, Kew.

A BURMANNIA IN JAPAN.—Through the kindness of Mr. Tokutaro Ito we have lately received at Kew specimens of a *Burmanna*, discovered by him in Japan, which, on comparison, proves to be *B. nepalensis*, Hook. f. (*Gonyanthes nepalensis*, Miers). A few years ago Mr. Ford, Superintendent of the Hongkong Botanic Garden, collected the same species on the Lofau mountains, in the province of Kwangtung; but it does not appear to have been found between there and India. It is however an exceedingly slender colourless plant two or three inches high, and might easily be overlooked. The Japanese habitat is Obi in the province of Hiogo, Kiusiu.

W. BOTTING HEMSLEY, Kew.

FLORA OF THE SOLOMON ISLANDS.—The Rev. R. B. Comins, who has spent some years in these islands, brought home a small but interesting collection of dried plants towards the end of last year. This collection is being worked out at Kew, and will form the subject of some notes in an early number of the 'Annals of Botany'. It contains several curious new plants, including a new genus of Scitamineae, and the very singular apocynaceous *Lepinia taitensis*, Decne., figured in the 'Annales des Sciences Naturelles' in 1849.

W. BOTTING HEMSLEY, Kew.

ON RHYNCHOSIA? ANTENNULIFERA, J. G. Baker.

In a note at the end of the enumeration of the genus *Rhynchosia* in Oliver's 'Flora of Tropical Africa,' vol. ii. p. 223, Mr. Baker described, under the above name, an imperfect specimen of a plant collected by Dr. Meller in Zambesi-land. Since then much better material has been received at Kew. Sir John Kirk appears to have been the first to collect it, though the specimens did not reach Kew until 1883, having formed part of a collection that was 'lost' in a government warehouse at Southampton for nearly a quarter of a century! He collected it at Mungazi, in Zambesi-land, in 1859, and Dr. Meller collected it in 1861; both specimens wanting leaves and ripe fruit. In 1881, the Botanical Society of Edinburgh sent excellent specimens to Kew, collected by Mr. Buchanan in the Shiri

Highlands. More recently it has been collected in a leafless condition by a German traveller very much farther to the north, in the Uniamwesi country.

A very marked peculiarity of the plant is that the bracts, bracteoles, and long narrow calyx-lobes, terminate in a club-shaped gland, and on this account Mr. Paul Taubert, of Berlin, has considered it should be classed as a new genus. Not having identified it with the plant described by Baker, Taubert first described and figured it under the name of *Eminia eminens* (Ber. der deutsch. Bot. Gesellschaft, ix. 1891, p. 28), and on being informed from Kew that it was the same as *Rhynchosia? antennulifera*, J. G. Baker, he altered the name to *Eminia antennulifera* (Bot. Centralblatt, xlv. 1891), following the rule of according priority to the first specific name given to the plant. As already mentioned, he had only a leafless specimen to deal with, and it was otherwise imperfect, as is clear from his description of the inflorescence.

Whether *Eminia* can be regarded as a good genus it is not easy to decide without examining a large number of the plants most nearly allied; but the gland-tipped calyx-segments seem to afford a very slender character on which to found a genus, especially if we take into consideration the extreme variation in the calyx of the genus *Rhynchosia*, as usually limited. This, however, is a secondary matter. Buchanan's specimens afford complete material for a description, but it will be sufficient to supplement the previously published descriptions here: *Radix* grandis, carnosa (*vide* Buchanan), caulibus pluripedalibus scandentibus liquescentibus interdum fere semipoll. diametro. *Folia* pinnatim trifoliolata, saepe longe petiolata, crassiuscula sed vix coriacea, utrinque sed praecipue subtus appresse sericeo-hirsuta vel strigillosa, cum petiolo usque ad 6 poll. longa, stipulis parvis oblongis; foliola breviter petiolulata, late trilobata (usque 3 poll. longa lataque) lobis rotundatis simul minute apiculatis, lateralibus multo minoribus, foliolorum lateralium lobo interior interdum fere obsoleto, venis subtus saepe ferrugineis, stipellis subulatis ferrugineis. *Flores* fasciculato-racemosi, racemis usque sesquipedalem longis.

In looking through the tropical African species of *Rhynchosia* in the Kew Herbarium, in connection with the foregoing, a second species having gland-tipped bracteoles and calyx-lobes was detected. This was collected by Dr. E. Holub in the Leshumo Valley, Zambesi, and

is quite distinct from *R. antennulifera*. But this second species rather weakens than strengthens *Eminia* as a genus, and it is proposed to treat it as a section of *Rhynchosia* here.

Rhynchosia (§ *Eminia*) *Holubii*, Hemsl. nov. spec.: foliis per anthesin persistentibus, foliolis oblongis sinuatis; racemis folia vix superantibus; calyce quam corolla dimidio brevior, laciniis 3 inferioribus saepius 2-3 glandulosis; stylo per totam longitudinem glabro.

Herba, ut videtur, perennis, caulibus . . . ? *Folia* graciliter petiolata, pinnatim trifoliolata, coriacea, strigillosa, cum petiolo 3-5 poll. longa; foliola breviter petiolulata, oblonga vel anguste ovato-oblonga, 2-3 poll. longa, lateralia paulo minora, sinuata vel obscure paucicrenata, utrinque obtusissima, simul apice minute apiculata, supra parce strigillosa, scabrida, venis elevatis grosse reticulatis, subtus argentea, dense strigillosa, venis primariis lateralibus utrinque circiter 5, stipellis obsoletis. *Flores* circiter 9 lineas longi, fasciculato-racemosi, brevissime pedicellati, racemis axillaribus folia subaequantibus calyceque argenteis strigilloso-hirsutis; calyx sub-bilabiatus, alte inequaliter 4-fidus (i. e. laciniis 2 superioribus fere ad apicem connatis), lacinia inferiore saepius apice 3-glandulosa, laciniis lateralibus saepius 2-glandulosis, labio superiore saepius eglanduloso; petala fere aequilonga, unguiculata, glabra, vexillo lato leviter emarginato; stamina glabra; ovarium subsessile, apice praesertim longissime setulosum, stylo longissimo breviter exserto glabro. *Legumen* ignotum.

Apart from the great difference in foliage, and apparently in habit, this species differs in the relative length of corolla and calyx, and especially in the two upper calyx-lobes being connate nearly to the apex and eglandular, and in the three lower being furnished with two or three glands at the apex.

W. BOTTING HEMSLEY, Kew.

ON THE PRESENCE OF A DIASTATIC FERMENT IN GREEN LEAVES.—I have been led to re-investigate this subject in consequence of the statement made by Wortmann¹ in a paper recently published, that green leaves contain no diastase or only such a minute quantity that it cannot be of any serious importance in the transformation of starch into sugar which takes place so actively in those organs. In contradiction of the results obtained by Baranetzky²

¹ Botanische Zeitung, 1890.

² Die Stärkeumbildenden Fermente in den Pflanzen: Leipzig, 1878.

and of Brasse¹, which seem to prove the presence of diastase, Wortmann finds that watery extracts of green leaves have no diastatic action, and concludes that the normal conversion of starch into sugar is effected in the living leaf by the direct action of the protoplasm.

I am unable, within the limits of a note, to criticise Wortmann's experiments in detail, or to give a full account of my own. In the way of criticism I would only point out that Wortmann's method is open to serious objection: the mixing of a certain quantity of leaf-extract with a certain quantity of starch-solution, and then using the iodine-reaction as a means of determining the amount of chemical change effected, is not a method calculated to give definite results; for, as Wortmann himself admits, the colouring-matters and other foreign substances in the leaf-extract interfere with the colour-reactions with iodine. Again, it is disadvantageous to filter, as Wortmann did, the watery extract of the leaves before adding it to the starch-solution. I have found that the turbid extract, merely strained, is much more active than the clear extract obtained by filtration: probably Wortmann's negative results were mainly due to this cause.

There is one experiment upon which Wortmann lays so much stress that it calls for special notice. He finds that the starch will not disappear from the cells of a living leaf if the leaf be kept in an atmosphere of carbon dioxide; and from this he concludes that the transformation of starch into sugar must be a direct vital act of the protoplasm, dependent upon the supply of free oxygen. Assuming the correctness of the observation, a more simple and satisfactory explanation of it would be that, in the absence of free oxygen, the protoplasm is unable to secrete the necessary diastatic ferment.

My experiments appear to establish the fact that a diastatic ferment is present in green leaves. The following description of a single typical experiment will give an idea of the methods adopted and of the nature of the results obtained:

500 grmes. of grass (with some Clover and *Achillea* intermixed), cut from a lawn, were well triturated in a mortar with 500 cc. distilled water: the mass was pressed through a strainer and a turbid slightly acid liquid, the leaf-extract, was obtained. In the afternoon, about four hours later (4.30 p.m.), the following mixtures were made in six jars, and were allowed to stand on the laboratory table till 6.45 a.m. the following morning, when they were all boiled at once; they were

¹ Comptes rendus, t. xcix, 1884.

then decolourised, and the presence of sugar and its amount in each was volumetrically determined by means of carefully prepared Fehling's solution :

Jar No.	Nature of Mixture.	Amt. of Sugar (estd. as Dextrose).	per 100 cc.
1	— 50 cc. extract + 50 cc. starch-solution	. . .	·0793 grme.
2	— 50 cc. extract (<i>boiled</i>) + „	. . .	·0450 „
3	— 50 cc. extract + 50 cc. „ + thymol	·0740 „
4	— „ „ + „ „ + boracic acid .5 grme.	. . .	·0690 „
5	— „ „ + „ distilled water	·0444 „
6	— „ starch-solution + „ „ „	no trace.

The starch-solution used was obtained by boiling .5 grme. of starch with 100 cc. of dist. water; the liquid was allowed to cool and settle in a closed vessel, and only the nearly clear supernatant portion was used.

The activity of the ferment is represented by the difference between the amount of sugar in the leaf-extract to begin with, and the amount ultimately found in the mixture of leaf-extract and starch-solution: thus, from Nos. 2 and 5 it appears that the amount of sugar originally in the extract was about .045 per cent., so that the amount of sugar formed from the starch-solution by the ferment in No. 1 is about .034 per cent. It may be objected that this represents a very small amount of diastatic activity, so small indeed that it may be neglected as a factor in the almost wholesale conversion of starch into sugar which takes place in the living leaf; but this objection is deprived of weight by the consideration that, though the amount of ferment which can be extracted from leaves at any given moment is so small, yet the ferment is doubtless being constantly secreted, so that the total amount secreted during a night, for instance, would suffice to effect the observed conversion of starch into sugar.

In two cases (*Rheum hybridum*, *Daucus Carota*) somewhat peculiar results were obtained. In the former, the mixture of leaf-extract and starch-solution was found to contain less sugar ($\cdot 1587\%$) than the mixture of leaf-extract and distilled water ($\cdot 2702\%$), after standing for 24 hours: in the latter also the mixture contained less sugar ($\cdot 1052\%$) than the leaf-extract diluted to the same bulk ($\cdot 1250\%$). It would appear that, in these cases, the added starch was not attacked at all: hence the question arises as to the explanation of these varying amounts of sugar. An explanation is suggested by the further observation, made as a control-experiment in the case of *Daucus*, that

an equivalent quantity of diluted leaf-extract which was boiled at the beginning of the experiment contained only about 0.08% sugar. Since the unboiled leaf-extract, whether diluted with water or with starch-solution, contained more sugar than the boiled leaf-extract, it is clear that some amount of starch must have become converted into sugar; and it is also clear that, since this increase of sugar is most marked in the leaf-extract to which no starch-solution had been added, it must be due to the conversion of starch already present in the cells of the leaf. The presence of added starch appears to interfere with the action of the ferment upon the leaf-starch.

I have assured myself that the substance which reduces the Fehling's solution is really a sugar; but it does not appear to be maltose, as might be expected, for it is not dextrorotatory though it seems to be fermentable. Further details are given in the paper which I am preparing to be read at the meeting of the British Association at Cardiff.

S. H. VINES, Oxford.

On Aggregations of Proteid in the cells of *Euphorbia splendens*.

BY

R. E. FRY, B.A.

—+—

With Plate XXIV.

—+—

WHILE examining sections of the stem of *Euphorbia splendens* (using spirit-material) I observed in many of the cells, particularly in the parenchyma immediately surrounding the vascular bundles, certain spherical bodies, which refracted light strongly and in some cases had double contours, though they were not doubly refracting.

They stained deeply with the following reagents:—haematoxylin, Hanstein's violet, eosin, Hoffmann's blue. With iodine they were stained the yellowish brown colour characteristic of proteids.

They were exceedingly insoluble, not being affected by saturated NaCl-solution, 5 per cent. potash, hydrochloric or acetic acids, or ether. These reactions suggested the presence of a coagulated proteid. This view was confirmed by the use of Millon's reagent, and the xanthoproteic test, which gave the characteristic red and deep yellow colours.

I also used a test described by Loew¹. It consists in precipitating the proteid by the action of a solution of potassium ferrocyanide and acetic acid, washing out these by treatment with 60 per cent. alcohol for half an hour and

¹ Bot. Zeit. No. 18, May, 1884.

[Annals of Botany, Vol. V. No. XX. November, 1891.]

adding dilute ferric chloride. The proteid is then stained blue. This test confirmed the results already obtained.

Thus the bodies were shown to consist of coagulated masses of proteid; the coagulation being probably in part the result of the action of the alcohol. In the fresh state the proteid occurs in various forms:—

(1) It may be distributed throughout the cell-contents either as a fluid or in finely divided granules. If cells containing this diffused proteid be treated with 1 per cent. ammonium carbonate for twenty-four hours the proteid crystallizes out.

(2) A form common in young shoots is that shown in Fig. 1 *a*. These long crystalloids occur either singly in bundles or united to form sphaerocrystals. They are similar to those of *Galtonia candicans*¹ and *Urtica urens*².

(3) The long rod-like crystalloids produced artificially by the action of ammonium carbonate on (1) also occur naturally. They are shown in Fig. 1 *β*. They correspond to the forms found in *Griffithsia neapolitana*³.

(4) A form of crystalloid that is common in the epidermis of the leaf is the common rhombohedral crystalloid which is found in the tuber of the Potato, the berries of *Solanum americanum*, and in *Bertholletia excelsa*. Like the crystalloids of the last-named plant, those of *Euphorbia splendens* are not doubly refracting. The crystalloids of the potato-tuber, on the contrary, are doubly refracting. Fig. 1 *γ*.

Thus we see that this one species contains all the more remarkable forms of crystalloids that have been described as occurring elsewhere in widely different plants. But besides these there is a peculiar form. This is shown in Fig. 2, which represents a section of the stem in the fresh state mounted in water.

There are really two forms here, (1) the loose aggregations

¹ Leitgeb, Mitth. aus dem Bot. Inst. zu Graz, 1886.

² Kallen, Flora, 1882, No. 5.

³ Klein, Pringsheim's Jahrb. für wiss. Bot., vol. XIII.

of proteid granules shown at (c), and (2) the compact spheres (a) with strongly marked double contours; these are highly refracting. Possibly (1) is only a stage in the formation of (2). The granules showed Brownian movements and appeared to consist of globulin, as they were immediately dissolved with 10 per cent. NaCl-solution. The more aggregated spheres only became clearer in the centre, indicating possibly a globulin centre with a more insoluble shell. But the outer part also dissolved in dilute acids and was therefore probably composed of derived albumin.

Such are the forms which the proteid contained in this species assumes under various conditions. I will next discuss their distribution with a view to showing its probable function in the economy of the plant.

Distribution in the stem. This is best seen by a reference to Fig. 3, which shows a cross-section of part of the stem. The cells containing proteid occur (1) in the inner layers of the cortex just outside the bast, (2) in the medullary rays (*m*), (3) in the pith (*p*) just within the wood.

The inner parts of the cortex contain large numbers of latex-tubes whose thick walls were stained faintly blue when treated with Loew's ferrocyanide-test, a fact which may be worth noticing by the way as it tends to support Wiesner's hypothesis of the impregnation of the cell-wall by proteid.

Although the cells surrounding the latex-tubes frequently contained proteid, there did not appear to be any such definite relation between the two as to suggest that the latex-tubes function as channels of distribution for the proteid. Scattered irregularly here and there are cells containing starch (*s*), which do not, however, form a regular starch-sheath. Cells containing proteid do not occur quite so constantly in the medullary rays and pith as in the inner layers of the cortex, but large quantities of proteid were frequently found in those parts.

In quite young stems proteid was frequently observed in the peripheral layers of the cortex.

The cells of the growing-point and the pulvinus of young leaves are also full of proteid in a diffused form.

Distribution in the leaves. The epidermis of the petiole and lamina of the leaves frequently contains crystalloids of the cubical form.

In the mesophyll there is also a certain quantity of proteid, mostly diffuse or in irregular lumps. It is especially abundant in the cells of the palisade-parenchyma (*p*) lying over the small fibro-vascular bundles and tracheid-bundle-endings (Fig. 4). The ordinary elongated cells of the palisade-parenchyma are here replaced by a number of small isodiametric cells with abundant cell-contents, consisting for the most part of irregularly formed masses of proteid.

From the same figure it will be seen that the parenchymatous sheath immediately surrounding the fibro-vascular bundles and tracheid-endings contains a number of spherical highly refracting bodies which at first sight seem to resemble the proteid masses of the stem; their outlines, however, are more regular and they have a faint yellow tinge. Indeed they are not unlike oil-drops. They are not doubly refracting. They were insoluble in a mixture of absolute alcohol and ether, which showed they were not of an oily nature. They were also insoluble in 5 per cent. potash, and in saturated and 10 per cent. common salt solution. Dilute nitric and strong hydrochloric acid dissolved them completely. With dilute hydrochloric they became granular, less highly refracting, and less spherical.

When treated with ammonium chromate they gave no colour, showing the absence of tannin. Nor did they stain with corallin-soda, alkanet or methylene-blue. With eosin, Hoffmann's blue and Hanstein's reagent they stained deeply. With iodine they gave a deep yellow colour.

Such a behaviour towards reagents would lead one to suppose that they might be of a proteid nature, but all attempts to confirm this by positive methods failed. With Millon's reagent they gave a dull brown, with the xanthoproteic test I sometimes thought I obtained a faint yellow, but it was

exceedingly difficult to apply, as they were dissolved in any but very weak nitric acid. With Loew's ferrocyanide-test I sometimes obtained a faint blue, very different to the deep clear blue given by the proteid masses of the stem. Perhaps the best hypothesis is to consider them as bodies very closely allied to proteid, but not answering to all the tests for it. One might perhaps compare with them mucin, which gives the characteristic proteid-reaction with the xanthoproteic test, but not with any other. Moreover since it is probable that nitrogenous food-material travels from one part of the plant to another in the form of glycines, we may provisionally regard these bodies as intermediate between the true proteids which constitute the nitrogenous reserve material, and the glycines which diffuse from cell to cell.

This view is supported by the fact that they disappear in a starving leaf.

The question naturally arises, What is the value of these proteid masses in the economy of the plant? With a view to answering this I made several observations. The very nature of the substance makes it probable that they are of importance to the plant as reserve material, and all my observations tended to support this view. I took some quite small cuttings from a plant of *Euphorbia splendens* and grew them with a strong bottom heat, so that they might form roots rapidly. The plants were then cut in half longitudinally and a thin slice treated with hot Millon's reagent. The distribution of proteid could then be observed macroscopically by the distribution of the red colour. The base of the stem was much redder than the apex, owing to the quantity of proteid required there for the growing roots: whereas under normal conditions the apex, where cell-division is going on, is more plentifully supplied than any other part of the stem.

I then applied a macroscopic proteid-test to the leaves. They were treated thus:—decolourized with alcohol, the cuticle carefully removed with strong and hot hydrochloric acid, and Loew's ferrocyanide-test applied. This treatment was applied to two similar leaves of two similar cuttings,

one of which had been kept in the dark for some days, the other in the light. As was to be expected, the etiolated leaf had used up much of its reserve proteid.

I next investigated the effect of light on the formation of proteid by imitating exactly Sachs' macroscopic starch-test, except that I substituted Loew's ferrocyanide-test for treatment with iodine. In no case did I find that light had any effect on the quantity of proteid formed.

These observations then tend to show that the proteid is used as reserve nitrogenous material, answering to starch among carbohydrates. It is noteworthy that the distribution in the stem of the cells containing proteid is similar to that of the irregular starch-sheath, cells containing proteid alternating with cells containing starch. In all physiological respects these proteid-containing cells resemble the 'Eiweiss-schläuche' of the Cruciferae described by Heinricher¹, as also in many respects in their distribution.

I may mention that I examined many species of the Euphorbiaceae and many latex-containing plants of other families, belonging to the genera *Manihot*, *Hoya*, *Hevea*, *Oxypetalum*, *Ficus*, *Sapium*, *Pharmacosycea*, without finding any such aggregation of reserve proteids.

I ought to add that *Euphorbia Bojeri*, by some considered as a variety of *E. splendens*, is exactly similar to it as regards its accumulations of proteid.

In conclusion I must thank Professor Vines and Mr. Gardiner for their helpful suggestions and advice in this investigation.

¹ E. Heinricher, Eiweiss-schläuche d. Cruciferen, Mitth. aus dem Bot. Inst. zu Graz, 1886.

Fig. 1, α

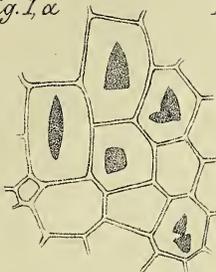


Fig. 1, β

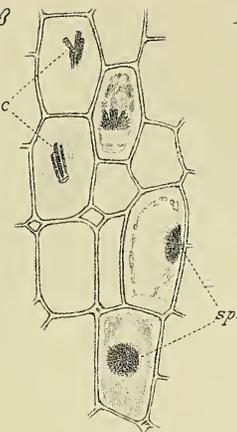


Fig. 1, γ

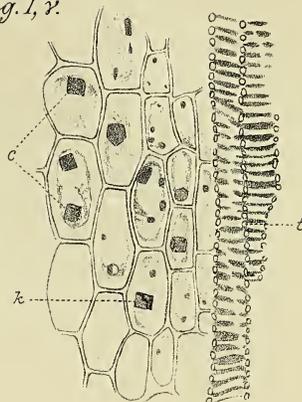


Fig. 3.

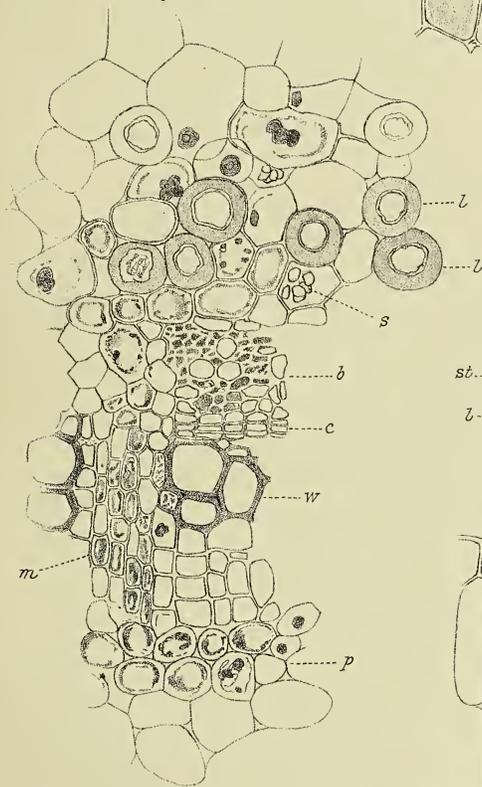


Fig. 2.

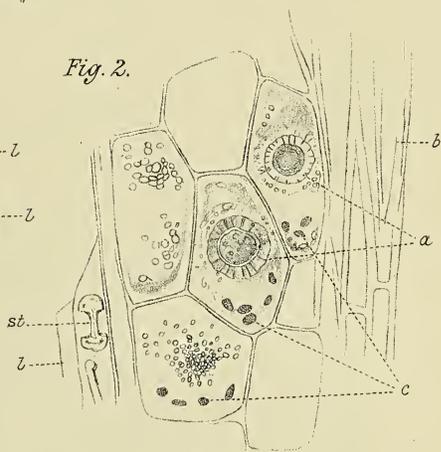
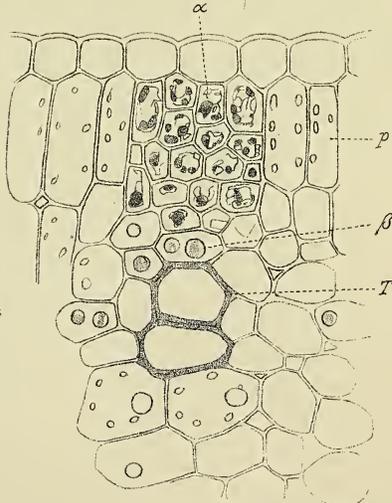


Fig. 4.



Fry del.

University Press, Oxford.

¹ On the Fructification of *Bennettites gibsonianus*, Carr.

BY

H. GRAF ZU SOLMS-LAUBACH.

—♦—
With Plates **XXV** and **XXVI**.
—♦—

WE have long been acquainted with numerous stems which are found in the Jurassic and Lower Chalk of England; and which, wrapped all round in a close armour of leaf-bases, are, on account of the similarity of habit, usually classed with Cycadeae. It was only gradually that it became known that many of these stems, especially when silicified, show the internal structure in the most beautiful manner. Buckland² was the first who established this fact in the case of the objects known as 'birds'-nests' from the dirt-beds of the Island of Portland. He also succeeded, with the help of R. Brown, in giving a satisfactory explanation of the most important features in the internal structure of the stem and of the panoply of leaf-bases. Further investigations in the same direction were made

¹ The Editors have thought that this important paper, based as it is entirely on English material, should have a place in the pages of the *Annals*. They desire to express their thanks to Graf Solms for the permission to translate his paper; and to Mr. H. E. Garnsey, of Magdalen College, Oxford, for the trouble he has taken in preparing this careful translation. The paper was originally published in the *Botanische Zeitung* for 1890.

² Buckland, 'On the Cycadoideae, a family of fossil plants found in the Oolite quarries of the Isle of Portland,' *Trans. Geol. Soc. of London*, ser. 2, vol. ii. (1829), p. 395.

by G. A. Mantell¹ with material obtained from the Isle of Wight. He says of a stem which he had picked up as a pebble on the shore of Brook Bay: 'This fragment is highly interesting, for the calcareo-silicious earth, of which the stem now consists, is of a finer texture than in any of the Tilgate Forest specimens, and transverse sections display under the microscope more satisfactory indications of the organisation of the original. Without many figures and more lengthened descriptions than our space will admit of, the peculiarities of structure exhibited in these slices could not be demonstrated; it must therefore suffice to state that the organisation, so far as it can be determined, shows a near approach to that of the Cycadeae.' I believe that I recognise this specimen in a stem at present in the Geological Department of the British Museum, which has been cut through and marked on the upper surface with the word 'Brook' written in ink. I am not perfectly certain on this point, because there are several fragments of the same mineral substance lying close to it and known to have come from Mantell; and because this particular specimen, strange to say, does not bear the number which indicates its place in Mantell's collection.

Mantell also states² that Mr. Saxby, of Bonchurch, in the Isle of Wight, had lent him the section of a *Clathraria*-stem showing structure, 'in which the bundles of vascular tissue in the petioles appear to be made up of spiral vessels.' I have not been able to ascertain where this preparation is preserved. Almost at the same time Corda³ published a figure and description of the structure of the leaf-bases of his *Zamites Bucklandi* which belongs to this group; he suspects that the specimen in the imperial collection at Vienna came from England.

It may seem strange that, under such circumstances, no further contribution to our knowledge of the anatomical struc-

¹ Mantell, 'The Medals of Creation,' ed. 2, vol. ii. p. 162, and 'Geological Excursion round the Isle of Wight,' p. 215. London, 1854.

² Mantell, 'The Medals of Creation,' ed. 2, vol. ii. p. 162.

³ Corda, 'Beiträge zur Flora der Vorwelt,' p. 38, t. 17. Prag, 1845.

ture of the stems in question made its appearance before the year 1868, when Carruthers' excellent account of them was published¹, and that nothing has since been added respecting them with the exception of Caruel's description of his *Raumeria cocchiana*², though a rich store of material has been lying waiting for examination in various museums. Massalongo and Scarabelli, indeed, began the study of the specimens found in Upper Italy, and a number of drawings had been completed when the work was interrupted by the death of Massalongo; it has been resumed by Capellini and myself, and the Marchese Scarabelli, of Imola, has in the kindest manner handed over to us the material and also the figures which have been already executed.

But the neglect of this very interesting subject, even after attention had been drawn to it by Carruthers, becomes intelligible when we learn to know the peculiar difficulties with which its study is surrounded. The specimens are rare, often unique, the ornament and pride of the different museums; they are scattered over the whole of Europe, and have recently been heard of from America also, and unfortunately it is not always easy to obtain leave for the close examination which necessarily presupposes the making sections through them. Another specially embarrassing circumstance is the size of the specimens, which in some cases is astonishing, and makes it difficult to transport them, and extremely laborious and costly to cut them. It is only in a few workshops that it is possible to deal with such huge and at the same time hard and intractable masses of stone. The size is a very great and special hindrance in the way of obtaining thin slices; and this was still more the case when Carruthers undertook his investigations than it is at the present day; but notwithstanding this difficulty he has explained the structure of the stems and leaf-

¹ Carruthers, W., 'On fossil Cycadean stems from the secondary rocks of Britain,' *Trans. Linn. Soc.* vol. 26 (1870), p. 675. See also the summary in F. Dixon, 'The Geology of Sussex,' New Edition, revised by Rupert Jones, p. 277. Brighton, 1878.

² Caruel, T., 'Osservazioni sul genere di Cicadacee fossili *Raumeria*, descr. di una specie nova,' *Bolletino del Reale Com. Geol. d'Italia*, no. 7, 8 (1870), p. 181.

bases, and that of the fructifications squeezed in between the bases of the leaves, in so masterly a manner from his numerous preparations, that at present I have chiefly only to confirm his results, though, as might be expected, a fresh examination may be found to throw further light on some questions of detail.

Carruthers' investigations embraced a large number of stems which had been discovered in the course of time chiefly in the south of England, and their result was to show that in all cases alike there were certain anatomical characters which indicate an essential difference from recent Cycadeae. The leaf-trace was found in every case to be formed of a single strand, which, separating by repeated division into numerous branches before it issues from the leaf, runs perpendicularly downwards through the cortex to enter the ring of wood; in its lower portion it contributes largely for a certain distance to the secondary growth of the wood. There is no sign of the arching of the leaf-traces to form a girdle, such as we see in our living forms, and on this point I may venture to speak quite decidedly after repeated and most careful examination of many specimens. The somewhat feebly developed hollow cylinder of the secondary growth separates normally into a ring of bast and a ring of wood; it is divided by rather broad intervals, filled with parenchyma, into segments of unequal size. The tangential section which Carruthers had before him only in the case of his *Bennettites saxbyanus*, and which I find to have exactly the same structure in one of the Italian stems, shows a broadish rhomboid gap in the wood and bast over each of the emerging strands. It is these gaps filled with parenchyma, which cause the interruptions in the woody ring on the transverse section. The entire cylinder of wood and bast thus becomes a trellis-work, with spindle-shaped meshes, and consequently presents a very striking though superficial resemblance to the vascular bundle-system of the stems of Ferns, as Carruthers himself says on page 696: 'The analogy between these fossil stems and the caudex of a tree-fern is very remarkable.' Closer examination will doubt-

less disclose a greater affinity with the course of the vascular bundles in many Coniferae¹. The structure of the bundles and of the secondary wood and bast must be further investigated, but this much is certain, that it shows great similarity to the same structure in recent Cycadeae. In *Bennettites*, as in Cycadeae, pith and cortex are permeated by more or less numerous gum-passages. The pith of *B. peachianus*, Carr., from the Jurassic of Sutherland in the north of Scotland, shows, besides these passages, peculiar irregular rings which have not yet been fully investigated². Caruel³ found something of the same kind in his *Raumeria cocchiana*, and of this I have now at my disposal the material necessary for examination, through the kindness of Professor d'Ancona, of Florence. I have been able to determine that we are here dealing with periderms, of which a fuller account will be given in another place. I hope before long to be able to say whether this is the case in *Bennettites peachianus* also; the other stems which have been examined hitherto show nothing of the kind.

These stems, like those of recent Cycadeae, are inclosed in an unbroken armour of leaf-bases, the internal structure of which has been elucidated by Carruthers and shows no peculiar features. Each leaf-base is transversely rhombic in cross-section; in its parenchyma lie numerous bundles which together form a rhomboid figure parallel to the contour of the section, except on the upper side where the two limbs bend downwards and inwards. The epidermis bears a large number of hairs, like theramenta of Ferns, composed of one or more layers of tissue, and so close together as to form a regular felt which completely fills the fissures between the several leaf-bases. The tissue of the leaf-bases had very often rotted away before petrification, and only the epidermal layers and the masses of hair between them were preserved. In such

¹ See on this point Geyler, 'Ueber den Gefässbündelverlauf in den Laubblattregionen der Coniferen,' Pringsheim's Jahrb. vi, tt. iv-ix; and Bertrand and Renault, 'Recherches sur les Poroxylons,' pp. 254-256.

² See Carruthers, loc. cit., pl. 62.

³ See Caruel, as cited above.

cases the outer surface shows a network of projecting ridges separating deep rhomboid cavities from one another. *Clathropodium foratum*, Sap.¹, is a good example of this state of preservation.

But the leaf-armour, viewed from without, shows other unevennesses of surface in varying numbers and irregular distribution, having a whorled appearance. Where these are well preserved, they are seen to be the transverse fractures of smaller leaves arranged round a centre of their own². They are leafy lateral branches which have forced their way through between the leaf-bases, considerably altering their shape, and which terminate in inflorescences or fructifications of very peculiar construction. These fructifications are at present known only in one species, *Bennettites gibsonianus*, Carr., in which their preservation is evidently due to the shortness of the axis, which prevents the spadix, as the structure may be termed, from rising above the surface of the leaf-bases. In all the other forms as yet described they projected above the surface; consequently the upper free portion has disappeared, and the middle of the transverse fracture is occupied by the transverse section of the axis.

It is on the sum total of these characters that Carruthers has founded his group Bennettiteae, which he would have us regard as a subdivision of Cycadeae. But his own account of the structure of the fructification is sufficient to show that we are dealing here with a tribe of plants quite distinct from Cycadeae; they may perhaps be coordinated with Cycadeae, but they certainly cannot be subordinated to them. Judging by the vegetative characters only, which recur in the same characteristic manner in countless stems, the nature of the fructification being known only in one species, *Bennettites gibsonianus*, we arrive at the surprising result that all the Jurassic and Neocomian stems which are termed *Cycas*-stems, so far as anything is known of their structure, belong to Bennettiteae, and that not a single one of them has been

¹ See Paléontologie Française, terrain jurassique, vol. II, tab. 54.

² See Carruthers, loc. cit., pl. 58, fig. 3.

proved to be a genuine stem of Cycadeae. This further shows how precarious is the identification of fossil remains when it rests on superficial characters only.

It was observed as early as 1851 by R. Brown¹ that while the transverse section of all stems from the dirt-beds of the Island of Portland is circular, that of the stems from the Isle of Wight is distinctly elliptical. This difference is seen most plainly in the pith and ring of wood, and can hardly be attributed to subsequent compression. Carruthers has employed it to distinguish his Bennettiteae into two genera; *Bennettites*, Carr., containing the specimens with an elliptical transverse section; and *Cycadoidea*, Buckl., in which the section of the stem is circular. I do not believe that this distinction will be maintained, for among the specimens found in Italy and preserved in the Museums of Bologna and Imola, we find, besides the two types above-mentioned, others which are almost circular, and show only a very slight compression. I should therefore rather confine the name *Bennettites* to the species in which we know the characters of the fructification, that is to *B. gibsonianus*, Carr. Among the Italian specimens there will perhaps be found some forms resembling *B. gibsonianus*, and requiring to be placed with it; all the rest, which have only the basal portion of the fruiting shoot, may for the present be properly included under the name *Cycadoidea*, Buckl., whether their transverse section be round or elliptical. At the same time I do not propose to carry out this nomenclature, which would have been suitable enough in the beginning, but now, whilst we are still awaiting the final determination of all the facts of the case, would merely have the effect of increasing the synonymy, which is already sufficiently difficult.

Carruthers' account of the structure of the fructification of his *Bennettites gibsonianus* has often been misunderstood. It is really a very apt description of the fossil, but it is so concise that to understand it thoroughly requires very careful study and constant comparison of the figures. There are also some obscure points here and there which the author could not at

¹ See Carruthers, loc. cit., p. 694.

the time clear up; to do this would have required such an exactly transverse orientation of the slices as could not be obtained thirty years ago without difficulty and great waste of material. If I have contributed anything to the explanation of some of these points, as I think that I have, it is entirely due to the great liberality of Sir J. D. Hooker and Mr. Thiselton-Dyer in entrusting me with a portion of the precious material for the preparation of new slices, and of Carruthers himself in affording me repeated opportunities of examining the specimen preserved in the British Museum, and the preparations on which his work is founded. And if the present paper is occupied exclusively with the inflorescences of *Bennettites gibsonianus*, Carr., it is because my chief object is, by a detailed discussion of the characters disclosed in these fructifications, to obtain a foundation for the examination which I hope in time to make of the other forms.

The material employed in the study of *Bennettites gibsonianus* was obtained from a single large block, found in 1856 or 1857 by Thomas Field Gibson, in Luccomb Chine, at Bonchurch, in the Isle of Wight, the history of which appears in the memorandum given below. It is true that Carruthers¹ says that waterworn fragments of this species and of *B. saxbyanus* have been mistaken for portions of *Bucklandia anomala* by Mantell in his 'Medals of Creation²,' and that Fig. 57 in that work gives a very good woodcut of these fragments, &c. But after examination of these specimens, which are in the Geological Department of the British Museum, I am not satisfied that they really belong to *B. gibsonianus*. Of one of them, to which Mantell's statements respecting the internal structure probably apply, I have spoken above; the others bear the numbers from Mantell's collection, I. 38361 and 38363. No. I. 38361 is labelled *gibsonianus*, No. 38363 *saxbyanus*, in Carruthers' own handwriting. Lastly, No. 38360, of which Mantell gives a separate figure, is also named *B. gibsonianus* by Carruthers. All these fragments are specimens

¹ See Carruthers, loc. cit., p. 700.

² See vol. i. p. 163.

of Bennettiteae, but they have no fructifications, and show only the basal transverse sections of the lateral spadices. I shall have to return to them in another place.

With regard to the specimen known to be the original block of *Bennettites gibsonianus*, we have the following memorandum, which was communicated to Carruthers by a member of the family of the discoverer, and which I was permitted to copy in the British Museum. It runs thus: 'This fossil plant was found by Thomas Field Gibson, Esq., in the Lower Greensand at Luccomb Chine, Isle of Wight, in the year 1856 or 1857. In the spring of 1858 it was taken to Mr. Yates' house at Highgate, where it was examined by Dr. Hooker and Mr. Morris, Professor of Geology at University College. They split it open, and found oval pods containing little seeds arranged regularly round near the edge. Each pod was about an inch and a half long. The best pieces containing the most perfect pods were kept by Mr. Gibson and Dr. Hooker, but this piece is much larger than the other part which was broken up, being about two-thirds of the original lump. I believe a similar specimen was found by Dr. Leeson, of Bonchurch.'

It appears, therefore, that the original block was broken in two with a hammer, and was thus split into two unequal halves, and beside these into a large number of smaller fragments. This explains why the two main pieces do not fit into one another in their present state. Hooker took the smaller (upper) main piece, and it is now in the Museum at Kew; the larger (under) main piece was made over by Gibson's family to the Botanical Department of the British Museum. Hooker appears to have used some of the smaller fragments for the preparation of slices; others were kept by Morris, from whose hands they passed into the private possession of Carruthers. I gather this from the fact that Carruthers has a fragment which still bears Morris' label written with his own hand.

Thus the material of *Bennettites gibsonianus* consists in its present state of the following pieces:—

1. Of the large and fine block in the Geological Department

of the British Museum. This block is twenty centimetres in height, twenty-seven centimetres broad in the longer axis of the elliptical transverse section, and eighteen centimetres and a half in the short axis of the same. It is the lower portion of the original block; it becomes gradually smaller below, and terminates in a roundish projection. Externally it is angular and has sharp edges; on the fresh surface of the fracture its colour is a dark chocolate brown, everywhere else it is covered with a yellowish brown ochreous crust. It shows no sign whatever of having been worn and smoothed by the action of the sea. The panoply of leaf-bases has been preserved all round. Two polished section-surfaces are seen in the rough block where portions of the margin have been cut off. The first of these has a tangential direction, passing transversely through the leaf-armour and the inclosed fructifications. The second shows the transverse section of the stem, and cuts longitudinally through the leaf-bases and fructifications. The petrification of the specimen is very perfect; the material, as was said above, is tricalcium phosphate; but there are gaps here and there which are usually filled with clay-stone or with crusts of iron oxide. Unfortunately the examination of many places, especially in the fructifications, is greatly obstructed by the presence in large quantities of opaque pyrites distributed throughout the entire block.

2. Of the upper and much smaller fragment of the original block, which now belongs to the Museum at Kew. This is less perfect than the piece in the British Museum; a portion of the leaf-armour has disappeared on one side; the outer surface even cuts off here and there a corner of the ring of wood and of the pith. The surface of one fracture has been cut smooth to obtain a polished transverse section of the stem. Part of the marginal portion thus set free has already been used to make slices; the remainder, inclosing a fructification, has supplied the chief material for my new preparations.

3. Of a few small fragments in Carruthers' possession, which came from Morris as the label on one of them shows. This

fragment supplies an instructive fracture, which passes obliquely through a fructification.

4. Of a large series of slices, the material employed in Carruthers' investigation, partly supplied by Hooker. These are sections in various directions through the fructifications. From the character of the stone and the structure I am satisfied that a slice, without a label, showing the transverse section of pith and woody cylinder, is one of this series.

5. Lastly, of the slices recently taken by myself from the fragment at Kew; the chief of these are preserved at Kew; a few duplicates have remained in my possession.

Note. In presence of the fact that so many stems of *Bennettiteae* have been found only in secondary places of deposit, it is very necessary to determine with all possible exactness the place of origin of all important specimens. I therefore visited Lucomb Chine in August 1889. The chine is a deep ravine entirely in the Lower Greensand. The lowermost bed of the formation on the sea-shore is rather less deeply cut into than the beds above it, and forms a nearly vertical wall from two to three metres high, of dark colour and sandy character. It is full of green grains of glauconite and small bits of iron pyrites, the iron giving rise to an ochreous coating on the surface in moist spots, and it contains an unusual quantity of small fragments of coal which deserve closer examination, though it would be necessary for this purpose to obtain unweathered material from within the bed. It also contains concretions like those of the Loess, which weather out and then lie on the sand of the shore among the fragments of flint; comparison of the products of weathering with the bed leaves no doubt that the concretions come from the bed. If we break up the concretions we usually find at the centre of them a fragment of coniferous wood in good preservation, and sometimes covered with only a thin crust of stone. The wood is of a grey colour as long as it is quite fresh, but it passes into chocolate-brown as soon as it begins to weather. The material of petrification is calcium carbonate and tricalcium phosphate.

The original block of *Bennettites gibsonianus* found at the same spot greatly resembles these concretions, and the rock adhering to it here and there has the same composition, but its outer surface is coloured ochre-brown all over, in consequence probably of being rich

in iron oxide and pyrites, and of having lain exposed a long time since it weathered out. All the facts show beyond doubt that it really comes from the Lower Greensand. A further proof is that in the argillaceous coating of the microscopical preparations in the British Museum I found a Foraminifer resembling a *Rotalia*, and this points to the marine character of the deposit containing the stem. I made enquiries after the Cycadean stem mentioned in the memorandum above as in the possession of Dr. Leeson, of Bonchurch, and purchased it; it was found on a heap of stones on the land of the discoverer, now deceased. It is in fact what it appears to be, a second specimen of *Bennettites gibsonianus*; its further examination must wait some future opportunity.

The fruit-bearing lateral spadices of *Bennettites gibsonianus* are, according to Carruthers, of axillary origin, as had been already stated by R. Brown. But they do not by any means occur in every leaf-axil; on the contrary, the majority of leaf-axils are in most cases empty. I would remark, however, that this view is very natural, and is indeed highly probable, but that we can hardly hope to give a decisive answer to the question. A short time since we were still in ignorance as to the mode of origin of the flowers in living Cycads. The position of the fructifications in Bennettiteae, as far as I can judge from the slices at my command, follows no fixed rule; in some cases they emerge singly from between the leaf-bases which cover the stem; in others they appear in groups, and are sometimes so crowded together as to be in close contact with one another. I also observed, when cutting a fragment into transverse slices, that the spadices are not all of the same length; and that in the lower sections new ones, completely covered by the leaf-bases which close over them, were exposed between those previously observed. On comparing these preparations, I could not resist the impression that the new spadices were lateral branches of those which projected further from the axis. If this is the case, we should occasionally find fascicled systems of fertile axes emerging in a body and in close contiguity with one another, or thrusting their shoots singly into the interstices between the leaf-bases of the armour. But

distinct proof of this cannot be obtained without an unlimited supply of material for making series of slices. The leaf-bases between the spadices are usually much out of shape, and the transverse section is irregular and distorted; this makes it impossible, as a rule, to determine the precise relative position of the two kinds of organs. Where the spadices occur singly, they are indeed sometimes exactly over a leaf-base; in other cases again they are thrust quite to one side. Displacements from pressure within the closed layer of contiguous organs would necessarily cause the disappearance of any positional arrangements which may have originally prevailed. But if the material at our disposal does not suffice to determine that the shoots in Bennettiteae were axillary, there is on the other hand nothing to show that they were terminal as in living Cycads, and that the stem which bears them was a sympodium. In no transverse section which we possess of any stem of Bennettiteae do we find even a trace of the bundle-system running into the pith, which is so characteristic of the flower-bearing termination of the axis in Cycadeae; and where such shoots are so abundant as in the armour of *Bennettites gibsonianus* and other stems, it would be very strange if no section had ever hit upon a system of the kind.

Each of the shoots terminating in spadices is composed of a large number of abbreviated internodes, and bears spirally disposed lanceolate acuminate cataphyllary leaves, biconvex in transverse section with two sharp edges. This is shown by Carruthers in figure 3 of plate 58 which gives the transverse section, and in figure 5 which is the oblique longitudinal section; but the latter figure is not so clear as it would have been if the section had been truly median. The transverse section gives the axis of the shoot surrounded by its leaves, which are closely packed with no gaps, but with only narrow layers of the characteristic ramenta between them. There is an indication of the parastichies in the figure first cited. That these leaves are lanceolate and have no terminal lamina can be known for certain only where their surface, or the mould of it, is laid bare by the fracture. Here we can see both their

form and the median keel which gradually slopes towards the margins and projects on both surfaces, and gives the transverse section its characteristic shape. The block in the Museum at Kew may be specially mentioned as having a fine fracture of this kind, though the like may be seen also in other stems of Bennettiteae when the whole of the fruit-bearing shoot has decayed away or been broken off from the scale-armour, leaving only the basal internodes behind. The resulting funnel-shaped cavity is then lined with the narrowly lanceolate leaves. The reader is referred for this state of preservation to Carruthers' figure of his *Mantellia inclusa*¹. The conditions here described are to be seen very distinctly in the original specimen of *Bennettites maximus*, Carr., in the Jermyn Street Museum in London.

The cataphyllary leaves are similar in their internal structure to the leaf-bases of the armour of the stem. Here their fundamental parenchyma consists in all cases, not of thin-walled, but of stout cells thickened after the manner of scalariform tracheides, and incloses many broad cylindrical gum-receptacles which are much elongated longitudinally and contain a copious brown matter. One important difference is that each leaf has only three vascular bundles of delicate herbaceous texture and with a roundish transverse section; the tissue is usually very badly preserved, and frequently shows nothing but a succession of empty spaces. The distinct epidermis is formed of one layer of very small cells. I have searched in vain for stomata in every slice. The section of one of these leaves given by Carruthers² is very true to nature, only the vascular bundles are not shown having been probably overlooked by the draughtsman; there must have been one visible on the portion of the section represented in the figure.

The peculiar paleaceous hairs (ramenta) of the leaf-bases of the stem are found, as has been already said, on the cataphyllary leaves, but they are fewer and smaller and very thin, and form intermediate layers which disappear in places

¹ Carruthers, loc. cit., pl. 63, fig. 3.

² Carruthers, loc. cit., pl. 60, fig. 6.

altogether. These hairs are so very peculiar and differ so greatly from the simple unicellular twisted bristles which take their place in *Cycas* and *Dioon*, that we may devote a few words to them. They are leaf-like and resemble the ramenta of Ferns; radial longitudinal sections show that they possess considerable length, and are folded repeatedly between and with one another in relation to the space which they have to occupy. Owing to these flexures and folds, we never see them in their full extension in surface-sections; and for the same reason I have never been able to form a clear idea of the nature of their margin, and still less, of course, of their general figure. They are spindle-shaped in transverse section, and have a sharp edge to the margin on both sides. They are usually composed of a single layer of cells, but not unfrequently of two layers lying one on the other; and in the middle they may contain as many as three layers, but at the margin there is never more than one layer. All their cell-walls appear to have been strongly thickened, and are broad, homogeneous, and of a dark brown colour; in many cases indeed the secondary thickening-masses can be distinguished from the evident and lighter coloured middle lamella. The appearance of the transverse section of the hairs is admirably represented by Carruthers¹, and also in Corda's figures which belong to *Zamites Bucklandi*, and were incorrectly explained by this author, who took them for the macerated remains of the cataphyllary leaves between the leaf-bases. Tangential preparations show us the shape of the cells, which are elongate-tubular, with oblique ends thrust in between one another.

Nathorst² has suggested that the fructifications of *Bennettites gibsonianus* may have been parasitic on the stem of Cycads, and has attempted a comparison of them with the genus *Lophophytum*. If any further argument against this view were still wanting, to which the author of it himself no

¹ Carruthers, loc. cit., pl. 60, figs. 7 and 11.

² Nathorst, 'Några anmärkningar om *Williamsonia*, Carr.,' Öfversigt af Kongl. Vetenskaps. Akad. Förhandlingar. 1880, No. 9.

longer adheres, it would be found in the structure of the axis of the cone. Carruthers has told us that in the species of his genus *Mantellia* (the *Cycadoidea* of Buckland) the lateral axes show the structure of Cycadeae. His words are¹: 'and show there a woody cylinder agreeing in structure with the principal axis of the plant.' He had before him no transverse slice of the fertile shoot of *Bennettites gibsonianus* suitable for determining this point. It could be seen from those prepared by myself that the axis, which had lost its shape owing to the pressure of the surrounding leaf-bases and become very irregular, has a woody cylinder which is thin indeed and weak, but in all other respects is like that of the stem and follows the irregularities of the transverse section; it can therefore only have reached its ultimate development after the distortion was complete. The transverse sections of numerous leaf-traces are visible on the outer surface in the cortex which, like the pith, consists of thin-walled parenchyma with many gum-passages.

Of the seminiferous spadix which terminates the lateral shoot, and is enveloped in its leaves, Carruthers² says: 'The branch terminates in a fleshy subpyriform enlargement which bears the seeds. This is composed of, first, a cellular cushion; second, vascular cords supporting the seeds; and third, a mass of irregular cellular tissue enveloping the whole.' It is not plain from this account, or from the special description which follows it, whether the author considered the 'vascular cords' to be organs quite distinct from one another, or only differentiated tissue-strands traversing a homogeneous fundamental parenchyma. And this again makes it difficult to give a satisfactory account of the 'mass of tissue' which surrounds the whole. To settle this point requires in fact careful study of numerous sections in different definite directions, such as were not in existence when the above passage was written. Renewed examination of new, as well as old, preparations had somewhat advanced my knowledge,

¹ Carruthers, loc. cit., p. 697.

² Carruthers, loc. cit., p. 697.

when I was studying the genus *Bennettites* for my 'Einleitung in die Palaeophytologie,' and yet profounder study places me already under the necessity of modifying the account contained in that publication in some not unimportant points.

To form the spadix the axis terminates in a slightly flattened hemisphere¹ on which a whole cluster of closely crowded organs takes its rise. Its succulent parenchyma, which consists of thin-walled cells with wide lumina, is generally destroyed, though it is better preserved in some of the slices in the British Museum. The vascular bundle-system of the shoot which bears the spadix comes to an end in the parenchyma; beneath its convex apex may be seen numerous sections of small bundles which have different directions, and evidently supply the members of the cluster of organs which proceed from it. This is shown in a figure of Carruthers², which is not however very perfect.

On the convex upper surface of the apex, or 'cushion' as it is termed by Carruthers, the seed-bearing 'cords' take their rise, a closely crowded cluster of erect stalk-like bodies united into a club-shaped mass. In studying it minutely we shall do well to begin with a transverse section immediately beneath the upper convexity of the fleshy 'cushion.' Examining the section with a lens, we distinguish at once a main central mass and a thin zone which surrounds this and in its turn separates into two successive layers. The central portion presents the picture given in a figure by Carruthers³, which shows the irregularly polygonal transverse sections of the 'cords' imbedded in a homogeneous fundamental tissue, the 'fleshy pericarp' of Carruthers' description. However, exactly transverse sections teach us that this apparent fundamental tissue is by no means homogeneous, but is composed of the transverse sections of very many smaller organs pressed close to one another and filling up the intervals between the 'cords'

¹ Carruthers, pl. 59, fig. 3, reproduced here in Plate XXV, fig. 9.

² Carruthers, loc. cit., pl. 60, fig. 4.

³ See pl. 60, fig. 1.

as has been described already in my *Palaeophytologie*¹. The transverse section of the 'cords' shows a stout peripheral layer of very thick-walled quite homogeneous and uniform cells, bounded on the outside by a simple epidermis without ramenta. In the longitudinal section these cells are seen to be elongated pointed fibres with thick walls which appear to be entirely destitute of pits. In ordinary states of preservation this layer of fibres surrounds a cavity in the tissue filled with the structureless material of petrification, often also with pyrites, and containing only scattered remains of tracheal elements. Bounding the cavity there is regularly a simple layer of cells, firmly connected with one another laterally, but not essentially different in other respects from the fibre-cells; this layer may not unreasonably be supposed to be an endodermis, though of this there is no proof. It is only in rare and exceptional cases that we find, instead of the central cavity, a more or less well-preserved delicate tissue of cells with rather wide lumina, in the middle of which is a weak and irregularly shaped tracheal strand consisting only of a few elements. The smaller transverse sections of the organs lying between these 'cords' are all pressed closely against one another, and owing to this pressure are very irregularly polygonal. They consist chiefly of thin-walled parenchyma, with isolated gum-passages, inclosed in a simple very strongly developed and distinct epidermis. In the centre of this homogeneous parenchyma is the tracheal strand with essentially the same structure as that of the 'cords.' On the longitudinal section I have not been able to demonstrate with certainty the portions of tissue which belong to these organs, on account of the close crowding and the winding course of all the constituents of the spadix (Plate XXV, Fig. 2, where *a* is the 'cords,' and *b* the transverse sections of the organs lying between them).

Going on to the peripheral zone of our section, we find that its inner layer is formed of the same elements as those

¹ See the *Palaeophytologie*, p. 98 [*Fossil Botany*, Oxford, 1891, p. 96]; and also Plate XXV, figs. 11 and 12 of the present paper.

which are observed in the central portion of the spadix ; only the transverse sections of the 'cords' are here usually much smaller and fewer and farther removed from one another. On the other hand the small transverse sections of the interstitial organs are much more numerous and are at length almost exclusively present towards the outside (see Plate XXV, Fig. 2), as I have before endeavoured to show in the *Palaeophytologie*. Their well-preserved, dark-coloured, closely appressed epidermal layers contrast strangely with the often indistinct yellowish-brown inner tissue, and appear as irregular bands traversing the latter.

Lastly, the outer layer of the peripheral zone cannot be resolved into transverse sections of different members, but consists of homogeneous dark-brown rather large-celled parenchymatous tissue, which surrounds a considerable number of cells with strongly-thickened apparently lignified walls, and is covered towards the outside with an epidermis, which is present over its entire surface, and impinges immediately on the surrounding cataphyllary leaves. Not unfrequently sharp and tolerably deep indentations penetrate from without into this homogeneous external layer ; these indentations are covered with the epidermis, and probably answer to the cross-sections of a superficial areolation of the entire fructification ; they are particularly well and clearly seen near the base of the spadix in Fig. 12 of Plate XXV. Carruthers has endeavoured to illustrate the matter by a figure showing the details taken from the base of the spadix¹.

If we now examine transverse sections of the spadix lower than the one just described, we find the structure essentially unaltered, except that we get in addition in the centre the transverse section of the upper convexity of the 'cushion' surrounded by the constituents of the central portion already described. The lower the section, the narrower is the ring formed by this part of it, and the inner layer of the peripheral zone also gradually diminishes till at last, in the lowermost section, the slender compact tissue-mass of the outer layer is

¹ Carruthers, loc. cit., pl. 60, fig. 3 ; also Plate XXV, fig. 8 of this paper.

the only one that remains, and this now enters into direct connection with the tissue which occupies the middle of the 'cushion' and becomes continuous with it. This continuity is particularly well seen in suitable longitudinal sections, especially in the median longitudinal section¹ or in one that is slightly inclined obliquely to the median². Here I am obliged to give new drawings of the basal portions of both preparations, because the published figures give too little detail. My figures are perfectly accurate, and were drawn in my presence in the British Museum by Mr. Charles Berjeau. We see in the median section (Plate XXV, Fig. 10) how the homogeneous external layer takes its rise, far down in the periphery of the entire cluster of organs, directly from the axis of the spadix at the margin of the 'cushion'; how it appears notched by penetrating fissures; and lastly, how it extends round the entire spadix, becoming broader indeed, but less distinct, above. The other section (Plate XXV, Fig. 8) shows exactly the same thing; but in consequence of its oblique direction it has touched only the upper part of the basal cushion on the lateral margin, so that its connection with the shoot which bears it is not seen. Below it, the section passes necessarily through the outermost marginal attachment of the homogeneous outer layer of the spadix in a partly oblique tangential direction; hence the layer seems in this case also to be closed below. But the incisions are particularly distinct just at this part, and they unite here and there to form polygonal compartments or areolae (see Plate XXV, Fig. 8, a).

But if the transverse sections are made through the upper portion of the spadix the picture is quite changed, for new constituents are introduced into it in the shape of the ripe seeds. These lie in a simple peripheral layer, surrounded by the closed tissue of the external layer, which is here rather strongly developed, and are everywhere nearly equidistant from its surface. They are generally cut through in an

¹ Carruthers, loc. cit., pl. 59, f. 3.

² Ibid. pl. 59, f. 1.

oblique direction, so that the apex and the base are not touched, the testa therefore seems to be of uniform structure all round. It is only in preparations in which the section passes quite close beneath the apex of the spadix that we are able to see some of the seeds in exact transverse section. They are, in fact, so disposed that the longitudinal axis is everywhere perpendicular to the convex surface of the spadix¹. Exact longitudinal sections are not easy to obtain, but they show that each seed, which is about three millimeters in length and two in breadth, is borne on a long stalk which is the structure hitherto termed the 'cord' by Carruthers; and moreover that the seed is not, as a matter of fact, lodged, as it appears to be, in the tissue of the external layer, but fills a flask-shaped pit or depression, and has a slender process passing through the narrow open canal of the pit, and terminating at the surface of the spadix. This surface has a peculiar appearance from the number of seed-containing pits with their narrow orifices, and reminds us of *Dorstenia*, or, as Carruthers² aptly suggests, of *Tambourissa*. Carruthers' figure³ is not readily intelligible without a knowledge of the object, and even then is not clear. The exactness with which the seed fills the pit which contains it is peculiar: there is nowhere the smallest interval between it and the wall of the pit, so that it is difficult to be quite sure whether or not there is continuity between the two, or how far it may extend; I am obliged to suppose that at the base such continuity exists.

In many seeds the contents are entirely destroyed, and then we find crystals and structureless remains of organic substance in their place. In other and not very few cases, they are very well preserved, and may be seen to be an embryo, in which radicle, hypocotyl, and the two fleshy cotyledons lying one on the other as in the bean, can be distinguished, if the

¹ In Carruthers' work they are represented in the transverse section in pl. 59, f. 5; in the tangential section in pl. 59, figs. 1, 2, 4; in the oblique radial section in pl. 59, fig. 3; and in Plate XXV, fig. 9 of the present paper.

² Carruthers, loc. cit., p. 698.

³ Carruthers, loc. cit., pl. 59, fig. 6.

section is exactly longitudinal. The radicular end is slightly pointed; the growing-point of the stem is visible in the best preparations as a short transverse line, above the middle of which the division between the two cotyledons comes to an end. In one seed, which I studied in the British Museum, and of which I possess a photograph through the kindness of Mr. A. Gepp (Plate XXVI, Fig. 6), the position of the growing-point is particularly prominent because local destruction of the tissue has produced a cavity directly above it filled with colourless stone. In all the embryos which I have seen the cotyledons occupied as a rule two-thirds, the stem-portion one-third, of the entire length. In some of them the tissue was in a good state of preservation (Plate XXVI, Fig. 5), especially in the cotyledons. This tissue is a parenchyma without intercellular spaces, consisting of brick-shaped cells arranged transversely to the surface of the cotyledons. In one case (see Plate XXV, Fig. 4, and Plate XXVI, Fig. 5) I could see that the tissue in the hypocotyl was formed of isodiametric polygonal cells, and was traversed by a central strand, the vascular bundle, from which a branch passed beneath the growing-point into each cotyledon; but sections of such exact orientation are rare and accidental. If the longitudinal section, as sometimes happens, runs parallel to the bounding surface of the cotyledons, the embryo must necessarily appear as a homogeneous mass of tissue. In the much more common transverse or oblique sections¹ we see the circular, or in the latter case the more and more thoroughly ovoid,

¹ See Carruthers as cited above, pl. 59, f. 4. This preparation has supplied the photographs of the transverse section of the seed (see Plate XXVI, figs. 1-4), for which I am also indebted to Mr. Gepp's kindness. But the section looks differently now from what it did when the figure was drawn, because the whole of the middle portion has crumbled away and the marginal portion only, which contains the seeds, is still preserved. It was the custom at that time in England, and is still to some extent, not to keep the slices under cover-glasses, their thickness making it rather inconvenient to do so. But this custom leads ultimately to decomposition of the upper surface, and, when pyrites is present, to the destruction of the entire preparation. It is simply the oxydation of the pyrites which has caused the disintegration and crumbling of the central portions of the slice in question, and this would certainly have been avoided by covering it with a cover-glass.

section of the embryo, divided into two halves by a usually very distinct line which coincides with the long axis of the ellipse, and is continued through its whole length. This line is the division between the two cotyledons. Where the section is not too oblique and the preservation is also good, six points may be seen in each cotyledon which form a median transverse row, and are undoubtedly the transverse sections of as many vascular bundles (Plate XXVI, Figs. 1-4). Carruthers had not noticed this remarkable state of preservation of the embryo; he saw the parenchyma in the inner body of the seed, but he took it for the endosperm, for he says on p. 698: 'Enclosed by these envelopes is the nucleus, with its membranous covering, and abundant albumen. The sub-rectangular cells of the albumen are obvious in several specimens, but I have not hitherto detected the embryo.' Nevertheless there is an indication at least of the embryo to be seen in the corresponding figure¹; a portion of the boundary line between the two cotyledons is given in the drawing, but it was probably taken for a merely accidental splitting.

The embryo is surrounded by a thin membrane in the form of a brown line. In many cases the membrane lies immediately on the embryo, in others there is a fissure-like space between them filled with the material of petrification. We might be tempted to see in this interval (Pl. XXVI, Figs. 2, 3) the trace of an endosperm which was present though in small quantity. But it is against this view, that the space in question is not found uniformly on all sides of the embryo, and further there is the important fact that a perfectly similar fissure is very often seen between the two cotyledons, where it can only be referred to shrinking. It must therefore be due probably to the same cause in the periphery, and we must suppose that the seed was without endosperm. As regards the brown investing membrane, this appears usually as a simple line, its cellular structure has nowhere been demonstrated with any certainty; but I have no doubt that it will be found to answer

¹ Figure 9 in pl. 59.

to the bounding-line of the nucellus, and therefore represents Williamson's 'nucular membrane.' There is some appearance at its upper extremity of a conical process, which extends beyond the radicular end of the embryo and enters the lower portion of the tubular prolongation of the testa; this is best seen in the preparation on which Fig. 8 of Pl. XXVI is founded. Unfortunately after repeated examination I can still only speak thus conjecturally respecting the presence of the nucellar apex which contains the pollen-chamber.

Turning now to the testa, we find three distinct regions in it which require separate consideration: (1) the middle portion inclosing the seed-cavity and the embryo in it; (2) the basal region; and (3) the apical portion which extends as a tubular canal beyond the seed proper, and pushes through the narrow orifice of the seed-pit till it reaches the surface of the fructification (Pl. XXVI, Fig. 10).

In the middle portion the testa is pretty closely applied to the 'nucular membrane'; three distinct strata may be seen in it in all cases of good preservation; the middle is a simple layer of short prismatic very thick-walled dark-brown cells, standing side by side as in palisade-tissue, while the inner and outer are formed of rather small-celled thin-walled tissue in several layers. In the inner stratum this tissue is often compressed and indistinct; in the outer it forms a lighter area round the hard palisade-tissue, and seems to be continuous to a greater or less extent on the outer side with the surrounding wall of the seed-pit. At least I often found, when examining a single seed, that it was only in places here and there that I could perceive a sharp line of demarcation between the two parts (see Pl. XXV, Fig. 5). Carruthers has figured this structure admirably¹; the middle hard layer of the testa stands out sharply in all his drawings.

The basal region is figured by Carruthers² in a slightly oblique longitudinal section which deviates from the median line towards the upper part. I have before me several similar preparations (see Pl. XXV, Fig. 1). In these may be seen in

¹ Carruthers, loc. cit., pl. 59, f. 8.

² Carruthers, pl. 59, f. 7.

the hard middle layer of the testa a small gap *a*, towards which the vascular bundle of the seed-stalk advances from below. Inside the hard layer is a small flat expansion of compact tissue, produced, as the surface-view shows, by the divergence from one another of the tracheal elements of the vascular bundle which terminates here (see Pl. XXV, Fig. 3). On this point there can be no doubt; we have here the behaviour which we so often find in the chalaza of gymnospermous ovules. If the testa is separated from the nucellus in breaking open the fructification, as sometimes happens, and the nucellus of the seed is exposed (Pl. XXV, Fig. 6), it shows, at the spot where the chalaza expands, a small impression from which a number of shallow furrows radiate towards the apex.

The most difficult part to understand in the whole of the seed is the tubular prolongation of the testa beyond the apex of the nucellus. It is far from being so simple as it appears in Carruthers' drawing¹, and my own diagrammatic delineation is probably not quite correct, even if it comes on the whole near the actual condition. There are difficulties in the way of investigation which are quite insuperable with such scanty material. First of all the peculiar position of the seeds in the spadix makes it impossible to secure the necessary exactness in the direction of the sections. We can follow the general direction, but beyond this we are dependent on chance. Further, the upper extremity of the seed is so extremely slender that the slightest deviation from the median line at once produces oblique sections. Then the periphery of the spadix, which in this case is the important part, is usually particularly rich in pyrites, and this drops out when the slices are reduced to the needful thinness. Under these circumstances, to obtain an exactly median longitudinal section in serviceable preservation is a piece of pure good luck, which has never fallen to my lot. The pyrites is also particularly embarrassing in the case of preparations which are tangential to the surface of the spadix, and in which we get a more or less exact transverse section of the apex of the seed; more-

¹ Carruthers, loc. cit., pl. 59, f. 6.

over sections of this kind can hardly be made at all where the material is so scanty, for they involve a very considerable expenditure of the same. I have at my disposal only one such slice of very moderate character. The account which follows has therefore been obtained by combining together a multitude of very defective pictures with inexact orientation, and I regret that I cannot now reproduce the material on which it rests in the form of figures, or can do so only to a very limited extent; but various attempts to draw or photograph these objects have had no satisfactory result. Still I believe that very thorough study of all the preparations, at least a dozen times during five or six years, has carried me as far as it is at present possible to go. Examination of the original preparations deposited in the British Museum and in the Museum at Kew will enable every one to judge for himself how far the following statements are to be trusted.

The process, then, of which we have been speaking is in the lower half almost as broad as the seed itself, but narrows rather suddenly above that point, and assumes the form of a thin cylinder, which increases slightly in breadth and terminates in a valley-like depression in the surface of the spadix (Pl. XXVI, Fig. 10). Its form has been given in my earlier diagrammatic drawing, and is not open to any doubt. In the lower broader portion the testa is very thick, and seems to inclose the conical prolongation of the 'nucular membrane,' which has been already mentioned. But this is just the most obscure and doubtful point in the whole matter. The before-mentioned enlargement of the testa appears to be essentially due to the middle stratum, which consists in this part of several layers, and loses the palisade-arrangement of its cells. The outer and the inner strata are similarly preserved; the latter, in a preparation in the Kew Museum, being evidently formed of several layers of thin-walled cells.

At the spot where the neck of the seed begins to narrow into the slender cylinder, the hard middle stratum of the testa thins out and disappears, and the further continuation contains only delicate tissue and is solid on the transverse section, the

inner cavity having disappeared probably by the stopping up of the micropylar canal in the usual way.

Whether this cylindrical process is formed entirely from the inner stratum of the testa, while the middle and outer strata come to an end at the place where it begins to narrow; or whether, while the middle hard stratum dies out, the inner and outer strata unite to form the process, I cannot positively say. In the former case the testa would probably have been developed from two integuments; in the latter we may assume that it is only from one. After weighing all the circumstances I incline to the latter view. The question can only be settled by obtaining a slice which should be tangential to the surface of the spadix, and show the apex of the seed in exact transverse section. Unfortunately the only preparation of the kind before me is in too imperfect a state of preservation; its appearance is reproduced, as far as it can be, in Pl. XXVI, Fig. 7. The transverse sections of the apices of the seeds are seen as dark circles, sections of solid cylinders consisting of a small-celled tissue and surrounded by a single layer of larger cells. Lines radiating from one section to another may be distinguished at one part of the preparation. Their presence shows that the section has passed close beneath the surface of the spadix; they answer to the bounding lines of the superficial areolae.

As already explained, the 'cords,' the seed-stalks of the spadix, each terminate in a seed. In each case the vascular strand enters the chalaza where it forms a small expansion; its peripheral fibrous layer adheres all round to the basal portion of the testa (Pl. XXV, Fig. 1), and gradually loses its distinctive character. But whence comes the closed tissue forming the outer rind of the cone, in the depressions of which the seeds are imbedded? My idea once was that this mass of tissue was produced by the upward growth of the peripheral portion of each seed-stalk forming a wall round the seed, and by the lateral fusion of all the seed-containing cavities thus produced. But this view can no longer be combined with the account of the facts here given. There remains only the possibility, that it is the structures with a smaller transverse section, lying

between the 'cords,' which overtop the seeds, and, becoming clavately broader at the apex, unite there with one another to form the continuous external layer. The formation of the seed-bearing cavities is explicable in this way, and perhaps more naturally than by the earlier theory; and it finds a strong support in the circumstance that, as was shown above on p. 438, this continuous external layer may be followed to the very base of the fructification, and grows at the lowest margin directly out of the tissue of the 'cushion,' thus occurring in places where there are no longer any seed-stalks (see Pl. XXV, Figs. 8 and 10).

From all these considerations we arrive at something like the following conception of the entire fossil. We have in the fructification (spadix) two kinds of organs of different character and closely crowded together; the seed-stalks (cords) diverging above cluster-wise, and each terminating in a seed; and the interstitial organs increasing constantly in length from the periphery of the cluster towards the inside, appearing by themselves in the periphery but mixed with the seed-stalks further in, overtopping the seeds with their apices, and forming by the union of their apices the homogeneous tissue-layer of the surface of the fructification. In consequence of this arrangement every seed is sunk in a pit, the orifice of which then narrows over the seed owing to the lateral overgrowth of its walls¹.

If we now try to realise the nature of the surface-view of a spadix having a longitudinal section answering to our scheme, we shall be inclined to think of it as marked with areolae or compartments corresponding to the upper extremities of the several interstitial organs, and between these there must be narrow openings leading to the seed-cavities below. After the account given above on page 438, of the indentations and areolations at the base of the surface of the spadix, I have no doubt that such a division into areolae is in fact present everywhere, and that each areola was raised,

¹ See on this point the diagrammatic figure in my *Einleitung in die Palaeophytologie* [Fossil Botany, Fig. 5 A, p. 96].

probably as a pyramidal protuberance, above the surface. We see, in fact, quite plainly in many preparations that the surface of the spadix is uneven, and that the sections through the projecting parts appear as protuberances of varying height and steepness. According to our supposition this must be the case, since the areolae are cut through sometimes exactly in the middle, sometimes only on the margin, and therefore cannot possibly have the same height. Unfortunately we have never been able to get a surface-view of any portion of the spadix of *Bennettites gibsonianus*. But we get some help from a fossil which has been described by Saporta as *Williamsonia Morièrei*¹. The figure which is given of it shows such absolute agreement with the fructifications of *Bennettites*, that I have no doubt whatever that it belongs to that genus. In this specimen the surface of the fructification was laid bare to some extent when the fossil was broken up, and it shows exactly the character which we have been endeavouring to show was probably that of *Bennettites*. As the specimen is changed into spathic iron, it will probably show structure; it is very desirable that its anatomy should be examined, for it might possibly throw a welcome light on some still dark points. Saporta also associates *Podocarya*, Buckl. and *Goniolina* with his fossil. This is a bold step, and I can express no opinion on the matter, since *Goniolina* has never been found with the structure preserved, and the original specimen of *Podocarya* in the Museum at Oxford is at present not accessible, so that we have only the figure to depend upon, though that appears to be very good².

There is one point which requires to be mentioned in conclusion. We have hitherto tacitly assumed that all the organs of the fructification, the seed-stalks and the interstitial organs, spring directly from the upper surface of the cushion of the axis of the spadix, and simply run through the whole of the cluster in the same number and position. But

¹ Saporta, 'Paléontologie française, terrain jurassique,' vol. iv.

² Buckland, 'Geology and Mineralogy,' 2nd Ed. : and Saporta, loc. cit., vol. iv, on Proangiosperms.

it might be otherwise, and a portion of the interstitial organs might possibly originate from the seed-stalks; for the preparations which we possess do not show whether the organs of the central part, of which we have transverse sections in slices from various parts of the spadix, are the same in all of them or not. Some might terminate inside the cluster, and others take their place.

How then shall we interpret the facts as here presented in accordance with the principles of general morphology? There can be no doubt about the axis which bears the spadix. But the seed-stalks may be axial members, or they may just as well be carpels, though in that case we should have the unusual phenomenon of terminal seeds. Then the interstitial organs may be aborted seed-stalks crushed between the others; or they may, if the seed-stalks be axes, belong to a different category and be leaves. I leaned formerly to the former alternative; but now that their peculiar connection with the formation of the homogeneous outer rind of the spadix has been ascertained, I incline rather to see in them the bracts and prophylls of the seed-stalks, to which must be added also such bracteoles, preceding the seed or flower, as may happen to spring from the seed-stalks.

It appears therefore that there are the following possible modes of explaining the members which constitute the spadix: (1) All its organs are carpels, some being fertile with a single ovule at the summit of each carpel, some sterile, but projecting beyond the fertile carpels with their coherent apices, the whole forming a single flower. (2) All the organs are axial members, with no development of leaves, some being sterile, others ending in a flower, which, like that of *Taxus*, is reduced to a single naked ovule. (3) The seed-stalks are one-flowered axes, the interstitial organs are leaves, either exclusively bracts, in which case we should have a gymnospermous capitulum, *sit venia verbo*, like that of Compositae, or partly also prophylls and bracteoles of the lateral axes in more exact analogy with the head of *Echinops* or Dipsacaceae.

Whatever the conclusion may be, the formation of the pits

which contain the ovules is due to the cohesion of the apices of the interstitial organs, and in this, as in all similar cases, we see a contrivance for protection. Nor will it seem too fanciful to appeal, as to analogous conditions, to the closing of the carpels in forming the ovary, or to the position of the inferior ovary. If we suppose the enveloping coherent interstitial organs or leaves to spring from the seed-stalk itself, we should actually have an ovary, in rudimentary form indeed, but still of essentially similar character to the ovary in Angiosperms; we need only add a stigma to make it complete. But if the cohering members do not belong to the seed-stalk, but originate wholly from the axis of the spadix, this would certainly imply so primitive a stage in the formation of the flower that we could not point to any fitting analogue amongst existing plants. Still we might form an idea of it from the capitulum in Compositae, if we were to imagine the scales of the involucre and those on the receptacle all fully developed and coherent above, whilst the flowers were reduced to the simplest condition, to naked ovules. To realise this idea to some extent, we might call to mind the female capitula in the genus *Xanthium*. The effect, which is so often produced in our existing plants by intercalary growth of the tissue of the axes (Monimiaceae, *Dorstenia*), would result in the present case from the cohesion of the last leaves of the main axis which bears the flowering shoot. The wall of the ovary thus formed would therefore belong to an older shoot-generation than the ovule; and if we are prepared to adopt the standpoint of some morphologists and maintain that the ovule is formed from the leaf, the only change of importance required would be a change in the terminology, for the entire shoot would then become a flower with numerous leaves, some of which are sterile and serve to form the involucre, while the others bear the ovules.

If in the course of the above account the Bennettiteae have constantly been compared with Cycadeae, it is because I am convinced that Cycadeae, notwithstanding all differences, are the nearest known allies of Bennettiteae, and on this point I shall be at one with nearly all palaeontologists and botanists.

Hitherto indeed stems of Bennettiteae have been placed without hesitation among Cycadeae, and it is possible that many of the mesozoic Cycad leaves grew on Bennettitean stems. But still it must not be forgotten that we have at present no proof of the correctness of this view. There are resemblances between the two groups which cannot be disputed; but there are such important differences, especially in the structure of the flower, to be set against these, that we are driven to seek for other groups to fill up the chasm.

If we suppose that, as a matter of fact, a real relationship exists between Bennettiteae and Cycadeae, it can still be shown most distinctly that the one group cannot be derived from the other, but that the two must be the terminations of different phyla springing from the same stock. For the Cycadeae, which we should naturally consider to be the younger group, are far behind the Bennettiteae in the complexity of the structure of the flower, while the Bennettiteae on the other hand show a much simpler and primitive structure in the vegetative organs. That the peculiar two-stranded girdle-forming leaf-traces of Cycadeae are a comparatively new character which has made its appearance in their progress towards perfection, is proved in my opinion by the fact that in the flowering extremities of the shoots of the sympodium, where the vegetative development is less vigorous, we may observe in the course of the vascular bundles, which resembles that of Bennettiteae, a return to the primitive more simple arrangement¹. This circumstance seems to me to be the most important argument for the approximation of the two groups. We do not know what was the appearance of the parent-group from which the two divergent phyla proceeded: but it must in all probability be sought in very remote epochs of the development of the earth, for we have some certain knowledge of the type of the flower in the genus *Cycas* from the base of the Lias; and therefore I have no doubt that this parent-group may have given rise to various other derivative types besides those of Cycadeae and Bennettiteae. The idea which we frame for ourselves of the original parent-stock will

¹ See my fuller account of this in Bot. Ztg., 1890, p. 177.

of course be less satisfactory, the smaller the number of the derived forms from which we can abstract its characters.

Saporta¹ unites *Bennettites* with *Williamsonia*, but I cannot enquire at present whether or not there are any grounds for this proceeding; he also places both genera in his 'stade proangiospermique.' I have already endeavoured to show that there are in fact certain points of resemblance between the structure of the flowers in *Bennettites* and the formation of the ovary in Angiosperms, but that we know too little of the other characters to carry the comparison further. Though there is something very attractive in the idea of the 'stade proangiospermique,' yet we naturally hesitate when we find Saporta² conceiving of Progymnosperms and Proangiosperms simply as ancestral groups of our modern classes and saying: 'In every way we see clearly that Gymnosperms and Angiosperms form two branches which have proceeded from one common stock of heterosporous Cryptogams, but have taken different directions from the beginning.' I cannot say that such filiation is impossible, but its probability seems to me to be diminished by the fact that I meet everywhere with accumulating evidence that descent works in more complex ways than by the method of simple alternatives. I suggested in a former paper³ that the formation of the superior and inferior ovary, of monosepalous calyces, of monopetalous corollas, of the inflorescences in the depressed urn-like receptacles of *Ficus*, of the ceramidia of *Polysiphonia*, of the conceptacles of *Fucus*, of the perithecia, pycnidia, and spermogonia of so many Fungi, is based on one and the same principle, which I have endeavoured to express by the term *cupular formation*. I look upon this as one of the means placed within reach of the plant in the course of its development for producing constantly increasing complexity of its organisation, while the repeated application, so to speak, of this means in a great variety of derived forms at very various

¹ Saporta, G. de, 'Paléontologie Française, terrain jurassique,' vol. iv.

² Saporta, 'L'évolution du règne végétal,' vol. i (1885), p. 201.

³ Solms-Laubach, Bot. Ztg., 1889, p. 741.

times gives rise to an infinite number of different but always analogous results, because the substratum to be modified in each case has meanwhile been essentially changed. I have no doubt that we shall in time be able to refer other groups of phenomena also to common operative principles of adaptation.

If this may be assumed, it is clear that Saporta's Proangiosperms cannot represent a well-defined group in the genetic system, but must consist of the members of different analogous developmental series, which have undergone evolution of a similar kind. The number of ancestral forms which pass through such a proangiospermous stage may then be very large; their other characters may be very different. How many of them, whether one or several, and which, have become the parents of our modern Angiosperms, may at present be beyond our conception. In the many phylogenetic speculations which have sought to explain the mutual relations of different classes in the vegetable kingdom, the botanical authors have as a rule disregarded or incorrectly applied the results of palaeophytology. It is much to be desired that these results should be more highly valued in the future. For this study, though now fragmentary and incomplete, is much better suited than that of the classification of living plants to throw light upon the enormous difficulties which stand in the way of all attempts of the kind, and thus to warn us at every moment against precipitation, and to bid us be cautious.

EXPLANATION OF THE FIGURES IN PLATES
XXV AND XXVI.Illustrating Graf Solms' paper on *Bennettites*.

PLATE XXV.

Fig. 1. Median longitudinal section through the basal portion of the seed, showing the passage of the seed-stalk into the testa, and the small expansion within the testa, where the vascular bundle terminates. The entirely black places are deposits of opaque pyrites.

Fig. 2. Transverse section of the periphery of the spadix taken from its lower portion where there are no seeds: showing at *a* a seed-stalk with its central bundle 4 (should be *x*); at *b* a number of interstitial organs in close contiguity; at *c* the continuous external layer of the peripheral zone. At *d* is a small portion of the transverse section of one of the surrounding cataphyllary leaves (see Figs. 11 and 12 of this plate).

Fig. 3. The small expansion of the vascular bundle at the chalazal end of the seed which, in the ripe seed, is situated in the hard testa.

Fig. 4. Diagrammatic longitudinal section of the mature embryo. Designed chiefly from Plate XXVI, Fig. 5, with the help of many other preparations. (The number is misplaced. The figure referred to lies between Figs. 2, 3, and 5.)

Fig. 5. Longitudinal section through the testa of two seeds close to one another, showing the hard layer and the inner layer on the two sides. The outer layer has evidently coalesced with the intermediate tissue.

Fig. 6. Seed with the nucellus exposed by breaking away the testa, seen obliquely from behind, so that the basal depression and the lateral furrows radiating from it are brought into view.

Fig. 7. Copy of a figure of Carruthers (pl. 59, fig. 1); oblique tangential section through the entire spadix, showing the seed-stalks (cords) obliquely cut through, and in the upper part the seeds.

Fig. 8. Exact representation of the basal portion of the preparation in Fig. 7: a new drawing by Mr. Berjeau of London, showing the interstitial organs between the seed-stalks and the continuous outer layer furnished with indentations; at *a* indications of the areolae which answer to the indentations. The clear roundish patch above this spot represents an oblique section passing quite through the marginal portion of the cushion-like termination ('cushion') of the shoot, from which the seed-stalks spring (2/1).

Fig. 9. Copy of fig. 3 on pl. 59 of Carruthers' work, giving a not quite radial longitudinal section of the entire spadix. The cushion-like termination of the shoot from which the seed-stalks spring is particularly well shown.

Fig. 10. New and perfectly accurate drawing, by Mr. Berjeau of London, of the basal portion of Fig. 9, showing the attachment of the seed-stalks, and especially that of the continuous external layer of the entire spadix to the cushion-like extremity of the shoot. The indentations of the outer layer answering to the superficial areolation are very plainly seen (2/1).

Fig. 11. Fragment from the periphery of an exactly transverse slice through the spadix, showing the sections of the seeds in the homogeneous external layer with its indentations. Internally to the seeds are the transverse sections of the seed-stalks, and of the small interstitial organs between them; some of the cataphyllary leaves round the spadix are also indicated. Drawn by Berjeau.

Fig. 12. Similar fragment of a transverse section through the spadix with the surrounding cataphyllary leaves, but taken from a lower region of the spadix in which there are no seeds. The external layer with its notches answering to the areolation is very distinct. Drawn by Berjeau.

PLATE XXVI.

Figs. 1, 2, 3, 4. Transverse sections of the seed, showing the two cotyledons of the embryo with their plane surfaces touching one another and their vascular bundle-traces; from photographs by Gepp of Carruthers' original preparations (see pl. 59, fig. 4, loc. cit.). In Figs. 2 and 3 the hard layer of the testa with its lighter cells is plainly marked. Figs. 2 and 4 show fissures beside the embryo and between its cotyledons, filled with structureless mineral substance.

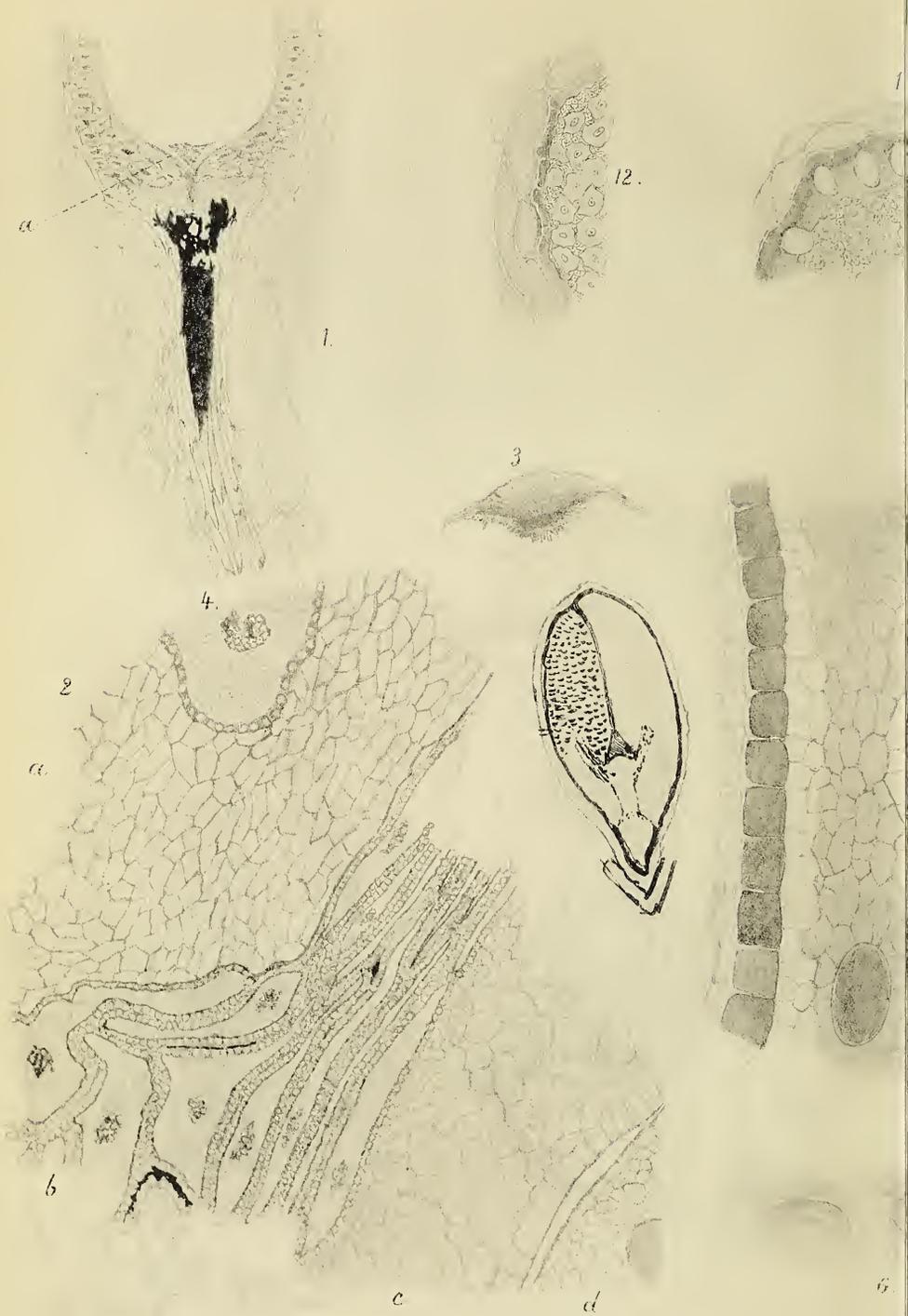
Figs. 5, 6. Longitudinal sections of embryos from one of Carruthers' original preparations photographed by Gepp; *a* in both figures the growing-point. The cleft between the cotyledons is very distinct in both figures; and in Fig. 5 the tissue also of the cotyledons. It is more difficult to distinguish in Fig. 5 the central strand in the hypocotyl and the attachments of the bundles which pass into the two cotyledons. Compare the diagrammatic representation in Pl. XXV, Fig. 4.

Fig. 7. Attempted representation of a portion of a tangential section just beneath the surface of the spadix. The numerous irregularly-shaped lighter places are intended for parts filled with pyrites and disintegrated in slicing. The darker round figures are the transverse sections through the pointed extremity of the testa of the different seeds touched by the section. Some of them are united by straight lines, an indication perhaps of the areolation of the surface of the spadix. The figure is very imperfect, but it is the best I could get after many attempts to photograph the section had produced no serviceable picture. It was done with Winkel's drawing-apparatus and is slightly magnified.

Fig. 8. Sketch of the longitudinal section of a seed, showing, but not very distinctly, the conical prolongation of the nucellus (Williamson's nucular membrane), which would probably inclose the pollen-chamber, if there is one.

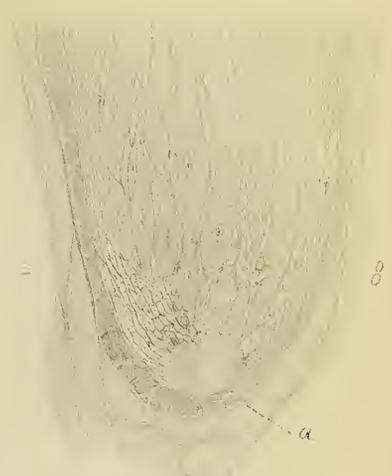
Fig. 9. Photograph of a radial longitudinal section through the seminiferous upper extremity of a spadix. The embryos with their two cotyledons are seen with perfect distinctness in the seeds.

Fig. 10. Longitudinal section of the entire seed, showing the shape and structure of the tubular apical portion of the testa; *a* the points of section of the circular zone where the middle stratum of the testa thins out, and the sudden narrowing of the entire process begins.





10.



8

a



5.

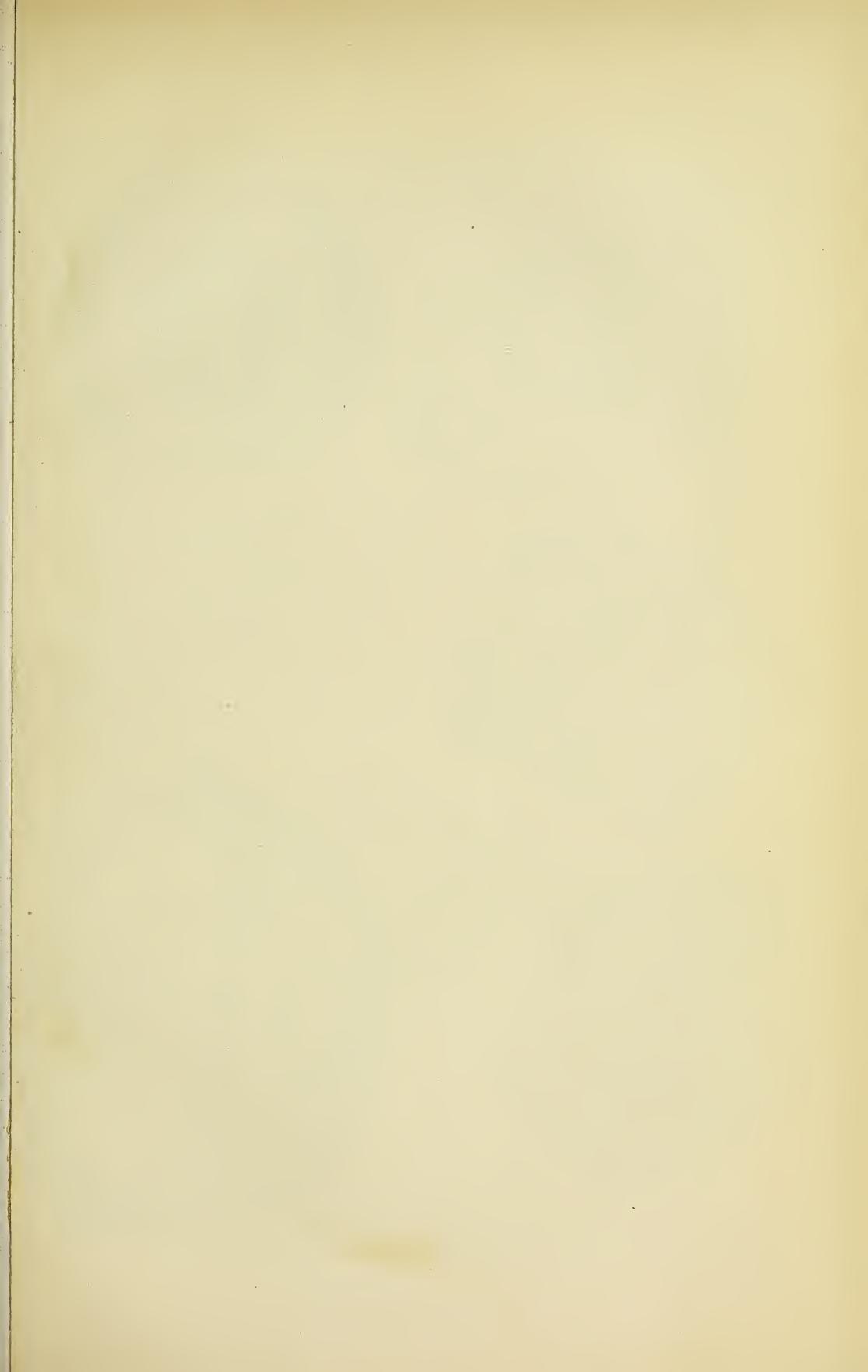


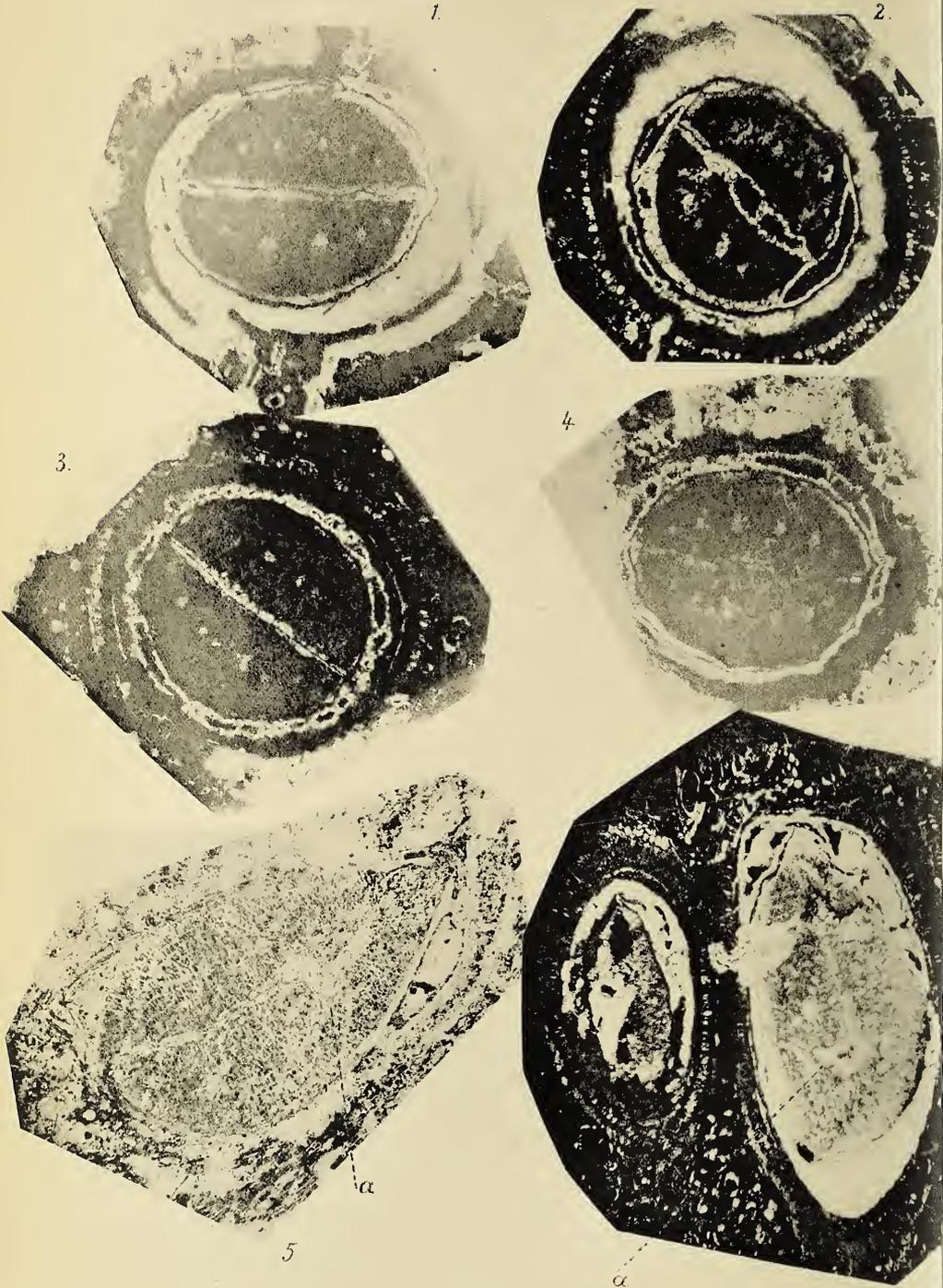
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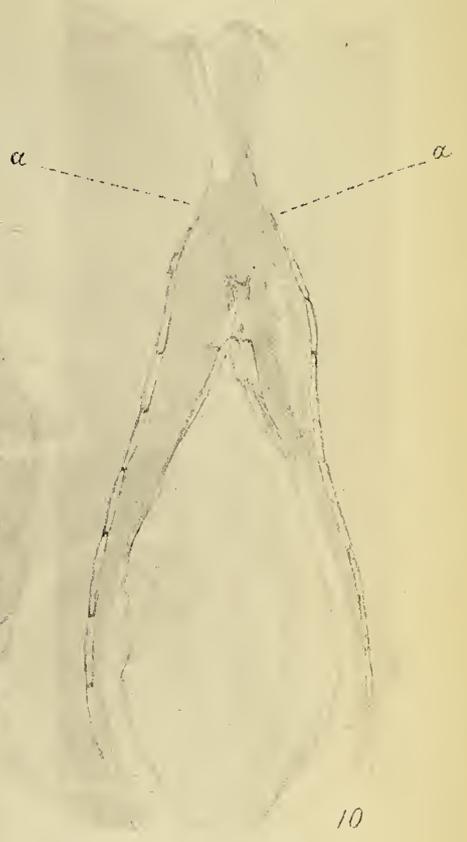
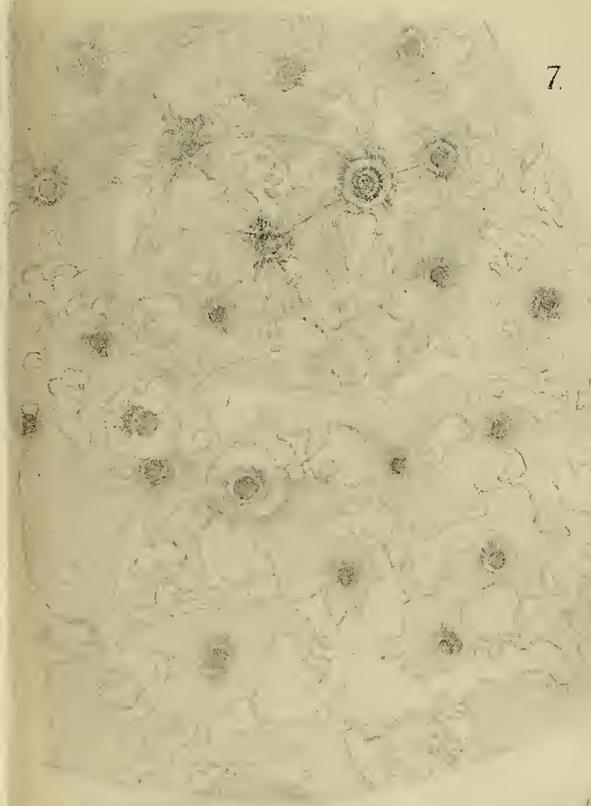
9

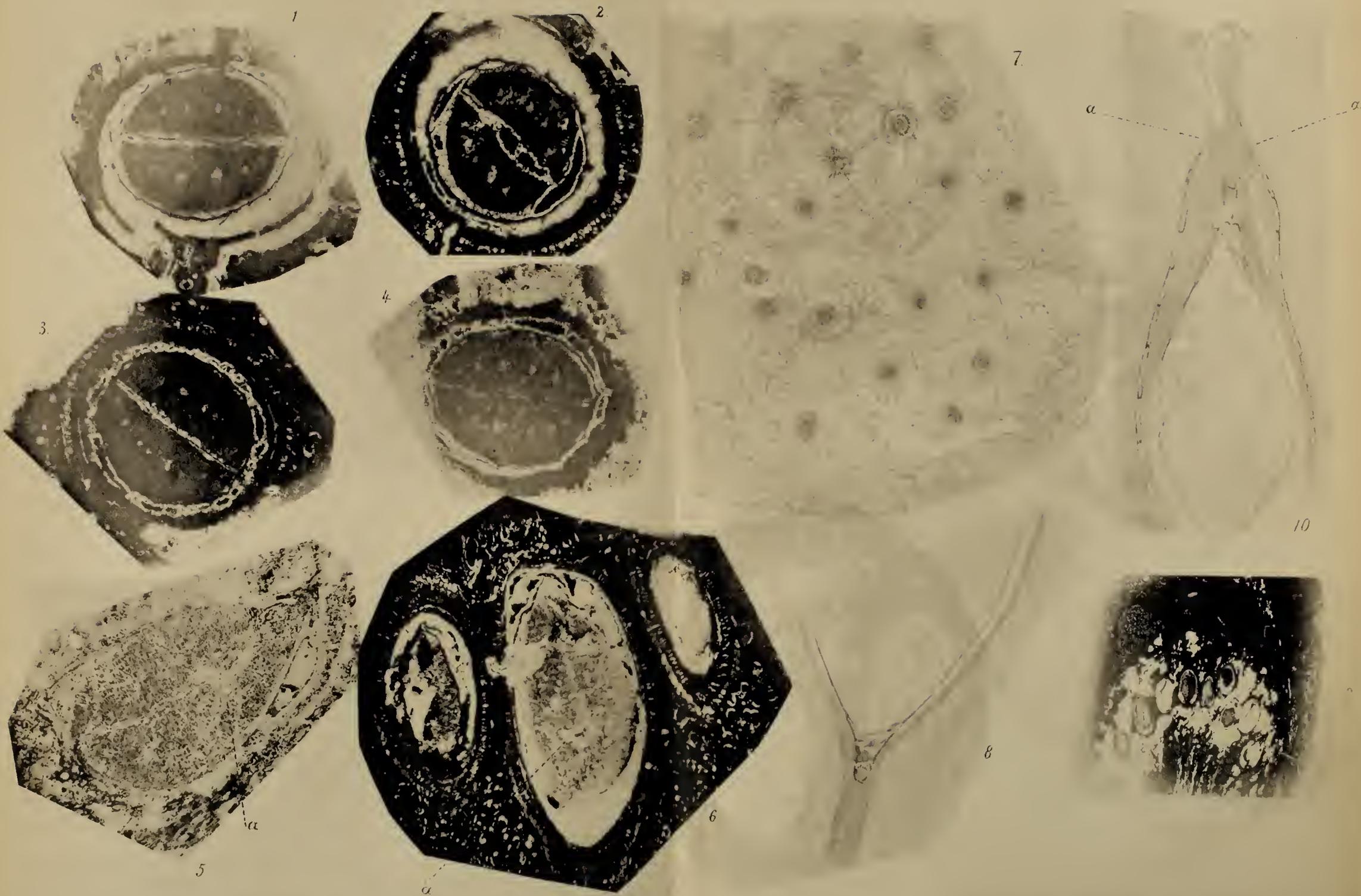






SOLMS. — ON BENNETTITES.





A Summary of the new Ferns which have been discovered or described since 1874.

BY

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(Conclusion.)

Genus 46. OLEANDRA, *Cav.*

- 3*. *O. cuspidata*, Baker, in *Malesia*, III, 44. New Guinea, *Beccari*.
3*. *O. Whitmeei*, Baker, in *Journ. Bot.* 1876, 11. Samoa,
Whitmee.

Genus 47*. LUERSSENIA, *Kuhn.*

1. *L. kehdingiana*, Kuhn; Luer. in *Bot. Centralblatt*, 1882,
III, 77. Sumatra. Sori and indusium like those of *Fadyenia*.
Fronds simple, lanceolate, rooting at the tip.

Genus 48. POLYPODIUM, *Linn.*

Subgenus *Phegopteris*.

- 1*. *P. Krameri*, Franch. et Savat. *Enum. Pl. Jap.* II, 244; *P. oya-*
mense, Baker, in *Journ. Bot.* 1877, 366. Japan.
1*. *P. gymnogrammoides*, Baker, in *Journ. Bot.* 1888, 229.
China; *Mount Omei, alt. 3000 feet, *Faber*. Very near *P.*
Krameri.
8*. *P. blandum*, Baker; *Phegopteris blanda*, Fée, *Mem.* VIII, 91.
Mexico; Mirador, *Schaffner*, 222.
9*. *P. Crossii*, Baker, sp. n. Rootstock not seen. Stipe cas-
taneous, naked, 6-9 in. long. Frond oblong-lanceolate, bi-
pinnatifid, subcoriaceous, hairy only on the midribs of the
pinnae beneath, 8-9 in. long, 2-2½ in. broad at the middle,
narrowed to the base. Pinnae lanceolate, the largest an inch
long, ¼ in. broad, cut down nearly to the rachis into oblong

- segments $\frac{1}{2}$ in. broad, with incurved edges. Veins 5-6-jugate, simple, erecto-patent. Sori round, medial. Andes of Loxa, *Cross*. Habit of *N. conterminum*.
- 10*. *P. Lechleri*, Baker = *P. laevigatum*, Baker, in Syn. Fil. edit. 2, 505. Peru, *Lechler*, 2628. The name *laevigatum* used previously.
- 11*. *P. sylvicolum*, Baker, in Journ. Bot. 1881, 205. New Granada, province of Antioquia, *Kalbreyer*, 1807.
- 13*. *P. omeiense*, Baker, in Journ. Bot. 1888, 229. China; Mount Omei, *Faber*, 1059.
- 15*. *P. hydrophilum*, Baker; *Phegopteris hydrophila*, Fée, Fil. Ant., tab. 13, fig. 3. Guadeloupe. Further specimens gathered by MM. L'Herminier and Mazé show that this is quite distinct from *P. germanianum*.
- 15*. *P. euchlorum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 58. Andes of Ecuador, *Sodiro*.
- 15*. *P. demeraranum*, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 290. Mount Roraima, *in Thurn*. Habit of *Nephrodium diplazioides* and *pachyrachis*.
- 17*. *P. roraimense*, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 291. Mount Roraima, *in Thurn*. Habit of *Gymnogramme diplazioides*.
- 17*. *P. Thomsoni*, Jenman, in Journ. Bot. 1886, 272. Jamaica, *Jenman*. Habit of *Nephrodium conterminum*.
- 18*. *P. tuberculatum*, Baker; *Nephrodium tuberculatum*, Cesati, Fil. Becc. Polyn. 4. New Guinea; Mount Arfak, *Beccari*.
- 18*. *P. Percivalii*, Jenm. in Herb. Guian. No. 2080. British Guiana, *Jenman*, 2080. Near *P. rude* and *decussatum*.
19. *P. decussatum*, Linn. I cannot separate specifically *P. velutinum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 59, from the Andes of Ecuador.
- 19*. *P. dentatum*, Baker, n. sp. Stipe $1\frac{1}{2}$ ft. long, brown; paleae lanceolate. Frond oblong-deltoid, bipinnatifid, green, glabrous, 2 ft. long; rachis brown, scaly: pinnae lanceolate, the lowest the largest, 6-8 in. long, $1\frac{1}{2}$ -2 in. broad, cut down to the rachis into lanceolate dentate segments $\frac{1}{6}$ - $\frac{1}{5}$ in. broad. Veins 10-12-jugate, simple, arcuate, ascending. Sori round, medial. Andes of Ecuador, *Sodiro*. Near *P. rude* and *decussatum*.

- 19*. **P. Michaelis**, Baker, in Journ. Bot. 1877, 164. Andes of Ecuador, *Sodiro*.
- 20*. **P. rheosorum**, Baker, sp. n. Stipe incomplete. Frond deltoid, bipinnate rigid, glabrous, 6–8 in. long; rachis very scaly; pinnae lanceolate, the lowest the largest, 3–4 in. long, $\frac{3}{4}$ in. broad; segments distinct, entire, linear-oblong, $\frac{1}{2}$ in. broad. Veins obscure, immersed. Sori medial, globose, confluent. China: province of Che-Kiang, *Macarthy*. Habit of small forms of *Aspidium varium*.
- 22*. **P. Mazei**, Baker; *Phegopteris Mazei*, Fourn. in Mazé, Fil. Guadelup. Exsic. Caudex erect. Stipes tufted, scaly, a foot long. Fronds oblong-lanceolate, bipinnate. $1\frac{1}{2}$ –2 ft. long. Pinnae lanceolate; pinnules linear-oblong, obtuse, entire or shallowly obtusely lobed, $\frac{1}{4}$ – $\frac{1}{3}$ in. broad. Veins in pinnate groups opposite the lobes; veinlets bijugate, simple, very short. Sori at the end of the short veinlets. Guadeloupe, *Mazé*.
- 23*. **P. ichtosmum**, Sodiro, Crypt. Vasc. Prov. Quit. 59. Andes of Ecuador, *Sodiro*. Near *P. macrophyllum*, Hook., but distinct specifically.
25. **P. Phegopteris**, L. Has been gathered in Lahul by Dr. Watt and in Kashmir by Dr. Aitchison.
- 25*. **P. Clarkei**, Baker, sp. n. Stipe naked. Frond deltoid, bipinnate, membranous, glabrous, 6–8 in. long. Pinnae lanceolate, sessile, the lowest the largest, $\frac{3}{4}$ in. broad, cut down to the midrib in oblong crenate secondary segments $\frac{1}{2}$ in. broad. Veinlets 6–8-jugate in the secondary segments, usually simple and not produced beyond the medial orbicular sori. Sandwich Islands; East Maui, *F. L. Clarke*. Sent to Kew by Mr. G. E. Davenport in 1882.
26. **P. distans**, Don. Gathered lately in China and the island of Formosa.
- 26*. **P. stenopteron**, Baker, in Journ. Bot. 1888, 229. West China; Patung, *Dr. Henry*, 3682.
- 27*. **P. oxydon**, Baker, in Journ. Bot. 1879, 66. Sulu archipelago, *Burbridge*. Near *P. caudatum*, Kaulf.
- 35*. **P. myriotrichum**, Baker, in Journ. Bot. 1885, 217. Rio Janeiro, *Glaziou*, 15734. Recalls *Lonchitis pubescens* in general habit.

- 35*. *P. hemsleyanum*, Baker, in Hemsl. Biol. Cent. Amer. III, 660, tab. 108. Guatemala, *Salvin* and *Godman*.
- 39*. *P. Willsii*, Baker. Stipe 6–8 in. long, densely clothed in the lower half with squarrose linear-subulate paleae. Frond lanceolate-deltoid, tripinnatifid, 15–18 in. long, 8–9 in. broad, bright green, pilose on the ribs beneath. Pinnae lanceolate, the lowest the largest; pinnules lanceolate, the lowest only not adnate and deeply pinnatifid, with contiguous linear-oblong tertiary segments. Veins pinnate in the lowest tertiary segments. Rio Janeiro, sent to Kew alive by Mr. Justice Wills in 1881. General habit of *Nephrodium Filix-mas* var. *elongatum*.
- 40*. *P. leptophyllum*, Baker, sp. n. Stipe a foot long, slender, brown, fragile. Frond subdeltoid, 4-pinnatifid, membranous, glabrous, 15–18 in. long, 9–10 in. broad. Pinnae oblong-deltoid, the three lower pairs petioled, 4–5 in. long, 2 in. broad; pinnules oblong-deltoid, petioled; tertiary segments oblong-deltoid, unequal-sided, deeply pinnatifid, with oblong lobes. Veins pinnate in the quaternary segments; veinlets simple, ascending. Sori crowded, globose, costal. Japan, *Hancock*, 15. Near *P. unidentatum* and *Oldhami*.
- 41*. *P. hirtum*, Presl. Reliq. Haenk. I, 27 (1830), non Hook. Stipe not seen complete. Frond deltoid, decompound, a foot long, moderately firm, glabrous; rachises clothed with copious adpressed linear brown paleae; lower pinnae the largest, deltoid, produced on the lower side; central oblong-lanceolate; final segments oblong, entire, $\frac{1}{2}$ in. broad; veinlets paucijugate, erecto-patent. Sori medial. Philippines, *Haenke*. Final segments like those of the glabrous forms of *Nephrodium villosum*. The name antedates *P. hirtum*, Hook., our No. 99.
- 42*. *P. Davidi*, Franch. Pl. David. II, 157. Moupine, Tibet, *David*. Near the European *P. alpestre*.
- 43*. *P. laserpitiifolium*, Scortech.; Beddome, in Journ. Bot. 1887, 324. Perak, *Scortechini*. Habit of the most compound forms of *Nephrodium sparsum*.
- 43*. *P. alcicorne*, Baker, in Journ. Bot. 1888, 229. West China; Mount Omei, alt. 3000 ft., *Faber*. Habit of *Aspidium multifidum*, Mett.; Baker, in Hook. Ic., tab. 1067.
- 43*. *P. Gordoni*, Baker, in Journ. Bot. 1879, 297. Fiji Islands, *Horne*. Habit and texture of *Nephrodium boryanum*.

- 43*. *P. alsophiloides*, Baker, in Journ. Bot. 1879, 297. Fiji Islands, *Horne*. Near the last.
48. *P. punctatum*, Thunb. I cannot separate specifically *P. rufo-barbatum*, Colenso, in Trans. New Zeal. Instit. 1883, 347.
- 48*. *P. manipurense*, Beddome, in Journ. Bot. 1888, 235. Manipur, *Dr. Watt*.
- 48*. *P. Balansae*, Baker; *Phegopteris alsophiloides*, Fourn. in Ann. Sc. Nat. sér. 5, XVIII, 289. New Caledonia, *Balansa*, 25. Not seen.
- 48*. *P. Henriquesii*, Baker, in Henriq. Cat. St. Thom. 30, t. 3. Island of St. Thomas, West tropical Africa, *Moller*, 25.
- 50*. *P. subarborescens*, Baker, in Journ. Linn. Soc. XXIV, 259. Sarawak, Borneo, *Bishop Hose*. Habit of the largest forms of *Nephrodium Filix-mas* var. *elongatum*.
- 50*. *P. spinulosum*, Baker; *Phegopteris spinulosa*, Hilleb. Pl. Haw. 566. Sandwich Islands. Near *P. sandwicense*, Hook. et Arn.
- 50*. *P. aneitense*, Hook. Sp. Fil. IV, 268. New Hebrides. Appears to be distinct from *P. sandwicense*.
- 50*. *P. subtripinnatum*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 545, tab. 80, fig. 1. Himalayas. According to Beddome, this is an ex-indusiate form of *Nephrodium boryanum*.
- 50*. *P. persimile*, Baker, in Journ. Bot. 1876, 344. Samoa; *Whitmee*, 204. Habit of *Nephrodium boryanum*.
- 51*. *P. camptocaulon*, Baker; *Phegopteris camptocaulon*, Fée, Fil. Bras. Suppl. 60, tab. 98, fig. 1. Rio Janeiro, *Glaziou*, 4618. Not seen. Rachis very flexuose. Pinnae deflexed; pinnules lanceolate, with short oblong lobes.
- 53*. *P. sharpianum*, Baker, in Journ. Bot. 1880, 369. Madagascar, *Kitching*.
- 53*. *P. Baroni*, Baker, in Journ. Linn. Soc. XXII, 535. Madagascar. Near the ex-indusiate glabrous forms of *Nephrodium villosum*.
- 55*. *P. loxoscaphoides*, Baker, in Journ. Bot. 1890, 107. New Guinea; Mount Musgrave, *Sir W. Macgregor*.
- 55*. *P. cheilanthoides*, Baker, in Malesia, III, 45. Mountains of New Guinea, *Beccari*.
- 55*. *P. ornatum*, Wall.; Beddome, Fil. South Ind. t. 171; *Phegopteris ornata*, Beddome, Ferns Brit. Ind. 294, fig. 152. Himalayas, South India, Malay peninsula. Beddome and Clarke concur in treating this as a distinct species.

Subgenus **Cyrtomiphlebium**.

- 56*. **P. polyxiphion**, Baker, in Bull. Linn. Soc. Paris, 534. Comoro Islands, *Humboldt*, 102. Dr. Kuhn tells me this is identical with *Phegopteris biformis*, Mett.=*Polypodium biforme*, Baker, Syn. Fil. edit. 2, 505.

Subgenus **Goniopteris**.

- 57*. **P. holophyllum**, Baker, in Journ. Bot. 1888, 325. Sarawak, Borneo, *Bishop Hose*. Habit of *Meniscium simplex*.
- 57*. **P. subintegrum**, Baker, in Journ. Bot. 1877, 164. Andes of Ecuador, *Sodiuro*.=*Nephrodium subintegrum*, Sodiuro, Recens. 54.
- 57*. **P. aoristisorum**, Harringt. in Journ. Linn. Soc. XVI, 30. Panay, Philippines, *Steere*.
- 62*. **P. oligophlebium**, Baker, in Journ. Bot. 1891, 6. North-west Madagascar, *Last*. Near *P. poecilophlebium*, Hook.
64. Beddome transfers to **Nephrodium**: 64. **P. urophyllum**, Wall., as *N. urophyllum*, Beddome; 72. **P. multilineatum**, Wall., as *N. moulmeinense*, Beddome; and 71. **P. lineatum**, Coleb.=*P. costatum*, Wall., non Hook., as *N. costatum*, Beddome.
- 64*. **P. megacuspe**, Baker, in Journ. Bot. 1890, 266. Tonquin, *Balansa*. Near *P. urophyllum*.
- 64*. **P. arfakanum**, Baker, in Malesia, III, 45. Mountains of New Guinea, *Beccari*.
- 64*. **P. Pinwillii**, Baker, sp. n. Stipe incomplete. Frond oblong, simply pinnate, minutely pubescent, 2 ft. long. Pinnae lanceolate, serrato-crenate, caudate, 9-10 in. long, 1½ in. broad. Main veins arcuate, ⅙-⅓ in. apart. Sori very copious, often confluent. Malacca, *Pinwill*. Near *P. urophyllum*.
- 64*. **P. coalescens**, Baker, in Journ. Bot. 1877, 104. Andes of Quito, *Sodiuro*.
- 66*. **P. Rivorei**, Baker; *Goniopteris Rivorei*, Fée, Fil. Ant., t. 18. Guadeloupe. Specimens lately received from M. Mazé show that this is distinct specifically from *P. crenatum*, Sw.
67. **P. Gheisbreghtii**, Linden. Gathered lately from Guatemala by Baron von Turckheim, No. 1407. Sent to Kew by Captain Donnell Smith.
98. **P. faucium**, Liebm. Mr. Jenman has identified this with *P.*

- obliteratum*, Sw., and gathered it in both the West Indies and Guiana.
- 70*. *P. granulatum*, Presl. Reliq. Haenk. tab. 4, fig. 2. Timor, *Haenke*.
74. *P. reptans*, Sw. Mettenius long ago referred this to *Aspidium*, and in 1882 Mr. Sime sent specimens from Jamaica showing the presence of a reniform indusium when the plant is very young. If placed in Aspidieae its position will be *Nephrodium* 177*.
- 76*. *P. imponens*, Cesati, Fil. Becc. Polyn. 5. Mount Arfak, New Guinea, *Beccari*. Habit of *Nephrodium ferox*.
77. *P. stegnogrammoides*, Baker, Sandwich Islands, proves to be identical with *P. polycarpum*, Hook. and Arn. Bot. Beech. 104 = *Phegopteris polycarpa*, Hilleb. Fil. Haw. 560.
78. *P. pennigerum*, Forst. I cannot separate specifically *P. sub-simile*, Colenso, in Trans. New Zeal. Instit. 1888, 238.
- 78*. *P. Metcalfei*, Baker, sp. n. Rootstock not seen. Stipe stramineous, 3-4 in. long, with a few lanceolate paleae at the brown base. Frond oblong-lanceolate, bipinnatifid, membranous, above 2 ft. long, 9-10 in. broad, obscurely hairy beneath. Pinnae lanceolate, many of the lower ones much dwarfed; largest 5-6 in. long, $\frac{3}{4}$ in. broad, cut down to a broad wing into entire linear-oblong lobes $\frac{1}{8}$ in. broad. Veinlets distinct, 10-12-jugate, about the three lower uniting. Sori small, medial. Santa Cruz, New Hebrides, *P. H. Metcalfe*. Near *P. pennigerum*.
- 80*. *P. heterophlebium*, Baker, in Journ. Bot. 1884, 363. Costa Rica, *Harrison*. Near *P. tetragonum*.
- 80*. *P. lunanianum*, Heward, in Mag. Nat. Hist. 1838, 460. Jamaica, *Lunan*. Habit of *Nephrodium amboinense*.
- 80*. *P. Lebeufii*, Baker, n. sp. Rootstock not seen. Stipe 1-1 $\frac{1}{2}$ ft. long, naked, pale brown. Frond oblong-lanceolate, bipinnatifid, membranous, finely pilose, 15-18 in. long, 4-5 in. broad at the middle, narrowed gradually to the base. Pinnae sessile, lanceolate, $\frac{3}{4}$ -1 in. broad, cut down to a broad wing into lobes $\frac{1}{8}$ in. broad. Veinlets 10-12-jugate. Sori nearer the midrib than the edge. Cambodia, *Godefroy-Lebeuf*, 69. Near *P. tetragonum*, but lobes longer, and lower pinnae distant and much dwarfed.

Subgenus **Dictyopteris**.

- 84*. **P. chattagrammicum**, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 548, tab 81. = *Dictyopteris chattagrammica*, Beddome, Ferns Brit. Ind., 299. Chittagong, at a low level.
- 85*. **P. andaiense**, Baker, in Malesia, III, 45. Andai, New Guinea, *Beccari*.
- 85*. **P. fernandense**, Baker, sp. n. Stipe slender, stramineous, naked. Frond deltoid, decompose, moderately firm, $1\frac{1}{2}$ ft. long and broad. Lower pinnae the largest, deltoid, unequal-sided, petioled; upper lanceolate, sessile, deeply pinnatifid; ultimate lobes oblong, $\frac{3}{4}$ -1 in. broad. Main ribs distinct to the margin; veinlets forming copious distinct areolae, with a few included free veinlets. Sori large, forming regular rows near the main veins. Fernando Po, *Henderson*. Smaller and less compound than *P. cameroonianum*, Hook.
- 87*. **P. rheosorum**, Baker, in Journ. Bot. 1884, 363. Costa Rica, *Harrison*. Habit of *Aspidium trifoliatum*.
- 90*. **P. Haynaldi**, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 61. Andes of Ecuador, *Sodiro*.
- 90*. **P. nicotianaefolium**, Baker, in Journ. Bot. 1877, 165. Andes of Ecuador, *Sodiro*. Gathered also by Seemann and Spruce.
- 90*. **P. beccarianum**, Cesati, Fil. Becc. Polyn. 5, 8. New Guinea; Ramoi, *Beccari*. Near *P. heterosorum* and *draconopterum*.

Subgenus nov. **Depariopsis**.

Differs from *Dictyopteris* by having the sori protruded beyond the margin of the lamina.

- 90*. **P. deparioides**, Baker, in Journ. Bot. 1879, 297. Fiji Islands, *Milne, Horne*. Habit of *Deparia Moorei*.

Subgenus **Eupolypodium**.

Fronde simple.

- 91*. **P. minimum**, Baker, in Journ. Bot. 1879, 41. Borneo, *Burbidge*.
- 91*. **P. synsorum**, Baker, in Journ. Linn. Soc. XVI, 203. Central Madagascar, *Miss Helen Gilpin*.
- 91*. **P. Gilpinae**, Baker, in Journ. Linn. Soc. XVI, 204. Central Madagascar, discovered by Miss Helen Gilpin, and gathered lately in the north-west of the island by Mr. J. T. Last.

- 91*. *P. Poolii*, Baker, in Journ. Linn. Soc. XV, 419. Central Madagascar, *Pool*.
- 93*. *P. albosetosum*, Bailey, in Plants Bellend. Ker Exped. 29. Bellenden Ker Range, Queensland, alt. 4000-5000 ft., *Bailey*. Near *P. Hookeri*. Not seen.
96. *P. subavenium*, Baker. Gathered lately in Perak by Father Scortechini.
- 96*. *P. holophlebium*, Baker, in Journ. Bot. 1880, 370. Madagascar; Tanala, *Kitching*.
- 97*. *P. Fawcettii*, Baker, in Journ. Bot. 1889, 270. Jamaica; high mountains, on trees, *Moore, Jenman*.
98. *P. hirtellum*, Blume. Found lately in Perak, China, and the Philippines.
- 98*. *P. trichopodium*, F. M. & Baker, in Journ. Bot. 1890, 107. Mountains of New Guinea, *Sir W. Macgregor*.
- 98*. *P. Wallii*, Beddome, Suppl. t. 380. Ceylon, *Wall*.
99. *P. hirtum*, Hook. Name antedated by *P. hirtum*, Presl., therefore we must fall back on *P. Reinwardtii*, Mett.
- 99*. *P. mollipilum*, Baker, in Journ. Bot. 1890, 107. New Guinea; Owen Stanley range, *Sir W. Macgregor*.
- 99*. *P. parietinum*, Klotzsch, in Linnea, XX, 373. Columbia, *Moritz*, 253.
- 99*. *P. congener*, Hook.= *Grammitis congener*, Blume, Fil. Jav. tab. 46, fig. 3. Java and Sumatra. Differs from *P. Reinwardtii* by its subglabrous frond, longer less pilose stipe and more compound venation.
- 100*. *P. padangense*, Baker, in Journ. Bot. 1880, 213. Sumatra; Mount Singalan, alt. 5000-6000 ft., *Beccari*.
- 100*. *P. Whitmeei*, Baker, in Journ. Bot. 1876, 12. Savaii, Samoa, *Whitmee, Powell*.
- 101*. *P. knutsfordianum*, Baker, in Journ. Bot. 1890, 107. Mount Knutsford, New Guinea, *Sir W. Macgregor*.
- 101*. *P. stanleyanum*, Baker, in Journ. Bot. 1890, 107. New Guinea; near the summit of the Owen Stanley range, *Sir W. Macgregor*.
- 101*. *P. Baldwinii*, Baker, sp. n. Rhizome short-creeping; paleae dense, small, linear-oblong, obtuse. Stipe none or very short. Frond simple, ligulate, subcoriaceous, glabrous, 3-5 in. long, ¹ in. broad at the middle, narrowed gradually to the base. Veins

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- distinct, ascending, with 2-3 branches. Sori globose, superficial, submarginal, $\frac{1}{2}$ in. diam. Sandwich Isles, *Baldwin*. Received from Professor Eaton, of Yale.
- 103*. *P. savaiense*, Powell; Baker, in Journ. Bot. 1876, 344. Savaii, Samoa, *Powell, Whitmee*.
- 105*. *P. simplex*, Baker, in Journ. Bot. 1876, 12. Samoa, *Powell, Whitmee*.
- 106*. *P. universe*, Baker, sp. n. Densely tufted. Fronds simple, sessile, rigidly conaceous, linear, $1\frac{1}{2}$ -2 in. long, $\frac{1}{2}$ - $\frac{1}{8}$ in. broad above the middle, narrowed gradually to the base, furnished with deciduous brown hairs. Midrib distinct; veins immersed, hidden. Sori oblong, crowded, uniseriate, confined to the upper part of the frond, where they fill up the whole space between the midrib and margin. Penang, *Curtis*, 633. Habit of *P. linearifolium*, Hook.
- 106*. *P. cryptophlebium*, Baker, in Journ. Bot. 1880, 370. Madagascar; between Tamatave and Antananarivo, *Kitching*.
- 106*. *P. Rutenbergii*, Luerss. Reliq. Ruten. I, 48, tab. 1, figs. 1, 2. Madagascar, *Rutenberg*.
- 108*. *P. australe*, Mett. I cannot clearly separate specifically the New Caledonian *P. pseudaustrale*, Fourn. in Ann. Sc. Nat. sér. 5, XVIII, 282; the New Zealand *P. paradoxum*, Colenso, in Trans. New Zeal. Instit. XIV, 337; *Grammitis pumila*, Armst. in Trans. New Zeal. Instit. 1880, 341; the Stewart Island *P. crassum*, Kirk, in Trans. New Zeal. Instit. 1884, 232; nor the Chilian *Grammitis araucana*, Phil. in Linnaea, XXXIII, 304.
- 108*. *P. subselligueum*, Baker, in Journ. Bot. 1890, 107. New Guinea; Mount Knutsford, *Sir W. Macgregor*.
- 108*. *P. Mollerii*, Baker, in Henriq. Cat. Pl. St. Thom. 30, tab. 4, fig. B. Island of St. Thomas, West Tropical Africa, *Moller*.
- 110*. *P. scabristipes*, Baker, in Journ. Bot. 1890, 108. New Guinea; near summit of Owen Stanley range, *Sir W. Macgregor*.
- 111*. *P. locellatum*, Baker, in Journ. Bot. 1890, 108. New Guinea; Mount Victoria, *Sir W. Macgregor*.
112. *P. flabellivenium*, Baker. *P. holophyllum*, Baker, in Journ. Bot. 1879, 43, proves to be identical. It has been gathered lately by Burbidge and Bishop Hose.

Fronds compound.

- 117*. *P. sumatranum*, Baker, in Journ. Bot. 1880, 214. Mount Singalan, Sumatra, alt. 5000-6000 feet, *Beccari*.
- 118*. *P. percassum*, Baker, in Journ. Bot. 1887, 26. Costa Rica, *Cooper*.
- 119*. *P. alternidens*, Cesati, Fil. Born. Becc. 25, tab. 2, fig. 4. Borneo, first gathered near Sarawak by Beccari; since by Burbidge and Bishop Hose.
120. *P. subpinnatifidum*, Blume, Gathered lately in Perak by Morgan.
121. *P. cucullatum*, Nees. Found lately in New Guinea by Beccari, and in Fiji by Horne.
- 123*. *P. nimbatum*, Jenman, in Journ. Bot. 1886, 271. Jamaica. Near *P. truncicola* and *organense*.
- 123*. *P. Sherringii*, Baker; Jenm. in Journ. Bot. 1882, 326. Mountains of Jamaica, *Sherring*.
- 124*. *P. Okurboi*, Yatabe, in Bot. Mag. (Jap.) V, 35, t. 21. Japan.
- 125*. *P. albobrunneum*, Baker, Fil. Maurit. 505. Seychelles, *Horne*. Near *P. leucosorum*, Hook.
- 125*. *P. subpinnatum*, Baker, in Journ. Linn. Soc. XV, 419. Central Madagascar, *Pool*.
- 128*. *P. stenopteron*, Baker, in Journ. Bot. 1884, 183. Fiji Isles, *Sir J. B. Thurston*.
129. *P. subserratum*, Hook. Must be omitted. It was refound in a fertile state by Burbidge, and proved to be identical with *Asplenium porphyrorachis*, Baker.
- 129*. *P. barathrophyllum*, Baker, in Journ. Bot. 1891, 107. West Borneo, Sarawak, *Bishop Hose*.
- 130*. *P. deltoideophyllum*, Baker, in Journ. Bot. 1876, 345. Samoa, *Whitmee*.
- 131*. *P. Glaziovii*, Baker, sp. n. Rhizome short-creeping; paleae dense, linear, light brown. Stipes 1-3 in. long, densely covered with fine spreading brown hairs. Frond lanceolate, subcoriaceous, glabrous, 8-10 in. long, $1\frac{1}{4}$ - $1\frac{1}{2}$ in. broad at the middle, narrowed very gradually to the base, cut down nearly to the rachis into linear entire lobes, the largest $\frac{1}{2}$ - $\frac{3}{4}$ in. long, $\frac{1}{8}$ in. broad. Veins 12-15-jugate, distinct, once forked, falling short of the margin. Sori small, superficial, medial. South Brazil, *Glaziou*, 9062. Near *P. inaequale*, Fée.

- 131*. *P. Burbidgei*, Baker, in Journ. Bot. 1879, 42. North Borneo, Lawas river, *Burbidge*. Habit of *Davallia Emersoni*.
- 132*. *P. moniliforme*, Lag. This Andine species has now been found on the mountains of Jamaica.
- 132*. *P. streptophyllum*, Baker, in Journ. Bot. 1879, 42. North Borneo, *Burbidge*. Very near *P. cucullatum*, but fully pinnate, with an apical sorus.
- 132*. *P. triangulare*, Scortech.; Beddome, in Journ. Bot. 1887, 324, tab. 278, fig. 1. Perak, *Scortechini*.
- 132*. *P. saxicolum*, Baker, in Journ. Bot. 1877, 264. Jamaica, *Jenman*. Very near *P. moniliforme*.
133. *P. exiguum*. The original authority for the name is Heward, not Grisebach, and the length is 6–24 lines, not inches.
- 133*. *P. musgravianum*, Baker, in Journ. Bot. 1890, 108. New Guinea; Mount Musgrave, 7000–8000 feet, *Sir W. Macgregor*.
- 133*. *P. oosorum*, Baker, in Henriq. Cat. St. Thom. 30, tab. 4, fig. A. Island of St. Thomas, West tropical Africa, alt. 6000 feet, *Moller*.
- 133*. *P. nutatum*, Jenm. in Journ. Bot. 1886, 272. Jamaica.
- 133*. *P. Hartii*, Jenm. in Journ. Bot. 1886, 272. Jamaica, *Jenman*: Dominica, *Eggers* and *Higgins*. Differs from *trichomanoides* by its immersed oblong sori.
- 134*. *P. trichomanoides*, Sw. Has lately been found on the mountains of Mozambique at an altitude of 5000 feet by M. de Carvalho.
- 134*. *P. antioquianum*, Baker, in Journ. Bot. 1881, 205. New Granada; province of Antioquia, *Kalbreyer*, 1703.
- 135*. *P. albo-punctatum*, Baker, in Journ. Bot. 1877, 265. Jamaica, *Jenman*. Between *P. flabelliforme* and *P. subtile*.
- 136*. *P. subscabrum*, Klotsch; Baker, in Journ. Bot. 1887, 165. Andes of Quito, *Sodirol*. Further material sent by Father Sodirol shows that this is a distinct species.
139. *P. parvulum*, Bory. The Himalayan plant must be excluded.
- 139*. *P. fuscopilosum*, F. M. & Baker, in Journ. Bot. 1887, 169. Mountains of Queensland, 3000–4000 feet, *Sayer* and *Davidson*. Near *P. parvulum*.
- 139*. *P. heterotrichum*, Baker, in Journ. Bot. 1879, 262. Jamaica, *Jenman*. Near *P. parvulum*.

141. *P. jubaeforme*, Kaulf. Has also been found in Guiana (*P. confusum*, J. Smith) and Brazil.
- 141*. *P. undosum*, Baker, in Journ. Bot. 1890, 108. New Guinea; Mount Musgrave, *Sir W. Macgregor*.
144. *P. cultratum*, Willd. Has lately been found in Madagascar.
- 145*. *P. macrorhynchum*, Baker, in Journ. Bot. 1880, 370. Madagascar; province of Tanala, *Kitching*.
148. *P. obliquatum*, Blume. I cannot separate specifically *P. Schenkii*, Harringt. in Journ. Linn. Soc. XVI, 31, gathered in the Philippines by Steere.
- 149*. *P. perludens*, Baker, in Journ. Linn. Soc. XVI, 204. Central Madagascar. *Miss Helen Gilpin*. Very near *P. repandulum*, Mett.
- 149*. *P. deltodon*, Baker, in Journ. Linn. Soc. XV, 419. Central Madagascar, *Pool*.
- 157*. *P. Eggersii*, Baker, in Hook. Ic. tab. 1671. Dominica, *Eggers*, 937. Intermediate between *pendulum* and *suspensum*.
- 157*. *P. comorense*, Baker, in Journ. Bot. 1877, 72. Johanna Island, *Hildebrandt*, 1788.
- 158*. *P. devolutum*, Baker, in Journ. Linn. Soc. XV, 19. Central Madagascar, *Pool*. Near *P. suspensum*.
- 159*. *P. kokenaamae*, Jenman; Baker, in Trans. Linn. Soc. ser. 2. Bot. II, 292. Mount Roraima, *im Thurn*, 186, ex parte. Near *P. Kalbreyeri*.
- 159*. *P. brunneo-viride*, Baker, in Journ. Bot. 1877, 265. Mountains of Jamaica, *Jenman*.
- 159*. *P. Kalbreyeri*, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 191. New Granada, *Kalbreyer*, 387. Mount Roraima, *im Thurn*, 186.
160. *P. celebicum*, Blume. Has been found in Sumatra by Beccari.
165. *P. madrense*, J. Sm. I should now place this, and *P. oulolepis* (not *ontolepis*), Fée, as varieties of *P. plebeium*.
167. *P. fuscatum*, Blume. Has been found in Perak by Scortechini and Sumatra by Beccari.
- 168*. *P. ? davalliaceum*, F. M. & Baker, in Journ. Bot. 1890, 108. Mountains of New Guinea, *Sir W. Macgregor*.
- 168*. *P. nutans*, Blume, Fil. Jav. tab. 86 A: Baker, in Journ. Bot. 1880, 214. Java and Sumatra. Further material, received from Curtis and Beccari, shows that this is distinct specifically from *P. decorum*.

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- 168*. *P. aturense*, Maury, in Journ. de bot. 1889, 134, tab. 3. Upper Orinoco, *Gaillard*, 111. Not seen.
- 169*. *P. Hornei*, Baker, in Journ. Bot. 1879, 298. Fiji Islands, *Horne*.
- 169*. *P. craterisorum*, Harringt. in Journ. Linn. Soc. XVI, 31. Mount Mahayhay, Philippines, *Dr. Steere*.
174. *P. papillosum*, Blume. Has lately been found in Perak by Wray.
- 175*. *P. Leysii*, Baker, in Journ. Bot. 1879, 66. Sulu Archipelago, *Burbidge*.
- 175*. *P. Curtissii*, Baker, in Journ. Bot. 1881, 367. Padang, Sumatra, *Curtis*.
- 175*. *P. cesatianum*, Baker, in Journ. Bot. 1879, 42. Sarawak, Borneo, *Beccari*.
176. *P. elasticum*, Rich., and 179, *P. pectinatum*, L. Both these widely-spread tropical American species have been found to extend northward to Florida.
- 177*. *P. paraguayense*, Baker, in Journ. Bot. 1878, 301. Paraguay, *Balansa*, 388. Near *P. recurvatum*, Kaulf.
- 177*. *P. manabyanum*, Baker, in Journ. Bot. 1877, 165. Andes of Ecuador, *Sodiro*. Near *P. taxifolium*.
183. *P. chnoophorum*, Kunze. Has been found in Paraguay by Balansa.
- 184*. *P. Endresi*, Baker, sp. n. Rhizome stout, epigaeous, paleaceous. Stipe naked, wiry, pale brown, 4-5 in. long. Frond oblong-lanceolate, simple pinnate, firm, glabrous, $\frac{1}{2}$ -1 ft. long, 3-6 in. broad. Pinnae lanceolate, entire, sessile; lowest not spaced out, dwarfed; largest 2-3 in. long, $\frac{1}{2}$ - $\frac{5}{8}$ in. broad. Veins very distinct, with 1-2 short branches on each side. Sori round, superficial, forming a single row midway between the margin and midrib. Costa Rica, *Endres*. Near *P. Martensii*, Mett.
- 184*. *P. microchasmum*, Baker, in Journ. Bot. 1887, 44. Jamaica, *Mrs. Baker*. Near *P. vulgare* and *P. Martensii*.
- 184*. *P. quitense*, Baker, in Journ. Bot. 1877, 165. Andes of Ecuador, *Sodiro*.
187. *P. clavifer*, Hook. Has lately been found in the mountains of New Guinea by Beccari.
- 188*. *P. graveolens*, Baker, in Journ. Bot. 1877, 265. Jamaica, *Jenman*. New Granada, *Kalbbreyer*, 1947. Near *P. tenuifolium*, H. B. K.

- 199*. *P. atacamense*, Baker; *P. squamatum*, Philippi, in Linnaea, XXIX, 107, non Linn. Desert of Atacama, *Philippi*.
- 208*. *P. abietinum*, Eaton, in Proc. Amer. Acad. 1886, 219. Sandwich Isles. Near *P. hymenophylloides*.
210. *P. tenuisectum*, Blume. The Samoan *P. sertularioides*, Baker, in Journ. Bot. 1876, 12, appears to be the same species. It has also been found in Perak by Scortechini.
- 210*. *P. taxodioides*, Baker, in Journ. Bot. 1879, 42. Kinabalu, North Borneo. alt. 3000 ft., *Burbidge*.
- 212*. *P. bipinnatifidum*, Baker, in Journ. Bot. 1890, 109. Summit of Owen Stanley range, New Guinea, *Sir W. Macgregor*.
- 212*. *P. melanotrichum*, Baker, in Trans. Linn. Soc. ser. 2. Bot. II, 292. Mount Roraima, *in Thurn*, 125. Near *P. achilleae-folium*.
- 212*. *P. pozuzoense*, Baker, in Hook. Ic. tab. 1672. Andes of Pozuzo, alt. 8000 feet, *Pearce*, 248.
- 212*. *P. torulosum*, Baker, in Journ. Linn. Soc. XVI, 204. Central Madagascar, *Miss Helen Gilpin*. Bourbon, *Delisle*.
- 218*. *P. aspidiolepis*, Baker, in Journ. Bot. 1887, 26. Costa Rica, *Cooper*. Near *P. murorum*.

Subgenus *Goniophlebium*.

- 225*. *P. moupinense*, Franchet, Pl. David. II, 159. Moupine, Tibet, *David*. Habit of *Drymoglossum carnosum*. Not seen.
- 228*. *P. caudiceps*, Baker; *Goniophlebium caudiceps*, Moore, in Gard. Chron. 1886, I, 234. Formosa, *Hort. Williams*. Not seen.
- 229*. *P. Eatoni*, Baker; *P. Gheisbreghtii*, Eaton Cat. Pl. Gheisbr. 2, non Linden. South Mexico, *Gheisbreght*, 273.
- 229*. *P. Veitchii*, Baker, in Gard. Chron. n. s. XIV, 494. Japan, *Bisset, Maries*.
- 229*. *P. stenoloma*, Eaton, in Pl. Gheisbr. No. 386. South Mexico, *Gheisbreght*. Habit of *P. sororium*, with fewer pinnae and anastomosing venation.
230. *P. niponicum*, Mett. Has been found lately in China by Shearer, Maries, Faber, and Hancock, and in Manipur by Dr. Watt.
- 230*. *P. formosanum*, Baker, in Journ. Bot. 1885, 105. Formosa, *Hancock*, 50.

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231. *P. amoenum*, Wall. Has lately been found in China by Dr. Henry.
- 231*. *P. yunnanense*, Franchet, in Bull. Soc. Bot. France, 1885, 29. Yunnan, *Delavay*.
- 231*. *P. subamoenum*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 550, tab. 82, fig. 2. Ridge between Sikkim and Nepal, alt. 11,000–12,000 feet.
237. *P. translucens*, Kunze. We have received from Messrs. Veitch a curious monster with the lower pinnae deeply pinnatifid, gathered in Juan Fernandez by Downton.
- 237*. *P. columbianum*, Baker, sp. n. Rootstock epigaeous, $\frac{1}{8}$ in. diam., clothed with dense lanceolate membranous pale brown paleae. Stipe naked, wiry, 3–4 in. long. Frond oblong-lanceolate, simply pinnate, membranous, glabrous, 6–10 in. long, 4–7 in. broad. Pinnae 6–9-jugate, sessile, linear, obscurely crenate, 2–4 in. long, $\frac{1}{3}$ in. broad, the lowest not dwarfed. Areolae and sori in a single row. Columbia, *Moritz*, 191, 194. Near *P. translucens*.
238. *P. lachnopus*, Wall. I cannot separate specifically *Gonio-plebium fieldingianum*, Moore, Ind. Fil. 389.
242. *P. Catherinae*, F. & L. I cannot specifically separate *P. Weisbaurii*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 65, and now think it would be better to treat *P. Catherinae* as a mere variety of *P. loriceum*.
243. *P. loriceum*, L. Kalbreyer has gathered in the Andes of New Guinea a curious monstrous form with deeply pinnatifid pinnae.
- 243*. *P. chartaceum*, Baker, in Journ. Bot. 1877, 166. Andes of Ecuador, *Sodiro*.
- 246*. *P. remotum*, Baker, sp. n. Stipe 9–12 in. long, naked, stramineous. Frond oblong, simply pinnate, moderately firm, glabrous, 9–12 in. long, 6–9 in. broad. Pinnae 15–20, remote, linear, acuminate, sessile, spreading, 3–5 in. long, $\frac{1}{4}$ – $\frac{1}{3}$ in. broad, entire or lobed at the base. Areolae and sori in a single row, the latter small, superficial, globose. New Granada, *Kalbreyer*, 843. Demerara, *Jenman*, 1434. Near *P. sarrucuchense*, Hook.
252. *P. verrucosum*, Wall. Has lately been found in Queensland and New Guinea.
- 253*. *P. ? tachiroanum*, Luer., in Engl. Jahrb., 1883, 362. Kiu-siu archipelago, south of Japan, *Tachiro*. Not seen.

- 254*. *P. nanegalense*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 65, Andes of Ecuador, *Sodiro*. Near *P. attenuatum*, H. B. K. Not seen.
- 259*. *P. Sampsoni*, Baker, sp. n. Rhizome slender, wide-creeping, firm, glabrous, with only a few lanceolate membranous paleae. Stipe naked, $1\frac{1}{2}$ -2 ft. long. Frond oblong, simply pinnate, moderately firm, glabrous, above a foot long, 7-8 in. broad. Pinnae 11, oblong-lanceolate, entire, cuspidate, sessile, cuneate at the base, the largest 4-5 in. long, an inch broad, the lowest dwarfed. Main veins erecto-patent, distinct to the edge, $\frac{1}{1\frac{1}{2}}$ in. apart; areolae and sori 5-6 between each main vein, the latter superficial, globose. West river, Canton, *Sampson* (Herb. Hance). Near *P. fraxinifolium*, Jacq.
260. *P. menisciifolium*, L. & F. I should not now separate this as a species from *P. neriifolium*.
- 261*. *P. xantholepis*, Harringt. in Journ. Linn. Soc. XVI, 36. Oroya railway, Andes of Peru, *Dr. Steere*.

Subgenus **Phlebodium**.

- 263*. *P. nematorhizon*, Eaton, in Pl. Fendl. Trinit. No. 73. Trinidad, *Fendler*: and gathered long ago in the same island by Aldridge. Habit of *P. lycopodioides*. A plant gathered by Bridges in 1846 in the Andes of Bolivia is either the same species or very near it.
266. *P. decumanum*, Willd. Has been found lately in Mexico and Jamaica.

Subgenus **Campyloneuron**.

269. *P. sphenodes*, Kunze. Has been found in Guatemala by Salvin and Colman, and in Peru by Dr. Steere.
273. *P. Phyllitidis*, L. This very common and well-known Tropical American species has lately been found in the island of St. Thomas, in West Tropical Africa, by M. Moller. We are indebted for a specimen to Dr. Henriquez.

Subgenus **Niphobolus**.

276. *P. confluens*, R. Br. The true plant of Robert Brown proves to be 316. *P. glabrum*, Mett. I now look upon 276 as merely a smaller, more slender variety of 277. *P. serpens*, Forst

- 278*. *P. breve*, J. Sm.; *P. jaintense*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 552, tab. 82, fig. 4; *Niphobolus brevis*, Beddome, Ferns Brit. Ind. 325. Khasia hills. Both Clarke and Beddome agree in separating this as a species from *P. adnascens*.
- 278*. *P. Davidii*, Baker, sp. n. Rhizome slender, wide-creeping; paleae small, brown, lanceolate. Fronds homomorphous, linear or lanceolate, 2-3 in. long, $\frac{1}{4}$ - $\frac{5}{8}$ in. broad at the middle, narrowed into a distinct stipe, thinly tomentose beneath. Sori small, mainly confined to the upper half of the frond, continuous from the midrib to the margin. Pekin, *Father David*, 558. Intermediate between *P. adnascens* and *Lingua*.
- 278*. *P. pachydermum*, Baker, in Journ. Linn. Soc. XV, 108. Little Kei Island, *Moseley* (Challenger expedition).
- 278*. *P. macropodium*, Baker, in Journ. Linn. Soc. XV, 108. Aru Islands, *Moseley* (Challenger expedition).
280. *P. Lingua*, Sw. Has lately been traced northward to Manchuria by Mr. James.
- 282*. *P. polydactylon*, Hance, in Journ. Bot. 1883, 269. Formosa, *Hancock*. Near *P. tricuspe*, Sw.
- 282*. *P. drakeanum*, Franchet, Pl. David. I, 355. China; South Chensi, *Father David*. Between *P. stigmatum* and *Lingua*.
- 282*. *P. Sheareri*, Baker, in Journ. Bot. 1875, 201. Central China; first gathered by Dr. Shearer; since by Maries, Everard, and Henry.
- 283*. *P. calvatum*, Baker, in Journ. Bot. 1879, 304. Central China; first gathered by Ford; since by Henry and Faber.
- 283*. *P. princeps*, Mett. Larger than *P. stigmatum*, more coriaceous in texture, with tomentum not at all fimbriated. Patches of sori thicker and veins slanter and more raised. New Guinea, *Beccari*.
- 285*. *P. angustissimum*, Baker, sp. n. Rootstock slender, wide-creeping, clothed with lanceolate pale brown adpressed paleae. Stipe none or very short. Frond linear, rigid, 3-4 in. long, $\frac{1}{2}$ - $\frac{1}{8}$ in. broad, with revolute edges, bright green and naked above, densely coated below with thick woolly tomentum. Veins quite hidden. Sori small, confluent, covering the whole surface of the upper part of the frond. Patung, China, *Henry*, 5137. Habit of *P. linearifolium*, Hook.
286. *P. floccigerum*, Mett. I do not now think this can be sepa-

- rated as a species from *P. fissum*, which has lately been found in China, Madagascar, and the Zambesi Highlands.
- 287*. *P. assimile*, Baker, in Journ. Bot. 1875, 201. Central China; gathered by Shearer, Maries, and Henry.
- 290*. *P. asterosorum*, Baker, in Journ. Bot. 1880, 214. Mountains of Sumatra, alt. 5000–6000 ft., *Beccari*, 458. Distinct in the group by its very large non-contiguous sori.
294. *P. penangianum*, Hook. Has lately been found in Burma, Perak, and Java.

Subgenus **Phymatodes**.

- 297*. *P. involutum*, Baker, in Journ. Bot. 1889, 177. West China; province of Hupeh, *Dr. A. Henry*, 6859.
- 297*. *P. Bakeri*, Luerssen; *P. torulosum*, Baker, in Journ. Bot. 1880, 215, non Journ. Linn. Soc. XVI, 201. Mount Singalan, Sumatra, alt. 5000–6000 ft., *Beccari*, 445.
- 297*. *P. hammatisorum*, Harringt. in Journ. Linn. Soc. XVI, 32; *Pleopeltis nummularifolia*, Moore herb. Philippines, *Cuming*, 121; *Steere*.
- 297*. *P. inconspicuum*, Baker, in Journ. Bot. 1884, 143. North-east Madagascar, *Humboldt*, 143.
- 297*. *P. Lewisii*, Baker, in Journ. Bot. 1875, 201. China; province of Kiu-Kiang, *Dr. Shearer*.
- 297*. *P. Wrayi*, Baker, sp. n. Rhizome slender, wide-trailing; paleae dense, lanceolate-acuminate, ciliated, ferruginous. Fronds simple, dimorphic, sterile, oblanceolate, obtuse, thick, glabrous, 1–1½ in. long; ¼–⅓ in. broad, with a naked stipe 1–15 lines long; fertile with a longer stipe and a linear blade 2–3 in. long, ⅓–½ in. broad. Sori globose, superficial, medial. Perak, alt. 5000 ft., *Wray*, *Scortechini*.
- 297*. *P. stenopteris*, Baker, in Journ. Bot. 1879, 43. Borneo; moist rocks near the Lawas river, *Burbidge*. Near *P. soridens*, Hook.
- 298*. *P. cyclophyllum*, Baker, sp. n. Rhizome thread-like, wide-creeping; paleae minute, linear-subulate, spreading. Fronds nearly sessile, simple, dimorphic, orbicular or obovate-oblong, entire, firm, glabrous, ½–1 in. long, ¼–⅓ in. broad; midrib not continued to the apex; veins anastomosing copiously in irregular areolae. Sori large, globose, uniserial, confluent, confined to the upper half of the blade. China; Ningpo, *Hancock*, 32.

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- 298*. *P. drymoglossoides*, Baker, in Journ. Bot. 1887, 170. Central China, *Henry*, 1576, *Faber*, 1046.
- 298*. *P. macrosorum*, Baker, in Journ. Bot. 1885, 106. Formosa, *Hancock*. Near *P. accedens*, Blume.
299. *P. rostratum*, Hook. Has been found in West China by Mr. C. Ford.
301. *P. oodes*, Kunze. Has been found in Borneo by Burbidge.
304. *P. lineare*, Thunb. I cannot separate specifically *P. Alberti*, Regel, Descr. Pl. Nov. VIII, 122, Turkestan; and *P. Onoei*, Franch. et Savat. Enum. Jap. II, 246, 642, Japan.
- 304*. *P. clathratum*, Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 559, tab. 82, fig. 1. Western Himalayas, and gathered lately by Hancock in North China. Very near *P. lineare*.
- 304*. *P. oligolepidum*, Baker, in Gard. Chron. n. s. XIV, 494. China; Mountains of Kiu-Kiang, *Maries*. Between *P. lineare* and *lanceolatum*.
- 304*. *P. subsparsum*, Baker, in Journ. Bot. 1880, 215. Mountains of Sumatra, *Beccari*. Between *P. lineare* and *rostratum*.
- 304*. *P. aspidiolepis*, Baker, in Journ. Bot. 1888, 230. West China; Mount Omei, alt. 4500 ft., *Faber*, 1063. Differs from *P. simplex* by its submarginal sori.
- 304*. *P. bullatum*, Baker, in Journ. Linn. Soc. XV, 420. Central Madagascar, *Pool*. Since gathered by Hildebrandt, 4173, Kitching, and Scott Elliot.
- 305*. *P. tonkinense*, Baker, in Journ. Bot. 1890, 266. Tonquin, *Balansa*, 148. Near *P. tenuilore*, Kunze.
- 305*. *P. Playfairii*, Baker, sp. n. Rootstock slender, wide-creeping. Fronds simple, sessile, oblanceolate, acute, moderately firm, glabrous, 4-6 in. long, 1-1½ in. broad above the middle, narrowed gradually to the base; midrib black; veins indistinct. Sori minute, superficial, arranged in irregular erecto-patent rows, many to a row. Formosa; Ape's Hill, Taiwan, *Playfair*, 383. Near *P. tenuilore*, Kunze.
- 305*. *P. ningpoense*, Baker, sp. n. Rhizome slender, wide-creeping; paleae lanceolate, brown, membranous. Fronds lanceolate, subsessile, entire, thin but firm, glabrous, 4-5 in. long, ¾-1 in. broad; midrib distinct from base to apex; areolae copious, with many free included veinlets. Sori scattered, moderately large, superficial, globose. China; Ningpo, *Hancock*.

- 307*. *P. induratum*, Baker, sp. n. Rhizome slender, wide-creeping. Stipe wiry, naked, 3-4 in. long. Frond simple, linear, rigidly coriaceous, glabrous, 8-9 in. long, $\frac{1}{2}$ in. broad at the middle, narrowed gradually to the base and apex. Veins immersed, quite hidden. Sori middle-sized, globose, superficial, forming a single lax row of each side of the midrib, with a few others forming an outer row at the middle of the frond. New Guinea: Mount Yule. Received from Sir F. Mueller, April 1891.
311. *P. superficiale*, Blume. Has lately been found in West China by Faber.
- 311*. *P. sarawakense*, Baker, in Journ. Linn. Soc. XXII, 228. Sarawak, Borneo, *Bishop Hose*. Very near *P. superficiale*.
- 311*. *P. papuanum*, Baker, in Malesia, III, 48. Mountains of New Guinea, *Beccari*.
- 311*. *P. buergerianum*, Miquel, Prolus. 334. Japan: regathered lately by Dickins. *P. brachylepis*, Baker, in Gard. Chron. n. s. XIV, 494, from Central China, province of Kiu-Kiang, Maries, is probably the same species.
- 311*. *P. Steerei*, Harringt. in Journ. Linn. Soc. XVI, 32. Formosa, *Steere*.
312. *P. schomburgkianum*, Kunze. An earlier name is *P. megalophyllum*, Desv. Ann. Linn. Soc. Par. VI, 226.
315. *P. linearifolium*, Hook. Has now been found in Japan by Maximowicz, Moseley, and Dickins.
316. *P. glabrum*, Mett. Authentic specimens from R. Brown's herbarium show this to be *P. confluens*, R. Br. Prodr. 146, a much earlier name. It is also *Drymoglossum Cunninghami*, Moore, Ind. Fil. 343. Norfolk Island.
317. *P. angustatum*, Sw. New South Wales to be omitted.
318. *P. samarense*, Mett. There is some confusion here: Cuming's, 323, on which *Gymnosorium samarense*, Presl, Epim. 140, is founded, is *Niphobolus varius*, to which it was long ago referred by John Smith; but I do not think the plant, of which a scrap is figured by Mettenius, Polyp., under this name is identical. Our specimen of Cuming's No. 93 is very near *P. angustatum*, but probably distinct by its crowded sori.
- 322*. *P. Annabellae*, Forbes, in Journ. Bot. 1888, 33, tab. 280. Mountains of New Guinea, *H. O. Forbes*. Differs from *P. lycopodooides* by its cordate-orbicular sterile frond.

- 322*. **P. Thurnii**, Baker, sp. n. Rhizome slender, wide-creeping, densely clothed with large adpressed lanceolate brown paleae. Stipe very short. Fronds simple, lanceolate-acuminate, moderately firm, glabrous, 6–8 in. long, $1-1\frac{1}{2}$ broad at the middle, cuneate at the base. Veins distinct, anastomosing copiously. Sori large, globose, superficial, forming a single row midway between the edge and midrib. British Guiana; gathered by Ankers 1829, and recently again by Jenman. Midway between *P. lycopodioides* and *P. persicariaefolium*.
- 322*. **P. rampans**, Baker, in Journ. Linn. Soc. XV, 109. Admiralty Isles, *Moseley* (Challenger expedition).
327. **P. normale**, var. **madagascariense**, Baker, in Journ. Linn. Soc. XV, 420. Central Madagascar, *Pool*. Near the Cape *P. Pappi*, Mett. Var. **sumatranum**, Baker, in Journ. Bot. 1880, 205, connects *normale* and *superficiale*.
329. **P. linguaeforme**, Mett. Has been found in Borneo by Bishop Hose, and the Admiralty Islands by Moseley.
- 329*. **P. glossipes**, Baker, sp. n. Rootstock wide-creeping, with a few small squarrose linear brown paleae. Stipe $1\frac{1}{2}$ in. long. Frond lanceolate or oblong-lanceolate, chartaceous, glabrous, acute or obtuse, narrowed very gradually at the base, 6–8 in. long, $1\frac{1}{2}-2\frac{1}{2}$ in. broad. Veining as in *P. myriocarpum*. Sori globose, superficial, $\frac{1}{2}$ -in. diam., scattered all over the frond. Mountains of New Guinea, *Beccari*. Near *P. linguaeforme*, but frond stipitate, and narrowed gradually to the base.
- 330*. **P. Morgani**, Zeiller, in Bull. Bot. Soc. France, XXXII, 76. Perak, alt. 3500 ft., *Morgan*.
- 330*. **P. lateritium**, Baker, sp. n. Rhizome very slender, wide-creeping; paleae dense, brown, squarrose, linear-subulate. Stipe erect, naked, 1–2 in. long. Frond lanceolate or ovate-lanceolate, entire, rigidly coriaceous, glabrous, $1\frac{1}{2}-3$ in. long, $\frac{1}{2}-1$ in. broad. Main veins erecto-patent, distinct nearly to the edge, $\frac{1}{4}$ in. apart, connected by irregular cross-bars. Sori globose, superficial, uniseriate, 2–3 in each row. Fronds when old turn brick-red. Cambodia, *Godefroy-Lebeuf*, 862. Near *P. lanceolatum*.
- 331*. **P. campyloneuroides**, Baker, in Journ. Linn. Soc. XX, 229. Borneo; Sarawak, alt. 2000 ft., *Bishop Hose*, 127.
- 332*. **P. plebiscopum**, Baker, in Journ. Linn. Soc. XV, 110.

- Summit peak of the Island of Ternate, *Moseley* (Challenger expedition).
- 333*. *P. costulatum*, Baker, in Journ. Bot. 1880, 215; *Acrostichum costulatum*, Cesati, Fil. Becc. Polyn. 8. Mount Singalan, Sumatra, alt. 5000-6000 ft., *Beccari*.
334. *P. triquetrum*, Blume. Has now been found in Ternate, New Guinea, Samoa, and Fiji.
- 334*. *P. leucophorum*, Baker, in Journ. Linn. Soc. XXII, 229. Sarawak, Borneo, *Bishop Hose*, 129.
335. *P. rupestre*, Blume. Has now been found in Sumatra and Perak.
336. *P. ovatum*, Wall. Has now been found in several localities in China, and is evidently a mere form of the Japanese *P. ensatum*, Thunb., our No. 344.
- 336*. *P. dimorphum*, Baker, sp. n. Rhizome stout, woody, short-creeping. Fronds dimorphic; sterile many, with a slightly paleaceous stipe, 2-3 in. long, and a simple oblong-lanceolate acuminate blade 3-4 in. long, 18-21 lines broad at the middle, narrowed to the base; fertile with a stipe 7-8 in. long, and a lanceolate blade under an inch broad. Main veins of sterile frond erecto-patent, flexuose, $\frac{1}{2}$ in. apart, not quite reaching the edge. Sori irregularly 2-3-seriate between the main veins, large, globose or two confluent in an oblong mass. Hainan, Formosa, *Rev. B. S. Henry*. Near *P. triquetrum*.
337. *P. platyphyllum*, Sw. Has been found in Perak by *Scortechini*.
- 338*. *P. Picoti*, *Rev. Hist.* 1886, 20, fig. 62. Brazil; not determinable. May be a form of *crassifolium*.
339. *P. membranaceum*, Don. Has now been found in West China and the Philippines.
- 339*. *P. Lastii*, Baker, in Journ. Bot. 1891, 5. North-West Madagascar, *Last*. Very near *P. membranaceum*.
- 339*. *P. Scortechinii*, Baker, sp. n. Rhizome woody, wide-creeping, flexuose, calvate. Stipe brown, naked, 15-16 in. long. Frond oblanceolate, acuminate, membranous, glabrous, 16-18 in. long, 3-3 $\frac{1}{2}$ in. broad, obscurely repand, narrowed gradually from the middle to the base. Main veins distinct to the edge $\frac{1}{2}$ -in. apart. Sori minute, superficial, scattered all over the surface of the frond, often confluent. Perak, *Scortechini*.

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- 340*. *P. xiphias*, Baker; *Pleopeltis xiphias*, Moore, in Gard. Chron. 1888, I, 331. Southern Polynesia, introduced into cultivation by Bull. Near *P. membranaceum* and *heterocarpum*.
- 341*. *P. millisorum*, Baker, in Journ. Linn. Soc. XV, 109. Little Kei Island, *Moseley* (Challenger expedition). Near *P. irioides*, Lam.
342. *P. musaefolium*, Blume. Has now been found in Perak by Scortechini and in New Guinea by Beccari.
- 348*. *P. subhastatum*, Baker, in Journ. Bot. 1889, 177. West China: province of Hupeh, *Henry*, 5450.
- 349*. *P. deltoideum*, Baker, in Journ. Bot. 1888, 230. West China: Ichang, *Henry*, 3279.
- 349*. *P. Engleri*, Luer. in Engler Jahrb. 1883, 361. Japan, *Doderlein*. Not seen.
- 352*. *P. (Dipteris) quinquefurcatum*, Baker, in Journ. Linn. Soc. XXIV, 269. West Borneo, *Bishop Hose*. Near *P. bifurcatum*, Baker.
- 354*. *P. hemitomum*, Hance, in Journ. Bot. 1883, 369. Canton, *Rev. B. Henry* (Hance herb. 22,404). A doubtful species. The cutting looks abnormal, and there are no sori in Dr. Hance's type specimen now at the British Museum.
354. *P. leucosporum*, Klotsch. I now regard this an abnormal more or less deeply pinnatifid form of *P. lanceolatum*, our No. 314.
- 355*. *P. pentaphyllum*, Baker, sp. n. Rhizome wide-creeping, woody, $\frac{1}{6}$ in. diam.; paleae small, sparse, lanceolate-acuminate. Stipe naked, an inch long. Frond above a foot long, membranous, green, glabrous, simple in the lower half, forming a mere wing to the rachis, deeply pinnatifid in the middle; lobes distant, linear-lanceolate, $\frac{1}{3}$ – $\frac{1}{2}$ in. broad; veins fine, anastomosing, copious. Sori minute, scattered. Philippines, *Wallis*. Texture and sori of *P. tenuilore*.
- 355*. *P. glaucopsis*, Franchet, in Bull. Soc. Bot. France, 1885, 29. Yunnan, *Delavay*. Near *P. trifidum*, Don.
- 355*. *P. quinquefidum*, Baker, in Journ. Bot. 1880, 216. Mount Singalan, Sumatra, alt. 5000–6000 ft., *Beccari*. Very near *P. trifidum*.
- 355*. *P. senanense*, Maxim. in Bull. Imp. Acad. Petersb. XII, 571. Japan, *Tschonoski, Hancock*. Very near *P. trifidum*. It

- is the plant so called by Franchet and Savatier, Enum. II, 247.
- 356*. *P. crenato-pinnatum*, Clarke, in Journ. Linn. Soc. XV, 99, tab. 42. North Manipur, *Clarke*. Yunnan, *Delavay*. Near *P. malacodon*.
357. *P. incurvatum*, Blume. Has been found in Perak by Scortechini.
357. *P. fossum*, Baker; *Pleopeltis fossa*, Moore, in Gard. Chron. 1882, II, 586. Eastern Archipelago, *Hort. Veitch.*, received from Leyden.
- 360*. *P. Hancockii*, Baker, in Journ. Bot. 1885, 106. Formosa, *Hancock*, 100. Sori as in *P. affine*, Blume.
- 361*. *P. novae-zelandiae*, Baker, in Hook. Ic. t. 1674; Field, Ferns New Zeal., 142, tab. 27, fig. 3. Waikato district, New Zealand. First sent to us by Mr. Cheeseman in 1877. Near *P. Billardieri*, R. Br.
- 361*. *P. pictum*, Baker; *Pleopeltis picta*, Moore, in Gard. Chron. 1881, I, 331. Polynesia.
- 361*. *P. vitiense*, Baker, in Journ. Bot. 1879, 298. Fiji Isles, *Horne*.
362. *P. Phymatodes*, L. Has been found in Perak by Scortechini.
363. *P. nigrescens*, Blume. Has now been found in Queensland, and is probably *P. membranifolium*, R. Br. Prodr. 147, which is an older name than *nigrescens*.
- 364*. *P. expansum*, Baker, in Journ. Bot. 1876, 12; *Drynaria acuminata*, Brackenr. Fil. 47 now 41. Samoa, *Powell*, *Whitmee*.
- 366*. *P. macrourum*, Baker, in Gard. Chron. 1886, XXX, 136. Received at Kew alive in 1886 from the Brisbane botanic garden. Native country uncertain.
- 366*. *P. grandidentatum*, Baker; *P. dilatatum* var. *grandidentatum*, Cesati, Fil. Born. Becc. 27. Stipe above a foot long below the wing; wing $\frac{1}{2}$ foot to lowest pinna. Frond oblong, membranous, bright green, glabrous, deeply pinnatifid, 3 ft. long; lobes lanceolate, the lower much dwarfed, central 8-9 in. long, $1-1\frac{1}{4}$ in. broad, sharply toothed. Main veins erecto-patent, distinct to the edge, $\frac{1}{2}$ in. apart. Sori copious, minute, scattered. Borneo; Sarawak, *Beccari*. Differs from *dilatatum* by its toothed pinnae and main veins and sori produced up to the margin.

- 372*. **P. Sauvineri**, Baker, sp. n. Rootstock not seen. Stipe naked, stramineous, 4-5 in. long. Frond oblong-lanceolate, firm, glabrous, simply pinnate, $1\frac{1}{2}$ ft. long, 4-5 in. broad at the middle, narrowed to the base. Pinnæ 30-40-jugate, linear, entire, obtuse, $\frac{1}{4}$ in. broad, adnate by a dilated base. Veins hidden. Sori in a single medial row, sunk in deep pit and showing as papillae on the upper surface, about 20 in a row in the central pinnæ. Celebes, *Sauvinière*, 382.
- 372*. **P. macrochasmum**, Baker, in Journ. Bot. 1880, 216. Mount Singalan, Sumatra, alt. 5000-6000 ft., *Beccari*, 468. Perak, *Morgan*.
373. **P. Heracleum**, Kunze. Has now been found in Perak by Scortechini and New Guinea by D'Albertis.
- 376*. **P. (Drynaria) nectariferum**, Beccari; Baker, in Malesia, II, 217, III 47. Mount Arfak, New Guinea, *Beccari*. Habit of *P. meyenianum*, but sterile and fertile fronds distinct.
- 377*. **P. (Drynaria) Parkinsoni**, Baker, sp. n. Rhizome wide-creeping, $\frac{1}{6}$ in. diam.; paleae adpressed, brown, membranous, ciliated. Sterile frond not seen. Fertile frond oblong-lanceolate, coriaceous, pinnate, a foot long, half as broad. Pinnæ about 5-jugate below the pinnatifid apex, lanceolate, entire, broadly adnate to the rachis, an inch broad when fertile, $1\frac{1}{2}$ in. when sterile. Main veins erecto-patent, $\frac{1}{6}$ in. apart; cross-bars 5-6 between midrib and edge, one oblong brown sorus in each square. New Britain, *Parkinson*. Received from Sir F. Mueller in 1887. Texture of *P. conjugatum*, but no drynarioid base.
- 383*. **P. Baudouini**, Baker; *Drynaria Baudouini*, Fourn. in Ann. Sc. Nat. sér. 5, XVIII, 285. Differs from *P. diversifolium* by segments of sterile frond more numerous, narrower, with acute sinuses, serrated fertile segments, areole biseriata, costular series alone soriferous and by its softer more translucent texture. New Caledonia, *Baudouin*. Not seen.
- 384*. **P. Moseleyi**, Baker, in Journ. Linn. Soc. XV, 110. Ternate, *Moseley* (Challenger expedition). Near *P. palmatum*, Blume.
386. **P. Lehmanni**, Mett. Further material shows that this cannot be separated as a species from *P. himalayense*, Hook., which has now been gathered by Ford, Faber, and others in Western China.

- 387*. **P. Wardii**, Clarke, in Journ. Linn. Soc. XXV, 99, t. 43. Naga hills, *Clarke*. Bhotan, *Griffith*. Very near *P. himalayense*.
388. **P. leiorhizon**, Wall. Add to the localities Neilgherries and Western China.
389. **P. albo-squamatum**, Blume. The name should be *albido-squamatum*. It has been found in New Guinea by D'Alberty.

Genus 50. NOTHOCHLAENA, R. Br.

The above is the original spelling of the name as given by R. Brown.

- 1*. **N. Reynoldsii**, F. M. Fragm. VIII, 175. Mount Olga, sub-central Australia, *Gosse*, 161. Habit of *Gymnogramme Muellieri*, next to which Bentham places it.
4. **N. lanuginosa**, Desv. The oldest name is *N. vellea*, R. Br. Prodr. 146. It has now been found in Nubia, Afghanistan, and the Western Himalayas.
- 4*. **N. Parryi**, Eaton, Ferns south-west. 306. California, Arizona, and Utah.
- 4*. **N. Balansae**, Baker, in Journ. Bot. 1878, 301; Hook. Ic. t. 1677. Paraguay, *Balansa*, 330.
- 6*. **N. chinensis**, Baker, in Gard. Chron. n. s. XIV, 494; Hook, Ic. t. 1676. Ichang gorge, Central China, *Maries*.
- 10*. **N. eckloniana**, Kunze. Has been found lately in Angola by *H. H. Johnston*.
- 12*. **N. paucijuga**, Baker. Is accepted by Mueller and Bentham as *N. pumilis*, R. Br. Prodr. 146, and has been refound on the Endeavour river by Dr. Norman Taylor.
- 12*. **N. Prenticei**, Baker; *Cheilanthes Prenticei*, Luer, in Bot. Centralblatt, 1882, 442. Thursday Island, Queensland, *Prentice*. Near *N. fragilis*. Hook. Not seen.
- 18*. **N. tricholepis**, Baker, in Journ. Bot. 1883, 245. Usagura Mountains, East tropical Africa, *Bishop Hannington*.
19. **N. tenera**, Gillies. Has been found in Mexico and California.
- 19*. **N. Palmeri**, Baker, in Hook. Ic. tab. 1678. Central Mexico, *Parry* and *Palmer*, 991.
- 19*. **N. Grayi**, Davenport, in Bull. Torrey Club, VII (1880), 50. Arizona and New Mexico.

Subgenus **Cincinalis**.

- 22*. **N. aurantiaca**, Eaton, in Proc. Amer. Acad. XXII, 462. Jalisco, North Mexico, *Palmer*, 83.
- 22*. **N. californica**, Eaton, in Bull. Torrey Club, X (1883), 27. Is the Californian plant which has been referred to *N. candida*.
- 22*. **N. rigida**, Davenport, in Pringle, Pl. Jalisco, No. 2509. Jalisco, North Mexico, *Pringle*.
- 22*. **N. Pringlei**, Davenport, in Bull. Torrey Club, 1886, 132, tab. 58. North Mexico; Coahuila, *Palmer*, 1382, 1383; Chihuahua, *Pringle*, 441.
- 22*. **N. Hookeri**, Eaton, Ferns south-west, 308; Baker, in Hook. Ic. t. 1679. California, Arizona, and New Mexico.
- 22*. **N. Lemmoni**, Eaton, in Bull. Torrey Club, VIII (1880), 63. Arizona, Chihuahua, and Jalisco.
26. **N. dealbata**, Kunze. Has now been found in many of the western states and fuller material shows that it cannot be separated specifically from *N. nivea*, Desv.
27. **N. Fendleri**, Kunze. Has now been found in several of the western states.

Abnormal Species.

- N. pteridiformis**, Baker, in Malesia, III, 49; *Gymnogramme pteridiformis*, Cesati, Fil. Becc. Polyn. 5, 8. Andai, New Guinea, *Beccari*. Habit of *Polypodium tenellum*, with round marginal sori.

Genus 51. MONOGRAMME, *Schk.*

- M. interrupta**, Baker, sp. n. Stipes densely tufted, wiry, naked, 2-3 in. long. Frond linear, thick, rigidly coriaceous, glabrous, 1-1½ in. long, ¼ in. broad. Veins quite hidden. Sori filling the whole space between the midrib and margin, which is broken up into a series of pits of unequal length, in which the sporangia are immersed. New Guinea; Mount Yule. Received from Sir F. Mueller, April 1891. Forms a new subgenus of Monogramme, distinguished by its broken band of fructification.

Genus 52. GYMNOGRAMME, *Desv.*

- Gymnogrammeae* is monographed in Kuhn's Choetopterides and divided into eight genera, viz. *Aspleniopsis*, *Trichogramme*,

Taenitis, *Platytaenia*, *Cheiropleuria*, *Psilogramme*, *Gymnogramme*, and *Monachosorum*.

Subgenus **Leptogramme**.

- 9*. **G. Levingei**, Baker; *G. aurita* var. *Levingei*, Clarke, in Trans. Linn. Soc. Bot. ser. 2, I, 568. Rhizome slender, wide-creeping; paleae lanceolate, membranaceous. Stipe slender, naked, 6-8 in. long, stramineous with a brown base. Frond lanceolate or oblong-lanceolate, bipinnate, membranous, pubescent, 1-1½ ft. long, 3-4 in. broad at the middle, narrowed to the base. Pinnae lanceolate, sessile, ½-¾ in. broad, cut down to the rachis into contiguous erecto-patent linear-oblong pinnules. Veinlets erecto-patent: upper simple, lower forked. Sori oblong or globose, placed nearer the margin than the midrib. West Himalayas; Jhelum valley, alt. 4000 feet. *Levinge*. I follow Mr. C. W. Hope in treating this as a species.
- 10*. **G. subsimilis**, Hook. Sp. Fil. V, 142, tab. 293. Further specimens gathered by Kalbreyer in the Cameroons show this is a good species, which should be placed here.
- 11*. **G. gigantea**, Baker, in Journ. Bot. 1889, 177. West China: Hupeh, *Dr. Henry*, 6517. Habit of American *Asplenium dubium*, Mett.
- 11*. **G. Cominsii**, Baker, in Journ. Linn. Soc. XIX, 296. Solomon Isles, *Rev. R. B. Comins*. Near the last.

Subgenus **Eugymnogramme**.

- 14*. **G. cyclophylla**, Baker, in Trans. Linn. Soc. ser. 2. Bot. II, 293, tab. 53; figs. 1-2. Mount Roraima, *in Thurn*, 295. Falls under *Pterozonium*, Fée, near *G. reniformis*, Mett.
- 15*. **G. elaphoglossoides**, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 293, tab. 54, figs. 1-5. Mount Roraima, *in Thurn*, 101, 215. Habit of *Acrostichum Lingua*. The confluent sori finally fill up the whole surface of the frond except a band near the margin.
- 16*. **G. sinuata**, Moore herb. Habit of *Polypodium trifurcatum*, L. Stipes tufted, slender, about 2 in. long, densely clothed with spreading brown hair-like paleae. Frond lanceolate, membranous, 6-8 in. long, ½-¾ in. broad at the middle, narrowed gradually to the base, shallowly obtusely lobed, furnished on

- both sides with hair-like paleae like those of the stipe. Veins pinnate opposite the lobes. Sori medial, linear, often $\frac{1}{8}$ in. long. Andes of Quito, *Jameson*.
- 17*. **G. Delavayi**, Baker, sp. n. Rhizome short-creeping; paleae dense, linear, ferruginous. Stipes tufted, wiry, castaneous, pilose, 3-4 in. long. Frond oblong-lanceolate, subcoriaceous, simply pinnate, 3-4 in. long, $1-1\frac{1}{4}$ in. broad, green and nearly naked above, densely clothed beneath with lanceolate brown membranous paleae. Pinnae oblong, $\frac{1}{2}-\frac{3}{4}$ in. long, $\frac{1}{8}$ in. broad, the lower lobed on one or both sides at the base. Sori oblique, quite hidden beneath the paleae. Yunnan, *Delavay*. Near *G. Muelleri* and *vestita*.
21. **G. Pozoi**, Kunze. I cannot separate specifically **G. alpina**, Potts, in Trans. New Zeal. Instit. X, 361, from the mountains of New Zealand.
22. **G. Andersoni**, Beddome. As has been already stated **Woodsia lanosa**, Hook., must be placed here as a synonym.
- 24*. **G. longifolia**, Baker, sp. n. Rhizome wiry, short-creeping; paleae minute linear-subulate, castaneous. Stipe flexuose, wiry, castaneous, naked, 1-4 in. long. Fronds lanceolate, bipinnatifid, 4-6 in. long, $\frac{1}{2}-\frac{3}{4}$ in. broad: apex indefinite, circinate. Pinnae 20-30-jugate, oblong, obtuse, shortly petioled, obtusely lobed. Veins flabellate in the lobes. Sori oblong. Mountains of Central Brazil, *Glaziou*, 7017. Very near the Andine *G. angustifrons*, Baker.
- 33*. **G. vellea**, Baker, in Journ. Bot. 1881, 206. New Granada; province of Antioquia, alt. 8800 feet, *Kalbreyer*, 1487. Near *G. Warcewiczii*, Mett.
35. **G. javanica**, Blume. Has now been found in West China, Madagascar, and East tropical Africa.
- 43*. **G. Schaffneri**, Baker; *Bommeria Schaffneri*, Fourn. in Bull. Soc. Bot. France, 1880, 327. Mexico, *Schaffner*. Fournier's genus *Bommeria* is founded on *Gymnogramme pedata*, Kaulf.
44. **G. leptophylla**, Desv. Has now been found in Madagascar, Kumaon, and Paraguay.
- 48*. **G. schizophylla**, Baker, in Journ. Bot. 1877, 266; Hook. Ic. t. 1682. Mountains of Jamaica, alt. 4000-5000 feet, first found by Miss Taylor. Rediscovered by Jenman and Nock in 1875 and introduced into cultivation.

- 48*. **G. Lathamiae**, Moore, in Gard. Chron. 1884, II, 360. Supposed to be a garden hybrid between *G. decomposita* and *schizophylla*. Raised by Mr. W. B. Latham, of the Birmingham Botanic Garden.
- 48*. **G. dubia**, Baker; *Psilogramme dubia*, Kuhn, Choetop. 17. Central Brazil, *Glaziou*, 5321. Not seen. Placed by Kuhn near *G. insignis* and *orbignyana*.
- 48*. **G. domingensis**, Baker, sp. n. Rootstock not seen. Stipe stout, naked, castaneous, 4-6 in. long. Frond lanceolate, firm, decomposed, glabrous above, hispid on the ribs beneath, a foot long, 3-4 in. broad at the middle, narrowed to the base: rachis straight, stout, naked, castaneous. Pinnæ oblong-deltoid, cut away on the lower side at the base, the largest 2-2½ in. long, an inch broad: pinnules oblong-deltoid; final segments short, linear-oblong, 1-nerved. Sori short. Alto Causal, San Domingo, alt. 7000 feet, *Hort. Bull.* (Herb. Moore.)
- 49*. **G. prehensibilis**, Baker, in Hook. Ic. t. 1683. Has been regathered in the Andes of New Granada, province of Antioquia, by Kalbreyer.
- 50*. **G. xerophila**, Baker, in Journ. Bot. 1881, 206. New Granada: province of Antioquia, *Kalbreyer*, 1563. Near *ferruginea* and *aureo-nitens* in vestiture and shape of final segments, but large and more compound.

Subgenus **Ceropteris**.

- 51*. **G. chrysoSORA**, Baker, in Journ. Linn. Soc. XXIV, 260. Sarawak, Borneo, collected by Forstermann, sent to Kew by Bishop Hose.
- 51*. **G. longipes**, Baker, in Journ. Bot. 1878, 301. Paraguay, *Balansa*, 333, and a denudate variety, *Balansa*, 334. Near *G. trifoliata*.

Subgenus **Syngramme**.

58. **G. borneensis** var. **major**, Baker, in Journ. Bot. 1879, 299. Fiji, *Horne*, 926.
- 58*. **G. Dayi**, Beddome, in Journ. Bot. 1888, 5, tab. 279 B. Perak, *Day*.
- 60*. **G. scolopendrioides**, Baker, in Journ. Bot. 1879, 299. Fiji Isles, *Horne*. Near *G. obtusifolia*.

- 64*. *G. valleculata*, Baker, in Journ. Bot. 1888, 325. Borneo; Sarawak, *Bishop Hose*, 239.
 65. *G. quinata*, Hook. Has been found in New Guinea by Beccari.

Subgenus *Selliguea*.

66. *G. lanceolata*, Hook. Has now been found in Kaffraria.
 66*. *G. grammitoides*, Baker, sp. n. Rhizome wide-creeping. Fronds simple, oblanceolate, sessile, glabrous, 2–3 in. long, $\frac{1}{3}$ in. broad, obtuse or subacute, narrowed gradually to the base. Veins anastomosing copiously. Sori oblong or linear, oblique, confined to the upper part of the frond. West China; Hupeh. *Dr. Henry*, 5451, and a nearly allied plant from Szechwan, *Dr. Henry*, 7531. Habit of *Polypodium australe*.
 69. *G. elongata*, Hook. *Taenitis Swartzii*, Jenman, in Journ. Bot. 1877, 100, is a synonym.
 71*. *G. acuminata*, Baker, in Journ. Bot. 1888, 326. West Borneo, *Bishop Hose*, 238. Near *G. membranacea*, Hook.
 71*. *G. campyloneuroides*, Baker, in Journ. Linn. Soc. XXIV, 261. West Borneo, *Bishop Hose*, 208.
 72*. *G. Henryi*, Baker, in Journ. Bot. 1887, 171. Nanto, China, *Dr. Henry*, 2114. Near *G. Wrightii*, Hook.
 72*. *G. Sayeri*, F. M. & Baker, in Journ. Bot. 1887, 163. Mountains of Queensland, alt. 5000 ft., *Sayer and Davidson*.
 76*. *G. cantoniensis*, Baker, in Hook. Ic. t. 1685. North River, Canton, *Ford*.
 81*. *G. finlaysoniana*, Baker; *Grammitis finlaysoniana*, Wall. Cat. No. 776; *Gymnogramme digitata*, Baker, in Journ. Bot. 1890, 694. Cochin China, *Finlayson, Gaudichaud*; Tonquin, *Balansa*, 102. Like *G. elliptica*, but subdigitate in habit with 3–5 segments.
 81*. *G. longisora*, Baker, in Journ. Bot. 1890, 267. Tonquin, *Balansa*, 1870. Very near *G. elliptica*.
 81*. *G. ampla*, Benth. Fl. Austral. VII, 775. Queensland. Very near *G. elliptica*.
 82. *G. pinnata*, Hook. *G. subtrifoliata*, Hook., mentioned under this species in the Synopsis Filicum, proves to be an abnormal form of *Acrostichum sorbifolium*.

83. *G. japonica*, Desv. Has now been found in several places in China.
84. *G. podophylla*, Hook. An older name is *G. ehrenbergiana*, Klotsch, in *Linnaea*, XX, 411. It has now been found in Guatemala.

Excluded species.

- G. edulis*, Cesati, Fil. Born. 28, is *Asplenium esculentum*, Presl.
- G. microphyloides*, Cesati, Prosp. 8, is *Cheilanthes tenuifolia*, Sw.

Genus 52*. ENTEROSORA, *Baker*, in *Trans. Linn. Soc. ser. 2*, Bot. II, 294, tab. 55.

- E. Campbellii*, *Baker*, loc. cit. Mount Roraima, in *Thurn*, 184, ex parte. Rose Hill, Jamaica, *Fawcett* (collected by Moore). Habit of *Polypodium trifurcatum*, with immersed oblong sori, finally bursting through the cuticle.

Genus 54. MENISCIMUM, *Schreb.*

- 1*. *M. beccarianum*, Cesati, Fil. Becc. Polyn. 8. Andai, New Guinea, *Beccari*. Fiji, *Horne*.
- 2*. *M. giganteum*, Mett. Has now been found in Ecuador and New Granada by Sodiro and Kalbreyer. *M. grande*, Hort. Wendl., received alive at Kew in 1881, differs from the type by its shorter stipe, clothed up to the top with spreading paleae.
- 4*. *M. Hosei*, *Baker*, in *Journ. Linn. Soc. XXII*, 230. Sarawak, West Borneo, *Bishop Hose*, 160. Near *M. Thwaitesii*, Hook.
- 4*. *M. stenophyllum*, *Baker*, in *Journ. Bot.* 1891, 108. West Borneo, *Bishop Hose*.
- 9*. *M. opacum*, *Baker*, in *Journ. Bot.* 1877, 166. Andes of Ecuador, *Sodiro*.
- 10*. *M. reticulatum*, Sw. I cannot separate specifically *M. andreanum*, Sodiro, *Recens. Crypt. Vasc. Prov. Quit.* 71. *M. oligophyllum*, Hort. Linden, differs from the type by having only 5-9 pinnae.

Genus 55. ANTROPHYUM, *Kaulf.*

- 1*. *A. vittarioides*, *Baker*, in *Journ. Bot.* 1890, 267. Tonquin, *Balansa*, 1921. Stands on the boundary line near *Antrophyum* and *Vittaria*.

- 1*. **A. minimum**, Baker, sp. n. Rootstock slender, wide-creeping. Fronds linear, obtuse, moderately firm, glabrous, $1-1\frac{1}{2}$ in. long, $\frac{1}{8}$ in. broad, narrowed gradually from the middle to a short stipe. Veins, about three, all down the centre of the frond, anastomosing by a few short cross-bars. Sori few, linear, vertical, sunk in a distinct groove. Mountains of Costa Rica, alt. 4000-5000 ft., *Endres*.
7. **A. reticulatum**, Kaulf. Has now been found in Madagascar by Mr. J. T. Last.
11. **A. sessile**, Kunze. Has now been found in Mexico by M. Finck.
14. **A. mannianum**, Hook. Has now been found in East Tropical Africa by Mr. J. T. Last.

Genus 56. VITTARIA, *Smith*.

- 2*. **V. intramarginalis**, Baker, in Journ. Bot. 1877, 266. Mountains of Jamaica, gathered by Wilson and Jenman.
- 3*. **V. sulcata**, Kuhn. Has now been found in Perak by Scortechini and New Guinea by Beccari (*Taenitis simplicissima*, Cesati).
- 3*. **V. wooroonooran**, Bailey, in Plants Bellend. Ker Exped. 27. Mountains of Queensland, alt. 4000-5000 ft., *Bailey*. Not seen.
- 3*. **V. sikkimensis**, Kuhn; Clarke, in Trans. Linn. Soc. ser. 2, Bot. I, 574. Eastern Himalayas.
9. **V. scolopendrina**, Thwaites. Has now been found in Fiji, Eastern Himalayas, Perak, Bourbon, and Mauritius.

Genus 57. TAENITIS, *Sw*.

3. **T. lanceolata**, R. Br. Has now been found in Florida, the Bahamas, and Mexico.
5. **T. blechnoides**, Sw. Range is Himalayas and Ceylon, eastward to Fiji.

Genus 58. DRYMOGLOSSUM, *Presl*.

1. **D. carnosum** var. **obovatum**, Harringt. in Journ. Linn. Soc. XV, 33. Formosa, *Dr. Steere*.

- 2*. *D. niphoboloides*, Baker, in Hook. Ic. t. 1686; *Taenitis niphoboloides*, Luerss. in Rel. Ruten. I, 49, tab. 1, figs. 3-6. Madagascar, gathered first by Rutenberg, since by Baron, Humblot, and Last.

Genus 59. HEMIONITIS, *Linn.*

1. *H. lanceolata*, Hook. Has been found in New Guinea by Beccari.
- 1*. *H. Hosei*, Baker, in Journ. Bot. 1891, 108. West Borneo; Sarawak, alt. 1500 ft., *Bishop Hose*. Very near *H. lanceolata*.
- 1*. *H. Zollingeri*, Kurz. Has been found in Sumatra by Curtis and the Philippines by Dr. Steere.
- 2*. *H. Levyi*, Fourn. in Bull. Soc. Bot. France, XVII, 237. Nicaragua, *Dr. Levy*. Near *H. cordata*.
- 4*. *H. elegans*, Davenport, in Pringle, Plant. Jalisco, No. 2585. Jalisco, North Mexico, *Pringle*.
6. *H. pinnata*, J. Sm.; Baker, in Hook. Ic. t. 1687. Was regathered in Jamaica in 1875 by Sherring and Jenman.

Genus 60. ACROSTICHUM, *Linn.*

Subgenus *Elaphoglossum*.

- 1*. *A. Curtisii*, Baker; *A. schizolepis*, Baker, in Journ. Bot. 1881, 368; non Journ. Linn. Soc. XV, 421. Madagascar, *Curtis*, 121. Like dwarf *conforme*.
- 2*. *A. caespitosum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 74. Andes of Ecuador, *Sodiro*. Near *A. tambillense*, Hook.
- 4*. *A. gramineum*, Jenm. in Journ. Bot. 1879, 263. Mountains of Jamaica. Near *A. simplex*, Sw.
- 4*. *A. Wawrae*, Luerss. in Flora, 1875, 420. Sandwich Islands. Near *A. simplex*, Sw.
- 7*. *A. Yoshingae*, Yatabe, in Bot. Mag. (Japan), V, 109, tab. 23. Japan.
- 7*. *A. inaequalifolium*, Jenm. in Journ. Bot. 1886, 273. Mountains of Jamaica, *Sherring*. Near *A. conforme*.
- 9*. *A. viridifolium*, Jenm. in Journ. Bot. 1886, 273. Mountains of Jamaica. Near *A. flaccidum*, Fée.
- 9*. *A. tenerum*, Baker, in Journ. Bot. 1878, 302. Paraguay, *Balansa*, 370.

- 9*. **A. Miersii**, Baker, sp. n. Rhizome short; paleae dense, lanceolate, brown, membranous, crisped. Stipe of sterile frond 1-4 in. long. Sterile frond lanceolate, acuminate, subcoriaceous, naked, 6-8 in. long, an inch broad at the middle, narrowed to the base and apex; edge horny; veins ascending, distinct, moderately close. Fertile blade lanceolate, an inch long. Rio Janeiro, *Miers*.
- 9*. **A. beccarianum**, Baker, in *Malesia*, III, 27. Sarawak, Borneo, *Beccari*. Near *A. flaccidum*.
9. **A. flaccidum** var. **stipitatum**, Baker, in *Journ. Bot.* 1887, 26. Costa Rica, *Cooper*.
- 10*. **A. macrorhizum**, Baker, sp. n. Rhizome thick, woody; paleae dense, lanceolate, acuminate, brown, membranous, crisped. Stipe of sterile frond 5-6 in. long. Sterile frond lanceolate, very thin, quite naked, 1½-2 ft. long, 1½-2 in. broad at the middle, narrowed to the base and apex, edge scariose, distinct. Veins distant, distinct. Fertile frond linear, under a foot long, under an inch broad. Rio Janeiro, *Miers*.
- 10*. **A. castaneum**, Baker, in *Journ. Bot.* 1877, 166. Andes of Ecuador, *Sodi*ro. New Granada, *Kalbreyer*.
- 11*. **A. borneense**, Burck, in *Ann. Jard. Bot. Buitenzorg*, IV, 98. Borneo, *Teuscher*. Not seen. Near *A. Norrisii* and *melanostictum*.
- 16*. **A. pallidum**, Baker, in *Journ. Bot.* 1879, 263. Mountains of Jamaica, *Jenman*.
- 19*. **A. maximum**, Baker, sp. n. Stipe stramineous. Sterile frond oblong-lanceolate, acute, subcoriaceous, glabrous, 1½ ft. long, 5-6 in. broad; veins indistinct, close, rather ascending, casually anastomosing. Fertile frond not seen. Andes of New Granada, *Paton*. Like *latifolium* on a large scale.
- 19*. **A. versatile**, *Sodi*ro, *Recens. Crypt. Vasc. Prov. Quit.* 76. Andes of Ecuador, *Sodi*ro. Near *A. latifolium*.
- 19*. **A. sessile**, Baker, in *Journ. Bot.* 1884, 143. North-east Madagascar, *Humboldt*, 568.
- 19*. **A. madagascariense**, Kuhn, in *Hildebr. Plant. Madag. Exsic.* No. 4167. Madagascar, *Hildebrandt*. Near *A. latifolium*.
21. **A. melanopus**, Kunze. I cannot distinguish specifically the Mexican **A. attenuatum**, *Fée*.

- 23*. **A. backhousianum**, Baker; *Elaphoglossum backhousianum*, Moore, in Gard. Chron. 1882, I, 672. Mexico, *Hort. Backhouse*. Near *A. Prestoni*, Baker.
- 25*. **A. stipitatum**, Bory; Fée, Acrost. 38, tab. 4, fig. 3. Bourbon, *Dr. Cordemoy*.
27. **A. squamipes**, Hook. Has now been found in Central Brazil by Glaziou.
- 27*. **A. borbonicum**, Baker, sp. n. Rhizome creeping, as thick as a quill; paleae linear, brown, membranous, under $\frac{1}{2}$ in. long. Stipe of sterile frond 1-1 $\frac{1}{2}$ in. long; blade oblong, obtuse, cuneate at the base, $\frac{1}{2}$ -1 in. long, dotted all over beneath with distant minute peltate paleae; veins lax, erecto-patent, simple or forked. Fertile frond not seen. Bourbon, *Dr. Balfour*. Near *A. squamipes*, Hook.
- 29*. **A. squarrosum**, Klotzsch. Has now been found in the Andes of Ecuador by Father Sodiro.
- 30*. **A. cochlearifolium**, Fée, Gen. Fil. 42, 43; Icon. Nouv. II, tab. 1, fig. 3. Mountains of Venezuela, *Fendler*, 495.
32. **A. Huacsaro**, Ruiz. Has now been found in the Mountains of Jamaica.
- 32*. **A. tenuiculum**, Baker; *Elaphoglossum tenuiculum*, Moore herb. Venezuela, *Fendler*, 222. Andes of Bolivia, *Rusby*, 299. Like dwarf *viscosum*.
- 33*. **A. gardnerianum**, Fée. Has now been found in the Andes of New Granada.
- 33*. **A. furfuraceum**, Baker, in Journ. Bot. 1877, 166. Andes of Ecuador, *Sodiro*. Near *A. gardnerianum*.
- 33*. **A. albescens**, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 75. Andes of Ecuador. Near *A. gardnerianum*.
- 33*. **A. Lastii**, Baker, sp. n. Basal paleae large, ovate-lanceolate, brown, membranous. Stipe of sterile frond 1 $\frac{1}{2}$ in. long, stiffly erect, scaly throughout. Frond linear-oblong, thick, coriaceous, 3 in. long, under an inch broad, clothed all over the lower surface with adpressed lanceolate brown paleae; veins immersed, obscure. Fertile frond not seen. Zanzibar, *Last*. Near *A. gardnerianum*.
36. **A. Aubertii** var. **crinitum**, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 294. Mount Roraima, *in Thurn*, 278.
- 36*. **A. achroalepis**, Baker, in Journ. Bot. 1880, 371. Madagascar,

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- between Tamatave and the capital, *Kitching*. Veining and stature of *A. Aubertii*; paleae different.
- 38*. **A. asterolepis**, Baker, in Journ. Bot. 1880, 371. Central Madagascar, *Kitching*. Near *A. Welwitschii* of Angola.
- 38*. **A. Salvini**, Baker, in Hemsl. Bot. Cent. Amer. III, 688. Guatemala, *Salvin*.
- 38*. **A. aspidiolepis**, Baker, in Journ. Bot. 1880, 371. Ankaratra Mountains, Central Madagascar, *Kitching*.
- 39*. **A. chartaceum**, Baker; Jenm. in Journ. Bot. 1882, 325. Mountains of Jamaica.
- 43*. **A. tricholepis**, Baker, in Journ. Bot. 1891, 5. North-west Madagascar, *Last*. Between *A. villosum* and *A. scolopendrifolium*.
- 43*. **A. papillosum**, Baker, in Journ. Bot. 1877, 167. Andes of Ecuador, *Sodi*ro.
- 43*. **A. Bakeri**, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 77. Andes of Ecuador, *Sodi*ro. Frond 2-3 ft. long, 5-6 in. broad; stipe as long as the frond.
- 43*. **A. heliconiaefolium**, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 78. Andes of Ecuador, *Sodi*ro. Sterile frond like a leaf of *Heliconia hirsuta*.
- 45*. **A. leptophlebium**, Baker, in Trans. Linn. Soc. ser. 2, Bot. II, 295. Mount Roraima, *in Thurn*, 237.
- 45*. **A. Sodiroi**, Baker, in Journ. Bot. 1877, 167. Andes of Ecuador, *Sodi*ro.
- 45*. **A. lepidoglossum**, Baker, sp. n. Rhizome slender, wide-trailing; basal paleae lanceolate, pale brown, large, membranous. Stipe of sterile frond nearly naked, 4-8 in. long. Sterile frond ovate, obtuse, $\frac{1}{2}$ foot long, 3 in. broad, deltoid at the base, green on both sides, thinly scaly on the surfaces, not fringed; veins close, distinct, ascending, mostly simple. Fertile frond lanceolate. Andes of New Granada, *Kalbre*yer, 994. Habit of *A. Lingua*, Raddi.
- 46*. **A. schizolepis**, Baker, in Journ. Linn. Soc. XV, 421. Central Madagascar, *Pool*. Near *A. spathulatum*, Bory.
- 48*. **A. Galvini**, Glaziou herb. Rhizome short-creeping; basal paleae dense, small, linear, castaneous. Stipes tufted, 1-2 in. long, densely paleaceous; paleae lanceolate, fimbriated. Sterile frond linear, 3-6 in. long, $\frac{1}{4}$ - $\frac{1}{3}$ in. broad at the middle, nar-

- rowed gradually to the base; upper surface slightly, lower densely paleaceous; paleae much fimbriated. Fertile frond similar but smaller. South Brazil, *Glaziou*, 9304. Habit of large forms of *A. spathulatum*; paleae different.
- 50*. *A. araneosum*, Eaton, in Proc. Amer. Acad. XXII, 461. North Mexico, *Palmer*, 333.
51. *A. succisaefolium*, Thouars. Has been found by Delisle in the Antarctic Amsterdam Island. We had it before only from Tristan d'Acunha.
- 51*. *A. Poolii*, Baker, sp. n. Rootstock erect. Stipes densely tufted, 1-1½ in. long, densely clothed with imbricated bright red-brown ovate aliated membranous paleae. Sterile frond ovate-oblong, ¾-1 in. long, 4-6 in. broad, densely clothed beneath, less densely above, with ovate densely ciliated, imbricated obtuse paleae. Fertile frond not seen. Central Madagascar, *Pool*.
- 52*. *A. Eggersii*, Baker, in Journ. Bot. 1888, 34. San Domingo, alt. 8000-9000 ft., *Baron Eggers*, 2201.
- 52*. *A. Eatonii*, E. G. Britton. Quichara, *Pearce*. Andes of Bolivia, *Rusby*, 342. Habit of *Niphobolus*, with long rigid linear fronds with a reflexed margin, clothed beneath with thick ferruginous woolly pubescence.
- 53*. *A. boragineum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 80. Andes of Ecuador, *Sodiro*.
55. *A. villosum*, Sw. I cannot separate specifically *A. siliquoides*, Jenm. in Journ. Bot. 1881, 53.
- 55*. *A. quitense*, Baker, sp. n. *A. samoense*, Sodiro herb., non Baker. Stipes densely tufted, 1-6 in. long, densely clothed with spreading hair-like brown paleae. Sterile frond firm, lanceolate, 6-8 in. long, ¾-1 in. broad, more or less densely clothed with bristle-like brown palae. Veins immersed, obscure. Fertile frond smaller, with a very long stipe. Andes of Ecuador, *Sodiro*.
- 55*. *A. Haynaldii*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 80. Andes of Ecuador, *Sodiro*. Near *A. villosum*.
- 58*. *A. fimbriatum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 84. Andes of Ecuador, *Sodiro*. Very distinct. Rhizome wide-creeping. Stipe long. Fronds small, lanceolate, with a dense fringe of ovate brown paleae.

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- 58*. *A. argyrophyllum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 85. Andes of Quito, *Sodiro*. Habit of *A. latifolium*; under surface dotted over with minute paleae; edge minutely fringed.
- 58*. *A. trivittatum*, Sodiro, Recens. Crypt. Vasc. Prov. Quit. 82. Andes of Ecuador, *Sodiro*. Near *A. muscosum*, Sw.
- 64*. *A. magnum*, Baker, in Gard. Chron. n. s. XX, 135. Demerara; banks of the Mazaruni River, *Jenman*, 769. Allied to *A. per-elegans* and *A. Sprucei*.

Subgenus *Stenochlaena*.

66. *A. sorbifolium*, L. Has lately been found in New Guinea. *Gymnogramme?* *subtrifoliata*, Hook. is an abnormal form.

Subgenus *Polybotrya*.

- 71*. *A. stenosemioides*, Baker, in Journ. Linn. Soc. XXII, 230. Malang, Sarawak, alt. 2000 ft., *Bishop Hose*.
- 82*. *A. botryoides*, Baker, in Journ. Bot. 1881, 206. New Granada; province of Antioquia, *Kalbreyer*, 1873. Fertile frond of *A. canaliculatum*; sterile much more compound.

Subgenus *Aconiopteris*.

- 89*. *A. savaiense*, Baker, sp. n. Rhizome creeping, $\frac{1}{4}$ in. diam.; paleae lanceolate, brown, membranous, $\frac{1}{8}$ in. long. Stipe of sterile frond 4–5 in. long. Sterile frond oblanceolate, naked, rigidly coriaceous, 9–10 in. long, 3 in. broad at the middle, narrowed to the base; veins $\frac{1}{2}$ line apart, anastomosing by a distinct intramarginal line. Fertile frond narrower, with a longer stipe. Samoa, *Powell*. Near *A. gorgoneum*, Kaulf.

Subgenus *Stenosemia*.

- 91*. *A. teysmannianum*, Baker, in Malesia, III, 56. Island of Sumba, Timor, *Teymann* (Herb. Beccari).

Subgenus *Gymnopteris*.

- 93*. *A. oligodictyon*, Baker, in Journ. Linn. Soc. XXIV, 261. Sarawak, Borneo, *Bishop Hose*, 210. Near *A. linneanum*, Hook.

- 95*. *A. Listeri*, Baker, in Journ. Linn. Soc. XXV, 361. Christmas Island, *J. J. Lister*. Near *A. variabile*, Hook.
- 99*. *A. Hollrungii*, Baker; *Gymnopteris Hollrungii*, Kuhn, in Schum. et Hollrung, Flora Kais. Wilh. land, 8. Northern New Guinea, *Hollrung*, 640. Near *A. taccaefolium*, Hook.
100. *A. flagelliferum*, Wall. Has now been found in Borneo, Sumatra, Solomon Isles, and New Guinea.
- 100*. *A. neglectum*, Bailey, Synops. Queensl. Flora, 222; Baker, in Hook. Ic. t. 1689. Queensland; gullies of Trinity Bay Ranges, *Bailey*. Near *A. virens*, Wall.
- 101*. *A. Taylori*, Bailey, Synops. Queensl. Flora, Suppl. 65. Queensland; banks of Johnstone River, *Bailey*. Very near *A. repandum*. Not seen.
- 101*. *A. Fendleri*, Baker, in Jenm. Journ. Bot. 1887, 100. Trinidad, *Fendler*, 88. Habit of *Meniscium reticulatum*.
- 105*. *A. Hartii*, Baker, sp. n. Rhizome wide-creeping; basal paleae lanceolate, membranous, pale brown. Stipe of sterile frond above a foot long, pale brown, naked. Sterile frond oblong-lanceolate, simply pinnate, moderately firm, glabrous, 1½–2 ft. or more long. Pinnae lanceolate, sessile or nearly sessile, 4–6 in. long, 1¼–2 in. broad, narrowed gradually to the point, entire or shallowly lobed. Veins in pinnate groups, as in *Eunephrodium*; veinlets 4–5-jugate; lower joining by their tips. Fertile frond bipinnate, distinct or ending the sterile frond; fertile segments torulose, at most—½ in. long. Trinidad, *Hart*, 228.
- 105*. *A. juglandifolium*, Baker, in Journ. Bot. 1881, 207; Hook. Ic. t. 1691. New Granada; province of Antioquia, *Kalbreyer*, 1798.
- 105*. *A. polybotryoides*, Baker, in Journ. Bot. 1881, 207; Hook. Ic. t. 1690. New Granada; Ocana, *Kalbreyer*, 1254.
- 105*. *A. suberectum*, Baker, in Journ. Bot. 1881, 207; Hook. Ic. t. 1692. New Granada; Antioquia, *Kalbreyer*, 1877.
- 105*. *A. insigne*, Baker, in Journ. Bot. 1877, 167. Andes of Ecuador, *Sodirol*. The last four are all nearly allied.
- 106*. *A. Preslianum*, Hook. Has now been found at Fernando Po by Henderson.
- 107*. *A. exsculptum*, Baker, in Journ. Bot. 1888, 326. Sarawak, Borneo, *Bishop Hose*, 244. Near *A. virens*, Wall.

Subgenus **Chrysodium**.

- 108*. **A. modestum**, Baker, in Journ. Linn. Soc. XXII, 231. Sarawak, West Borneo, *Bishop Hose*, 159. Near *A. Wallii*, Baker, of Ceylon.
- 108*. **A. phanerodictyon**, Baker, in Henriq. Cat. Pl. St. Thom. 32, tab. 4, fig. C. Island of St. Thomas, West Tropical Africa, *Moller*. Near *A. minus* and *lanceolatum*.
- 109*. **A. Rawsoni**, Baker, sp. n. Rootstock erect; basal paleae small, dense, linear, dark brown, crisped. Stipe of sterile frond 6–7 in. long, fragile, naked, pale brown. Sterile frond simple, lanceolate, membranous, glabrous, 6–8 in. long, 1–1¼ in. broad, rounded to a cuneate base. Areolae copious, without free included veinlets. Stipe of fertile frond ½ ft. long; blade linear, 6–7 in. long, ⅛–⅞ in. broad, with enrolled edges. Grand River, Mauritius, *Sir Rawson Rawson*, gathered in 1853. Habit of *A. lanceolatum*; veining different.
- 110*. **A. antrophyoides**, Baker, in Journ. Linn. Soc. XXII, 231. Malang, Sarawak, *Bishop Hose*, 162.
- 111*. **A. gillianum**, Baker, in Journ. Bot. 1882, 310; Hook, Ic. t. 1693, Brazil; province of Minas Geraes, *Glaziou*, 13341.
115. **A. bicuspe**, Hook. Has now been found in New Guinea.
118. **A. pandurifolium**, Hook. Has been found by Father Sodiro in the Andes of Ecuador.
- 122*. **A. Humblotii**, Baker, in Journ. Bot. 1884, 144. North East Madagascar, *Humblot*, 300. Near *A. blumeanum*, Hook.

Subgenus **Hymenolepis**.

129. **A. spicatum**, Linn. A very curious *Hymenolepis* has been sent by Sir F. von Mueller from the New Hebrides. It shows no structural difference from this species, but the leafy part of the frond is only 2–3 in. long and the apical fertile ¼–½ in., resembling the spike of *Eleocharis palustris*.

Subgenus **Photinopteris**.

- 132*. **A. Thomsoni**, Baker, in Journ. Linn. Soc. XV, 111. Admiralty Isles, *Moseley* (Challenger expedition).

Genus 61. **PLATYCERIUM**, *Desv.*

- 1*. **P. andinum**, Baker, n. sp. Habit of *P. alciorne*, but the sterile frond much larger, 2–3 ft. long, and the fertile frond 6–10 ft.

long, with the soriferous patches placed at the base of the long strap-shaped final segments. East Peru, *Spruce*, 4729. Paquichas, *Pearce*, 786.

2. **P. aethiopicum**, Hook. *P. elephantotis*, Schweinf. in Bot. Zeit. 1871, 361, is identical with *P. angolense*, Welw. I cannot distinguish specifically a plant from Guiana of which Messrs. Sander and Co. of St. Albans have sent several specimens lately to Kew.
- 2*. **P. Ellisii**, Baker, in Journ. Linn. Soc. XV, 421; Hook. Ic. t. 1695. Madagascar, first gathered by the Rev. W. Ellis in 1870.
- 2*. **P. madagascariense**, Baker, in Journ. Linn. Soc. XV, 421. Madagascar, first gathered by Mr. W. Pool in 1876.

OSMUNDACEAE.

Genus 62. OSMUNDA, *Linn.*

6. **O. regalis**, L. var. **O. japonica**, Thunb. Has been gathered in Angola by Mr. H. H. Johnston.

Genus 63. TODEA, *Willd.*

2. **T. wilkesiana**, Brack. Has now been found in New Guinea and Samoa.
3. **T. hymenophylloides**, R. & L. **T. grandipinnula**, Moore, in Gard. Chron. 1886, I, 752, is probably a form of this species.

SCHIZAEACEAE.¹

Genus 64. SCHIZAEA, *Smith.*

2. **S. pusilla**, Pursh. Has been found in Nova Scotia by Mrs. Britton.
15. **S. pennula**, Sw. **S. plana**, **S. tenuis**, and **S. Balansae**, characterised by Fournier in Ann. Sc. Nat. sér. 5, XVIII, 353, all three gathered by Balansa, are to be compared with this species. I have not seen specimens.

¹ See Prantl's Untersuch. z. Morph d. Gefässkryptogamen, Heft II, Die Schizaeaceen, Leipzig, 1881, 410, pp. 161, 8 plates. In this paper 22 species of *Lygodium*, 46 of *Ancimia*, and 19 of *Schizaea*, are kept up.

Genus 65. ANEMIA, Sw.

3. *A. oblongifolia*, Sw. var. *lanosa*, Baker, in Journ. Bot. 1885, 217, and var. *microphylla*, Baker, loc. cit. 218, are varieties of this species gathered in Central Brazil by Glaziou.
21. *A. Phyllitidis*, Sw. Mr. Carruthers tells me that the type specimen of *A. hirsuta*, Sw. in the herbarium of the British Museum ranges here.
22. *A. aurita*, Sw. Has now been found in Porto Rico.

Genus 66. MOHRIA, Sw.

1. *M. thurifraga*, Desv. Has now been found in Angola, the Zambesi highlands, and on Mount Kilimanjaro.
2. *M. vestita*, Baker, in Hook. Ic. t. 1696. Mount Kilimanjaro, in crevices of rocks at 6000 feet, *H. H. Johnston*.
3. *M. lepigera*, Baker; *Notochlaena lepigera*, Baker, in Journ. Bot. 1884, 53. Mount Dzomba, Zambesia, alt. 6000-7000 ft., *Sir John Kirk*.

Genus 68. LYGODIUM, Sw.

- 5*. *L. hians*, Fourn. in Ann. Sc. Nat. sér. 5, XVIII, 355. New Caledonia, *Balansa*, 1564, 2737, *Veillard*, 2606. Near *L. articulatum*, A. Rich. of New Zealand.
- 7*. *L. gracile*, Baker, in Journ. Bot. 1888, 35. San Domingo, *Baron Eggers*, 2536.
11. *L. polystachyum*, Wall. Has lately been found in Anam by Dr. Kuntze.
12. *L. subalatum*, Bojer=*L. Kerstenii*, Kuhn. The latter name having a short priority in publication.

Prantl transfers the name of *L. pinnatifidum*, Sw. to *L. polystachyum*, Wall., on the ground that it was Willdenow's *Hydroglossum pinnatifidum*, in part.: he divides *L. pinnatifidum* of our Synopsis into two species, calling the Asiatic plant *L. salicifolium*, Presl, and the African *L. smithianum*, Presl.

MARATTIACEAE.

Genus 71. DANAEA, Sm.

- 5*. *D. serrulata*, Baker, in Journ. Bot. 1881, 208. Hook. Ic. t. 1699. Antioquia, New Granada, *Kalbreyer*, 1352.

8. *D. moritziana*, Presl. Has lately been found in Jamaica and Costa Rica.
- 11*. *D. polymorpha*, Leprieur. Stipe long, 1-jointed. Sterile frond oblong, a foot long; rachis not winged; pinnae 7-9, petioled, oblong-cuspidate, the end one the largest, 5-7 in. long, 2-2½ in. broad; veins distinct, erecto-patent. Fertile frond with a jointed stipe 1½ ft. long and 9-11 narrower pinnae. Guadeloupe, *Mazé*; Grenada, *Sherring*. Perhaps a mere variety of *D. elliptica*. *D. oligosora*, Fourn., also gathered by Fournier in Guadeloupe, has about the same number of pinnae as *D. polymorpha*, but they are only 1¼-1½ in. broad, and narrowed more suddenly at the base.

OPHIOGLOSSACEAE.

Genus 73. OPHIOGLOSSUM, *Linn.*

The genus is monographed very carefully by Prantl, in Jahrb. Bot. Gart. Berlin, III, 297, tabs. 7-8. He admits 29 species, dividing into several our *O. lusitanicum*, *nudicaule*, and *vulgatum*, on characters furnished by the rootstock and the venation of the barren frond.

- 1*. *O. minimum*, Armstr. in Trans. New Zeal. Instit. 1880, 342. New Zealand. I have not seen a type-specimen, but suppose it to be identical with *O. coriaceum*, A. Cunn., which is kept up as a species by Prantl.
- 5*. *O. costatum*, R. Br. Prodr. 163, should clearly be kept up as a primary species. It is spread from North Australia to West Africa and under it range *O. brevipes*, Beddome, *O. Wightii*, Hook. et Grev., *O. aphrodisiacum*, Welw., and *O. fibrosum*, Schum. et Thonn.
7. *O. intermedium*, Hook. Further material shows this a mere form of *O. pendulum*.
9. *O. palmatum*, L. Has now been found in Florida and Madagascar.

Genus 74. HELMINTHOSTACHYS, *Kaulf.*

1. *H. zeylanica*, Hook. Has now been found in the Solomon Islands and New Guinea.

Genus 75. BOTRYCHIUM, Sw.

Monographed by Prantl along with *Ophioglossum*, as above cited.
He admits 15 species out of substantially the same materials
as our six.

3. **B. Lunaria**, Sw. Has now been found in New Zealand and the Northern United States.
4. **B. ternatum**, Sw. The New Zealand **B. biforme**, Colenso, in *Trans. New Zeal. Instit.* 1885, 223, exactly matches the North American *B. dissectum*, Muhl.

New Solomon Islands Plants.

BY

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—♦—
With Plate XXVII.
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THE Solomon Islands are situated in the tropics, between the Admiralty Islands and the New Hebrides, and extend over an area of 600 miles in length, trending from north-west to south-east. Several of the larger islands are from 50 to 100 miles in length, and 15 to 30 miles in breadth; and, speaking generally, are of volcanic origin and mountainous in character, the mountains rising to an altitude of 8000 feet in Guadalcanar, in the south, and to an altitude of 10,000 feet in Bougainville, in the north. On the other hand many of the small islands are entirely of coral limestone.

Many expeditions have visited the Solomon Islands, including D'Urville in 1838, and Denham (H.M.S. Herald) in 1853, and there are many allusions to the vegetation in the writings of various travellers; but even now the botany is very imperfectly known. William Milne, who was attached to the 'Herald' in the capacity of botanical collector for Kew, collected about 200 plants on the islands of San Christoval and Guadalcanar, but they were mostly common things from the coast region. A more representative collection of dried plants made in the north-western part of the group by Dr. H. B. Guppy was presented to Kew in 1885, and a rough list of them appeared in his narrative of his investigations in the islands. Unfortunately, however, Dr. Guppy had had no

previous experience in selecting specimens of plants, and many unmistakable novelties were insufficient for description. This collection came chiefly from Shortland, Treasury, and Faro, small islands in Bougainville Straits. Last year the Rev. R. B. Comins brought home a small though interesting collection from San Christoval, which is situated in the extreme south-east of the group. Here again the specimens are often inadequate for satisfactory description, consequently we must await further material. Happily there is a chance of obtaining this, as Mr. Comins has returned to the islands with a better idea of what is required for botanical purposes.

Notwithstanding the incompleteness of the collections of plants hitherto made in the islands they are sufficient to enable us to judge of the general character of the flora, and to understand its affinities. Of the aspects and striking features of the flora much may be learnt from Dr. Guppy's book referred to above, and from the writings of Mr. C. M. Woodford¹.

There are two specially noteworthy features in the composition of the flora, namely, the presence of distinct endemic generic types, associated with rare Malayan and Polynesian types, as distinguished from the shore plants of very wide or general distribution in the tropics. The almost total absence of Australian types in the collections is more remarkable, though we must not assume that they are actually so rare as would appear. Even the widely dispersed and conspicuous *Metrosideros polymorpha* is not among the plants collected. Indeed, with the exception of an undetermined species of *Grevillea*, and *Dendrobium hispidum*, there is nothing to indicate any connection. On the other hand the presence of *Riedelia curviflora* and *Lepinia taitensis*, point to a flora of considerable age and wider area. The former has hitherto only been collected in the island of Buru, some 35 degrees west of the Solomon Islands, and the latter only in Tahiti, about 50 degrees to the east. *Lepinia* is a most singular member of the Apocynaceae, described and figured by Decaisne² in 1849.

¹ See Proceedings of the Royal Geographical Society, 1890, f. 393.

² Annales des Sciences Naturelles, 3^me série, xii. p. 160. t. 9.

The peculiarity is in the fruit. In the flowering stage the four-celled ovary appears undivided, but soon after the fall of the corolla the carpels separate, except at the tips, and develop slender, almost filiform stalks, about six inches long, curving outwards and forming a kind of depressed pyriform framework. The seed-bearing portions of the carpels are terete, almost horizontal, and joined together by their tips, forming a cross, the arms of which are about an inch and a half long and a quarter of an inch in diameter. Each carpel contains one fluted seed.

This highly curious tree was collected by Mr. Comins in San Christoval. He describes it as about fifteen feet high, and growing by a river-side. In Tahiti it is said to grow on the mountains, and attain a height of eight to ten metres. It must be very rare, one would imagine, in Tahiti, or some of the many English travellers who have botanized there would have collected such a very remarkable thing.

Noteworthy among the novelties of which the specimens are insufficient for description, are a species of *Drimys*, a *Sterculia*, an apparently new genus of Rutaceae-Todalieae, several species of *Canarium* besides the one described below, several Olacineae, Sapindaceae, Myrtaceae and Melastomaceae, a species of the New Caledonia araliaceous genus *Delarbrea*, several Sapotaceae one having very large seeds, a *Cyrtandra* or allied new genus, about half a dozen species of *Ficus*, as many Pandani, Palmae, Aroideae, Orchideae, and Scitamineae. A new genus of Pandanaceae, discovered by Dr. Guppy in Faro Island, is specially interesting. It is a tree fifty feet high, having long narrow leaves and branching female spadices three or four feet long. The male inflorescence is unknown, and the specimen consists of a leaf and detached female flowers. Dr. Guppy also collected one new species of *Myrmecodia* and two of *Hydnophytum*, whose thick, short, tuberous, galleried stems are inhabited by ants.

The discovery of *Pueraria Thunbergiana* in San Christoval by Mr. Comins is an interesting geographical fact. This plant is very common in China and Japan, where it is also culti-

vated, and the fibre it yields is made into a kind of cloth. There is a specimen of it from Buru in the Kew Herbarium, but with this exception I have seen neither specimens nor record of specimens between South China and the Solomon Islands.

Taken as a whole, at least as represented by the small collections, the flora of the Solomon Islands is decidedly Fijian in character.

The following are some of the more interesting plants of which the material is sufficient for description.

Canarium sapidum, Hemsl. n. sp.

Arbor 80-100 pedalis, novellis omnino glabris, ramulis floriferis crassis. *Folia* imparipinnata, nunc parva, 5-foliolata (ramulorum floriferorum), nunc ampla, multifoliolata (ramulorum sterilium), distincte petiolata, petiolo tereti leviter sulcato vel striato; foliola longe petiolulata, petiolulis tenuiter striatis apice incrassatis, vix coriacea, oblonga vel oblongo-lanceolata, rarius ovata, 4-15 poll. longa, abrupte acuminata, interdum caudato-acuminata, basi plus minusve obliqua, undique glaberrima, venis primariis lateralibus numerosis conspicuis prope marginem inter se anastomosantibus et cum venis secundariis subparallelis conjunctis, venulis ultimis sat conspicue reticulatis. *Flores* trimeri, coriacei, circiter 3 lineas longi, racemosi, pedicellis flores æquantibus, racemis axillaribus vel extra-axillaribus glabris vix bipollicaribus. Calyx puberulus, crassus, cupularis, glaber, lobis brevibus deltoideis obtusis; petala 3, crassa, oblongo-ovata, obtusa, basi lata, apice truncata, extus supra medium dense tomentosa; stamina 6, libera, summo disci inserta; ovarium glabrum, 3-loculare, stigmata trilobulato-capitato fere sessili: fructus oblongo-ovoideus circiter bipollicaris, glaber, nitidus, exocarpio carnosus, endocarpio lignoso durissimo.

Treasury Island and Oima-atoll, Dr. Guppy; San Christoval, Rev. R. B. Comins.

Fruit much eaten by pigeons, and the seed eaten and much prized by the natives.

Linociera sessiliflora, Hemsl. n. sp.

Arbor grandis, ramulis floriferis glabris fulvis, internodiis quam folia multo brevioribus. *Folia* brevissime petiolata, subcoriacea, undique glabra, ovato-oblonga, circiter semipedalia, obtuse caudato-acu-

minata, basi cuneata, venis primariis lateralibus utrinque 8-10 sat conspicuis, venis secundariis immersis obsoletis. *Flores* lutei, sessiles, densissime fasciculati, fasciculis circiter 6-floris axillaribus sessilibus, bracteis latis crassis imbricatis persistentibus suffultis; calycis hirsuti lati lobi fere rotundati; petala fere libera, 4-6 lineas longa, angusta, basi dilatata, longitudinaliter involuta; antheræ sessiles; ovarium glabrum.

San Christoval, Rev. R. B. Comins.

Very distinct in the dense axillary sessile fascicles of sessile flowers.

Anodendron oblongifolium, Hemsl. n. sp.

Frutex supra arbores alte scandens, ramulis floriferis glabris graciliusculis ut videtur subcompressis. *Folia* distincte petiolata, tenuia sed vix membranacea, glabra, oblonga, 5-7 poll. longa, abrupte obtuseque acuminata, basi rotundata, subtus pallidiora, venis primariis lateralibus utrinque circiter 10 eleganter arcuatim divergentibus sed vix inter se anastomosantibus. *Flores* pallide lutei (ex Comins) breves, vix semipoll. diametro, cymoso-paniculati, paniculis pedunculatis angustis densiusculis quam folia brevioribus, pedicellis brevissimis; calycis segmenta vix ultra lineam longa, erecta, ovato-oblonga, obtusa, versus margines tenuissima albida, ciliolata; corollæ hypocraterimorphi tubus calycem non excedens, lobis longioribus oblique oblongis obtusis æstivatio dextrorsim obtegentibus sinistrorsim tortis; stamina inclusa, antheris sessilibus brevissime caudatis: folliculi virides (ex Guppy), divaricati, clavati, semipedales, obtusi, glabri, nudi, demum subcrustacei; semina ovalia, compressa, fere plana, rostrata, longe comosa, cum coma ultra tripollicaria, coma ampla fulva sericea.

Faro Island, Dr. Guppy, in fruit; San Christoval, Rev. R. B. Comins in flower and fruit.

Furnishes an excellent fibre, used by the natives for making fishing lines, nets, etc., in both localities from which we have specimens.

Hoya (§ *Euhoya*) *Cominsii*, Hemsl. n. sp.

Species ex affinitate *H. parasiticæ* et *H. samoensis*, sed petalis, saltem in siccis, multo tenuioribus patentibus, etc.

Folia carnosa, glabra, late ovata, cum petiolo crasso usque 5 poll. longa, obtusa vel subacuta, palmatim 5-7 nervia. *Pedunculi* crassi, diu perennantes, demum usque ad bipollicares (forsan interdum

longiores), floribus numerosis quotannis ad apicem pedunculi confertissimis, pedicellis gracilibus (an vivis?), 6-12 lin. longis. *Flores* cremei (fide Comins) circiter semipoll. diametro; calycis minuti segmenta ovato-oblonga, obtusissima; corollæ rotatæ lobi obscure puberuli vel pulverulenti, late ovati, vix acuti; coronæ squamæ amplæ, ovoideæ, compressæ, subinflatæ, apice emarginatæ. *Folliculi* ignoti.

San Christoval, Rev. R. B. Comins.

The substance of the flowers may have been much reduced by immersion in boiling water before drying; but the corolla appears much less fleshy and the coronal scales much less crustaceous than in the allied species.

Dischidia Milnei, Hemsl. n. sp.

Folia carnosula, sessilia, reniformi-rotundata, 1-1¼ poll. diametro, glaberrima, venis immersis inconspicuis. *Pedunculi* crassi, folia vix æquantes, 2-cymosi, pedicellis confertissimis quam flores brevioribus. *Flores* cremei (fide Comins) 1½-2 lineas longi; calycis lobi breves rotundati tenues glabri, corollæ carnosæ subcampanulatæ, lobi erecti, obtusissimi, intus barbati. *Fructus* ignotus.

Solomon Islands, without locality, Milne; San Christoval, Rev. R. B. Comins.

Myristica faroensis, Hemsl. n. sp.

Arbor 15-pedalis (fide Guppy), ramulis fructiferis, crassiusculis, rigidis, rectis, glabris, cinereis. *Folia* petiolata, coriacea, utrinque glabra, oblonga vel ovato-oblonga, 6-9 poll. longa, 2½-4 poll. lata, obtusissima, basi obscure cordata, subtus pallidiora, subglauca, venis primariis lateralibus utrinque 12-15 subtus sat conspicuis, petiolo circiter semipollicari. *Flores* ignoti. *Capsulæ* cymosæ 3-6 aggregatæ, distincte pedicellatæ, oblongæ, 1-1¼ poll. longæ, breviter stipitatæ, acuminatæ, fulvæ, demum bivalvæ, pedunculo circiter pollicari; semen oblongum, circiter 9 lineas longum, arillo coccineo tenuiter lacerato omnino involutum, testa crustacea, albumine concolori luteo.

Faro, Solomon Islands, Dr. H. B. Guppy.

There are two other apparently undescribed species of *Myristica* in the collections, but the material is hardly sufficient for description.

Grammatophyllum Cominsii, Rolfe, n. sp.

Folia linearia, acuta, 22 poll. longa, ¾ poll. lata. *Pedicelli* 3½ poll. longi. *Sepala* obovato-elliptica, obtusa, undulata, 1½ poll. longa. *Petala* subor-

biculari-obovata, $1\frac{1}{2}$ poll. longa, 13-14 lin. lata: *labellum* recurvum, trilobum, $\frac{3}{4}$ poll. longum; lobi laterales triangulari-oblongi, obtusi, basi semi-cordati, lobus medius oblongus, obtusus, 4 lin. longus, $2\frac{1}{2}$ lin. latus; discus pubescens venis incrassatis, lamellis ternis brevibus erectis subadpressis in medio. *Columna* incurva, 5 poll. longa.

San Christoval, Rev. R. B. Comins, 57. Flowers with 'dark brown spots on light yellow ground.'

Allied to *G. speciosum*, Blume, but readily distinguished by its smaller flowers, with more slender, shorter pedicels, and other differences. The spots on the segments are very numerous, and range from half a line to nearly a line in diameter.

Dendrobium tigrinum, Rolfe, n. sp.

Folia oblanceolato-oblonga, obtusa, basi attenuata, 8 poll. longa, $1\frac{1}{2}$ poll. lata. *Flores* magni, insignes. *Pedicelli* $2\frac{1}{2}$ poll. longi. *Sepala* petalaeque infra medio undulatissima, supra attenuato-acuminata: sepalum posticum $1\frac{1}{4}$ poll. longum, basi ovatum, 6 lin. latum; lateralia paullo longiora, basi 8-9 lin. lata. *Petala* 2 lin. longa, basi 4 lin. lata: *labellum* trilobum, $1\frac{3}{4}$ poll. longum; lobi laterales obliqui, late semiovato-rotundati, 6 lin. longi; lobus medius ovato-lanceolatus, acuminatus, apice recurvus, $1\frac{1}{2}$ poll. longus; callus erectus, lamellatus, carnosus, crenulatus. *Columna* brevissima; mentum 5-6 lin. longum, rotundatum.

San Christoval, Rev. R. B. Comins, 187. 'Flowers white and purple.'

A remarkable and very distinct species, belonging to the section *Stachyobium Speciosæ*, allied to *D. atrovioleum*, Rolfe, but with all the segments considerably elongated, and the sepals and petals very undulate in their basal half, where they are also spotted and somewhat veined with dark purple. All the nerves of the lip are dark purple, the ground colour, as of the rest of the flower, being white.

COMINSIA, Hemsl. Marantearum novum genus, proxime *Phrynium*. *Sepala* 3, angusta, obtusa. *Corollæ* tubus quam sepala fere dimidio longior, angustissimus, lobi 3, angusti, oblongi, obtusissimi, æquales, patentés vel recurvi. *Androecii* tubus breviter exsertus, limbus 5-merus; staminodiis 2 exterioribus lanceolatis acutis cæteros excurrentibus, et quorum 1 cum labello et stamino fertili alternanti altero cum stamino fertili et staminodio interiore lato 1-auriculato alternanti; labello lato brevi laminato-cristato. *Ovarium* 3-loculare, 3-ovulatum, extus basi barbatum; stylus incurvus, stigmatibus bilamellatis.

Fructus triangulato-oblongus, loculicide trivalvis, pericarpio cartilagineo. *Semina* 3, oblique-oblonga, subquadrata, testa crustaceo-suberosa, grosse rugosa, hilo discoideo, arillo annulato angustissimo; embryone magno leviter curvato, excentrico, cum vacuo verticali subparallelo.

Cominsia Guppyi, Hemsl. n. sp.

Herba perennis, erecta, undique glabra, caudicibus petiolo vaginanti cum axi inflorescentiæ, floriferis monophyllis absque folii lamina 6–8 pedibus inflorescentia simplici sesquipedali recurva supra medium vaginæ pendula. *Folia* absque petiolo 2–5 pedalia et circiter 9 poll. lata, membranacea, oblonga, breviter acuminata, venis primariis lateralibus majus conspicuis cum venis circiter 8 unius conspicuis alternantibus. *Flores* albi vel straminei, fasciculati, sessiles, circiter 6, intra bracteas angustas complicatas spathiformes 2–2½ poll. longas distichas aggregati, singulatim evoluti, perianthii limbo cum genitalibus tantum ex apice bracteæ exserto.

Faro, Dr. H. B. Guppy; San Christoval, Rev. R. B. Comins.

The nearest affinity of this remarkable plant is with the section *Spicata* of the genus *Phrynium*, differing in the elongated, pendulous, distichous inflorescence; the very much elongated corolla-tube; the remarkably rugose seed; and the decidedly dehiscent fruit.

DESCRIPTION OF THE FIGURES IN PLATE XXVII.

Illustrating Mr. Hemsley's paper on New Solomon Islands Plants.

Portion of leaf and portion of inflorescence of *Cominsia Guppyi*, Hemsl., natural size.

Fig. 1. Terminal cluster of flowers, with the bract set back to show the flowers and bracteoles.

Fig. 2. Ovary and base of perianth.

Fig. 3. Upper part of the tube and the limb of the androecial series, consisting of lip and four dissimilar unsymmetrically arranged lobes, two of which have been removed nearly to the base. Of the other two, the one on the right is antheriferous, and the one numbered 4 is auricled on the other side.

Fig. 4. Part of auricled lobe of androecium, seen from the outside.

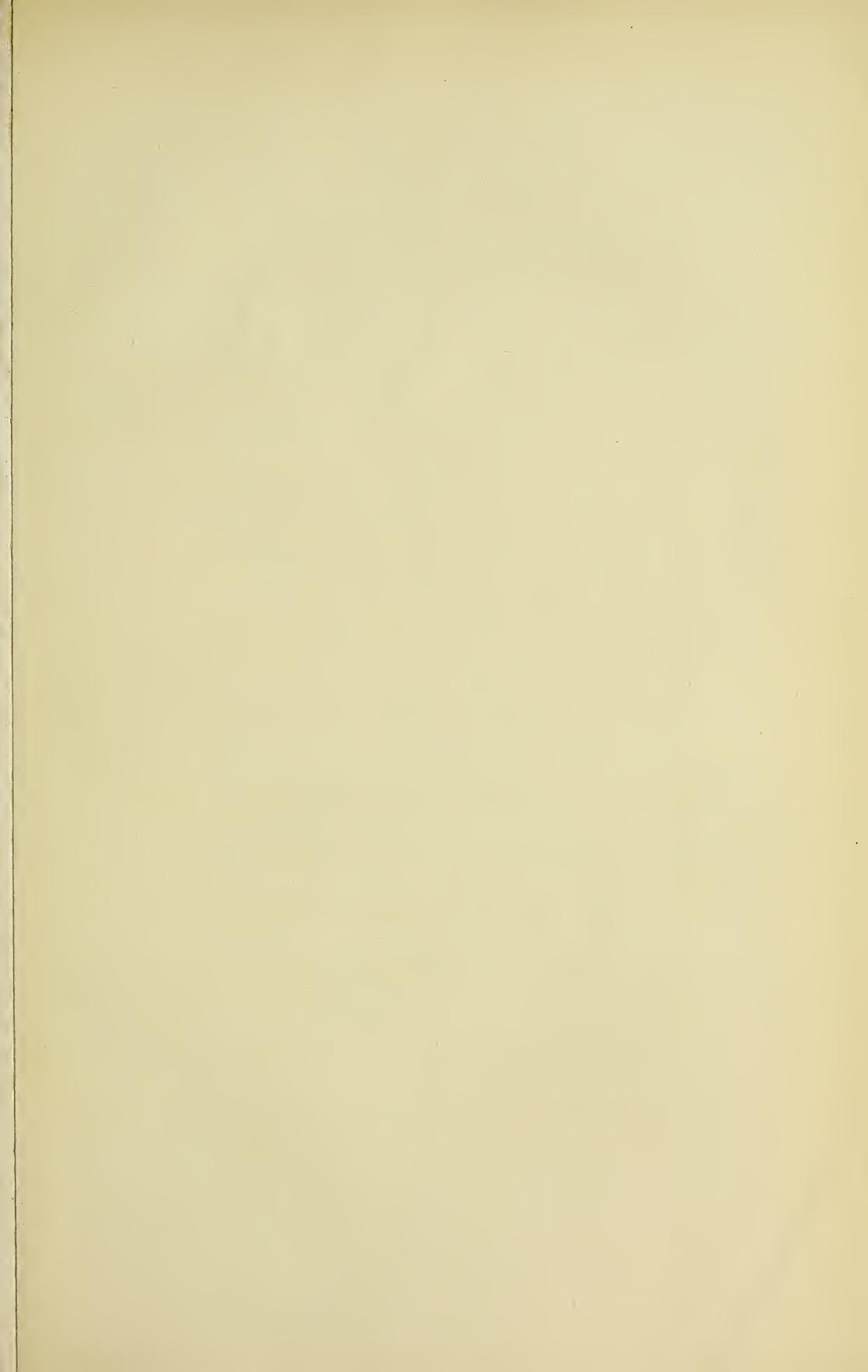
Fig. 5. Antheriferous lobe, seen from the inside.

Fig. 6. Portion of style, with recurved stigma.

Fig. 7. Capsule from which one valve has been removed.

Fig. 8. Section of seed, showing embryo and cavity in albumen.

All more or less enlarged.





M. Smith del.



University Press, Oxford.



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COMINSIA GUPPYI, Hemsl.

NOTES.

A NEW GENUS OF TUBERCULARIEAE.—*Hobsonia*, Berk., in herb. Sporodochia verruciformia, superficialia; conidia muco initio immersa, cylindracea, hyalina, in tubum spiralter laxe convoluta, pluriarticulata.

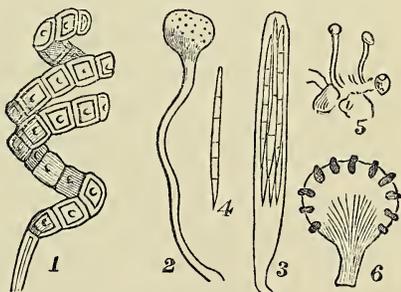
The present genus was never described by Berkeley, but with the above MS. name located in his herbarium amongst the Tremellini, with which it agrees superficially in the subgelatinous consistency when moist, becoming cartilaginous when dry. The genus, however, belongs to the Hyphomycetes, Fam. Tubercularieae, Sect. Helicosporae, and is distinguished by the multiseptate conidia being arranged in a lax spiral forming a cylindrical or conical body. Of the two genera previously included in the section, *Everhartia* has the conidia multiseptate and spirally wound in one plane, whereas in *Troposporium* the conidia are aseptate and compactly spirally wound, forming a cylindrical or fusiform body.

Named by the late Rev. M. J. Berkeley in honour of Colonel Hobson.

Hobsonia gigaspora, Berk., in herb. Sporodochiis ochraceis, hemisphaericis vel subinaequalibus, saepe confluentibus, 2-4 mm. diam.; conidiis cylindraceis dense septatis, articulis cuboideis, 10-11 μ diam., hyalinis, in spiras 4-6 laxe convolutis, tubulum oblongum 70-80 \times 35-40 μ formantibus.

On culm of bamboo. Venezuela. (Type in Herb. Berk., Kew.)

Horny and irregularly contracted when dry, and in this condition closely resembling a small *Tremella* or *Dacryomyces*.



WOODCUT 4.

Fig. 1. Conidium of *Hobsonia macrospora*, Berk., \times 400.—Fig. 2. *Cordyceps Sherringii*, Mass., \times 7.—Fig. 3. Ascus of same, \times 400.—Fig. 4. Ascospore.—Fig. 5. Stromata, nat. size.—Fig. 6. Head of Stroma, \times 12.

GEORGE MASSEE, Kew.

A NEW CORDYCEPS.—In the examination of the large collection of Ferns recently made for the West India Fauna and Flora Committee of the British Association by Mr. R. V. Sherring in the island of Grenada, the dried remains of a species of ant were observed to be attached to a fern-frond. On these remains there was growing what proved to be a new species of *Cordyceps*.

Cordyceps Sherringii, Mass., sp. nov. Stipite flexuoso, pallide ochraceo, 1 cm. alt., 1 mm. cr., capitulo globoso, ochraceo, 2 mm. diam., peritheciis prominulis granuloso; ascis cylindraceis, $80 \times 7 \mu$; sporae filiformes $60 \times 1.5 \mu$, utrinque acutiusculae, hyalinae, quinque-septatae. (See Woodcut 4, Figs. 2-6.)

Gregarious on an ant, springing from various parts of the body, most firmly attached to the frond of a fern by a dense mass of pale ochraceous mycelium. Allied to *Cordyceps myrmecophila*, Cesati, but quite distinct in the globose head and the constantly 5-septate spores.

Grenada. Coll. R. V. Sherring, F.L.S.

The present species belongs to one of a small group of genera characterised by having exceedingly minute, needle-shaped spores, and more especially by being true parasites on living plants or animals. The members of the above-mentioned generic group of fungi are morphologically closely allied: in fact so close is the agreement that the perithecia, asci, and spores are almost indistinguishable in the species belonging to the various genera, and the modifications met with appear, so far as can be ascertained, to be solely in connection with spore-diffusion. The species of all the genera have the perithecia or spore-producing structures immersed in a portion of the fungus called the stroma. The spores when mature escape from the perithecia into the air.

In the genera *Oomyces* and *Epichloe* the stroma is thin and crust-like on the leaves and stems of living grasses; no conidial form of reproduction is known. In *Claviceps*—which leads up to the fully-evolved structure for securing spore-dissemination met with in *Cordyceps*—the species are parasitic on the fruit of various grasses: the stroma, known as 'ergot' in one species, first produces a conidial form of reproduction, and afterwards bears the perfect ascigerous form, the head bearing the perithecia being supported on a more or less elongated stalk. Finally, in *Cordyceps* the species, with two exceptions that are parasitic on fungi, are parasitic on living

insects. In many species a conidial form of reproduction, not produced on the surface of the compact stroma as in *Claviceps*, but borne on an erect, branched structure, appears first, being followed by the higher form of reproduction, the globose or club-shaped head bearing the perithecia being supported on a stem varying in length in the different species from one-sixth of an inch to six inches in length, the entire fungus being often eight inches high, as in *Cordyceps Robertsii*, Hook., parasitic on a large caterpillar in New Zealand. As a rule the larva is attacked by the fungus, the conidial fructification being produced on the active pupa, which often succumbs to the parasite, the higher fructification appearing after death. In other cases both forms of fruit mature on the still living caterpillar, or in other species one or both forms of fruit appear on the living imago state, as in some species of Lepidoptera. The great advantage to the fungus, from the point of view of spore-dissemination, of having the mature fruit raised on a long stalk and carried about, especially by a winged insect, is obvious.

The number of species included in the above-named genera are as follows: *Oomyces*, 1; *Epichloe*, 3; *Claviceps*, 5; *Cordyceps*, 47, and the genus is cosmopolitan.

G. MASSEE, Kew.

ON THE OCCURRENCE OF DIASTASE IN POLLEN¹.—

The germination of the pollen-grain and the formation of the pollen-tube involve questions similar to those which arise in connection with the germination of the seed. In both cases we have to deal with the utilisation of certain reserve materials which in the case of the pollen-grain are stored within it. As the pollen-tube has to attain a certain length before it can avail itself of any external nutriment which it may find in the tissue of the style, it is evident that the material which it uses in the early period of its growth must be the result of the transformation of the starch, sugar, &c., which are part of the contents of the grain.

In these processes ferment-action plays a definite part. Some years ago, Van Tieghem found that he could demonstrate in the pollen-grain the presence of invertase which converts cane-sugar into glucose. In the present paper an account is given of certain experi-

¹ Abstract of paper read at the meeting of the British Association, August, 1891.

ments made during the present summer on the occurrence of diastase in pollen.

The experiments so far are only preliminary, but they establish the existence of the ferment in the pollen of *Lilium*, *Helianthus*, *Gladiolus*, *Anemone*, *Antirrhinum*, and *Pelargonium*. The method of preparation was to collect the pollen from freshly dehisced anthers, and to grind it up carefully between plates of glass with a little water or dilute glycerine until the microscope showed the grains disintegrated. So prepared it was mixed with very dilute starch-paste, containing about 1% of starch. Half the mixture was then boiled for a short time and both the boiled and the unboiled halves were set aside at a temperature of about 20·23°C. After a few hours traces of diastatic action became evident. The unboiled tube lost its opalescence, and the addition of iodine to samples taken from it at intervals showed the starch undergoing the ordinary stages of conversion into dextrin and sugar. Simultaneously with the changes indicated by the iodine, the use of Fehling's fluid showed a continuous accumulation of grape-sugar, the reduction of the copper oxide becoming more and more marked as time went on. The boiled controls showed no change. The blue colour on the addition of iodine remained constant and no copper-oxide-reducing body was formed.

Further experiments showed that the diastatic power was not associated with the protoplasm of the disintegrated pollen-grain. The contents of several anthers of the Lily were ground up with diluted glycerine, allowed to stand for some hours and then filtered. The solution so made was clear, transparent, and free from the debris of the pollen. This solution when mixed with the same starch-paste caused it to go through the same series of changes, soluble starch, dextrin, and sugar, appearing as the action went on. As in the former case the activity of this extract was destroyed by boiling. We find consequently that the pollen-grains of many plants contain diastase which can be extracted from them as readily as from other parts of the plant.

Further experiments are in progress, which will deal with the nitrogenous and fatty reserve materials, and with the power of the pollen-tube to avail itself of the nutriment obtainable from the tissue of the style as germination proceeds through its later stages.

J. R. GREEN, London.

ON A NUCLEAR STRUCTURE IN THE BACTERIA¹.—Owing to the small size of the cells in the Bacteria, the presence of a nucleus, or of anything akin to a nucleus or nuclear structure, has not yet been satisfactorily demonstrated in them. Dr. P. Ernst has, however, described certain bodies which to him appeared to be of the nature of nuclei, inasmuch as when treated with reagents they give a reaction different from that observed in spores.

It is interesting to note that, in the closely allied group of the Cyanophyceae, Scott and Zacharias have been able to detect a structure resembling a nucleus. Zacharias has, however, recently shown that these nuclear bodies possess very little nuclein, and he is in consequence not inclined to regard them as nuclei.

According to Butschli, the central portion of the protoplasmic contents of the Bacterium-cell is to be regarded as of the nature of a nucleus in that it very readily takes up certain aniline dyes. It should be noted, however, that such stains as haematoxylin, carmin, safranin, &c., have but little staining power for the contents of the Bacterium-cell, compared with such stains as gentian, violet, fuchsin, &c., which stain them deeply, but which also stain the protoplasm of the cells of higher plants almost as deeply as the contents of the Bacterium-cell. This seems to show that the Bacteria contain very little of the chromatic substance which is found in the nuclei of the higher plants.

The author of this paper has, for some time, been working at the Bacteria in the hope of elucidating this point, and has obtained a *Bacillus* in which a distinct nuclear structure can be observed.

The *Bacillus* referred to forms a thin scum on the surface of water containing *Spirogyra* in a state of decay. The cells of this organism consist of short rods which occur either singly or in pairs. They are about 2.5 to 3 μ in length and from 1.3 to 1.5 μ in diameter, and when seen in a fresh state one or more highly refractive granules can be observed in each cell. In cover-glass preparations stained with fuchsin, all stages in the division of the *Bacillus* could be observed. The preparation should be made during the earlier stages of the development of the scum on the surface of the water, while the bacillus is in a healthy growing state.

In the centre of each cell a substance, deeply stained by the fuchsin, is found. This in young cells consists of two rods, deeply stained, placed side by side, with a less deeply stained substance

¹ Abstract of paper read at the meeting of the British Association, August, 1891.

between them, the whole being surrounded by a very thin membrane which is only visible at the two ends. This is the structure which we may call a nucleus. It is surrounded by a space containing a substance which is only slightly stainable, and this again is surrounded by a deeply stained membrane, outside which is the slightly stained gelatinous envelope. Previously to its division the cell elongates; the nucleus also elongates and contracts slightly about the middle of its length. A dumb-bell shaped structure is thus obtained. The two nuclear rods divide completely to form two groups containing two rods each, which remain connected together for some time by the less deeply stained portion of the nucleus. The constriction becomes more and more pronounced until finally the two halves of the nucleus are completely separated. The outer capsule or cell-wall has meanwhile been also contracting towards the middle; the contraction keeping pace with the division of the central mass. This contraction goes on until, at a certain stage, a delicate transverse partition appears dividing it into two, each half contains one of the halves of the original nucleus. Ultimately the two halves become completely separated and two new cells are formed.

In the majority of cases the cells are completely separated before the division of the nucleus again begins, but in many instances the nuclear rods were seen to be dividing in cells which were still connected with each other.

After a time the division of the cells takes place less rapidly and finally ceases altogether. The division of the nucleus becomes very irregular, and at the time when cell-division has ceased the nucleus has become broken up into granules which are distributed irregularly in the contents of the cell.

This breaking up of the nucleus appears to be preliminary to the formation of spores, although the formation of these has not been satisfactorily observed.

HAROLD WAGER, Leeds.

ORIGIN OF POLYSTELY IN DICOTYLEDONS.—Nearly all flowering plants have a monostelic structure in stem and root; that is to say, their conducting system forms a single central cylinder (stele), which consists of the xylem- and phloëm-strands, and of the conjunctive parenchyma by which they are united and surrounded, the whole being enclosed by a general endodermis belonging to the cortical

tissue. This central cylinder is common to stem and root, though the two organs differ in the distribution of its constituent tissues.

In spite of the almost infinite anatomical diversity which is met with among Phanerogams, this monostelic structure is scarcely ever departed from. Whatever may be the arrangement of the wood and bast, however much the differentiation of the conjunctive tissue may vary, whether there be indefinite cambial increase or not, or whatever form this increase may take, still the presencē of a single central cylinder is an almost constant character.

In the Vascular Cryptogams this is not the case. Although in many Equisetums, in *Lycopodium*, *Isoetes*, some species of *Selaginella*, and some of the simpler Ferns, the axis is monostelic, in the great majority of the Ferns, and in many Selaginellas a different type prevails. In these the central cylinder no longer remains simple; it bifurcates repeatedly, and the mature stem is traversed by a number of distinct, but anastomosing, vascular cylinders (the "concentric bundles" of De Bary's Anatomy), each of which is homologous with the single cylinder of a monostelic stem. It is, however, a fact of essential importance that in all vascular plants whatsoever the *embryonic* structure is monostelic, the stem, like the root, primarily containing a single cylinder of small diameter and simple organization. In the flowering plants progress takes the direction of increase in the size and complexity of the one cylinder; in the Cryptogams above cited a complex conducting system is attained in another way; the original cylinder branches and the stem becomes *polystelic*, in all the later-developed internodes¹.

Van Tieghem, the originator of the anatomical conceptions which have just been indicated, well says that polystely is the most important modification which the structure of the stem can undergo². According to our present knowledge there are only two genera of flowering plants in which polystely occurs, namely *Auricula*³ and *Gunnera*. Though systematically so remote from each other, these genera agree, so far as most of their species are concerned, in posses-

¹ *Leclerc du Sablon*, Recherches anatomiques sur la formation de la tige des Fongères. Annales des Sci. Nat., Bot., Sér. VII, t. xi, 1890.

² *Traité de Botanique*, 2^{me} éd. 1891. Pt. I, p. 767. See also *Van Tieghem et Douliot*, Sur la polystélie. Ann. des Sci. Nat., Bot., Sér. VII, t. iii, 1886.

³ *Auricula* is usually regarded as a section of *Primula*. Van Tieghem makes it a separate genus, and his nomenclature is provisionally adopted here, though I express no opinion on the systematic question.

sing a number of distinct vascular cylinders in the main stem. Both genera indeed include monostelic species, such as *Auricula reptans*, and *Gunnera monoica* etc., but the majority are polystelic, the number of cylinders varying in different species from two to eighty. In the monostelic species of each genera the single cylinder has precisely the same structure as each of the many cylinders of the polystelic forms. In every case each 'stele' is almost destitute of pith, has its vascular bundles crowded together, and shows little or no secondary growth in thickness.

Now it is remarkable that both *Auricula* and *Gunnera* have near relations which are aquatic in habit, and which have the reduced vascular structure characteristic of aquatic plants. Among the Primulaceae there is *Hottonia*, in which the submerged stem has a central cylinder of simple structure, with little pith, confused vascular bundles, and little or no secondary thickening, just as is found in *Auricula reptans*, or in a single 'stele' of any of its allies. Van Tieghem, after pointing out this identity of structure, adds: 'Mais l'*Hottonie* doit sans doute l'étréitesse de son cylindre central à sa végétation submergée, de sorte que sa structure n'est pas rigoureusement comparable à celle des Auricules'¹.

Gunnera also, as a member of the Order Halorageae, has a number of aquatic relations, the central cylinder of which (at least in *Myriophyllum* and *Hippuris*) perfectly agrees with that of the monostelic *Gunneras*, or with the several cylinders of the polystelic species. In drawing this comparison, Van Tieghem repeats the remark just quoted as to *Hottonia* and *Auricula*.

In the polystelic *Auriculas* the flower-stalks and the leaves have normal structure. In the *Gunneras* on the other hand polystely extends both to the pedicels and to the petioles and larger veins of the leaf.

It is a striking fact that the two Dicotyledonous genera, in which alone, so far as we know, polystely prevails, belong to families remote from each other, but agreeing in the fact that they include aquatic representatives of reduced monostelic structure.

The suggestion which I wish to bring forward is this: is it not possible that these polystelic Dicotyledons may owe their exceptional structure to descent from aquatic ancestors? When a plant becomes adapted to submerged aquatic life, we find as a rule that its vascular

¹ Sur la polystélie, l. c., p. 295.

cylinder becomes narrowed and reduced; the pith tends to disappear, the bundles are confused together, and the power of secondary growth in thickness, in the case of Dicotyledons, is nearly or wholly lost. Where the plants are entirely submerged this reduction may affect the whole axis; where however the flowering stem rises above the surface of the water it may retain a typical vascular cylinder, as is conspicuously the case in *Hottonia*.

Now supposing the descendants of a reduced aquatic Phanerogam to return to a terrestrial mode of life, they will evidently once more need that higher development of the vascular system which is proper to land-plants. The favourable variations bringing about this change may indeed take the direction of a renewed dilation and differentiation of the single cylinder, and if a Dicotyledon is in question, secondary thickening may again make its appearance. But it is also possible that the available variations may take a different line. Instead of the one vascular cylinder again becoming more complex, the necessary amount of conducting tissue may be provided in the form of many distinct cylinders, arising from the bifurcation of the original one. This is what undoubtedly happened in the case of most Ferns, which, when they originally adapted themselves to life on land, became as a rule polystelic¹. It may well have happened also in the case of certain Dicotyledons, which, in having become aquatic, had sunk to the anatomical level of the simplest Pteridophyta.

On this view then the polystely of *Auricula* and *Gunnera* may be regarded as the anatomical expression of the return of plants of aquatic habit to a terrestrial mode of life.

We may conjecture that the Auriculas, which always retain a normal structure in their pedicels and leaves, may be descended from only partially submerged ancestors. *Gunnera*, which belongs to a more distinctly aquatic family, may well have had ancestors which had more completely lost the typical monostelic differentiation, and hence the renewed adoption of terrestrial habit may have been accompanied by polystelic modifications extending to all the subaerial organs.

D. H. SCOTT, London.

¹ Anatomical complexity in Ferns nearly always takes the form of polystely. But in *Botrychium* we have an indication of the other alternative— indefinite development of the single stele. If *Lyginodendron* and its allies really had Filicine affinities, this monostelic differentiation must have gone much further in the Palaeozoic representatives of the class.

APPENDIX TO THE REVISED LIST OF BRITISH MARINE ALGAE¹.—In the preparation of the Revised List of British Marine Algae, which is, we believe, the first attempt that has been made in recent years to show the distribution of Marine Algae reported to occur in Britain, it was almost inevitable that some errors would pass unobserved by us.

I. It has been objected to our method of mapping out Britain into littoral districts that while some places are included in two separate divisions, others are not included in any of them. This objection, we think, may be easily met by a very slight alteration in the delimitation of the districts, which in no way affect the distribution given in the body of the work.

1. From Duncansby Head to Ardnamurchan Point, including the Orkneys, Shetlands, and the outlying Hebrides in the same latitude.

2. From Ardnamurchan Point to the Esk, including the outlying islands.

3. From Duncansby Head to Aberdeen.

4. From Aberdeen to the Tweed.

5. From the Esk to the Great Orme's Head, including the Isle of Man.

6. From the Great Orme's Head to the Land's End, including Anglesea, Lundy Island, and the Scilly Islands, &c.

7. From the Tweed to Cromer.

8. From Cromer to Dover.

9. From the Land's End to, and including Dover, the Isle of Wight, and the Channel Islands.

IRELAND.

10. From Malin Head to Llyne Head, including the outlying islands.

11. From Llyne Head to Crow Head, including the outlying islands.

12. From Malin Head to Howth.

13. From Howth to Raven Point.

14. From Crow Head to, and including Raven Point.

II. It has been affirmed² that we were in error when we stated that the 'type-specimens' of Mrs. Griffiths were in the possession of the Linnean Society of London, and those of Mrs. J. E. Gray in the Herbarium of the University of Cambridge. In the passage adverted on we employed the word 'type' in the same broad sense in

¹ See *Ann. Bot.*, Vol. V, p. 63.

² See *loc. cit.*, p. 228.

which Mr. Thiselton-Dyer uses the word, where he says: 'The type-collection is certainly not there (i. e. Linnean Society, Burlington House), for the simple reason that it is where it has always been since Mrs. Griffiths' death, at Kew.' It is evident that in neither of these cases could the word 'type' be used in the most limited sense, i. e. as referring to the actual specimens on which the original descriptions of the plants were founded, since it is generally understood that Mrs. Griffiths *did not describe any new species*. Our object in giving the list was to indicate, for the use of actual students of algology, where the special herbaria of previous algologists are to be found, since these would obviously represent the species as understood by them. Mr. Thiselton-Dyer states that Mrs. Griffiths' type-collection is at Kew, and that 'this fact is well known to critical algologists, for Dr. Bornet writing to me mentions incidentally: L'herbier de Mrs. Griffiths et celui de Berkeley sont conservés au Musée de Kew.' The evidence on which our statement is founded is as follows:—

1st. In the Proceedings of the Linnean Society, bearing date November 10, 1858 (vol. iv. pt. i), the following words occur: '*The valuable collection of British Algae formed by the late Mrs. Griffiths, arranged according to Harvey's Manual of British Algae. Presented by the subscribers to a fund for its purchase.*'

A similar statement is repeated on p. lxxxviii.

That this collection was purchased as *the special one* of Mrs. Griffiths seems evident from the fact that Dr. Cocks' collection of marine algae in the possession of the Linnean Society is described as: *A collection of British Marine Algae, formed by Dr. Cocks of Plymouth. That the collection was purchased by the Society as the special collection made by Mrs. Griffiths for her own use, is confirmed by a letter received by one of us (B), from Mr. W. Carruthers, F.R.S.*

2nd. The collection in the Kew Herbarium was received at Kew *four years later*, according to the Kew Report, 1862, and was presented by Lady Burdett-Coutts. It presumably consisted of Mrs. Griffiths' very large stock of duplicates.

3rd. It is certain that both Mrs. Griffiths and her daughter gave away other collections made by the former, for there is one collection at the Devon and Exeter Institution at Exeter, presented by Miss Griffiths in 1861, and another exists in the Museum at Torquay. Hence the word 'etc.' placed after the words 'Linnean Society' in our list (p. 66).

With respect to the sentence quoted by Mr. Thiselton-Dyer from Dr. Bornet's letter to prove that the existence of Mrs. Griffiths' special collection of algae at Kew is accepted as a fact by critical algologists, we have Dr. Bornet's permission to say that his authority for the statement is the following quotation from De Candolle's *Phytographie*:—'Griffiths (Mad.) de Torquay, Algues britanniques: herb. royale de Kew, Rep. (1862); herb. de la Société Linnéenne de Londres (3 vol. in fol.)'

Dr. Bornet adds in his letter to one of us (H): 'La première de ces indications est confirmée par les auteurs du "Bibliographical Index of British and Irish Botanists" qui a paru dans le Journal of Botany, 1889, vol. xxvii. p. 47, Griffiths, Amelia W., Algologist, Algae at Kew.' [By James Britten, F.L.S., and G. S. Boulger, F.L.S.]

It will be seen therefore that the foundation for the opinion of Dr. Bornet actually rests on the Kew Report, the statement in which, as we have shown above, is not in accordance with facts published elsewhere.

III. In the same note exception is taken to our statement that Mrs. Gray's specimens are in the Herbarium of the University of Cambridge, and the suggestion is made that the specimens alluded to by us are one of a series of sets made up by Mrs. Gray for distribution to various public institutions.

The evidence on which our statement rests is as follows:—The Herbarium has been examined by one of us (H) and is evidently a large and valuable collection, containing as it does an extensive series of specimens of many of the species, and many rarities. We have still further confirmation for our statement in the following letter, bearing date May 16, 1891, received from Professor C. C. Babington, Professor of Botany in the University of Cambridge:—

'We certainly have both Dr. and Mrs. Gray's special Herbaria of Algae in the Cambridge Herbarium. It came through her executors.'

IV. It is pointed out¹ that the type-specimen of *Ectocarpus fenestratus*, Berk., in the Berkeley Herbarium at Kew, has been lent to Dr. Bornet at his request and has proved to be identical with *E. Lebelii*, Crn., and it is assumed that the former species must therefore be discarded. This, however, by no means follows as a necessary sequence.

Neither of us examined the type-specimen of *Ectocarpus fenestratus*.

¹ See loc. cit., p. 227.

tratus, and indeed when we were preparing the 'Revised List' we did not know that it was accessible for examination: we therefore willingly bow to the decision of Dr. Bornet, that *E. fenestratus* is the same species that is known in France under the name of *E. Lebelii*, Crn. At the same time we venture to think that few algologists would have come to this conclusion from an examination of Harvey's figure and description. The *Elachista*-like epiphytic tuft, 'rameuse dès la base' of *Ectocarpus Lebelii*, only one centimetre in height, bears but a small resemblance to the sparingly branched alga 'one or two inches high' figured by Harvey under the name of *E. fenestratus*, and which he remarks is not 'unlike many specimens of *Ectocarpus siliculosus*' (*E. confervoides*, Le Jol.).

Granting, however, that the two plants belong to the same species, the name *fenestratus* is certainly the older of the two, having being published in 1849 in Harvey's second edition of the 'Manual' of British Algae; it was also figured in the *Phycologia Britannica* before 1851¹.

On the other hand *Ectocarpus Lebelii* was apparently described for the first time in 1867 by Crouan frères in their *Florule du Finistère*, where they quote their 'Liste des Algues Marines du Finistère,' which was published in May and November, 1860, in the *Bulletin de la Société Botanique de France*. On referring to that work (vol. vii. p. 836), *Ectocarpus Lebelii* (Aresch. MS.), Crn. is given as the new name for *Elachista Lebelii*, Aresch. MS., but no description of the plant is appended. We have not been able to find any mention of the plant in any of Areschoug's published writings previous to the date of the *Florule*, and are therefore compelled to consider the description of the species in that work as the earliest one. In the list given in vol. i. of Crouan's 'Algues Marines du Finistère,' which contains the *Ectocarpaceae*, we find that no mention is made either of *Elachista Lebelii* or of *Ectocarpus Lebelii*; and as it does not occur in the list given in the *Bulletin de la Société Bot. de France* in May, 1860, but in that published in the following November, it would appear that the plant was not identified by the brothers Crouan until that year. Consequently the name given by Berkeley has a priority of eleven years, and the species must therefore be retained under the name of *E. fenestratus*, Berk.: but as the plant described by the brothers Crouan differs in

¹ The *Phycologia Britannica* was published in monthly parts, all of which had been issued before 1851.

several important particulars from the typical form, we propose to keep it as a well-marked variety under the name of *E. fenestratus*, Berk. var. *Lebelii*, Holm. et Batt., and to regard the plant described by Kjellman under the name of *E. Lebelii* var. *borealis* as another variety, under the name of *Ectocarpus fenestratus* var. *borealis*, Holm. et Batt.

V. Our attention has also been called to several small errors, principally in regard to authorities for names, which we do not propose to deal with at present. The following corrections and additions may, however, be made.

P. 68. 'Tribe II.—Lyngbyeae' *should precede* '**Phormidium** Kütz.'

P. 70. *Immediately after* 'Anabaena torulosa, Lagerh.' *insert* 'Species requiring confirmation,' Sphaerozyga Berkeleyana, Thur. 6; Sphaerozyga Broomei, Thur. 6.

P. 76. *To follow* 'Cladophora crystallina.'

Cladophora gracilis, Kütz. 5. 6. 9!

P. 76. *Under* 'Species requiring confirmation,' *after* 'Cladophora lanosa, Kütz.', *insert* 'Cladophora Gattyaе, Harv.'

P. 77. *Read* Codium tomentosum, Stackh.

f. amphibia, Holm. et Batt.

instead of C. adhaerens, C. Ag.

f. amphibium, Holm. et Batt.

P. 78. *To follow* 'Striaria attenuata, Grev.,' *add* as a 'Species requiring confirmation,' 'Striaria fragilis, J. Ag.'

P. 87. *For* 'Diploderma miniatum, Kjellm.,' *read* 'Wildmania miniata, Fosl.': *and for* 'D. amplissimum, Kjellm.,' *read* 'W. miniata f. amplissima, Fosl.'

P. 95. *For* 'Polysiphonia byssoides, Grev.,' *read* 'Lophothalia byssoides, J. Ag.', and place it after **Pterosiphonia**.

VI. During the present year several species of Marine Algae have been detected as natives of Britain, and others collected by us before the present year have been identified. We therefore embrace the present opportunity of publishing the additional species.

P. 68. *Under* **Oscillariaceae** *add* Lyngbya lutea, Gom. 5!

P. 71. *Under* **ULVACEAE**, *and above* Pringsheimia scutata, *add* Protoderma marinum, Rke. 2!

Ulvella lens, Crn. 2!

Monostroma fuscum, Wittr. 2!

- P. 73. **CHAETOPHORACEAE**: *add* under *Trichophoreae*,
Acrochaete repens, Pringsh. 2!
- P. 78. **PUNCTARIACEAE**.
Punctaria latifolia, Grev.
f. laminarioides, Holm. et Batt. 2! 9!
- ” ” **ECTOCHARPACEAE**.
Streblonema intestinum, Holm. et Batt. 9!
Streblonema sphaericum, Thur. 2! 9!
Ectocarpus erectus, Born. 9!
- P. 82. **CHORDARIACEAE**.
Mesogloea lanosa, Crn. 2! 9!
Myriocladia tomentosa, Crn. 9!
- P. 87. **PORPHYRACEAE**.
Porphyra miniata, J. Ag. 2!
Wildmania miniata, Fosl.
f. tenuissima, Fosl. 2! 4!
- P. 90. **RHODOPHYLLIDACEAE**.
Cystoclonium purpurascens, Kütz.
f. cirrhosa, J. Ag. 9!
- P. 93. **RHODOMELACEAE**.
Laurencia obtusa, Lamx.
var. pyramidata, J. Ag. 9!
- P. 97. **CERAMIACEAE**.
Rhodochorton seiriolanum, H. Gibs. 6! 9!
- P. 99. *Ceramium strictum*, Harv.
var. *delicata*, J. Ag. 9!
- P. 100. **NEMASTOMACEAE**.
Nemastoma marginifera, J. Ag. 9!
- P. 102. **CORALLINACEAE**.
Lithothamnion corallioides, Crn. 2!

It has been suggested to us that some indication of the present state of knowledge concerning the reproductive organs in the Marine Algae found in Great Britain might be useful to students of algology. We therefore offer the following necessarily imperfect list of species in which, so far as we have been able to ascertain, various organs of reproduction are still unknown, or imperfectly known.

CHLOROPHYCEAE.

PROTOCOCCACEAE.—The sexual mode of reproduction has been observed only in **Chlorochytrium**.

Characidae. Sexual reproduction unknown.

BLASTOSPORACEAE. Sexual reproduction unknown.

ULVACEAE. Reproduction, both asexual and sexual, unknown in **Capsosiphon**, and imperfectly known in the species of the genera **Monostroma** and **Ulva**.

CHAETOPHORACEAE. Sexual reproduction unknown in **Achrochaete**, **Bolbocoleon**, **Entoderma**, and **Epicladia**: no mode of reproduction known in **Ochlochaete**.

CLADOPHORACEAE. Asexual zoospores unknown in **Rhizoclonium** and **Chaetomorpha**. Sexual reproduction known only in one species of **Cladophora** (*C. sericea*, Kütz.).

GOMONTIACEAE. Sexual reproduction unknown.

DERBESIACEAE. Sexual reproduction unknown.

CODIACEAE. Asexual reproduction unknown, conjugation of gametes (?) not observed.

PHAEOPHYCEAE.

Plurilocular sporangia are unknown in the genera **Desmarestia**, **Dictyosiphon**, **Stictyosiphon**, **Striaria**, **Battersia**, **Stypocaulon**, **Petrospongium**, **Chorda**, **Laminaria**, **Saccorhiza**, **Alaria**, **Sporochnus**, **Carpomitra**, and **Aglaozonia**, and in the following species;

Litosiphon Laminariae.

Elachista Areschougii.

„ *flaccida*.

Sphacelaria radicans.

„ *olivacea*.

„ *tribuloides*.

„ *plumula*.

„ *plumigera*.

Ralfsia spongiocarpa.

Chordaria flagelliformis.

Leathesia crispa.

Unilocular sporangia are unknown in the genera **Sorocarpus**, **Halothrix**, **Arthrocladia**¹, **Phyllitis**, and **Scytosiphon**: and in the following species;—

¹ See, however, Johnson, *Ann. Bot.*, Vol V, p. 140.

- Streblonema fasciculatum.
 ,, intestinum.
 ,, simplex.
 Ectocarpus erectus.
 ,, parvulus.
 ,, caespitulus.
 ,, fenestratus.
 ,, Crouani.
 ,, Sandrianus.
 ,, virescens.
 ,, secundus.
 ,, longifructus.
 ,, acanthophorus.
 ,, Hincksiae.
 ,, brachiatus.

RHODOPHYCEAE.

Antheridia and cystocarps are both unknown in *Actinococcus*, *Haematocelis*, *Haematophlaea*, *Hildenbrandtia*, *Monospora*, *Rhodochorton*, and *Rhododermis*.

Antheridia are unknown in *Ahnfeltia*, *Calosiphonia*, *Compsothamnion*, *Cordylecladia*, *Dilsea*, *Dumontia*, *Euthora*, *Grateloupia*, *Schmitziella*, and *Sphaerococcus*.

Tetraspores are unknown in *Ahnfeltia*, *Bonnemaisonia*, *Calosiphonia*, *Helminthora*, *Helminthocladia*, *Naccaria*, *Nemalion*, *Scinaia*, and *Sphaerococcus*.

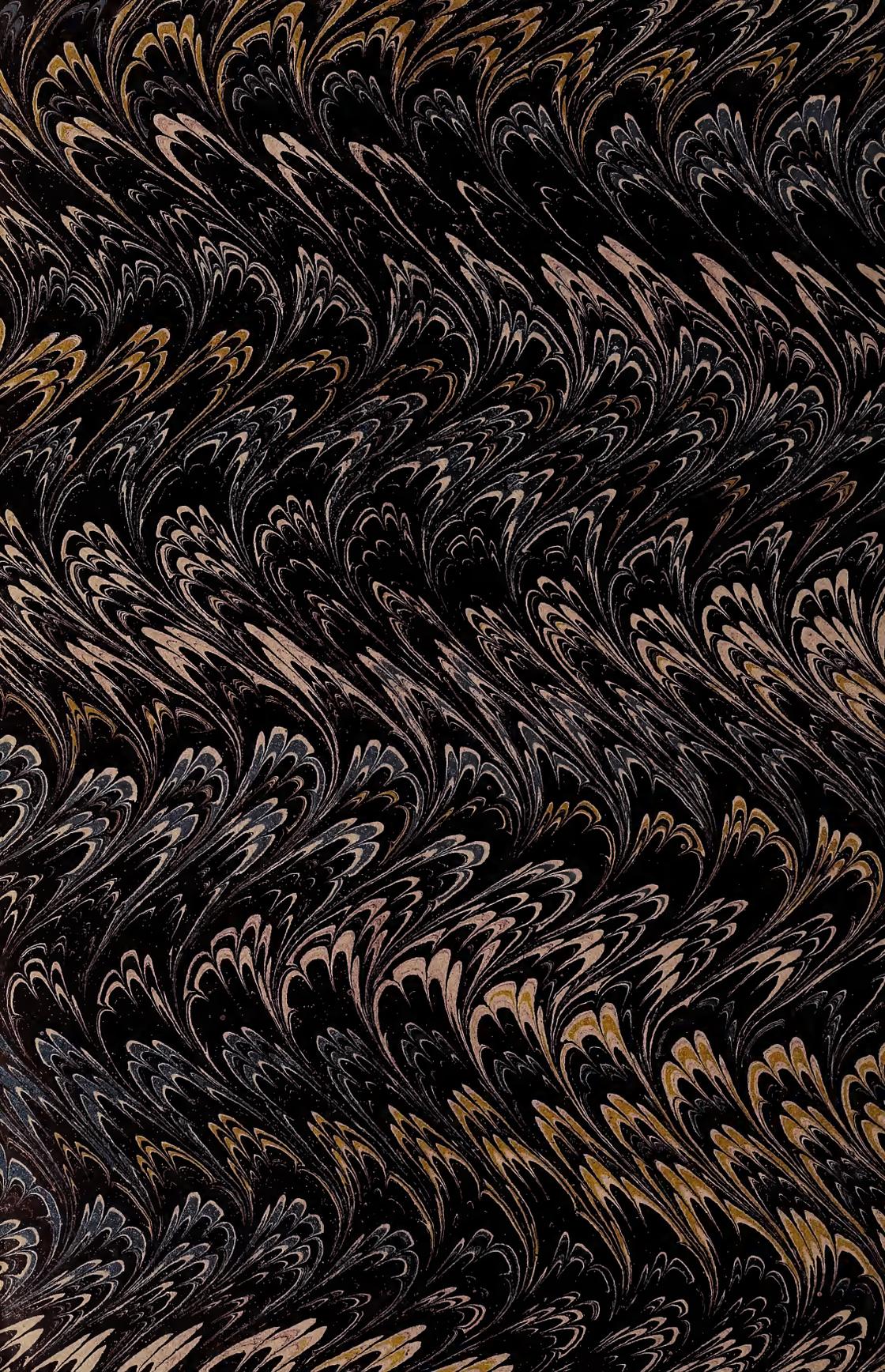
In the following species one or more organs of reproduction are unknown and are indicated thus:—a.=antheridia; c.=cystocarps; t.=tetraspores.

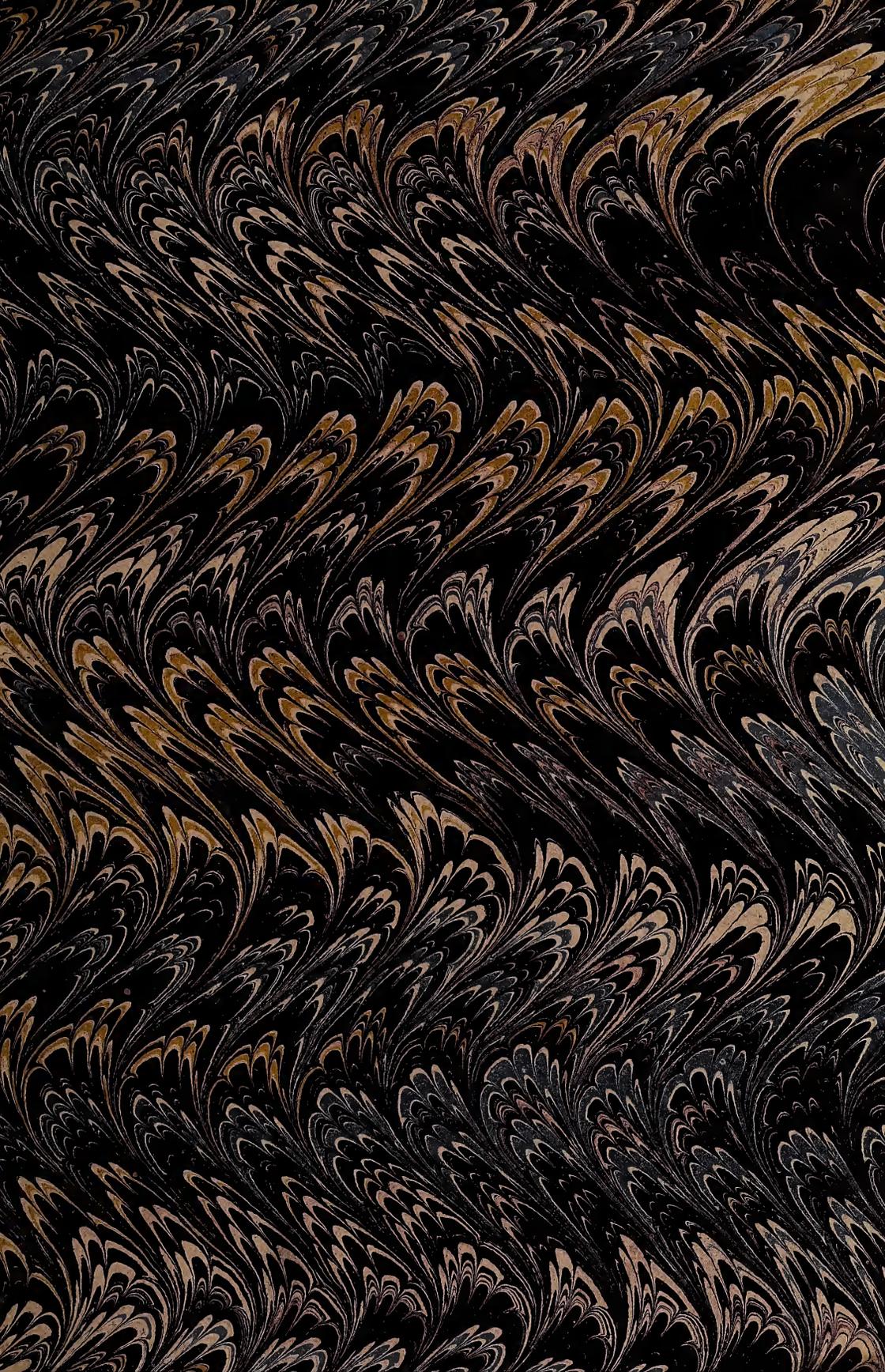
- Antithamnion floccosum*: a.
 ,, *barbatum*: a., c.
Callithamnion affine: a., c.
 ,, *interruptum*: a., c.
 ,, *fruticulosum*: a.
 ,, *tripinnatum*: a., c.
Ceramium acanthonotum: a.
 ,, *ciliatum*: a.
Chondrus crispus: a.

- Dasya ocellata* : a.
 „ *punicea* : a.
 „ *Cattloviae* : a., c.
Gigartina mamillosa : a., t.
Gracilaria multipartita : a., t.
 „ *divergens* : a., t.
Halymenia ligulata : t.
Lomentaria rosea : a.
Nitophyllum literatum : a.
 „ *reptans* : a., t.
 „ *uncinatum* : a.
 „ *versicolor* : a.
Peyssonnelia Harveyana : a.
Phyllophora Brodiaei : a., t.
 „ *rubens* : t.
 „ *Traillii* : t.
Polysiphonia elongella : a.
 „ *foetidissima* : a., c.
 „ *furcellata* : a., c.
 „ *Richardsoni* : a., c.
 „ *parasitica* : a.
 „ *simulans* : a.
 „ *spinulosa* : a.
 „ *subulata* : a.
 „ *subulifera* : a.
 „ *variegata* : a.
Pterosiphonia complanata : a., c.
Rhodymenia nicaeensis : a.
 „ *palmata* : c.

E. M. HOLMES.

E. A. L. BATTERS.





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