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CONTENTS

Errata

Page 11, line 17, insert end of bracket after sind.

Page 13, line 7, for auf gestellten read aufgestellten.

Page 13, last line, for p. 294 read p. 204.

Page 14, line 4 from bottom, for Polla read Palla.

Page 15, line 8, for morphologische read morphologisch.

Page 15, line 13, for Specializrung read Specialisirung.

Page 17, line 4 from bottom, *delete* the.

Page 18, line 10, for 219 read 119.

Page 84, line 17, for not read to.

Page 84, line 20, for Pl. 9 read Pl. 11.

Page 85, line 11 from bottom, for pp. read ff.

Page 87, line 16 from bottom, *delete* the.

Page 87, line 13 from bottom, for Siberia and Asia read Siberia in Asia.

Page 87, last line, for skins read stems.

Page 88, line 3, *delete* the.

Page 91, line 1, after same insert name.

Page 91, line 17 from bottom, *delete* the before *S. Humuli*.

Page 93, line 4, for *Cladosorium* read *Cladosporium*.

Page 93, line 8, for fungus on read fungous.

Page 94, line 10, *delete* in.

Page 95, line 20, for *Euphorbia Cyparissias palustris* read *Euphorbia Cyparissias* (40) *E. palustris*.

Page 95, line 12 from bottom, for 145 read 147.

Page 96, line 7, *delete* Although.

Page 96, line 7, add of at end of line.

Page 102, line 2, for Szumo read Izumo.

Page 106, line 19, for Pl. 28 read Pl. 23.

Page 107, line 10, for set read sent.

Page 108, line 2, for attached read attacked.

Page 182, line 16 from bottom, for pl. 1 read pl. 9.

Page 190, line 11, for skin read stem.

Page 191, line 10, for no. read near.

Page 192, line 6, for habitat read habit.

Page 195, line 4 from bottom, for 72 read 70.

Page 201, line 9 from bottom, for 30 read 50.

Page 207, line 12 from bottom, for f. 20 read f. 21.

Page 208, line 3 from bottom, for tenibus read tenuibus.

Page 547, line 17, the paragraphs commencing "The Cusick specimen" to the words "Brewer specimen" on page 548, line 14, belong under *Lappula Californica* on page 546.

Page 628, line 7, for *Gypmnopteris* read *Gymnopteris*.

Page 498, line 20, for preceding read following.

Page 499, line 7 from bottom, for 23 read 22.

Page 501, line 14, for 24 read 23.

Page 502, line 19, after pl. insert 22.

Page 504, line 5, for 0.009 read 0.019.

Page 504, line 21, for 24 read 23.

Page 506, line 3, for 25 read 24.

Page 507, line 12 from bottom, for 23 read 22.

Page 509, line 13, after stenophylla insert and L. hamulata

Page 509, line 18, after propagala insert (pl. 24. f. 10).

Page 509, line 6 from bottom, for PLATE 23 read PLATE 22.

Page 510, line 8, for PLATE 24 read PLATE 23.

Page 510, line 21, for PLATE 25 read PLATE 24.

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Memoirs. (See last page of cover.)

Vol. 29 No. 1

BULLETIN

OF THE

TORREY BOTANICAL CLUB

An unfortunate typographical error occurred in the December Bulletin for which apologies are due to the writer; will those receiving this slip please insert it in the December number opposite page 668?

Errata

Page 668. Paragraph commencing "Specimens are represented" should be transferred to the end of the matter on page 674.

Page 671. Commencing with the paragraph "Besides the specimens collected at Bodega Port" all the matter following to the end of the article should have appeared before the matter commencing on page 669.

It is hoped that this correction of an inexplicable mixing of the galleys will help to make this valuable contribution of Miss Eastwood more intelligible. [Editor.]

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the following must be noticed. Hennings (31), in his "Fung. *japonici*," has described the following as new species or varieties: *Phyllactinia suffulta* var. *moricola*, *Microsphaera Japonica*, *M. sambucicola*, *Sphaerotheca Kusanoi*, *S. phtheirospermi*, *Uncinula Shiraiana*, *U. zelkowae*, *U. clandestina* forma *Japonica*, *U. verniciferae*,

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* Memoirs Torrey Club, Volume 9. The numbers refer to the bibliography which will appear at the close of the article.

[Issued 28 January]

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BULLETIN

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TORREY BOTANICAL CLUB

JANUARY 1902

Supplementary Notes on the Erysiphaceae

BY ERNEST S. SALMON, F.L.S.

Since the completion of my monograph (**67**)* on the Erysiphaceae, I have had the opportunity of examining a considerable amount of further material. This has enabled me to continue the study of the critical forms of several species; to investigate many cases of the reported occurrence of a species on an unusual host plant; and to extend the geographical range and add further hosts for many species. In the following pages will be found an enumeration of most of the species of the Erysiphaceae (following the order in which they are placed in my monograph) and under each species are arranged the critical notes, additional localities, host plants, etc. These records are based on personal examination, except in those cases in which they are followed by a number placed in brackets. These numbers indicate a published record, which will be found in the work of the author quoted under the respective number in the bibliography.

Before proceeding to give these notes, however, mention must first be made of several important papers dealing with the Erysiphaceae which have appeared recently. Of taxonomic interest, the following must be noticed. Hennings (**31**), in his "*Fungi japonici*," has described the following as new species or varieties: *Phyllactinia suffulta* var. *moricola*, *Microsphaera Japonica*, *M. sambucicola*, *Sphaerotheca Kusanoi*, *S. phtheirospermi*, *Uncinula Shiraiana*, *U. zelkowae*, *U. clandestina* forma *Japonica*, *U. verniciferae*,

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[Issued 28 January]

and *Erysiphe pisi* var. *desmodii*. To this number of supposed new Japanese species, Sydow (82) has added another, viz. *Uncinula Kusanoi*. With one exception—*Uncinula verniciferae* P. Henn., which appears to be distinct—I consider that these Japanese plants are all to be referred to already described North American species, or to cosmopolitan ones. Notes on some of these Japanese plants will be found in my "Erysiphaceae of Japan" (68); the remaining species are discussed in the following pages.

The Erysiphaceae of South America have been noticed by Spegazzini (79) and also by Neger (52). The former author has described as a new species "*Erysiphe deserticola*" from the Argentine Republic, and has recorded other species of *Erysiphe* from the same country. The only specimens I have been able to see of "*E. deserticola*" have been in an immature condition, and I am inclined to think from these that the plant will prove to belong to the cosmopolitan species *E. polygoni* DC. The other South American species of *Erysiphe* recorded by Spegazzini prove to be *E. cichoracearum* DC. and *E. galeopsidis* DC. Of special interest is Spegazzini's (79, p. 330) record of the occurrence in the Argentine Republic and Uruguay of the conidial (*Oidium*) stage of members of the Erysiphaceae on no less than 98 different species of host plants—a fact which shows that these fungi flourish at all events in some parts of South America.

Neger (52) has described as new species, from the Argentine Republic, *Phyllactinia clavariaeformis*, *Microsphaera myoschili* and *Erysiphe Fricki*. *Phyllactinia clavariaeformis* proves to be identical with *P. antarctica* Speg., and although presenting somewhat remarkable characters which perhaps entitle it to be regarded as an incipient species—cannot be regarded as distinct from the old *P. corylea* (Pers.) Karst. The question of the relation of "*P. clavariaeformis*" to the type, is discussed in detail below, where mention is made of the fact that forms of *P. corylea* quite similar to the South American "*P. clavariaeformis*" appear sporadically on various hosts in Europe and Asia, along with all intermediate forms. *M. myoschili* is certainly only one of the forms of *M. alni* which show a much-branched apex of the appendages. *E. Fricki* is indistinguishable from *E. polygoni*.

In Europe Serbinov (76) has described from Russia a var.

borealis of *Microsphaera euonymi*, and a var. *polemoniacearum* of "*E. lamprocarpa* Lév." These two plants I have not seen, but the description given of the latter seems to show that it is a form intermediate between *E. cichoracearum* and *E. galeopsidis*.

In Japan a very distinct new species of *Uncinula*, *U. septata* Salm. (**69**) has appeared. The species has been found in two localities, and in each case it is associated with *Sphaerotheca lanestris* (*S. Kusanoi*).

From a geographical point of view, the record by Raciborski (**60**) of the occurrence of *Oidium*-forms in Java is noteworthy.

The occurrence of the New World species, *Sphaerotheca mors-uvae* (Schwein.)—the American gooseberry mildew—in a garden at Ballymena, County Antrim, Ireland, in 1900, is of special interest (see **71, 72**). The question of the possibility of its introduction from America is considered under the species.

Two important papers dealing with the Erysiphaceae by Grant Smith and Neger have appeared.

Grant Smith, in his paper, "The Haustoria of the Erysipheae," (**77**) has given a detailed account of the structure and development of these organs, and has added several interesting facts to our knowledge of the subject. While finding that the mature haustorium contains almost invariably a single normal nucleus (as Harper had already stated), the author records an isolated case, where the haustorium of "*Erysiphe communis*" on *Geranium maculatum* contained two nuclei. It was also found that occasionally haustoria have a septum in the neck portion. As has long been known, a mature haustorium is nearly always surrounded by a thick sheath-like layer. The correct interpretation of this sheath according to Grant Smith, is different from that which has hitherto been given. De Bary was of the opinion that it belonged to the protoplasm of the host cell, while Harper (Pringsh. Jahrb. wiss. Bot. **29**: 664), considered that this sheath is, as in the case of that of *Puccinia*, the disorganizing nucleus of the host cell. Smith says, however, that the sheath "does not belong to the protoplasm of the cell as de Bary supposed, nor is it the host nucleus as Rosen observed in *Puccinia;* but the contents of the sheath consist of disintegrated cellulose from the distal end of the cellulose ingrowth through which the haustorium has made its way. The bounding membrane of the sheath, on the other hand, is the plasmic membrane of the host cell stretched and greatly enlarged by the osmotic forces involved."

The haustoria of *Erysiphe graminis* are, as is well known, peculiar in being provided with long finger-like processes. These haustoria Smith has studied in detail, and shown well in several figures. With reference to these haustoria it is observed, "this form of absorbing organ may be looked upon as the result of a special effort of this species to obtain abundant food. The heavy growth of mycelium and the immense number of conidia produced by this species show the success it has attained. * * * Certainly these haustoria give an impression of activity not gained from other Erysipheae."

The most interesting discovery of Smith, however, is in connection with the haustoria of *Uncinula salicis*. Examples of *U. salicis* on *Salix discolor* were used for investigation, and the development of the haustoria was found to take place as follows: The mycelium (proper) is entirely external; on the upper surface of the leaf the lobed appressoria give rise to penetrating tubes which enter the epidermal cells. All of these tubes, however, do not (as in all other cases known) develop in the epidermal cells into haustoria. Although normal haustoria are formed abundantly in these epidermal cells, in addition numerous slender hyphae can be observed reaching from the outer walls across the epidermal cells to their inner walls. These hyphae are the penetrating tubes or necks of subepidermal but otherwise normal haustoria in the palisade cells. On the lower surface of the leaf, in a similar manner, some of the penetrating tubes reach into the mesophyll cells immediately under the epidermal layer, and form haustoria there.

Smith has also investigated the intercellular hyphae of *Phyllactinia*, and has found that occasionally the hyphae produce haustoria in the palisade cells. It was observed that the majority of the intercellular hyphae (which may consist of three to five, or perhaps more, or rarely of only two cells) take a more or less direct course towards the vascular bundles—a region abundantly supplied with available food; the fungus therefore shows a selective chemotropism.

Examples of *Phyllactinia* on *Xanthoxylum Americanum* were found to offer some striking differences with respect to the development of haustoria. The intercellular hyphae have thicker walls, and the intercellular appressoria are conspicuous, flattened, sucker-like structures pressed tightly against the cells of the leaf. So far as could be ascertained, these appressoria never give rise to the normal haustoria as in other examples of *Phyllactinia*, the only penetrating organs observed being minute tubes, bearing a vesicle apparently without protoplasmic contents. These latter Smith considers to be modified or stunted haustoria.

Neger's paper is entitled "Beiträge zur Biologie der Erysipheen" (52), and is a valuable contribution to our scanty knowledge of the subject. Some points in this paper I shall here criticise in detail, and at the same time record some observations I have made on the same subject.

Neger, by means of microtome radial sections, has carefully investigated the structure of the perithecial wall in many species of the Erysiphaceae. Summarized briefly, the following modifications of structure were found.

In *Erysiphe polygoni*, *E. cichoracearum* and *E. galeopsidis* no marked difference in the cellular structure of the lower and upper halves of the perithecium occurs. In *E. graminis*, and more markedly in *E. taurica*, the perithecial wall consists towards the exterior of several layers of very strongly thickened cells with an almost obliterated lumen. These layers of thick-walled cells are more numerous on the under than on the upper side. In consequence of this structure the perithecium becomes in a dry condition (on loss of turgescence) slightly concave on the upper surface, but never on the under surface. It may be noted here that Neger is incorrect in stating (on p. 365) that the genus *Erysiphe* (excluding *E. graminis*) is characterized by "Perithecien nicht dorsiventral," as in *E. taurica* and in many forms of *E. cichoracearum* (*e. g.* the large form on *Arctium*) the perithecium becomes in the dry state very strongly concavo-convex.

In the species of *Sphaerotheca* examined, no difference in the cellular structure of the wall in the lower and upper halves of the perithecium was found to exist; consequently the perithecium in drying contracts equally on all sides.

In the genus *Microsphaera* (*M. alni*, *M. euonymi*, *M. grossulariae*, *M. berberidis*, and *M. euphorbiae* were examined) a well-marked difference of structure in the perithecial wall distinguishes the upper from the lower side. The wall of the upper side of the perithecium is composed of thick-walled cells, and is consequently rigid, while the lower side, being composed of thinner-walled cells, is flexible. As the result of this structure the perithecium in drying becomes strongly concave on the lower surface—a fact, according to Neger's interpretation, of great biological importance.

Podosphaera resembles *Microsphaera* in the structure of the perithecia.

The genus *Uncinula* is divided by Neger into two groups—*Microsphaeroidea* and *Euuncinula*. In the first named group, in which the species *U. salicis*, *U. prunastri*, *U. macrospora*, *U. flexuosa*, *U. necator*, and *U. clandestina* were examined, the cellular structure of the perithecial wall resembles that found in the genus *Microsphaera*. In the species of this group *Microsphaeroidea*, however, the difference of structure between the tissues of the under and upper sides is even more marked. A rigid layer of cells with strongly thickened walls surrounds the perithecium on its upper surface and at the sides, while layers of delicate-walled cells having a wide lumen occur on the lower surface.

The group *Euuncinula* comprises *U. aceris*, *U. polychaeta*, and *U. circinata*. Here a differentiation exists between the cell-structure of the under and upper halves of the perithecium, but it is not identical with that found in the last group. In *U. aceris* the cells toward the upper surface have only slightly thicker walls and a slightly smaller lumen than those towards the lower surface ; in *U. polychaeta* the same characteristics are more marked ; in *U circinata*, however, exactly the converse is found. The perithecia of *U. aceris* (see monograph, p. 92) and of *U. polychaeta* become, when dry, concave on the under surface ; while in *U. circinata*, in consequence of the tissue towards the upper surface being composed of tender cells with a wide lumen and those towards the under surface being relatively thick-walled, the perithecia never become concave on the under surface, but usually become slightly so on the upper.

In *Phyllactinia* the cells of the tissue towards the base of the perithecium have a narrower lumen than those towards the upper surface; consequently the perithecium in drying never becomes concave on the under surface.

Neger considers that the difference of structure in the upper and lower halves of the perithecium which is found in many species, and which in many cases causes the under surface of the perithecium to become strongly concave on loss of turgescence, is of great biological importance. In describing the ripe perithecium of *Microsphaera astragali*, he remarks (p. 351): "Die Fruchtkörper lösen sich, wenn sie einen gewissen Grad der Reife erreicht haben, vom Substrat los, indem sich die Unterseite der Perithecien bei abnehmendem Turgor einwärts wölbt und dadurch die Mycelfäden, an welchen das Perithecium entstand, zerrissen werden. Diese constant einseitige Einwärtswölbung kommt dadurch zu Stande, dass die Perithecienwand an der Oberseite einen starren, aus englumigen dickwandigen Zellen gebildeten Panzer darstellt, während die Zellen der Unterseite relativ weites Lumen und zartere Wände besitzen. * * * Es kann demnach kein Zweifel bestehen, dass wir es hier mit einer Einrichtung zu thun haben, welche eine spontane Loslösung der Perithecien vom Substrat ermöglicht. * * * Es sei gleich hier bemerkt, dass alle (von mir untersuchten) *Microsphaera-Podosphaera-* und die meisten *Uncinula*-Arten den gleichen Loslösungsmechanismus besitzen."

According to the behavior of the ripe perithecium, Neger divides the Erysiphaceae into the following biological groups:

A. Perithecia not spontaneously falling off, mostly attached to the mycelium by their appendages: *Sphaerotheca*, *Erysiphe* (*U. circinata ?*).

B. Perithecia falling off when ripe.

  1. Detachment caused by the shrinking of the perithecium base.

    (α) Cellular tissue of upper half of perithecium formed of narrow strongly thickened rigid cells; cells of lower half delicate-walled: *Podosphaera*, *Trichocladia*, *Microsphaera*, *Uncinula* (§ *Microsphaeroidea*).

    (β) Cells of the perithecial wall of about the same size on the under and upper sides of the perithecium; on the upper side with narrow lumen, on the under with more or less delicate walls. Cells in the regions of the greatest curvature very large and flexible, becoming shrunken on the drying of the perithecium. The under surface of the perithecium consequently becomes concave. *Euuncinula* (excl. *U. circinata*).

  2. Detachment of the perithecium follows through the pressure exerted against the substratum by the appendages which turn downwards. The perithecium in drying suffers no important change of shape: *Phyllactinia*.

In connection with the statement made above that the detachment of the perithecium from the mother-mycelium is caused in many instances by the shrinking of the perithecium base, Neger remarks (p. 358): "Ich habe nun häufig beobachtet, dass die Reactionsfähigkeit der Perithecien auf Turgoränderungen sehr gross ist, d. h. dass bei Uebertragung eines Fruchtkörpers aus einem feuchtem Raum in einen Exsiccator die Gestaltveränderung sehr schnell erfolgt. Wäre es da nicht denkbar, dass bei der durch Turgorabnahme herbeigeführten Schrumpfung des Wandgewebes die Loslösung, d. h. Zerreissung der festhaltenden Mycelfäden, so gewaltsam erfolgt, dass das Perithecium eine starke Erschütterung erleidet und sich dabei auf die Seite legt (auch diese Lage ist an reife Perithecien sehr oft zu beobachten) oder sogar umkehrt? Es ist mir allerdings nicht gelungen, diesen Vorgang selbst zu constatiren."

Whether or not it be correct to consider that the detachment of the perithecium from the substratum is caused generally by the base of the perithecium shrinking and becoming concave, it may be noted that this contraction is, in one case at any rate, not essential to the process. This can be seen by observing ripe perithecia of *U. circinata.* Neger is in error in stating that the perithecia of this species do not spontaneously become free from the mycelium. If perfectly ripe examples of *U. circinata* are examined, *e. g.*, those in Ell. & Everh. Fung. Columb. n. 110 (in herb. Kew), it will be found that many of the perithecia are in a reversed position, *i. e.*, the apex of the perithecium, covered with the numerous appendages, is pressed against the surface of the leaf, while the base of the perithecium, to which there are usually a few mycelial threads attached, is exposed to view. The appendages of these fully ripe perithecia are always very numerous and well developed; and from Neger's remark that in the specimens examined by him the appendages were badly developed it is evident that he was dealing with immature material. The reversal of the perithecia of *U. circinata* mentioned above implies of course a spontaneous loosening of the perithecium from the mycelium. The perithecium, however, of this species does not, in consequence of its cellular structure (see above), become concave on the lower surface, so that it is evident that in the case of this *Uncinula* at all events some other cause brings about the detachment of the perithecium.

In many cases the perithecia of species of the Erysiphaceae appear to become free through the gradual dying away and disappearance of the mycelium.

Some observations I have made on the spontaneous detachment and reversal of the perithecium in some species of *Uncinula* may be mentioned here.

At p. 92 of my monograph I pointed out that the perithecia of *Uncinula aceris* are, from some cause, frequently turned over, and that the appendages which are thus pressed against the leaf, become mucilaginous and attach the (reversed) perithecium to the leaf. Some observations I have made since show that this phenomenon occurs in many other species of *Uncinula*. In *U. salicis* it can be seen on examining perfectly ripe examples that many of the perithecia have become turned over, so that the apices of the appendages rest against the surface of the leaf. This can be well seen in the specimens in De Thüm. Fung. austr. 655 (in herb. Kew). In a few instances, I have observed, in herbarium specimens, that the perithecia, through the mucilaginous degeneration of their appendages, have become actually fixed in this position to the leaf. It is easy to produce the same result artificially. A leaf after having been placed in water for a few minutes, and then freed from the superficial moisture, was laid on the surface of a leaf which bore numerous ripe perithecia of *U. salicis*—an example being chosen in which the appendages of the perithecia were spreading upwards. After a few hours, the superposed leaf was examined, and it was then found that several reversed perithecia were adhering by their appendages to its surface. These perithecia required a slight amount of force to be detached. Perithecia of *U. salicis* were placed upside down on damp leaves of *Hedera Helix*, and it was found after a short time that these had adhered to it by their appendages. In *U. macrospora*, *U. prunastri*, and *U. Clintonii* the same reattachment of the perithecia in a reversed position can be observed. An ivy-leaf, was laid upon a leaf of *Tilia Americana* bearing numerous perithecia of *U. Clintonii* in which the appendages were spreading upwards. After a few hours perithecia reversed and fixed by their appendages were found on the ivy-leaf.

On account of their large size, the reattachment of the perithecia can be most easily seen in *U. polychaeta.* In this species the very numerous crowded appendages spread widely, and attach the reversed perithecium by a film-like layer spreading beyond the diameter of the perithecium on every side. The mucilaginous breaking down of the walls of the appendages is very evident here, and the reattachment of the perithecium is as firm as that caused by the penicillate cells of *Phyllactinia.*

In *U. circinata,* also, if reversed perithecia are placed on a damp leaf, they will be found subsequently to have become attached to it by their appendages.

This phenomenon of the spontaneous freeing of the perithecium and its subsequent reattachment by the appendages has been the cause, I believe, of leading systematists into several curious errors. The first case that may be mentioned is that of "*Uncinula Columbiana* Selby," on *Scutellaria lateriflora* from the United States. This fungus, as I pointed out in my monograph, p. 86, agrees exactly in all its characters with *U. salicis.* *U. salicis* is only known to grow on species of *Salix* and *Populus,* and I suggested at the time that its presence on the *Scutellaria* was perhaps accidental. I feel now little doubt that we have here an instance in nature of the perithecia of *U. salicis* becoming attached by their appendages in the manner described above to a foreign substratum, in this case the leaves of a herbaceous plant. In a second case it seems quite certain that reversed perithecia of *U. salicis* attached by their appendages have been under observation. I refer to the "*U. salicis* var. *epilobii*" of Vestergren (Bot. Notiser, 1897: 256), which was described as growing at Upsala on *Epilobium angustifolium,* (see monograph, p. 87). In the description Vestergren remarks: "The most obvious presumption would be that the perithecia of the *Uncinula* in question had been transferred by the wind to the *Epilobium* from, *e. g.*, some *Salix* bushes growing in the neighborhood. Apart from the fact that there were none of the usual host-plants of *U. salicis* in the neighborhood, one must quite reject this presumption when one observes (under a slight microscopic magnification) how firmly the perithecia of the var. *epilobii* are fixed to the substratum by means of the appendages radiating on all sides." We may, I think, safely infer here that groups of perithecia of *U. salicis* must have been blown on the *Epilobium,* and adhered by the appendages in the manner described above.

In the case, also of Sredinski's (**80**) record of the occurrence of *U. salicis* on *Hedera Helix* the same explanation probably holds good.

I have seen also two specimens labelled "*Uncinula Wallrothii* on *Lonicera Xylosteum.*" The perithecia of the *Uncinula* on this plant, I have ascertained, are in the majority of cases adhering, in a reversed position, by means of their appendages; and there is no reason for believing that the *Lonicera* was serving as a host-plant (see monograph, p. 97).

It will, in all probability, be found that the example of *U. geniculata*, occurring on leaves of *Hydrophyllum appendiculatum* (see monograph, p. 112) consists of perithecia attached by their appendages.

The following remarks of Neger's require criticism. Neger writes (**54**, p. 344): "Man hat bisher, wie aus den meisten *Erysipheen* behandelnden Werken (besonders soweit dieselben mit Abbildungen versehen sind zu entnehmen ist, allgemein an der ansicht festgehalten, dass die Perithecien aller Erysipheen annähernd gleichen anatomischen Bau aufweisen. Dies ist aber ein grosser Irrthum und es ist unverständlich, wie z. B. Tulasne in seiner Carpologia von *Sphaerotheca Castagnei* eine abbildung geben konnte, die, was Gestalt und relative Grösse der Perithecienwandzellen anlangt, durchaus nicht auf *Sphaerotheca*, sondern viel eher auf *Uncinula*, oder *Erysiphe* passt." Neger is apparently unaware that in *S. Castagnei* the size of the external cells of the perithecium varies from 10–40 μ wide. Under the old name "*S. Castagnei*" were included the two plants now known as *S. humuli*, in which the external cells of the perithecium measure from 10 to 20 μ wide, averaging 15 μ; and *S. humuli* var. *fuliginea*, in which the cells measure from 20–30, rarely 40 μ, averaging 25 μ wide (see monograph, pp. 45 and 49), Neger apparently intends by "*S. Castagnei*" the segregate last-named, since he remarks: "Die Wandzellen bei *Sphaerotheca* sind im Verhältniss zum Peritheciendurchmesser auffallend gross und sind von sehr unregelmässiger Gestalt, während die Wandzellen bei *Erysiphe*, *Uncinula* und anderen Erysipheen relativ viel kleiner sind und mehr oder weniger runde oder polygonale Gestalt besitzen. Z. B. für *Sphaerotheca* resp. *Uncinula* lässt sich das Verhältniss der Grösse einer

Wandzelle zum Peritheciendurchmesser durch folgende approximative Zahlen ausdrücken: 1:5 resp. 1 : 18." Now the size of the cells in the species of *Uncinula* varies from 10 to 15 μ wide, reaching rarely to 20 μ; so that it is perfectly correct to represent the perithecial wall of some forms of "*S. Castagnei*" as being of similar structure to that of species of *Uncinula*. As regards the proportion between the number of cells and the diameter of the perithecium also, *S. humuli* type agrees with species of *Uncinula*.

Neger, it may here be noted, has raised De Bary's section "*Trichocladia*" of *Erysiphe* to generic rank, and places in the genus *Microsphaera astragali* and *Erysiphe tortilis*. I consider this arrangement undesirable for the following reasons: The two genera *Microsphaera* and *Erysiphe* are undoubtedly very closely allied, and it seems to me to be more in accordance with the principles of a natural classification to include in these genera the species which on both sides approach each other, than to take these out and base a new genus on them. Further, if we follow Neger and place *M. astragali* in the new genus *Trichocladia*, it is clearly unnatural for *M. Bäumleri*, so closely allied, to be generically separated, and we should find it impossible to draw a satisfactory line between "*Trichocladia*" (including *M. Bäumleri*) and *Microsphaera*. It still seems to me to be better to include *M. astragali*, which although certainly approaching some forms of *E. polygoni*, yet on the other hand is closely allied to *Microsphaera Bäumleri* and *M. euonymi*, in the genus *Microsphaera*, and to keep *E. tortilis* in *Erysiphe* on account of its relationship with certain forms of *E. polygoni*.

Neger (**52**, p. 337) referring to the fact that I included in my monograph under the name *Erysiphe polygoni* all plants which showed certain morphological characters, notwithstanding that they grew on the most diverse host-plants—no fewer than 190 different species of plants (belonging to 89 genera) being given as hosts, observes: "Freilich, ob diese Anschauung berechtigt ist, ist bis heute durch nichts bewiesen. Es liegen nämlich nur ganz vereinzelte auf culturversuche begründete Bestätigungen dieser gewöhnlich in extenso angenommenen Voraussetzung vor, was um so mehr auffallen muss, als doch bei anderen Pilzfamilien, z. B. den Uredineen, trotz der dort bestehenden grösseren Schwierigkeiten, die Frage der Wirthzugehörigkeit für eine grosse Anzahl von Arten durch experimentelle Untersuchungen klargelegt worden ist." Further, with reference to the fact that in my monograph a great reduction of species was made, Neger remarks : "Inwieweit dieses summarische Verfahren berechtigt ist, muss die Zukunft lehren. Hieraus ergibt sich aber das zweite, einer Lösung dringend bedürftige Problem : Welcher der bisher auf gestellten, auf morphologische Merkmale begründeten Erysipheenarten erweisen sich physiologisch als solche ? oder um die von Rostrup bei den Uredineen angewandte Bezeichnung zu gebrauchen : Werden nicht viele der bisher als morphologisch gleich erkannten Formen in 'biologische' Arten aufzulösen sein ?"

The question of the possibility of the occurrence of "biological species" in the Erysiphaceae is one of primary importance, not only from the scientific side, but also from the economic point of view—for if "biological species" do exist, then we should endeavor to ascertain if the species of mildew which cause such widespread damage to cultivated plants belong to this class. If, for instance, it were found that the "hop-mildew" constituted a "biological species," then we should know from which of the common weeds of the hop garden (*Spiraea, Ulmaria, Potentilla* spp., *Epilobium* spp., etc.) which serve as the host-plants of the morphological species called *Sphaerotheca humuli*, it could pass on to the hop ; or whether, as might possibly prove to be the case, the spread of this hop-disease is dependent on infection from hop-plant to hop-plant.

It will be well here to review the evidence with regard to this point. Direct experiments, and observations bearing on the subject are, so far as I am aware, very few in number. The experiment of taking the conidia of a mildew growing on a certain host-plant, and sowing them on the leaves of another plant has been performed by three botanists : (1) Magnus (in Bericht. deutsch. bot. Gesellsch. **16** : 68. 1898) has stated that the conidia of *Sphaerotheca humuli* (DC.) growing on the hop will germinate and produce a conidia-bearing mycelium when sown on the leaves of *Taraxacum officinale*. (2) Iwanowsky (**32**) made some experiments in connection with the *Oidium** occurring on the to-

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* This *Oidium* De Thümen described as *O. tabaci ;* it is in all probability the conidial condition of *Erysiphe cichoracearum* DC. (see monograph, p. 294).

bacco plant. Iwanowsky observed an *Oidium*, which he referred to the conidial form of "*E. lamprocarpa*" (= *E. cichoracearum*), occurring on the leaves of some Compositae, especially *Inula Helenium* and *Lappa tomentosa*. This *Oidium* he found on examination to resemble strongly the *Oidium* on the tobacco plant. To quote the author's words: "Bei der Aussaat dieser Conidien auf die Blätter der Tabakspflanze entwickelte sich in der That das Tabaks-*Oidium*; hieraus folgt, dass Letzteres zu *Erys. lamprocarpa* gehört; jedoch bildet dieser Pilz auf dem Tabak keine Fruchtkörper. In Form von Fruchtkörpern überwintert er auf den genannten Compositen und inficirt im folgenden Sommer die Tabakspflanze." (3) Neger (**54**, p. 339) records the following observations: "Auch das Nährsubstrat scheint Einfluss zu haben auf die äussere Gestalt der Conidien. Ich übertrug Conidien von *Erysiphe communis*, welche auf *Ranunculus* sp. entstanden waren, auf eine vollkommen gesunde, unter einer Glasglocke stehende Pflanze von *Galium silvaticum*; die Infection gelang; nach einigen Tagen trug das *Galium* Rasen von Conidien-trägern. Der Vergleich ergab, dass die Conidien auf *Galium* beträchtlich länger waren als diejenigen auf *Ranunculus*."

Cases apparently showing that in nature a species of mildew on one host-plant sometimes passes over to a contiguous plant of another species are mentioned by two botanists: (4) Allescher (in the Bericht. botan. Verein. Landshut, 146–152. 1887) has recorded the occurrence of *Microsphaera Ehrenbergii* (= *M. alni* var. *lonicerae*) on *Syringa vulgaris*, and has stated that the *Syringa* affected stood in the immediate neighborhood of a bush of *Lonicera Tatarica* attacked by the same fungus. On Allescher's specimen sent to me it was noted that the fungus occurred only on the branches of the *Syringa* which were close to the *Lonicera*. (5) Brannon (**8**) has recorded "*Erysiphe communis* (Wall.) Schl." occurring "on *Ranunculus recurvatus* and an aster growing in the same place which had probably received the mildew from its neighbors."

(6) Polla (in Bericht. deutsch. bot. Gesell. **17**: 67. 1899) has made some observations bearing on the present subject. This author, having observed that in certain districts only *Berberis vulgaris* and *Corylus Avellana* were attacked by *Phyllactinia*,

while other trees, growing intermixed with the *Berberis* and *Corylus* (such as *Carpinus*, *Betula*, *Fagus*, *Fraxinus*, etc.), which in other districts are liable to be attacked, here remained perfectly free from the *Phyllactinia*, was led to the conclusion "dass *Phyllactinia suffulta* eine Sammelspecies darstellt, and dass die auf den verschiedenen Nährpflanzen beobachteten Formen, wenn auch vielleicht nicht eine jede einer besonderen, doch mindestens mehreren verschiedenen, morphologische einander sehr ähnlichen oder gleichen Arten angehören, welche nur auf ganz bestimmten Nährpflanzen gedeihen. Zweifelsohne liegt bei *Phyllactinia* und wohl auch noch anderen Gattungen der Mehlthaupilze bezüglich der Speciesfrage dieselbe Erscheinung vor, wie sie bei den Rostpilzen aufgedeckt worden ist und als *Specializrung des Parasitmus* bezeichnet wird."

Reviewing the experiments given above, I should like to point out with reference to those, (1), (2) and (3), in which conidia were taken from one host-plant and sown on another, that such experiments require the greatest precautions being taken to ensure that the plant on which the conidia are sown has not been naturally infected previous to the experiment, and that it is not liable to infection during the course of the experiment. Two cases which show the necessity of the greatest care being taken in this direction have come under my notice. A plant of *Cineraria*, taken direct from a greenhouse in which the plants were apparently free from mildew, was placed in a greenhouse where the cinerarias were badly affected with *Oidium*, and kept covered over by a bell-jar. Experiments were made with the object of trying to infect this *Cineraria* with an *Oidium* occurring in the same greenhouse on *Celsia*, and for this purpose the bell-jar was removed two or three times to allow the placing of the *Oidium*-conidia on the leaf, and subsequently to observe if infection had taken place. The experiment failed, as on the marked places on the *Cineraria*-leaf where the conidia of the *Celsia-Oidium* were sown, no *Oidium* appeared. In other spots on one or two of the leaves experimented with, however, an *Oidium* began to grow, and spread gradually in large patches over the leaf, producing conidiophores in large numbers. A microscopic examination of the conidia of this *Oidium* showed that it resembled the *Oidium* that grew on the cinerarias in the greenhouse, the conidia differing from those of the *Oidium* on *Celsia* in being smaller and in possessing distinct fibrosin-bodies. It is clear, therefore, that infection must have taken place by some means from the adjacent cinerarias.

In the second case, some rose bushes in a garden were observed covered with an *Oidium*, and it was noticed after a few days that an *Oidium* had now appeared on some adjacent raspberry suckers. To ascertain if the rose-*Oidium* had really, as it appeared, spread from the rose to the raspberry, the following experiment was carried out. The raspberry suckers, mentioned above, which were attacked by the *Oidium*, were situated on one side of a garden path; on the other side of the path were two isolated suckers, both of which at this time showed no signs of *Oidium*. On one of these, conidia taken from the rose were sown, and the sucker covered over with a bell-jar. The next day it was found that this sucker was slightly attacked by an *Oidium*, which in the course of a few days spread and showed itself on most of the leaves at the apex of the sucker. During the whole time, the adjacent sucker, left untouched and uncovered, remained free from any *Oidium*. It might readily have been assumed that we had here the proof of the passing of an *Oidium* from one species of host-plant to another, but a microscopic examination showed that such was not the case. The shape of the conidia on the raspberry plants agreed exactly with that of the conidia of *Sphaerotheca humuli* (this species is recorded on the raspberry by Burrill in Ellis and Everh., N. Amer. Pyrenomycetes), and differed from that of the conidia on the rose (*S. pannosa*) in shape and size. The difference between the conidia of *S. humuli* and *S. pannosa* I have elsewhere pointed out (71). On examining the *Oidium* which appeared on the raspberry sucker experimented upon, the conidia were found to agree in shape with those of *S. humuli* and not of *S. pannosa*. It might be suggested, of course, that the difference in shape was due to the influence of a different species of host-plant on the same species of fungus, but in the face of repeated experiments (made in a garden where no raspberry-*Oidium* occurred) in which it was found that conidia taken from the rose and sown on raspberry suckers invariably failed to produce any infection, we are forced to conclude that in the first experiment mentioned above the raspberry sucker must have been already naturally infected by the *Oidium* on the raspberries before being experimented upon.

With regard to Magnus' experiment (1), I have already (monograph, p. 18) pointed out the special difficulties which arise if we consider that the *Oidium* which appeared on the *Taraxacum* really resulted from the sowing of the conidia of *S. humuli* from the hop.

Experiment (2) would seem, if scientific precautions were taken to prevent the access of other conidia to the tobacco leaf under observation, to prove satisfactorily that *Erysiphe cichoracearum* can pass from the leaves of a host-plant belonging to the Compositae to one belonging to the Solanaceae.

The acceptance of the conclusions drawn by Neger from his experiment (3) involves us in the same difficulties as in the case of Magnus' experiment. If the conidia of *E. polygoni* were really the ones that produced the *Oidium* on the *Galium* (the fact that the *Galium* plant was kept under a bell-jar does not, unless special precautions were taken, preclude the possibility of infection by other conidia having taken place) it seems strange that we do not find in nature *E. polygoni* occurring on *Galium*. It is true that many authors have recorded "*E. communis*" or "*E. Martii*"—synonyms of *E. polygoni*—on species of *Galium*, chiefly *G. Aparine*, but this has always been due, I believe, to a wrong identification of the fungus having been made, as in all cases investigated the fungus has proved to be *E. cichoracearum* (see monograph, p. 20). It is to be noted, too, that Neger expressly states that the *Oidium* which appeared on the *Galium* showed morphological differences from that on the *Ranunculus*—a fact certainly favorable to the idea that infection from some other source had taken place.

With regard to case (4) I have, through the kindness of Professor P. Magnus, seen Allescher's specimen of "*M. Ehrenbergii*" on *Syringa vulgaris*. The fungus, which is certainly growing on this host, as the presence of mycelium and young perithecia show, presents the characters of the var. *lonicerae* (= *M. Ehrenbergii*) rather than those of the *M. alni* type (which grows commonly on *Syringa vulgaris* in the United States). It seems, therefore, that we can, as Magnus (Bericht. deutsch. bot. Gesellsch. **16**: 68. 1898) has done, accept the case as affording proof that the var.

lonicerae has here passed over from the *Lonicera Tatarica* to the *Syringa*.

(5) I have not seen a specimen of the *Erysiphe* on *Aster* referred by Brannon to "*E. communis*." If the fungus has been correctly determined, it would be a remarkable instance of the passing over of the species to an unusual host-plant, as the *Erysiphe* which occurs so commonly on *Aster* in the United States has hitherto invariably proved to be *E. cichoracearum*.

It has long been noticed (*cf.* Léveillé, Ann. Sci. Nat. III. **15**: 219. 1851), that certain species of the Erysiphaceae, or examples of a species on a certain host-plant, only rarely, or (in the second case) perhaps never, produce perithecia. In connection with this subject Neger (**54**) asks the question: "Von welchen Factoren hängt die Conidienbildung, von welchen die Perithecienbildung ab?" With a view to obtain evidence on the subject, Neger kept under observation species of mildew growing on *Artemisia vulgaris*, *Ranunculus*, and *Epilobium montanum*. These were first kept at a room-temperature in a damp atmosphere under bell-jars, and it was found that under these conditions the formation of conidia was extremely luxuriant, but that no formation of perithecia took place. Afterwards, in November, the plants were placed in a cold greenhouse, in which the temperature and atmospheric conditions were similar to those occurring in the open at the normal time for the production of perithecia. It was then found that no perithecia were formed on these plants. Neger remarks also, that in nature no production of perithecia takes place, as a rule, on those host-plants which have been injured by an excessively heavy crop of conidia, and cites *Uncinula necator* on *Vitis*, *Sphaerotheca pannosa* on roses, and *S. Castagnei* on *Spiraea* as examples. Also, it is observed that when the development of conidia is slight, then an abundant formation of perithecia occurs, *e. g.*, *Microsphaera alni* on *Viburnum Lantana*, *Phyllactinia corylea* and *S. Castagnei* on *Comarum palustre*. Neger, as a deduction from these facts, and from the results of his single series of experiments, believes that an answer to the question stated above can be given as follows: "Conidienbildung wird befördert durch einen aus frischen, turgescenten Pflanzentheilen bestehenden Nährboden. Temperatur- und Feuchtigkeitsverhältnisse scheinen von untergeordneter Bedeutung zu sein. Perithecienbildung setzt einen aus älteren (meist ausgewachsenen) Pflanzentheilen bestehenden und durch Conidienfructification noch nicht erschöpften Nährboden, sowie ein mehr oder weniger reich entwickeltes Luftmycel voraus."

I cannot agree with Neger that he has here given the causes which account for the formation or non-formation of perithecia in the Erysiphaceae. We find in nature so very frequently perithecia produced on the same leaf by the mycelium which had previously produced conidia that I am inclined to look upon this as the normal course of development, and to consider the non-production of perithecia on conidia-bearing mycelium as exceptional, instead of *vice versa*, as we should be obliged to do if we accepted Neger's view. In many cases, the non-production of perithecia seems undoubtedly connected with the influence of certain host-plants on the fungus ; *e. g.*, it is only in rare cases (see monograph, p. 202) that *Erysiphe cichoracearum* produces perithecia on cultivated plants of *Cucumis* and *Cucurbita*. Further, it is to be noted that when perithecia do occur, they are found (in the case of the fungus on *Cucurbita Pepo* (vegetable marrow), not on distinct parts of the host-plant, but in the midst of the parts covered with the *Oidium*-bearing mycelium. Exactly the same occurs in the examples of *E. cichoracearum* on the tobacco plant. On several species of *Myosotis* an *Oidium* occurs which has been commonly referred to *E. cichoracearum*, but neither on living plants, nor on the numerous specimens in exsiccati and herbaria, have I ever been able to find any perithecia. In conformity with the rule which obtains for many parasitic fungi, the normal course of development for the Erysiphaceae consists of two phases—a conidial stage in which successive crops of conidia are produced during the summer months when the host-plant is growing vigorously, followed (omitting exceptional cases) by a formation of perithecia at the time when the life of the host-plant begins to fail, so that resting-spores (here represented by the ascospores are formed in order to continue the life of the fungus in a dormant condition through the winter when no host-plants are available. This relation to food-supply may be compared with the well-known fact of the production in the Zygomycetes of zygospores, which can be artificially induced at any time by diminishing the food supply of the fungus.

It may be remarked here that little is known in connection with the germination of the ascospores. Wolff succeeded in germinating those of *Erysiphe graminis*, and in infecting grass leaves with them, but apparently no one since has repeated the experiment. Galloway germinated the ascospores of *Uncinula necator*, but failed in all attempts to infect leaves with them. In September, 1900, I placed a number of leaves bearing ripe perithecia of *Erysiphe tortilis* on the ground. These leaves were fully exposed to the weather, and were kept in every way under natural conditions. From time to time during the winter the dried remains of the leaves bearing still numerous perithecia were examined, but no opening of the perithecium or change in the appearance of the asci or ascospores was found. Finally, in the early summer of the next year, all the material was examined, consisting of about twenty perithecia on fragments of leaves, and it was then found that externally the perithecia appeared quite unchanged. On opening the perithecia it was found that many of the ascospores had collapsed, and in the surviving ones no germination could be induced. It may be worth noting that in *E. tortilis* the appendages of the perithecium are very persistent, being found little changed at the end of eight or nine months of exposure. In *U. necator* Galloway found that the appendages soon disappeared on exposing the perithecia to the weather.

With regard to the sudden appearance of "*Oidium*" on plants, it has long been remarked that it is especially liable to occur after cold nights. Some experiments I have made (71) in connection with the germination of conidia seem to give some direct evidence on this subject. In the case of *S. humuli* on strawberries it was found that the conidia when sown in hanging drops at ordinary temperature showed only a feeble germination. On subjecting the conidia, however, before being sown to a low temperature—either by placing them on blocks of ice, or by subjecting leaves bearing conidia to a temperature of 0° C. the germinating power shown subsequently was very perceptibly greater. As I have already (71) remarked, it would appear, therefore, that in nature a decrease of temperature may cause plants to be attacked by mildew, not only because the vitality of the plants may perhaps be weakened, and so rendered less able to withstand the attacks of parasites, but also by directly increasing the germinating powers of the spores of the parasitic fungus. Eriksson ("Ueber die Förderung der Pilzsporenkeimung durch Kälte," Centralbl. für Bakter. und Parasitenk. **1**: 557–565. 1887) has also experimented on the same lines with regard to the germination of uredospores, and found that cooling down to freezing point had a favorable influence on their germinating powers.

As Zopf (**90**) has pointed out, bodies of a definite shape are found in the cell-contents of the conidia of certain species of the Erysiphaceae. These bodies are composed of a substance which Zopf calls fibrosin, and which he states to be almost indistinguishable in its reactions from fungus cellulose. The bodies are minute, the largest measuring 6–8 μ in the greatest diameter, and are of varied shape, flattened discs, conical and hollow, or cylindrical. These fibrosin bodies belong to the group of carbohydrates, and according to Zopf function as reserve material; he observed that on the germination of the conidia the fibrosin bodies were gradually absorbed. They were first observed in the conidia of *Podosphaera oxyacanthae*, but were also seen by Zopf in *Sphaerotheca* and in some species of *Erysiphe*. Neger (**54**) has observed them well-developed in the conidia of species of *Uncinula*, but states that in *Microsphaera* they appear to be absent or almost too small to be visible. Zopf's statement, however, that these fibrosin bodies constitute the only case known in fungi in which a carbohydrate serves as reserve material—in the place of fat or oil—is erroneous, as other carbohydrates are known to occur not uncommonly (see Errere in Ber. deutsch. bot. Gesellsch. **5**: lxxvi. 1887).

Harper in an important paper in the Annals of Botany (**25**), in which the question of relationship of the Erysiphaceae to other fungi is discussed, replies in detail to the article of Dangeard (**14**) in which an attempt is made to discredit Harper's previously published account of the development of the perithecium in *Sphaerotheca*.

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(To be continued.)

Dasyscypha resinaria causing Canker Growth on Abies balsamea in Minnesota

BY ALEXANDER P. ANDERSON

(WITH PLATES 1 AND 2)

In the fall of 1896, while collecting plants in the vicinity of Walker, on Leech Lake, northern Minnesota, the writer noticed that the trunks and larger branches of *Abies balsamea*, which grows abundantly in the bogs around this place, were affected to a great extent with some fungus or insect, producing numerous canker-like growths and swellings on the stems. This was true especially of the lower part of the tree trunks, and around the branches that had been shaded out and had died on account of an insufficient amount of light. On some trees almost every knot and dead branch was surrounded by one or more of these canker swellings, the canker not infrequently extending all around the tree trunk, or branch (*fig. 2*). When younger stems or branches were affected in this way the portion above the canker, and often the whole stem, had been killed by the girdling (*fig. 1*).

The trees and cankers were carefully examined, to see whether the cause of the deformation might not be due to insects, like the one causing the common tumors and "witch-brooms" on *Picea nigra* * which also grows in the bogs of northern Minnesota. No *Chermes* nor other insect of any kind was present on the affected trees, nor could any indications of any be found, either on the surface of the trees, or on the inside of the bark and wood.

The rough bark of the canker was found to have on it, numerous ascomata (*fig. 3*) which were very similar to those of *Dasyscypha calycina* (Schum.) Fuckel (*D. Willkomii* Hartig), the com-

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* These "witch-brooms" on *Picea nigra* sometimes become a meter or more in diameter and are usually spherical, when full grown. They are caused by some species of *Chermes*—probably *Chermes abietis*. Compare von Tubeuf, Forst-naturw. Zeitschr. **2** : 76. *pl. 5*. 1893; Anderson, A. P., Bot. Gazette, **24** : 312. 1897; and Brodie, W., The spruce Gall-louse, Ontario Department of Agriculture Bureau of Forestry, Toronto, May 1, 1893 In the last, mention is made of *Chermes abietis* as occurring on *Picea nigra* and *Abies balsamea* in Canada.

mon larch canker-producing fungus of Europe, which were familiar to the writer in their living and natural condition. The canker swellings and deformations had much the same appearance as those caused by *D. calycina*, especially in the profuse resin exudation and flow from the wound.

The external character of the canker-swellings and the presence of the ascomata, which were found only on the affected parts, led me to believe that the fungus, if not *D. calycina*, was a parasitic one, closely related to the larch canker, *Dasyscypha*, of Europe.

Material of the affected stems and fungus was collected at the time, which has since been worked up. The more important characters of the fungus and its effect on the stems are given in this paper.

THE FUNGUS

The ascomata are found only on the bark of the canker-swellings and deformations on living trees or on the similar swellings on branches and stems which have recently been killed by the cankers. The fungus is not present on the bark of any other part of the tree.

The ascomata are stipitate when mature, but sessile in their developing condition (*fig. 3, a*). The cups of immature and mature ones are approximately of the same diameter—one-half to one millimeter across. The stipe varies from one-fourth to one millimeter in length. The whole ascoma is covered over with pilear hairs (*fig. 3*), which are longer and more abundant on the cup, especially around the disc, than on the stipe (*figs. 4 and 6*).

The hairs, which surround the disc, project upwards perpendicularly to the disc when the ascoma is wet or moistened, but when in a dry condition the hairs of the fringe are turned inwards and almost cover and exclude the disc from view. The reason for this movement will be explained later in the paper. The disc is slightly orange colored, seen best in younger ascomata, soon after they have opened. The stipe and surface of cups of mature ascomata are grayish, becoming whitish and more easily seen on the bark, when in a dry condition. The ascomata, although of a leathery consistency, become brittle and easily drop off when dry.

Sections of the ascoma shows it to correspond, in its structural characters, to those of the Helotiaceae, so well described and figured by Durand,* and to the genus *Dasyscypha.*

The asci are small, cylindrical and slightly club-shaped, tapering at the base, and becoming broader towards the rounded apex. They vary in size from 2.5 × 20 to 4 × 30 μ. The ascus wall is extremely hyaline and difficult to find and measure. It can usually be made out, however, in thin sections, from the position of the spores which lie eight in a row, appearing as if the ascus wall had dissolved away, leaving the spores in their position (*fig. 5*).

The spores are elliptical and extremely small. They vary somewhat in size, the lower ones of the ascus being smaller than the ones nearer the apex. Measurements of spores in several asci gave the following: 1.66 × 2.5 μ, 1.95 × 2.6 μ, 2.07 × 3.0 μ, 2.29 × 3.07 μ, 2.49 × 3.5 μ.

The paraphyses are cylindrical, tapering slightly at the base and are rounded at the tip; otherwise they are of the same diameter throughout. They are about one and one-half to two times as long as the asci, and vary in diameter from 0.8 to 1.5 μ. The asci and paraphyses are free at their ends, there being no epithecium present.

The hypothecium consists of a thin layer of closely interwoven and extremely slender hyphae, which are made out with difficulty.

The excipulum (peridium) is made up of two not clearly differentiated portions, the medullary and the extal. The medullary consists of more loosely interwoven, colorless hyphae, which run in all directions, filling up the upper central portion of the stipe and forming a thin layer below the hypothecium. The extal layer of the excipulum consists of longer, thick-walled and closely interwoven hyphae, which are more regular in their course, running almost parallel with each other and with the surface of the ascoma. Some of the extal layer hyphae change their course or become separated from the other and project from the surface of the ascoma, forming the so-called hairs or pili. These pili or projecting hyphae have a greater diameter (3 to 4 μ) than any of the extal

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* Durand, Elias J., The classification of the Fleshy Pezizineae with Reference to the Structural Characters illustrating the Bases of their Division into Families. Bull. Torrey Club, **27**: 481. 1900.

hyphae (1 to 2 μ), from which they grow. The pili are shortest on the stipe of the ascoma (40 μ long) and longest on the margin of the cup (80 μ), where they form a fringe of hairs which project vertically upwards, when the cup is moist and open, but are turned inwards, almost covering and meeting in the center of the disc, when the ascoma is dry (*fig. 6*).

This movement of the fringe of pili, surrounding the disc, is a hygroscopic one, due to tissue tensions. Thus the longer, thicker-walled and more compact peridial hyphae, running up and down and almost parallel with each other and with the surface of the ascoma, would, on drying, contract less than the medullary portion, consisting of loosely interwoven and thinner-walled hyphae, running more or less in all directions. As a consequence, when the ascoma dries the greater contraction of the medullary portion tends to pull in, or draw down, the hymenium, making it more concave, and at the same time causing an inward curvature of the fringe of hairs which project from the margin of the peridial portion extending around the hymenium. The pili or projecting hyphae, forming the fringe, do not curve, but remain at the same angle to the peridial substratum which makes this hygroscopic movement.

The pili, projecting from the surface of the ascoma, especially those forming the fringe around the disc, are dotted over with minute particles of, what appears to be calcium carbonate (*fig. 6*). The particles disappear when sections are placed in a weak solution of either acetic or hydrochloric acid. I have not been able to notice any evolution of carbon dioxiode from acid treated sections under the microscope. The differences in color of the ascoma in its wet and dry condition, is due partly to the presence of these particles on the pili.

IDENTIFICATION OF THE FUNGUS

The ascomata, as well as the cankers, in their external characters, resembles those of *Dasyscypha calycina* (Schum.) Fuckel, which has been found in the United States. It was collected by Judge Peters in Alabama, on *Pinus*.* Tubeuf also states that the

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* Underwood, L. M., and Earle, F. S., A preliminary List of Alabama Fungi. Bull. Ala. Agric. Exp. Sta. 80: 202. 1897.

larch canker *Dasyscypha* occurs in the United States * and further that it is the only parasitic species in the genus *Dasyscypha.* Since the publication of Tubeuf's "Pflanzenkrankheiten," however, Wagner † has found that *Dasyscypha calyciformis* (Willd.) Rehm, is parasitic on *Pinus silvestris*, *Abies pectinata* and *Picea excelsa*, in Germany. These two are the only parasitic species of *Dasyscypha* that have heretofore been reported, but there can be no doubt but that more of the ones inhabiting the bark of living trees, will be found to be parasitic, when a careful examination of these is made

That the Minnesota *Dasyscypha* on *Abies balsamea* is neither *D. calycina* nor *D. calyciformis*, is shown by the extreme minuteness of its spores, which are smaller than those of any of the species which it resembles. The ascoma resembles that of *D. Agassizii* B. & C., but is much smaller. The size of the ascoma, as well as that of the spores, agrees most closely with those of *D. chamaeleontina* (Peck) Sacc. described by Peck‡ from specimens collected at Sandlake, New York, on the under surface of hemlock-wood lying on the ground. Peck states that there is scarcely any appearance of hairiness on the cups, and that when the cups are bruised, they change in color from white to yellow, then to pink or red. The cups of the Minnesota *Dasyscypha,* do not change in color when crushed, nor are its spores "stipitate" as in *D. chamaeleontina.*

All the characters of the Minnesota *Dasyscypha* correspond most closely with those of *Dasyscypha resinaria* (Cook and Phil.) Rehm., which has been found in North Wales and in Hungary. It resembles this species so closely that there can be no doubt as to its being this one. In the following table, comparisons are made between the closely related species :

Inthe original description of *D. re sinaria*§ the size of the spores was give as 5 × 2.5 μ. This was found by Massee‖ to be too large, as shown by the following, copied from Massee's de-

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* Tubeuf, K. von, Diseases of Plants induced by Cryptogamic Parasites. English translation by Dr. W. G. Smith, 271.

† Wagner, G., Beiträge zur kenntniss d. Pflanzenkrankheiten. Zeitschr. Pflanzenkrankheiten, **6** : 321. 1896.

‡ Peck, C. H., Reg. Report, **30**: 60.

§ Grevillea, **3** : 185. 1875; and Phillips, British Discomycetes, 242. 1887.

‖ Massee, George, British Fungus Flora, **4** : 344.

	D. calycina (Schum.) Fuckel. (*D. Willkomii* Hartig.)	D. Agassizii B. & C.	D. chamaeleontina (Peck) Sacc.	D. resinaria (Cooke & Phil.) Rehm.	Minnesota Dasyscypha. D. resinaria (Cooke & Phil.) Rehm.
Ascomata.	Gregarious and scattered. Stipitate, hairy; hairs 100 to 150 × 4 μ.	Bunched or fascicular. Only slightly stipitate and hairy.	Short stiped and slightly hairy.	Gregarious and stipitate. 1.5 mm. high. Externally whitish and hairy; hairs unbranched; septate and with particles of $CaCO_3$; unbranched.	Gregarious and stipitate. 1–1.5 mm. high when mature. Externally grayish and hairy; hairs 40–80 × 3–4 μ; septate (?) and unbranched.
Disc.	Expanded when moist. Concave when dry. 1–3 mm. broad. Orange yellow.	Flattened when moist. Concave when dry. Margin undulating. 1–3 mm. broad; orange.	Disc expanded. 0.13–0.5 mm. broad; reddish.	Margin usually incurved; .75–1 mm. across. Concave; pale orange.	Margin incurved when dry, but open when moist; 5–1 mm. across; concave when dry; pale orange.
Asci.	Cylindrical, obtuse and 8-spored.	Subcylindrical.	Clavate. 25–35 μ long.	Small, cylindrical and clavate; 8-spored.	Small, cylindrical, clavate. 2.5–4 × 20–30 μ. 8-spored.
Spores.	Elliptical-fusiform. 18–25 × 6–8 μ.	Elliptical. 6.5–7.5 × 4 μ.	Oblong-ovate. Subulate and stipitate. 5 μ long.	Elliptical and hyaline, smooth, 3 × 1.5–2 μ. 5 × 2.5 μ according to Phillips.	Elliptical and hyaline, smooth; 3.5–2.5 × 2.4–1.6 μ.
Paraphyses.	Slender and cylindrical.			Slender; 15 μ thick; longer than the asci.	0.8–1.5 u thick; longer than asci.
Habitat.	On *Pinus* and *Larix*. Europe and United States, America.	On *Abies*. Lake Superior, etc., and an *Pinus contorta* in California.	On *Tsuga Canadensis*, Sandlake, N. Y.	On *Abies excelsa* in N. Wales and in Hungary.	On *Abies balsamea* at Walker, Minnesota.

scription: "Described from specimens in Phillip's Elv. Brit., no. 66. The size of the spores—5 × 2.5 μ—as given by Phillips in Disc. Brit., is certainly too large. I have never found them above 3 μ long."

The spores of the specimens found in Hungary were 3 × 2.5 μ; also smaller than the size given by Phillips in his description, but of same size as spores of specimens found in Minnesota.

No European specimens of *D. resinaria* have been examined by the writer, but the descriptions of it correspond so closely with the Minnesota *Dasyscypha*, that there can be little doubt about the two being the same species.

THE CANKER

The characteristic smooth bark of *Abies balsamea*, becomes rough at the canker spot, by the formation of ridges and bark projections, soon after the infection has taken place. The outer bark (peridium and epidermis) does not become hypertrophied, but is broken through, and scales off, sooner than normally, on account of the increased growth of the inner layers of the bark, which become hypertrophied.

PRIMARY CORTEX (MIDDLE BARK)

In the bark of the canker, the periderm as well as the primary cortex, and outer layers of the secondary cortex, are very soon cut off by the formation of a new phellogen layer. This causes the death of the cut-off layers of the bark which dry up sooner than in the normal. The resin-canals are also cut off and disturbed and their resin contents begin to diffuse into the surrounding tissues, but mostly collect in the resin-vesicles or "blisters," which are also formed sooner in the primary cortex of the canker than in the normal bark. The vesicles of the canker depart from the normal, especially in their size (*figs. 7 and 8*), being either abnormally large or small. The resin of the canker vesicles is forced out by the increased pressure on the vesicle, by the shrinkage of the surrounding dead layers of the bark, cut off by the new phellogen. The resin thus forced out runs down the trunk of the tree, the more volatile substances evaporating, leaving the solid resin, which hardens and gives the trunk a glazed appearance easily seen at some distance from the tree. The exudation of resin from the canker spot, however, is not due entirely to the early drying and forcing of the resin out of the vesicles, but also to an increased resin secretion at the cambium and parenchyma cells of the secondary cortex. The resin-canals and vesicles for the storage and reception of the resin having, as explained, already been cut off, a part of this resin diffuses into the outer dry bark but the remainder is forced to the surface where it collects in drops (Fig. 3, *e*) which hardens as soon as exuded, or when the exudation is profuse a part of the resin flows down the trunk.

THE SECONDARY CORTEX (INNER BARK)

The cambium at the canker spot produces an increased number of cortical as well as wood-cells. The secondary cortex does not depart much from the normal in its structures, except in its increased thickness, often eight to ten times that of the normal, due to the greatly increased number of cells formed. The secondary cortex is normal in that it does not contain any resin-canals nor resin-vesicles.

THE WOOD

The annual rings of the wood formed at the canker are wider than those formed before the infection. This increased width of the rings is due to an increase in the number of tracheids produced by the cambium. These tracheids, as well as the cells of the medullary rays, are usually of a greater diameter than the normal, which also accounts for the greater width of the rings formed at the canker.

This increased growth of wood and cortex takes place anywhere the cambium still remains alive. In all of the cankers examined, the cambium had been killed, usually about the center. The dead spot varies in size in different cankers but it seldom extends completely around the stem or branch. When it does, as in *fig. 1*, the branch becomes girdled at this place and soon dies. More often the dead area is small, remaining about the same size for a period of years. An effort is made by the living cambium surrounding the dead area to heal it over. This it is not able to do on account of the fungus mycelium. With the increase in the number of annual rings of the wood a cavity or pocket is thus formed at the dead spot. Often several such cavities are formed when the cambium has been killed at more than one spot. All these cavities or pockets are always filled with hardened resin, forming one or more resin-pockets or "resin-galls." *

These resin-pockets are formed at first between the bark and wood where the cambium has been killed, but they are later enclosed in the wood by the formation of new annual rings of wood (*fig. 7*).

The normal wood of *Abies balsamea* does not contain any resin canals, but in wounded and hypertrophied wood, such organs are not infrequently formed. The writer has already called attention to the occurrence of pathogenic resin-canals in the tumors formed by *Aecidium elatinum*, when affecting the branches of *Abies balsamea.* †

The wood of the canker invariably contains pathogenic resin-canals, which are similar to those formed in tumors caused by the *Aecidium* (*fig. 10*). The canals are all vertical ones, no horizontal canals are formed. The canals vary in diameter from 25 to 85 μ and in length from a few millimeters to 2–4 centimeters. They do not extend through the whole length of an internode or year's growth, like the normal resin-canals of *Pinus* and *Picea.* In the wood of *Abies* the canals are formed in groups or chains on one side of an annual ring and usually in the spring wood (*figs. 7 and 8*). Usually only one chain or ring of canals is formed each year, but sometimes two are formed in the same ring, one in the spring and one in the fall-wood zone. Not infrequently, a chain of canals is formed in the fall at the end of the growing season and another one the following spring in the new wood (*fig. 8*). In this case, it seems that the abnormal resin secretion, necessitating the formation of the canals, begins in the late fall or summer, when it is not completed, but continues the following spring. A new set of canals are now formed at the cambium, the canals formed in the fall having in the meantime become thick-walled and their resin contents hardened.

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* It appears that resin-pockets would be a better term than "resin-galls" ("Harzgallen") with which to designate the solid masses of resin which are not infrequently found in the wood of the Abietineae, since the term gall conveys the idea of a visible hypertrophied living part of a plant organ caused mainly by insects and fungi.

† Bot. Gazette, 24 : 337.

The canals of the chains are separated only by one or two medullary rays and very few tracheids are formed in the zone of the resin canal chain. The lining cells of the canals are of parenchymatic origin, shown by the numerous simple pits present in their walls. Wound parenchyma cells are always present in the canal zone. These cells are thick-walled and simple pitted and are best seen in tangential sections (*fig. 11*).

The lumina of many of the canal lining-cells are filled with hardened resin. The same is true also of many of the tracheids surrounding the canals. These "resin-cells" (*figs. 9 and 10*), are also present in the normal wood of *Abies balsamea*, but fewer than in the canker wood. They are not uncommon in the wood of other genera of the Abietineae. *

In trunks and branches with several canker spots (*fig. 2*) the wood of the apparently healthy portions of the stems between the swellings contains chains of pathogenic resin-canals. These chains are present in the apparently normal wood, even at a distance of 20 cm. from the canker spot (*fig. 9*). The formation of these canals is not due directly to the presence of the fungus mycelium, which does not spread more than one to two centimeters outside of the canker spot, but to the pathological condition of the whole tree when many cankers are formed on its trunk. The chains of canals in the canker-wood and those in the apparently normal wood at some distance from the canker are similar in every respect.

The resin-canals in the wood of *Abies balsamea* affected with this fungus are similar in their characters and distribution in the rings to the chains of canals found in the normal wood of *Abies firma* of Japan. According to Dr. Nakamura † the canals in the wood of *Abies firma* are formed only in the fall-wood zone, where they are arranged in a chain or arc, with approximately one canal for every four tracheids. Vertical canals only, and no horizontal ones, are formed. The cells lining the canals are also like those in *Abies balsamea*, thick-walled and provided with numerous simple pits.

The resin-canals in *A. balsamea* are similar also to those formed

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* Mayr, Heinrich, Harz der Nodelpölzer, Berlin, 8o 1894.

* Nakamura, Dr. Yaroku, Ueber den Anatomischen Bau des Holzes der Wichtigsten Japanischen Coniferen. Unters. Forst. botan. Inst München, 3 : 17. 1883.

in the wood of branches of *A. pectinata*, produced experimentally by Nottberg * who fractured the branches by partly bending them. The characteristic canal chains were formed in the wood near the fracture, three months after the wound had been made.

Hartig † found the same pathogenic resin-canal chains in the wood of trees of *Abies pectinata* that had been injured by lightning.

Resin-canals in the wood of species of *Abies* appears to be not an uncommon occurrence. They are formed only when the wood has been wounded mechanically in some way or when it becomes hypertrophied by the presence of certain fungi at the cambium.

PARASITISM OF DASYSCYPHA RESINARIA

Although the writer has had no opportunity to make infection experiments with a view to determine for a certainty that the cankers formed on the trunks and branches of *A. balsamea* are caused by *D. resinaria*, there can be little doubt but that they are caused by this fungus, which is always found on the bark of the canker spots only and nowhere else on the trees.

Like the European larch canker *Dasyscypha*, *Dasyscypha resinaria* fruits on the canker bark after the branch or stem affected has been killed. As far as was possible to make out, this fruiting on the dead stems continues only for one season after the stems have been killed by the parasite. Dead branches which have dropped from the tree have no ascomata on them excepting on the canker spots, and on these only when the branch has dropped off within a year previous.

The absence of insects and the presence of the mycelium in the bark, as well as at the cambium of the canker; also the absence of the ascomata on the normal bark of the living tree, as well as on stems that have been dead for more than one year, seems, at present, to be sufficient evidence for including *Dasyscypha resinaria* among the parasitic species of this genus. The infection takes place, as a rule, around the base of the imperfectly self-

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* Nottberg, Dr. P., Experimental-Untersuchungen Uber die Entstehung der Harzgallen und Verwandter Gebilde bei Unsere Abietineen. Zeitschr. Pflanzenkrankheiten, 7 : 142. 1897. Also in Archiv der Pharmacie, 235 : 256. 1897.

* Hartig, Dr. R., Untersuchungen über Blitzschläge in Waldbäumen. Forst. naturwiss. Zeitschrift, 6 : 150. 1897.

pruned branches of the lower part of the trunk. At these places the spores gain access to the living inner bark and to the cambium, where they germinate and cause the increased growth of the wood and secondary cortex. Wounds caused by insects and by hail and by the breaking of the branches by snow and ice, also expose the cambium to the fungus spores.

Explanation of Plates 1 and 2

FIG. 1. Dead branch from affected tree, with canker swelling at *a*, completely surrounding the branch. Ascomata (not visible in the figure) are present only on the hypertrophied bark of the canker, ⅛ natural size.

FIG. 2. Portion of affected trunk with three canker swellings; *a*, dead branch around which a small canker has formed and at the base of which the infection took place; *a′*, dead branch with older canker which has spread almost around the trunk; *b*, hypertrophied bark, consisting mainly of the secondary cortex, ¼ natural size.

FIG. 3. Magnified portion of bark, at canker, with unopened ascoma at *a*, and mature one at *b*; at *a* and *c* is shown a drop of exuded and hardened resin, × 30.

FIG. 4. Section of ascoma, × 30.

FIG. 5. Section of ascoma through hymenium and sterile portion; *a*, hymenium; *b*, hypothecium; *c*, medullary portion of excipulum; *d*, extal layer of excipulum; *e*, pili, × 450.

FIG. 6. Portion of cup with pili forming the fringe around the disc; *a*, particles of excreted calcium carbonate with which these hairs are dotted over, × 125.

FIG. 7. Cross section of stem, through canker; *a*, resin vesicle in primary cortex, larger than normal ones on opposite healthy portion of stem; *bb*, two chains of pathogenic resin-canals; *c*, resin-pocket formed where cambium had been killed; filled with hardened resin, × 1½.

FIG. 8. Section through portion of canker; *a*, resin vesicle of greater diameter than normal; *bb*, two chains of pathogenic resin-canals, one in fall and the other in spring wood of the following year, × 15.

FIG. 9. Part of cross section of apparently healthy wood, 6 centimeters below the canker spot; *a*, pathogenic resin-canals; *b*, "resin cells," lumina of which are filled with hardened resin, × 160.

FIG. 10. Part of cross section of wood at canker, with pathogenic resin-canals (*a*) and "resin-cells" (*b*), × 160.

FIG. 11. Tangential section through a chain of pathogenic resin-canals; *a*, wound parenchyma; *b*, lining cells of resin-canals; *c*, medullary rays, × 160.

Tilletia horrida Tak. on Rice Plant in South Carolina

By Alexander P. Anderson

At the time of the discovery of the smut on *Oryza sativa* L., in South Carolina, in 1898, the somewhat close similarity between it and the then already described *Tilletia corona* Scribn. (now *T. rotundata* (Arth.) Ell. & Ev.), led the writter to suppose that the rice smut in South Carolina was identical with *T. rotundata* (Arth.) Ell. & Ev., which had been found on *Panicum* and other grasses in the United States.

Shortly before, in 1896, Takashi described a new smut on the rice plant in Japan.* In my paper † the original description of *T. horrida* Tak. was copied, and the suggestion made that the South Carolina rice smut and the one in Japan might be the same. No specimens of *T. horrida* had at that time been seen by the writer, but since then it has been found in seed rice imported from Japan. The spores and affected ovaries of the Japanese rice smut, and the South Carolina one, are identically the same in all their characters, so that there can be no doubt but that the rice smut found at Georgetown, South Carolina, was introduced through seed rice imported from Japan.

Upon inquiry I found that Japanese seed rice had been sent to Georgetown, South Carolina, by the Clyde Steamship Company in 1896 and experimented upon by two planters near Georgetown,‡ which explains the appearance of *T. horrida* Tak. at this place.

That the rice smut at Georgetown, South Carolina, was *Tilletia horrida* Tak., has already been called attention to by Professor F. S. Earle.§ This had probably been overlooked by Professor L. H. Pammel in his recent bulletin on the Grasses of Iowa,‖ where he makes mention of *Tilletia rotundata* (Arth.) Ell. & Ev., as occurring on the rice plant in South Carolina.

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*Tokio Bot. Mag. 10: 20. 1896.

† Bot. Gazette, 27 : 472. 1899.

‡ Bull. S. C. Agric. Exp. Sta. 41 : 13.

§ Bot. Gazette, 28: 138. 1899.

‖ Iowa Geol. Survey Bull. 1 : 253. 1901.

Massee makes no mention of *T. horrida* Tak., on the rice plant. He had evidently overlooked it at the time of the publication of his monograph on *Tilletia.*[*]

On account of the mistake made by me in my first paper, on the South Carolina rice smut, published soon after its discovery, there appears to be some confusion as to its name, which I hope the above note will correct.

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[*] Bulletin Kew Gardens, London.

Seeds and Seedlings of Arisaema triphyllum and Arisaema Dracontium

BY ROSINA J. RENNERT

(PLATE 3)

Some interesting facts in the germination of the seeds of *Arisaema Dracontium* have been recently described by Dr. MacDougal, and the author has devoted a greater part of the last year to the comparative study of the morphology and physiology of the seedlings of this species and of *A. triphyllum.* Some attention was also given to seedlings of a hybrid between the two species and those of *A. flavum* from Sikkim, India.

It was previously found by Dr. MacDougal that the plumule of *A. Dracontium* emerges from the cotyledonary sheath only in a small proportion of the seedlings, and that only a few of those emerging exhibited a development sufficient to carry the lamina of the first leaf up into the air and unfold it to the light.*

According to Braun, the closely related species *Arum maculatum* displays a similar behavior. He says "So spielt auch an der Keimpflanze die Niederblattbildung eine grossere Rolle, als bei *Calla*, in dem nach Irmisch auf dem Cotyledon zunachst mehrere unterirdische vegetirende Niederblatte folgen bevor ein Laubblatt, und zwar erst im zweiten Jahre zum Vorsche in kommt."† This statement seems to have escaped the notice of Scott and Sargant who have recently made an extended study of these seedlings.‡

The seedlings of *A. triphyllum*, on the other hand, send up a plumule as soon as the hypocotyl is firmly established in the soil, while the hybrid between *A. Dracontium* and *A. triphyllum* displays a curiously intermediate type of germination. The hypo-

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* MacDougal, D. T. Seedlings of *Arisaema*. Torreya, 1 : 2. 1901.

† Braun. Ueber das Vorkommen mehere Hullblätter am Kolben von *Arum maculatum* L., *Calla palustris*, und *Richardia Africana* Kth. Verh. bot. Ver. Brandenburg, 1 : 94. 1859.

‡ Scott and Sargant. On the Development of *Arum maculatum* from the Seed. Annals Bot. 12 : 399. 1898.

cotyl, in this case, increases in size at first without sending up a plumule, and it is only after the seedling has exhausted the entire food supply of the endosperm and has separated from the seed that the plumule appears.

Like *A. triphyllum* the Indian species, *A. flavum*, follows the normal type of germination, and its plumule arises shortly after the hypocotyl emerges from the seed. The seedling is only about one half the size of that of *A. triphyllum*.

As the general structure of the seedling of *A. triphyllum* resembles most closely that displayed by *A. Dracontium*, this species was chosen as a basis for comparison in the study of the curious variations of *A. Dracontium*.

The fruits of *A. Dracontium* and *A. triphyllum* are very similar. In both the scarlet berries, which have a sweetish, slightly acrid taste, are closely crowded upon the spadix. The berries of *A. Dracontium* are larger and fleshier than those of *A. triphyllum* and contain from three to six seeds, while those of *A. triphyllum* are one- or three-seeded. In shape the seeds of both are somewhat ovoid. At the hilum, the seed of *A. Dracontium* is generally puckered into two or three ridges and the short stalk of the funiculus is conspicuous, while in *A. triphyllum* the seed is flattened in the hilar region, but also bears a prominent funiculus. Elsewhere the seeds are well rounded, except when flattened by the pressure of other seeds in the same berry. Both seeds bear a rudimentary aril which consists of a small disc-shaped fleshy mass situated immediately inside the coats at the hilar end of the seed, and extending as a core down the funiculus. The average size of the seeds of *A. Dracontium* is 3.5 mm. in transverse and 4.25 mm. in longitudinal diameter, while the average seed of *A. triphyllum* is 4 mm. in transverse and 3.5 mm. in longitudinal diameter, almost exactly reversing the proportions of *A. Dracontium*. When only a few are produced in a berry, the seeds of *A. Dracontium* are larger in both axes than those of *A. triphyllum*, which develop singly. When, however, a number of seeds mature in the same berry they develop in such a position as to exert a lateral pressure upon each other and in consequence the transverse diameter remains shorter. In these cases the seeds of *A. Dracontium* do not attain the size of even the smallest of *A. triphyllum*. On the whole, however, *A.*

Dracontium has the larger seed. The surface of both seeds is finely pitted and sometimes minute reddish spots are to be seen upon them. *A. triphyllum* has a yellowish color and *A. Dracontium* a reddish-yellow blush. This color is due to substances in the wall of the inner coat of the seed, as the testa is translucent.

In the general microscopic structure the seeds present only slight dissimilarities. The outermost row of cells in the testa of both species are brick-shaped and are set close together with their long axes at right angles to the radius of the seed. In both the walls of this outer row of cells are mucilaginous, swelling greatly when they come in contact with water. In *A. Dracontium* they are slightly larger and their outer walls are considerably thicker. A cuticle covers this row of cells in both species. Some of the cells below the outer row of the testa contain tannin, others are filled with mucilage in which raphide cells are imbedded, still others have a red coloring matter within them. It is to these latter cells that the dotted appearance sometimes noted on the seeds is due. The tegmen consists of three rows of tabular cells with very thick mucilaginous walls. In *A. Dracontium* these walls are orange-colored, and in *A. triphyllum* yellowish in color and so serve to give each seed its distinctive appearance. There is a cutinized lamella on either side of the tegmen cells.

The seeds of both plants are orthotropous and the embryo is imbedded in an abundant endosperm. In *A. triphyllum* the endosperm appears entirely homogeneous to the naked eye, while in *A. Dracontium* there is a horny layer next the seed coats. Upon microscopic examination, however, but slight differences are evident. The outer portion of the endosperm of *A. Dracontium* consists of 3 to 5 rows of cubical aleurone cells with walls capable of great swelling in water. These cells contain granular proteid globules, a single crystalloid, and also a small amount of fat. The aleurone cells of *A. triphyllum* are of exactly the same character, but are generally only from two to four rows deep, and also a trifle smaller. Within the layers of aleurone cells, making up by far the greater part of the endosperm, are large starch-bearing cells which have thin cellulose walls. Numerous crystalloids are imbedded in the starch of these cells. These crystalloids are slightly more numerous in the seeds of *A. Dracontium*. In both cases, however, they are very abundant near the aleurone cells and become scarcer toward the embryo at the center of the endosperm. It will be seen that the only difference between the two seeds lies in the size of the cells which compose the aleurone layer and the seed coats. It follows from the greater size of the seed of *A. Dracontium* that this species has a food supply slightly greater than that of *A. triphyllum*.

Both resting embryos occupy a position near the base of the seed. In fact the aleurone cells near the micropyle are obliterated and the base of the hypocotyl of each embryo is close to the tegmen at this point. The cavity in which the embryo lies, but does not entirely fill, corresponds in general shape to that of the embryo and extends as an axis from the micropyle to the hilar region through the center of the seed. Its sides are formed of starch-bearing cells, aleurone cells close to the cavity at the hilar end, while the tegmen bounds it at the opposite end as described above. The embryos are club-shaped and small in proportion to the amount of endosperm contained in the seeds. In *A. Dracontium* they are 2 mm. long and .75 mm. thick, while those of *A. triphyllum* are slightly larger, measuring 2.75 mm. in length and .5 to .875 mm. in thickness. In *A. triphyllum* three fourths of the length of the embryo consists of cotyledon, the remainder is taken up by the hypocotyl. This relation is different in *A. Dracontium*, for the cotyledon in this case bears a slightly greater proportion to the entire length of the embryo. A slight constriction marks the insertion of the cotyledon on the hypocotyl, and a very small protuberance at the base of the hypocotyl is the incipient radicle.

Five regions are already differentiated in the resting embryo of each species, the dermatogen, procambium, root cap, meristem and fundamental parenchyma. The dermatogen is continuous with the epithelial layer which covers the entire embryo and, at the slit for the emergence of the plumule in the cotyledonary tube, is deflected back to line the plumular cavity. In the plumule of *A. triphyllum* dermatogen is already clearly differentiated but in *A. Dracontium* it is not so evident. The dermatogen is composed of a single row of narrow cells with their long axis at right angles to the longitudinal axis of the embryo. They are filled with aleurone grains and each contains a crystalloid. The procambium strands which foreshadow the bundles have already been laid down in the cotyledon, stem-bud and hypocotyl. Near the tip of the cotyledon the procambium strands branch and anastomose irregularly and therefore no definite number or arrangement of them can be determined, but at the base the number becomes constant and each strand occupies a regular position. The plan of arrangement in both species is similar. In cross section the strands mark out a crescent in which the largest is at the middle of the bow. In *A. triphyllum* which has regularly five strands, two lie on either side of the central ones, while the cotyledon of *A. Dracontium* shows the same arrangement of its five principal strands, but has in addition one or two smaller ones. When there are two, these extra strands occupy positions on either side of the large middle trace. When only one extra strand is retained, it invariably is at the right. In the tubular portion of the cotyledon, the largest strand is in the thickest part of the wall. The strands are composed of six or seven rows of narrow elongated cells which have their long axis four to six times the length of their radial, and parallel with the longitudinal axis of the embryo. In the stem-bud, procambium strands have also been differentiated. In *A. Dracontium* the strands in the plumule are faint and there is some variation in the number of the procambial regions. They are never more numerous than three and at times only the pro-cambium of the future midrib has been laid down. In *A. triphyllum* five distinct procambium regions can be distinguished in the plumule. Procambium strands are also present in the hypocotyl and occupy fully one half of its entire diameter. They are continuous with the procambium of the stem-bud and form at the base of the hypocotyl the rudimentary root stele. At the base of the hypocotyl the root-cap may be distinguished, made up of several rows of rather large cells which stretch across its entire base and are continuous at the sides with the dermatogen of the embryo. In the outer rows the cells are empty. Meristem tissue is to be found at the stem-bud and at the base of the hypocotyl where the root takes its origin. These cells are very small and nearly isodiametric. Their nuclei are large and fill almost the entire cell. Parenchyma cells make up the rest of the embryo. They are two or three times the size of the epidermal cells and are packed with starch. Scattered through the inner tissue are large cells filled with proteids in which a crystalloid also is embedded. These proteid cells are distributed through the tissues in those regions where the pro-cambium strands first make their appearance.

The embryos of the two species are similar in shape, position in the seed and general structure. *A. Dracontium* differs from *A. triphyllum* in four particulars: (1) Its size, (2) The proportion which the length of its cotyledon bears to its hypocotyl, (3) The number of procambium regions to be found in the cotyledon and (4) The state of differentiation of the procambium strands in the plumule. Here already the tendency in *A. Dracontium* to delay the development of the plumule is evident.

THE GERMINATION OF THE SEEDLINGS

In both species when water reaches the seeds the mucilaginous walls of the outer row of cells of the testa swell, while the cells below, pulled out by the swelling outer row and pushed out by the increase in size of the mucilaginous tegmen and the walls of the aleurone cells, separate and show an irregular alternation of large and small cells, which are, of course, empty. The seeds now increase considerably in size by the absorption of water, and the action of the moisture slowly reduces the outer row of the testa cells to a gelatinous film about the seeds. The mucilaginous tegmen is also soon dissolved, while all that remains of the seed coat is the inner part of the testa. The tannin in the vesicles contained within this becomes diffused through the whole of the cellulose coat and makes it more resistant to the disintegrating action of the soil. This part of the coat alone adheres to the seed until the last particle of endosperm is dissolved. The mucilaginous cells of the seed coat and the thick walls of the aleurone cells serve to increase the absorption of water, while the outer row of the testa is instrumental in bringing about the attachment of the seed to the soil.* The cellulose layer of the testa, impregnated with tannin, protects the endosperm during germination. When water reaches the embryo in the seed it swells and fills the cavity in which it lies, so that its epithelial cells are in contact at the sides with the starch

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* Klebs. Beiträge zur Morphologie und Biologie der Keimung. Untersuch. a. d. Botan. Institut z. Tubingen. 1: 536. 1885.

cells of the endosperm. Here the diastase formed by the epithelium of the embryo can begin to act upon the stored starch of the seed and a proteolytic enzyme to dissolve the crystalloids. The starch of the endosperm is absorbed before the crystalloids, and when the cells in contact with the embryo have been emptied of their contents the cell walls are pushed back by the advancing growth of the cotyledon and the enzyme acts upon the contents of the cells next outside. The proteids of the aleurone cells do not become soluble until late in the history of the seedling. The cell walls of the endosperm do not seem to be acted upon by any enzyme, and are wholly intact until the seed separates from the seedling.

While the epithelial cells are secreting the enzymes, the cotyledon increases in length and by its elongation pushes the hypocotyl, bearing the stem-bud, through the seed coats at the micropyle. *A. Dracontium* requires fully a month longer than *A. triphyllum* for its hypocotyl to protrude. When the hypocotyl has wholly emerged from the seed it is directed down into the ground at right angles to the plane of the cotyledon, which is still in the seed. This is effected by means of a bend in the cotyledon at the place where it leaves the seed. This downward pull of the hypocotyl serves to tilt the seed up, and is sufficient when the seed has not been planted deep to break through the ground and bring the seed to the surface. In all cases it loosens the earth about the seedling, and so renders it easier for the pumule to make its way through the soil.

A great part of the cotyledon is confined within the seed during its entire development. The length which the cotyledons attain varies in both species, but those of *A. Dracontium* are on the average shorter than those of *A. triphyllum*. The average length of the *A. Dracontium* cotyledons outside of the seed is 3 mm., while those of *A. triphyllum* reach an average length of 7 mm. The number of the cells in the cotyledon is not increased by its elongation, for its entire growth is due to the increase in size of the already existing cells. The epithelial cells, which in the resting embryo had their axis perpendicular to the longitudinal axis of the embryo, now in the region of the cotyledon have this relation completely changed. Their long axes are parallel with the longitudinal axis of the embryo. The cells of the parenchyma have also taken on an elongated form. The only region in the cotyledon where new cells are added is that occupied by the procambium and fibrovascular bundles. Here the cell division is very active. Radial growth takes place only as the contents of the endosperm cells is absorbed. The shape, arrangement of cells and manner of elongating are exactly similar in the cotyledons of *A. Dracontium* and *A. triphyllum.* It is only in the fibrovascular system that any difference between them has been discovered. Here in both cases, as in the procambium strands in the embryo, the bundles near the tip, branch and anastomose so that their distribution is irregular. At the base, however, the number of bundles is constant. *A. Dracontium* as a rule possesses six bundles: one of these strands is very weak and occupies the same position as the sixth procambium strand in the cotyledon, *i. e.*, at the right of the largest central bundle. The left hand strand which corresponds to the seventh in the resting embryo disappears before the cotyledon has proceeded very far with its development. The cotyledon of *A. triphyllum* has five bundles arranged as in the resting embryo. In a few instances chlorophyl has been found in that part of the cotyledon of *A. Dracontium* which protrudes from the seed both when the plumule was functional and when it was not. These cases, however, are uncommon.

Up to this point there is almost absolute identity in the germination of these two species: the only difference between them lies in the various sizes which the cotyledons attain. After this stage in the germination has been reached, however, various differences in the order of development of the organs become apparent.

The rudiments of all the structures of the mature corm are present in the hypocotyl of both *A. triphyllum* and *A. Dracontium* and the formation of the corm is brought about by the enlargement of the base of the hypocotyl and the laying down in it of the definitive tissues. In both it increases in bulk at least to a small extent before the first primary root is sent out. The hypocotol of *A. Dracontium* enlarges at a very much more rapid rate in the first stages of germination than does *A. triphyllum* and generally attains a considerable development before the root appears. A seedling of *A. Dracontium* with two roots each only 1 mm. in length may have a corm 4 mm. in diameter while in a well-developed seedling of *A. triphyllum* with a strong system of roots and a plumule well grown, the corm may be only 1.75 mm. in diameter. The enlargement of the corm of *A. triphyllum* becomes marked only after the leaf is well established as a photosynthetic organ. In those seedlings of *A. Dracontium* in which the plumule does not become functional the corm, when its growth is completed, averages 4.5 mm. in diameter. When, however, the seedling has a functionating leaf the corm may attain a diameter of 6 mm. The corm of *A. triphyllum* may have a diameter of 5.75 mm. at the end of the season, but in many cases it is much less.

The enlargement of the hypocotyl is due to the increase both in size and number of its cells. As its growth is rather radial than longitudinal, the epithelial cells become isodiametric in shape. The storage cells increase in size and in number in all directions and so maintain the same relative dimensions. The starch grains contained in these cells are several times as large as those of the endosperm of the seed. The procambium cells of the hypocotyl are very active, dividing both in their longitudinal and transverse diameters and the fibro-vascular system soon becomes differentiated. Raphide cells are numerous in the corm and in all parts of the seedlings of the two species. As the corm enlarges, a layer of periderm arises on the outside, from which are cut off tangentially five or six rows of empty flattened cells. In addition to the protection they afford the corm, these periderm cells are instrumental in effecting a separation between the cotyledon and the corm, after the food supply of the endosperm has been absorbed. They grow between the cotyledon and the corm and separate the two by proliferating cells from their surface. In several instances chlorophyl has been formed in the two or three rows directly beneath the layers of periderm. The only difference in the development of the corm of the two species lies in the earlier enlargement of the hypocotyl of *A. Dracontium* and the greater average size of its completed corms.

The time at which the roots of *A. Dracontium* appear varies markedly. In some cases the hypocotyl enlarges greatly, becoming, as was described above, about 3 mm. in diameter before the first root arises. In other instances the roots are developed as soon as the hypocotyl has found its way into the ground. Seedlings of *A. Dracontium* vary greatly also in the number and kinds of roots which they send forth. Those with the most well developed system have two primary roots from the base of the hypocotyl and later a thick root arising adventitiously from the the nodes. This secondary root, becomes contractile and transversely ridged for part of its length. One of the primary roots also often becomes contractile and helps to draw the corm deeper in the ground. A secondary root, however, is developed only in those seedlings which also send up a plumule and a few even of these have none. The seedlings in which the plumule has not started into activity have as a rule two primary roots, one of which becomes thickened and assumes the function of contraction. In some cases neither of the primary roots is contractile and in others only one short thin root is produced. A direct correlation between leaf and root development is here evident. Variations in the structure as well as the number of the roots occur. The contractile roots which are for the most part simple have been observed occasionally to be branched. In another instance (the single case in which two contractile roots occurred in the lot of *A. Dracontium* seedlings observed) two contractile roots were fused for part of their length. The root system of *A. triphyllum* is very much better developed than is that of *A. Dracontium*, for the roots are both longer and more numerous. The seedlings have always two and often three primary roots which reach a length of 5 cm. and in addition after the seedling is well under way, three thick adventitious roots appear, budding from the nodes. These roots are contractile and show the same transverse ridges as the contractile roots of *A. Dracontium*. In some cases they pull the hypocotyl down as much as 2 or 3 cm. below the level at which it germinated. After the secondary roots become firmly established, the primary roots grow no more and the greater part of the entire root function is discharged by the contractile roots which bear root hairs near their tips and become about 7 cm. long.

The only difference in microscopic structure between the contractile, secondary and primary roots consists in the greater radial elongation of the cells of the inner cortex of the contractile roots. In *A. Dracontium* the root stele of the primary root shows a diarch structure and the secondary roots are tetrach as a rule. Some, however, have been observed to be triarch ; in *A. triphyllum* both primary and contractile roots are triarch. After the contraction of the roots the outer cortex cells are very much strained and twisted, but the radial elongation of the inner cells protects the stele from any distortion. The roots of *A. Dracontium* are more variable in all respects than those of *A. triphyllum.*

The stem-bud of *A. Dracontium* and *A. triphyllum* have the same structure in the resting embryo, with the exception that the procambium stands in the bud leaves have reached a more advanced stage of differentiation in *A. triphyllum.* During the first season's growth, however, the structure of the bud in the two species has an entirely different history. Like the roots the plumules of the *A. Dracontium* seedlings vary greatly in the state of development which they attain. As a rule the plumule of *A. Dracontinm* develops to at least a small degree after germination, forming a lamina and a short petiole which although it may break through the cotyledonary sheath, yet rarely reaches the air and is often represented only by a rudiment 2 mm. in length remaining permanently enclosed by the cotyledon and enwrapping in its turn the stem-bud of the next year. This undeveloped plumule is cut off at the end of the season by the formation of a periderm between it and the corm in the same way as the cotylendon is separated from the corm. About 10 per cent. of the seedlings of *A. Dracontium* produce functional plumules. They appear at different stages during the growth of the corm, generally when it has already attained a considerable size and in some cases only after the seedling has entirely separated from the seed. Its method of emergence from its enclosing cotyledon is exactly the same as that of *A. triphyllum* which produces a plumule normally. As soon as the root has secured a firm hold on the soil and the hypocotyl is only slightly enlarged, the plumule with its blade recurved parallel to the petiole and rolled in at the margin breaks through the tubular part of the enclosing cotyledon through a longitudinal slit which is already present in the resting embryo. The plumule becomes green rapidly while the petiole at the base of the lamina straightens out and the folded blade unrolls and grows larger.

The functional plumules of *A. Dracontium* exhibit a tendency toward degeneration. A comparison of the plumules of the two species will well demonstrate the particular instances. The fully grown leaves of *A. triphyllum* are ovate, the largest being 36 mm. in length and 30 mm. in width, while the smaller are 25 mm. by 13 mm. The functional leaves of *A. Dracontium* vary greatly in the shape and size of the lamina and in the length of the petiole. In outline they range from broadly elliptical to nearly circular and all bear a mucronate point at the tip as does *A. triphyllum*. The largest leaves of *A. Dracontium* are about 25 mm. in length by 22 mm. in width, but the greater number are smaller, some being only 6 mm. by 3 mm. The margin of nearly all leaves of *A. triphyllum* are very finely serrulate; while some leaves of *A. Dracontium* display a tendency to serrulation, more often they are entire. The upper surface of the *A. triphyllum* leaf is covered with faint whitish lines; this appearance is due to the presence of elongated raphide cells in the mesophyll directly beneath the epidermis. *A. Dracontium* has numerous raphide cells in the mesophyll but they are not so large as those of *A. triphyllum* and cannot be distinguished without the aid of the microscope. The under surface of the leaves of *A. triphyllum* is covered with a waxy bloom and the upper surface also shows some wax. In *A. Dracontium* the wax is very much thinner on the under surface and barely discernible on the upper. As a consequence the leaf of *A. Dracontium* wilts very quickly after being removed from the plant. The development of stomata on both leaves is about the same. The leaves of both species are pinnately net-veined. In *A. triphyllum* one pair of the lateral branches is more strongly marked than the others, foreshadowing distinctly the plan of the mature trifoliolate leaf. In *A. Dracontium* the plan of venation is more generalized. The lateral veins have all equal value and are neither so well marked as some nor so faint as other lateral veins of the leaf of *A. triphyllum*. The mesophyll of the *A. Dracontium* leaf is not so well developed nor so well supplied with chlorophyll as is that of *A. triphyllum*. Those plumules of *A. Dracontium* which become assimilatory organs are functional for a shorter period than those of *A. triphyllum*, for they wither upon the plant much sooner. Those of longest duration last not more than three months while some send up a petiole only, the blade being shriveled before it expands. Monstrosities seem to be very frequent in the leaves of *A. Dracontium*, for instance, the displacement of the mucronate point from the tip to the middle of the under surface of the midrib or the multiplication of these points upon the under surface. The blade is also often lobed upon one side and in one instance both sides of the leaf showed this peculiarity.

The petioles of the leaves of both species are streaked with red, the color being most abundant near the base. The petiole of *A. Dracontium* is considerably shorter than *A. triphyllum* and the fibro-vascular system is weaker on the whole although some stems of *A. Dracontium* and *A. triphyllum* show scarcely any difference. In the arrangement of tissue within the stem there is exact similarity. The bundles are arranged to form an open cylinder generally, in *A. Dracontium*, three on each side of the largest bundle. Those stems which attain the greatest development may have in addition a bundle running through the center of this cylinder, while in *A. triphyllum* the fibro-vascular system may include still another bundle, completing the cylinder and making nine bundles in all.

The development of the buds goes on during the growth of the seedling. Each rudimentary leaf arises as a hollow elevation enclosing the next youngest. At the end of the season the stem-bud of *A. Dracontium* has four bracts which enwrap the bud at the center and *A. triphyllum* agrees exactly with this plan in structure. All but the innermost of these enclosing bud leaves remain as rudiments upon the corm protecting the bud. The fourth grows large enough to protect the leaf as it pushes through the soil the second year, but remains at its base as a membraneous sheath.

The second season all *A. Dracontium* corms, like those of *A. triphyllum*, produce one trifoliolate leaf enclosed at the base by a sheath which, in those cases where no plumule is produced, must be regarded as the first leaf sent up by the plant. The functional leaf of the second season is trifoliolate normally, but is subject to great variation, such as the whole or partial fusion of two of its lobes or the complete obliteration of one of them. Even when the leaf is regularly trifoliolate great variations occur in the shape of the individual leaflets. In some, the side leaflets may be narrowly lanceolate while others may approach an elliptical shape. The mid leaflet is generally broader than the lateral ones, but here too a variety of forms may occur. At the end of the second season's growth there is still a slight difference in the size of the corms of those plants of *A. Dracontium* which have borne a plumule the first year and those that have not. The root systems are, however, similar; six adventitious roots are developed in each. Except in the retarded development of its plumule, the development of the stem-bud of *A. Dracontium* agrees with that shown by *A. triphyllum*. The repression of the plumule does not seem to be correlated with any variations in the stem-bud of the second season, since variations of leaf form occur as frequently in second-year plants which produced a functional plumule the first season.

The principal differences between the seedlings of *A. Dracontium* and *A. triphyllum* consist not only in the reduction and variability of the roots, the variation and repression of the plumule on the part of *A. Dracontium*, but also in the precocious enlargement of the corm. This difference arises as soon as germination starts; in *A. Dracontium* the foodstuff of the endosperm is employed directly to build up the hypocotyl at the expense of the development of root and plumule. In *A. triphyllum*, however, as soon as the hypocotyl breaks through the seed coats, the roots are sent out and attain some development at once, the plumule then appears, and in normal cases it is only after this assimilatory organ is well established and the seedling has separated from the seed that the hypocotyl begins to enlarge. In *A. triphyllum* the endosperm furnishes the material which is necessary to bring the root and plumule to an advanced stage of development, and the food material for the hypocotyl is supplied by the assimilation of the plumule. The early enlargement of the corm and the repression of the plumule can scarcely be held to be due to a pathological condition of the seed or to an unfavorable environment, as the seeds planted were perfectly sound and the plumules in the embryos of those from the same lot which were examined showed no evidence of the attacks of parasites or any abnormality, while the conditions under which the plants were grown corresponded to the normal environment of these plants as was well demonstrated by the vigorous growth of *A. triphyllum* which was subjected to the same conditions.

On the other hand the small proportion of functional plumules developed by seedlings of *A. Dracontium* and, in the cases in which a leaf was produced, the great variations in shape, the small size, the generalized form and venation, the delicacy of the lamina and the weak development of wax upon it, the shortness of the petiole and the frequent appearance of monstrosities, all are indications of degeneration and lead to the conclusion that this seedling is losing its power to produce a normal assimilating plumule. This conclusion is borne out by an examination of the internal structure. The petioles of the smaller leaves of *A. triphyllum* show the same arrangement of fibrovascular bundles as the largest of *A. Dracontium* and a series of increasingly smaller plumules which may easily be obtained from a number of seedlings shows a successively more generalized development of fibrovascular system until in the least developed system it becomes reduced to a mere rudiment. The highly organized fibrovascular system of the hypocotyl, which is of very little service to the seedling without a plumule and only a weakly developed root system, is still retained and bears evidence that the present type of seedling which brings a plumule to various stages of imperfect development may be a degeneration from a condition like that of the seedlings of *A. triphyllum* with a plumule normally functional.

So far as has been observed this type of germination is of no benefit to the seedlings. It does not seem to enable the corms to escape from the danger which they incur of being torn up by animals, for the development of the seedling without a strong root system of course precludes any great downward pull upon the corm by the contraction of its roots. Those plants of *A. Dracontium* which develop a leaf and correlated with this a stronger root system have invariably been found buried deeper than the plants whose plumule is not functional, for although in the plumuleless seedlings there is no upwardly directed force to bring the corm near the surface such as the plumule exerts in forcing its way through the ground yet on account of the weakness of the root system the tendency is such as to keep the corms very near the depth at which the seeds germinated. The repression of a plumule, of course, prevents the destruction of young seedlings by grazing animals; but the well-developed plumule contains enough raphide cells to protect it from attacks of this kind and the advantage which the plants enjoy in this respect is largely over-balanced by positive disadvantages. This variation, therefore, can scarcely have been perpetuated because of the advantage as a means of defense which plumuleless seedlings possess. As far as can be discovered at present this variation is of no benefit to the plant but, on the contrary, there are great disadvantages in this method of germination, which tend to throw the plant entirely upon the food supply of the parent form for another season.

The germination of *A. Dracontium* consists essentially in the conversion of the hypocotyl of the embryo into the corm of the seedling by the transfer of the food material contained in the endosperm. In some aroids,* this resorption of the endosperm and conversion of the base of the hypocotyl into a corm takes place before the embryo leaves the seed; that is to say, the development of the seed is not completed until a bulbiform embryo with true fibro-vascular bundles and no trace of cotyledon has been formed. An example of this type is *Spathyema foetida*. When the seed of this plant germinates the stem-bud pushes out of the micropyle and breaks through the ground first; later adventitious roots spring from the nodes. No primary root is produced. It will be seen that the only difference between the germination of this seed and the sprouting of the first year's corm of *A. Dracontium* is the fact that in the former case the seed coats which surround the bulbiform embryo must be penetrated by the stem-bud. If the corm formation of the seedling of *A. Dracontium* took place within the seed coats (and this could be brought about simply by the arrest of the elongation of the cotyledon) the two cases would be exactly similar. In fact the cotyledon of *A. Dracontium* is varying in just this direction, for it often displays a tendency to be shorter than the cotyledon of *A. triphyllum* as has been pointed out above. The delay in germination at first, moreover, may be another indication of a tendency to carry on the entire development of the corm within the seed.

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* Engler. Monographiae Phanerogamarum, Araceae, 11: 34.

Owing to the lack of time and material the development of the corm of *Spathyema* within the seed could not be traced but an examination of the literature of the subject brought out the fact that many aroids manifest a tendency to carry on the development of the plant as far as possible before actual germination, *i. e.*, emergence from the seed and development of assimilatory organs occurs.*

SUMMARY

The seeds of the two species present only a few unimportant differences in shape. In histological structure they are similar. The embryos are comparatively small and are imbedded in a copious farinaceous endosperm. The only essential distinction between them consists in the slightly greater amount of food material in the seed of *A. Dracontium*, the extra procambium strand of its cotyledon and the weaker development of procambium in the plumule of its resting embryo. The first stages of the germination of the two seeds are of the same character and consist in the emergence of the hypocotyl and stem-bud from the seed coats at the micropyle, by means of the elongation of the cotyledon.

As the development of the seedlings proceeds, the production of roots and a plumule takes precedence in *A. triphyllum* while in *A. Dracontium* the enlargement of the hypocotyl begins at once and the growth of the root and plumule is retarded. This precocious development of the corm often takes place to such a degree as to entirely inhibit the production of a functional plumule. The same differences between the two species in regard to the fibrovascular development is exhibited by the seedlings as is displayed by the resting embryo. The structure of the stem-bud which develops upon the corm during the first season's growth is absolutely the same in both species.

The seedling of *A. Dracontium* is diverging from what seems to be the normal type of germination in *Arisaema, i. e.*, the development of an assimilatory plumule and the production of a corm by means of the product of the photosynthetic activity of this organ, and is tending to produce a corm without the aid of a plumule by the direct transfer of the food material of the endosperm to the

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* Engler. Monographiae Phanerogamarum. Araceae, 11 : 34, 35.
Griffith. Trans. Linn. Soc. 20 : 274–276. 1847.

hypocotyl. This type of germination does not seem to be due to a diseased condition of the seed or embryo or to an unfavorable environment nor does it appear to be advantageous to the young seedling. It might be suggested therefore that it is an expression of an inherent tendency in aroids to carry the young plantlet as far as possible in its development before an assimilatory organ is produced. If this conclusion be correct we have in *A. Dracontium* a transition stage between a seedling forming its corm outside of the seed coats with the aid of a plumule as in *A. triphyllum* and a corm formation within the seed coats at the expense of the endosperm as is the case with *Spathyema foetidus.*

Explanation of Plate 3

FIG. 1. Seedling of *A. Dracontium* showing hypocotyl just emerging from seed.

FIG. 2. Seedling of *A. Dracontium.* Hypocotyl has begun to enlarge, short root has appeared.

FIG. 3. Seedling of *A. Dracontium.* Root has elongated, root hairs have arisen.

FIG. 4. Seedling of *A. Dracontium.* Hypocotyl has enlarged greatly, first root has elongated, second root is just appearing.

FIG. 5. Seedling of *A. Dracontium.* Hypocotyl has attained full size of first year's corm.

FIG. 6. Seedling of *A. Dracontium.* Specimen in which the root system has been only slightly developed.

FIG. 7. First-year corm of *A. Dracontium.* Formation of periderm at base of cotyledon has separated corm from seed.

FIG. 8. Seedling of *A. Dracontium* which has produced plumule.

FIG. 9. Seedling of *A. Dracontium.* More advanced; note single contractile root, developed only in those cases where plumule is sent up.

FIGS 10, 11, 12. Variations in form of plumule in those seedlings of *A. Dracontium* which send up a leaf.

FIGS. 13, 14. Second-year leaves of *A. Dracontium* when a plumule had been developed by seedling.

FIGS. 15, 16, 17, 18, 19. First leaves produced by *A. Dracontium* corms which have been developed without the aid of a plumule.

FIG. 20. Seedling of *A. triphyllum.* Hypocotyl just emerging.

FIG. 21. Seedling of *A. triphyllum.* Cotyledon lengthened, hypocotyl has begun to enlarge, root has arisen.

FIG. 22. Seedling of *A. triphyllum.* Second root appearing.

FIG. 23. Seedling of *A. triphyllum.* Second root has increased in length.

FIG. 24. Seedling of *A. triphyllum.* Plumule has emerged from cotyledonary sheath.

FIG. 25. Seedling of *A. triphyllum.* Petiole of plumule has lengthened, a third root has appeared. Hypocotyl perceptibly enlarged.

FIG. 26. Seedling of *A. triphyllum.* Contractile root formed, plumule fully expanded.

FIG. 27. Seedling of *A. hybrida.* Plumule produced.

FIGS. 28, 29, 30. Variations in form of leaf produced second year by *A. hybrida.*

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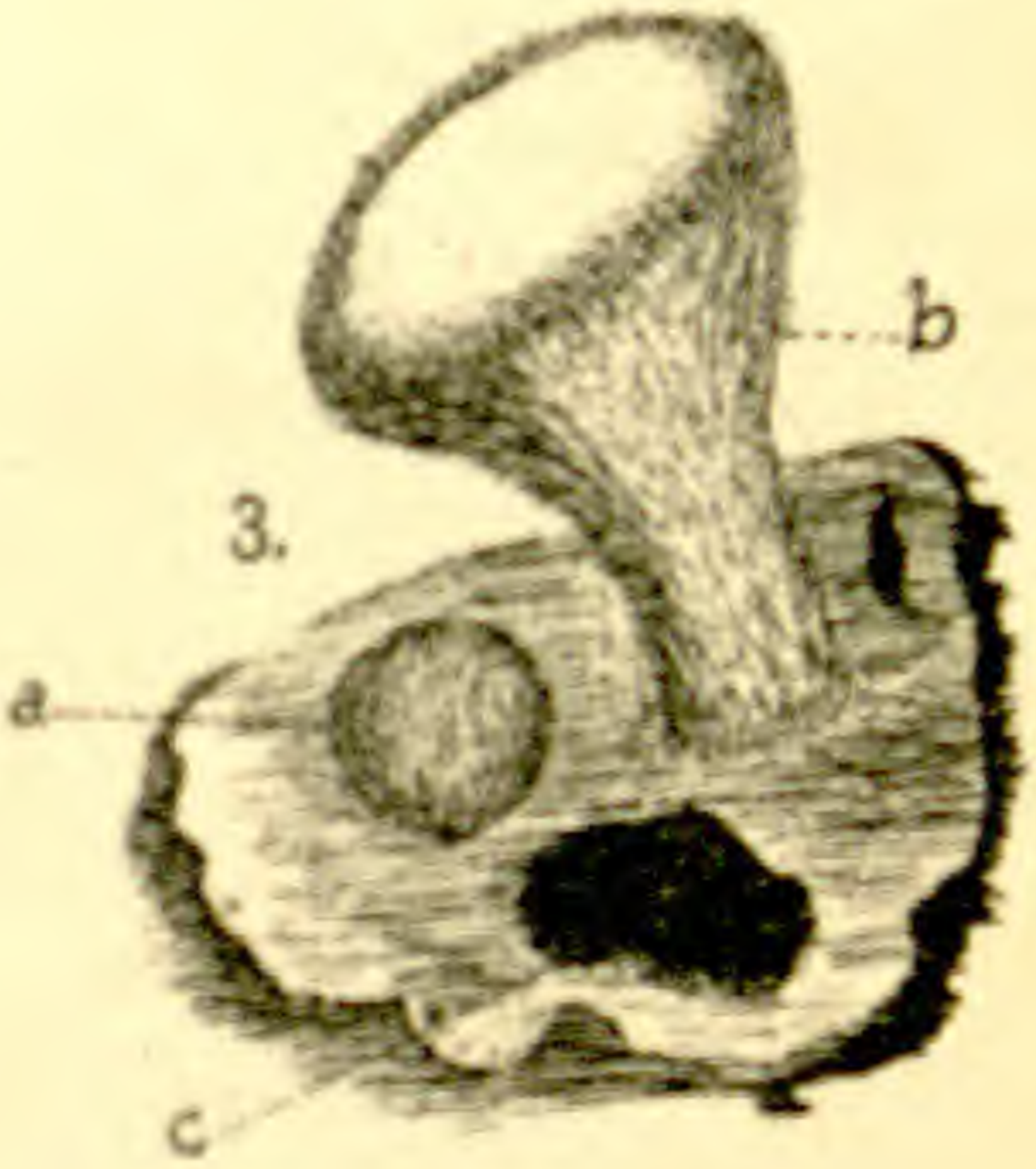

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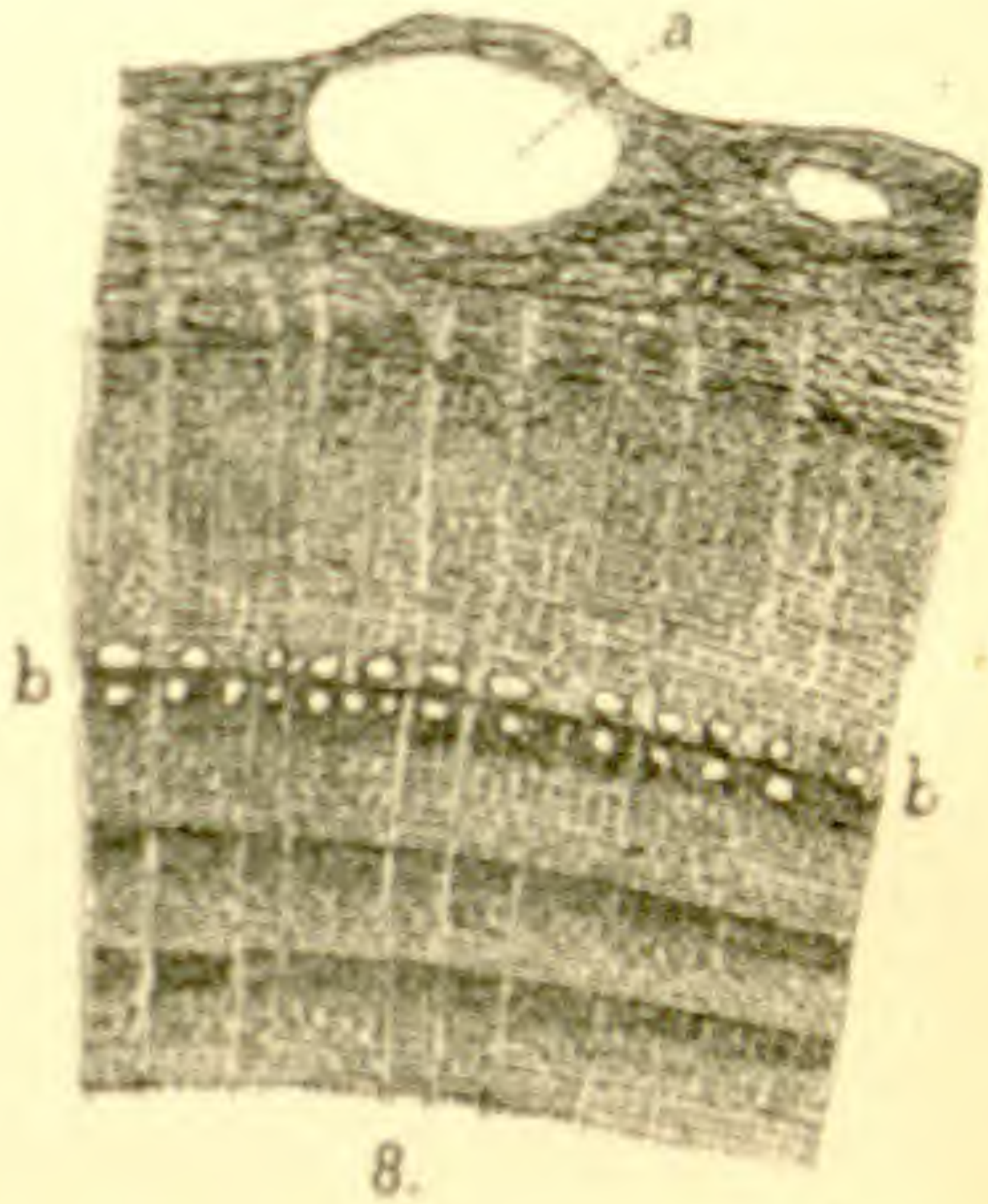

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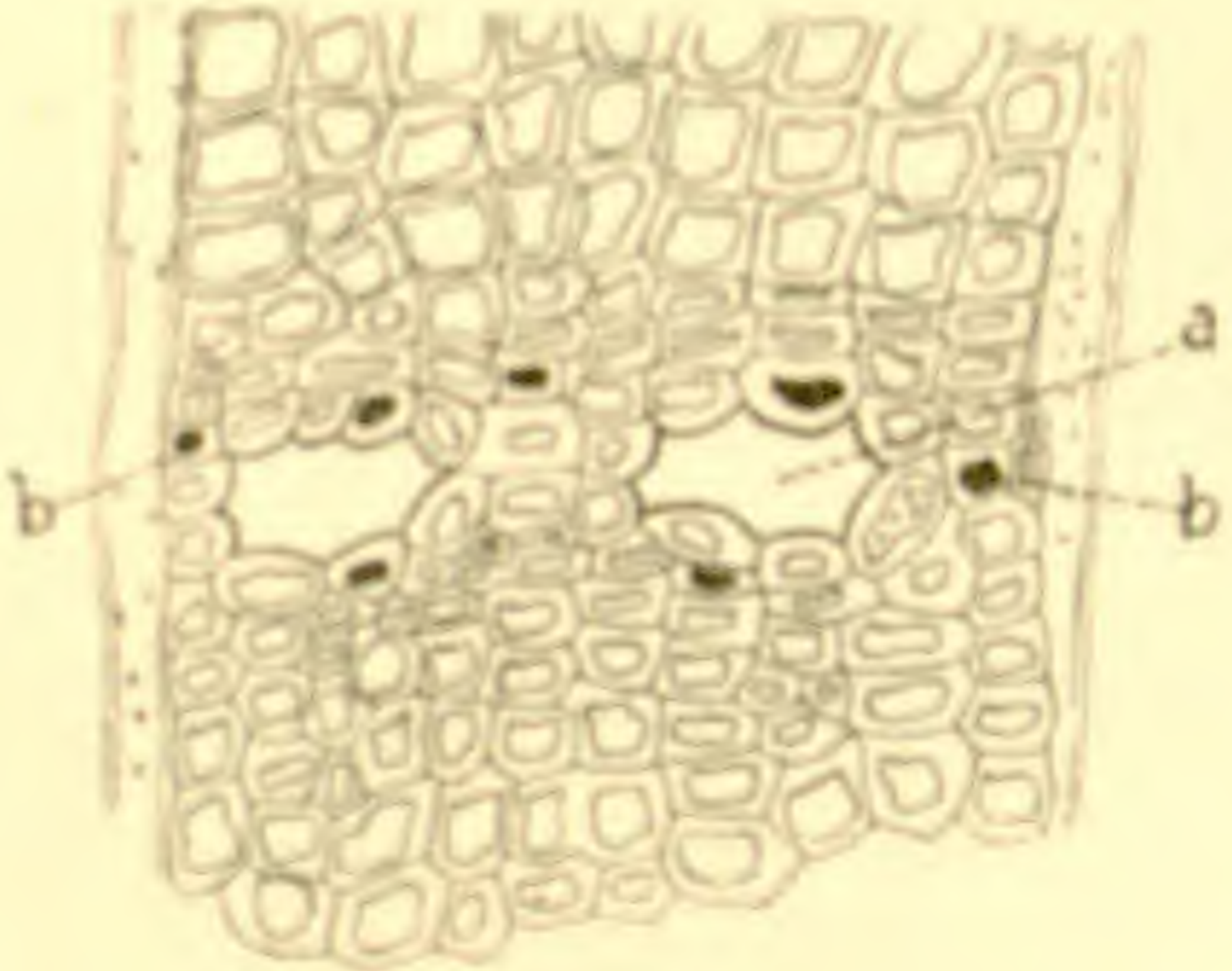

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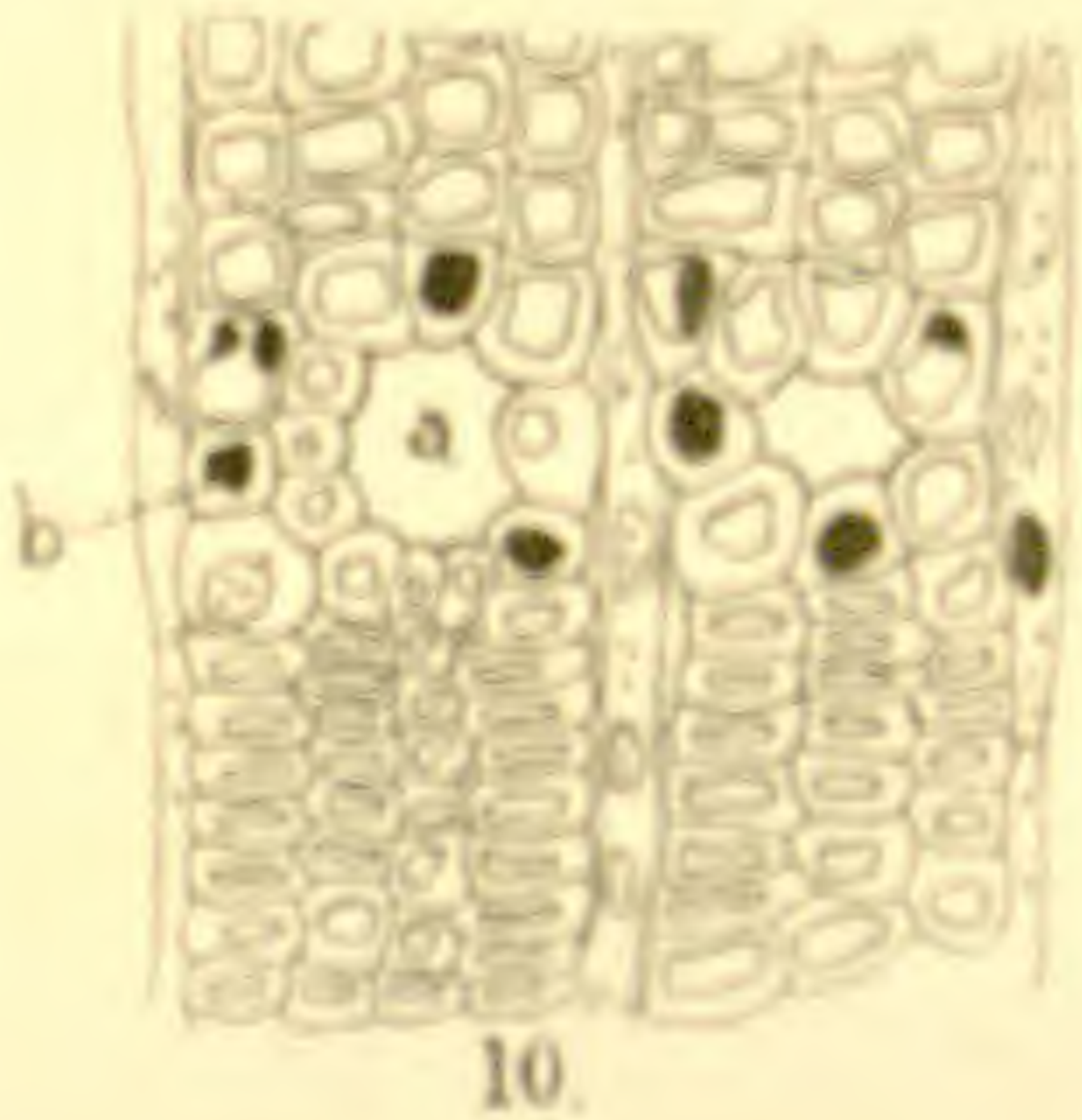

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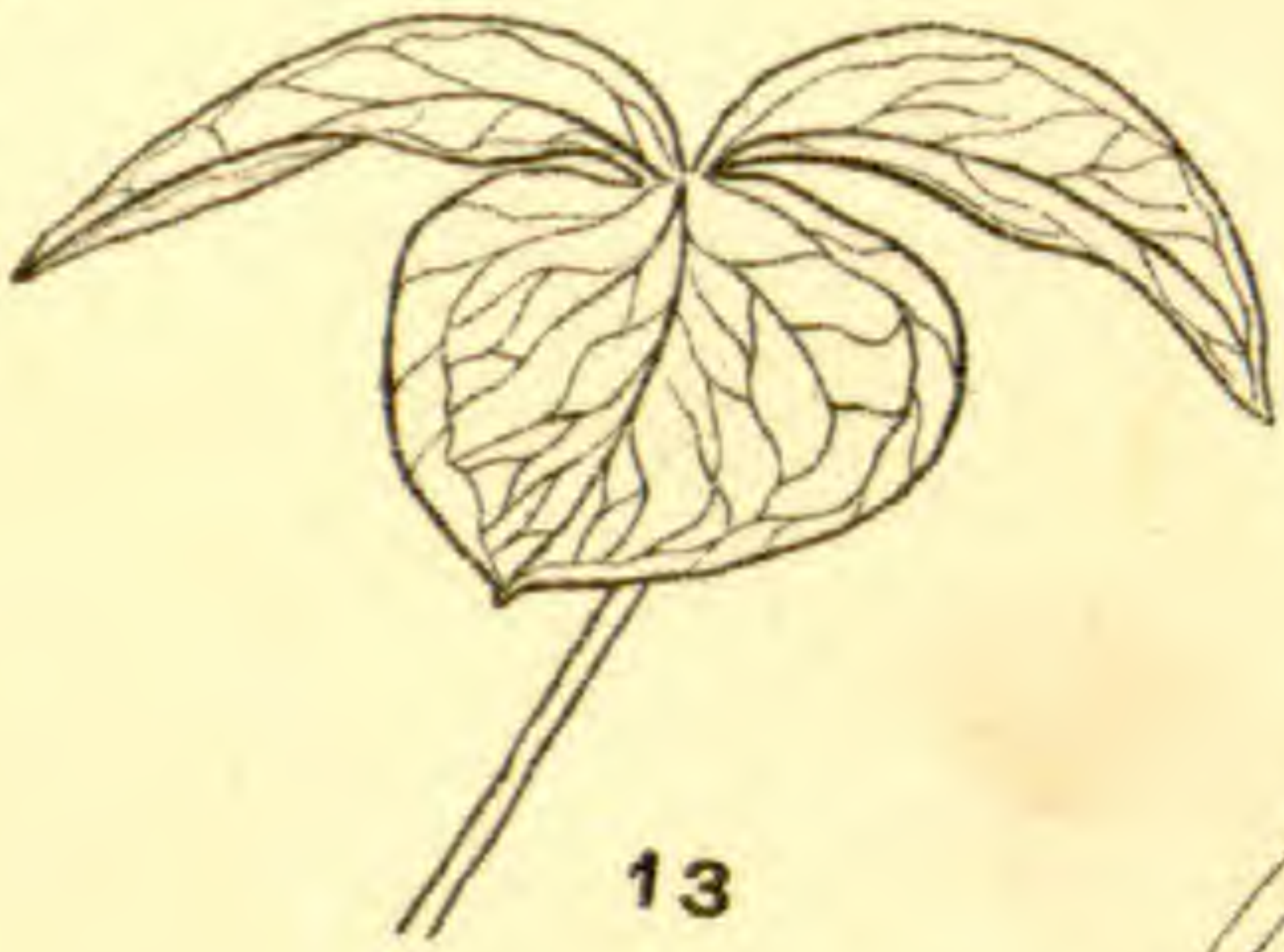
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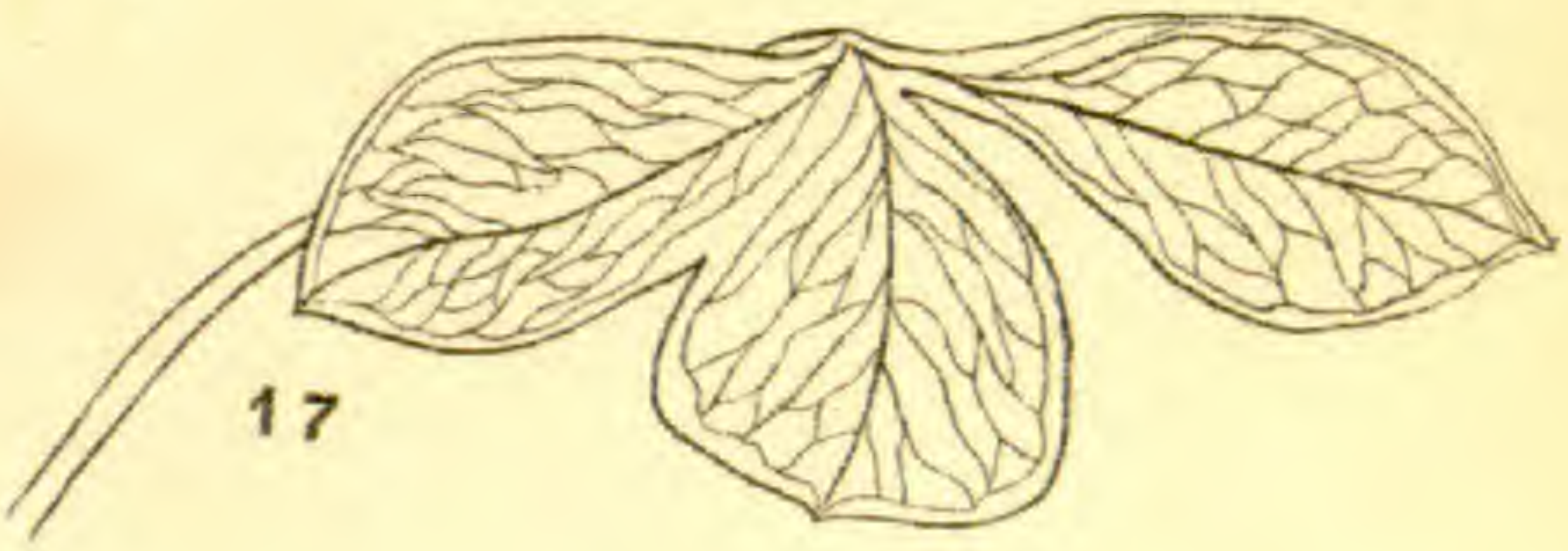
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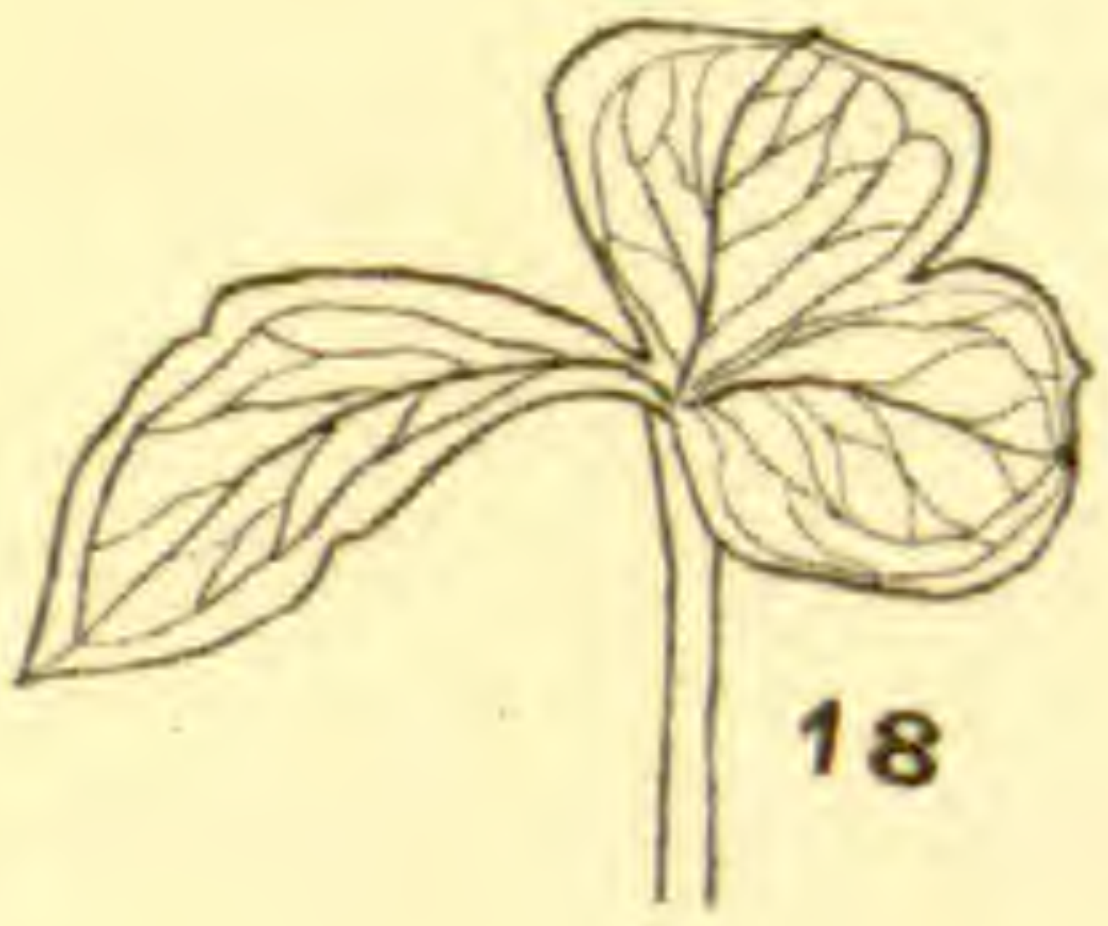
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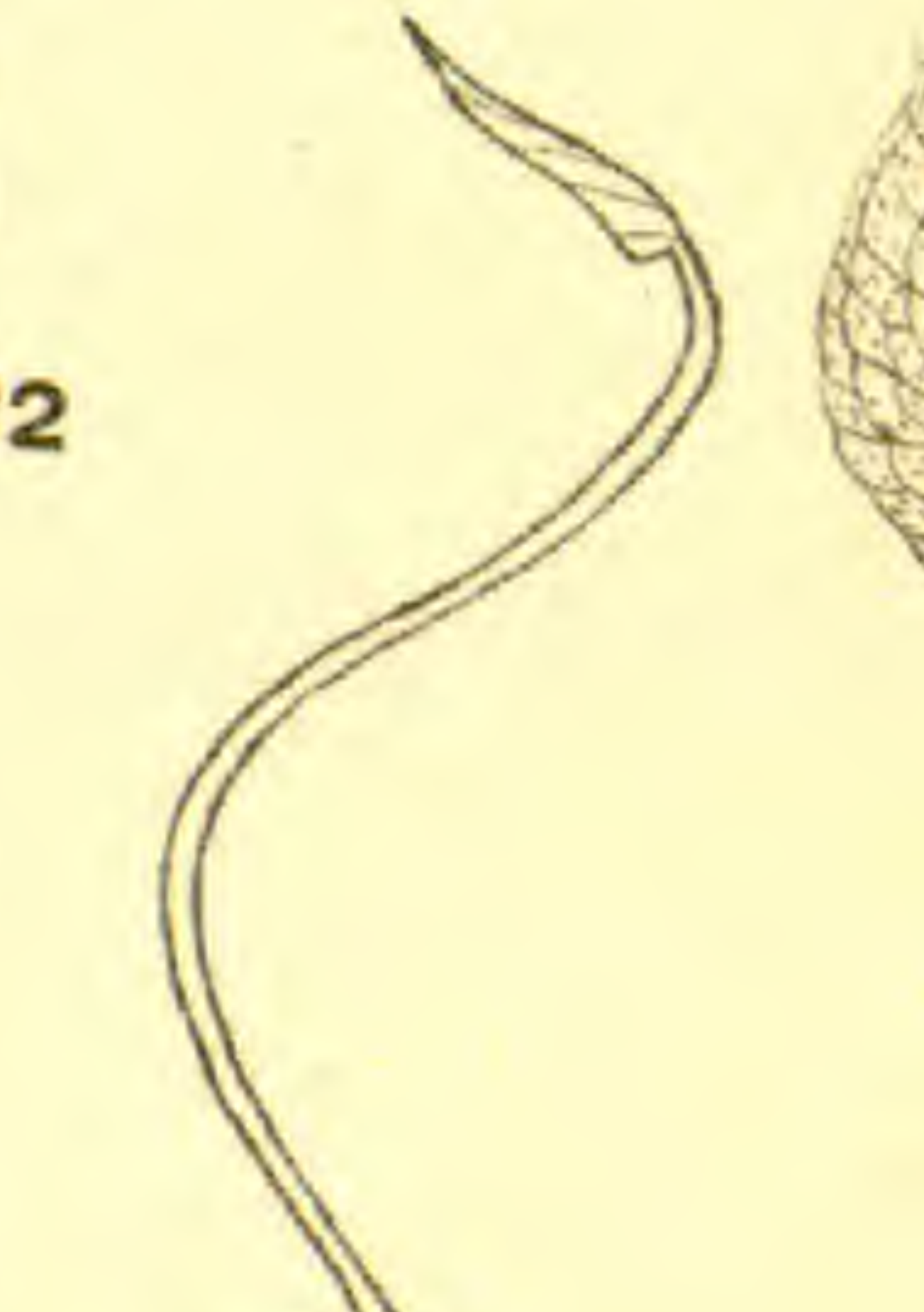
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Memoirs. (See last page of cover.)

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FEBRUARY 1902

On the Teaching of Vegetable Pathology*

BY HERMANN VON SCHRENK

It is generally recognized at the present time that the scientific man has not completed his labors when he has determined to his own satisfaction what the solution of any particular phenomenon in which he is interested, may be. The time was when it was considered sufficient for him to publish his results in an abstract form where a few of his colleagues might read and understand them. To-day we regard it as one of the duties and privileges to make accessible to those not immediately engaged in one particular line of research, the results of the work in the laboratory and the field.

I take it, that as many of us are engaged in teaching the various branches of botanical science to students, it may be a legitimate question to discuss before this Society what we are doing with our college classes, and how we can best accomplish our object. It is my purpose to-day to bring before you for discussion, some thoughts as to how we can best train those who intend to devote themselves to the study of vegetable pathology.

Of the several lines of botanical research, that which is generally termed vegetable pathology is beginning to claim more general attention at this time. Courses are being offered in some of our colleges and universities, which deal with diseases of plants, although for the most part these are mere adjuncts of courses in

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*A paper read before the Society of Plant Morphology and Physiology, New York. 31 December 1901.

[Issued 25 February]

cryptogams. The time is not far distant, however, when vegetable pathology as a separate branch of botanical science will assert itself and claim recognition independent of the other branches of this science, and when we will have professors of pathology, who will devote their time and attention to this subject alone. At the present time the demand for properly trained men to take up work in the study of plant diseases is increasing every year, and with the rapid development of scientific agriculture, economic questions involving the study of plant pathology are becoming more numerous, and demand more urgent solution. The economic side alone will be sufficient to bring about radical changes in the present condition of this science in our institutions of higher education.

By vegetable pathology I mean to imply the study of plant diseases in its widest sense. It is perhaps not easy to define disease accurately, but for our present purposes, it will be sufficient to speak of disease as abnormal physiology, or, as it has been termed by Marshall-Ward, "a variation of functions in directions which threaten the life of the plant."

It is essential that we understand at the outset that we are dealing with a living plant and the reactions which its parts show toward environmental conditions. What we are studying are diseased *plants*, as distinguished from disease-causing factors. This is to be the fundamental conception of this paper. We have been studying mildews and rusts long enough, and in so doing made ourselves believe we were studying pathology, and it is high time that it were realized that the patient is after all more important than the disease-bringing factor. Assuming that all are agreed upon this point, and taking this as a starting-point, let us inquire how we can go about to teach this conception of pathology. It is evident that a knowledge of the morphology of fungi will not be sufficient, and that a very different method must be adopted from the one in vogue in many of our colleges at this time.

In the first place let me say that we can learn much from the kindred science of animal pathology. The study of this subject is generally divided into three groups: (1) Diagnosis, (2) Etiology, (3) Therapeutics. In all cases the living object is first consulted, then the causal factors, and lastly the remedy. Applying this to plants we find that the symptoms of disease are on the whole not as sharply defined as in animals. This is due in part to the lower degree of organization of the plant, and also to the fact that a good many disturbing factors give rise to similar symptoms. We can, however, analyze the symptoms with far greater ease than is possible in animals. Environmental conditions can be controlled, and by a method of elimination the disturbing factor can be determined positively. The study of the disturbing factor, whether it be environmental or due to living organisms, can also be carried on with more success with plants than with animals. In other words, we can make the study of pathology one involving experimentation with living plants.

This brings me to speak of the things necessary for a course in pathology conforming to the above. In the first place one or more greenhouses are absolutely essential, together with a liberal supply of living plants. If carried on in the spring and summer the greenhouse is not so essential. Access to greenhouses where different kind of plants are growing is also desirable. In St. Louis we have established a vegetable clinic, where patients are received and observed. The greenhouse, or houses, ought to be divided into numerous compartments, each completely sealed from the others preferably, so as to prevent the spreading of fungus spores. I wish to call attention to a series of houses built by Dr. von Tubeuf at Dahrlem, near Berlin, which are ideally arranged for work in experimental pathology. The number and kind of plants needed depend largely upon the amount of work which one contemplates doing. Wheat, corn, oats, cabbages, roses, lettuce, cotton, and other common plants easily obtained, will be found ample in most cases. Living material of fungi, obtained from diseased plants, or kept as cultures, will also be essential.

Before proceeding further a word ought to be said about the preparation which we ought to expect of students engaging in this study. As pathology is essentially abnormal physiology, a thorough knowledge of plant physiology should be required. This is so obvious that it is hardly necessary to urge it, and yet it is a curious fact that, so far as I have been able to determine, this is demanded, and that not very decidedly, in only one institution. Too much stress cannot be laid on this requirement, and under no consideration ought pathology, as we now understand it, to be studied without physiology as a basis. I can leave this part by simply referring to the absurdity of a medical student studying human pathology without understanding the circulation of the blood. Next in importance comes a knowledge of chemistry, and preferably at least a year of organic chemistry, and a knowledge of physics. Physiological problems are becoming more and more physico-chemical problems, and a thorough understanding of these sciences is absolutely essential. A good reading knowledge of modern languages, an understanding of the morphology of higher plants, and if possible of fungi and bacteria, together with an ability to grow fungi and bacteria may complete the list. This preparation would mean that a course in pathology could not be begun until the senior year or thereafter.

Coming now to the main subject as to what we are to teach, I would simply offer a few broad suggestions. It really does not make much difference as to how the subject is divided, so long as some of the fundamental conceptions of disease are included. The amount of work which one will be able to accomplish will depend upon the individual. I believe firmly that we ought to train a student so that he can think and work for himself, and that this should be kept uppermost at all times. It is impossible in the course of a year to study all diseases of plants, and granting that this is true, we must select certain fundamental facts to impress upon the student, allowing him to work out many others for himself later on. Such fundamental facts are the cause of disease, the symptoms of disease, the way in which diseases spread, the prevention of disease, and the nature of disease. In his treatise on the Diseases of Plants recently issued, Professor Marshall Ward has discussed the topics just mentioned in a suggestive manner, and in a way not presented before.

Taking it for granted that the student is familiar with the normal physiological behavior of a cell and cell-groups, one may begin the study of disease by noting the change in single cells or cell-groups under abnormal conditions, and the reactions which are induced by these conditions. The study of wounds offers a very fruitful field for the beginner, for we find in a wound one set of changes which cells undergo when diseased. The irritable nature of the cell which enables it to form a protection against the air, and later on the protecting cork layer and the callus is fully brought out in that connection. I have found succulent stems and leaves very good for the study of wounds, particularly the leaves of the cauliflower. In this connection the wounds caused by insects can be studied, and the peculiar response which the living tissue makes to the disturbing cause. Plant lice abound everywhere, and so do gall flies, so that there is never any trouble in getting living material for study. Following this one may observe the influence of living organisms in cells, for instance, the manner in which the various Chytridiaceae influence the leaf tissue. From these one may continue with the more complex reactions of fungi like *Albugo*, *Exoascus*, and *Gymnosporangium*. With all of these it is possible to keep the fungus, and the leaves attacked, under constant observation. With some it is not easy, for instance the *Exoascus* and *Gymnosporangium*; these had best be observed out-of-doors in the spring; with a little judicious planning it is feasible to postpone the study of these complex reactions until the latter part of the course. *Albugo* and *Synchytrium* can be grown on plants in greenhouses. Very different from the influence exerted by these fungi is that exerted by others like *Botrytis*, the Uredineae, and the Peronosporeae. It will be sufficient for me to refer to this simply, as the reasons why these should be included are obvious enough.

If time permits, the changes in cell-groups near wounds and spots attacked by fungi can be studied, *i. e.*, the formation of wound gums, the increased evolution of heat and the rapid transformation of plastic food bodies, the accumulation of starch, etc.

A second line of work grows out of the question as to what causes disease. This question involves most of the others mentioned above, and can be made the starting point for all. Using the convenient division of disease caused by the action of either environmental factors of living organisms, one can begin by experimenting with unfavorable environmental conditions. In doing so it is of course hardly necessary to say that great care must be used in devising experiments which will give definite results. To illustrate: if the influence of excessive heat is to be studied, one must be sure that the light, moisture and gaseous conditions are the same. As a rule it will prove most satisfactory to work with those factors which can be most readily handled, for it is after all, as has been said, the method of study that we are after, rather than a long series of facts. This part of the work can of course be carried on hand-in-hand with that part first suggested, for it is not possible to separate cause and effect.

Coming next to the influence of living organisms, a large field is opened with any number of possible lines of work. One of the first points to be demonstrated is that fungi or bacteria are the causes of disease. For this purpose it is well to select a fungus which grows readily and reproduces rapidly. There are a number of these. This fall we found *Erysiphe graminis* growing on wheat, a most interesting fungus to work with. I can perhaps make my meaning clearest by relating briefly what we did. A preliminary discussion brought out a number of questions which we desired to answer, such as : (1) Does this fungus produce the disease of wheat which it was found connected with, *i. e.*, will it make perfectly healthy plants diseased? (2) How does it do so; in other words, what is the relation of the fungus and the wheat leaf? (3) Will the spores of the fungus produce the disease in other plants besides the wheat plant, for instance oats, rye, wheat, *Poa*, corn, roses, etc. (4) Is there any connection between the ease with which this fungus attacks the wheat, and the condition of the plant to be infected? (5) What factors favor development of the fungus? Will the fungus grow on dead leaves? (6) How does the spore get from plant to plant? (7) What are the factors which determine germination of the spores?

Each student was instructed to find a method for answering these questions, and such others as arose, and as a result we had a series of experiments started, which were watched with the utmost interest. The questions dealt with broad subjects applicable to most other fungi or disease-causing factors. The results showed that the fungus does produce the disease, and thereby answered one of the most important questions. To the average mortal "seein' is believin'," and when a student actually sees himself producing the disease in question, as he thinks, the impression gained is that of the original investigator, and is apt to be remembered. The results brought into discussion the problem of susceptibility, both of plant races and individuals ; it was found that of all the plants the wheat alone was attacked, and again that the stronger plants were less liable to attack. Again it was found that crowding helped the fungus, that moisture and warmth had the same effect, and that the spores could germinate in a drop of water. We spent a long time studying *Erysiphe graminis*, but I believe that the results amply warranted our doing so.

One might have used other fungi, for instance the clubroot of the cabbage, the cotton wilt, and others, bearing in mind that rapid growth is desirable, for when you have to wait six months or more the interest is liable to wane.

Having carried on one series such as the one described, it may be well to continue with as many more as one may have time for. Where live material of the bacterial diseases can be obtained, those will probably offer as satisfactory objects for study as could be wished for. The effect which bacteria produce on the plant is usually noticeable after brief periods. Then again pure cultures can be made easily, and these can be subjected to various conditions, to show whether vigor of the parasite has anything to do with the virulency of the disease. The rusts can be used to some extent, particularly after several years, when one has succeeded in establishing barberry plants with aecidia. The species of *Melampsora* and *Puccinia* furnish useful material.

The smuts are very instructive. We have one section of our greenhouse devoted to these, using several grains. These are covered with spores before planting and after several months the new spore crop is obtained. We have not yet tried any of the anthracnoses, probably because of the lack of living material, but they ought to be easy to handle, as pure cultures can so readily be made and kept. One might go on at length with this phase of the study. This is hardly necessary now, for to the live teacher new points of view will present themselves from time to time.

A word ought to be said about insects here, for they destroy plants as much as fungi do. The entomologist has reigned supreme in this field hitherto, probably for the same reason that the systematic mycologist has had charge of the fungus side. The biting insects which injure plants by making wounds have little interest for the pathologist aside from the wounds made. Those insects which form galls, which mine in leaves and stems, or under the bark of trees, have a decided interest for him, and ought to be alluded to at least in any course of vegetable pathology.

A third phase which I wish to touch upon briefly deals with the influence of environment on the disease-causing factors, particularly the fungi. Many spores of fungi must undergo resting periods of various lengths of time before germinating; others do not ripen until late in the winter. Sclerotia must undergo freezing or a resting period. I believe truly that there are many of us that know positively that the ascospores of *Microsphaera* germinate sometimes and produce patches of mycelium, and that the sclerotia of *Claviceps* form perithecia bearing heads, but how many of us have ever seen these spores germinating, or tested the length of time necessary to do so? We have built a "resting frame" so-called for our fungus friends in the Missouri Botanical Garden, where they lie under leaves, and are disturbed every once in a while, and put under conditions where they might change, side by side with spores or sclerotia kept indoors all the time. Sometimes our spores germinate and sometimes they never do. But even then the student learns the lesson that the spores of fungi have adapted themselves to the peculiar conditions of environment, and will respond only when these are exactly right. Under proper conditions most spores will germinate, and it is a far more instructive lesson to have them do so after repeated failure than to give up the first time. I have always remembered the sad face and drawl of the man in my class at college who said that it was all very nice to study the sections of cluster cups and see mounts of germinating teleutospores and sporidia, but he didn't think they ever did those things outside, if so, why didn't we ever see them.

Therapy, or healing, forms a small part of our study, for with plants the maxim that prevention is better than cure must always hold true. Spraying and other fungicidal methods may properly be experimented with on a small scale, but only with infected plants. With smuts the various seed treatments can be carried out without much trouble, at the same time that smut-infected seeds are planted.

Summing up briefly, I would emphasize the fact that in all the phases of this study the living plant must be kept in the foreground. It goes without saying that the division suggested above cannot be rigidly maintained, nor is it desirable. The various factors work too closely one with or against the other, but with care, each can be emphasized at the proper time. The theoretical considerations of immunity, the symptoms of disease, the spreading and the nature of disease, must go hand-in-hand with the experimental work, but should at all times be subordinated to it. Questions such as that belong to the end of a course, after the student has thoroughly grasped the meaning of the complex interrelation of plants to each other and their surroundings. Personal acquaintance with one or more diseases, and a careful analysis of each, will lead to a broader conception of disease by itself, and will make a more lasting impression on the student when he must puzzle over these questions on his own account. Nowhere is too much teaching to be deplored more than in experimental work of the kind mentioned above.

Two new Western Mosses

By R. S. Williams

(With Plates 4 and 5)

Eurhynchium Taylorae

Evidently dioicous; no ♂ flowers found. In loose tufts with stout, creeping stems (in places denuded of leaves and with dense tufts of radicles) up to 20 cm. long and 0.44 mm. in diameter; cross sections show a well-defined central strand of numerous small cells and outer wall of about three rows of small thick-walled cells; branches rather short (1 to 2 cm.), irregular and often distant; stem and larger branch leaves loosely spreading, obtusely pointed, the branch leaves often truncate or praemorse at tip, decurrent, serrulate all round to a little above the base, reflexed on margin above and near base and costate about ⅞ up, the costa ending in spine and more or less papillose below; stem leaves measure up to 2.5 × 1.5 mm., middle branch leaves 1.5 mm. and upper branch leaves 0.875 mm. long, the lowest branch leaves very small, roundish and often ecostate; inner perichaetial leaves ecostate or very faintly costate, abruptly narrowed to a slender flexuous serrulate point and irregularly toothed and lacerate at base of point; leaf-cells mostly linear-vermicular, median .004 × .06 to .08 mm., apical very short and irregular, alar forming an elongated not well-defined group of pale cells about .008 mm. wide and two to four times longer, the basal cells somewhat thickened and pitted, especially toward costa; capsule mostly horizontal, contracted more or less under the mouth when dry, without lid 2.5 by 1.5 mm., lid with obliquely rostrate beak 2 mm. long, stout, smooth seta up to 15 mm. high, annulus of two or three rows of cells; peristome teeth very slender-pointed, striate below, papillose above, hyaline bordered, the segments more or less split with mostly two somewhat appendiculate cilia between; stomata roundish, .025 mm. in diameter; spores nearly smooth, up to .014 mm.

In size this plant most nearly approaches *E. Oreganum* of any of our North American species but is less regularly pinnate with smooth seta, etc. It much more closely resembles *E. striatum* of Europe, but is a more creeping plant with less divided stems and leaves never acutely pointed as in that, which also lacks the spine at apex of costa.

Collected by J. B. Leiberg on decaying logs in streams, April, 1889, Traille River Basin, Idaho (172). Named for the artist who has made the excellent drawing which accompanies this description, Miss Alexandrina Taylor.

Brachythecium Pringlei

Monoicous; ♂ flowers abundant on fruiting stems. Growing in compact tufts with ascending, more or less branching stems 4–5 cm. long and 0.25 mm. in diameter; cross sections of stem show a distinct central strand and 3 or 4 rows of thick-walled outer cells; branches mostly short, rather irregular, with curved tips; stems and branch leaves very similar, up to 2.5 × 1.5 mm., secund, mostly broadly ovate with short acute point, long decurrent, concave, scarcely or not plicate, borders flat, entire or slightly serrulate above; leaf-cells somewhat thickened and near base, pitted; median cells linear, about .04 × .005 mm., alar cells mostly about .012 × .016 mm., often forming a distinct convex cluster packed with chlorophyll; inner perichaetial leaves erect, gradually lanceolate-pointed, the point somewhat variable in width, nearly entire and ecostate; seta distinctly papillose in upper part, about 1 cm. high; capsules (not quite mature in only specimens seen) ovate-oblong, not quite symmetrical, nearly erect, with lid 2.5 mm. long; lid highly conical, .8 mm. high; annulus narrow, of 1 or 2 rows of cells; teeth about .430 mm. high and .065 mm. wide at base, rather broadly and irregularly pointed, hyaline bordered, rather irregularly striate and somewhat papillose below, and distinctly papillose above; basilar membrane of endostome extending about two fifth up, segments more or less split, cilia mostly 2 and not appendiculate; stomata slightly elongated, about .025 mm. long; spores (immature) smooth, .015 mm.

This plant with its short-pointed, scarcely plicate and secund leaves with vein sometimes forking, has much the appearance of a *Limnobium* (*Hygrohypnum*), but the seta rough above and the highly conical lid seem to relate it most closely to *Brachythecium*, which also contains all the first-mentioned characters. Collected by C. G. Pringle in the Huachuca Mts., Arizona, July, 1884 (22).

Explanation of Plates

Drawings made with a magnification twice the diameter reproduced on the plates.

PLATE 4

FIG. 1. Plant, natural size.
FIG. 2. Stem leaf, × 15.
FIGS. 3, 4, 5. Lower, middle and upper branch leaf, × 15.
FIG. 6. Alar region of stem leaf, × 120.

FIG. 7. Apex of same, × 120.
FIG. 8. Cross section of costa.
FIG. 9. Part of cross section of stem, × 87.
FIG. 10. Perichaetial leaf, × 15.
FIG. 11. Capsule, × 7.5.
FIG. 12. Stoma, × 210.
FIG. 13. Portion of peristome with annulus, × 120
FIG. 14. Spores, × 120.

PLATE 5

FIG. 1. Plant, natural size.
FIG. 2, 3. Stem leaves, × 15.
FIG. 4. Branch leaf, × 15.
FIG. 5. Alar region of stem leaf, × 120.
FIG. 6. Apex of same, × 120.
FIG. 7. Median cells, × 210.
FIG. 8. Cross section of leaf, × 120.
FIG. 9. Part of cross section of stem, × 120.
FIG. 10. Antheridial bud, × 15.
FIG. 11. Antheridia and paraphyses, × 45.
FIG. 12. Perichaetial leaf, × 17.
FIG. 13. Capsule with upper part of seta.
FIG. 14. Oblique view of seta showing papillae, × 162.
FIG. 15. Stoma, × 210.
FIG. 16. Part of peristome and capsule, × 120.
FIG. 17. Spores, × 120.

New Species of Fungi

By Charles H. Peck

Tricholoma niveipes

Pileus at first hemispherical or very convex, becoming broadly convex or nearly plane, dry, innately fibrillose, almost virgate, dark brown or grayish-brown; flesh white; lamellae rather narrow, close, sinuate, snowy white; stem equal or nearly so, solid or stuffed, snowy white; spores oblong, 7–8 μ long, 3 μ broad.

Pileus 5–12 cm. broad; stem 5–7 cm. long, 6–12 mm. thick.

Sandy soil under or near pine trees. South Yarmouth, Mass. October. S. Davis. The species is allied to *T. terreum* and its variety *fragrans*, from both of which it is separable by its more fibrillose pileus, its closer pure white lamellae and very white stem and by its more narrow spores.

Hygrophorus pallidus

Pileus thin, convex, becoming nearly plane with the margin somewhat decurved and sometimes wavy, glabrous, hygrophanous, pale lilac or mauve and sometimes striatulate on the margin when moist, grayish-white when dry; lamellae rather thick, distant, arcuate, adnate or slightly decurrent, colored nearly like the pileus when moist, subcinereous when dry; stem slender, equal or narrowed downwards, glabrous, hollow, white; spores white, subglobose, 5–6 μ long, 4–5 μ broad.

Pileus 1.5–3 cm. broad; stem 2.5–5 cm. long, 2–4 mm. thick.

Damp, mossy or swampy ground. Mass. September. S. Davis. This is apparently related to such species as *H. sphaerosporus* and *H. Peckii.*

Hygrophorus pusillus

Pileus convex, thin, slightly viscid, glabrous, white; lamellae arcuate, subdistant, decurrent, white; stem short, glabrous, hollow, white, with a white mycelioid tomentum at the base; spores 4–6 μ long.

Pileus 1–2 cm. broad; stem 2–2.5 cm. long, 1–2 mm. thick.

Growing on the ground in dense woods. Moscow Mountains, Idaho. November. L. F. Henderson. The species is apparently related to *H. niveus*, but its pileus is not at all umbilicate, and the plant has a pleasant anise-like odor. By its hollow stem and smaller spores it is separable from *H. russo-coriaceus*.

Hygrophorus paludosus

Pileus fleshy, convex, obtuse, covered with a thick yellowish or brownish gluten, whitish; flesh white, taste slightly acrid, odor earthy; lamellae adnate or slightly decurrent, subdistant, whitish, stained with greenish-yellow when old; stem nearly equal, rather long, flexuous, often curved at the base, solid, glutinous, white, with yellowish glandular dots at the top, streaked with brownish fibers or shreds of the dried gluten when dry; spores white, broadly elliptic, 8–10 μ long, 5–7 μ broad.

Pileus 2–4 cm. broad; stem 5–10 cm. long, 4–8 mm. thick.

Growing among peat mosses. Greenville, Mich. September. B. O. Longyear. The species is apparently related to *H. chrysodon*, but its habitat is different, it is a more slender plant, the dots at the top of the stem become black in drying, and there are yelish stains at the base of the stem.

Russula pulverulenta

Pileus rather thin, convex, soon centrally depressed or subumbilicate, even on the margin, pulverulent or scurfy, grayish-brown; flesh white, taste disagreeable, odor fetid; lamellae moderately close, adnate, white, the interspaces veiny; stem subequal, thickly beset with yellow dots or granules, white at the top, pallid below; spores globose, 8 μ in diameter.

Pileus 3–5 cm. broad; stem 3–4 cm. long, 8–10 mm. thick.

Woods. Michigan. July. B. O. Longyear.

The relationship of this species is apparently with *R. foetens* and *R. granulata*, from both of which it is very distinct by the yellow pulverulence of the pileus and stem and by the even margin of the pileus.

Russula ventricosipes

Pileus thin, broadly convex, nearly plane or slightly depressed in the center, glabrous, varying in color from tawny yellow to pale alutaceous; flesh white; lamellae thin, narrow, close, slightly sinuate, adnate, white or whitish, becoming discolored in drying; stem stout, firm, ventricose, solid, or somewhat spongy within, subglabrous, whitish above, reddish toward the pointed base; spores broadly elliptic or subglobose, 6–8 μ long, 6 μ broad.

Pileus 5–7 cm. broad; stem 5–7 cm. long, about 2.5 cm. thick in the middle, more narrow toward each end.

Sandy soil under or near pine trees. South Yarmouth, Mass. October. S. Davis.

A singular species resembling in some respects *Tricholoma compactum*, but apparently a *Russula*. Remarkable for the thin, slightly sinuate lamellae and the stout ventricose stem which seems out of proportion to the small thin pileus.

Cantharellus pulchrifolius

Pileus thin, convex or slightly depressed in the center, glabrous, distantly and obscurely ciliate on the margin, white; lamellae simple, unequal, distant, decurrent, bright yellow; stem nearly equal, glabrous, hollow, white; spores elliptic, 8 μ long, 4–5 μ broad.

Pileus about 1 cm. broad; stem 1–1.5 cm. long, about 1 mm. thick.

Decayed wood. Moscow Mountains, Idaho. October and November. L. F. Henderson.

This is a small but beautiful species. The bright but delicate yellow hymenium, approaching a deep chrome, contrasts prettily with the clear white color of the pileus and stem. The cilia on the margin of the pileus are distant and easily overlooked. The lamellae are unbranched but a few short ones intervene.

Marasmius tomentosipes

Pileus thin, convex, becoming nearly plane, generally umbilicate, glabrous, widely striate on the margin when moist, brownish yellow or ferruginous, becoming brown with age; lamellae thin, subdistant, unequal, arcuate, decurrent, pale yellow, interspaces venose; stem slender, tough, elastic, hollow, blackish-brown, covered with a tawny tomentum which is more dense and matted at the base; spores elliptic, 6–7 μ long, 3–4 μ broad.

Pileus 1–3.5 cm. broad; stem 2–4 cm. long, about 1 mm. thick.

Vegetable mold in damp mossy places in coniferous woods. Moscow, Idaho. December. L. F. Henderson.

This species bears a close resemblance to *Omphalia campanella* and might easily be mistaken for it if the tomentum of the stem is overlooked. This is sometimes collected in minute tufts which to the naked eye give a pulverulent appearance to the surface of the stem. The plants revive under the influence of moisture.

Lentinus Americanus

Pileus thin, convex, nearly plane, centrally depressed or subinfundibuliform, glabrous, irregular or lobed on the margin, pallid; lamellae moderately close, dentate and lacerate on the edge, slightly decurrent, whitish; stem short, nearly equal, even, solid, brown with a reddish-brown strigose villosity toward the base; spores broadly elliptic or subglobose, 6 μ long, 5–6 μ broad.

Pileus 2–2.5 cm. broad; stem 1–1.5 cm. long, 2–4 mm. thick.

Growing singly or in tufts, rarely on rotten logs, commonly on the ground in moist shady thickets. Volmer, Idaho. L. F. Henderson.

The stem is sometimes eccentric but it is not at all sulcate. The plants have a delicate odor resembling that of apricots and an agreeable taste.

Entoloma nigricans

Pileus thin, convex, becoming irregularly expanded and centrally depressed, innately silky fibrillose, shining, dark gray or blackish, the cuticle often radiately cracking, inodorous; lamellae broad, subdistant, sinuate, adnate, salmon color; stem equal, silky fibrillose, at first solid, becoming hollow, shining, white streaked with black, sometimes scurfy at the top; spores salmon color, angular, uninucleate, 8–12 μ long, nearly as broad.

Pileus 2.5–4 cm. broad; stem 2.5–5 cm. long, 4–8 mm. thick.

Woods in low ground. Near St. Louis, Mo. October. N. M. Glatfeldter. In the dried specimens the margin of the pileus is somewhat striate or sulcate, but the pileus is not striate when fresh nor is it hygrophanous.

Locellina Starnesii

Pileus fleshy but thin, convex or nearly plane, somewhat umbonate, white with a sepia brown center from which radiate brown streaks or lines intermingled with minute brown spots or dots; flesh white; lamellae narrow, close, free, concealed when young by the membranaceous white veil, pink or rosy tinted, becoming cinereous brown with age; stem slender, often curved, sometimes straight, stuffed with a small pith, white, ending below in a cup-like bulb; annulus superior, often torn and adhering partly to the stem and partly to the margin of the pileus; spores brown, elliptic, 5–6 μ long, 4 μ broad.

Pileus 2.5–5 cm. broad; stem 2.5–5 cm. long, about 4 mm. thick.

Bath, Georgia. October. V. Starnes.

So far as known to me, this is the first representative of this genus found in our country. I find no description to match it and take great pleasure in dedicating it to its discoverer.

Agaricus Sterlingii

Pileus fleshy, firm, convex or sometimes slightly depressed in the center, slightly silky and sometimes with appressed spot-like scales in the center, pale brown or grayish-brown; flesh dingy, white or brownish; lamellae thin, close, free, pale brown, becoming blackish-brown with age; stem equal or nearly so, solid or stuffed, whitish, sometimes darker above the annulus; veil thick, partly adhering to the margin of the pileus and partly to the stem; spores broadly elliptic, 6–8 μ long, 4 μ broad.

Pileus 5–12 cm. broad; stem about 2.5 cm. long, 8–12 mm. thick.

Cespitose. December and April. New Jersey. E. B. Sterling.

This is one of the few species of the genus *Agaricus* in which the lamellae show no pinkish hues in any stage of development. Even in the young plant they have a light sepia tint which becomes darker with age. This mushroom is edible and is regarded by the two families who have eaten it freely, as richer in flavor than the common mushroom. It seems to be more productive and less quickly perishable. Specimens were sent me by Mr. Sterling to whom the species is dedicated.

Clavaria grandis

Stem stout, distinct, radicating, divided above into numerous long erect or slightly diverging branches which are repeatedly branched, solid but very fragile, glabrous, reddish-brown with white tips at first, becoming somewhat pulverulent and ferruginous brown with concolorous tips when old, somewhat fragrant; spores ferruginous, broadly elliptic or subglobose, distinctly verrucose, 10–12 μ long, 6–8 μ broad.

Plant 12–20 cm. high, nearly as broad above; stem 2–2.5 cm. thick.

Thin woods under *Smilax* bushes. Maryland. September. F. J. Braendle.

According to Mr. Braendle this large *Clavaria* is edible when prepared as pickles and put up in spiced vinegar.

HELVELLA MACROPUS **brevis** var. nov.

Cups small, 8–16 mm. broad; hymenium black or nearly so; stem short, 8–16 mm. long; spores uninucleate.

Massachusetts. G. E. Morris.

The small size, darker hymenium and very short stem, which is scarcely more than half an inch long, are the distinguishing characters of this variety. A conglobated mass of earth adheres to the bottom of the stem which thereby appears at first sight to be bulbous.

Some new Species of Californian Plants

By Alice Eastwood

(With Plates 6 and 7)

Fritillaria Purdyi (Plate 6)

Corm with fibrous roots, deep-seated, with a large bublet on one side and a very small one on the other; stem flexuous, enlarged below the leaves, extending underground 15 cm.: radical leaves opposite but apparently whorled in 3 pairs, thick, pale green, oblong-lanceolate; the outer 3 cm. broad, 9 cm. long; the inner about half as broad and of almost equal length; margin strongly undulate, crisped along the very edge; cauline leaves 4, alternate, lanceolate, obtuse or callous-tipped: flowers 1–2, 2.5 cm. long, white, mottled with purple in lines and spots, on erect pedicels that recurve at apex; outer divisions obovate, 13 mm. wide, slightly incurved at base, the middle marked by a greenish-yellow band which later becomes purple; inner divisions oblong-lanceolate, as long as the outer but narrower, 8 mm. wide: stamens with versatile anthers, filaments 1 cm. long: ovary 6-ribbed, cylindrical, 5 mm. long, spotted with purple, tipped by the style, which is 2 mm. long: fruit purplish, obconic-orbicular, obtusely 6-sided, each side being marked by a prominent nerve but without wings or ribs, abruptly tapering at base, flat on top, about 15 mm. long: seeds somewhat thickened on one side, winged on the opposite side, 6 mm. long.

This description was drawn from fresh specimens sent by Carl Purdy in whose honor it is named. The specimens were grown in Mr. Purdy's garden in Ukiah from bulbs sent by Mr. Charles Lowe from Kneeland, Humboldt county, California. It was blooming in April in Mr. Purdy's garden and the ripe fruit was sent to me by Mr. Lowe, May 27. He collected it where he had collected the original bulbs. Mr. Lowe also sent blooming plants in April which were not so tall nor so luxuriant as those from which the description was made. The type is in the herbarium of the California Academy of Sciences. The drawing, from the fresh specimen, was made by Miss Margaret W. Buck.

Monotropa Californica (Plate 7)

Stems solitary or in clumps, about 1 dm. high, glabrous, waxy-white: leaves deltoid to ovate, sessile by a broad base, acute, entire or slightly erose, 1–2 cm. long, about 6 mm. wide at base: flowers in a densely-flowered erect spike, terminating the erect stem, containing about 15 flowers; bracts similar to the leaves, but narrower, the upper ones becoming spatulate with broad, short petioles; terminal flower first in bloom, with 5 petals and sepals and 10 stamens; lower flowers with 4 petals, 2–4 sepals and 8 stamens: sepals rhomboidal oblanceolate or linear, keeled, the blade when present about as long as the claw, altogether 12 mm. long, 2–4 mm. wide, margin slightly erose, outer surface glabrous, inner sparingly hairy: petals oblong-obovate, 12 mm. long, 4 mm. wide, densely hairy within, saccate at base, the sac containing nectar, lower margin ciliate, upper erose and sometimes slightly cleft on one side: stamens linear, ribbon-like, woolly, most densely so under the anthers, alternately long and short, 6–7 mm. long, .5 mm. wide, without any dilation at base; anthers bright red, shaped like a strawberry, opening by two equal slits on each side; pollen white: ovary 4–5-lobed, with each lobe obtusely 2-ribbed; style thick, as long as the ovary, densely woolly, especially below the yellow depressed-capitate stigma which is hairy at the center and around the viscid yellow outer rim.

The entire plant, except the red anthers and yellow stigma, is pure white and without any odor, except an earthy smell like a fungus.

Its erect habit at once distinguishes it from *Monotropa Hypopitys* to which it is most closely allied. The stamens seem different from those of other species of *Monotropa*, judging by the figures and descriptions. These were probably made from dried specimens and perhaps from stamens from which the pollen had been discharged.

This species was found on a hillside bordering Little Carson Creek, in Marin county, California. The hill was covered with a dense growth of small trees of *Quercus densiflora*. *Clintonia Andrewsiana* was abundant and occasional specimens of *Coralorhiza Bigelovii* and *C. multiflora* were found near by. The first specimen (in bud) was found on May 12th. This was a solitary plant. On May 30th a clump of five plants was found in the same neighborhood, but no more have been seen though searched for diligently.

Unless the anthers are peculiar, this belongs to the section *Hypopitys*, which is considered a distinct genus by some botanists.

Type in the herbarium of the California Academy of Sciences.

Cycladenia venusta

Stems low, 1–1.5 dm. high, several from a horizontal woody rootstock, glaucous and glabrous throughout except the flowers: lowest leaves scale-like; the others broadly ovate to orbicular, 2–6 cm. in diameter, coriaceous, prominently nerved; apex obtuse, acute, or abruptly acuminate; base broadly cordate or cuneate; margin entire or slightly undulate; petioles broad, flat, longer than the blades on the lower leaves, shorter on the upper, connate-clasping: flowers in axillary corymbs, 3–7-flowered; peduncles rather stout, generally shorter than the leaves; pedicels less than half as thick, glabrous or sparingly pubescent, 1.5–3 cm. long; bracts ovate-acuminate, glabrous externally, with a few scattered hairs within and on the margins, about 5 mm. long: divisions of the calyx extending almost to the base, linear-lanceolate, 5 mm. long, 1 mm. broad, clothed on both sides with scattered, spreading hairs: corolla funnel-form, with tube slightly shorter than the calyx, limb almost 2 cm. long, lobed about half way with five equal orbicular-oblong lobes, 7 mm. in diameter, bright rose-color, hairy externally, especially on the tube, somewhat pubescent within and viscid: stamens with short, hairy filaments, inserted at the top of the tube on the ribs; anthers sagittate with the apex and tips cuspidate: stigma as in the genus: follicles glabrous and glaucous, immature, 4 cm. long.

This beautiful species was first collected by the writer on the summit of Santa Lucia Peak, in Monterey county, California, June 9, 1893. It was collected by Mr. R. A. Plaskett on Cone Peak in the same range of mountains in fruit in 1898.

It differs from *Cycladenia humilis* Benth. in the shape of the leaves, much larger flowers, corolla with shorter tube and more open-campanulate border, and the pubescence of the flowers.

Type in the herbarium of the California Academy of Sciences.

Potentilla Hickmani

Perennial from a woody tap-root; the caudex densely clothed with the brown, dry stipules and petioles; stems low, decumbent, 8–15 cm. high, sparingly clothed with appressed hairs: leaves mostly radical, with generally six pairs of rather distant, petiolulate leaflets; these cuneate, digitately 3–4-cleft or divided, with linear or lanceolate divisions, 2–8 mm. long, 1–3 mm. wide, veiny, glabrous or with a few scattered hairs on the upper surface, more densely appressed-hairy on the lower; stipules attached to the petiole, the free portion linear-acuminate, about 5 mm. long; cauline leaves few and distant, with large, obliquely ovate stipules which are adnate to the petiole up to the blade; these are similar in form to the leaflets but larger: cyme with 2–4 branches, each 1–2-flowered: calyx clothed with appressed pubescence, more densely so at base; divisions ovate, obtuse, 6 mm. long, 3.5 mm. wide: bractlets 1/3 as long, ovate: petals yellow, 6 mm. long, 5 mm. wide, cordate with shallow sinus: receptacle white-hairy: filaments narrowly subulate, 2 mm. long: style slender, attached to the akene a little below the apex, glabrous, 3 mm. long: akene glabrous, gibbous.

This seems to come nearest to *Potentilla Plattensis* Nutt., from which it differs in having larger flowers, with obtuse calyx lobes and bractlets and digitately cleft leaflets less imbricated. The broad stipules are noticeable on the cauline leaves, those on the radical leaves being much narrower.

This was collected in a forest of *Pinus radiata* Don., near the reservoir which supplies Pacific Grove, California, along the road to Cypress Point, April 4, 1900. It is named in honor of Mr. J. B. Hickman who has collected many interesting plants in Monterey county and who was my guide on the trip on which this was collected.

Type in the herbarium of the California Academy of Sciences.

Orthocarpus psittacinus

Perennial, stems several from a branched caudex, generally also branching above, 1.5–2 dm. high, striate, pilose with spreading white hairs: lower leaves linear, entire, 2–6 cm. long; upper ones broader, 3–5-cleft near the apex into linear lobes, the middle lobe longest; floral leaves broader, the middle lobe generally irregularly 2–5-cleft, the ultimate division often broadening at the apex, greenish-yellow, surpassing the flowers: calyx with membranous tube enclosing the corolla and with four lanceolate-filiform divisions, equal or unequal, extending below to the ovary and above to the throat of the corolla, greenish-yellow: corolla the same color, 2 cm. long; upper lip straight, slightly surpassing the lower, obtuse; lower lip 3-cleft with oblong, obtuse divisions, 2 mm. long, plicate below: stamens with glabrous filaments and 2-celled anthers, the cells unequal: style exserted; stigma capitate; ovary acute, minutely papillose: seeds 1 mm. long, the outer coat membranous, deeply pitted.

This is probably one of the forms included under *Orthocarpus pilosus* Watson. The leaves are not divaricately lobed as in that species, the divisions of the calyx are equally cleft and much narrower, the corolla is longer with the divisions more nearly equal in length, and the seeds are more membranous and more deeply pitted. I have compared it with specimens of *O. pilosus* collected near Lake Tahoe and Summit Station on the C. P. R. R. This is in the same region as the original collection, Washoe county, Nevada.

This species came from Warner Mountains, Oregon and was collected by Mrs. Bruce, July, 1898 (no. 2240).

Type in the herbarium of the California Academy of Sciences.

Spraguea pulchella

Apparently annual, low, with slender decumbent stems, glabrous throughout: radical leaves spatulate on long margined petioles, longer than the blades, together 5–20 mm., purplish, entire, obtuse; cauline leaves of two kinds, one like the radical leaves but smaller, the others bract-like: flowers in scorpioid subcapitate spikes, closely imbricated, at the ends of slender divaricately spreading branches; pedicels short; bractlets broadly ovate-cordate, rose-color, membranous: sepals somewhat unequal, orbicular, emarginate at apex, reniform at base, rose-color with darker or somewhat greenish stripe down the middle, 3 mm. in diameter: petals 4, oblong to linear, acute, thin, veiny, conniving over the ovary after anthesis, slightly over 2 mm. long: filaments about as long as the petals, filiform: anthers elliptical, .5 mm. long, yellow, not exserted: style long and slender, the two-cleft apex surpassing the corolla: ovary with 1–2 ovules on slender funiculi: seeds the same number, showing through the diaphanous walls of the orbicular capsule, brown when ripe.

This comes nearest to *Calyptridium monospermum* Greene. It differs in the shape of the sepals and petals, in having invariably not more than two ovules, while *C. monospermum* has from one to several, ripening 1 or 2 seeds. The panicle is more open and the entire plant more slender and delicate. My specimens were compared with the duplicate of the type, no. 2135 of the Death Valley Expedition, collected in Big Cottonwood Meadows by F. W. Koch. It was kindly loaned me by F. V. Coville, Chief of the Division of Botany, Department of Agriculture, Washington, D. C.

This species was collected by Mr. J. W. Congdon near Pea Ridge road, Mariposa county, California, April 19, 1901.

Type in the herbarium of the California Academy of Sciences.

Sidalcea rostrata

Perennial from a rather short horizontal rootstock which is generally conspicuously verrucose with the old axillary buds: stem erect, 3 to 4 dm. high, sparingly hispid with simple forked or stellate spreading or irregularly appressed hairs, obtusely angled: leaves strongly nerved, pubescence as on the stem but more abundant, especially on the petioles; radical leaves orbicular reniform, 5 cm. broad, crenate with every alternate sinus deeper, on ribbed petioles 6 to 15 cm. long; cauline leaves similar in outline, on shorter petioles, diminishing upwards, 7-lobed, the lobes again lobed or deeply crenate-dentate; stipules ovate-lanceolate, 5 mm. long, soon deciduous: inflorescence racemose-spicate, of about 16 flowers: lower bracts 5-parted into lanceolate divisions, surpassing the calyx, upper ones becoming more simple and smaller, not equalling the calyx: pedicels 5 to 10 mm. long: calyx open-campanulate, deeply parted into 5 deltoid-acuminate divisions about 1 cm. long, densely hispid externally with conspicuous spreading hairs, tomentose within at the apex and along the margin: petals rose-purple, obovate, 2.2 cm. long, 1.8 cm. wide, glabrous, veiny, densely ciliate at base above the broad short claw, deeply emarginate or cordate at apex with margin somewhat erose: stamineal column double, hispid: phalanges distinct, the outer less divided than the inner: anthers dark purple, papillose: carpels (immature) 8, sparingly pubescent, conspicuously rostrate with the yellowish beak densely hispid.

This was collected by H. E. Brown near Mendocino, California, June, 1898 (no. 815).

Type in the herbarium of the California Academy of Sciences.

This species belongs to the group of closely allied species where *Sidalcea malvaeflora* Moc. & Sess., is found. The carpels are, however, quite unlike those of any other species of the group and would be sufficient to mark it as distinct were it not for the other characteristic features.

Stachys flaccida

Perennial, from running rootstocks: stems stout, hollow, erect, about 10 dm. high, nearly glabrous below except for the pustulate retrorse bristles on the four prominent angles: leaves ovate-cordate, acute at apex, crenate, thin and flaccid, 10–13 cm. long, 5–8 cm. wide, woolly pubescent on the lower surface with irregularly appressed iridescent, fine white hairs, the pubescence on the upper surface more regularly appressed but less dense; petioles equalling or a little shorter than the blades, broad, flat, nerved, densely ciliate, clasping the stem and forming conspicuous nodes: spike leafy at base, about 15 cm. long, the leaves diminishing to linear-oblong bracts; peduncles densely glandular-villous; verticels 1–3 cm. apart, generally 4-flowered: calyx villous-pubescent and glandular, obliquely 2-lipped on pedicels, 1.5 mm. long; divisions deltoid, aristate, 3-nerved, about 9 mm. long, the two lower divisions somewhat shorter than the three upper, all shorter than the campanulate tube: corolla rose-color; tube 2 cm. long, villous-arachnoid; upper lip glandular-villous, rounded or truncate, about half as long as the lower lip; lower lip 3-lobed, the middle lobe hooded, surpassing the auriculate lateral lobes and hoary within: stamens inserted on the throat; filaments flattened, bearded, not exserted: divisions of the stigma equal; styles shorter than the filaments: nutlets immature.

This is nearest to *Stachys Chamissonis* F. & M. (Linnaea, Suppl., **6**: 80), of which it might be considered a variety. The flaccid foliage and smaller flowers are more suggestive of *S. ciliata* but the leaves are not acuminate as in that species. It appears to be an intermediate form for which at present a specific name seems better than a varietal, applied to either species. The type locality of *S. Chamissonis* is not given but it was collected by Chamisso and probably some place not far from San Francisco. Compared with specimens collected at Lake Merced near San Francisco this differs, besides in regard to the characteristics mentioned above, in having longer petioles and much more scanty pubescence.

This was collected by H. E. Brown near Mendocino, California, May, 1898. It is no. 836 of his collection. Type in the herbarium of the California Academy of Sciences.

Trifolium tenerum

Perennial, matted-caespitose, from running rootstocks, canescent and softly villous throughout with fine white loosely-spreading hairs: leaves, in general, longer than the internodes; petioles filiform, about as long as the leaflets; these 3, narrowly elliptical to oblanceolate, 5–10 mm. long, 1–2 mm. wide, aristate-acuminate; margin setosely serrulate; surface with conspicuous veins, terminating in the marginal setae, the lower more pilose than the upper; stipules 8 mm. long, adnate for more than one half their length; lower part scarious, veiny; the free upper portion green, subulate-aristate, serrulate: heads few-flowered (1–6), on filiform peduncles which are shorter or longer than the leaves;

involucre glabrous, very small, of 2–5 separate, laciniate-aristate bracts, 2–4 mm. long: flowers 1 cm. or so long, on pedicels less than 1 mm. long: calyx open-campanulate, with subulate aristate divisions a little longer than the tube; tube membranous between the strong veins: corolla long and slender; banner with 3 rounded teeth at the truncate apex; wings slender, as long as the banner, auriculate at base of blade; keel two thirds as long, tipped with an obtuse erect beak, the keel itself purple, auricled at base: ovary obovate, pilose at summit, 1-ovuled.

This seems to be the nearest to *T. pauciflorum* Nutt. from which it differs in habit, pubescence, leaves, flowers, ovary, etc.

It is one of the clovers which carpet the ground in the higher meadows on the trail to the south fork of King's River. It was collected by the writer at Summit and Bearskin Meadows, July 1–13, 1899. The first named specimens are considered the type specimens. Type in the herbarium of the California Academy of Sciences.

Explanation of Plates

PLATE 6. *Fritillaria Purdyi* Eastwood

1. Plant, natural size. 2. The bulb and roots. 3. The perianth spread out. 4. An outer division of the perianth. 5. The ripe capsule. (All natural size.)

PLATE 7. *Monotropa Californica* Eastwood

1. A single stem, natural size. 2, 3. Sepals. 4. Petals. 5. Pistil. 6. Front view of anther before it opens. 7. Back view of same. 8. Anther discharging pollen. 9. Appearance after the pollen has been discharged. The parts of the flowers are all enlarged five times.

Supplementary Notes on the Erysiphaceae

BY ERNEST S. SALMON, F.L.S.

(Continued from page 22)

PODOSPHAERA OXYACANTHAE (DC.) de Bary. (Monograph, p. 29)

Syn. add: P. clandestina Lév. var. *ramulicola* Thüm. Bull. Soc. Imp. Nat. Mosc. **56**^{2}: 126. 1882.

Exsicc. add:* Shear, New York Fungi, 138 (in herb. Jaczewski),

Distrib. add: Asia; Siberia (Minussinsk).

Hosts, add: Crataegus nigra (40), *C. sanguinea, C. tanacetifolius* (80), *Prunus Persica* (2*) (40*), *Vaccinium Vitis-Idaea.*

Professor N. Martianoff has kindly sent me a specimen of the *Podosphaera* on which Thümen founded his "*P. clandestina* var. *ramulicola.*" Thümen gave the following diagnosis: "Peritheciis dense aggregatis, numerosissimis, pulviniformibus; mycelio candido, non evanido; ascis sporisque typicis. In ramulis vivis *Crataegi sanguineae* Pall. in sylvis prope Minussinsk." The specimen is remarkable for the manner in which the perithecia are densely compacted in extended patches along the branch of the *Crataegus.* Due probably to this dense crowding, causing lateral pressure, some of the perithecia are oblong-pyriform in shape. The structure of the perithecium, the asci and spores are normal for the species. The perithecia are not fully mature, but the apices of the appendages show the beginning of the characteristic branching of *P. oxyacanthae.* On the whole, I consider that Thümen's plant, being characterized merely by the crowded habit of the perithecia is to be regarded as only a form, and not as a true variety, of *P. oxyacanthae.*

Examples of *P. oxyacanthae* with quite the same habit as that of the "var. *ramulicola*" are seen in the specimen in Ellis and Everhart's N. Amer. Fungi, no. 2335, "on leaves of *Crataegus,*

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*Only those exsiccati are quoted which have been personally examined, and unless prefixed by an asterisk, or followed by information as to the source, all the numbers refer to the copies in the Kew Herbarium. Those distinguished by an asterisk are to be found in the herbarium of the British Museum (Natural History), London.

London, Canada, July, 1889 (J. Dearness)." These specimens show further the manner in which this form passes gradually into the type: perithecia with a normal habit occur on both sides of the leaves; on the under side of the leaves about the midrib, we find perithecia congregated in patches with persistent mycelium; and on the branches themselves the perithecia are crowded into dense patches among persistent mycelium.

Other examples of *P. oxyacanthae* occur in the United States —on *Crataegus punctata* and other species of *Crataegus*, on *Prunus Virginiana*, etc.—in which the perithecia are densely crowded along the midrib of the leaf (although the aggregation is not quite so marked as in Thümen's plant), and in these cases it is to be noted that the mycelium is subpersistent in exactly the same manner as in "var. *ramulicola*." It may be observed that among the forms of *Sphaerotheca humuli* the plant on *Neillia opulifolia*, etc. (see monograph, p. 63), stands in the same relation to the type as the "var. *ramulicola*" does not typical *P. oxyacanthae*.

In a specimen of *P. oxyacanthae* on *Crataegus oxyacantha* from "Belluno, Italy (Speg. 7/10 '78)," the spores according to drawings by Spegazzini which are reproduced at *Pl. 9, f. 22*,* are very strongly curved. In the specimen sent to me I was unfortunately unable to find any mature perithecia containing spores. The almost allantoid shape of the spores shown in Spegazzini's drawings is certainly remarkable; although in *P. oxyacanthae* var. *tridactyla* I have observed that the spores are sometimes slightly curved, and in *Erysiphe trina* Harkn., the curving is more frequent and more pronounced.

In another specimen of *Spegazzini's* collecting, from the same locality and on the same host, the appendages reach from 2½ to nearly 3 times the diameter of the perithecium. Such cases as these show clearly the impossibility of keeping the *P. myrtillina* of Kunze and Schmidt apart from *P. oxyacanthae*. (See monograph, p. 32.)

Bailey (**2****) refers the fungus known commonly in the United States as the "peach mildew" to the present species, and observes: "the peach mildew (*P. oxyacanthae*) has been serious in various parts of western New York the past season. In the Niagara belt

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* The plates will appear with the final part in the BULLETIN for March.

it has attacked Crawfords, and upon Seneca lake I have seen a peach known as the Denton almost ruined by it. The fungus generally appears when the peach is very small, as irregular mouldy or frost-like patches upon the surface. Later on, these patches become brown and hard, and the peach cracks. The same mildew also attacks the leaves, covering them with a whitish mould-like substance and causing them to become hard and curled."

Waite (Ann. Rep. Dept. Agric. for 1888 : 353. 1889) also observes that *P. oxyacanthae* causes considerable harm to the peach. Other writers, however, state that the peach mildew is *Sphaerotheca pannosa* (see p. 92).

P. OXYACANTHAE TRIDACTYLA (Wallr.) Salm. (Monograph, p. 36)

Hosts, add: Prunus Grayana, Pyrus Aucuparia (18).

Distrib. add: Tasmania (62).

Professor Shotaro Hori has sent me the present plant on the leaves of *Prunus Grayana* from Mt. Isukuba, Japan (coll. T. Nishida, Nov. 1900). This is the second record of the var. *tridactyla* from Japan, the fungus in the first case having occurred on *Prunus communis*. The present form on *P. Grayana*, although clearly referable to the var. *tridactyla*, slightly approaches the type in the tendency shown by the appendages of many of the perithecia to diverge somewhat instead of being erect. The apex of the appendages frequently shows the elongated primary branches characteristic of the var. *tridactyla* (see monograph, pp. 110, 111).

Bubak has recorded (9) the occurrence in Bohemia of "*P. tridactyla* De By." on the leaves of *Potentilla reptans*. Dr. Bubak informed me that the specimens have unfortunately been lost. It is most unlikely that the *Potentilla* was here really serving as a host-plant; probably, if the fungus was correctly determined, the perithecia of the *Podosphaera* were merely accidentally adhering to the *Potentilla* leaves (see monograph, p. 23, for similar cases).

P. BIUNCINATA Cooke & Peck. (Monograph, p. 39)

Exsicc. add: * Rehm, Ascomycet. 1100; Shear, New York Fungi 139 (in herb. Jaczewski).

P. LEUCOTRICHA (Ell. & Everh.) Salm. (Monograph, p. 40)

Ref. add: Sphaerotheca mali Burr.; Lüstner, Mitteil. über Obst und Gartenbau, **16**: 82 *pl.* 1901.

Distrib. add: N. America, U. S., New York (57).

Hosts, add: Pyrus communis.

Lüstner (**42**) gives an interesting account, accompanied by good figures, of the occurrence of the present species on both the leaves and fruit of pear trees in a nursery at Geisenheim, Germany, where it was the cause of some injury to the trees. Hitherto *P. leucotricha* has been known only on the apple in Europe and the United States, and on *Pyrus Sieboldi* in Japan.

P. leucotricha appears to be on the increase in Germany, where there have been numerous reports of late of serious injury caused by this fungus to apple orchards. Bordeaux mixture has been found to be ineffectual as a fungicide, but sulphur is stated to give good results (see Wehmer **86**, **87**, and Magnus **44**, **45**, **46**). Cutting off and burning the affected shoots is, however, a far better method of dealing with the disease than spraying, as, unless this method is adopted, the present fungus, like the "peach mildew" (see p. 92), is liable to recur year after year on the same trees. (See Schlichting **72***).

The mildew that frequently attacks the young shoots of apple trees in England and in severe cases spreads on to the apples themselves, covering them with a white powdery film, in all probability belongs to the present species, although up to the present I have not seen any perithecia from a British locality.

Goethe (**21**) has recorded the occurrence of *Sphaerotheca pannosa* on apple trees at Geisenheim in Germany; according to specimens (now in the Kew Herbarium), however, sent to me by Dr. Lüstner, the fungus in question is *P. leucotricha.*

Despeissis (**15***) records a fungus as the "Apple and Pear Powdery Mildew (*Podosphaera* sp.)," from western Australia, and remarks: "This disease, which from its appearance at a later stage, is also known as 'Fire Blight,' is more widespread in some seasons than others. It affects the young shoots of pear and apple trees and stunts their growth."

SPHAEROTHECA HUMULI (DC.) Burr. (Monograph, p. 45)

Syn. add: *Torula epilobii* Corda, Ic. Fung. **4**: 23. *pl. 6. f. 75.* 1840.

Oospora epilobii (Cord.) Sacc. & Vogl.; Sacc. Syll. Fung. **4**: 12. 1886.

Oidium fragariae Harz. in Bot. Centralbl. **32**: 314. 1887; Sacc. Syll. Fung. **10**: 520. 1892.

Exsicc. add: *Rehm. Ascomycet. 1349 a; Shear, New York Fungi, 136 (in herb. Jaczewski); Krieg. Fung. saxon. 1212, 1215 (in herb. Jaczewski).

Distrib. add: Europe: Bulgaria (10), Faeröe Islands (63).

Asia: Turkey (Bithynia, in reg. infer. montis Keschisch-dagh (Olympi), supra Brussa (2–300 m. s. m.). 1899. (J. Bornmüller, Iter Anatol. tert. no. 2065)!

Siberia; Poseka, Lusino (Sacc. Malpighia, **10**: 269. 1896).

Hosts, add: *Alchemilla Helvetica, Epilobium obscurum* (40), *Fragaria* sp. (cult.), *Geranium dissectum, Geum rivale, Potentilla collina* (40), *P. Sibbaldi* (40), *Rubus Idaeus* (Burrill; Ell. & Everh., N. Amer. Pyren. 6), *R. villosus, Tragopogon pratensis* (40), *Veronica Virginica Sibirica.*

Among the specimens of Erysiphaceae sent to me by Professor Kingo Miyabe, there occurs a *Sphaerotheca* on *Veronica* which must be referred to the *S. humuli* type. This occurrence is specially interesting on account of the fact that up to the present only the var. *fuliginea* of *S. humuli* has been known on species of *Veronica.* In Europe, Siberia and Asia, and North America *S. humuli fuliginea* occurs on *Veronica Virginica* (Rab.-Wint. Fung. Eur. 3657, from Missouri, U. S. A., *sub S. Castagnei* Lév.); on *V. spicata* (Roumeg. Fung. gall. exsicc. 2741, from Rouen, France, *sub S. Castagnei* Lév.); on *V. longifolia* (Syd. Myc. March. 1239, from Berlin, Germany, *sub S. Castagnei* Lév.), (Rab. Fung. Eur. 2026, from Saxony, *sub Erysiphe Castagnei* forma *veronicarum*), (de Thüm. Myc. univ. 1839, from Minnussinsk, Siberia, occid., *sub S. Castagnei* Lév.). In all the above-cited examples the fungus is typical *S. humuli fuliginea*, with perithecia measuring from 60–70 μ in diameter, and the cells of the outer perithecial wall, averaging 25 μ wide. The Japanese plant, of which two examples have been sent—"on the skins of *Veronica Virginica* var. *Sibirica*, Sapporo, Sept. 17, 1890, coll. E. Tokubuchi," and "on the leaves of *V. Sibirica*, Sapporo, Oct. 10, 1894, coll. N. Hiratsuka," belongs, as mentioned above, to the *S. humuli* type. The perithecia measure about 100 μ in diameter, and the cells of the outer wall average 15 μ wide. *V. Sibirica* is treated by most botanists as synonymous with *V. Virginica*.

Corda's figures of his "*Torula epilobii*" well represent the conidial (*Oidium*) stage of *S. humuli*, which occurs not uncommonly on species of *Epilobium*. Saccardo has transferred Corda's *Torula epilobii* to the genus *Oospora*—evidently by a slip, as in the key to the genera of the *Hyphomycetes* (Saccardo, Syll. **4**: 3) *Oospora* is placed in the section comprising genera which contain "species saprophilae," and Corda expressly described his plant as parasitic.

During the season 1900 *S. humuli* was the cause of the destruction of the strawberry crop in many districts of England. The fungus, in its conidial stage—to which the name *Oidium fragariae* Harz has been given on the Continent—spreads from the leaves of the strawberry plant to the fruit, investing it with a white powder, and ruining it for market purposes. I have already (**71** and **72**) given an account of this outbreak of the "strawberry mildew," with notes as to the varieties which are most attacked and those which appear to be immune. The fungicide which was found to be most effective was prepared in the following manner: one ounce of carbonate of copper is mixed with 5 ounces of carbonate of ammonia, and dissolved in a quart of hot water; when dissolved 16 gallons of water are added. The plants should be sprayed repeatedly with this fungicide as soon as any trace of the mildew appears on the leaves, for it has been found that once the fungus is in full vigor on the fruit nothing can be done to save the crop.

Professor McAlpine reports from Australia that during 1901 strawberry plants were very severely attacked by a "strawberry *Oidium*," and that although the strawberry plants were carefully examined at the end of winter, no perithecial stage could be found.

The disease known to hop-farmers under the name of "red mould" is probably caused, as Hammond (**24**) has pointed out, by *S. humuli*. In hops attacked by "red mould" the bracts of the cones lose their normal bright yellowish-green color, and become tinged reddish-brown. Other writers, however, have stated that this reddish color is due to the incipient death of cells caused by certain atmospheric conditions, excessive dryness of soil, etc., and consider that the fact of the red color being sometimes present in hops which show no trace of the *Sphaerotheca* affords conclusive proof that "red mould" is not caused by the present fungus. I have, however, found in studying the "strawberry mildew" disease, caused by *S. humuli*, that strawberry leaves may commonly be found (after the disease has been running for some time) on which no trace of any fungus is to be found, yet which bear reddish discolored patches on the under surface. Continuous observation of diseased strawberry plants showed that these reddish patches were composed of epidermal cells which had been killed or whose contents had been modified, by the haustoria of *S. humuli*, and that the mycelium after causing this injury, had completely disappeared.

S. HUMULI FULIGINEA (Schlecht.) Salm. (Monograph, p. 49)

Syn. add: S. microcarpa Hazslinszky, M. Tud. Akad. Math. ès Terméśzettud. Közlemènyck, **15**: 20. 1878. *S. phtheirospermi* P. Henn. & Shirai, Engler's Bot. Jahrb. **29**: 147. 1900. *S. fuscata* (B. & C.) Serbinov. Scripta Bot. Univ. Petropol. **18**: (16). 1901.

Exsicc. add: Krieger, Fung. saxon. 1210, 1211, 1213, 1214, (in herb. Jaczewski); Rehm, Ascomycet. 1349b; Shear, New York Fungi, 137 (in herb. Jaczewski).

Distrib. add: Europe, Bulgaria (10); Asia, Siberia, Yeniseisk, "flum. Yenisei inter 58° et 71°" (A. Kitmanoff).

Hosts, add: Arabis alpina, Bidens pilosa, Calamintha umbrosa, Clerodendron trichotomum, Coreopsis trichosperma (84), *Crepis virens, Impatiens Balsamina, Microseris senella, Phtheirospermum Chinense, Saxifraga punctata, Senecio Cineraria* (cult.), *S. Muhlenbergii.*

Hosts recorded for the aggregate: "*S. Castagnei* Lév." *add: Arctium minus* (19), *Bupleurum linearifolium* (59), *Calendula fulgens* (40), *Centaurea Babylonica* (59), *Cnicus arvensis* (65), *Plantago major* (80), *Veronica Chamaedrys* (76), *V. orientalis* (40).

Hazslinszky described in 1878 (**28**) a *Sphaerotheca* from Hungary as a new species under the name *S. microcarpa*, with the following diagnosis (I am indebted to Professor A. Mágócsy-Dietz for the translation of the Hungarian): "*S. microcarpa* nov. spec. Mycelium spinnwebartig, weiss. Perithecien zerstreut, sehr winzig, kugelig, endlich schwarz, mit einem kugligen Ascus. Die Wand des Ascus ist sehr dünn auf der sich papillös erhebenden Spitze. Unter dem Ascus, entgegengesetzt dem Scheitel, sitzt ein Discus mit kuchenartiger Gestalt, von welchem der Ascus sich schwer loslöst. In dem Ascus befinden sich 6–8 elliptische Sporen. Die Anhängsel sind weiss, unregelmässig und bestehen aus ungetheilten Fäden.—Wächst auf der unteren Fläche der Blätter von *Xanthium spinosum* im Comitate Ung (Ungarn). Es ist leicht möglich, dass der Pilz nicht selten ist und überall die Wirthspflanze begleitet." From the description given it is evident that the fungus is *S. humuli fuliginea*, which is found not uncommonly on *Xanthium spinosum*, *X. strumarum*, *X. Canadense*, *X. Italicum*, etc.

S. phtheirospermi P. Henn. & Shirai, Engler's Bot. Jahrb. **29**: 147. 1900, on *Phtheirospermum Chinense*, Mt. Takao, Prov. Musashi, Japan (Kusano, no. 130, Nov. 8, 1899), is typical *S. humuli fuliginea*, quite similar in all respects to European examples on *Taraxacum officinale*, and on a number of hosts belonging to the Scrophulariaceae (*Bartsia*, *Euphrasia*, *Melampyrum*, *Pedicularis*, etc.). The specimen, labelled as above, of "*S. phtheirospermi*" (now in the Kew Herbarium) kindly sent to me by Dr. Hennings, shows perithecia 60–90 μ in diam., with the cells of the outer wall large and distinct, and measuring 15–30 μ wide; the appendages are few and distinct; the ascus is broadly ovoid to subglobose, and measures 50–60 × 45–50 μ. *S. humuli* var. *fuliginea* occurs not uncommonly on a number of plants in Japan (see "Erysiphaceae of Japan" (**68**, p. 446)).

Serbinov (**76**) has transferred the *Erysiphe fuscata* of Berk. & Curt. (Grevillea, **4**: 159. 1876), to the genus *Sphaerotheca*, giving the plant the name *S. fuscata* (B. & C.) Serbin. Serbinov, however, has overlooked the fact that, as pointed out by Burrill (Ellis and Everhart's N. Amer. Pyren. 8), and at p. 51 of my monograph, "*E. fuscata*" is identical with *S. humuli fuliginea*.

The fungus recorded as *S. Castagnei* by Rabenhorst (**59**) on *Euphorbia* from Persia, proves to be *Erysiphe taurica* Lév.; that recorded (*l. c.*) under the same on *Hibiscus esculentus* bears, according to specimens from Rabenhorst's herbarium, no perithecia, but, from the mycelial characters shown, probably also belongs to *E. taurica.*

The *S. Castagnei* recorded by Magnus (Bericht. des naturwiss.-med. Ver. Innsbruck, **24** : 6. 1898, on *Caltha palustris*, proves to be a small form of *Erysiphe polygoni* DC.

The fungus recorded as *S. humuli* Schroet., on *Plantago major*, by Feltgen (**18**), proves from specimens sent to be *E. cichoracearum* DC.; and that recorded (*l. c.*) under the same name as occurring on "*Mentha longifolia*" proves from specimens sent to be *S. humuli fuliginea* on *Veronica longifolia.*

The plants recorded as *S. Castagnei* Lév. *p.p.* Burr. (= *S. humuli fuliginea*) on *Shepherdia argentea* and *Collomia linearis* from Wyoming, by Griffiths (Bull. Torrey Club, **26**: 142, 143. 1899), prove from specimens sent by the writer to belong to *S. humuli* (DC.) Burr. They are small forms of the species—the perithecia in the example on *Collomia*, measuring 75–100 μ in diam., and in that on *Shepherdia* 90–110 μ—with quite the general appearance of the var. *fuliginea*, but with the cellular structure of the perithecium characteristic of the *S. humuli* type.

S. PANNOSA (Wallr.) Lév. (Monograph, p. 65)

Exsicc. add: * Linhart, Fung. hungar. 354.

Distrib. add Europe, Austria-Hungary; Australasia, Tasmania (62).

Hosts, add: Rosa Eglanteria (40), *R. fragrans* (40).

Spegazzini records (**79**), *Oidium leucoconium* Desm. as occurring "ad folia viva *Rosarum* cultarum vulgatum in tota Republica Argentina et in Montevideo, per ann., 1880–1897." If correctly determined, this refers to *S. pannosa*, as *Oidium leucoconium* is the conidial stage of this species; it may be noted, however, that in North America a peculiar form of *S. humuli* occurring on roses has commonly been mistaken for *S. pannosa* (see monograph, p. 68).

The fungus reported by Goethe (**21**) as *S. pannosa*, occurring on apple trees in Germany, proves to be *Podosphaera leucotricha.* In the case of Cavara's record, also mentioned by Magnus (46), of

S. pannosa on apple trees, the same mistake in identification has in all probability been made.

The fungus known as the "peach mildew" is apparently *S. pannosa*, although some writers, *e. g.*, Waite and Bailey refer it to *Podosphaera oxyacanthae* (see p. 85). This doubt as to the specific identity of the mildew on the peach is due probably to the fact that—as in the case of *Podosphaera leucotricha* on the apple—the conidial stage, which causes the injury, is usually the only stage in which the fungus occurs. I have, however, seen in a European example, the pannose mycelium of the perithecial stage of *S. pannosa* on the stem of a peach tree.

Smith (Journn. Mycol. **7**: 90, 91. 1892, and Selby (**75***) both refer to the "peach mildew" as "*S. pannosa*," and give the following accounts of the injury caused by it. Smith observes: "This mildew usually attacks the leaves and young stems. On the latter it forms a dense, felt-like, persistent hyphae-complex which is first white and afterwards a dirty gray, the epidermis being cracked open and destroyed or much injured and a thick brown layer of cork being formed under the mycelial patches. The mildew produces conidia in abundance, but perithecia have not been found, although the search has been continued into winter." Smith noticed that the disease recurred year after year upon the same individual peach trees, whilst the surrounding trees were entirely free, and remarks: "The fungus has been found on the unfolding shoots of a tree so early in the spring and to such an extent as to make it almost certain that it had wintered over in the form of perennial mycelium. From other trees fresh-looking mycelium has been taken in mid-winter, and I have no doubt as to its perennial nature." It was found also that "peach trees with gland-bearing leaves remained free from mildew, while mildewed trees bore leaves destitute of glands." Smith remarks: "It would seem, therefore, as though peach trees of the type bearing glandular leaves are more resistant to this mildew than other varieties, but whether this will hold good for all localities and all varieties remains to be seen."

Selby reports the "peach mildew" as attacking the fruit as well as injuring the leaves and twigs, and observes: "Upon the fruit, this mildew causes large, light-colored spots, with an enormous multiplication of epidermal hairs or fuzz of the peach. Under the affected spots there is a hardening of the fruit and the consequent effect upon the quality is less marked though quite similar to that produced by the scab (*Cladosorium carpophilum* Thüm.). To cut and burn affected shoots is recommended as a preventative measure for mildew. Spraying is unlikely to yield favorable results."

Halsted (**23** *), in mentioning the fungus on diseases observed on fruit trees during 1894 at the New Jersey Agricultural Experiment Station, remarks: "*S. pannosa* has interfered with the growth of the young twigs of peach trees, coating them over in much the same manner that *S. mors-uvae* does the stems of the gooseberry."

S. MORS-UVAE (Schwein.) Berk. & Curt. (Monograph, p. 70)

Distrib. add: Europe, in a garden, Ballymena, County Antrim, Ireland (? introduced). N. America, U. S., Utah (73), Indiana (84).

The appearance in 1900 of the "American gooseberry-mildew," *S. mors-uvae*, up to that time known only from the United States, in Ireland has already been noted (**51**) (**71** and **72**). In the present year (1901) the disease has reappeared in the same garden at Ballymena, County Antrim, and the gardener there has reported to me the following facts: "The disease this year was even more extensive than last; and the young wood seems more affected at this time of year (August) than it did last year. I have not heard of any neighboring gardens being affected as yet. Some varieties of gooseberries are far more subject to the disease than others. The "large green" gooseberry is not affected, while the "small green" is very much affected, although both berries are smooth. The "amber" is by far the worst of any. Some varieties of "red" seem proof against the fungus, while others are nearly as susceptible as the "amber"; the "smooth red" is the worst.

Magnus is of the opinion that the fungus has been introduced into Ireland from America, and suggests (**47**) that imported gooseberries bearing the fungus may have been the source of infection. This, however, cannot have been the case, as the authorities at the

Customs House (London), inform me that no importation of gooseberries into Britain from the United States occurs. I have learned, however, through Mr. F. W. Moore, of the Royal Botanic Gardens, Dublin, that two firms of florists in Ireland some years ago imported gooseberry plants from the United States. It is certainly possible that by this means the disease may have been introduced from America. But, on the other hand, we must remember that Ireland possesses some indigenous plants found elsewhere only in North America. Also, as I have already pointed out (monograph, p. 72), in the fungus known as *Sphaerotheca euphorbiae* (Cast.), which is not uncommon on the Continent on species of *Euphorbia*, appears to be morphologically indistinguishable from *S. mors-uvae*.

It may be noted here that De Wildeman (**16**) has lately enumerated *S. mors-uvae* among the Erysiphaceae of Belgium. The record runs, "sine loco (Em. Marchal)"; up to the present I have not been able to obtain any information about this Belgian record.

It may be well here to draw attention to the serious economic danger with which European fruit farmers will be confronted if this "American gooseberry mildew" is allowed to establish itself in Europe. The practical aspect of the subject is ably dealt with by Beach (**2****), in Bull. N. Y. Agric. Exper. Station, 114, where a full and well-illustrated account of the cultivation of gooseberries in the United States is given. It is here remarked: "The one great hindrance to the cultivation of European gooseberries in this country is their susceptibility to attacks of the mildew, *Sphaerotheca mors-uvae*. From the standpoint of the American fruit-grower gooseberries falls into two classes, those which suffer from the mildew and those which do not. The former class includes all European varieties and their American grown seedlings, or in other words, all varieties of the species *Ribes Grossularia* L. The latter class includes the cultivated varieties of the native American species *oxyacanthoides* L. and *Cynosbati* L., and some hybrids between them and the European species. * * * On account of their liability to serious attacks of mildew, European gooseberries should not be planted for commercial purposes, except by those who are prepared to contend with that disease." We may infer from these observations that if the fungus were to become widespread in Europe, the whole gooseberry crop would be seriously affected. Beach (*l. c.*) observes: "spraying to prevent mildew should begin as soon as the buds begin to unfold, using one ounce of potassium sulphide for every two gallons of water. Repeat the applications at intervals of ten days till the fruit is nearly ready to market. Should frequent heavy rains occur spray more frequently. Be sure the spray reaches all the foliage, especially on the inner and under parts of the bush which are usually slighted. The use of Bordeaux mixture is objectionable because it is apt to stick to the fruit and injure its market value, even though the application be made several weeks before the crop is marketed."

A valuable account, describing the mode of attack, best methods of prevention, etc., has also been given by Halsted (**23**).

S. euphorbiae (Cast.) Salm.

Botrytis euphorbiae Cast. Supp. Cat. Pl. Mars. 81. 1851. (For further synonymy *cf.* Monograph, p. 71.)

Syn. add: *Oidium euphorbiae* Thüm. mss. in herb.

Exsicc. add: *Rehm. Ascomycet. 1049.

Hosts, add: *Euphorbia Cyparissias palustris.*

The specimen in the Kew Herbarium, ex herb de Thümen, named "*Oidium euphorbiae* Thüm. mss. on *Euphorbia dulcis*, Austria inf., Krems, 7.71" belongs to the present species.

S. LANESTRIS Harkn. (Monograph, p. 74)

Syn. S. Kusanoi P. Henn. & Shirai, Engler's Bot. Jahrb. **29**: 145. 1900.

Hosts, add: *Quercus glandulifera.*

Distrib. add: Japan; Prov. Kozuké, Mt. Myogi (Kusano, Nov. 4, 1899). Mt. Tsukuba (T. Nishida, Nov. 2, 1900)!

Hennings and Shirai (**31**) have lately described a *Sphaerotheca* from Japan as a new species under the name of *S. Kusanoi.* Dr. Hennings has kindly sent me a specimen of this fungus (now in the Kew Herbarium) labeled "on *Quercus glandulifera*, Prov. Kozuké, Mt. Myogi (Kusano, no. 123, Nov. 4, 1899)." This fungus is, in my opinion, *S. lanestris* in a slightly immature condition. The authors remark of *S. Kusanoi:* "Die Art ist mit *S. lanestris* Harkn. verwandt, aber duch das völlig farblose Mycel, durch die pfriemlichen vom Mycel völlig getrennten Anhängsel, durch die am Scheitel nicht verdickten, 5–6 Sporen enthaltenden Asken, sowie durch die mit einem Tropfen versehenen, im Innern nicht gekörnelten Sporen gut verschieden." Of the character here given, the completely colorless mycelium would if constant be the most important, as separating the plant from *S. lanestris*, but this distinctive character certainly does not hold good. Although the specimen is undoubtedly for the most part immature, as is shown by the fact that the ascus of most of the perithecia is found, on being pressed out, to be still completely enveloped in the separating inner wall of the perithecium. But even in this stage some of the hyphae of the mycelium, intermixed with colorless ones, show a decided brown color under the microscope. Moreover, in one corner of a leaf in the specimen sent, a small patch of mycelium has turned completely brown, and presents all the appearances of that of *S. lanestris*. The appendages of the perithecium in "*S. Kusanoi*" are in most cases quite rudimentary or even absent; occasionally, however, they equal or slightly exceed, in length the diameter of the perithecium. The asci are 6–8-spored; the wall becomes thin towards the apex of the ascus (as is shown, *e. g.*, at Fig. 118 of monograph). The complete separation of the inner wall of the perithecium from the outer is a characteristic feature *S. lanestris* (see monograph, p. 75).

Since writing the above, I have received another example of this Japanese *Sphaerotheca* on *Quercus glandulifera*, from Professor Shotaro Hori, collected at Mt. Tsukuba (coll. T. Nishida, Nov. 2, 1900). In this specimen, although the fungus is immature, the mycelium has everywhere taken a decided tinge of brown.

S. lanestris has been known hitherto only from the United States, where it occurs on six species of *Quercus* in the Southern, Middle and Western States. Its occurrence in Japan is of great interest, adding as it does another species to the list of mildews common to North America and Japan (see "Erysiphaceae of Japan" (**68**, p. 442).

UNCINULA SALICIS (DC.) Wint. (Monograph, p. 81)

Exsicc. add: *Linhart, Fung. hungar. 78; *Rehm, ascomycet. 549b; * Fl. exsicc. austro-hungar. 3177; * Krypt. exsicc. (Mus. Pal. Vind.) 121; Shear, New York Fungi 140 (in herb. Jaczewski).

Distrib. add: Europe ; Bosnia (10).

Hosts, add: Populus suaveolens, Salix gracilistyla, S. multinervis, S. stipularis.

Sredinski (80) has recorded from Russia the occurrence of *U. salicis* on *Hedera Helix.* In all probability, however, the perithecia in this case were merely adhering by means of their appendages to the leaves, as it is most unlikely that the *Hedera* was really serving as a host plant. " *U. salicis* var. *epilobii* Vestergr." on *Epilobium angustifolium* and " *U. Columbiana* Selby on *Scutellaria lateriflora* afford apparently similar cases (*ante*, p. 10).

Brannon (8) has recorded the occurrence in rare cases, of eight spores in the ascus of *U. salicis.*

The haustoria of *U. salicis,* according to the observations of Grant Smith (77), differ in an important manner from those of other species of the Erysiphaceae, being produced not only in the epidermal cells of the host-leaf, but also in the subepidermal (palisade and mesophyll) cells (*ante*, p. 4).

U. MIYABEI Salm. (*U. salicis* var. *Miyabei* Salm. monograph, p. 88)

Hosts, add: Tilia Miqueliana.

From the study of further material, the present fungus, originally described as a variety of *U. salicis*, seems to be worthy of specific rank, the character of the appendages (especially that of the basal part becoming, when mature, thick-walled) separating it clearly from all forms of *U. salicis.* Further, I have not been able to find among numerous specimens of *U. salicis* from Japan. any forms approaching in any way *U. Miyabei*, such as might be expected to occur were the latter only a variety of *U. salicis.* Since its original discovery in Japan on *Alnus incana* and *A. maritima, U. Miyabei* has been found at Hokkaido, Prov. Ishikari, Shintotsugawa (coll. T. Hawakami) on *Tilia Miqueliana* see Erysiphaceae of Japan (68), p. 440.

U. ACERIS (DC.) Sacc. (Monograph. p. 90)

Exsicc. add: * Krypt. Exsicc. (Mus. Pal. Vind.) 123 ; * D. Sacc. Myc. Ital. 60 ; * Linh. Fung. hungar. 77, 256.

Distrib. add: Bosnia.

Hosts, add: Acer opulifolium, A. palmatum, A. spicatum Ukuruduense.

In the examination of some *U. aceris* in the conidial stage on *Acer campestre* from Reigate, England, there was observed on all the leaves examined *Oidium*-like conidia much smaller than the normal *Oidium*-conidia with which they were associated. I was not able to ascertain if these smaller conidia which measured about 15 × 7 μ, were organically connected with the mycelium of the *Uncinula*, *i. e.*, whether they were really microconidia, or whether they were merely accidentally present. The presence of some intermixed hyphae of foreign mycelium and loose *Macrosporium* and other spores favor the latter view. The occurrence of these smaller *Oidium*-like conidia among the mycelium of *U. aceris* is of interest in connection with Fuckel's original description of the conidia of *U. Tulasnei* (see monograph, p. 94).

Rabenhorst (**59**) has recorded *U. aceris* on *Acer monspessulanum* from Boriter in Kurdistan. Specimens so labelled were kindly sent to me by Dr. Hennings from Rabenhorst's herbarium, but these bore only a barren mycelium.

Neger (**54**, p. 338) states that the conidia of *U. aceris* vary in shape according to external conditions,—to quote his words: "Die Conidien zeigen je nach den Wachsthumsbedingungen (feuchter oder trockener Umgebung) verschiedene Gestalt; in trockener Luft entstandene Sporen sind lang und schlank, während sie in feuchter Umgebung mehr abgerundete und gedrungene Formen zeigen."

U. PRUNASTRI (DC.) Sacc. (Monograph, p. 95)

Distrib. add: Bulgaria (10), Poland (6).

In Spegazzini's herbarium a specimen occurs labelled "*U. Wallrothii f. lonicerae Xylostei*, Belluno, Italy, 10. 8. 78; rarissime." I had already (monograph, p. 97) expressed the opinion that the presence of *U. Prunastri* on the host here given was to be considered only accidental, and an examination of these specimens of Spegazzini shows this view to be correct. We find here that the perithecia—or at least many of them—are fixed upside down by means of the adherence of the mucilaginous apices of the appendages to the leaf of the *Lonicera*. This reversal and reattachment of the perithecium is just what occurs in *U. aceris* (see monograph, p. 92), and has also been observed in several other species of the present genus (*ante*, p. 9).

U. CLANDESTINA (Biv. Bern.) Schroeb. (Monograph, p. 97)

Syn. add: U. clandestina Bivon. form. n. *Japonica* P. Henn. Engler's Bot. Jahrb. **29**: 149. 1900.

Hosts, add: Ulmus parvifolia.

The "forma *Japonica*" of Hennings (*l. c.*) from Tokyo: Botan. Garten auf lebenden Blättern von *Ulmus campestris* Sm. var. *vulgaris* Pl. (Kusano, no. 155, Oct. 11, 1899) is described as follows: "Die Form ist durch Grössenverhältnisse von der typischen Art etwas unterschieden. Die Perithecien sind 75–85 μ gross mit meist 20 an der Spitze hakenförmig gekrümmten 60–80 μ langen Anhängseln. Die 2–3 Asken jedes Peritheciums sind eiförmig 40–60 × 40–55 μ, mit 2–3 elliptischen 19–25 × 14–18 μ grossen, gelblichen, granulierten Sporen." There are no characters given here of sufficient importance to justify the separation in any way of the Japanese plant from the *U. clandestina* of Europe and Algeria. I have seen several specimens of *U. clandestina* from Japan, and have found them identical with European examples of the species. It may be noted that in Hennings' description, the measurement of the spores is given as "19–25 × 14–18 μ"; in a specimen (now in the Kew Herbarium) sent to me by Dr. Hennings; however, the spores measure up to 30 μ long.

U. NECATOR (Schwein.) Burr. (Monograph, p. 99)

Exsicc. add: Shear, New York Fungi, 141 (in herb. Jaczewski).

Distrib. add: Europe, Germany, N. America, U. S., Georgia (74). S. America, Chili (37).

Hosts, add: Vitis cordifolia (84).

The interesting discovery at Geisenheim in Germany of the occurrence of perithecia of *U. necator*—hitherto known in Europe only from France—has been made by Dr. G. Lüstner, who gives (41) the following account: "Die von mir aufgefundenen Perithecien wurden an einer an einem Geiztrieb gebildeten Traube, an welcher gleichzeitig auch conidienbildendes Mycel vorhanden war, am 15 November angetroffen; sie sassen an den Beerenstielen in Gruppen beisammen." Dr. Lüstner kindly sent me a microscopic mount of some of the perithecia. These latter, which undoubtedly belong to *U. necator*, are immature, some of the appendages being still uncolored and not yet showing the uncinate apex. The fungus at this stage somewhat resembles *Erysiphe polygoni*—a fact which very probably accounts for the record by Berkeley (Gard. Chron. **21**: 22. 1884, of the occurrence of "*Erysiphe communis*" on vine leaves, from Washington, U. S. A., growing with *U. necator*.

Professor H. O. Juel has informed me that he found in Sept., 1900, at Bonn, Germany, "one leaf of *Vitis vinifera* that was covered with *Oidium*, and had also some well-developed perithecia of *Uncinula spiralis*."

It still seems necessary to assume, however, that *U. necator*, although occasionally producing perithecia in Europe, as a rule survives the winter by means of persistent mycelium or hibernating conidia. (See Wortmann, **88**.)

Pierce (**58***) in his monographic study of the "California Vine Disease," gives a full account of the manner in which *U. necator* attacks the vines of California.

U. MACROSPORA Peck. (Monograph, p. 107)

Exsicc. add: Shear, New York Fungi, 143 (in herb. Jaczewski).

U. CLINTONII Peck. (Monograph, p. 109)

Syn. add; *U. Kusanoi* H. &. P. Syd. Mém. Herb. Boiss. **4**: 4. 1900. *U. Zelkowae* P. Henn. Engler's Bot. Jahrb. **29**: 149. 1900.

Exsicc. add: *Rehm, Ascomycet. 1198; Shear, New York Fungi, 142 (in herb. Jaczewski).

Distrib. add: Florida.

Hosts. add: Celtis Sinensis.

As I have pointed out in the "Erysiphaceae of Japan" (**68**, p. 438) *U. Clintonii* is variable as regards the shape of its appendages. These may show a much enlarged clavate apex, often measuring 30 μ across, or the apex is only slightly enlarged, measuring 20 μ across. "*U. Kusanoi* H. & P. Syd." on *Celtis Sinensis* from Japan, has appendages of the latter description, and exactly matches certain examples of *U. Clintonii* on *Tilia Americana* from the United States.

The record of *U. Clintonii* from Florida is based on a specimen sent to Kew from the Florida Agricultural College, Lake City, Fla. (coll. H. H. Hume). It is an interesting form of the species, the perithecia possess few (7–12) rather short appendages, very unequal in length on the same perithecium, and scarcely swollen at the apex.

"*U. Zelkowae* P. Henn." is described (31) as follows: "amphigena; mycelio arachnoideo, tenui, evanescente, albido; peritheciis gregariis, subglobosis, atris, 100–120 μ, appendicibus radiatis, simplicibus ca. 20, hyalinis, apice convolutis usque ad 10 μ incrassatis, 100–200 μ longis, 5–7 μ crassis; ascis (3) ellipsoideis vel subovoideis, 3–4-sporis, 35–50 × 30–40 μ, basi vix stipitatis; sporis ellipsoideis utrinque obtuse rotundatis, 1-guttulatis, hyalinis, 18–22 × 12–15 μ. Tokyo; auf lebenden Blättern von *Zelkowa acuminata* Pl. (Kusano, no. 153, Oct. 1, 1899)." The diagnosis here given shows that the fungus is the same as that sent to me from Kobe, Japan, on *Zelkova acuminata* (*Z. Keaki*), by Professor Kingo Miyabe. This I have described in my monograph, p. 110, and have given there my reasons for considering it only a small form of *U. Clintonii.*

U. POLYCHAETA (Berk. & Curt.) ex Ellis. (Monograph, p. 113)

Syn. add: U. Shiraiana P. Henn. Engler's Bot. Jahrb. **29**: 148. 1901.

Distrib. add: S. America, Uruguay, Argentine Republic, Tucuman and Salta (79).

Hosts, add: Celtis Boliviensis (79), *C. Selloviana* (61), *C. Sinensis.*

In some examples of this species sent by Spegazzini from Uruguay on *Celtis tala* many of the perithecia attained a diameter of 390 μ, and contained from 150–175 asci each.

"*U. Shiraiana* P. Henn." is a form with 2–4-, or very rarely 5-spored asci. It is not, I consider, distinct from *U. polychaeta* (see "Erysiphaceae of Japan," **68**, p. 439). *Phyllactinia corylea,* which usually possesses bisporous asci, shows much the same variation as the present species (see under that species).

U. VERNICIFERAE P. Henn.

U. verniciferae P. Henn., Engler's Bot. Jahrb. **29**: 149. 1900. Salm. Bull. Torrey Club, **27**: 440. 1900.

Distrib.—Japan: Tokyo, Botan. Garten. (Kusano no. 151, Oct. 27, 1899). Prov. Szumo (Tanaka, Nov. 29, 1900).

Hosts.—*Rhus succedanea* (fruit), *R. vernicifera* (leaves).

Hennings (*l. c.*) gives the following diagnosis: "amphigena; maculis fuscis effusis, mycelio arachnoides tenui, albido; peritheciis gregariis subglobosis, atris 100–110 μ; appendiculis 12–16, simplicibus, subulatis interdum apice cirrhatis 100–150 × 6–10 μ, hyalinis; ascis (2–3) ellipsoideis, vel subovoideis vix stipitatis, 8 sporis 40–50 × 35–45 μ; sporis ellipsoideis, utrinque rotundatis, 1 guttulatis, hyalinis, laevibus 17–20 × 9–11 μ. Die Art is mit *U. flexuosa* Peck und *U. aceris* DC. verwandt, durch die viel weniger askenreichen Perithecien u. s. w. verschieden."

Dr. Hennings sent me a specimen of his species (from Tokio), and on this I have remarked ("Erysiphaceae of Japan," **68**, p. 440). "The specimen sent is too immature to enable me to give a full description of the plant. It appears, however, a distinct species, showing affinity with *U. Sengokni* Salm., but differing in the thicker walled appendages, slightly narrowed upwards to the closely coiled frequently helicoid apex."

I have since received from Professor Shotaro Hori an *Uncinula* which proved on examination to be the above species on the fruit of *Rhus succedanea.* The mycelium of the fungus covers the numerous depressions which occur in the fruit of the *Rhus*, and in the specimen sent bears only a few immature perithecia. The appendages are sometimes as few as seven in number; they are not swollen upwards, and terminate in a closely coiled often helicoid apex; towards the base they become refractive and thick-walled.

U. SEPTATA Salm.

U. septata Salm. Journ. Bot. **38**: 427. 1900.

Host.—*Quercus glandulifera.*

Distrib.—Japan: Mt. Myogi, Prov. Kozuké, (Kusano, Nov. 4, 1899, no. 123 (in part); Mt. Tsukuba (T. Nishida, Nov. 2, 1900).

"Hypophyllous: mycelium evanescent; perithecia more or less scattered, large, rounded-lenticular, 160–210 μ in diameter, cells of outer wall of perithecium distinct, small, 5–10 μ wide; appendages crowded, very numerous, 100–170 or more in number, unequal in length (50–100 μ long) on the same perithecium, simple, smooth, 1–8- (usually about 5-) septate, amber-colored in the lower half, thin-walled throughout, about 5 μ wide, apex often helicoid; asci 6–12 (immature). In habit, and in the large size of the perithecia, *U. septata* resembles *U. circinata* Cooke & Peck, from which it is at once distinguished by the septate appendages; from *U. necator* (Schwein.) Burr. and *U. australiana* McAlp.—the only species of the genus at present known which possess colored (septate) appendages—the large perithecia with the crowded appendages at once distinguish the present species. The absence of spores in the ascus shows that the specimens examined are immature; but I have no hesitation in describing the plant in this condition, as the presence of densely crowded septate appendages shows it to be quite distinct from all other species at present known. The appendages when well developed cover more or less completely the upper half of the perithecium—just as is the case in *U. circinata*. Seen in the mass, the appendages are of a pale amber tint; very probably they acquire towards the base, on maturity, a deeper shade of brown, like those of *U. necator*." Salm. (*l. c.*)

U. septata was first found associated with "*Sphaerotheca Kusanoi* P. Henn., of Shirai," on a leaf of *Quercus glandulifera*, in a specimen sent to me by Dr. Hennings. I have since, through the kindness of Dr. Hennings, been able to look over all the original material of "*S. Kusanoi*," but have not been able to find any perithecia sufficiently ripe to contain spores; I have observed, however, that the appendages are frequently 10-septate. Professor Shotaro Hori has sent me a specimen of *S. lanestris* ("*S. Kusanoi*") or *Quercus glandulifera* from Mt. Tsukuba (coll. T. Nishida, Nov. 2, 1900), and on the leaf a few immature perithecia of *U. septata* occur. It is interesting to find that in this, its second known locality, the present species again occurs associated with the *Sphaerotheca*.

MICROSPHAERA BERBERIDIS (DC.) Lév. (Monograph, p. 123)

Exsicc. add: * Linhart, Fung. hungar. 258.

Distrib. add: Italy.

M. EUONYMI (DC.) Sacc. (Monograph, p. 125)

Exsicc. add: Krieger, Fung. saxon. 1225 (in herb. Jaczewski).

Hosts, add: Caragana frutescens.

In Professor Jaczewski's herbarium there occurs a most interesting mildew on *Caragana frutescens* Medic. from Russia, which with scarcely any doubt must be referred to *M. euonymi.* The fungus forms when mature clinging floccose masses chiefly on the under surface of the leaf; the perithecia measure 100–130 μ in diameter; the appendages are 12–24 in number, 3–5 times the diameter of the perithecium, flaccid and penicillate when mature, with the apex dichotomously branched; asci 4–9, about 60 × 30 μ, 3–5-spored, spores 22–23 × 11–12 μ. The branching of the apex is represented at *Pl. 9, f. 3–5*, and agrees with that found in some forms of *M. euonymi* on *Euonymus Europaeus;* although the apex is perhaps scarcely so much branched as is usual for the species. The type of branching is, however, quite different from that found in *M. Bäumleri* P. Magn., the only other species to which this fungus on *Caragana frutescens* approaches. I have seen only the single Russian specimen mentioned above; and in this, although the perithecia are sufficiently ripe to contain asci with spores, the final branching of the apex of the appendages has not apparently in many cases yet taken place. There is, however, an exact agreement between the branching shown by some of the appendages and that which occurs in some examples of *M. euonymi.* The occurrence of *M. euonymi,* so long known only on *Euonymus,* on another genus of host plants is a notable fact. *M. Caraganae* P. Magn. Bericht. deutsch. bot. Gesellsch. **17**: 150. *pl. 9. f. 1–4.* 1899, on *Caragana arborescens* is in my opinion not a *Microsphaera* at all, but a form of *Erysiphe polygoni* DC. (see monograph, p. 187).

Serbinov (**76**) has lately described from Russia (Gouv. St. Petersburg) a form of *M. euonymi* as a new variety under the name var. *borealis.* I have not seen a specimen of the plant. The following diagnosis is given: "Varietas hypophylla, a *M. euonymi* (DC.) Sacc. mycelio differens persistente, compacto, floccoso, peritheciis gregariis. — Die von mir in einem alten Garten Oranienbaums auf *Euonymus Europaeus* gefundene *M. euonymi* Sacc. hat ein interessantes Mycel. Dasselbe entwickelb sich so kräftig und stark dass ein von ihm befallenes Blatt wie mit Spinngewebe überzogen erscheint. Nach den Angaben von Saccardo ist das Mycel dieses Pilzes *arachnoideus et fugax*, während es bei von mir gefundenen Exemplaren *floccosus* and *persistens* ist. In Folge eines solchen Unterschiedes des von mir gefundenen Pilzes mit der typischen *M. euonymi* Sacc., fasse ich erstere als eine nördliche Varietät auf, und nenne sie *M. euonymi* (DC.) Sacc. var. *borealis* (mihi)."

M. ASTRAGALI (DC.) Trev. (Monograph, p. 127)

Neger (**54**, p. 353) states that in all the mature examples of *M. astragali* which he examined, he found the appendages of neighboring perithecia wound round and so bound together by the hyphae of some secondary fungus, usually *Monilia candida*.

Exsicc. add: Krieg. Fung. saxon. 1222 (in herb. Jaczewski).

Syn. add: *Trichocladia astragali* (DC.) Neger, Flora, **88**: 351. 1901.

M. ALNI (Wallr.) Salm. (Monograph, p. 129)

Syn. add: *M. syringae* (Schwein) P. Magn. Bericht. deutsch. bot. Gesellsch. **16**: 67. 1898.

M. Myoschili Neger, Bericht. deutsch. bot. Gesellsch. **17**: Generalversamm.-heft. (241), 1899.

M. Japonica P. Henn. Engler's Bot. Jahrb. **28**: 271. 1900.

Exsicc. add: *Rehm, Ascomycet. 1117, 1299; *Krypt. Exsicc. (Mus. Pal. Vind.), 128; Shear, New York Fungi 144 (*sub M. vaccinii* (Schw.) Cooke & Pk.) in herb. Jaczewski; *Jacz. Kom. Franz. Fung. Ross. exsicc. 337*b* (*sub M. berberidis* (DC.) Lév.).

Hosts, add Berberis vulgaris, Betula pumila (84), *Carpinus Americana* (84), *Chionanthus Virginica, Corylus rostrata Sieboldiana, Ilex verticillata* (84), *Lathyrus palustris, Lonicera hirsuta, L. Sullivantii, Myoschilos oblongum, Quercus discolor, Q. serrata, Styrax Japonicum.*

Distrib. add Europe: Bosnia (10). North America: U. S. A., Florida. South America: Argentine.

Dr. Neger has kindly sent me a specimen (now in the Kew Herbarium) of "*M. Myoschili*" on *Myoschilos oblongum*, from "prope lacum argentinum dictum Quillen in Andibus valdivianis, vulgatissima." The plant shows these characters: perithecia 90–130 μ in diameter, cells of outer wall of perithecium 10–15 μ wide; appendages 5–20, 1–1½ times, or rarely twice, the diameter of the perithecium, becoming thick-walled toward the base when mature, apex 4–6 times regularly dichotomously branched, tips of ultimate branches recurved; asci 4–12, 45–55 × 30–35 μ, spores 3–5, rarely 6. The fungus is, I feel convinced, merely one of the forms of the polymorphous species *M. alni*, with a much-branched apex to the appendages. Quite similar forms are common in the United States on several host-plants, *e g.*, on species of *Quercus* on *Menispermum Canadense*, *Cornus alternifolia*, etc. Occasionally, moreover, in "*M. Myoschili*" the apex of the appendage is only 4 times dichotomously branched, and the fungus is then seen to be identical with the more common form of *M. alni*. In some instances—evidently to be regarded as "sports"—an appendage occurs which forks from near its base into two wide branches, each of which is dichotomously divided at the apex as in a normal appendage. Dr. Neger's figure (*l. c.*, *Pl. 28*, *f. 7*) represents the apex of an appendage in an immature condition—the tips of the ultimate branches (here shown as straight) become revolute at maturity (see *Pl. 9*. *f. 10*).

In Rehm's Ascomycet., no. 1117, there is a very interesting example of *M. alni*, collected by Professor P. Magnus on *Rhamnus catharticus* at Brandenburg, August, 1893. The apex of the appendage in many of the perithecia is more branched (see *Pl. 9. f. 11*) than is usual for the species in Europe, and exactly corresponds in this respect to certain American forms of *M. alni* on *Quercus*, *Cornus*, etc., which have by some authors been considered as distinct species under the names of *M. pulchra*, *M. quercina*, etc. The branching of the apex of the appendages in this Brandenburg specimen agrees so closely with that found in "*M. Myoschili*" (see above) as to show clearly that the latter must be regarded as merely a form of *M. alni* (*cf. Pl. 9. f. 10, 11*).

A rather remarkable form of *M. alni* has been sent by Professor Kingo Miyabe on *Corylus rostrata* var. *Sieboldiana* from Hakkoda Mountains, Prov. Mutsu, Japan (N. Hiratsuka, August 26, 1897)." Unfortunately the fungus is immature. The specimens are remarkable for possessing appendages which are 2–4-septate and colored below for half their length or more and are often geniculate or irregularly bent. Only one mature apex of the appendages was found and this was identical with that of *M. alni*, being four times dichotomously branched, with the tips of the ultimate branches regularly recurved. The form certainly requires further study. As regards the presence of colored appendages, a similar Japanese form on *Corylus rostrata Mandschurica* has already been noted (monograph, p. 142).

The fungus set out as "*M. berberidis* (DC.) Lév., in foliis vivis *Berberidis vulgaris* L., Petrovsko-Rasumoskoje prope Mosquam, 1899 XI. Legit Serebriaunikov," in Jacz. Kom. Franz. Fung. Ross. exsicc. no. 337*b* is certainly not that species, but *M. alni.* The specimens are immature, and the appendages of most of the perithecia have an undeveloped apex, here and there, however, one may be found in which the apical branching characteristic of *M. alni* has occurred (see *Pl. 9. f. 16, 17*). The occurrence of the present species on *Berberis vulgaris* and the presence of mycelium and young perithecia show that it is undoubtedly growing on this plant is most interesting, as *Berberis* is the usual host-plant of *M. berberidis.*

Freeman's record (**20**) of the occurrence of *M. alni* on *Tilia Americana*, from "Hennepin, Minnesota, U. S. A. (Freeman, no. 58, 1898)" proves to be due to an error, the host plant having been wrongly identified. According to specimens sent to me, the fungus is growing on *Corylus Americana.*

"*M. Japonica* P. Henn." on *Cornus macrophylla*, from Japan, cannot be distinguished from *M. alni* (see "Erysiphaceae of Japan," **68**, p. 439).

M. ALNI LONICERAE (DC.) Salm. (Monograph, p. 142)

Exsicc. add: Krieger Fung. saxon. 1224 (in herb. Jaczewski).

Hosts, add: Syringa vulgaris.

I have had the opportunity, through the kindness of Professor P. Magnus, of examining the specimen of "*M. Ehrenbergii*" (= *M. alni lonicerae*) found by Allescher (see Bericht. botan. Verein. Landshut, 146–152. 1887) on *Syringa vulgaris.* The fungus certainly appears to belong to the present variety. The

Syringa affected stood in close proximity to a bush of *Lonicera Tatarica* attached by the same fungus, so that it would appear that we have here a case of a species of mildew passing directly from one host-plant to another.

M. ALNI DIVARICATA (Wallr.) Salm. (Monograph, p. 146)

Exsicc. add: Krieger, Fung. saxon. 1223 (in herb. Jaczewski).

M. ALNI EXTENSA (Cooke & Peck) Salm. (Monograph, p. 152)

Exsicc. add: Shear, New York Fungi, 146 (*sub M. quercina* (Schw.) Burr. (in herb. Jaczewski).

Hosts, add: Quercus cinerea.

Distrib. add: North America; United States, Florida.

The examples from Lake City, Florida (coll. H. H. Hume), are interesting, as occasionally showing a pale brown color towards the base of the appendages.

M. ALNI LUDENS Salm. (Monograph, p. 154)

Distrib. add: North America; U. S., Helena, Montana (F. D. Kelsey).

Kelsey has recorded (Journ. Mycol. **5**: 83. 1889), the above Montana plant on *Vicia Americana linearis* as "*Erysiphe communis* (Wallr.) Fr." Specimens sent by the author, however, show that the fungus belongs to the present variety of *M. alni.*

M. GROSSULARIAE (Wallr.) Lév. (Monograph, p. 157)

Syn. add: M. sambucicola P. Henn., Engler's Bot. Jahrb. **29**: 148. 1900.

Exsicc. add: Shear, New York Fungi, 145 (in herb. Jaczewski).

Distrib. add: New Zealand (36) (56).

In a "Leaflet for Gardeners," issued by the New Zealand Board of Agriculture (**56**) the present species, which sometimes seriously attacks cultivated gooseberry bushes, is recorded from New Zealand. Bordeaux mixture, or sulphide of potassium (1½ lbs. to 50 gallons of water) is here recommended as a fungicide.

"*M. sambucicola* P. Henn." on *Sambucus racemosa* from Tokyo, Japan, is quite similar to American examples of *M. grossulariae* on *Sambucus racemosa* and *S. Canadensis* (see "Erysiphaceae of Japan" (**68**, p. 439).

M. MOUGEOTII Lév. (Monograph, p. 159)

Distrib. add: Poland (6).

M. DIFFUSA Cooke & Peck. (Monograph, p. 161)

Distrib. add: N. America, U. S., Indiana (84).

M. EUPHORBIAE (Peck) Berk. & Curt. (Monograph, p. 164)

Distrib. add: N. America, U. S., Indiana (84).

M. BÄUMLERI P. Magn. (Monograph, p. 170)

Ref., add: Salm. Journ. Quekett Micr. Club, II. **7** : 371. *pl. 20. f 1–3.* 1900.

Exsicc. add: * Krypt. Exsicc. (Mus. Pal. Vind.) 131 (b, only) *sub Erysiphe pisi.*

Distrib. add: Switzerland, Sweden.

Hosts, add: ? *Lathyrus niger.*

The fungus recorded by Tolf (Bot. Notiser, 1891 : 219) as *Erysiphe Martii* Lév. on *Vicia cassubica* from Småland, Sweden, proves, from specimens communicated to me by the author, to be the present species, which has not previously been known from Sweden.

Jaczewski, in his "Monographie des Erysipheés de la Suisse," 729 (Bull. Herb. Boissier, **4** : 1896), has recorded "*Erysiphe Martii* Lév., on *Vicia* sp., Aug. 29, 1891, herb. Jaczewski no. 76." From a specimen, so labelled, I find the fungus to be *M. Bäumleri*,—a species new to Switzerland.

The fungus recorded by Feltgen (**18**) as "*Erysiphe Martii* Lév. on *Lathyrus niger* proves, from specimens sent (now in the Kew Herbarium) to be a *Microsphaera* in an immature condition. Several appendages were found with the apex once dichotomously branched, and in one case an apex was observed which had forked twice. For the present this fungus on *Lathyrus niger* must be referred doubtfully to *M. Bäumleri*.

(To be concluded)

Texas Fungi.—I. Some new Species of Puccinia

BY W. H. LONG, JR.

The following species were collected by the writer in 1900–1901, mainly in the vicinity of Austin, Texas. They were submitted to Mr. E. W. D. Holway (to whom I am under many and lasting obligations for the many favors shown me), and also to Dr. P. Sydow.

The descriptions and drawings were made by the writer. The drawings, by the aid of an Abbe camera lucida, represent such forms as are usually seen under the microscope. They are made mainly from material boiled and mounted in lactic acid, as specimens thus treated are more nearly restored to their normal shape and size than when mounted in water; besides the acid brings out the germ pores and minor details. All drawings are made to the same scale; a Bausch and Lomb one-inch ocular, and one-sixth inch objective were used, with the paper on a level with the base of the microscope, and are reduced one-half in reproduction.

Where the writer has more than one collection of a species, he has thought it best to mark, as type, that special collection from which the drawings and descriptions were made; therefore under each species is given the date and number of the type material.

Puccinia cooperiae sp. nov.

I. Aecidia clustered into groups 3–6 mm. long, by 1–3 mm. broad. These clusters are scattered and intermixed with the uredo and teleutosori. Aecidia orange, oval-elliptical or orbicular, .3–.4

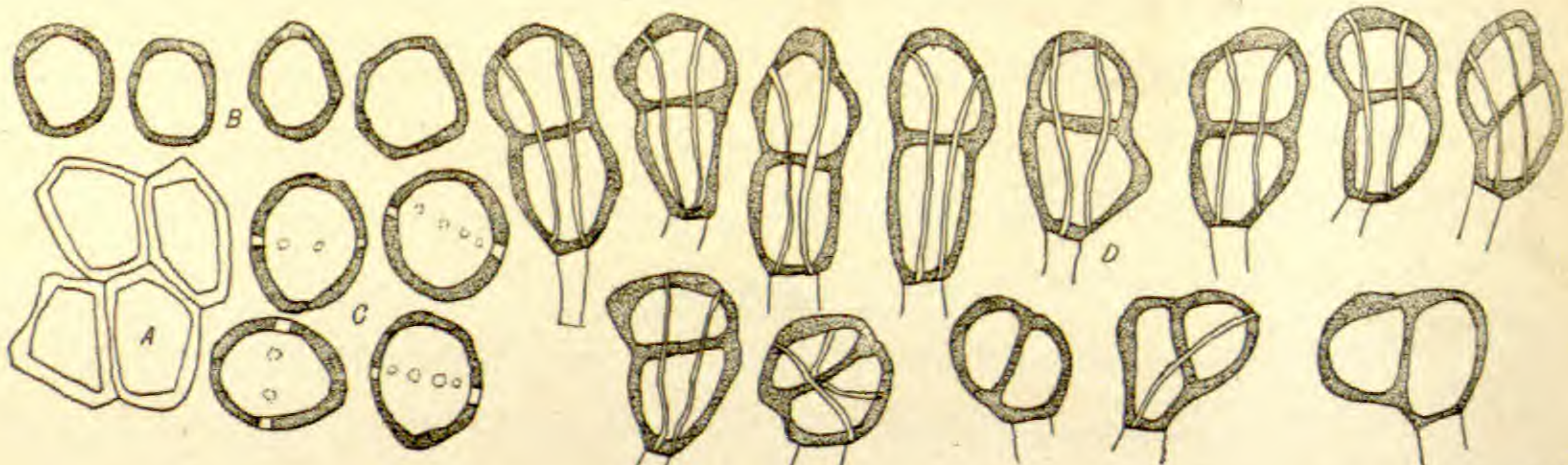

FIG. 1. *Puccinia cooperiae* on *Cooperia Drummondii*. *A*, four pseudoperidial cells. *B*, aecidiospores. *C*, uredospores. *D*, various forms of teleutospores.

mm. in diameter. Pseudoperidium prominent, somewhat reflexed and lacerate, white when desiccated. Cells of the pseudoperidium oval to irregularly polygonal. Aecidospores orange, oval, globose or irregularly polygonal, smooth or faintly granulose, 20–25 × 20–33 μ.

II. and III. Sori scattered over the leaves, intermixed.

Uredosori elliptical, chrome yellow, surrounded by the ruptured epidermis, .5 × 1–3 mm.

Uredospores yellow, minutely echinulate, obovate to globose, content yellow, appearing as oil globules when boiled in lactic acid ; germ pores apparently six and equatorially placed, 20–26 × 26–33 μ.

Teleutosori blue-black, long covered by the epidermis, but finally dehiscing through a median longitudinal fissure, surrounded by the ruptured epidermis, elliptical, .5–1 × 1–3 mm.

Teleutospores chestnut brown, smooth, very irregular in shape and insertion of the pedicel, especially the earlier spores ; usually oblong to oblong-oval, 20–26 × 33–50 μ; apex rounded, blunt or sometimes truncate ; cells unequal, lower usually longer and more triangular than upper ; epispore prominently marked by several (usually four) longitudinal lines ; septum often oblique to insertion of pedicel ; pedicel fragile, about 10 μ long, tinted.

On *Cooperia Drummondii*, Austin, Texas, Jan. 23, 1901, no. 1106 ; Jan. 24, 1901, no. 1107 ; Feb. 12, 1901, no. 1108 ; Feb. 28, 1901, no. 1111 ; March 2, 1901, no. 873 ; March 16, 1901, no. 874 ; April 6, 1901, no. 1113 ; April 27, 1901, no. 881. On *Cooperia pedunculata*, Austin, Texas, March 17, 1901, no. 1112 (II.).

This plant was first found in its aecidial stage, the latter part of January, 1901 ; from February to May all the stages were common, often on the same leaf. The later and fully mature teleutospores have the septa more normally placed and the longitudinal bands more prominent than those of the earlier teleutospores. Type of aecidial stage, March 2, 1901, no. 873 for II. and III., April 27, 1901, no. 881.

Puccinia cohaesa sp. nov.

II. Sori scattered on under surface of leaves, pale yellow, flat, powdery, orbicular to oval, .6–.75 mm., intermixed with the teleutosori.

Uredospores semihyaline, epispore pale yellow, echinulate, apex thickened for about 5 μ ; germ pores four, equatorial ; obovate to oval-oblong, 15–18 × 28–40 μ. Paraphyses sparingly intermixed, hyaline, smooth, clavate to subcapitate, walls thick, pale yellow, 13–20 × 25–70 μ.

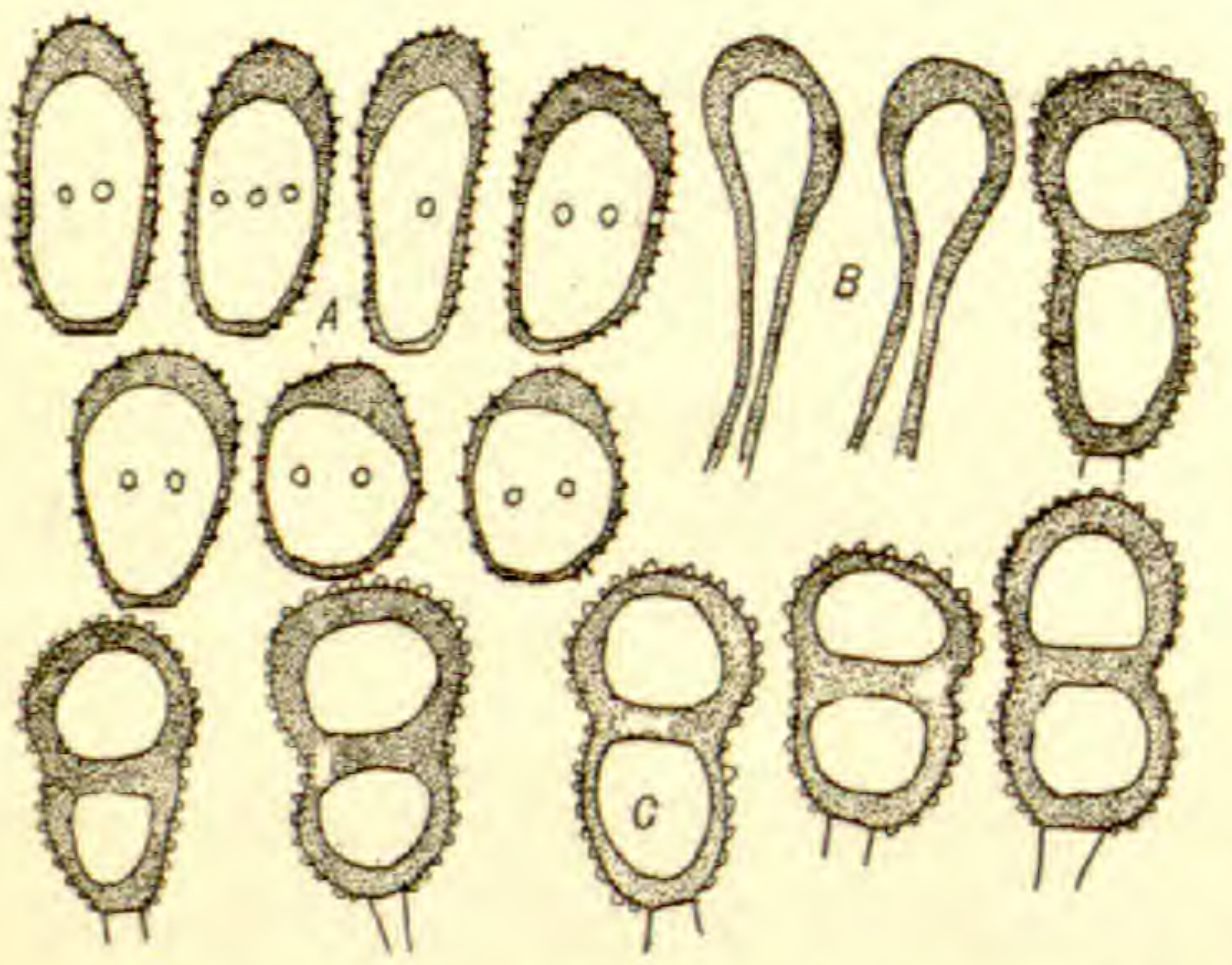

FIG. 2. *Puccinia cohaesa* on *Anemone Caroliniana*. *A*, various forms of uredo-spores. *B*, two paraphyses. *C*, teleutospores.

III. Sori usually scattered irregularly over the under surface of the leaves, but sometimes on both sides of the leaves and on the leaf stems, flat, purplish black, tardily naked, surrounded by the ruptured epidermis, powdery, very irregular in shape and size, from punctiform to orbicular and often 1–2 mm. in diameter; often concentric around a central sorus.

Teleutospores tuberculate, very uniform in size and shape, 20–23 × 34–50 μ; each cell usually regular in outline and subequal, firm, dark brown, spheroid, lower rarely attenuate, not easily breaking apart, constriction medium; tubercles large, short, blunt, not dense; few enough to be counted. Pedicel hyaline, short, sometimes length of spore.

On *Anemone Caroliniana*, Austin, Texas, March to May, 1900, no. 49; March 6 to April 25, 1901. Type for II. sori, March 14, 1901, no. 1126. Type III., April 25, 1901, no. 1127.

Through the kindness of Mr. M. A. Carleton, of the U. S. Department of Agriculture, the writer was enabled to compare this species with the U. S. Department specimens of *Puccinia fusca* from various parts of the world. This examination convinced him that *Puccinia cohaesa* was not *Puccinia fusca;* differing as follows: gross characters entirely different; microscopic characters also different, except as to size of the teleutospores; further, *Puccinia fusca* has no uredospores nor paraphyses, both of which are present with *Puccinia cohaesa.*

The water found constantly preceding and associated with *Puccinia cohaesa*, on the same plants, an aecidial form closely resembling *Aecidium punctatum.* As no positive proof of any connection between the two was at hand, the writer has not included an aecidial stage in this description, preferring to wait till cultures are made to determine this point. This rust like *P. cooperiae* continued until the leaves of the host were killed by hot water.

Puccinia Texana Holway and Long, sp. nov.

Sori hypophyllous on spots; spots ferruginous when fresh, dark brown when desiccated; sori orbicular to oval, firm, .4–.5 mm. in diameter, ferruginous, often confluent.

II. Uredospores globose to obovate, 20–26 × 23–30 μ, light brown, immature spores obovate to ovate-pyriform, walls thick, minutely echinulate, light brown, with four germ pores lying in two zones on either side of the equator.

III. Teleutospores intermixed with the uredospores, often on the periphery of the sorus; teleutospores oval to slightly obovate; 20–28 × 26–40 μ; slightly constricted at the septum; apex somewhat or not at all thickened, cells subequal, epispore smooth, pedicel up to 50 μ long, hyaline; germinated and desiccated teleutospores collapsing inward at base and apex. (See Fig. 3, *c*.)

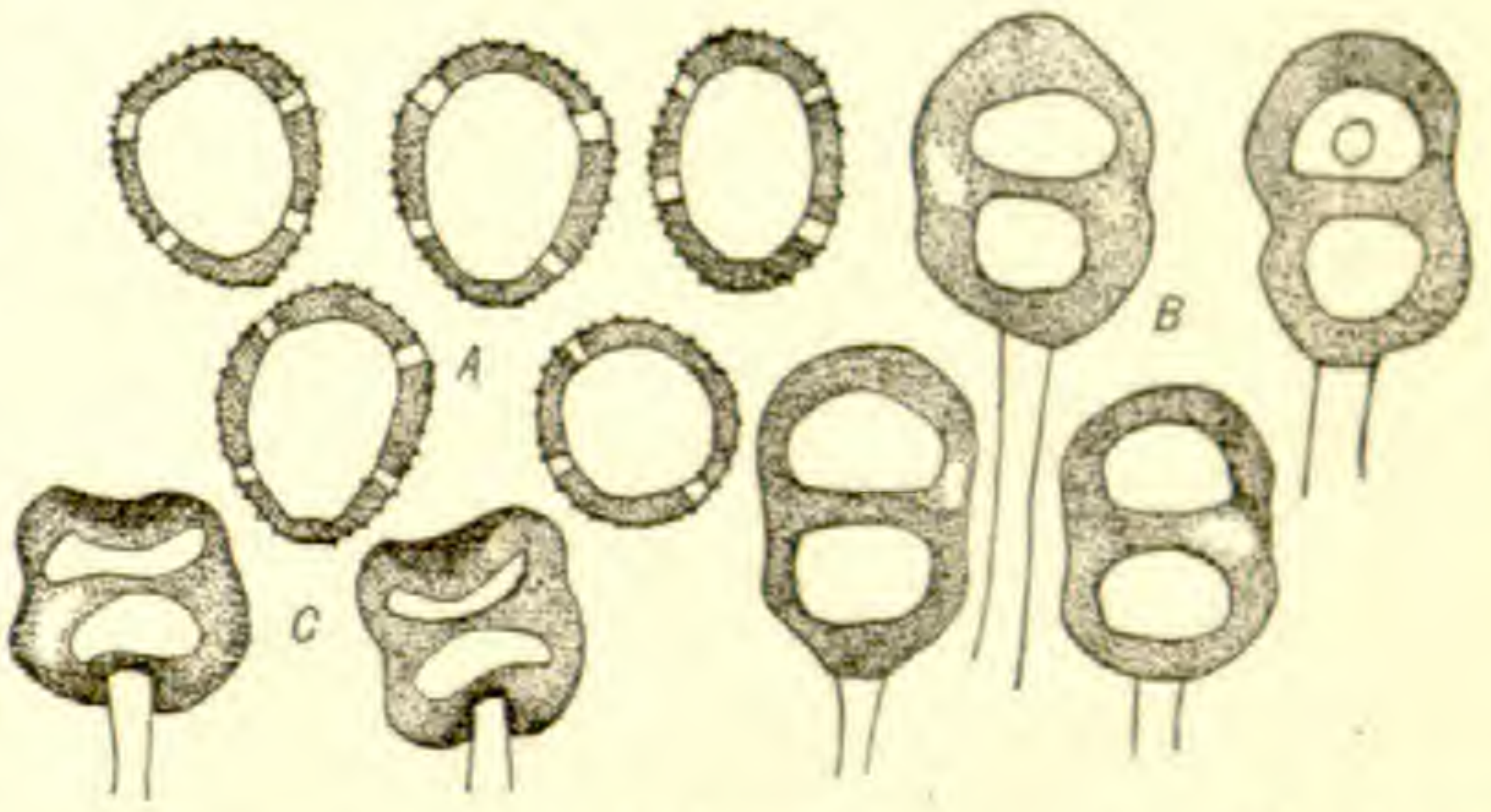

FIG. 3. *Puccinia Texana* on *Berberis trifoliolata*. *A*, uredospores. *B*, normal teleutospores. *C*, germinated teleutospores with apex and base depressed, the usual form seen in a water mount.

On *Berberis trifoliolata*, Austin, Texas, March 17, 1900, no. 44; Jan. to Dec., 1901. Type no. 44*a*, March 17, 1901.

This species is common in the vicinity of Austin, throughout, the entire year on the *Berberis* bushes, but usually only a few of the lower leaves are attacked by it. The teleutospores germinate while on the bushes. After germination the base and apex are much depressed (see Fig. 3, *c*), and this is the form usually seen under the microscope when the mount is in water; but if the teleutospores are first boiled in lactic acid, they swell out to their normal shape and size (see Fig. 3, *b*). Both uredo and teleutospores are present during the entire year, but the uredospores seem to predominate during the winter and spring months. The spots on the leaves usually appear only when the sori are old and fully matured, young sori being without the spots.

Puccinia similis sp. nov.

I. Aecidia irregularly scattered over the under side of the leaves, oval, oblong or irregular in shape, .5–1 mm.; pseudoperidium white, much exserted, with four or more lacerate segments which collapse over the aecidia when desiccated. Aecidiospores pale yellow, white when desiccated, verrucose, oval to globose, 20–27 × 27–30 μ.

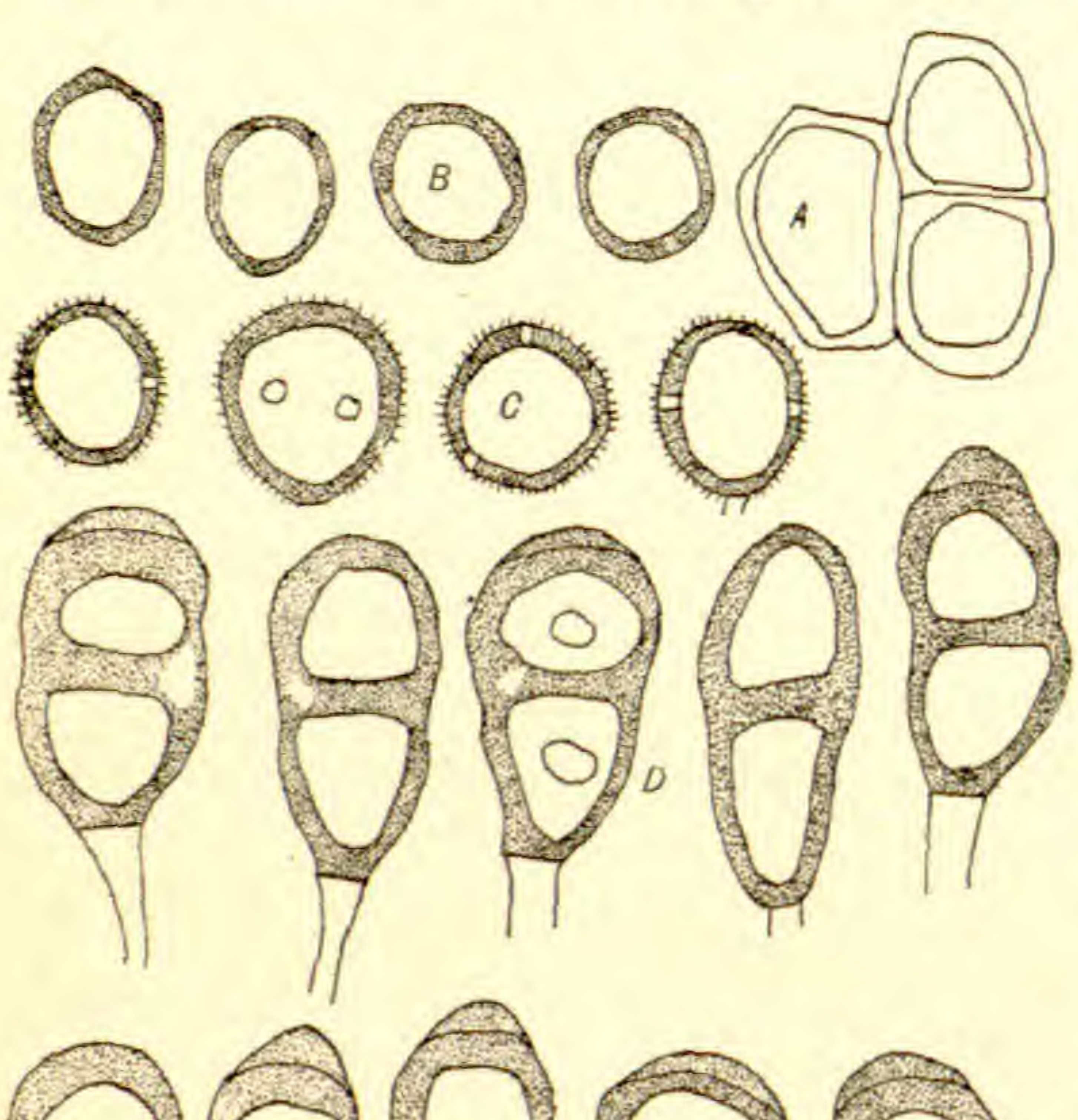

FIG. 4. *Puccinia similis* on *Verbesina Virginica*. *A*, pseudoperidial cells. *B*, aecidiospores. *C*, uredospores. *D*, earlier teleutospores. *E*, later and prevalent type of teleutospores.

II. Uredosori irregularly scattered over the under side of the leaves, often aggregated into groups, small, from punctiform to .5 mm. in diameter, powdery, ferruginous, often intermixed with the aecidia and later with the teleutosori.

Uredospores light brown, broadly ovate to subglobose, 23–26 × 24–28 μ, spinulose: germ pores apparently only two, equatorial.

III. Teleutosori thickly scattered over the entire under surface of the leaves, black, small, from punctiform to .75 mm., naked.

Teleutospores oblong, elliptical to subclavate, 23–33 × 40–54 μ: apex much thickened, rounded, constriction medium, cells usually unequal, lower often triangular, smooth, chestnut brown: pedicel usually shorter than the spore, but sometimes 60 μ long.

On *Verbesina Virginica*, Austin, Texas, Oct., 1900, to Feb., 1901; June to Dec., 1901. Type for I. and II., June 6, 1901, no. 866. Type II. and III., Dec. 1, 1900, no. 50.

The aecidia appear in June, intermixed during the latter part of the month with the uredosori, which continue till Oct., when teleutosori begin to prevail. Specimens of teleutospores collected in February have rust where the host is shaded.

Puccinia ximenesiae sp. nov.

Uredo- and teleutospores intermixed, sori scattered, mainly of teleutospores, on both sides of the leaves, black, orbicular, .5–1 mm. in diameter, semi-firm.

II. Uredospores light yellow, oval to globose, 17–30 × 20–30 μ, epispore echinulate: germ pores two.

III. Teleutospores chestnut brown, oval, slightly apiculate, 30–

34 × 42–50 μ; slightly or not at all constricted in the middle. Cells equal: pedicel short, stout, hyaline.

On *Verbesina encelioides* Gray (*Ximenesia encelioides* Cav.), Austin, Texas, Nov. 16, 1899, no. 65, by W. L. Bray.

This species was reported as common that year, but has not been collected since.

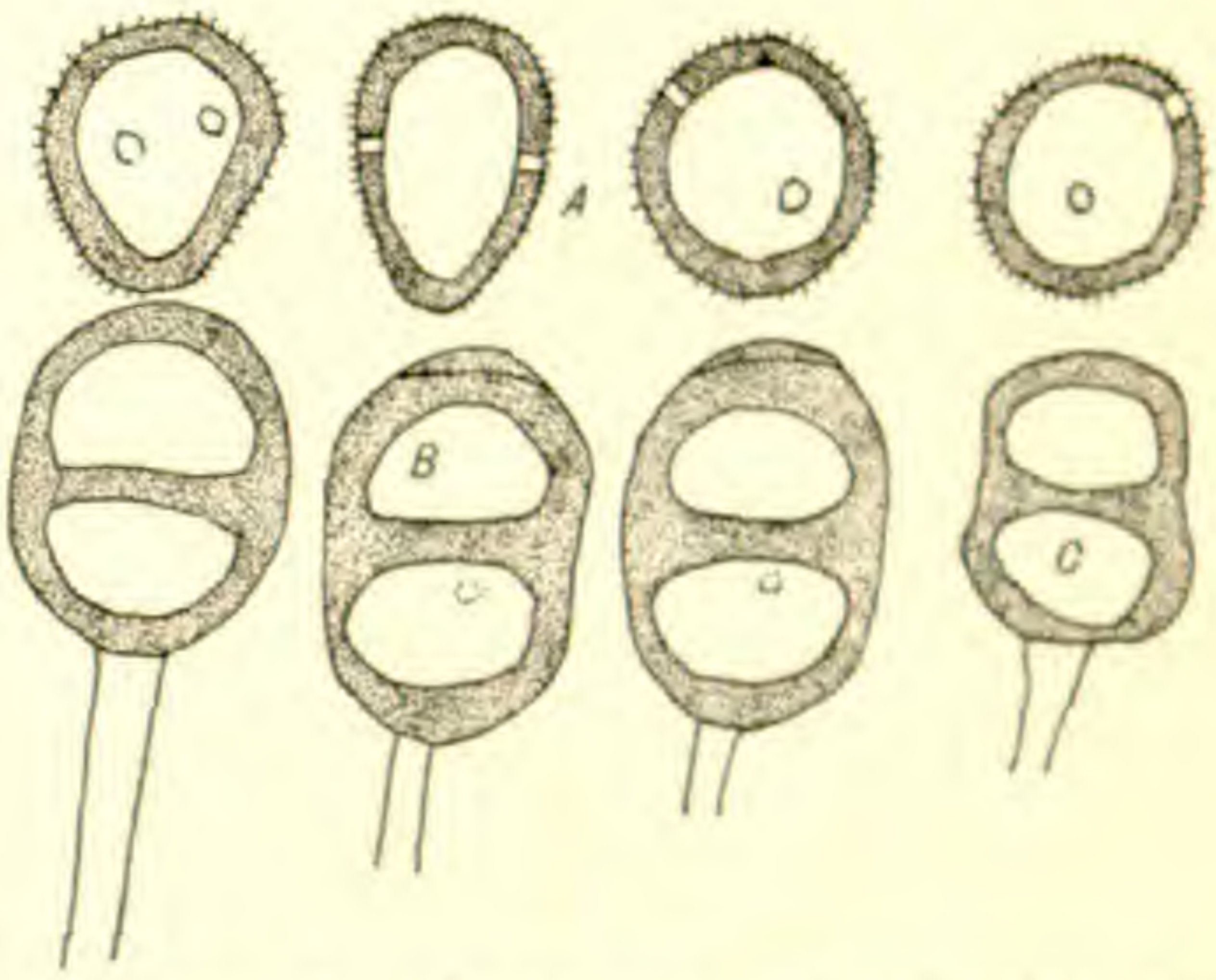

FIG. 5. *Puccinia ximenesiae* on *Verbesina encilioides*. *A*, uredospores. *B*, teleutospores when boiled in lactic acid. *C*, teleutospores when mounted in water.

Puccinia farinacea sp. nov.

Sori amphigenous, powdery.

II. Uredosori cinnamon brown, small, about .5 mm. in diameter, often densely covering parts of the leaf surface.

Uredospores subglobose, light brown, 20–26 μ, echinulate: germ pores two or three, mainly two and very prominent in fresh spores, with a convex cap over each pore.

III. Teleutosori scattered, black, orbicular, .5–1 mm. in diameter.

Teleutospores dark brown, broadly oval to subglobose, 26–30 × 30–34 μ, often apiculate, very slightly or not at all constricted at the septum, upper cell verrucose, lower faintly so: pedicel hyaline, weak, attenuate, about thrice the length of the spores; 1-celled teleutospores sparingly present,

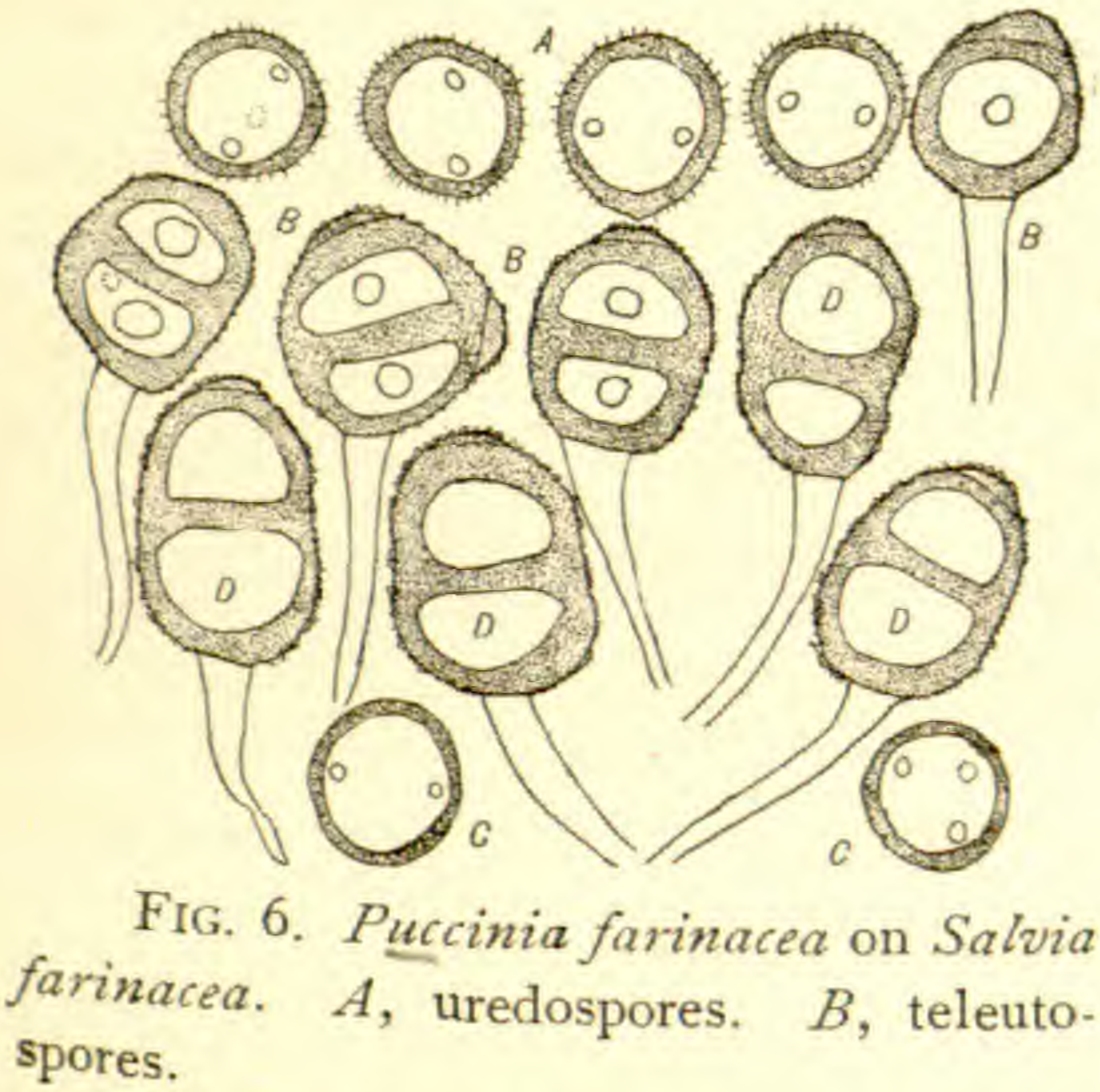

FIG. 6. *Puccinia farinacea* on *Salvia farinacea*. *A*, uredospores. *B*, teleutospores.

FIG. 7. *Puccinia ballotaeflora* on *Salvia ballotaeflora*. *C*, uredospores. *D*, teleutospores.

On *Salvia farinacea*, Austin, Texas, Oct. 31, 1900, no. 826; Nov. 12, 1900, no. 833 (type); April 4, 1901, no. 826 (II.); May 4, 1901, no. 858 (II.), and June 18, 1901. McNeal, Texas, May 12, 1901 (II).

Common on *Salvia farinacea* from April to December. Uredospores from April to October, teleutospores from then till frost kills the host.

Puccinia ballotaeflora sp. nov.

Uredospores intermixed with the teleutospores; light brown, echinulate, germ pores 2–3, oval to globose, 20–28 × 24–27.

III. Teleutosori powdery, mainly on the under side of the leaves, but sparingly on the upper surface; black; scattered, orbicular; punctiform to .75 mm. in diameter; sori on the upper surface mainly punctiform.

Teleutospores chestnut brown, both cells plainly verrucose, apiculate, slightly constricted at the septum, oval to elliptical, 24–30 × 37–50 μ; usual size 26 × 40 μ. Pedicel long, about twice the length of the spores, weak, hyaline, but *fulvous* near spores; somewhat attenuated near base. Septum often oblique or even perpendicular to the insertion of the pedicel. 1-celled teleutospores sparingly present.

On *Salvia ballotaeflora*, San Marcos, Texas, Nov. 19, 1900, no. 836.

The main points of difference between this and *P. farinacea* are as follows: Length and shape of teleutospores; this species having much longer and more elliptical spores; is also plainly constricted at septum, with upper and lower cell strongly verrucose, while *P. farinacea* has lower cell only faintly or not at all verrucose, with entire pedicel hyaline, and *P. ballotaeflora* has pedicel fulvous near the spore.

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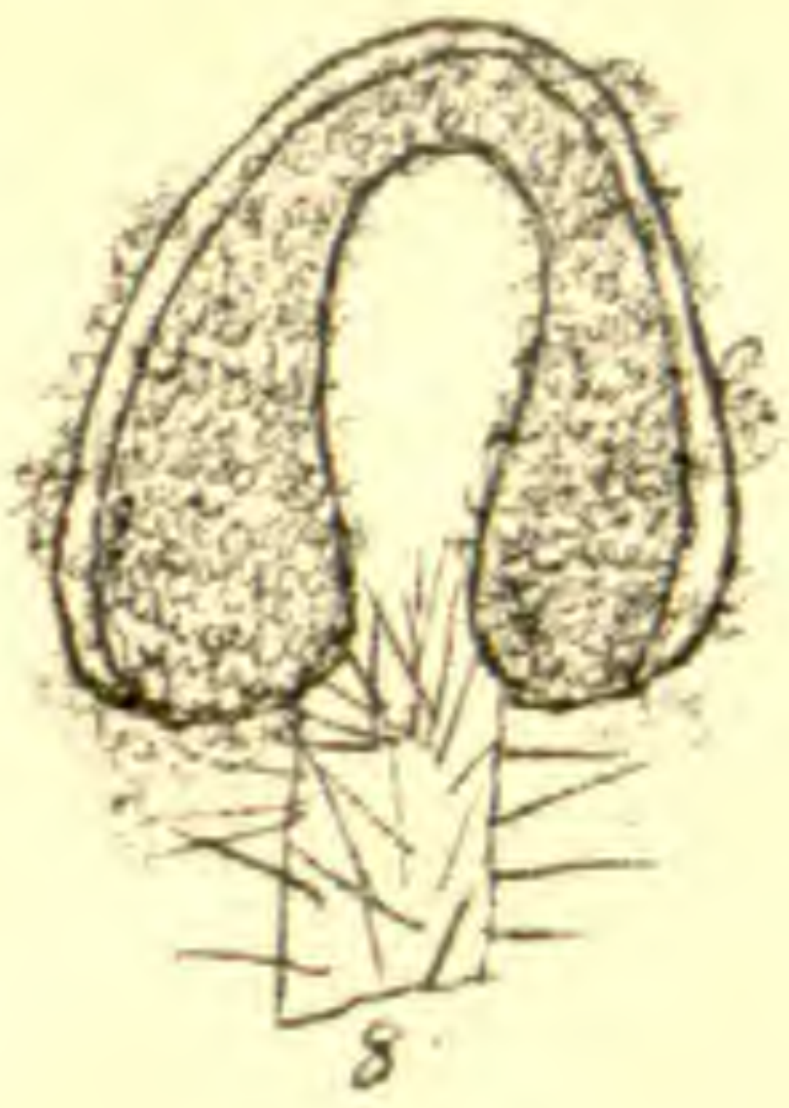
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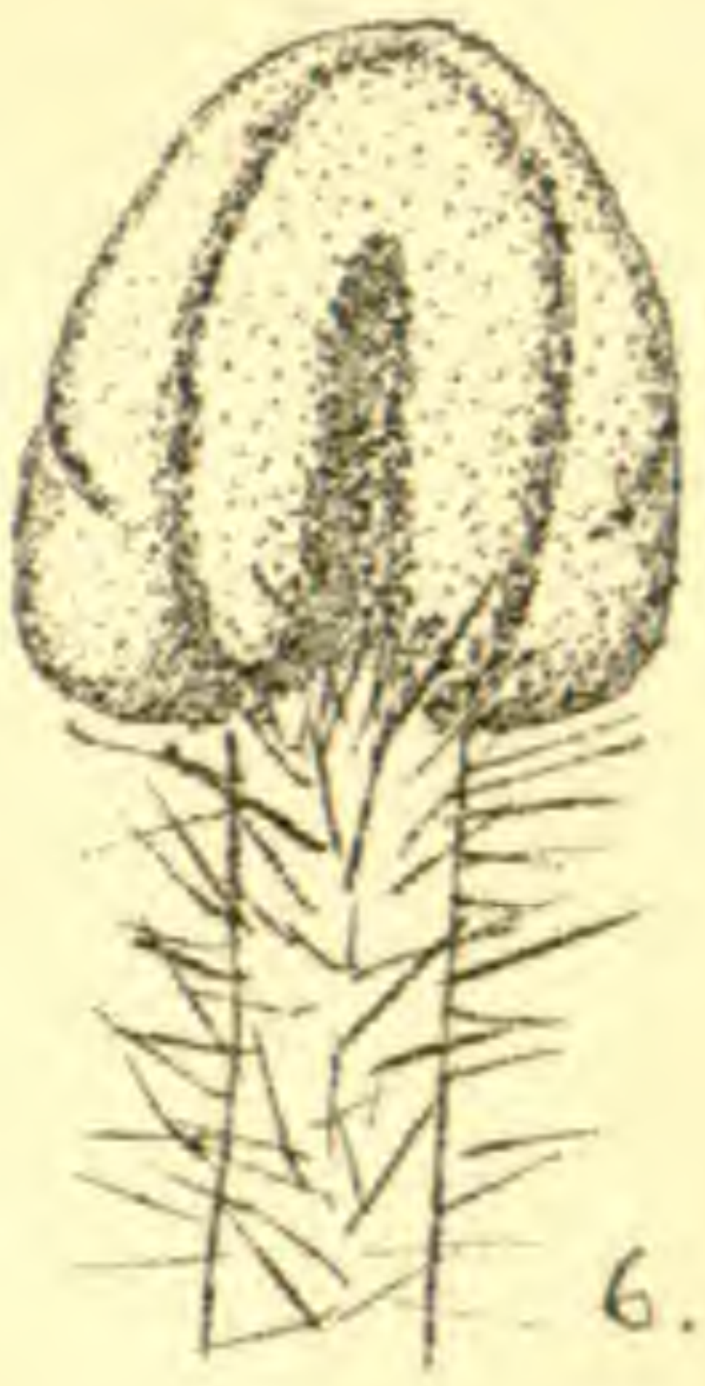
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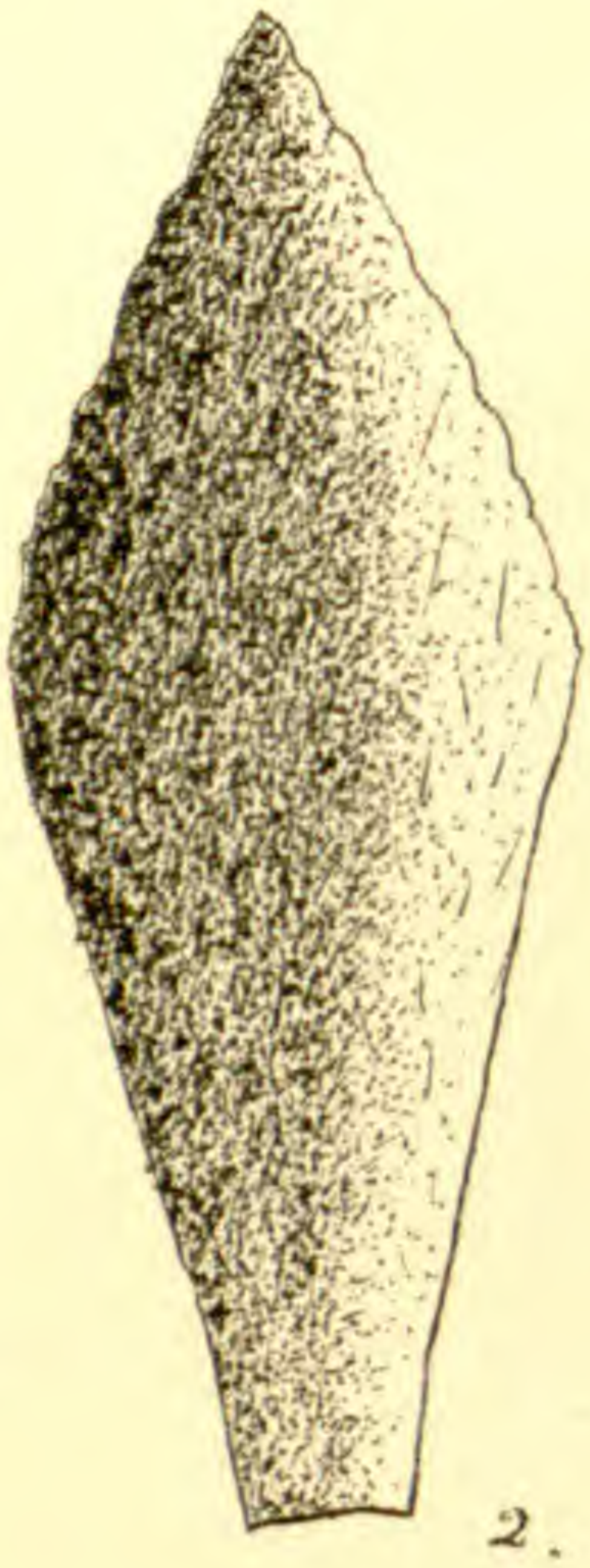
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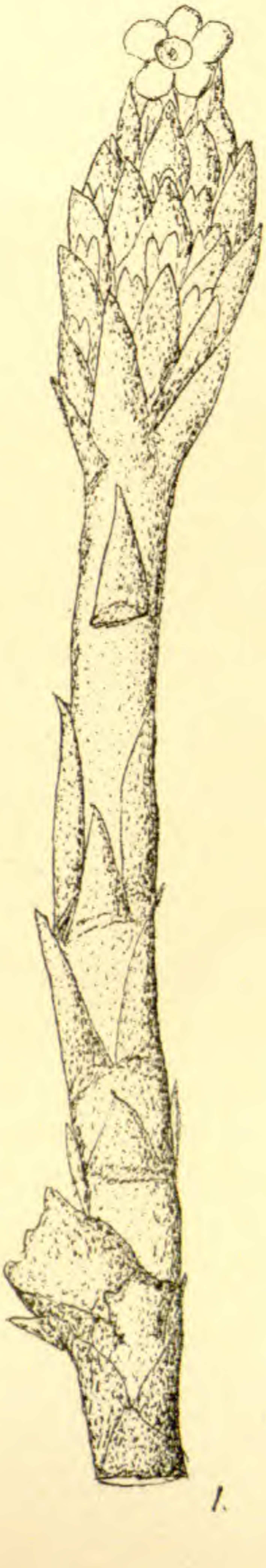
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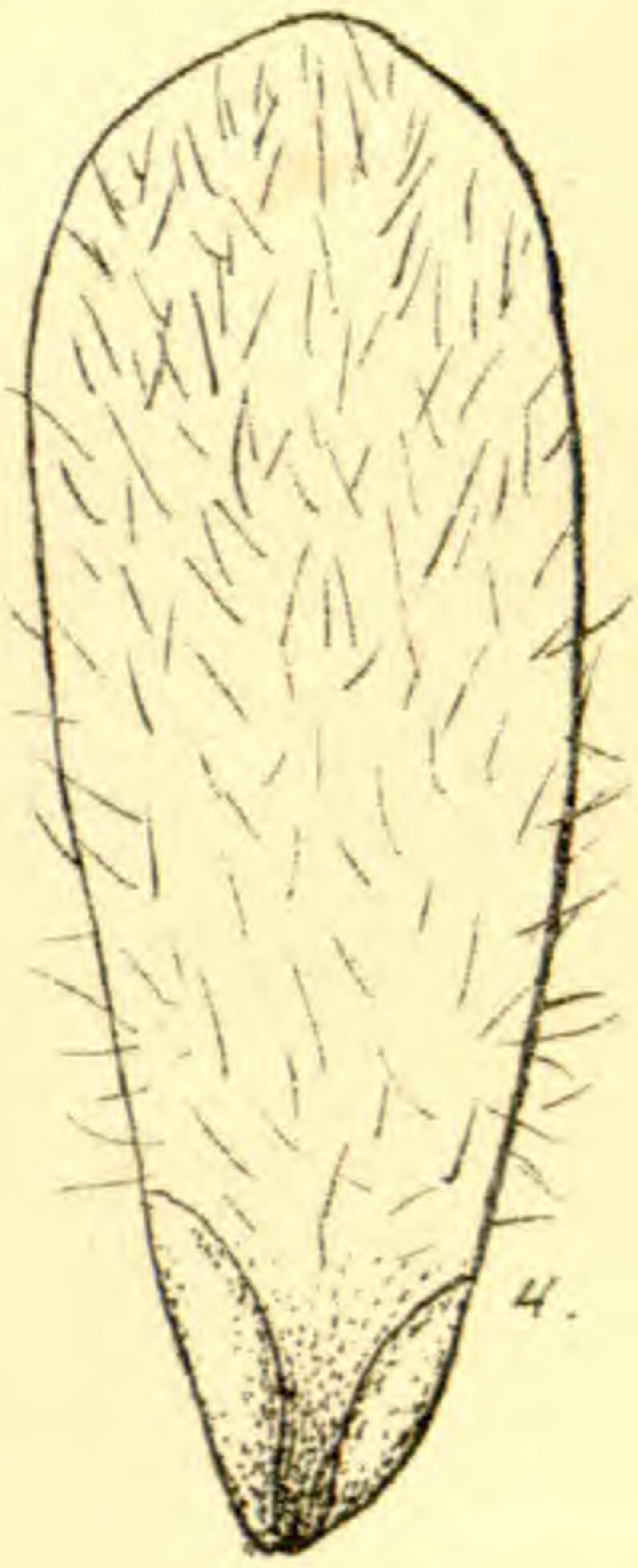
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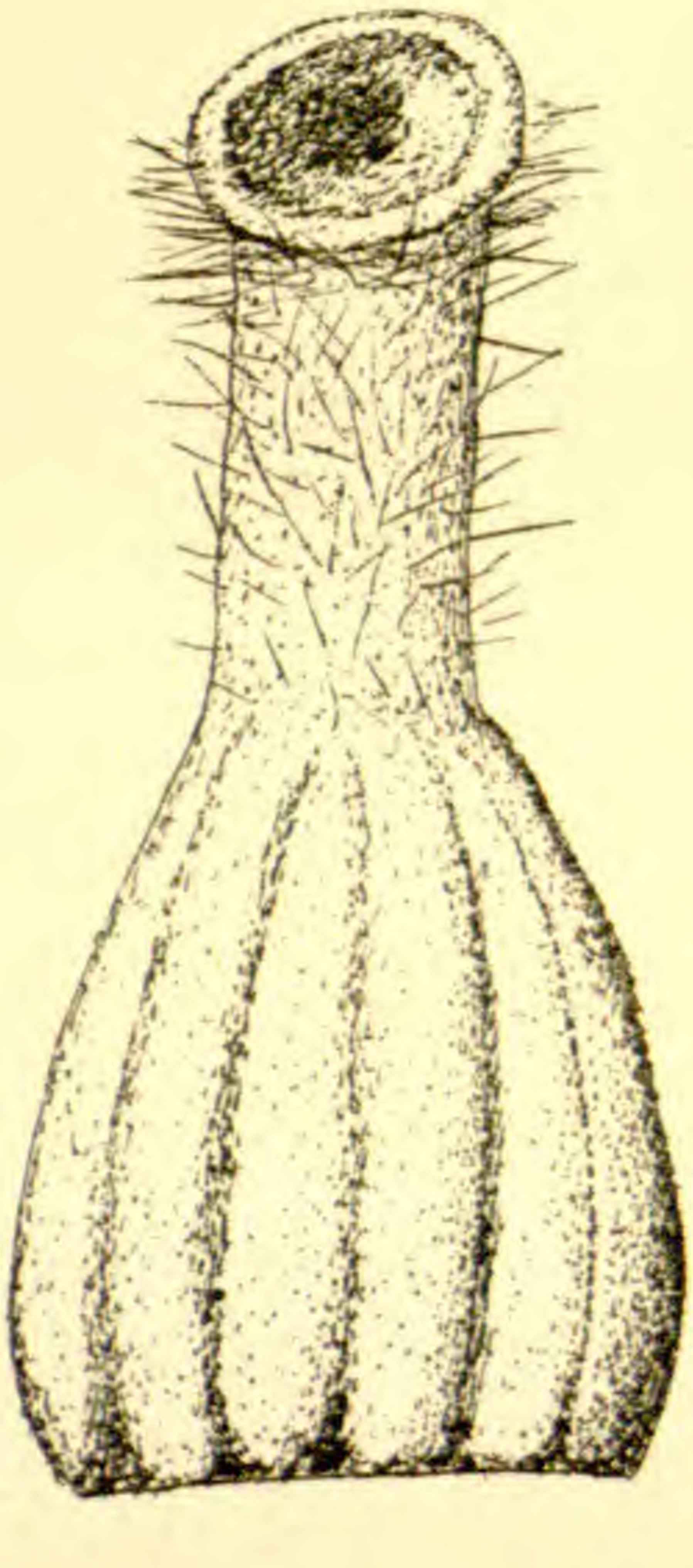
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Memoirs. (See last page of cover.)

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BULLETIN

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MARCH 1902

American Ferns—III. Our Genera of Aspidieae

By Lucien Marcus Underwood

The natural arrangement of fern groups has too often suffered materially by the systematist insisting exclusively on this or that set of characters as primary in importance, to the neglect of others, whereas the sum of characters combined with habit would seem to result in a more natural system. John Smith, whose knowledge of ferns in cultivation probably exceeded that of any other man, emphasized as primary the character of the rootstock, separating those genera in which the stipes are articulated to the rootstock from those in which the stipes are continuous. On this basis *Phegopteris* and *Polypodium*, which at Kew are still kept in one genus, were distributed at opposite ends of the family. Presl and Fée emphasized venation, while Hooker disregarded both these series of characters except for sectional (or subgeneric) distinctions and made the presence or absence of an indusium and its form primary characters in the separation of genera. Mettenius and his followers in the later German school have quite largely disregarded most of these characters, and the recent treatment in Engler and Prantl, while more rational in several other tribes, passes all bounds in the Aspidieae in uniting under a single genus forms even more diverse than those that exist in some of the Hookerian aggregates.

It is clear that in the Aspidieae several series of characters must be taken into account, and the following would seem to be the arrangement in which they appear in the order of their relative weight:

1. Type of venation.

[Issued 24 March]

2. Habit and growth characters of stem.
3. Position of sori in relation to veins.
4. Indusial characters.

The venation of the fern, forming as it does a part of the primary anatomical structure of the plant, must furnish characters which are subject to less variation than those which pertain either to the location of the sori on the veins or to the character of the indusial covering of the sorus, which at best is only a member of the epidermal system, normally a flattened trichome, and, like terminal or peripheral members generally, is subject to variation to a greater extent from external causes. While accidental conditions of united veins occur in certain free-veined species, and in certain genera there exist species closely related by habit and structure, in some of which the veins are normally free and in others the veins anastomose, still the characters of free or anastomosing veins follow, in general, very clearly defined types and can fairly be taken to represent one of the most fundamental elements in the determination of generic groups.

The determination of generic characters having been accomplished, the question of generic names is an entirely different problem. This is a direct corollary of the proposition that a genus is a group of related species. The botanists of the middle period of the last century proceeded without rule; priority was not considered, and in taking up names one followed one fancy, and another a wholly different one, which resulted in the same name being applied to widely different aggregates. Since the attempt has now been made to adjust nomenclature by rule rather than by individual fancy it has become necessary to fix upon certain species as generic types * with which the generic name will inseparably stand as valid

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* The student of generic types should not be misled by the use of the term type in a wholly different sense. In *Historia Filicum*, for example, John Smith uses the term "type" in the sense of the most common or well-known species included in his conception of the genus, whether it formed a part of the genus as originally proposed or not. Thus his type of *Nephrodium* is *Aspidium molle* Swz., which was not a part of the genus as originally founded by Richard, and is generically distinct from any species it did contain. The "biological type" or center of variation and divergence is also a wholly different matter and one that can never be fully determined until after the last species of any generic group has been described. The nomenclatorial type is the one considered here and, so far, it has only been definitely settled that this type must be a species mentioned in connection with the original publication of the genus.

or pass into synonymy according as views of generic limitations become closer or more elastic. The consideration of the present tangle is respectfully commended to those who are following the *ignis fatuus* of determining generic types by the subsequent history of the genus—a principle only slightly removed from the "method of residues" which in its original form now seems to be wholly abandoned by even its former strenuous advocates. For early genera only the historic type on which a genus was originally founded can stand before the acceptance of the first named species under the genus as its nomenclatorial type. This applies to all genera but principally concerns genera founded while botany was in a formative period when generic limits were not clearly drawn. Where a type species was named, that of course must take precedence over everything. Monotypic genera cannot come into question as their sole species must be the type on which they were founded.

Attention is called to the Aspidieae at this time, since we have recently had presented to us a rearrangement * of our native species under generic names, two of which are utterly untenable on any system of nomenclature yet followed, except that of personal preference. And, what is still more remarkable, this proposition comes from one who in the past has most loudly proclaimed against change of any sort and yet would now attempt to introduce among our fern names one that has never before been used in America, and one which is without question the worst selection that could possibly have been made. It is impossible in the light of all the evidence at hand to interpret this new departure in any other way than as a deliberate result of prejudice and an unwillingness to adopt a course of action simply because it accords with the principles of the Rochester system. Nothing short of this could explain the willingness to do a wrong thing, when the right one would have been not only the only correct course, but a perfectly natural course to pursue. To see that such is the case we have only to lay bare the facts underlying the history of the group.

The species of the present tribe Aspidieae so far as known to Linnaeus were included with his genus *Polypodium*. Ten years after the publication of *Species Plantarum*, Adanson published the

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* Rhodora, 4: 7–13. Ja. 1902.

first genus in the present alliance calling special attention to the distinctive character of the superior indusium which was perhaps the most obvious mark that distinguished the European Aspidieae from *Polypodium.* Not only was this distinction clearly defined, but he mentions in addition the type of the genus and refers to illustrations that are absolutely unmistakable. He says:

> "DRYOPTERIS: Paquets de fleurs ronds, disposés sur 2 rangs sous chaque division des feuilles. Enveloppe enparasol. Globules environnés d'un anneau élastique." Familles des Plantes, **2**: 20. 1763.

And on page 551 (index) he adds:

> "DRUOPTERIS Diosk. 20.
> Filix mas *Fuchs*, *Tour. t.* 311, 312.
> Fougere mâle Gall."

thus citing not only the origin of the name dating back to Dioscorides, but also the name used by the old herbalists, the authentic figures of Tournefort,* and the name then current in France, which like our own familiar male-fern is the name which the plant has borne for the last three centuries or more in northern central Europe, where it is the commonest member of this genus either wild or in cultivation. I cannot conceive of a more complete, direct, and explicit establishment of a generic name than this, and yet Mr. Davenport's only comment on this bit of history is that "a genus so ill-defined, with its type standing for one thing and its description for another, has no just claim for consideration as against the more clearly defined *Nephrodium* which has been in use for nearly a century." Surely we have here either an attempt to mislead those who do not have access to the original publications or a case of negligible ignorance of facts, either of which must stand in the same category of constructive error.

There being a definite genus established for our wood-ferns there is no necessity for another, but let us look a little farther into *Nephrodium* and discover if possible what this "more clearly defined" genus is. Richard, who edited Michaux's Flora, says:

> "NEPHRODIUM. *Fructif.* Puncta in disco frondis sparsa seu seriata; primum obtecta membranula reniformi aut lunata, hinc (servato nexu laterali) dehiscente." Michaux, Fl. Bor. Am. **2**: 266. 1803.

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* To those who do not have access to Tournefort's classic *Institutiones* it may be said that *t. 311* gives a clearly drawn figure of the upper third or so of a leaf of the male-fern showing the characteristic reniform indusia, and *t. 312* gives various details including a segment greatly enlarged with the same characteristics in stronger relief.

So much for his description. Now what are the contents of this clearly defined genus with their modern equivalents, for it should always be borne in mind that a genus is a group of related species, not a definition or a description. We cite the species in the exact order of publication :

1. *N. acrostichoides* = *Polystichum acrostichoides.*
2. *N. thelypteroides* = ?
   (= *Dryopteris Noveboracensis*, *fide* D. C. Eaton).
3. *N. marginale* = *Dryopteris marginalis.*
4. *N. punctilobulum* = *Dennstaedtia punctilobula.*
5. *N. bulbiferum* = *Filix* (*Cystopteris*) *bulbifera.*
6. *N. filix-foemina* = *Asplenium filix-foemina.*
7. *N. asplenioides* = *Asplenium filix-foemina.*
8. *N. cristatum* = *Dryopteris cristata.*
9. *N. tenue* = *Filix* (*Cystopteris*) *fragilis.*
10. *N. rufidulum* = *Woodsia Ilvensis.*
11. *N. lanosum* = *Cheilanthes lanosa.*
12. *N. Dryopteris* = *Phegopteris Dryopteris.*

Surely this is a parody on "a more clearly defined" genus, judging from the *mélange* which Richard, its founder, placed in it, containing among its twelve species representatives of no less than eight well recognized genera, now distributed among four distinct tribes! No comment is necessary, and we could only wish for our friend that he were one tithe as anxious to establish a rational basis for nomenclature as he is to antagonize the "Rochester advocates" at whatever cost of consistency or good judgment.*

In connection with Mr. Davenport's statement that *Nephrodium* has been in use for nearly a century, we might say, lest his state-

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* As a further illustration of misleading statements that occur in works supposed to carry the weight of authority, the following comment on *Nephrodium* is cited from John Smith (*Historia Filicum*, 206–207) : "This genus as originally characterized embraced species with both free and anastomosing veins, the technical character consisting in all having a reniform indusium. Schott restricted the genus to the species having anastomosing veins only." It is very probable that John Smith, like many another fern writer, never actually took the trouble to look inside Michaux's *Flora*, but assumed that because the great Hooker included both types in the genus that this was the condition in the original. Of the original twelve species described by Richard all are free-veined, and among the variety of indusia represented only two species have reniform ones and some have none at all!

ment should mislead the uninformed, that it has hitherto been used mainly at Kew, where their idea of its type (*Eunephrodium*) is entirely outside the range of even the diverse contents which its founder included in it; it has never been in use on the continent to include our north temperate wood-ferns and never at all in America since its foundation. *Dryopteris* was taken up by Schott and later by Asa Gray in the first edition of his *Manual*, and its use by Americans for the past decade has been practically unquestioned except by Mr. Davenport himself.

Another genus adopted by Mr. Davenport for our ferns is *Aspidium* of Swartz, which, by a sleight-of-hand performance unknown to any other advocate of the idea of a specific type for a genus, he lodges with *Aspidium trifoliatum* (*Polypodium trifoliatum* L.). Here again an insufficient examination of fern literature has placed him in a second error. We quote from a paper of Cavanilles published in 1799:

> "TECTARIA: *Fructificacion* en puntos redondos, esparcidos, situados en la superficie posterior de la hoja. *Tegumento* umbilicado. *Abertura* casi circular. Exemplo de este género: Polypodium trifoliatum de Linneo." Anales de Historia Natural,* 1:115. D. 1799.

It will thus be seen that the plant called *Aspidium trifoliatum* by Swartz is the monotype of *Tectaria*, which is a well-marked generic group as even Mr. Davenport is forced to admit. *Aspidium*, on the other hand, which he takes up for this species, was not proposed until 1801,† when Swartz described it as follows:

> "ASPIDIUM. *Capsulae* in puncta subrotunda sparsa digestae, *Indusiis* umbilicatis l. dimidiatis tectae." Schrader's Journal für die Botanik, 1800: 29. 1801.

Then follow some seventy or more species which Swartz combined in this genus and which are now variously distributed among several genera. The first six mentioned are:

1. *A. articulatum* = *Oleandra articulata.*
2. *A. pistillare* = *Oleandra neriiformis* Cav.
3. *A. trifoliatum* = *Tectaria trifoliata.*
4. *A. Lonchitis* = *Polystichum Lonchitis.*

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* At the time of the publication of my "Genera of Ferns" I had not seen this rare series, of which a complete set containing a number of Cavanilles' papers is now in the library of the New York Botanical Garden. The above is therefore the corrected date for *Tectaria* and *Oleandra* as published in my earlier paper.

† Mr. Davenport appears to be in doubt about this date, but had he examined the title page he would have found it perfectly clear.

5. *A. mucronatum* = *Polystichum mucronatum.*

6. *A. falcatum* = *Cyrtomium falcatum.*

On the application of the principle of regarding the first named species as the type of a genus, a principle which Mr. Davenport *professes* to accept, *Aspidium* becomes a straight synonym of *Oleandra*, which had been proposed by Cavanilles (*l. c.*) two years before, on the same page as *Tectaria* and immediately following it. On the unique application of a sliding scale in the matter of determining the type of a genus, which Mr. Davenport *actually does follow*, the name *Aspidium* would replace the later *Cyrtomium* proposed by Presl in 1836. But no one will be likely to consider seriously a system so illogical as his, and on any rational count *Aspidium* must pass into synonymy by the side of *Nephrodium;* we may consider ourselves fortunate to be able to dispense with two such unnatural groups of species as these were when first organized, and thus consign them to a merited oblivion.

The opening years of the fourth decade of the nineteenth century found us then with the following genera now forming a part of the Aspidieae properly established, each one traceable to a distinct and indisputable type :

DRYOPTERIS Adans. 1763.
MENISCIUM Schreber, 1791.
TECTARIA Cav. 1799.
POLYSTICHUM Roth, 1800 (?)[*]
DIDYMOCHLAENA Desv. 1811.
DIPTERIS Reinw. 1825.

It will be interesting to note the subsequent history of the group, since the extensive formation of fern genera has occurred since 1830.

In 1834 Schott[†] commenced a series of studies on genera, among which the following were considered :

ASPIDIUM, taken up for the species, *A. trifoliatum* Swz.

NEPHRODIUM, taken up for such species as *N. unitum*, *N. molle*, etc. This laid the foundation for the misconception of *Nephrodium* for species with connivent veins, and the application of the name to a group of species distinct from any originally in the genus.

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[*] As already noted (Mem. Torrey Club, **6**: 262. 1899) there is still uncertainty of the date of publication of Roth's third volume. With a preface dated 14 Sept. 1798, and a title page dated 1800, we have some of his genera cited in papers published in 1799.

[†] Genera Filicum, 1834.

POLYSTICHUM Roth.
DRYOPTERIS Adans.
THELYPTERIS, adopted for *Aspidium Thelypteris* (L.) Swz and its allies.
MENISCIUM Schreb.

Unfortunately Schott's studies were not systematized and were cut short by his death; several of the above genera even appear only in his "Observationes," a series of notes appended to his discussions and illustrations of genera.

It was Presl, however, who, in 1836,* commenced the process of generic expansion by founding a considerable number of new genera and adopting several older ones. His system was as follows:

ASPIDIACEAE

Nephrodiarieae
LASTREA Bory.†
OLEANDRA Cav.
NEPHROLEPIS Schott.
NEPHRODIUM Schott.

Aspidiarieae
POLYSTICHUM Schott.
PHANEROPHLEBIA Presl.
CYCLODIUM Presl.
CYRTOMIUM Presl.
SAGENIA Presl.
ASPIDIUM Schott.
DIDYMOCHLAENA Desv.

Presl cites Schott for several genera earlier named, thus recognizing the fact that he was using them in a sense different from that of their original authors.

Among his new genera was *Phanerophlebia* (p. 84) founded on *P. nobilis* (Schlecht.) to which must be joined *Amblia* (p. 184) which was founded on *A. juglandifolia* (H. & B.) on the misconceived notion that this species had no indusium.‡

Cyclodium (p. 85) was based on three species of the old world, of which *C. glandulosum* (Bl.) was first named, although *C. meniscioides* (Willd.) is perhaps better known. *Cyrtomium* (p. 85) was based on two old-world species, of which *C. falcatum* (L.) is not only the first named but is the long known plant common in

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* Tentamen Pteridographiae. Prag, 1836.

† *Lastrea* contained three sections, the first of which was called *Dryopteris* but singularly did not contain the type species of Adanson's *Dryopteris* (*D. filix mas*) which instead was placed in § *Thelypteris*.

‡ John Smith carelessly remarks (*Historia Filicum*, 204) "these two genera being evidently founded on specimens off which the indusium had fallen." This is true of *Amblia* but Presl (*l. c.*) says in establishing *Phanerophlebia*: "*Indusium orbiculare, peltatum.*" It is not always safe to trust the statements of the "authorities" and in taking up fern names it is often as essential to know fern literature accurately as it is to be familiar with growing ferns.

cultivation. *Sagenia* (p. 86) was founded on six species of which *S. lobata* (Rich.) is first named.

The non-indusiate species forming what has been known as *Phegopteris* (in its later Mettenian sense) were left by Presl with *Polypodium* in a distinct tribe. The free-veined species he left under *Polypodium*, where they had been placed by Linnaeus, but in a distinct section which he named *Phegopteris*. The old complex genus *Polypodium* was dismantled for the first time on the rational basis of venation, and among the aspidioid types, the genera *Goniopteris* and *Dictyopteris* were founded. *Goniopteris* (p. 181) was based on nine species, of which *G. incisa* (Swz.) was first named, and *Dictyopteris* (p. 194) was founded on four species, of which *D. attenuata* (R. Br.) was mentioned first; the last named genus is exclusively an old-world group, so need not be considered further here. *Pleocnemia* (p. 183), another old-world group, was also established, based on *P. Leuceana* (Gaud.) of the East Indies. *Meniscium* Schreb. was properly accepted, but appears under a third tribe (Grammitaceae) because of its elongate sori.

Link * was the next to divide the genera. His arrangement was as follows:

ASPIDIUM.
CYCLOSORUS.
NEPHRODIUM.
POLYSTICHUM.
TECTARIA.
BATHMIUM.
DIDYMOCHLAENA.

Of these, *Aspidium* was taken up for the species with a reniform indusium and free veins (= *Dryopteris*). *Nephrodium* was taken up for what Schott had named *Nephrolepis*, thus shifting the name in still a new direction beyond the range of the eight genera *Nephrodium* originally contained! *Tectaria* was adopted as a genus but was shifted to the group containing *Aspidium coriaceum* (Swz.), a species later included by Cavanilles in this genus; for *Tectaria trifoliata*, however, which was the sole type of its genus as founded, and its allies, Link proposed a new genus *Bathmium* (p. 114).† He also proposed *Cyclosorus* (p. 108) based on *C. gonglyodes*

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* Filicum species in hort. reg. bot. Berol. cultae, 1841.

† This name was first proposed by Presl as a subgenus of *Aspidium* for the group containing *Aspidium Singaporanum* Wall. (= *Podopeltis* Fée). Link included also species of *Sagenia* Presl in *Bathmium*, making a new genus include an older one!

(Schk.) a fern from Guiana which Moore reduces to a synonym of *Nephrodium unitum*. *Cyclosorus* appears to be the first name definitely applied to a member of the group with connivent veins and cordato-reniform indusia (the § *Eunephrodium* of *Synopsis Filicum*).

Presl included the species of *Phegopteris* in *Polypodium*, but *Goniopteris* was kept distinct.

In 1841 John Smith * established the genus *Leptogramma*, based on seven species, of which *L. asplenoides* (Swz.) was first named. This genus, which has been placed by the Hookerian school in that monstrously incongruous group known as *Gymnogramme*, differs from *Phegopteris* solely in the possession of elongated sori and in any natural system must stand next to *Phegopteris* if not united with it.

In 1842 Hooker and Bauer established the genus *Fadyenia* † based on the single species known from Jamaica. In this work, *Genera Filicum*, the Preslian genera were largely taken up and this publication represents the most sane and sound pronouncement that ever emanated from Kew on the subject of the classification of ferns. More species of ferns by far have been described from Kew than from any other center of study in the world, but since the publication of *Genera Filicum* in 1842 their utterances on general fern classification have lapsed into a harmless *laissez faire* policy a half century behind the times, and a much greater amount behind their magnificent opportunities in herbarium and conservatory equipment and facilities.

In 1846 John Smith ‡ further established the genus *Cyclopeltis*, based on a single West Indian species. His early views on genera quite closely coincided with those of Presl and his opinion of relationships merits particular attention since he knew growing ferns in cultivation probably better than any man who has ever lived. His later views on this group as expressed in *Historia Filicum* (1875) may be tabulated as follows (the exclusively old world genera in Roman type and those with American species in small capitals):

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* Hook. Journ. Bot. 4: 51. 1841.

† Genera Filicum, *pl. 53B*. 1842.

‡ Bot. Magazine, 1846.

Phegopterideae.

Stegnogramme Blume (1828).
GONIOPTERIS Presl.
DRYOMENES Fée.*
AMPHIBLESTRA Presl.†
Dictyopteris Presl.
Dipteris Reinw. (1825).

HYPODERRIS R. Br. (1830).
Trichiocarpa J. Sm.
PODOPELTIS Fée.‡
ASPIDIUM (incl. *Sagenia*).
CYCLODIUM Presl.
CYRTOMIUM Presl. (incl. *Phanerophlebia*).
Pleocnemia Presl.
NEPHRODIUM Schott.
Mesochlaena R. Br.§
FADYENIA Hook.

LASTREA Presl.
POLYSTICHUM Schott.
Acrophorus Presl.||
ADENODERRIS J. Sm.¶

Arthropteris J. Sm.**
Cyclopeltis J. Sm.
NEPHROLEPIS Schott.

Isoloma J. Sm.††

DIDYMOCHLAENA Desv.

STRUTHIOPTERIS Willd.

LEPTOGRAMMA J. Sm.
PHEGOPTERIS Fée.
Hypolepis Bernh. (1806).

In 1850–1852 Fée published his *Genera Filicum* in which this tribe appears as follows:

Cyclodieae

POLYSTICHUM Roth.
PHANEROPHLEBIA Presl.
HEMICARDION Fée.
AMBLIA Presl.

CYCLODIUM Presl.

CYRTOMIUM Presl.
PODOPELTIS Fée.
BATHMIUM Link.

Aspidieae

ASPIDIUM Swz.
CYSTOPTERIS Bernh.
LEPIDONEVRON Fée.
DICHASIUM A. Br.‡‡

OLEANDRA Cav.

NEPHRODIUM Rich.
HAPLODICTYON Presl.
ABACOPTERIS Fée.§§

PLEOCNEMIA Presl.
SAGENIA Presl.
PHLEBOGONIUM Fée.
CARDIOCHLAENA Fée.
FADYENIA Hook. & Bauer.

Besides *Nephrolepis* and other genera now placed in Davallieae.

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* Founded on *Polypodium menisciicarpon* of Blume, but extended by Smith to include *P. plantagineum* L. They represent the non-indusiate type paralleling *Tectaria.*

† Based on *Pteris latifolia* H. & B.

‡ To the type named by Fée, Smith adds a second species, *P. sinuata.*

§ Horsefield, Plantae Jav. rariores, 1838; based on *Polypodium villosum.*

|| Based on *Aspidium nodosum* Blume of the old world.

¶ Based on *Aspidium glandulosum* Hook. & Grev. of the West Indies.

** Based on *Polypodium tenellum* Forst., of New Zealand.

†† Based on *Lindsaea lanuginosa* Wall.

‡‡ This was based on *Aspidium Donianum* Spreng. and was proposed by A. Braun (Flora, **24**: 710. 1841) as a subgenus. Fée was, I think, the first to suggest generic rank for it (p. 302).

§§ Congr. Sci. de France **1**: 178. 1843, based on *A. Philippinarum* Fée.

In the above arrangement Fée took several untenable positions and was perhaps inclined to increase genera unduly on which we would comment as follows:

1. *Phanerophlebia* and *Amblia* were both maintained following Presl's earlier misconception (*cf. supra*).

2. *Hemicardion* was substituted for *Cyclopeltis* J. Sm. and was based on the same monotype. This was not due to ignorance of the fact of an earlier genus, for he cites Smith's work; it must be set down as a case of deliberate misappropriation of a genus, of which botanical literature is unfortunately too full of conspicuous examples.

3. In *Nephrodium*, as used by Fée, none of the original species were mentioned but it was confined to the species with connivent veins.

4. *Aspidium* was used for the free-veined species with cordato-reniform indusia (= *Dryopteris* Adans.), thus following Link.

5. *Bathmium* Link was taken up for *Tectaria trifoliata* and its allies.

6. Besides *Hemicardion* the following genera were established:

PODOPELTIS (p. 286) based on a single species, *P. Singaporiana* (Wall.). This has usually been united with *Tectaria.*

CARDIOCHLAENA (p. 314) based on several species of which *C. alata* from the Philippines is first named. This has usually been referred to *Sagenia.*

LEPIDONEVRON (p. 301) based on numerous species with the indusium adnate at the base and with pendulous leaves; the first named species is *L. bidentatum* (Presl); the genus is usually referred to *Nephrolepis*, and hence belongs outside the tribe under consideration.

PHLEBIOGONIUM (p. 314) based on *P. impressum* (Griffith), an old-world species.

The non-indusiate series were still kept with the Polypodieae; *Goniopteris* and *Dictyopteris* were retained, and *Phegopteris* of Presl was raised to generic rank (p. 242), *Polypodium Phegopteris* L. being properly named as the first and consequently type species.

In 1856 Mettenius * capped the climax of conservatism, and practically abandoned all structural characters except for sectional

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* Filices hort. bot. Lipsiensis, 1856.

limitations combining all the genera of this series into *Aspidium* and *Phegopteris*, the former containing the indusiate and the latter the non-indusiate species regardless of vein characters or habit. Christ in 1897 * followed his lead but included also *Fadyenia* Hook. & Bauer in the *mélange*.

During the next year Moore † published a synopsis of ferns which in general approximated those of Presl and Fée but differed in a number of features particularly in the inclusion of *Phegopteris* in *Polypodium*, a practice to which all Englishmen except John Smith seem to have been unfortunately addicted. Moore's arrangement is as follows :

Polypodieae.
- POLYPODIUM (incl. *Phegopteris*).
- GONIOPTERIS.
- DICTYOPTERIS.
- DIPTERIS.

Aspidieae.
- ASPIDIUM (adopted for *Bathmium* Link *p. p.*, and *Podopeltis* Fée).
- CYRTOMIUM (incl. *Phanerophlebia*).
- CYCLODIUM.
- POLYSTICHUM (incl. *Cyclopeltis*).
- FADYENIA.
- SAGENIA.
- PLEOCNEMIA.
- NEPHRODIUM (veins connivent).
- LASTREA (veins free).
- OLEANDRA.
- NEPHROLEPIS.

The arrangement of Hooker ‡ is well known. *Polypodium* was retained in its Swartzian sense regardless of habit or venation and consequently contained such strange bedfellows as *Phegopteris*, *Goniopteris*, *Dictyopteris*, and *Dipteris* besides the whole array of eremobryoid species ; *Aspidium* was taken up for the centrally peltate indusiate species of whatever type of venation and habit, and *Nephrodium* was similarly taken up for those species with a cordato-reniform indusium ; in the last genus, § *Lastrea* contained the free-veined species, § *Eunephrodium*, the connivent-veined species, while the species with anastomosing veins were distributed among the sections *Sagenia* and *Pleocnemia*. *Didymochaena*, *Fadyenia*, and *Meniscium* were also maintained. As stated above, generic limitations at Kew have never represented natural genera, and yet having been popularized in such a general work as *Synopsis Filicum* they have had an influence probably wider than any other system

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* Die Farnkräuter der Erde, 1897.

† Index Filicum, lxxxi–xc. Ap. 1857.

‡ Species Filicum, 4 : 5–150. 1862. Also Synopsis Filicum, 1874.

proposed, having been followed in the arrangement of herbaria and for tentative works by minor botanists the world over as a matter of convenience.

To give a telling example of the great range of nomenclatorial changes undergone by any particular species it is only necessary to follow the type of Adanson's genus *Dryopteris* through its various vicissitudes.

POLYPODIUM FILIX-MAS L., 1753, was placed in DRYOPTERIS by Adanson 1763, Schott 1834, Asa Gray, 1848, and Otto Kuntze, 1891; in ASPIDIUM by Swartz 1801 and 1806, Link 1841, Fée 1850–1852, Mettenius 1856, D. C. Eaton 1867, and Christ 1897; in LASTREA by Bory 1824, Presl 1836, Moore 1857, and John Smith 1875; and in NEPHRODIUM by Hooker 1862 and 1874.

Nephrodium as a genus has likewise had strange vicissitudes since its establishment for a grand *mélange* of American species in 1802. In 1834 Schott took it up for the conniventy anastomosing veined species with cordato-reniform indusia in which he was followed by Presl 1836, Fée 1850–1852, Moore 1857, and John Smith 1875. Hooker 1862, also recognized this group as constituting the true *Nephrodium* type of his more comprehensive genus. In 1841 Link transferred the name to what Schott had called *Nephrolepis*. In 1852 Hooker gave the genus a wider significance so as to cover all species with cordato-reniform indusia.

In limiting *Nephrodium* to the free-veined species it will be seen that Mr. Davenport is following an entirely new lead and his statement that *Nephrodium* has been in use for nearly a century thus loses practically all of its force. In the sense in which he proposes it, it has never been used anywhere, and the attempt to bring it into use at this time is as reprehensible as it is uncalled for and irrational.

Aspidium as a genus has had a still more varied history. In 1834 Schott limited it to *Tectaria* and in this he was followed by Presl in 1836 and by Moore in 1857. John Smith in 1877 combined *Sagenia* with this giving the genus a wider range of characters. In 1841 Link limited the name to species with a cordate indusium and free veins thus making it synonymous with *Dryopteris*. In this he was followed by Fée in 1850–52. In 1862 Hooker took up the name for all forms with a peltate indusium irrespective of the venation. In 1856 Mettenius went back to the Swartzian use of the genus including in it practically everything with a superior indusium; in this he was followed by D. C. Eaton in our own country, and by Dr. Christ of Basel.

After this *résumé* of migration and shifting of generic names and limits, if there be anyone who still supposes that the application of fern names in the past seventy years is a subject in which there has been any considerable degree of unanimity among the "authorities," or who still doubts the desirability and necessity of anchoring generic names to some fixed specific type in accordance with some rational principle, he is surely too blind to read history, or too slow to be worth waiting upon longer to make up his mind.

The ferns of our own country alone, or of the North Temperate zone even, do not form a sufficient series to enable one to judge clearly or logically in regard to true generic limitations. It is necessary to consider a wider range of species for this purpose. The following genera which are represented in America appear to us worthy of being retained; it will be seen that only three of these are represented in our Northern States. Certain extra-limital genera are also included to round up the system, and these representatives of the old-world flora are printed in italics, those of the American flora appearing in small capitals. Space forbids more than the briefest characterization here as follows:—

- Veins normally free, simple, forked, or pinnately branched.
  - Indusium normally absent.
    - Sori more or less elongate. LEPTOGRAMMA J. Sm.
    - Sori round, punctiform.
      - Margins of segments plane, herbaceous. PHEGOPTERIS Fée.
      - Margins of segments widely inflexed, membranous. PLECOSORUS * Fée.
  - Indusium orbicular, centrally peltate.
    - Pinnae continuous with the rachis; texture firm, more or less coriaceous. POLYSTICHUM Roth.
    - Pinnae articulated with the rachis, easily caducous; texture thin herbaceous. CYCLOPELTIS J. Sm.
  - Indusium oval, attached by a central axis to a thickened linear receptacle. DIDYMOCHLAENA Desv.
  - Indusium cordato-reniform, attached by the sinus.

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* *Plecosorus* was established by Fée (Gen. Fil. 150. 1850–52) on *Cheilanthes speciosissimus* A. Br., which the Kew writers have retained in *Cheilanthes*.

    - Leaves simple, pedate; veins obscure. CAMPTODIUM[†] Fée.
    - Leaves compound, pinnate; veins distinct. DRYOPTERIS Adans.
- Veins pinnate, usually uniting into simple areolae especially toward the outer margin, atypically free. PHANEROPHLEBIA Presl.
- Veins connivent, *i. e.*, the branches from contiguous pinnate groups uniting to form one or more arches.
  - Indusium normally absent.
    - Sori round, punctiform. GONIOPTERIS Presl.
    - Sori elongate on the more or less parallel transverse arches. MENISCIUM Schreb.
  - Indusium cordato-reniform, attached by the sinus. CYCLOSORUS[‡] Link.
  - Indusium oblong, attached longitudinally by the center. *Mesochlaena* R. Br.
  - Indusium orbicular, centrally peltate. *Cyclodium* Presl.
- Veins forming a single row of areolae next the midrib with free included veinlets; indusia elongate-cordate; leaves simple. FADYENIA Hook. & Bauer.
- Veins copiously anastomosing.
  - Indusium normally absent.
    - Leaves bipartite, the main veins dichotomous. *Dipteris* Reinw.
    - Leaves pinnate. *Dictyopteris* Presl.
  - Indusium orbicular, centrally peltate.
    - Areolae regular, with the included veinlets straight and directed towards the margins of the segments. *Cyrtomium* Presl.
    - Areolae irregular, fine, the included veinlets often branched and recurrent. TECTARIA Cav.
  - Indusium cordato-reniform, attached by the sinus. SAGENIA Presl.

In the above synopsis we have not included a series of extra-limital genera like *Luerssenia* Kuhn and *Cheiropteris* Christ of comparatively recent foundation, nor some of the older genera like *Pleocnemia* Presl, which are likewise extra-limital. The aspidioid generic groups which in *Synopsis Filicum* are wrongly bound up in the genus *Acrostichum* may form the subject of a later paper in the present series.

COLUMBIA UNIVERSITY, 24 February 1902.

[†] *Camptodium* was established by Fée (Gen. Filicum, 298. 1850–52) based on *Aspidium pedatum* Desv., an anomalous member of the group in habit and structure found in the West Indies.

[‡] *Cyclosorus* Link, 1841, appears to be the first name correctly applied to a member of the group of species with connivent veins and cordato-reniform indusia It represents the section *Eunephrodium* of *Synopsis Filicum* which followed the error started by Schott in 1834 in making *Nephrodium* stand for a group of species that its founder never included within its limits.

Studies on Urnula and Geopyxis

By Elsie M. Kupfer

(With Plate 8)

The apparent confusion in which the genus *Urnula*, as treated by various authors seemed to stand, and the belief that an examination of the anatomical structure might lead to some conclusions as to the relationships of the various species included under this name, led the writer to the present investigation. The results reached in the paper are threefold: (1) The reëstablishment of the genus *Urnula* upon its proper footing; (2) The determination of the relationship of the genera *Geopyxis* and *Urnula;* and (3) The establishment of a new genus *Chorioactis* allied to *Plectania* in the family Pezizaceae.

The excellent work of Dr. E. J. Durand on the Pezizineae has laid down the lines which investigation in such work must take; and it was the purpose of the writer to follow as closely as was feasible Dr. Durand's plan and method. Of necessity, the study was made entirely from dried material, which, while satisfactory in most respects, left something to be desired in one or two instances. The specimens were soaked up for a day in a mixture of equal parts of glycerine, alcohol, and water, then dehydrated and embedded in paraffin. The sections 3–10 μ in thickness were taken from the center of the cup, and were stained with haemalum. The tissue drawings were outlined with a camera lucida.

The genus *Urnula* was founded by Fries in 1849* on *Peziza Craterium* Schweinitz.† Fries' description of the genus was as follows: "*Excipulum coriaceum, inflatum, inane, clausum dein ore rotundo rimose dehiscens. Discus latera interiora vestiens sporis moniliformi-seriatis intermixtis paraphysibus superficiales byssisedae.*" Although the characters noted by Fries are, naturally, mainly external, there can be no doubt as to the limitation of the genus, since Fries mentions the type on which he originated it, which since the publication of Schweinitz' figure has been well known.

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* Summa Veg. Scand. **2:** 122.

† Syn. Fung. Car. sup. 9. *pl. 1. f. 7–11.*

During the next forty years three additional species were placed in the genus—*U. minor* Fries, 1855, from Guinea, *U. Hartii* Berk. from Greenland and *U. Microcrater* (Hazs.), from Hungary. As no material representing these species was available they are left out of consideration in the present article.

In 1889 Saccardo compiled descriptions of the existing species and added as a fifth, *U. terrestris* (*Podophacidium terrestre* Niessl). Saccardo's description of the genus was broad enough to include all five species.*

Rehm in his "Discomycetes" 1896 † perceiving a lack of relationship among the species of Saccardo, did what must be considered an utterly unwarranted step. Taking away from *Urnula* the type *Urnula Craterium* on which Fries had founded the genus, he reserved the generic name for the single species, *U. terrestris*, apparently unrelated to the former fungus; so that Rehm has a genus *Urnula* consisting of a single species which has no resemblance to the type of Fries, and which accords in but a very general way with the Friesian description. *Urnula Craterium* he transfers to *Geopyxis*. It may be mentioned here parenthetically, that Lindau's treatment in Engler-Prantl ‡ need not be specially considered as he has adopted almost entirely Rehm's views and classification.

A letter to Dr. Rehm asking the reason for his transfer received a somewhat unsatisfactory reply. He answered that *Urnula Craterium* was placed with its *related species* under *Geopyxis*, because *Geopyxis* was established by Persoon before *Urnula* by Fries; and that in order to retain the genus *Urnula*, under which Saccardo had placed *Podophacidium terrestre* of Niessl, he (Rehm) restricted the genus to this latter fungus. The two most essential points, however, were not answered. Why *Urnula Craterium* should be regarded as allied to *Geopyxis*, or why, except that Saccardo had placed it there, *Podophacidium terrestre* should be considered an *Urnula* are points left unexplained. On this latter point, indeed, Rehm has now serious doubts as will appear later; so that his present opinion seems to be that the genus *Urnula* must disappear entirely.

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* Sylloge Fungorum, **8**: 548 *seq.*

† Rabenhorst, Krypt. Flora, **1**: 971.

‡ Die natürlichen Pflanzenfamilien, **1**: 172–242, 253.

The genus *Geopyxis* was, as Rehm says, originated before *Urnula*. Persoon established it as a subgenus of *Peziza* about 1822.* As I understand his arrangement (which is somewhat obscure owing to errors in the synopsis), Persoon included forty-three species under the group *Geopyxis*. Of these, five, *G. carbonaria*, *G. micropus*, *G. bufonia*, *G. Catinus* and *G. verrucosa* still remain in the genus as described by Rehm. A comparison, then, of one of these forms with *Urnula Craterium* should show in how far the latter is allied to *Geopyxis* and by what right Rehm has placed Schweinitz' plant in this genus. For the purpose of this comparison *G. carbonaria* was chosen.

We have then to consider, by a study of external structure and internal anatomy, the relationships of these various fungi, *Gropyxis carbonaria*, *Urnula Craterium*, and *Urnula terrestris*. One other will come up for consideration. In 1891 Professor Underwood discovered a new fungus in Austin, Texas, which was sent to Professor Peck for identification. Peck described this in the forty-sixth report of the state botanist as *Urnula Geaster*. A doubt suggested by Professor Underwood as to the correctness of this generic reference was the direct occasion of this study, which was carried on under his guidance.

1. *Geopyxis carbonaria* (Alb. & Schw.) † is a small, fleshy fungus yellowish in color, and, at the most, 2 cm. in diameter. It is short-stalked, the stalks being 1–1.5 mm. long and 1–2 mm. wide. It is well figured in Cooke's Mycographia *pl. 74, f. 284*. An examination of the internal anatomy of *G. carbonaria* (*pl. 8, f. 1*) shows it to be a true member of the Pezizaceae and of *Geopyxis* according to Durand. The excipulum is entirely pseudoparenchymatous, the asci form a uniform layer, the stem is short and externally even—all of which points correspond to Durand's synopsis of this family and genus. In this *Geopyxis* the hypothecium is not particularly differentiated from the excipulum except by the smaller size of the cells. At the limiting border of the excipulum there are thicker walled cells, slightly darker in color. The cells of the excipulum average 14 μ in diameter; those of the hypothecium, 9 μ. The asci are about 170 μ long and 7–8 μ wide. The spores are 10–11 μ long and 3–4 μ wide.

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* Mycol. Europaea, 1: 224–242.

† Conspectus Fungorum in Lusatiae sup. 314. *pl. 5. f. 2.* 1805.

2. *Urnula Craterium* (Schw.) Fr. (*Geopyxis Craterium* Rehm.) This is a large leathery fungus 3–7.5 cm. wide, often over 7 cm. high, with a stalk 5 cm. long and sometimes 2 cm. broad. Even externally the fungus does not closely answer Rehm's own description of the genus *Geopyxis* under which he places it; the texture of the apothecium is described as fleshy, the stem, as short and sometimes thin; while in this plant, the leathery character of the cup and the length and thickness of the stem are its noticeable features; one of its most characteristic points is the dense black tomentum which serves as a hypothallus. The hypothallus in *G. carbonaria*, on the other hand, is very inconspicuous. The difference in the size of the asci and spores is also a point worthy of mention in the contrast between the two forms; the asci in *U. Craterium* are 430 μ long and 12 μ wide; the spores, 25–30 μ long and 8 μ wide. The asci in this fungus then are more than twice as long and the spores nearly three times as large as in the *Geopyxis*. But ignoring these facts, a comparison of the internal anatomy of the two forms will, I think, dispel all illusions as to their relationship. In *fig. 2* is represented a cross section of *U. Craterium*. The excipulum is seen to be divided into two distinct layers. At the outside, next to the limiting membrane, there are a few rows of rather regular polygonal cells; but the great mass of the excipulum and hypothecium is prosenchymatous, *i. e.*, made up of long non-septate interwoven hyphae giving an exceedingly fibrous appearance to the whole tissue. The hypothecium is differentiated from the medullary portion of the excipulum by the closer mesh and smaller diameter of the hyphae of which it is composed. It is about one fourth the width of the whole sterile part.

Urnula Craterium, then, belongs to a totally different genus from *Geopyxis carbonaria* and must be restored as the type of the genus *Urnula* as Fries founded it. Indeed there are very strong reasons, as will be seen shortly, for placing it in an entirely distinct family from *Geopyxis*, so that the inclusion of the two fungi under the same genus appears almost absurd.

3. *Urnula terrestris* (Niessl) * Sacc. This is a small rather leathery fungus 2–3 mm. in diameter with a very short stalk. Copies

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* Verh. Naturf. Ver. Brünn, 10: 63. 1872.

of Niessl's figures are given in Rehm, *l. c.* 990. The asci are about 124 μ long and 6 μ wide; the spores, 11–12 μ long and 4–5 μ wide. The cross section of *Urnula terrestris* (*fig. 3*) shows that here again there is no relation whatever with *Urnula Craterium;* the tissue is entirley pseudoparenchymatous, the excipulum being composed of two layers. The few outer rows are composed of cells about 11 μ in diameter with thick brown walls. The rest of the tissue is undifferentiated, so that we may call it excipulum with no marked hypothecium, or all hypothecium, restricting the term excipulum to these few rows of cells on the outside. Whatever we may call it, its character definitely separates it from a structure such as is found in *Urnula Craterium.* An additional fact pointing to the separation of the two species is one to which both Rehm and Lindau attach great importance in classification. Iodine colors the ascopores of *U. terrestris* blue, but does not those of *U. Craterium.*

Urnula terrestris as defined by Saccardo then, is not an *Urnula.* Niessl, in 1872, named the fungus *Podophacidium terrestre,* so that this old generic name, at least, we must restore. A point of interest, however, arises with regard to its specific name. In 1885 Boudier* established a genus *Melachroia* on *Peziza xanthomela* Pers. Schröter was the first to suspect the identity of the two fungi and called them *Podophacidium xanthomelan.* Rehm in his classification separates them, because the apothecium in *Urnula terrestris* splits into lobes, while in *Melachroia xanthomela* it remains nearly entire. In the letter before mentioned, however, Dr. Rehm says that he has no longer the least doubt that the two fungi are one and the same thing, and that the condition of the margin of the apothecium in *Urnula terrestris* is due merely to local conditions of growth. This view is substantiated by a comparison of the anatomy of the two forms. Dr. Rehm kindly sent specimens of both fungi which were sectioned as described above. The representation of *Urnula terrestris* (*fig. 3*) would do equally well for *Melachroia xanthomela;* the only difference revealed by the closest investigation was that the outer excipular portion was slightly thicker in the former fungus. This, however, may be regarded as purely accidental and of no significance. Consequently

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* Bull. Soc. Myc. 1: 112.

we must adopt Schröter's nomenclature, and consider both *Urnula terrestris* and *Melachroia xanthomela* under the name of *Podophacidium xanthomelan.*

Since, then, the internal structure is very different from *Urnula Craterium*, and the splitting of the margin into lobes, which was Saccardo's chief reason for regarding this species as an *Urnula*, is an uncertain character, any relation between the two genera is seen to be absolutely unreal. To quote Dr. Rehm: "Dann schwindet allerdings die Verwandschaft mit *Urnula* Fr. völlig, und ist den zusammengehörigen beiden Pilzen eine andere systematische Stellung zu geben."

It might be well at this point, before the consideration of the next species, to decide what systematic position is to be assigned to the two species *Urnula Craterium* and *Podophacidium xanthomelan.* From the character of its tissue, the latter seems to belong in the Pezizaceae. Owing to the fact that the ascopore turns blue with iodine, and that the fungus is stalked, its affinities seem to be with *Tarzetta* and *Plicaria* in this family.

As to *Urnula Craterium*, it is my belief that it is to be placed among Saccardo's Dermateae or in the family Cenangiaceae following Lindau; the leathery texture of the apothecium, the prosenchymatous tissue and well developed hypothecium indicate this as its proper position. Whether or not a definite epithecium is present, as in most of the members of this family, could not be decided from sections of the dried specimens. The paraphyses do not seem to endure drying well, and were difficult to make out; so that these are represented (*fig. 2*) as somewhat reconstructed, and very probably do not quite accurately reproduce the condition in the fresh specimen. Even if an epithecium should prove absent, however, the Cenangiaceae appear to me to be the most satisfactory position, and, indeed, the only place for the fungus.

4. **Chorioactis Geaster.** (*Urnula Geaster* Peck.)* Finally we come to the species which was called by Peck *Urnula Geaster*, and which, since it is not an *Urnula*, I propose to call *Chorioactis.* This is a very large leathery fungus from 4–7 cm. in diameter, narrowed to a stem about 3 cm. long and 1–1.5 cm. thick. The apothecium splits into 4–6 rays, giving the plant an appearance

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* Reg. Rep. **46**: 39. 1893.

very similar to a *Geaster*, so that Peck's specific name is an appropriate one. Both disc and stem are covered on the outside with a dense tomentum of soft brown hairs. The thickness of the apothecium is a striking characteristic; it sometimes reaches 2.5 mm. The outer layer of the apothecium is dark brown, the hymenium and flesh yellowish white; the asci are very large, 670 μ long; the spores are 49–60 μ long by 12–16 μ wide. The *Geaster*-like appearance of this fungus, the tough, leathery texture, the thickness of the disc, and the velvety tomentum which clothes the whole surface make of it an exceptionally characteristic and easily distinguishable genus and species. That it is not an *Urnula* seems to me just as evident from its external appearance as from an examination of its tissues. A comparison of internal characters shows, however, that there is no possible relation with *Urnula Craterium*. The tissue is made up wholly of large parenchymatous cells; those of the excipulum averaging 34 μ in diameter, those of the hypothecium 10–14 μ. The relative size of the cross sections of the various forms discussed can be seen from the fact that the sections of *Chorioactis Geaster* are magnified only thirty-five times, while all the others were magnified about two hundred times.

As to the position of *Chorioactis*, its entirely parenchymatous tissue will at once place it among the Pezizaceae. Following out Durand's scheme, its stipitate character, the tomentum and its elliptical spores indicate a relationship with *Plectania* and *Sarcoscypha* in this family. The genus *Chorioactis* will probably prove the most leathery in the whole family, but a comparison with *Sarcoscypha* and *Otidea* in this respect shows that among the Pezizaceae are to be included all gradations from a most fleshy brittle character, as in the majority of pezizaceous forms, to a texture as tough and leathery as that in the Cenangiaceae and other families.

To sum up briefly, then, the points brought out in this paper:

1. *Urnula Craterium* Fr. represents an entirely distinct genus not in any way related to *Geopyxis*. It is very probably to be placed in the family Cenangiaceae while *Geopyxis* is a member of the Pezizaceae.

2. *Urnula terrestris* (Niessl) Sacc. is not at all allied to *U. Craterium* and must consequently be removed from this genus. It is iden-

tical with *Melachroia xanthomela* Boud. and, following Schröter, must be called *Podophacidium xanthomelan.* Its position appears to be near *Tarzetta* in the Pezizaceae.

3. *Urnula Geaster* Peck forms a new genus, *Chorioactis,* distinct from *Urnula* and from all the other genera mentioned in this article. **Chorioactis Geaster** (Peck) seems to belong near *Plectania* and *Sarcoscypha* in the Pezizaceae.

Explanation of Plate 8

The illustrations were drawn from a magnification about two and one half times the reproduction appearing in the plate.

FIG. 1. Cross section of *Geopyxis carbonaria*, × 200.

FIG. 2. Cross section of *Urnula Craterium*, × 200..

FIG. 3. Cross section of *Podophacidium xanthomelan*, × 200.

FIG. 4. Cross section of *Chorioactis Geaster*, × 35.

Studies on the Rocky Mountain Flora—VII

By Per Axel Rydberg

Aquilegia Columbiana

Perennial with a short thick rootstock: stem 6–10 dm. high, glabrous or sparingly and finely pubescent above; basal leaves twice ternate; petioles 1–2 dm. long; segments rounded, obovate, 2–3 cm. long, more or less glaucous beneath, 2–3-cleft and deeply crenate at the apex; lower stem-leaves similar to the basal leaves, but with short winged petioles, the upper similar but often with larger segments: sepals and spurs very bright red; laminae yellowish: sepals ovate-lanceolate, acute, 15–25 mm. long, exceeding the spur, widely spreading or reflexed: lamina very short, scarcely 3 mm. long, truncate; spur 12–18 mm. long, thick, abruptly contracted about the middle: follicles erect, densely pubescent; styles about 12 mm. long.

This species is somewhat intermediate between *A. formosa* and *A. truncata* and has been mistaken for both. It has the habit, the spur and sepals of the former and the short truncate lamina of the latter.

Washington: Montesano, 1898, *A. A. & E. Gertrude Heller, 3936* (type in herb. N. Y. Bot. Garden); upper valley of the Nesqually, 1896, *O. D. Allen, 249;* 1889, *G. R. Vasey, 150;* Humptulips, 1895, *F. H. Lamb, 1180;* Puget Sound, *Wilkes Exped., 646.*

British Columbia: Banff, 1897, *Zoe W. Palmer.*

Alaska: Short Bay, 1895, *Gorman, 105;* Disenchantment Bay, *1892, F. Funston, 121.*

Idaho: Florida Mt., 1892, *A. Isabel Mulford.*

Aquilegia thalictrifolia

Perennial with a short rootstock: basal leaves twice ternate; petioles 1–2 dm. long; segments broadly obovate-cuneate, 2–3-cleft and crenate at the apex, 1–1.5 cm. long, bluish-green: stem 2–5 dm. high, glabrous below, finely viscid puberulent above: stem-leaves subsessile or very short-petioled, otherwise similar to the basal ones: flowers yellow: sepals 10–18 mm. long, ovate to ovate-lanceolate, acute: laminae of the petals 7–12 mm. long, truncate or rarely rounded at the apex; spur very slender from the base, 4–5 cm. long : follicles without the styles, about 3 cm. long and 5 mm. wide, strongly reticulate and pubescent, strongly curved above.

This species is nearest related to *A. chrysantha* with which it has been confused, but differs in the smaller flowers, blunter sepals, smaller and bluer segments of the leaves and the more curved follicles. It grows at an altitude of 1500–3000 m.

COLORADO : Cañon City, 1873, *E. L. Greene* (type in herb. Columbia University) ; Colorado Springs, 1893, *De Alton Saunders ;* Grand Cañon of the Arkansas, 1873, *Brandegee ;* Bear Creek Cañon, 1892, *C. S. Sheldon.*

TEXAS : West Texas, 1888, *Nealley.*

ARIZONA : Mt. Humphrey, 1897, *R. E. Kunze.*

Aquilegia Eastwoodiae

Aquilegia ecalcarata Eastwood, Zoe, 2 : 226. 1891. Not Hortul. ; Steudel. 1841.

This has been regarded as a spurless form of *A. micrantha* Eastw., but the form of the terminal segments of the leaves is different from any American species, being rhombic in outline and acute.

Aquilegia oreophila

Aquilegia coerulea alpina A. Nelson, First Rep. Fl. Wyo. 78. 1896. Not *A. alpina* L. 1853 ; *Aquilegia coerulea* var. *flavescens* Jones, Cont. West. Bot. **8** : 2. 1898. Not *A. flavescens* Wats. 1871.

This is evidently what Jones regards as *A. flavescens* Wats., but is not Watson's species, for he describes the spur as being curved. Specimens of both numbers cited by Watson, viz. *35* and *36*, are in the Columbia University herbarium and these as well as the plant cultivated under the name *A. flavescens* at Harvard have curved spurs and can not be referred as a variety to *A. coerulea.* Therefore, I can not see why Mr. Jones' *A. depauperata* should not pass into synonomy, being the same as the true *A. flavescens.* The flowers of *A. oreophila* resemble most those of *A. pubescens* Coville, but the habit is different and nearer *A. coerulea.*

Delphinium alpestre

A low cespitose perennial : stems several, about 1 dm. high, puberulent and viscid above, densely leafy ; leaves digitately divided into about 5 divisions, finely and sparingly puberulent when young, dark green ; petioles 4–5 cm. long ; divisions of the blades 1.5–2 cm. long, cuneate-obovate in outline, divided half-way into oblong mucronate lobes : inflorescence short and few-flowered ; pedicels ascending, 1 cm. or less long, viscid ; bractlets minute : sepals dark blue, oblong, obtuse or the upper acute, viscid-puberulent ; spur 8–9 mm. long : upper petals blue and yellowish, 2-toothed at the apex ; lateral petals 2-cleft ; lobes lanceolate : follicles not seen.

This is not closely related to any of the American species. It has the cespitose habit of *D. glaucescens*, but is a much smaller plant. It grows among rocks at an altitude of 3300 m. or more.

COLORADO : Mountains northwest of Como, 1895, *Crandall & Cowen, 1848* (type in herb. State Agric. Coll., Colo.) ; West Spanish Peak, 1900, *Rydberg & Vreeland, 6218*.

Delphinium multiflorum

A tall perennial with a woody caudex ; stem about 1 mm. high or more, viscid above, glabrate below : leaves palmately divided into 5–7 divisions, glabrous and glaucous, pubescent only on the margins and veins ; petioles 1–2 dm. long, slightly dilated at the base ; segments obovate-cuneate in outline, 5–7 cm. long, first cleft about half-way and then again cleft into lanceolate, ovate or oblong acute lobes : inflorescence long and dense, often branched ; bracts linear ; pedicels ascending, 1–1.5 cm. long, densely viscid-pubescent : bractlets small, linear, close under the calyx : sepals light blue with darker median lines or blotches towards the tips, oblong-oval, obtuse or the upper acutish, finely puberulent ; spur thick, straight or slightly curved, 12–15 mm. long, almost horizontal : petals of the same color as the sepals ; the lateral ones cleft only at the apex, often wavy-toothed : follicles erect, densely viscid-pubescent.

This is nearest related to *D. cuculatum* A. Nelson on one hand and to *D. occidentale* on the other. From the former it differs in the pubescence, which in *D. cuculatum* is strigose, in *D. multiflorum* viscid. *D. occidentale* has much darker flowers and more acute sepals. *D. multiflorum* grows along streams and in damp meadows or open woods at an altitude of 2000–2500 m.

WYOMING : Spread Creek, 1897, *F. Tweedy, 179* (type in herb. N. Y. Bot. Gard.) ; Yellowstone Lake, 1888, *R. S. Williams ;* Laramie Mountains, 1899, *Charles Schuchut ;* between Upper

Buffalo Fork and Du Noir River, 1899, *C. C. Curtis;* Snake River, 1899, *Aven & Elias Nelson, 6407.*

IDAHO: Henry's Lake, 1897, *Rydberg & Bessey, 4079.*

COLORADO: North Park, 1896, *C. F. Baker.*

Delphinium Brownii

Perennial: stem about 1 m. high, glabrous and shining throughout, simple: leaves palmately divided into about 5 divisions, puberulent; lower petioles 8–10 cm. long; divisions 4–6 cm. long, oblanceolate in outline, once to twice cleft into lanceolate, acute, somewhat spreading lobes: inflorescence a rather lax raceme; bracts linear; pedicels slender, 1–2 cm. long, almost erect, curved and twisted; upper portion sometimes slightly puberulent; bractlets linear-subulate, small, 3–4 mm. long: sepals dark blue or purple, oblong-oval, obtuse or the lower and upper acutish, 10–12 mm. long: lateral petals also blue or purplish; blade cleft only about one third its length; upper petals of the same color or paler, obliquely cuneate, acute; spur short and rather thick, 1 cm. or less long, straight and ascending: follicles erect, glabrous.

This is nearest related to *D. glaucum*, but differs in the puberulent leaves with narrower segments, the lax raceme with more erect pedicels and the darker flowers.

ALBERTA: Banff, 1893, *Addison Brown* (type in herb. Columbia University).

ALASKA: Porcupine River, 1891, *J. H. Turner.*

Delphinium elongatum

Tall perennial with a short woody caudex: stem glabrous and glaucous up to the inflorescence, which is slightly strigose: leaves digitately divided into about 7 divisions, glabrous and glaucous beneath; petioles fully 1 dm. long; divisions of the blade oblanceolate in outline, 5–7 cm. long, cleft into lanceolate, acute lobes: inflorescence strict and elongated; bracts small, linear, almost filiform; pedicels 1–2 cm. long, at first ascending, in fruit almost erect; bractlets minute, subulate: sepals and petals dark blue, the former oval, obtuse or acutish, about 1 cm. long; spur short, straight, about 12 mm. long: lateral petals cleft at the apex, more or less toothed: follicles erect, 12–15 mm. long, strigose-puberulent.

In some respects nearest to *D. glaucum,* but differing in the puberulent pod, strigose pubescence at least on the pedicels, and the narrower divisions and lobes of the leaves. It grows at an altitude of about 2000 m.

COLORADO: Larimer county, 1895, *Crandall & Cowen, 15* (type in herb. N. Y. Bot. Garden); Villa Grove, 1896, *F. Clements, 338;* Middle Park, 1861, *C. C. Parry, 85;* Baxton's Ranch, 1890, *Crandall, 1547*.

MONTANA: Lima, 1895, *Rydberg*.

Delphinium diversicolor

Perennial with a thick fleshy root, the branches of which are often fusiform: stem about 4 dm. high, simple, strict, densely viscid-pubescent above: leaves finely pubescent, palmately dissected into linear lobes; petioles of the lower leaves 3–5 cm. long, slightly dilated below; segments 1–3 cm. long, about 2 mm. wide: inflorescence a narrow raceme; pedicels .5–1 cm. long, or in fruit 1.5 cm., densely viscid, almost erect: sepals dark blue, oblong-oval, obtuse, 10–13 mm. long, slightly pubescent; spur almost straight, horizontal: petals all white with blue veins and yellowish below; the upper about 5 mm. long, obliquely spatulate, obtuse; the lateral ones slightly longer, curved; the blades deeply 2-cleft; each lobe of the form of one third of a circle: follicles densely hairy.

This species is perhaps nearest related to *D. simplex* and *D. Burkei.* From the former, it differs in white lateral petals and the pubescent leaves, and the latter is described as subscapose. The type was collected in a bog, at an altitude of 2000 m.

MONTANA: Rattlesnake Creek, Beaver Head county, 1887, *Frank Tweedy, 34* (type in herb. Columbia University).

Aconitum tenue

Perennial with small tubers about 8 mm. long and 4 mm. thick: stem very slender, about 3 dm. high: leaves few; the lower with petioles 5–8 cm. long, the uppermost subsessile: blades glabrous, thin, shining, almost pentagonal in outline, 5–7-divided to near the base; divisions rhombic in outline, 3-cleft and the lobes often again cleft, the ultimate divisions oblong-linear to linear-lanceolate, acute: inflorescence racemose, 2–6-flowered: pedicels erect and bent near the glabrous blue calyx: hood 15–18 mm. long, boat-shaped, slightly saccate, almost semicircular in outline; lateral sepals rounded ovate, only slightly oblique, 10–12 mm. long; lower sepals oblong, obtuse at the apex, 8–10 mm. long: fruit unknown.

The type was collected in a damp cañon among rocks at an altitude of about 2000 m. It is perhaps nearest related to the Alaskan *A. delphinifolium*.

SOUTH DAKOTA: Sylvan Lake, Black Hills, 1892, *P. A. Rydberg, 507* (type in herb. Columbia University).

✓ **Aconitum atrocyaneum**

Perennial with thickened-fusiform roots: stem stout, 4–6 dm. high, leafy, glabrous below, densely glandular viscid and purplish above: lower leaves with petioles 5–10 cm. long; blades about 6 cm. wide, glabrous, pentagonal in outline, 5–7-divided to near the base; divisions rhombic-cuneate to oblanceolate, usually twice cleft; ultimate segments lanceolate acute; upper stem-leaves similar but with short petioles or those of the inflorescence lanceolate, toothed and often with recurved basal lobes: inflorescence racemose, many-flowered, leafy: pedicels 1–3 cm. long, erect, very viscid: flowers dark indigo blue, more or less pubescent: hood deeply saccate, helmet-shaped, about 18 mm. long, with the front line more or less concave: beak somewhat porrect, acuminate, the lower margins nearlyhorizontal: lateral sepals broadly rounded-ovate, somewhat oblique, 12–15 mm. long: lower sepals 9–12 mm. long, oblong, obtuse.

This species is perhaps closest related to *A. ramosum* A. Nelson, but the divisions of the leaves are broader and the hoods are different, having a porrect beak, while in *A. ramosum* the beak is short and directed downward. The flowers are also darker and the inflorescence more viscid. It grows at an attitude of 2,500–3,400 m.

COLORADO: Boreas, 1897, *C. S. Crandall* (type in herb. N. Y. Bot. Garden; cotypes in herb. State Agric. College, Colo.); mountains about Steamboat Springs, 1891, *C. S. Crandall;* near Ironton, 1899, *C. C. Curtis;* Cameron Pass, 1896, *C. F. Baker.*

UTAH: Uinta Mountains, 1873, *T. C. Porter.*

✓ **Aconitum porrectum**

Perennial with thick fusiform roots: stem stout, 6–7 dm. high, leafy, glabrous below, densely viscid-pubescent above; basal leaves glabrous, with petioles about 1 dm. long; blades reniform-pentagonal in outline, 6–10 cm. wide, 5–7-divided to near the base; divisions rhombic or rhombic-oblanceolate, variously cleft above, cuneate at the base: inflorescence racemose or somewhat paniculate, not leafy; pedicels ascending, 1–3 cm. long: sepals dark blue, ciliate on the margins; hood very saccate, helmet-shaped; beak acuminate, porrect, horizontal or even slightly ascending, 15–18 mm. long; lateral sepals broadly obovate or semi-reniform, about 12–14 mm. long, very oblique; lower sepals lanceolate or oblong, acute, 7–10 mm. long.

This is closely related to the preceding, but differs in the broader and less deeply divided divisions of the leaves, the shorter lower sepals, the more open and less leafy inflorescence, and the more oblique lateral sepals. It grows at an altitude of 2400–2800 m.

COLORADO: Coffee Pot Spring, 1894, *Crandall* (type in herb. N. Y. Bot. Garden; cotypes in herb. State Agric. College, Colo.); Graymount, 1892, *Crandall;* foothills, Larimer county, 1895, *Crandall & Cowen;* Arapahoe Pass, 1891, *Crandall, 26;* Lake City, 1881, *J. S. Newberry;* North Park, near Teller, 1884, *C. S. Sheldon.*

Aconitum glaberrimum

Perennial with a tap root: stem almost 1 m. high, perfectly glabrous: leaves 5-divided, thin, perfectly glabrous, the lower long-petioled; the uppermost subsessile; divisions oblanceolate to rhombic-oblanceolate in outline, 5–10 cm. long, cuneate and entire at the base, irregularly doubly cleft above; lobes or teeth lanceolate, acute or acuminate: inflorescence compound; branches and pedicels spreading or divergent, glabrous: flowers blue: lower sepals lanceolate, 12–15 mm. long; lateral ones very oblique, as broad as long, about 15 mm. each way, rounded, slightly reniform on the upper side; hood about 2 cm. long, deeply saccate, elongated helmet-shaped; beak long-attenuate, very porrect or even ascending.

The type specimen was included in *A. Columbianum* by Dr. Gray, his "Syn. Fl. N. Amer." label being on the sheet; but it is so unlike all other material of that species that I can not see the reason why it should be included therein. The perfectly glabrous stem, the branched inflorescence, the peculiar, deeply saccate hood and the slender porrect beak are characters not found in any other American aconite.

SOUTHERN UTAH, NORTHERN ARIZONA: 1877, *Dr. E. Palmer, 11* (type in herb. Columbia University).

Anemone tuberosa

Anemone sphenophylla Britton, Ann. N. Y. Acad. **6**: 224, in part. Not Poepp. 1827–29.

Perennial with a thick tuberous root, basal leaves with petioles about 5 cm. long, twice ternate; divisions rhombic-cuneate in outline, ternately cleft and toothed; teeth oblong-ovate: scape 1–3 dm. high, perfectly glabrous below the involucre; peduncles finely appressed silky; involucral leaves similar to the basal ones, but short-petioled and with longer lobes and teeth; peduncle solitary or a second one with a smaller involucre: sepals white or purplish, 8–10, oblong-linear, 1–2 cm. long, finely silky: head of fruit ellipsoid, about 1 cm. thick and 2 cm. long: achenes densely woolly: style filiform, about 1.5 mm. long.

This is closely related to *A. sphenophylla* of Chili, but in that species the whole scape is decidedly pubescent with spreading hairs and the segments of the involucral leaves are narrower. The following species belong here:

ARIZONA: Sierra Tuscon, 1884, *C. G. Pringle* (type in herb. Columbia University); Fort Huachuca, 1892, *S. E. Wilcox.*

NEW MEXICO: Mountain near Las Cruces, 1895, *E. O. Wooton.*

UTAH: St. George, 1880, *M. E. Jones, 1607.*

CALIFORNIA: Panamint Mountains, 1891, *Coville & Funston, 500;* 1849 (locality not given), *Fremont.*

✓ Anemone lithophila

Perennial with a short thick rootstock: basal leaves several, glabrous or nearly so, thickish, shining, somewhat glaucous; petioles 5–8 cm. long; blades ternate; divisions obovate-cuneate, about 3 cm. long, strongly veined, deeply 3-cleft, again cleft and toothed; the ultimate segments short, oblong-oblanceolate: scape 1–2 dm. high, sparingly pubescent with long silky hairs: involucral leaves subsessile or short-petioled; divisions similar to those of the basal leaves: sepals silky, ochroleucous, tinged with blue, 12–15 mm. long, broadly obovate or oval: achenes densely villous all over: style filiform, about 2 mm. long.

The type was growing with *A. parviflora* at an altitude of 1800 m. As none of the specimens there had well-developed fruit and the plant is intermediate between *A. parviflora* and *A. globosa* Nutt., which also grew in the neighborhood, this species may be a hybrid. The strong veins and shiny glaucous leaves suggest the former but the general leaf-form the latter, although the segments are broader and shorter and the leaves more glabrate. Watson's specimen, which resembles the type perfectly has fully developed fruit, however. The type was labelled *A. Tetonensis,* which it resembles most in habit; but the achenes are wooly all over, not merely strigose on the back as in that species and the flowers are larger and lighter. The following specimens are to be referred here:

MONTANA: Little Belt Mountains, nine miles from Barker, 1896, *J. H. Flodman, 459* (type in herb. N. Y. Bot. Garden), and *463;* Lake Stanton, 1894, *R. S. Williams.*

UTAH: Uinta Mts., 1869, *S. Watson, 10.*

Anemone Piperi Britton

Perennial with a rather slender rootstock: stem 1.5–3 dm. high, slender, very sparingly appressed silky; basal leaves ternate, minutely appressed-puberulent when young, in age glabrous; petioles 1–2 dm. long; middle lobe rhombic-obovate or rhombic-cuneate, coarsely toothed above the middle, 2–7 cm. long; the lateral ones broader, obliquely ovate, 2-cleft to about the middle, coarsely toothed: involucral leaves similar, but the lobes usually narrower: petioles 1–3 mm. long: pedicel 2–5 cm. long, erect in fruit, sparingly appressed silky: sepals elliptic-obovate to oval, about 15 mm. long, 6–8 mm. wide, white, glabrous: achenes about 4 mm. long, densely short-pubescent, ellipsoid, slightly compressed, tapering to both ends: beak very short.

This has been included in *A. quinquefolia* and all specimens cited for that species from the Northwest may belong here. It differs, however, from that species in the form of the basal leaves, the erect pedicels and the short, almost straight beaks of the achenes.

IDAHO: Latah county, 1893, *C. V. Piper, 1469* (type in herb. Columbia University); Craig Mountain, 1892, *Sandberg, MacDougal & Heller, 194.*

WASHINGTON: Kamiac Butte, 1896, *A. D. E. Elmer, 393.*

Clematis Jonesii (Kuntze)

Clematis Douglasii var. *Jonesii* Kuntze, Verh. Bot. Ver. Brandenburg, **26**: 180. 1886.

Perennial with a thick rootstock or caudex: stems 3–6 dm. high, simple or later in the season branched, more or less woolly when young: leaves twice pinnately divided, 1–1.5 dm. long, villous when young, in age glabrate, rather firm, segments lanceolate to linear-lanceolate, often cleft, 1–5 cm. long, acutish: flowers nodding : calyx campanulate, brown, more or less villous, especially near the margins ; sepals 2–2.5 cm. long, ovate, acute or acuminate, upper half with a wavy dilated margin : achenes about 5 mm. long and 4 mm. wide, flattish, densely silky ; tails of the achenes 4–5 cm. long, beautifully plumose throughout.

This is nearest related to *C. Douglasii*, with which it has been confused. It differs from that species in the dilated margins of the sepals, the distinctly petioled and less compound leaves. In the true *C. Douglasii* the upper and middle leaves are twice pinnately divided and subsessile, so that they with the first pair of primary divisions look as if verticillate. Kuntze's description of *C. Douglasii* var. *Jonesii* is so meager that nobody could know from it what he meant, but fortunately we have one of Jones' specimens. The following specimens belong to *C. Jonesii.*

COLORADO : Howe's Gulch, 1899, *W. F. M.;* Dolores (7300 ft.), 1892, *Crandall ;* lat. 39°–41°, 1862, *Hall & Harbour, 2 ;* Howe's Gulch, 1893, *C. F. Baker ;* near Boulder, 1892, *H. M. Patterson, 168 ;* Dixon Cañon, 1891, *J. H. Cowen, 368.*

UTAH : Uinta Mountains, 1869, *S. Watson, 1 ;* American Fork, 1880, *M. E. Jones, 1351.*

WYOMING : Headwater of Tongue River, Big Horn Mountains, 1898, *Frank Tweedy, 171.*

Clematis eriophora

Perennial, from a woody caudex : stems and leaves prominently white-villous, the former 3–5 dm. high, simple : leaves 5–10 cm. long, distinctly petioled, twice pinnately divided ; ultimate segments narrowly linear, 1–3 cm. long, 1–2 mm. wide : flowers nodding ; calyx villous, campanulate, about 3 cm. long ; sepals oblong, obtuse, the upper third spreading, with a dilated margin : achenes oblong, about 6 mm. long and 3 mm. wide, silky, with a blunt ridge on each side ; tails about 4 cm., beautifully plumose.

This is closely related to the preceding and to *C. Bakeri*, but differs from the former in the narrower leaf-segments, the obtuse and thicker sepals and the denser and more persistent pubescence, and from the latter in the longer leaf segments and the obtuse dilated sepals. It grows at an altitude of 1500–2000 m.

COLORADO : Vicinity of Horsetooth, 1896, *J. H. Cowen* (type in herb. N. Y. Bot. Garden ; cotypes in herb. State Agric. College, Colo.); Foothills, Larimer county, 1893, *C. S. Crandall ;* Colorado, 1870, Dr. *G. W. Hulse;* 1844, *Fremont, 567;* Pagosa, 1883, *Brandegee;* Golden City, 1871, *E. L. Greene;* Clear Creek, 1873, *John Wolf, 92;* Colorado Springs, 1900, *Rydberg & Vreeland, 6232;* Rist Cañon, 1890, *Crandall, 272;* 1893, *1379;* Horsetooth Gulch, 1898, *Crandall.*

CLEMATIS WYETHII Nutt. Journ. Acad. Phila. **7**: 6 1834

I think that this species is distinct from *C. Douglasii* Hook., the leaves being never twice pinnately divided, having much broader segments and never being falsely verticillate as in that species. The specimens from Beaver Cañon, Idaho, cited in the synoptical flora under *C. Douglasii* var. *Scottii* and in Howell's flora of the Northwest under *C. Scottii* belongs undoubtedly here. A broad-leaved *C. Wyethii* and a narrow-leaved *C. Scottii* resemble each other very much and can be distinguished only by the flower, which in the former is campanulate with oblong-lanceolate sepals and in the latter rounded urn-shaped with broadly ovate sepals. *C. Wyethii* is common in Montana and northern Idaho. It is represented by the specimens cited under *C. Scottii* and some under *C. Douglasii* in my catalogue of the flora of Montana.

ATRAGENE OCCIDENTALIS Homem. Hort. Hafn. 1813 : 520

Atragene Columbiana Nutt. Journ. Acad. **7** : 7. 1834 ; *Clematis Columbiana* Torr. & Gray, Fl. N. Am. **1** : 10. 1838 ; *Clematis verticillaris* var. *Columbiana* Gray. Syn. Fl. **1** : 8. 1895 ; *Clematis Pseudoatragene a normalis* Kuntze, Verh. Bot. Ver. Brandenburg, **26** : 160, in part, 1884 ; *C. alpina a occidentalis* 3 *typica* Kuntze, *l. c.* 161.

Dr. Gray adopted the name *occidentalis* as a varietal name for another species, and cites Homeman's plant as a synonym. It is very evident that the latter is the common plant of the Columbia Valley with simply ternate leaves and subentire leaflets, for Homeman expressedly describes them as entire. Dr. Kuntze was so far right that he placed *Atragene occidentalis* Homeman with *A. verticillaris*, although he made both forms of *Clematis alpina*. His revision of *Clematis* is far from good especially as to the West American species. The only distinction he makes between *C. pseudoatragene* and *C. alpina* is the absence or presence of staminodia, a very unfortunate distinction, for in most of the West American forms both conditions exist. The filaments of the outer stamens are flattened and more or less petaloid. In some cases the outermost have no anthers (true staminodia), but often all are antheriferous. The present species is therefore placed in both species by Kuntze. *Atragene occidentalis* differs, however, from the eastern *A. Americana* in the fact that the staminodia as far as I know always are linear, while they are in *A. Americana* decidedly spatulate. *A. occidentalis* is common from British Columbia and the Canadian Rockies south to California and Colorado.

Atragene grosseserrata

Trailing or climbing over bushes: leaves ternate; petioles 5–8 cm. long; petiolules 1–2 cm. long; blades broadly ovate, oblique, somewhat cordate at the base, 3–4 cm. long, coarsely toothed and often somewhat lobed: peduncles 5–10 cm. long: sepals lanceolate, about 4 cm. long, 10–13 mm. wide, acute: staminodia about 18 mm. long, decidedly spatulate, a little exceeding the stamens: achenes small, sparingly hirsute: tails about 3 cm. long, plumose throughout.

This is closest related to the eastern *A. Americana;* but the leaves are deeper serrate and the sepals are longer, lanceolate, and resemble more those of *A. tenuiloba.* From *A. occidentalis* it differs in the spatulate staminodia, the shorter leaflets, which are coarsely serrate except the very base. In *A. occidentalis* the leaflets are entire or merely crenate above the middle.

IDAHO: Palouse county and about Lake Coeur d'Alene, 1892, *G. B. Aiton* (type in Herb. N. Y. Bot. Garden, flower).

WASHINGTON: Cascade Mountains, 1882, *F. Tweedy* (fruit).

Atragene repens (Kuntze)

Clematis alpina α occidentalis 2 repens Kuntze, Verh. Bot. Ver. Brandenberg, 27, 161, in part. 1884.

Plant trailing: leaves biternate, glabrous, firmer than in the two preceding: petioles 5–8 cm. long: secondary leaflets subsessile except the terminal, which is short-stalked, broadly ovate, coarsely toothed with broadly ovate teeth, 3–4 cm. long, abruptly short acuminate at the apex: peduncles over 1 dm. long: sepals ovate-lanceolate, about 4 cm. long, acute: staminodia linear: achenes about 5 mm. long, pubescent: tails about 4 cm. long, plumose throughout.

Dr. Kuntze's description of the subvariety *repens* is just as meaningless as the rest of his descriptions. He cites specimens, however, viz., *Jones* no. *1882* and *1887*. We have two sheets of each and they evidently do not belong together. No. 1882 in both the Columbia University and New York Botanical Garden herbaria are in fruit, have simply ternate leaves with subentire leaflets and must be referred to *A. occidentalis*. No. 1887 in flowers, on the contrary, has biternate leaves, and the leaflets are coarsely toothed. Dr. Kuntze's subvariety is, therefore, "eine zusammengesetzte" and according to some Germans, should be ruled out. After the part that belongs to *A. occidentalis* has been removed, I have adopted the name for the residue.

UTAH: American Fork, 1880, *M. E. Jones, 1887* (type in herb. N. Y. Bot. Gard.).

WYOMING: Wolf Creek Cañon, 1896, *Aven Nelson, 2294*, in part, the larger part belonging to *A. tenuiloba*.

Atragene pseudoalpina (Kuntze)

Atragene Ochotensis Gray, Pl. Fendl. 4. 1849. Not Pall. 1874; *A. alpina* var. *Ochotensis* A. Gray, Am. Jour. Sci. II. **33**: 241; *Clematis alpina* var. *Ochotensis* S. Wats. Bot. King Exp. **5**: 4; *C. alpina* var. *occidentalis* A. Gray; Powell, Geol. Surv. Dakota, 531. 1880. Not *Atragene occidentalis* Homem. 1813; *Clematis pseudoatragene γ pseudoalpina* Kuntze, Verh. Bot. Ver. Brandenburg, **26**: 160. 1884.

As stated above, the name *occidentalis* should be used for *A. Columbiana* Nutt. We are therefore obliged to adopt Kuntze's varietal name. In the Synoptical Flora *Clematis pseudoatragene* Kuntze is given as a synonym, but from the short description neither of the varieties *α*, *β* or *δ* can belong here. The var. *α normalis* is evidently partly *A. Americana* and partly *A. occidentalis* as here understood. The var. *δ subtriternata* is *A. tenuiloba* (A. Gray) Britton. What *Clematis pseudoatragene* var. *β Wenderothioides** is I do not know. In the Synoptical Flora the range is given as extending from New Mexico to Dakota and Washington. I have not seen any specimens from any station north of

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* What a name! Translated it would mean: A variety of the false Atragene Virgin's Bower, resembling Mr. Wenderoth.

Colorado and Utah. All specimens referred here from higher latitudes belong to *A. tenuiloba.*

Ranunculus Utahensis

Perennial with a cluster of fibrous fleshy roots, glabrous: stems 1–2 dm. high, branched above; basal leaves petioled; petioles 2–5 cm. long; blades almost orbicular, rather thick, crenate or round-lobed: stem-leaves sessile, deeply cleft or divided into 4–5 oblong or elliptic, obtuse segments: sepals somewhat hairy, elliptic to obovate, at last reflexed: petals 4–5 mm. long, exceeding the sepals: head of fruit oblong; achenes glabrous; style rather short.

This species resembles most a depauperate *R. abortivus* in the leaves, but the petals are much larger and the head of fruit is oblong instead of spherical. It has gone under the name of *R. affinis* var. *leiocarpus*, but it is not that of Trautvetter, and is distinguished from all of those species which have been included in *R. affinis* by its thicker leaves and their lobing.

UTAH: Alta, Wasatch Mts., 1879, *M. E. Jones, 1130* (type in herb. Columbia University); Uinta Mts., 1873, *T. C. Porter.*

Ranunculus micropetalus (Greene)

Ranunculus affinis var. *micropetalus* Greene, Pittonia, **2**: 110. 1890.

An excellent species, very distinct from *R. affinis* Hook., and still more from *R. cardiophyllus* Hook., with which Davis associated it.

Ranunculus Helleri

Perennial with a short rootstock, perfectly glabrous: stem slender, 1–2 dm. high: basal leaves and lower cauline with slender petioles 2–5 cm. long; blades of the earlier basal leaves reniform, 3-cleft ⅔ or ¾ the distance to the base; middle division oblong, entire, the lateral ones with 3 ovate lobes; blades of the other basal leaves and the lower cauline divided to near the base into 3 cuneate divisions, 15–20 mm. long; the middle division 3-lobed, the lateral ones 4-lobed; stipules of lower cauline leaves conspicuous, rounded: upper cauline leaves sessile, divided unto the base into 2–4 linear-oblong divisions: flowers solitary: sepals oblong, obtuse, about 5 mm. long: petals oblong to obovate, golden yellow, 6–7 mm. long: head of fruit short-oblong or spherical: achenes turgid, almost spherical, 1.5 mm. long, glabrous: style slender and curved.

This species is nearest related to *R. Eschschotzii* and *R. alpeo-*

philus. In the former, which is very rare in the Rockies, the upper stem-leaves have broad and short lobes, which are elliptical to obovate ; and in the latter the basal leaves are not reniform but almost orbicular in outline. *R. Helleri* grows in bogs at high altitudes.

IDAHO : Near Lake Pend d'Oreille, 1892, *Sandberg, MacDougal & Heller, 842* (type in herb. N. Y. Bot. Gard.).

WYOMING : Big Horn Mountain, 1899, *F. Tweedy, 2385.*

MONTANA : Sperry Glacier, 1901, *F. K. Vreeland, 1110.*

Ranunculus stenolobus

Perennial with a cluster of fibrous roots, perfectly glabrous : stems 1–3 from the same clump, 1–2 dm. high, usually branched : basal leaves and lower cauline petioled ; petioles 4–10 cm. long ; blades three times ternately dissected into almost linear segments, which are 6–15 mm. long and 1–3 mm. wide, usually somewhat narrowed at the base ; the primary divisions distinctly petiolulate : sepals oval, 4–5 mm. long : petals obovate, 7–8 (rarely 9–11) mm. long : head of achene spherical or slightly oblong, about 6 mm. broad : achenes turgid, glabrous : style slender.

This species is somewhat intermediate between *R. adoneus* and *R. triternatus*, but the stem is more elongated and branched. Some of the specimens cited below have been referred to the former, but in that plant the stem is usually simple, the petals over 1 cm. long, cuneate-flabelliform and overlapping each other, the lobes of the leaves narrower and not narrowed downward. In the leaf-form and flowers it resembles more *R. triternatus*, but that grows in big clumps with numerous stems, and the segments are more decidedly petiolulate.

WYOMING : Headwaters of Cliff Creek, 1900, *C. C. Curtis* (type in herb. N. Y. Bot. Gard.).

UTAH : Alta, Wahsatch Mts., 1879, *M. E. Jones, 1104 ;* Wahsatch Mt., 1869, *S. Watson, 30.*

Papaver pygmaeum

A cespitose and scapose perennial ; leaves all basal, numerous 2–3 cm. long ; blade less than 1 cm. long, broadly ovate in outline, deeply cleft into rounded-oblong or obovate segments, sparingly hispid or glabrous : scape 4–6 cm. high, sparingly hirsute ; so also the calyx, which is obovate in bud : petals yellow, 1 cm. or less long : pod obovoid, about 1 cm. long, densely bristly.

This species is nearly related to *P. radicatum* Rottb., but is a still smaller plant, with shorter, broader, less divided, less bristly leaf-blades and smaller flowers. It resembles still more the European *P. Pyrenaicum*, which has larger petals, 1–2 cm. long, stamens much exceeding the ovary and spherical flower-buds.

MONTANA: Mountain above Stanton Lake, 1894, *R. S. Williams, 992* (type in herb. N. Y. Bot. Garden).

ALBERTA: Sheep Mountain, 1895, *John Macoun, 10269;* top of Rocky Mountains, 1881, *G. M. Dawson.*

Argemone rotundata

Stem stout, densely and strongly bristly, but otherwise glabrous: leaves oval in outline; the cauline ones sessile and broadly auricled, bristly, especially on the veins and margins, round-lobed: flowers short-pedicelled or subsessile: calyx very bristly; its horns erect or slightly spreading, bristly: petals white, fully 4 cm. long: pod ovoid, very bristly.

This has been mistaken for *A. hispida* Gray but is perhaps nearer related to *A. intermedia* and *A. platyceras*. From *A. hispida* it is easily distinguished by the absence of a finer indumentum and by the round-lobed leaves. The latter character also distinguishes it from the other two species mentioned. It is also much more bristly than the two. It grows at an altitude of 1500–1800 m.

NEVADA: Diamond Mountains, July, 1868, *S. Watson, 47* (type in herb. Columbia University).

UTAH: Utah Valley, 1869, *S. Watson, 49*.

Bicuculla occidentalis

Perennial with a very short rootstock bearing numerous tubers: scape and leaves perfectly glabrous; petioles of about 1.5 dm. long; blades twice ternate; the divisions twice pinnately divided or cleft into linear-oblong lobes, 1–2 cm. long, 3–5 mm. wide: scape about 3 dm. high: raceme simple: sepals oval, about 5 mm. long: petals pink; the outer about 1 cm. long; their spurs about 12 mm., divergent, forming with each other an angle of 90° or more; crest of the inner petals prominent; capsule fusiform, with the style about 1.5 cm. long.

This is nearest related to *B. cucullaria*, and has been confused with it, but has coarser foliage, more diverging and longer spurs, more prominent crest on the inner petals and the underground parts more gruinose and not scaly. Its range includes parts of Oregon, Washington and eastern Idaho, and it grows on shaded hillsides.

WASHINGTON: West Klickitat county, 1892, *W. N. Suksdorf* (type in herb. Columbia University).

The Conjugation of Spirogyra crassa Kg.

BY EDWIN BINGHAM COPELAND

On an afternoon in September, 1900, the writer collected in a stagnant cut-off on Cheat River in West Virginia some *Spirogyra* so large that its conjugation was very evident to the naked eye. It was fixed in Flemming's fluid and preserved in alcohol. When it was examined and determined later, preliminary to class use, it was found to have some characteristics that are probably worth reporting.

Different species of *Spirogyra* vary in the intensity with which they possess distinct sexuality, as male or female plants. In all of them the cells show a difference in behavior, in that one is recipient, the other active, which is a marked advance over related genera in which the zygospore is formed midway between the gametes. But in some species the cells of a single filament conjugate in pairs, the conjugating tube passing around the transverse wall; in this case the filament as a whole is without sex. When the conjugation is between the cells of parallel filaments it is usually altogether in one direction, one filament acting as female and the other as male. But in such cases filaments sometimes occur which if traced far enough are found to bend about onto, and conjugate with, themselves, being female in one part, male in another. Such cases suggest that where a distinction of the sexes is just beginning to appear, sex may be a relative quality; if one part of a filament can be male with reference to another part as female, why might not a filament act as male with reference to one of its neighbors, but female with reference to another. In this *S. crassa* material sex is a positive quality of the filament. I have examined a great number of instances of polygamy and polyandry, cases in which a long filament conjugated at different places along its length with several others. I have never found a filament conjugating with itself, nor a single instance of a filament whose sex was not constant in its numerous alliances. Often three filaments were in contact, each with both the others; one would conjugate with both others indiscriminately, all the cells of both the others starting to form conjugating tubes with it; but the two of like sex never stimulated each other even enough to make the tubes start to grow. The filaments are then completely dioecious, and their sex must be determined in the zygospore. Complete dioecism is a higher degree of sexuality than would be anticipated in plants whose gametes are not visibly different * except in their part in conjugation.

In much higher plants, likewise dioecious, the sex is not always as fixed as it seems here: thus Lesquereux and James † say of *Atrichum undulatum* Beauv.: "This species is dioecious, but sometimes the young male plant produces from the center of the flower an innovation bearing female flowers and thus the male plant is transformed into a fertile one."

In the cells of the vegetative filaments the nuclei were large and centrally placed, the entire contents of the cells reasonably clear, and no unusual bodies to be seen in the chloroplasts. In cells which had progressed in conjugation to the meeting of the tubes there were usually some black granules in the chlorophyll bands, the body of the cell remaining as clear as ever. Where two filaments of one sex conjugated with one of the other, or where one filament of a pair had shorter cells than the other, there were cells which tried to conjugate but failed: some of these merely started to put out a conjugating tube, at other times this stimulated the development of a tube to meet it. In all of these cells the contents was discolored by the presence of distinct granules and of a diffused opacity. The shade varied from pale brown to deep black. The failure to conjugate has interfered in some way with the normal metabolism of the cells. Very likely it is that plastic matter intended for use in conjugation has accumulated as oil and has been blackened by the osmic acid. But it occurs in cells whose conjugating tube has completely formed. The pen drawing is made from a cell which failed to conjugate, and is drawn a little lighter in shade than is natural.

The position of the nucleus in conjugating cells was remarkable. A large part of my material was fixed at about the stage in

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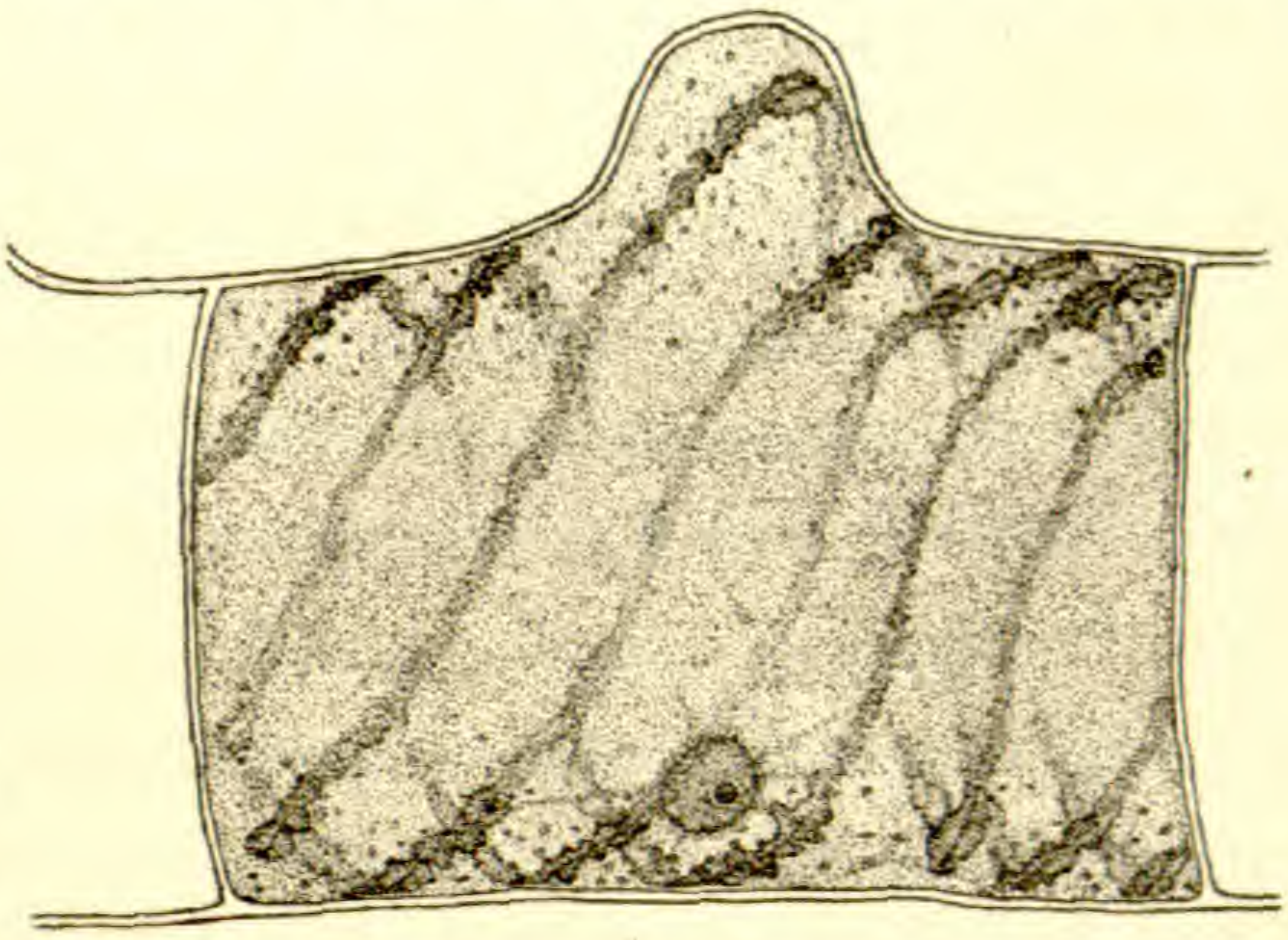
* Kny (Wandtafeln, Text, 11) says that the sex of filaments of his material—a large, not certainly identified species—was distinguishable by the shape of the cells, before conjugation began.

† Mosses of North America, 256.

conjugation when the wall between the tubes is absorbed: in all of it, in this stage and somewhat earlier, the nucleus was very constantly to be found close to the outer wall on the side *opposite* the conjugating tube. This could be seen in almost every conjugating cell. In the cells which failed to find mates the nucleus was more often invisible or obscured; but sometimes it was very evident, as in the cell drawn. In this position the nucleus is rather smaller and much less conspicuous than in vegetative cells.* This position of the nucleus is the opposite of that usually assumed in cells with localized growth.† As is suggested in a recent paper by Miehe,‡ the central position of the nucleus in young and active cells, instead of a lateral one, even when growth is more or less localized, is easily understood in consideration of the various functions of the nucleus. But this is the first instance known to me of a nucleus that moved to the opposite wall. This species, *S. crassa*, has been studied in the same connection by Gerassimoff,§ but not during conjugation.



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* Strasburger (Befructung und Zelltheilung, Jena, 5, 1878) says that early in the conjugation of *S. quinina* the nuclei become pale and disappear.

† Haberlandt. Ueber die Beziehungen zwischen Function und Lage des Zellkernes bei den Pflanzen. Jena, 1887. Physiologische Pflanzenanatomie. 2d Ed. 23–24. 1896.

‡ Ueber Wanderung des pflanzlichen Zellkernes, Flora, 88: 105–142. 1901.

§ Ueber die Lage und die Function des Zellkernes. Moscow, 1900.

A novel Seed Planter

BY DAVID GRIFFITHS

Much interest naturally attaches to a desert flora. In a humid region where the soil cover is maintained throughout the year, and the growing season continues for six or more months, there occurs such a gradual succession of species that the transition from spring to summer or summer to autumn is so gradual as to escape attention. The most striking change is the spring awakening which is dependent upon the return of invigorating higher temperature. In a desert region, however, the changes which occur are much more sudden and striking. A change from a naked surface dotted here and there by a stray sinuous shrub or a spiny cactus to a literal flower garden so dense and extensive as to be recognizable by the brilliancy of its golden hue a score of miles distant, is something which impresses the uninitiated with peculiar force. What the characteristics of this vegetation which comes so rapidly and dries up and blows away as it were in such a remarkably short time are: how it survives the long droughts and the intense heat; what the contrivances are by which it propagates itself; how it successfully maintains itself against such trying conditions are considerations of much scientific interest and growing economic importance. It is the purpose of this paper to record some observations on one contrivance by which one desert annual is able to cope more successfully with the conditions in which it finds itself.

While upon the deserts of southern Arizona during the winter of 1900–1901, it was often a matter of wonder to me how the multitude of seedlings which were springing up all over the mesa became established, and how the seeds succeeded in remaining on surfaces which had apparently been deprived of every vestige of tilth by the erosive action of fierce destructive showers whose only effect appeared to be the carrying away of everything not actually anchored to the subsoil. In such localities, however, in the vicinity of Tucson on areas where there appeared to be nothing left but the undisturbed hardpan subsoil there occurred a profuse growth of

Plantago fastigiata Morris, the "Indian wheat" of the region. How it was possible for these seedlings to establish themselves in such situations were matters for speculation only. In March the crop of this plant was in its prime and in many localities covered the ground almost completely and yielded as high as a ton of air-dry substance per acre. The crop of seed was truly wonderful and upon the maturity of the plant in April and the advent of the dry weather of May it became strewn all over the surface of the mesa. It was not, however, particularly conspicuous until after a shower of rain in the latter part of May. Although a light shower it was quite vigorous for a short time and caused water to run freely on the mesa, resulting in much of the seed strewn over the surface being washed into cattle tracks, gopher holes, and other surface depressions. It was then that an explanation of the wonderful "sticking qualities" of the seed was offered.

The seeds of the plantains are altogether too common to require any extended description. Those of this species, like all others with which the writer is familiar, are covered with a compact glossy or often white coating which absorbs water, expands wonderfully and becomes mucilaginous when an opportunity is offered. This coating of mucilage, as it is usually called, is considerably more pronounced in this and some other dryland species than in those which grow in more humid regions. When the coating has absorbed water to its full capacity, it loses any opacity which it may have due to the presence of air in the dried mucilage, and the whole seed and its coating assumes the appearance of a particle of jelly inclosing an oval hemilenticular particle in its center. When examined a little more closely, however, the coating is seen to have a definite structure. It presents a distinct radial appearance with the rays more or less regular in arrangement and formed by a greater concentration of matter than the intervening spaces.

When examining the plant after the shower of rain in May, the first things to attract attention were the masses of seed which had collected in the depressions. At first these masses were simply a mixture of seed, mucilage and débris from the general surface of the desert. After a time the seed separated largely from the refuse and a crust was formed both above and below. The upper one was formed by the rapid evaporation and the lower one by mixing with the drier earth below which abstracted water and furnished particles of sand to adhere to and mix with the mucilage making the mass more firm. In this way cakes were formed with a mucilaginous center and firm crusts on either side. All of the water soon evaporated, however, leaving a cake of seed and débris in every depression. These often measured two feet in length by three inches in thickness in the center. There were places on the mesa to the southeast of the University at Tucson where one could pick out an acre of ground which was one fourth covered with cakes of this seed. As the water evaporated and the cakes became thoroughly dried they presented a peculiar appearance indeed, for they naturally curled up at the edges. The surface of the mesa presented an appearance not unlike the surface of a table with photographic prints laid upon it to dry. It is quite probable that all of the seeds in these cakes were destroyed. At least one would naturally expect this result although an opportunity has not been given for actually observing their fate.

There were of course plenty of seeds which were not washed together and it is to the behavior of these that the greatest interest attaches, for upon them the next year's crop is dependent. After the surface of the ground had dried nearly every seed which had remained isolated was sunken in a little pit in the ground, the walls and bottom of which were made rigid by the hardened mucilage. The seed was inclosed in a little cup, as it were, sunken into the earth—not deeply—but evidently sunken to a depth about equal to the distance between its parallel side. The pit had a diameter of about three times that of the seed.

The agent which caused the sinking of the seed was evidently the mucilage, but how such a particle of lifeless matter could accomplish this result so nicely did not appear clear. The seed was as effectually sunken as though it had been done by human hands. It was not covered, but this would inevitably be accomplished in the succeeding dry months by the natural abrasion of the surface of the soil. The cup would be filled by silt and sand effectually completing the process of planting the seed.

Several experiments have been performed for the purpose of determining the mechanism by which this burial of the seed is accomplished. Sowings of seed collected in large quantities last spring have been made on several surfaces. Glass, tissue paper, blotting paper, clean sifted building sand, sand of a roadbed at Takoma Park, D. C., and some of the finer clayey soils have been used as seed beds. After being scattered the seed together with the substratum were moistened sufficiently to thoroughly distend the mucilaginous coatings. The behavior of the mucilage on the different surfaces when compared appears to me to indicate clearly its mechanical behavior in sinking the seed.

Upon the glass surface not only was the structure of the mucilaginous covering easily observed, but it was demonstrated that upon drying it does not return to its original position around the seed. It flattens out on the support instead, serving in this way to attach the seed very firmly to the surface. When dried the seed will therefore be firmly fastened to the glass and have surrounding it two distinct zones. The inner zone will have an irregular radial striation and a dense heavy appearance indicating that the greater amount of the mucilage is concentrated there. It has the appearance of having been thrown into minute radial folds in drying. The outer zone is much wider, contains much less of the mucilaginous substance but has no well-marked structure. Its outer as well as its inner boundary is very irregular and there are in it very faint irregular and indistinct radial thickenings. When the seed is forcibly removed from the glass both zones may accompany it, but usually the outer one remains attached to the glass.

When seed sown on blotting paper has dried, only a little of the inner zone of dried mucilage is apparent, the outer one being invisible on account of having sunken into the surface of the paper. When the seed is forcibly removed only a part of the inner zone of dry mucilage accompanies it, the outer one invariably remaining attached to the paper. Of course some of the paper usually accompanies the seed which is removed.

On tissue paper the appearance does not differ materially from blotting paper, the outer zone here again being sunken into the fibers. There is one decided difference, however. The paper has a tendency to wrinkle parallel to the long axis of the seed, leaving it in a trough of the folds with the elevations on either side.

The seed sown on clean building sand presented when dry a very different appearance from that on the deserts of Arizona. Instead of being sunken in a small pit they simply form the center of little wads of sand which are firmly attached to them by the adhesiveness of the mucilage. The seeds were slightly sunken but there was no sign of pits in the sand.

When the seed sown on the sand of a roadbed had dried, some of it had exactly the same appearance as that upon the clean building sand, while the remainder presented exactly the same appearance as that upon the hard limy soils in the vicinity of Tucson, Arizona.

That sown on the hard smooth surface, of reasonably stiff clayey soil differed in no way when dry from that described above for its natural habitat. The pits with the seed seated in them were as perfectly formed as one could wish to see them.

Bringing the phenomena of these different experiments together, it appears to me that we can formulate an explanation of the action of the mucilage in the sinking of the seed and the forming of the pit into which it gravitates, or rather is both pushed and pulled. When the mucilaginous coating is completely distended it measures about 5 x 7 mm. in its greatest horizontal diameters. The outer portion of the coating, especially, flattens out wonderfully and penetrates the substratum as shown by the experiments on paper. When the process of desiccation begins, the soil being porous will give up its moisture more readily both to the underlying strata, which are almost invariably dry in Arizona, as well as to the atmosphere than the mucilaginous seed coat.

This condition together with the fact that the outer layers lose moisture much more rapidly than those close to the seed results in drying and fastening the outer edge which has flattened out upon the soil and also sunken into it, as well as the lower surface, firmly to the soil particles. As soon as this occurs a tension is set up which would naturally be toward the center—that is the outer contracting layers would crowd the inner ones—but having become anchored to the soil particles and rendered rigid by drying, and having only a loose connection with the undried inner layers, the pull is outward in all directions. The underside of the mucilaginous particle in contact with the soil has also lost moisture, but here to a much less degree than the outer edges in better contact with the air. The lower layers are the dryest and, therefore, soon become attached to particles of earth, we will say 2 mm. below the surface. As drying proceeds the upper surface in contact with the air will sink, and the lower anchored to the particles below the surface will exercise a downward pull. The lower surface is drying from below so that successively higher particles are being subjected to the downward strain. There are, therefore, three forces acting, the first horizontal and outward caused by the anchoring of the outer edge of the flattened particle of mucilage, and the second downward owing to the contraction of the upper layers exposed to the air. The third acts from above downward and is the result of loss of water by the lower layers of mucilage. It should be stated that the seed is comparatively free from these three forces, for it is in the center of the mucilaginous particle which is the last to solidify. The resultant of these three forces is evidently a downward one which effects the solidifying of the soil below and immediately surrounding the seed to a depth of about 0.5 mm., or equal to the distance between its flat surfaces. All that is now necessary in order to have the planting completed, is to have a gust of wind or a shower of rain pack the soil around the seed in its little depression.

To summarize, therefore, it appears that the function of the mucilage is the burial of the seed and that this is accomplished by the tension set up owing to the contraction of the expanded mucilage which has become firmly attached around its outer and lower edges to the particles of soil into which it has penetrated, resulting in a compacting of the soil immediately below the seed and its coat so as to form a pit into which the seed is forced. The cup-shaped depression is subsequently filled with earth by entirely external influences.

On the Arizona deserts this phenomenon is not confined to the ordinary soils of the mesa, but may frequently be observed on the hard surface of a roadbed. To what extent this principle is applicable to flax, pepperwort and other mucilaginous seeds has not, so far as the writer knows, been investigated.

Notes on the comparative Resistance to high Temperatures of the Spores and Mycelium of certain Fungi

By Abigail A. O'Brien

It is a well-known fact that the spores of bacteria are more resistant to heat than are the vegetative cells. It has been generally believed that the same is true of fungi, that is, that the spore is better able to resist a high temperature than is the mycelium. The method of fractional sterilization has in fact been based upon that belief. Professor B. M. Duggar suggested to me that in the case of some fungi, especially those with thin-walled spores, the mycelium might be at least as resistant to moist heat as are the spores. His work on *Sporotrichum globuliferum* * indicated that with this fungus such is the case. The following series of experiments on five representative fungi, carried on under his directions, confirms his results in general.

Methods.—The fungi experimented upon were *Aspergillus flavus, Botrytis vulgaris, Rhizopus nigricans, Sterigmatocystis nigra* and *Penicillium glaucum.* They were grown upon beet cylinders in test-tubes. The mycelium used in these experiments was taken from the culture tubes within two and one half days after the fungus had begun to grow and before any spores had formed. The spores used in the experiments were from one to two weeks old. The spores were placed in sterilized test-tubes filled to the height of about one inch with beet decoction. The tubes were then put in a boiler heated to the desired temperature and left for five, ten, fifteen, thirty or sixty minutes. After the exposures, drop cultures of the decoction in the tubes were made in Van Tieghem cells. The spores of *Aspergillus* and *Sterigmatocystis* showed a tendency to float on the surface of the liquid and to collect in small masses. It was therefore found necessary to immerse them in distilled water before putting them in the decoction. In the experiments with the mycelium, a bit of the hyphal mass was removed from the plug with a sterilized needle, and was then treated exactly as the spores were. The cultures were in all cases

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* Bot. Gazette, 31 : 38–66. Ja. 1901.

accompanied by checks, which gave uniform growth .and are therefore not recorded. The cultures were usually examined twenty-four hours after they were made, and again within two or three days. Results were recorded after the first examination, but additions were sometimes made upon later examination.

The figures in the table indicate the percentage of growth. In the case of the mycelium it was found impossible to indicate the new growth by exact per cents., hence fresh growth is indicated in all cases by (g) which is recorded only where vigorous fresh growth appeared on all sides of the bit of mycelium.

No.	Temperature ° C.	Fungus	Spores					Mycelium				
			Time of Exposure in Minutes					Time of Exposure in Minutes				
			5	10	15	30	60	5	10	15	30	60
			Percentage of Germination Growth									
1	45	Botrytis.	all	90	40	50	2					
2		Rhizopus.	all	20	30	40	5					
3	47	Aspergillus.	98	98	98	98	80					
4		Botrytis.	50–75		5–15	10	0					
5		Rhizopus.	50–75	25	10	20	10					
6		Sterigmatocystis.				75	100					
7	50	Aspergillus.	90	40	10	0	0				g	g
8		Botrytis.	65	2	1 or 2 spores	1 or 2 spores	2				0	0
9		Rhizopus.	1 or 2 spores	45	15	0	0				g	g
10		Sterigmatocystis.	98	90	40	0	4				g	g
11	52	Aspergillus.	90	80	35			g	g	g		
12		Botrytis.	20	10	1			g	g	g		
13		Rhizopus.	1–2	2–3	0			g	g	g		
14		Sterigmatocystis.	all	90	80	0		g	g	g		
15	53	Aspergillus.						g	g	g		
16		Botrytis.						g	g	g		
17	55	Aspergillus.	0	0	0	0	0	0	0	0		
18		Botrytis.						0	0	0		
19		Rhizopus.						0	0	0		
20		Sterigmatocystis.	2	1	0	0	0	g	0	0		
21	60	Penicillium.	50	20–50	10–15	5	5	g	g	g	g	0
22	65	Penicillium.	0	0	0	0		g	g	g	g	g

Certain experiments were omitted, hence blank spaces appear in the table. For instance it was found that the mycelium of all the fungi except *Botrytis* gave vigorous fresh growth at 50° for the two longer exposures, 30 and 60 minutes, hence it is unnecessary to try it at lower temperatures. Also *Penicillium*, both spores and mycelium, gave vigorous growth at 55°, and was, therefore, omitted from the experiments at lower temperatures.

It will be noticed that the percentage of spores germinated does not always vary inversely as the length of the time of exposure, as would be expected. This discrepancy, however, can only be accounted for by the variation in resistance of individual spores.

The results given in the table, especially those of experiments 7, 9, 10, 12, 13, 22, seem to warrant the conclusion that in the five fungi studied, the spore, that is, the conidium, is no more resistant to moist heat than is the mycelium.

DEPARTMENT OF BOTANY, CORNELL UNIVERSITY.

Hesperaster nudus (Pursh) Cockerell and its Allies

By George E. Osterhout

There are four species of *Hesperaster* (*Mentzelia*) found on the plains and in the mountains of Colorado which have large white flowers. They are all vespertine as to the time of blooming. The largest flowered one is *Hesperaster decapetalus* (Sims) Cockerell (*Mentzelia decapetala* Urb. & Gil.). The size of the flowers so distinguish it that it is not likely to be mistaken for any of the others. *H. Rusbyi* (Wooton) Cockerell (*Mentzelia Rusbyi*) was described by Professor E. O. Wooton in the Bulletin of the Torrey Botanical Club, **25**: 261. This is a large plant having the upper leaves sessile by a broad base and acuminate. The flowers are smaller than those of the other species and the capsule only slightly foliose at base. It surely is not an annual as Professor Wooton suggests but seems to be about as enduring as the other species.

There are yet two species which have usually been referred to *Mentzelia nuda.* One of these is strict in manner of growth, branching at the middle or toward the summit; the leaves are decidedly hispid on both surfaces; the capsule has pinnatifid bracts at its base, is foliose at base, and the seeds are subovate. It grows on the plains. The other is a more branching plant; the leaves are not so hispid on the upper surface, the capsule is *not* foliose at base; the seeds are round and wing-margined.

Which of these, if either, is the *Bartonia nuda* Pursh? Some help may be had in solving the problem from the early descriptions. Nuttall says of *Bartonia nuda,* "capsule naked." This fact contrasted it with his *Bartonia ornata* (*i. e., H. decapetalus*) which has the "base of the capsule foliose," and probably suggested the name *nuda.* The description in Torrey and Gray's Flora is drawn from that of Nuttall and adds nothing of notes. But there is a specimen of Nuttall's plant yet in the herbarium of the Philadelphia Academy of Sciences, and the name *Bartonia nuda* is in Nuttall's handwriting. I am greatly indebted to Mr. Alex. MacElwee for comparing specimens with Nuttall's plant and for facts concerning it.

While this specimen is only of the top of a plant, having a few leaves and flowers it agrees with the description in that the capsule is not foliose at base. It also has the appearance of belonging to a branched and spreading plant. The first of the plants mentioned above then, is not of this species, but the second one agrees quite well with the description and plant of Nuttall and, if either of them, is the *Mentzelia nuda* (Pursh) T. & G. It seems to be found mostly along the foothills in rocky, gravelly soil in the vicinity of streams; and Nuttall says of *Bartonia nuda* "near the Great Bend of the Missouri on gravelly hills."

For the first of the species above mentioned then a description is offered.

Hesperaster stictus sp. nov.

Seemingly a perennial, certainly more enduring than a biennial, the stem white and hispid, 0.5–1 m. high, fastigiate and somewhat corymbose, leafy, the leaves gradually reduced upward: leaves oblong, about 1 dm. long toward the base of the stem, the lower on short petioles, the upper sessile, sinuate-toothed, obtuse, hispid on both surfaces, the short barbs pustular at base: capsule 2–3 cm. long, hispid, having pinnatifid acuminate bracts at its base: calyx lobes deltoid-acuminate: petals 10, of the same size, 2.5–3.5 cm. long, tapering to a broad claw of about one third its length: many filaments petaloid: seeds subovate, 4–5 mm. long, wing-margined.

Quite generally distributed on the plains east of the mountains in Colorado and probably the adjoining states. Specimens collected at New Windsor, Weld county, Colo., July 22, 1901, no. 2488, may be considered typical. Judging from the description this is the *Mentzelia nuda* of Porter and Coulter's Flora of Colorado, and many of the plants which have been collected on the plains are quite likely the same.

The genus to which the plants of this article belong was first published by Sims in 1812 as *Bartonia*. Torrey and Gray in their Flora of 1838–1840 included it in *Mentzelia*; but Professor T. D. A. Cockerell has republished it under the name *Hesperaster*, in *Torreya*, December, 1901. As this will probably be generally adopted it will be necessary to transfer another species recently described, *Mentzelia speciosa* Osterhout, Bull. Torrey Club, **28**: 689, and overlooked by Cockerell. This will become **Hesperaster speciosus.**

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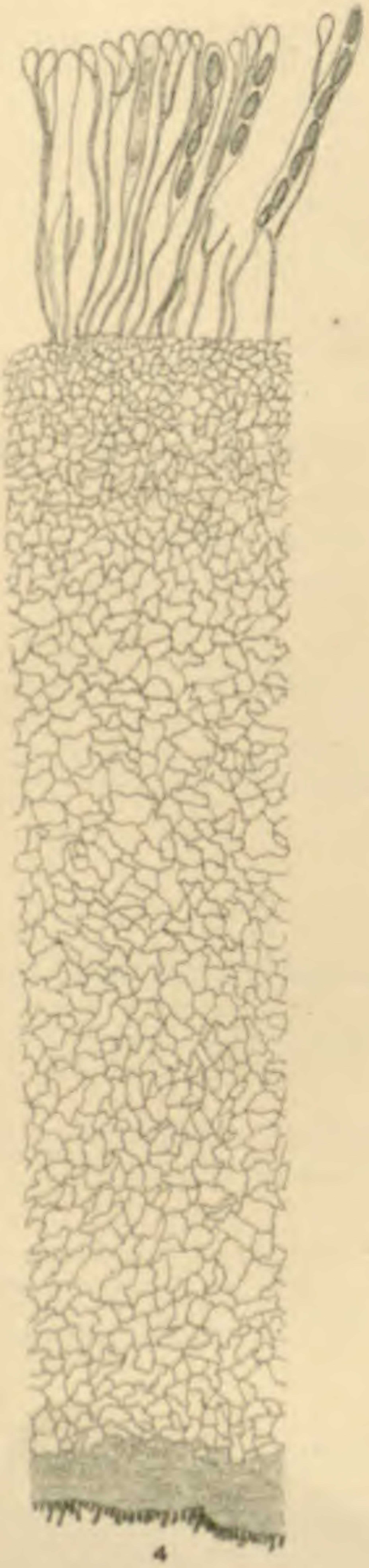

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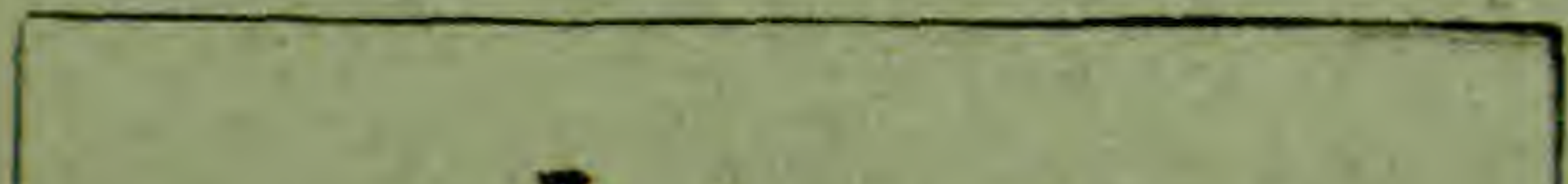

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Memoirs (See last page of cover.)

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BULLETIN

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TORREY BOTANICAL CLUB

APRIL 1902

Supplementary Notes on the Erysiphaceae

BY E. S. SALMON, F.L.S.

(WITH PLATES 9–11)

(Continued from page 109)

ERYSIPHE POLYGONI DC. (Monograph, p. 174)

Syn. add: E. Fricki Neger, Bericht. Deutsch Bot. Gesellsch. **17**: (Generalversamm.-Heft) 241. 1899.

E. pisi DC. var. *desmodii* P. Henn. Engler's Bot. Jahrb. **29**: 148. 1900.

Conidial form : Oidium monosporum Passerini, Nuov. Giorn. Bot. Ital. **13**: 282. 1881.

Exsicc. add: * Rehm, Ascomycet. 1350 (sub *Microsphaera Caraganae* P. Magn.); * Krypt. Exsicc. (Mus. Pal. Vind.) 130, 131 (a & c only), 132.

Distrib. add: Europe: Faröe Islands (63), Bosnia (3), Bulgaria (10).

Asia: Siberia, Yeniseisk ("flum. Yenisei inter 58° et 71°") (A. Kitmanoff), Poseka, Wostotchnoje, & Nitchka (Sacc. in Malpighia, **10**: 269. 1896); Palestine (43).

South America: Argentine, "in alta Cordillera, 39° lat. merid. 900 m. supra mare (Neger).

Hosts, add: Aconitum variegatum (40), *Actinostemma racemosum, Anemone nemorosa* (40), *Aster* sp. (8), *Ballota nigra* (80), *Brassica oleracea* (13*), *Cytisus capitatus* (40), *C. purpureus* (40), *Delphinium hybridum* (cult.), *D. Maackianum* (cult.), *Desmodium podocarpum* var. *Japonicum, Dipsacus silvestris* (18), *Echinops* sp.

[Issued 24 April]

(29), *Geranium pratense* (18), *G. Robertianum* (6), *Geum Chiloense, Heuchera Americana* (84), *Hieracium umbellatum* (38), *Hypericum tetrapterum* (40), *Isopyrum thalictroides* (40), *Lathyrus Clymenum* (12), *L. montanus, L. niger* (40), *L. ochroleucus* (15), *L. palustris* (84), *L. venosus, L. vernus* (40), *Leonurus Cardiaca* (80), *Lupinus angustifolius, Lycopersicum esculentum* (13*), *Melampyrum silvaticum* (40), *Mentha arvensis* (80), *Myosotis* sp. (80), *Onobrychis Crista-galli* (43), *Papaver Rhoeas, Phaseolus vulgaris* (18), *Physalis* (29), *Pisum arvense* (18) (49), *Pleurospermum Uralense, Ranunculus nemorosus* (33), *R. recurvatus* (8) (84), *Rhabdosciadium Aucheri* (59), *Robinia Pseudacacia, Scabiosa stellata, S. succisa, Sedum Telephium* var. *purpureum* (cult.), *Sisymbrium officinale, Sium latifolium* (76), *Sonchus oleraceus* (80), *Thesium alpinum* (40), *Torilis Anthriscus* (40), *Trifolium agrarium, T. spadiceum* (40), *Urtica urens, Valeriana officinalis* (6), *Valerianella* sp. (80), *V. olitoria* (40), *Vicia tenuifolia* (40), *V. venosa* var. *capitata.*

I have received from Dr. Neger a specimen (now in the Kew Herbarium) of "*Erysiphe Fricki*," labeled "in foliis *Gei Chilensis* Balb. in alta Cordillera 39° lat. merid. 900 m. supra mare." I am quite unable to separate the fungus in any way from *E. polygoni.* The perithecia measure from 90–135 μ in diameter, and contain four to twelve 3–5-spored asci. The asci measure 65–70 × 34–40 μ (*pl. 1, f. 12*). Neger (**52**) gives the size of the asci as "55–65 × 28–35 μ," and states that *E. Fricki* differs from *E. Martii* (= *E. polygoni*) "durch beträchtlich grössere Schläuche (bei *E. Martii* nur 40–50 μ)." I have already pointed out, however (monograph, 178), that in *E. polygoni* the asci vary in size from 46–72 (very rarely reaching to 80 μ) × 30–45 μ. I have seen specimens of *E. polygoni* occurring on *Geum urbanum* in New Zealand.

Hennings (**31**) has described an *Erysiphe* from Japan as follows: "*E. pisi* DC. var. *desmodii*: amphigena, mycelio arachnoideo, tenui, effuso, albido; peritheciis gregariis vel sparsis, atris, globulosis, 80–100 μ, appendicibus hyalinis usque ad 100 μ longis 5–8 μ crassis; 3–4 ascis piriformibus, stipitatis, vertice rotundatis, 50–60 × 30–35 μ; 5–6 sporis ellipsoideis, 1–2-gutulatis, aurantio-oleosis, 17–19 × 14–12 μ. Prov. Musashi: Mt. Takao auf lebenden Blättern von *Desmodium polycarpum* DC. var. *latifolium* Max. (Kusano, no. 132, 18 October 1899)." Hennings remarks of his plant: "Durch die askenärmeren Perithecien u.s.w. etwas verscheiden von der typischen Art." The character here specially mentioned—and indeed all those given in the diagnosis—are not important enough to separate the present plant even as a variety from *E. polygoni*, and are certainly not confined to the Japanese form, but occur on various hosts throughout Europe and North America. I have received, moreover, from Professor Kingo Miyabe a specimen labeled "*Ersyiphe polygoni* DC. (= *E. pisi* DC. var. *desmodii* P. Henn.). On *Amphicarpaea Edgeworthii* var. *Japonica* (not *Desmodium podocarpum*). Mt. Takao, Prov. Musashi, Oct. 8, 1899, (S. Kusano)." It would appear, therefore, that Hennings has founded his variety on the *Erysiphe* on *Amphicarpaea* This specimen sent by Professor Miyabc also cannot be separated in any way from *E. polygoni*. Professor Shotaro Hori has, however, sent me examples of *E. polygoni* on a host-plant which is certainly *Desmodium*, viz., *D. podocarpum* DC. var. *Japonicum* Maxim (Hakone, Prov. Sagami, Japan, coll. N. Nambu, Oct. 30, 1900). The occurrence of the present species on *Desmodium* is interesting, as hitherto the only mildew known on *Desmodium* (*D. Canadense*, *D. canescens*, *D. cuspidatum*, *D. paniculatum* and *D. sessilifolium*) was *Microsphaera diffusa* Cooke & Peck, which occurs not uncommonly in the United States, but which has not yet been recorded from elsewhere.

Magnus (Bericht. des naturwiss.-med. Ver. Innsbruck, **24**: 6. 1898), has recorded the occurrence of "*Sphaerotheca Castagnei* Lév." on leaves of *Caltha palustris*, from "Schruns in Vorarlberg (J. Bornmüller)." Through the kindness of Professor Magnus I have been able to see the original material on which the above record was based, and have found that the fungus in question is a small—or perhaps starved—form of *E. polygoni*, a species very common on many plants belonging to the Ranunculaceae (*Caltha*, *Clematis*, *Ranunculus*, *Aquilegia*, etc., etc.). This small form of *E. polygoni* is very likely to be mistaken for *S.* "*Castagnei*," and it may be well to point out here the distinguishing characters. In the first place, the appendages of this form of *E. polygoni* have the peculiar *facies* of those of the examples of this species occurring on *Clematis*, *Aquilegia*, *Ranunculus*, etc., and are fewer, longer, slightly wider (especially towards the base) and more distinct, and often more angularly bent, than the appendages of *S.* "*Castagnei.*" On opening the perithecia, 2 to 4, or rarely 5, asci are found. In Professor Magnus's examples 2 to 3 was the usual number. Very rarely, apparently only a single ascus occurs, but as a rule a second ascus—often empty or more or less aborted—is to be found. In the rare cases in which only a single ascus is observable, this form of *E. polygoni* is easily separable from *S.* "*Castagnei,*" not only by the nature of its appendages, but also by the more or less ovate (not subglobose) ascus, containing (in this form) only 2–3 spores, and not 8 as in *Sphaerotheca.* Moreover, in all such cases, the examination of several perithecia invariably shows the existence in most of several (2 to 5) asci, and so leads us to conclude that the perithecia containing only a single ascus are ill-developed examples. Quite similar specimens of this small form of *E. polygoni* occur on species of *Geranium*, and have been commonly confused with *S. humuli.*

Brannon (8) has reported, in the case of examples of *Sphaerotheca* "*Castagnei* Lév." on a species of *Erigeron*, the finding of two or three perithecia, each containing two asci, and observes: "In these unusual forms one ascus was much larger than its companion, but not as large as the ascus existing alone in a perithecium. A few of these unusual forms might lead to the questioning of what has, heretofore, been considered a strong generic difference between *Sphaerotheca* and *Erysiphe.*" This occasional occurrence of more than one ascus has also been noted by other observers in species of *Sphaerotheca;* in two instances I have found perithecia of *S. mors-uvae* (Schwein.) Berk. & Curt. containing three asci (see monograph, 73). We see, therefore, that in rare instances *Sphaerotheca* may approach *Erysiphe* in possessing more than one ascus; on the other hand perithecia of the small form of *Erysiphe polygoni* on *Caltha palustris*, mentioned above, may very rarely contain only a single ascus. It is clear, therefore, that *Erysiphe* on one side shows an affinity with *Sphaerotheca;* on the other, through *E. tortilis* it claims relationship with *Microsphaera* through *M. astragali* and *M. Bäumleri.*

Brannon (8) has reported the occurrence of *E. polygoni* on a species of *Aster* and considers that this host had probably received the mildew from neighboring plants of *Ranunculus recurvatus* which were attacked by this species. Species of *Aster* are the common host-plants of *Erysiphe cichoracearum*. If the fungus has been correctly determined, the present instance is of great interest as showing that occasionally a species of mildew is able to pass directly on to the usual host-plants of another species (see p. 14).

In Journ. Myc. **5**: 83. 1899, Kelsey has recorded "*E. communis*" on *Vicia Americana* var. *linearis* (from Helena, Montana, U. S. A.). Specimens communicated to me by the author show that the fungus here recorded is *Microsphaera alni* var. *ludens*. Spegazzini (**79**) has recorded "*E. umbelliferarum*" on *Bowlesia tenera*, from the Argentine, but the fungus, from specimens communicated, proves to belong to *E. cichoracearum*. The *Erysiphe* recorded by Bubak (**9**) as "*E. communis*" on *Plantago major* is *E. cichoracearum;* specimens sent by the author are in the Kew herbarium. The fungus recorded by Saccardo in Rev. Myc. **11**: 41. 1881, as "*E. communis*" on "*Tragopogon* sp.," proves, according to a specimen sent, to be *E. cichoracearum*. The host-plant is not *Tragopogon;* Professor Saccardo, when sending the specimen, wrote on it "fol. *epilobii*," but the fragments sent were too small to admit of certain identification. Professor Saccardo also sent a specimen of the fungus recorded (Bull. Soc. Roy. Bot. Belg. **28**: 86. 1889, as "*E. Martii*" on *Pedicularis resupinata* from Siberia, and this proves to be *Sphaerotheca humuli* var. *fuliginea*. Tolf, in Bot. Notiser, 1891: 219, has recorded "*E. Martii*" on *Astragalus glycyphyllus* and *Vicia cassubica* from Sweden. According to specimens (now in the Kew herbarium) sent by the author, the fungus on the first-named host is *Microsphaera astragali*, and on the second, *M. Bäumleri*. The record by Freeman (**20**), of the occurrence of "*E. communis*" on *Eupatorium ageratoides* belongs to *E. galeopsidis* (see p. 194). Professor Oudemanns writes to me that his record (Rév. Champ. des Pays-Bas. **2**: 97. 1897), of "*E. communis*" on *Geranium molle* was based on the occurrence of merely an *Oidium* on this host, and that the record (*l. c.*) of the occurrence of the same species on *Verbascum Thapsus* was "borrowed from other writers." The fungus recorded by Rabenhorst (**59**) as "*E. Martii*" on *Alhagi maurorum*, *Vicia tenuifolia*, and *Rhabdosciadium Aucheri*, in Kurdistan most probably belongs to *E. taurica*. I have seen several examples of the latter species on the first two hosts, and there are specimens in the Kew Herbarium labelled "*E. communis leguminosarum.* Ad. *Vicia tenuifolia.* Professor C. Haussknecht, Iter orientale, 1868, Luristan," which belong to *E. taurica.* The fungus recorded by Feltgen (18) as "*E. Martii*" or *Lathyrus niger* proves, from specimens sent, to belong to the genus *Microsphaera* and is probably *M. Bäumleri* P. Magn. That, recorded by the same author (*l. c.*), as "*E. pisi*" on *Galium Aparine*, proved, like all records based on the fungus on species of *Galium*, to belong to *E. cichoracearum.* The host-plant given as *Colutea arborescens* by Sydow, in his Mycotheca Marchica, no. 980, was, as Magnus (47*) has recently pointed out, wrongly determined and is really *Caragana arborescens. Colutea arborescens* must therefore be removed from the list of the host-plants of *E. polygoni.*

In 1870 de Bary (Beitr. Morph. Phys. Pilze, **1**: 50) raised the "*Erysiphe Martii* forma E." of Léveillé, occurring on various umbelliferous plants (see Lév. Ann. sci. nat. III. **15**: 166. 1851) to specific rank under the name *E. umbelliferarum*, and gave as host-plants *Angelica silvestris, Chaerophyllum hirsutum, Anthriscus silvestris, Pastinaca sativa, Falcaria Rivini* and *Heracleum Sphondylium.* De Bary stated that his species scarcely differed in perithecial characters from "*E. communis*," and remarked "Dagegen ist sie ausgezeichnet durch die Form der Conidien, welche genau walzenförmig, an beiden Enden flach, und mindestens (doch nicht immer) sehr langgestrecht sind. Bei den vorher genannten Arten allen haben die Conidien die (im Profil elliptische) Gestalt einer schmalen an den Enden abgerundeten Tonne." In my monograph (p. 184) I remarked that this character could hardly be considered sufficient to separate "*E. umbelliferarum*" as a species, and also doubted whether it were a constant and distinctive feature of the *Erysiphe* on Umbelliferae. I have since studied in a living state some conidial forms of *E. polygoni*, and have found that the shape of the conidium is extremely variable. On *Sisymbrium Alliaria* (Cruciferae) (*pl. 9, f. 7*) the conidia are for the most part distinctly cylindrical in shape, and intermixed with them one finds quite commonly elliptical conidia. The size of the conidium varies greatly; the cylindrical ones are usually about 38 μ long (and about 15 μ wide), but here and there a conidium occurs which measures over 50 μ long; the elliptical conidia measure 30–33 × 17–19 μ. On *Heracleum Sphondylium* (Umbelliferae) (*pl. 9, f. 2*) elliptical conidia are of quite common occurrence; considerable variation in size is found also here. On *Anthriscus sylvestris* (Umbelliferae) (*pl. 9, f. 1*) most of the conidia are cylindrical, but occasionally elliptical ones occur. Also, in examples on *Delphinium hybridum*, *D. elatum*, and *D. Maackianum* (Ranunculaceae) (*pl. 9, f. 9*) the shape of the conidia varies from elliptical to cylindrical. The reduction of "*E. umbelliferarum*" to *E. polygoni* appears therefore fully warranted.

It may be here pointed out that, as *f.* 1, 2, and 8 on *pl. 9* show, the conidiophores of *E. polygoni* bear only a single conidium at the apex, unlike the *Oidium* form of many mildews, where the conidia are concatenate in long chains (see monograph *f. 127* for that of *E. galeopsidis*, and *f. 140* for that of *E. cichoracearum*; see also *f. 115*, *117*, and *156*). It would be interesting to ascertain if this feature is characteristic of *E. polygoni*, as if so it might be of use in distinguishing the species in its conidial condition.

In connection with the fact mentioned above of the conidiophores of *E. polygoni* bearing only a single spore, we may note that Passerini has published the following description of a fungus (Nuov. Giorn. Bot. Ital. **13**: 282. 1881): "*Oidium monosporum* Passer. hb. Epiphyllum, maculas discoideas pulveraceo-cinereas demum fuscas efformans. Hyphae longae, subclavatae, articulatae, in sporam unicam oblongo-ellipticam desinentes. An *Ovulariae* Sacc. Michel. **6**: 17, analogum?—Sulle foglie della *Robinia hispida* L. nel R. Orto Botanico, Luglio." Professor C. Avetta has kindly sent me the type-specimens of "*O. monosporum*" from Passerini's herbarium at Parma University, and examination of this has convinced me that the fungus described is merely the conidial stage of *E. polygoni*. The subcylindrical conidia measure from 28–40 μ long × 13–16 μ wide. *E. polygoni* is known to occur on other species of *Robinia* (*R. Pseudacacia* and *R. viscosa*).

In germinating some conidia of *E. polygoni* on *Delphinium Maackianum* in a hanging drop of water, several cases were observed of the formation of lobed "appressoria" at the places where the tips of the germ-tubes had come into contact with the cover-glass (see *pl. 9, f. 9*). No formation of haustoria proceeding from these was observed. This phenomenon was first noticed by Büsgen (**11**), who remarks of the germinal hyphae proceeding from conidia of *E. polygoni* sown in the same way : " bei Berührung mit dem Objectträger erzeugten sie lappige Appressorien, mit deren Bildung ihr Wachsthum abgeschlossen war. Ein Austreiben der Appressorien fand nicht statt, obwohl der Inhalt der Gonidien noch nicht erschöpft schien. Es darf daraus geschlossen werden, dass auch bei den Erysipheen zur Entwickelung des Infectionsfadens ein Ernährungsreiz nothwendigist, der in der Natur nur von der Wirthspflanze ausgehen kann."

In the Journal of the Royal Horticultural Society (London) for 1900 (**35**) it is reported that the prevalence in autumn, in some parts of Britain, of the "pea-mildew" (*E. polygoni*), is causing the cultivation of late varieties of peas to be abandoned. A similar state of affairs has already been recorded in the western United States by Bessey (Seventh Biennial Report Iowa Agric. Coll., 1877). Dusting the infected plants over with flowers of sulphur (mixed with air-slacked lime), or spraying with a solution made by dissolving 3 oz. of carbonate of copper in 2 quarts of aqua ammonia diluted to 22 gallons, is stated to be the best means of combating the disease. (See Galloway, on the "Powdery Mildew of the Bean," Journ. Myc. **5**: 214. 1889.) Lodeman (**40***, p. 325) writes of the "Pea Mildew": "This disease could undoubtedly be easily checked by means of the copper sprays, but the foliage of these plants is of such a character that liquids do not readily adhere. Soap will assist in overcoming this difficulty if it is added to the liquids. Another line of treatment which might be followed by good results is to apply powder to the vines while they are wet with dew. Fostite should prove of value for this purpose."

In 1891 Comes (**13***) described under the name *Oidium ceratoniae* a mildew which had been observed for several years previously on the carob-tree (*Ceratonia Siliqua*) in southern Italy. This fungus is stated to attack by preference the younger leaflets, which become deformed and fall off, the young shoots, and the immature fruits. When the mildew appears at the time of flowering, fertilization fails—if afterwards, the young fruit does not fall, but usually becomes more or less atrophied or withered on the plant, and is always depreciated in quality. The mildew appears to be more prevalent in wet than in dry years, and is found more in localities in which water remains at the foot of the plant than in those in which the soil being permeable leaves the stock free from water. The disease always begins on trees which have their roots more or less affected and made rotten by stagnant water, and then spreads from these plants radially as from so many centers of infection. The means adopted of dealing with the disease is to bare the roots of the trees most seriously attacked, and to cut off those roots which are more or less rotten; and further to keep the soil soft and permeable at the foot of the trees by burying there faggots or straw. Cutting off the tops of diseased branches is also recommended.

Grimaldi (Come fare fruttificare abbondantemente il carrubio, Palermo, 1895) also reports that the present fungus seriously affects in some seasons the harvest of carob-beans (St. John's bread), and states that the disease is popularly known as "a farinedda."

Although no perithecia were observed on the carob trees affected, Comes referred his "*O. ceratoniae*" to *Phyllactinia corylea*, considering it to be the conidial stage of that species.

In 1899 I received from Professor P. Gennardius, Director of Agriculture, at Nicosia, Cyprus, some diseased pods of *Ceratonia Siliqua*, which on examination were found to be covered with a mildew. The fungus, which was stated to cause great damage to the carob crop in Cyprus in some seasons, is evidently the "*Oidium ceratoniae*" of Comes; it shows, however, all the characters of the conidial stage of *E. polygoni*. The presence of ordinary haustoria on the mycelium proves conclusively that the fungus is not to be referred to *Phyllactinia*. Specimens of "*O. ceratoniae*" have been issued in Briosa e. Cavarra, Fung. par. no. 238, from Sicily, where the fungus is stated to have seriously affected the harvest of carob-beans in 1892. The figures here given represent fairly well the conidial stage of *E. polygoni*. The conidia are described as cylindrical (truncate at the ends) and measuring 26–36 × 12–14 μ, and are stated to differ from those of "*O. erysiphoides*" in the wall being somewhat rough ("alquanto verrucosa"). The conidia I have seen measure about 30–35 × 12–15 μ, and have a smooth wall, although, as is generally the case with the conidia of the Erysiphaceae, very old conidia, through the wrinkling of the cell-wall, or through incrustation, appear falsely to be rough.

The fungicides, recommended for the "pea mildew" above, should prove efficacious here.

Comes (**13***, p. 246) also records cases of the tomato being seriously affected by the present species, and remarks, "In 1879 the tomato was attacked by it at Palermo. The plants presented grayish spots, which by degrees became black, both on the skin and on the leaves. Microscopic examination showed the presence of an *Erysiphe*, very similar to the preceding [*E. Martii*], but furnished with the characters of *E. communis*. In 1881 it injured the tomatoes in the region of Salerno, and in other localities of northern and central Italy. Moreover, this disease has been known in the region of Palermo for twenty-five to thirty years under the name of *male nero*; it attacks the plant at all seasons, but more readily about the beginning of May. The cultivators think that it is caused by excessive dampness, since the plant, cultivated under dry conditions, is exempt from it. They are convinced that the disease is contagious, and consequently if they observe that the disease appears in a nursery they destroy the affected plants immediately. They hold that sulphuring alone is useless; they are accustomed, instead, to cut back the plants, to leave them dry, and then to sulphur them. When the disease appears before or at the commencement of flowering, they prefer to destroy the affected plants." Tomaro (Le due crittogame che maggiormente danneggiano i pomidori; *cf.* Just's Bot. Jahresber. 1891, **2**: 245, 1893), has also reported the occurrence of "*E. communis*" on the tomato in the neighborhood of Bergamo, and states that the disease was induced by excessive moisture.

Var. SEPULTA (Ell. & Everh.) Salm. (Monograph, p. 191)

Distrib. add: United States of America, California, 7,000′ (A. Purpus) in herb. Jaczewski.

E. CICHORACEARUM DC. (Monograph, p. 193)

Exsicc. add: * Rehm, Ascomycet. 1199; & 1298 sub *E. Martii* Lév. f. *rubiacearum;* Krieg. Fung. saxon. 1218, 1219 1220, 1221 (in herb. Jaczewski).

Distrib. add: Europe: Bosnia, Bulgaria (10), Dalmatia (3).

Asia: Siberia, Yeniseisk, "flum. Yenisei inter 58° et 71°" (A. Kitmanoff), Transcaucasia, Lencoran (59); Turkestan, Taschkent, Tschïmkent (79*).

South America: Argentine Republic, "Puente de Inca, Audibus Mendozinis" (C. Spegazzini, May 3, 1901), Flores no. Buenos Aires, Nov. 20, 1888 (C. Spegazzini), Lincoln (79).

Hosts, add: Artemisia serrata (23**), *Aster azureus* (84), *A. lateriflorus* (17), *A. Novae-Angliae* (84), *A. undulatus* (8), *Bidens bipinnata* (79), *Bowlesia tenera, Calendula arvensis* (40), *C. fulgens* (40), *Centaurea Cyanus* (40), *C. pectinata, Cineraria* sp. (75), *Cnicus arvensis, Echinospermum Lappula* (6), *Echium vulgare, Eupatorium ageratoides* (15), *Euphorbia* sp., *Helianthus parviflorus* (84), *Hieracium umbellatum* (76), *Hydrophyllum appendiculatum* (84), *H. macrophyllum* (84), *Inula Britannica, Myosotis* sp. (3), *M. collina* (40), *M. palustris* (40), *M. sparsiflora* (40), *M. stricta* (40), *Parietaria Canadensis* (84), *P. judaica* (40), *Phlomis Herba-venti* (80), *Physalis Alkekengi, Pilea pumila* (84), *Plantago Cornopus* (38), *Salvia glutinosa* (66), *Senecio erucifolius* (34), *S. Fuchsii, S. silvaticus* (40), *S. viscosus* (40), *Solidago latifolia* (84), *Symphytum tauricum, Verbascum Lychnitis, Willughbya scandens* (17), *Zinnia elegans* (84).

A very interesting form (now in the Kew herbarium) has been sent to me by Dr. Spegazzini labelled "*E. andicola* Speg. n. sp. Puente de Inca, Audibus Mendozinis, May 3, 1901. In *Euphorbia* sp." The perithecia measure up to 180 μ in diameter, although most of them are smaller, being of the size, normal for *E. cichoracearum*, the asci measures from 70–85 × 25–30 μ, and the spores up to 28 μ long, although the latter are usually smaller (about 25 μ long). This South American example on *Euphorbia* matches exactly, in the persistent mycelium and the occasionally large size of the perithecium and asci, two North American forms of *E. cichoracearum*,—one on *Lygodesmia juncea*, from Helena, Montana, U. S. A. (Kelsey, September 15, 1890)—the other on *Bige-*

lovia—on *B. viscidiflora* (*B. Douglasii*), Willis, Montana, U. S. A. (F. W. Anderson, Oct. 1888), and on *Bigelovia* sp., Laramie Hills, Wyoming (E. Nelson, September 28, 1897). I have already remarked on the peculiarities of the form on *Bigelovia* (see monograph, p. 203). This South American plant on *Euphorbia*, while much recalling the Old World species *E. taurica* Lév. in habitat, and in the large size of some of the perithecia and asci, yet clearly belongs to *E. cichoracearum*, and exactly matches the large form of this species found on *Arctium* in Europe.

The fungus recorded by Hennings (**30**) as "*E. lamprocarpa*" on *Bigelovia* sp. from "Snow Mount, 7,000 ft., California" is according to a specimen collected by Purpus and labelled "California 7,000 ft." (in herb. Jaczewski) *E. polygoni* var. *sepulta*.

Spegazzini (**79**) has recorded "*E. umbelliferarum*" (= *E. polygoni*) on *Bowlesia tenera* from Flores near Buenos Aires, and in the diagnosis has described the spores as measuring 25–40 μ long × 14–18 μ diam." Professor Spegazzini has sent me a specimen of the plant (labelled "*E. umbelliferarum* var. *platensis*"), which proves to be *E. cichoracearum*. The few spores seen by me measured about 24 × 14 μ. The fungus recorded by Spegazzini (**79**) as "*E. lamprocarpa*" on *Tagetes glandulifera* proves to belong to *E. galeopsidis*.

The records by Bubak (**10**) of *E. cichoracearum* on *Verbascum phlomoides* and *V. Lychnitis* (and probably also that on *V. Blattaria*) from Bulgaria belong to *E. taurica*. Professor Oudemanns writes to me that his record (Rév. Champ. des Pays-Bas, **2**: 94. 1897) of "*E. lamprocarpa*" on *Verbascum thapsiforme* was based merely on the occurrence of an *Oidium* stage on this plant.

I have stated in my monograph (p. 202) that the *Erysiphe* occurring on *Echium* and *Anchusa*, although commonly referred to *E. cichoracearum*, has always proved in my experience to be *E. polygoni*. I have, however, since found in Professor Jaczewski's herbarium, a specimen on *Echium vulgare* ("St. Lubin-de-la-Haye, Eure-et-Loire, France") which is true *E. cichoracearum* (with regularly 2-spored asci, etc.). On *Anchusa*, however, the fungus in all the examples I have seen, belongs to *E. polygoni*—good specimens on this host are to be found in Syd. Myc. March, no. 655.

The fungus recorded by Raciborski (60) as *Oidium tabaci* from Java is probably the conidial stage of *E. cichoracearum.*

Examples of the form of *E. cichoracearum* (on *Galium*) with perithecia containing asci without any trace of spores (see monograph, p. 208) occur in the Paris Museum, labelled "*E. Martii* Lév. sur *Galium.* Souk el Arba [Algeria]. 1er Janvier 1893."

As *E. cichoracearum* frequently proves a serious enemy to cucumber culture—more especially to cucumbers forced in the greenhouse for a winter crop—the following notes on the successful treatment of the disease may be given. Humphrey (31*) states: "The disease may be kept in check in the greenhouse by spraying the plants as often as is necessary with a solution of sulphide of potassium (liver of sulphur) in water, an ounce of the sulphide to four gallons of water. A stronger solution injures the plants and fruits. Spraying with ammoniacal carbonate of copper (3 oz. carbonate of copper dissolved in one quart of ammonia; dilute with water to 25 gallons) has been found even more effective. But Professor Bailey finds more effective than either exposure to sulphur vapor. This is accomplished by closing the house as tightly as possible for half an hour or an hour at a time, while it is filled by the vapor arising from a vessel of sulphur kept a little above the melting point on a small oil stove. The vessel should be porcelain-lined, to protect the iron from the action of the sulphur. Great care must be taken to avoid the ignition of the sulphur." It may be noted that Humphrey found that the conidia of *E. cichoracearum* on cucumber leaves differed considerably in size in examples from different localities.

Stewart (81) records cases of field-grown cucumbers thickly covered with mildew. (See also for "Cucumber mildew," Bailey (2*).)

Oidium chrysanthemi Rabenh. Hedwigia, **1**: 19–21. *pl. 3. f. 1.* 1853, is probably the conidial stage of *E. cichoracearum*, and is frequently very troublesome on cultivated chrysanthemums. The fungicides recommended above should be used to check the disease.

E. GALEOPSIDIS DC. (Monograph, p. 204)

Distrib. add: Europe: Bulgaria (10).

Asia: Siberia, Yeniseisk, "flum. Yenisei inter 58° et 71°"

(A. Kitmanoff), Minussinsk (Martianoff), Monastir, Poseka, and Lake Karasin (Saccardo, Malpighia, **10** : 269. 1896).

South America: Argentine Republic, Lincoln (Spegazzini, Sept. 1899).

Hosts, add: Calamintha Acinos (40), *Galeopsis Ladanum* (18) (40), *Lamium amplexicaule, Phlomis tuberosa, Salvia officinalis* (34), *Scutellaria lateriflora* (84), *S. pilosa* (84), *Tagetes minuta, Teucrium Scorodonia.*

Freeman (**20**) has recorded "*E. communis*" on *Eupatorium ageratoides* L. (Hennepin, Oct. 1893. Sheldon 4083). The author kindly sent me part of the original material (now in the Kew herbarium), and I have found that the fungus is the *Erysiphe* with lobed haustoria which I have referred at p. 208 of my monograph with some doubt to *E. galeopsidis.* In the present case, as in the two other examples mentioned in my monograph (*l. c.*), the asci agree with those of *E. galeopsidis* in not containing spores on the living plant. *E. cichoracearum* with normal bisporous asci occurs on *Eupatorium cannabinum*, *E. perfoliatum*, and *E. purpureum*, and it is certainly very interesting to find on one species of the genus, viz.: *E. ageratoides*, a fungus constantly possessing lobed haustoria and asci without spores—a combination of characters only found in *E. galeopsidis.*

Professor Spegazzini has sent me a specimen (now in the Kew herbarium) of the *Erysiphe* recorded (79) by him as "*E. lamprocarpa* (Wallr.) Lév." on *Tagetes glandulifera* (= *T. minuta*) from Lincoln, Argentine Republic, Sept., 1899. On examining this fungus I found that the asci, although the perithecia in color, etc., appeared ripe, contained no spores, and on searching the mycelium for haustoria it was found that these were, for the most part at any rate, distinctly lobed (see *pl. 9, f. 13*). The fungus consequently must be referred to *E. galeopsidis.* The host-plant in the above case belongs to the Compositae and on this account the record is of special interest. *E. galeopsidis* had been supposed to be confined in its range of host-plants to genera belonging to the Labiatae and to *Chelone* in the Scrophulariaceae until the existence of an *Erysiphe* with lobed haustoria and asci without spores was discovered on *Eupatorium ageratoides* (see paragraph above). We have now an instance of the occurrence in South America of the same fungus on another genus of Compositae.

The fungus recorded by Bubak (**10**) as *E. galeopsidis* on *Marrubium peregrinum* from Bulgaria belongs to *E. taurica.*

Atkinson (Journ. Elisha Mitch. Sci. Soc. **10** : 75. 1894), has recorded *E. galeopsidis* from Alabama, U. S. A., "on *Verbena urticifolia,* October 23, 1891 (coll. B. M. Duggar)." Specimens (now in the Kew herb.) kindly sent to me by the author prove, however, that a wrong identification of the fungus has been made, the species being clearly *E. cichoracearum* DC., as is shown by the asci containing two or rarely three spores on the living host-plant and by the absence of lobed haustoria on the mycelium.

E. GRAMINIS DC. (Monograph, p. 209)

Ascigerous form.

Exsicc. add: *Linhart Fung. hungar. 80; Krieg, Fung. saxon. 1216, 1217 (in herb. Jaczewski).

Distrib. add: Europe : Faeröe Islands (63).

North America : United States, Indiana (84); East Greenland (Rostrup, Meddel. om Groenland, **18** : 61. 1896.

Australasia : Tasmania (62).

Hosts, add: Bromus mollis, Catabrosa aquatica (40), *Holcus lanatus* (13), *Lolium perenne* (38), *Milium effusum* (76), *Poa alpina* (40).

Conidial form.

Syn. add: Oidium tritici M. A. Libert, Pl. Crypt. Ard. fasc. IV, no. 385 (cum diag.) 1837; Sacc. Syll. Fung. **4** : 46. 1886.

Torula tritici (Lib.) Corda, Ic. Fung. **5** : 51. *pl. 2. f. 15.* 1842.

Torula bulbigera Bonorden, Bot. Zeitung, **19** : 195, *pl. 8. f. 8.* 1861.

Oidium bulbigerum (Bon.) Sacc. & Vogl.; Sacc. Syll. Fung. **4** : 47. 1886.

Torula rubella Bonorden, Bot. Zeitung **19** : 195. 1861.

Oidium rubellum (Bon.) Sacc. & Vogl.; Sacc. Syll. Fung. **4** : 46. 1886.

Exsicc. add: Lib. Pl. Crypt. Ard. fasc. IV, no. 385; Fckl. Fung. Rhen. 72; Jack, Leiner u. Stizenb. Krypt. Bad. 819; Rab. Fung. Eur. 477; Klotzsch, Herb. myc. ed. nov. 81; de Thüm. fung. austr. 541.

(*T. rubella*) Rab. Fung. Eur. 281.

Libert gives the following diagnosis of *Oidium tritici*: "Epiphyllum, caespitibus oblongis confluentibus fulvis; floccis simplicibus erectis in articulos pellucidos ovales secedentibus. Ad folia viva *Trictici repentis*, Aestate." Examination of the specimen of *O. tritici* in Lib. Pl. Crypt. Ard. fasc. IV, no. 385 shows that the fungus is identical with *Oidium monilioides* Link., the conidial stage of *E. graminis*. The bulbiform swelling at the base of the conidiophore seems a constant feature in the conidial stage of *E. graminis* (see monograph, *pl. 9. f. 156*; and also Garovaglio & Cattaneo, Archiv. Lab. Bot. Critt. Univ. Pavia, **2**: *pl. 2.* 1879), and was observed in all the specimens in the exsiccati of "*O. trictici*" quoted above.

Bonorden founded his "*Torula bulbigera*" on Rabenh. Fung. Europ. Cent. II. no. 275, and published the following diagnosis: "Sporis ovatis s. oblongo-ovatis 4–6 concatenatis hyalinis albis, hyphis (pedicellis) triseptatis, basi bulbosis; mycelio ramoso, septato et repente. Hab. in foliis graminum in Guestphalia." From the description and figures given there can be no doubt that "*Torula bulbigera*" is nothing more than *Oidium monilioides*. The inflated base of the conidiophore, relied upon by Bonorden as the chief specific character, is, as has been pointed out above, a constant feature in the conidial form of *E. graminis*. I have not seen Rabenb. Fung. Eur. no. 275.

Torula rubella Bonorden was founded on Rabenh. Fung. Eur. Cent. III. no. 281, and the following diagnosis given: "Sporis ovoideis 3–4 concatenatis; pedicellis articulato-septatis, rubicundis subrubiginosis. Hab. in foliis vivis graminum in Guestphalia." This also proves to be the conidial stage of *E. graminis*. In Rab. Fung. Eur. no. 281, the "*Torula*" can be seen passing over into pannose mycelium in which perithecia of *E. graminis* are immersed. The bulbiform swelling at the base of the conidiophore is present in these examples, just as in "*T. bulbigera*" (see above).

Spegazzini (**79**) records "*Oidium monilioides*" on *Bromus unioloides* and *Avena sativa*, in the "Parque de La Plata, winter 1882–95." Nees (Syst. Pilze u. Schwämme, 53. 1817) records a fungus under the same name from Germany on *Dinebra Arabica* (cult.).

The haustoria of *E. graminis* are peculiar in possessing long finger-like processes. They have been studied in detail by Grant Smith (**77**), and well figured. (See p. 4.)

E. TORTILIS (Wallr.) Fr. (Monograph, p. 213)

Syn. add: Trichocladia tortilis (Wallr.) Neger, Flora, **88**: 351. 1901.

Distrib. add: Bulgaria (10).

The record of the occurrence of *E. tortilis* on *Thalictrum aquilegifolium* by Massalongo (**50**) was due to an error of identification, the fungus in specimens sent to me proving to be *E. polygoni* DC. Professor Oudemanns writes to me, with regard to his record (Rév. Champ. des Pays-Bas, **2**: 95. 1897) of *E. tortilis* on *Cornus alba*, that "the leaves of the *Cornus*, examined with more care, prove not to belong to *C. alba*, but to another garden species, unable to be identified."

E. TAURICA Lév. (Monograph, p. 215)

Distrib. add: Bulgaria.

Hosts, add: Cerinthe (80), *Dorycnium herbaceum* (80), *Marrubium peregrinum*, *Saussurea* sp., *Verbascum Lychnitis*.

The example on *Marrubium peregrinum* from Bulgaria is recorded by Bubak (**10**) as *E. galeopsidis*, but from a specimen (now in the Kew herbarium) sent by the author the fungus proves to be *E. taurica*. Similarly, the fungus on *Verbascum phlomoides* and *V. Lychnitis*, referred by the same author to *E. cichoracearum* proves, from specimens sent (now in the Kew herbarium) to belong to *E. taurica*. The same is also probably the case with the fungus on *V. Blattaria*, referred also to *E. cichoracearum*, but the specimen sent is too immature to permit of certain identification, although the habit is that of *E. taurica*. The record by Brunaud (Actes Soc. Linn. Bordeaux, **32**: 155. 1878) of the occurrence of *E. taurica* on *Cnicus lanceolatus* from France proves to be erroneous, the fungus proving, from a specimen sent (now in the Kew herbarium), to be *E. cichoracearum*. Dr. Hennings has sent me from Rabenhorst's herbarium a specimen of the fungus recorded (**59**) as *Sphaerotheca Castagnei* Lév. on *Euphorbia* "am Berge Kellal in Sud-Persien, 10,000′ s. m." The species proves to be *E. taurica*. Another specimen sent from Rabenhorst's herbarium is the fungus which has been recorded (59) as *S. Castagnei* on *Hibiscus esculentus.* This bears no perithecia, but from the mycelial characters shown probably belongs to *E. taurica.*

Oidium haplophyllii P. Magnus (43) on *Ruta* (*Haplophyllum*) *Buxbaumii*, from Palestine, is probably the conidial condition of *E. taurica.*

Through the kindness of M. P. Hariot I have seen the specimens, in the Paris Museum, of the fungus recorded by Léveillé (Ann. sci. nat. III. 15: 161. 1851) as "*E. taurica.* On *Aplotaxis*, Himalaya (Jacquemont. Herb. Par.)." The fungus belongs as named, to the present species, and is growing on some species of *Saussurea* (*Aplotaxis*). The specimens are labelled "*Erysiphe compositarum* Lk.—in fol. *Aplotaxis.* Indes orientales, Jacquemont."

Speschnew (79*) has lately published as new species of *Erysiphe* two plants occurring in Turkestan on *Euphorbia lanata* and *Acanthophyllum glandulosum.* The following descriptions are given: "*E. euphorbiae* (sp. nov.) N. Speschnew. Mycelio epiphyllo, interdum hypophyllo, constricte effuso, confluente, tenui; hyphis repentibus, ramosis, flexilibus, undulatis, septatis, dense intertextis, crassiusculis, hyalinis, $4,_{9}$–$7,_{4}$ μ crass.; hypopodiis biclavatis, alternis, ça $14,_{8}$–$22,_{5}$ μ; peritheciis gregariis, globosis, dein subglobosis, in villo nidulantibus, 150–180 μ diam., atrobrunneis, setulis hyalinis, aseptatis, anucleatis, undulatis, apice pedaliformibus, 7–9 μ crassis, perithecio duplo longioribus; ascis elongato-piriformibus, de medio attritis, apice obtusis, operculatis, 3–6-sporis, 90–98 × 22–24 μ; sporis ellipsoideis, continuis, aseptatis, hyalinis, 20–24 × 11–15 μ; hyphis conidii feris illis mycelii similibus, conidiis elongato-ovoideis, mediocre cuncatis, 20–24 × 12–16 μ, episporio valde crasso, 2–3 μ. Habitat in foliis *Euphorbiae lanatae* Sisb. Primo leg. auct. prope Taschkent, 22, ix, 1898. *E. acanthophylli* (sp. nov.) N. Speschnew. Mycelio hypophyllo; hyphis tenuibus, non constringentibus, ramosis vel simplicibus, septatis, valde undulatis, achrois, granulatis, $1,_{5}$–2 μ crassis; hypopodiis nodosis, bifurcatis; peritheciis epiphyllis, solitariis, sparsis, haud immersis, globosis vel subglobosis, ca 160 μ diam., atris; setulis rectis, continuis, nucleatis, apice rotundatis, 2–3 μ crassis; ascis late piriformibus, 8-sporis, 38 × 28 μ; ascosporis subsphaericis, continuis, aseptatis, hyalinis, ca 8 μ diam.; hyphis conidiiferis illis mycelii similibus, conidiis elongato-ovoideis, ca 38–43 × 16–19 μ, episporio tenuissimo. Habitat in foliis cauleque *Acanthophylli glandulosi* Bg. Taschkent, Bukhara, Tschardjui, 27, ix, 1898."

The original Latin diagnoses given by Speschnew are rendered somewhat obscure by faulty construction. As far as possible I have corrected the mistakes in the diagnoses given above. From the description and figures given by Speschnew I am strongly inclined to think that both "*E. euphorbiae*" and "*E. acanthophylli*" are to be referred to *E. taurica*, notwithstanding the fact that Speschnew gives the number of spores in the ascus as 3–6 in "*E. euphorbiae*" and 8 in *E. acanthophylli*, while in *E. taurica*, in my experience, the asci contain when ripe only two spores. It is to be noted, however, that the young asci of *E. taurica* frequently contain one or two, or more, drops of oily matter, which much resemble immature spores. From the figures given by Speschnew, I am inclined to think that this author had under observation immature asci containing young spores and oily globules. The mistake of describing these oily globules as spores has apparently somewhat frequently occurred. "*Erysiphe lanuginosa*" (= *E. taurica*) on *Daucus maximus*, from Greece, was described by Fuckel (Bot. Zeitung, 29: 27. 1871), as possessing 8–12-spored asci, but in the examination of authentic specimens I have found the asci constantly bisporous. Two plants from Persia, in all probability the same as those found by Speschnew, have been described by Magnus as "*Erysiphe lanata*" on *Euphorbia lanata* and "*Microsphaera Bornmuelleriana*" on *Acanthophyllum glandulosum*, both of which I have referred at p. 218 of my monograph to *E. taurica*. The asci of "*E. lanata*" were described as containing 3–5 spores and those of "*M. Bornmuelleriana*" 4–6 spores. In specimens of these plants from Magnus' herbarium, however, I have been able to find in the ripe ascus only two spores. It is, however, quite possible that forms of *E. taurica* may occur with occasionally 3 or 4 spores in the ascus, for we must remember that this is the case with several species which are typically bisporous, *e. g.*, *E. cichoracearum* DC., *Uncinula clandestina* (Biv. Bern.) Schroet., *U. polychaeta* (Berk. & Curt.) Ellis, and *Phyllactinia corylea* (Pers.) Karst.

E. AGGREGATA (Peck) Farl. (Monograph, p. 221)

Exsicc. add: Shear, New York Fungi 147 (in herb. Jaczewski).

Distrib. add: Wisconsin (15).

Freeman (**20**) has reported the occurrence, from Minnesota, U. S. A., of the present species on the leaves of *Alnus incana*. The author has since written to me, however, that this record is a mistake, the habitat being, as is invariably the case, the cones of the *Alnus*.

PHYLLACTINIA CORYLEA (Pers.) Karst. (Monograph, p. 224)

Syn. add: Erysiphe stellata and vars. *coryli* and *alni* L. Marchand, Bijdr. tot de Natuurk. Wetensch. (Amsterdam), **4**: 272. 1829.

E. fungicola Schulz. Oest. Bot. Zeit. **26**: 58. 1876.

Phyllactinia fungicola (Schulz.) Hazslinszky, M. Tud. Akad. Math. és Természettud. Közleményck, **14**: 181. 1876–77.

? *P. fungicola* (Schulz.) Saccardo, Syll. Fung. **1**: 6. 1882.

P. clavariaeformis Neger, Bot. Centralbl. **80**: 11. 1899; Neger, Ber. Deutsch. Bot. Gesellsch. **17**: 235. 1899.

P. suffulta (Reb.) Sacc. var. *moricola* P. Henn. Engler's Bot. Jahrb. **28**: 271. 1900.

Excicc. add: * Ell. & Everh. Fung. Columb. 108 (b); * Krieg. Fung. saxon. 1226; * Krypt. exsicc. (Mus. Pal. Vind.) 120; * D. Sacc. Myc. Ital. 59, 475; * Fl. exsicc. austro-hungar. 2368; * Linhart, Fung. hungar. 255, 454, 455.

Distrib. add: North America: United States; Minnesota, Florida, New Jersey and Nebraska (17).

South America: "Carren-leofù, Patagonia andina, Jan. 1900 (Spegazzini); Lion Range, nr. Gregory Bay, Patagonia, April 20, 1882 (Spegazzini); Santa Cruz, Patagonia, Jan. 1882 (Spegazzini); Puente de Vacas, Andibus Mendozinis, Argentine, 2,500 m. alt., Mar. 2, 1901 (Spegazzini), Paraguay.

Hosts, add: Adesmia sp., *Aesculus Hippocastanum* (18), *Alnus incana* var. *glauca*, *A. viridis*, *Amelanchier Asiatica*, *Anarthrophyllum rigidum*, *Caesalpinia sepiaria*, *Crataegus nigra* (40), *C. parvifolia*, *Desmodium* sp. (8), *Embothrium coccineum*, *Excoecaria* sp., *Fraxinus oxyphylla* (59), *Juglans* sp. (27), *Magnolia Yulan*, *Populus* sp. (27) (28), *Pyrus Malus* (34), *Quercus Kelloggii*, *Ribes Magellanicum*, *Syringa vulgaris*, *Tilia* sp. (27).

Neger (**52**) has described a *Phyllactinia* from South America as a new species with the following diagnosis : *P. clavariaeformis* Neger n. sp. *Ph.* hypophylla mycelio latissimo per totam matricem effuso, peritheciis numerosis, laxe confertis, globoso-depressis, 100–122 μ altis, 200–230 μ latis, verrucosis, atro-opacis, 6–9 appendicibus suffultis; appendicibus 180–350 μ longis (plerumque 200–250 μ), media longitudine interdum subincrassatis; ascis 8–12 in quoque perithecio, ellipticis vel ovatis, apice truncatis, 62–75 μ longis, crasse stipitatis (stipite 12 μ longo, curvato), 2–4 sporis; sporis ellipticis continuis grosse guttulatis.—Species a *Ph. suffulta* Sacc. longe recedens cellulis penicilliformibus (peritheciis insidentibus) valde ramosis, formam *clavariae* cuiusdam ramosae imitantibus. *Ph. Antarctica* Speg. periheciis appendicibusque maioribus distincta." *P. clavariaeformis* is recorded "in foliis viventibus *Ribis* (*glandulosae* R. et. P.?) ad lacum dictum Quillon rei publicae argentinae (regionis andinae)"; also on *Embothrium coccineum* from the same locality, and on *Adesmia* sp. "im Pilolilthal (Argentien, Quellgebiet des Rio Alominé)."

Neger states that he finds, from an examination of the material in the Berlin Herbarium, that the penicillate cells of the perithecia of *P. corylea* are in their unbranched part relatively short (about 30–40 μ), while in *P. clavariaeformis* this part is considerably longer (60–100 μ). The main difference, however, according to Neger, between *P. corylea* and *P. clavariaeformis* is stated thus : Man beobachtet, dass bei *Ph. guttata* [= *P. corylea*] die Pinselzellen sich unmittelbar am Scheitel in zahlreiche an der Spitze mit einem stark lichtbrechenden Knopfversehene Fäden zertheilen; nur selten ist am Scheitel der Stielzelle eine seichte Zwei oder Dreitheilung zu beobachten. Bei *Ph. clavariaeformis* hingegen ist die Stielzelle in einer gewissen Höhe (ca. 30 bis 70 μ von der Basis entfernt) in 3, seltener 2 Aeste getheilt. Diese Verzweigung ist im entwickelten Zustand mehrfach wiederholb und überaus charakteristisch. Sie erinnert an diejenige gewisser verzweigter *Clavaria*-Arten; die fadenartigen Ausläufer der Verzweigungen unterscheiden sich in nichts von denjenigen der *Ph. guttata.*"

In order to ascertain if the characters here given were sufficiently distinctive and sufficiently constant to be of specific value, I have examined the whole of the rich material of *P. corylea*—

numbering several hundred specimens—in the Kew herbarium. The evidence obtained from the examination of these specimens (which come from all parts of the world) forces me to conclude that "*P. clavariaeformis*" is not a distinct species from *P. corylea*, and further that it is impossible to give specific value to such characters as the shape, size, etc., of the penicillate cells. The shape of the penicillate cells, in "*P. clavariaeformis*" is shown at *pl. 10, f. 1–6*, drawn from specimens (now in the Kew herbarium), on *Embothrium coccineum*, sent by Dr. Neger. Most of the cells are branched in a more or less "clavarioid" manner as described by Neger, but intermixed with these there occur not uncommonly apparently fully grown cells which are scarcely branched at all. (See *figs.*) In two specimens of the fungus called *P. Antarctica* by Spegazzini on *Ribes Magellanicum*—one from "Carren-leofù, Patagonia andina, January, 1900 (Spegazzini),"—the other (leg. P. Dusén, May, 1896) sent by Dr. Neger from Dr. Rehm's Herbarium,—the penicillate cells are formed as shown at *pl. 10, f. 10–12*. The majority of the cells show a "clavarioid" branching like that found in "*P. clavariaeformis*," and mixed among these simple or only slightly branched cells occasionally occur. In a third specimen, also on *R. Magellanicum* of "*P. Antarctica*" from "Lion Range, nr. Gregory Bay, Patagonia, April 20, 1882 (Spegazzini)"—the type locality—the penicillate cells are quite as much branched (see *pl. 10, f. 7–9*) as in "*P. clavariaeformis*," so that were the plant possessing penicillate cells with "clavarioid" branching to be kept distinct from *P. corylea*, it would have to bear the older name of *P. Antarctica* Speg. Dr. Neger writes to me that he is now of the opinion that his "*P. clavariaeformis*" is identical with "*P. Antarctica*." In a specimen labelled *P. corylea* from "Puente de Vapas, Andibus Mendozinis, 2,500 m. alt., March 2, 1901, in foliis vivis *Adesmiae* sp.," sent by Professor Spegazzini. I have found after examining some thirty or forty perithecia only unbranched penicillate cells (see *pl. 10, f. 13*). This is interesting as Neger has referred (52) a *Phyllactinia* on *Adesmia* sp. to "*P. clavariaeformis*." We must conclude, therefore, that on the same genus of host-plants, if not on the same species, the penicillate cells of *Phyllactinia* are sometimes simple and sometimes branched. An example on *Excoecaria* from "Paraguay, May 1883, nr. 3815" sent by Professor Spegazzini as "*P. suffulta* (Reb.) Sacc." [= *P. corylea*] is of interest from the fact that on the same perithecium we find, in about equal number, simple and branched penicillate cells (*pl. 10, f. 14–15*). [This is the plant recorded by Spegazzini, in "Fungi Guaranatici" (Anal. Soc. Cientif. Argentina, **20**: 66. 1886) as growing on *Colliguaya Brasiliensis.* This last name must therefore be expunged from the list of host-plants of *P. corylea*, as Professor Spegazzini has now written "*Excoecaria*" on the label of the specimen.]

It is, however, when we observe the variation which occurs in the shape of the penicillate cells in examples of *P. corylea* from different parts of the world that we obtain the most convincing evidence as to the worthlessness of the characters given as distinguishing "*P. clavariaeformis.*"

Taking first examples on various hosts in the United States, we find that a perfect series of intermediates exists between forms having branched or unbranched penicillate cells. In the specimens in Rav. Fung. amer. exsicc. no. 624, on *Alnus serrulata*, we find "clavarioid" branching in comparatively short cells (*pl. 10, f. 16–18*), on *Corylus Americana* similarly shaped cells occur, on *Alnus serrulata* (from South Carolina) much branched cells (*pl. 10, f. 16–18*), quite similar to those of "*P. clavariaeformis*," are found intermixed with unbranched ones; the same may be observed in the specimens in Ellis' North American Fungi, no. 1327, (*a*), on *Corylus Americana* (from Pennsylvania). Branched penicillate cells, intermixed with unbranched ones, also occur in specimens on *Carpinus Americana* (from Illinois) (see *pl. 10, f. 19*), on *Vaccinium stamineum* (from West Virginia) and on *Cornus Nuttallii* and *Quercus* (*pl. 11, f. 1*). The most remarkable North American form of *P. corylea*, however, occurs on *Catalpa syringaefolia*, from Aiken, South Carolina (Roumeg. Fung. select. exsicc. no. 4756). Here the branched stem-cell is, comparatively, extremely broad, measuring up to 35 μ across (*pl. 11, f. 2–5*). If, following Neger (see above) we took such a character as the length of the stem-cell of the penicillate cells as of specific value, then we should be compelled to make another "species" of a plant possessing such remarkably shaped stem-cells as these found on the *Phyllactinia* on *Catalpa.*

Proceeding to European material we may notice first that in some specimens of *P. corylea* on *Corylus Avellana* a slight but distinct branching is found in some of the penicillate cells. I have seen this in specimens from Surrey, England (*pl. 11, f. 7*), and in the specimens in Briosi e Cavarra, Fung. par. no. 170, from Italy. Ina specimen on *Corylus Colurna* from Copenhagen most of the stem-cells are branched at the apex in the manner shown at *pl. 11, f. 8*. The same occasional branching is found in some specimens on *Alnus*, *e. g.*, in Fckl. Fung. Rhen. no. 704 (*pl. 11, f. 11*). The degree of branching gradually increases until we find forms like that which occasionally occurs on *Betula alba* (see *pl. 11, f. 9, 10*) from Germany in which the branching is as "clavarioid" as that found in the South American "*P. clavariaeformis*." In certain specimens occurring on *Alnus glutinosa* (see *pl. 11, f. 12, 13*) drawn from a French example we find an elongated stem-cell, up to 80 μ long, as is usually the case in *P. clavariaeformis* (*cf. pl. 9, f. 1–5*). In a specimen on *Cornus Mas* from Italy (in Sacc. Myc. Ven. no. 625), several cells branched in the manner shown at *pl. 11, f. 14*, were found on the same perithecium amongst quite simple ones.

In most Japanese examples of *P. corylea* the penicillate cells were found to be unbranched, but here, as apparently everywhere in the geographical range of the species, occasional forms occur with a "clavarioid" branching. In specimens on *Magnolia conspicua* (*M. Yulan*), we find branched and unbranched cells in about equal number on the same perithecium (see *pl. 11, f. 17–19*). In the large form of *P. corylea* on *Paulownia imperialis* (see monograph, p. 233) the stem-cell may reach to a height of 110 μ, and be either branched or unbranched. (See *pl. 11, f. 15–16.*) Distinctly branched penicillate cells also occur, intermixed with unbranched ones, on Japanese examples of *P. corylea* or *Alnus incana* var. *glauca* and on *Broussonetia papyrifera.*

We must conclude, I think, from the evidence given above, that *P. clavariaeformis* has no claims to be considered a distinct species, but that it is merely a form of *P. corylea* which appears occasionally—and certainly not confined to any definite host-plants—throughout the geographical range of this species, and that moreover it is a form which merges imperceptibly into typical *P. corylea* (*cf.* figs. on *pl. 10, 11*). Considering the peculiar shape of the penicillate cells shown by some forms we may perhaps suspect that in such variation there is to be found the origin of an incipient species—in other words that throughout the geographical range of *P. corylea* an incipient species is evolving on these lines from the parent form. The characters of this form, however, are not yet sufficiently sharply marked off, and are altogether too sporadic in appearance to allow us to give the form a place in systematic classification.

As is now well known, the apex of the perithecium of *P. corylea* is provided with a mass of penicillate cells—outgrowths from the external cells of the perithecial wall—which at a certain stage in the ripening of the perithecium and probably under certain external conditions, become mucilaginous and perform a curious function in the life history of the species. At the stage referred to the perithecium bears a large whitish mucilaginous drop on its upper surface. Neger (54) mentions that he has observed swimming about in isolated patches over the surface of this drop a foam-like mass, the separate bubbles of which bear a strong resemblance to polygonal thin-walled cells. This is evidently, as Neger observes, the structure represented by Tulasne (Carpologia, **1** : *pl. 1. f. 2, 5, 6*) as a continuous cellular membrane covering over the penicillate cells. In contact with water the cellular appearance of this mass is soon lost, and the whole disappears, leaving nothing behind but a mere trace of a hyaline mucilaginous substance. Neger states that the foam-like mass, together with the mucilaginous drop, is excreted from the perithecium. By a mechanism to be described later, the attachment of the perithecia to the leaf is destroyed, and each perithecium stands free on the points of its reflexed appendages among the hairs, etc., of the leaf, and is liable to fall at the slightest touch to the leaf or to be blown away by a breath of wind. At this stage the wall of the ultimate branches of the penicillate cells breaks down into a mucilaginous substance. When the fungus reaches a new substratum, the reflexed position of the appendages causes the apex of the perithecium, bearing its drop of mucilage, sooner or later to come into contact with the surface of the leaf, etc., on which the perithecium has fallen. The mucilage adheres to the substratum, and hardens, so that a reattachment of the perithecium, in a reversed position, takes place, and so firm is this attachment that some force is necessary to remove the perithecium with a needle. This curious phenomenon can easily be observed in nature, since on most host-plants perithecia are to be found late in the season attached to the upper surface of the leaves—a position in which they could not, in most cases, have originated, but which is to be explained by their having dropped off from the under surface of higher borne leaves, and become reattached by the mucilaginous cells. This reattachment has been the cause of leading systematists into several curious errors. In the first place there is no doubt that the numerous herbs given as hosts for *P. corylea* are not hosts in the true sense of the word at all, but are merely the plants to which perithecia, blown by the wind or fallen from the leaves of trees above, have become attached in the manner just described. Neger (**53**) records the occurrence of perithecia transferred in this way to plants of *Viola*, *Urtica*, *Onobrychis*, *Lamium*, etc., which were growing under a tree of *Corylus* attacked by *P. corylea*. Saccardo (**66**) records on *Plantago lanceolata* perithecia of *P. corylea* "evidently proceeding from leaves of trees." I have seen perithecia firmly attached to the wood of *Fraxinus* (see monograph, p. 234), and they have been recorded also on grasses and on *Pertusaria* by Bagge (see Fuckel, Symb. Myc. 80). The fungus recorded as "*Erysiphe graminis* DC.?" on the leaves and stems of *Poa nemoralis* and *Festuca sylvatica* by Richon (Cat. Champignons de la Marne, 232, 1889) with the description "Les périthèces sont ornés de 6 ou 8 appendices simples et renflés à la base. Il constitue probablement une variété de *Phyllactinia suffulta* non signalée par les anteurs et différente de l'*Erysiphe graminis* de Saccardo," may now safely be identified as *P. corylea*. "*Erysiphella Carestiana* Sacc." was founded on perithecia attached by means of their penicillate cells to the pileus of *Fomes fomentarius*. There seems also every reason to believe that the "*Erysiphe fungicola*" of Schulzer on *Boletus duriusculus* is nothing more than *P. corylea*. Hazslinszky (**27**, p. 181) gives the following description of the fungus: (I am indebted to Professor A. Mágócsy-Dietz for the translation from the Hungarian): "Perithecien zerstreut und nicht zahlreich, winzig; auf einem aus radförmig-strahlig sich verbreitenden Mycelfäden sich aufbauenden besonderen Mycelium. Asci länglich mit 1–5 Sporen. Anhängsel ähnlich denen von *Ph. guttata.* Conidien wurden bis jetzt noch nicht beobachtet. Auf verkümmerten Fruchtkörper von *Boletus* bei Vinkovce in Slavonien Königreich Ungarn." From this description we may conclude, I think, that perithecia of *P. corylea,* attached by their penicillate cells to the pileus of the *Boletus,* were under observation. In Schulzer's original diagnosis (Oest. Bot. Zeit. **26**: 58. 1876), the description occurs, "Die Pyrenien [= perithecia] sitzen, jede für sich, auf einem aus strahlenförmigen kürzeren und längeren Hyphen bestehenden Mycelium." The "mycelium" here described by both authors, probably refers as Neger (**53**) has suggested, to the spreading penicillate cells, which frequently form a membranous mycelium-like layer under the perithecium and often extend a little way beyond it.

The loosening of the perithecium from its original point of attachment is, as Neger (**54**) has pointed out, brought about by a special contrivance. The wall of the bulbiform base of the appendages is, according to Neger, thickened in all parts except in the lower quadrant nearest the perithecium (see *pl. 11, f. 20, 21*), copied from Neger. If a living perithecium (the appendages of which will be spreading horizontally more or less in the plane of the leaf on which the fungus is growing) is placed in a dry atmosphere or in a salt solution, the watery contents of the basal bulbous part of the appendage diffuse through the thin-walled part. This causes a folding to take place at this spot (see *f. 20*) and a consequent turning downward of the whole appendage, until at last the perithecium is forced away from its point of attachment and stands loose on the points of the reflexed appendages. In a damp atmosphere, or in contact with water, the bulb swells out again in the folded part, and so causes the appendages to become horizontal again. Neger observes that an appreciable force is exerted by the appendages in turning downwards in the manner described above, and mentions that a rather thick cover-glass, which was placed on four perithecia, was, in an exsiccator, easily raised up by them.

It is worth while noting that some examples of *P. corylea* on *Fraxinus excelsior* possess asci which nearly always contain three spores. This is the case, *e. g.*, with the specimens in Rabenh. Fung. Eur. 1056 (from Saxony), in which nearly all the asci are trisporous, only rarely being bi- or tetrasporous (see *pl. 9, f. 14, 15*). This fact is interesting for two reasons. In the first place, for the evidence it affords in the question of the specific worth of "*P. Candollei* Lév." (see monograph, p. 230); and, secondly, for the parallel it offers to the variation found in *Uncinula polychaeta*. This species of *Uncinula* in the United States possesses as a rule regularly bisporous asci, only very rarely showing three (or, according to Tracy and Galloway, four) spores in the ascus; in China and Japan, however, the asci are usually trisporous, but sometimes bisporous, or rarely show four or even five spores. In the case of *U. polychaeta* the form which shows an increased number of spores in the ascus is more or less definitely connected with a certain area in the geographical range of the species, while in *P. corylea* this variation occurs quite independent of locality.

P. corylea has been described as being sometimes amphigenous; I believe, however, that this is erroneous, and that its mycelium is always strictly hypophyllous. The description of the species as epiphyllous is probably due to the fact that perithecia attached by their penicillate cells occur very commonly on the upper surface of leaves, and also to the fact that an epiphyllous species of mildew may grow on the same leaf with the *Phyllactinia*. In the Kew herbarium, *e. g.*, there are leaves of a *Quercus*, from the United States, which bear on the under surface the mycelium and perithecia in all stages of development of *P. corylea*, while on the upper surface there are the mycelium and perithecia of *Microsphaera alni*, and among the mycelium perithecia of *P. corylea* attached by their penicellate cells.

Freeman (20) has recorded the occurrence of *P. corylea* on *Tilia* sp. from Minnesota, U. S. A., but the author has since written to me that this record must be expunged, the host-plant proving to be probably a species of *Cornus*.

Feltgen (18) wrongly refers the name "*Erysiphe stellata γ alni* Marchand to *Microsphaera alni*. Marchand (49) described his plant as follows: "*E. stellata* N. Hypophylla, filamentis plurimis, tenibus, stellato-expansis. N. *β coryli* N.—*Erysiphe coryli* Hedw. *γ alni* N.—*E alni* DC." The description given, and the synonymy quoted, show without doubt that *P. corylea* was intended.

Explanation of Plates

(All figures, unless otherwise stated, are magnified 400 times)

PLATE 9

FIG. 1. Conidial stage of *Erysiphe polygoni* DC. on *Anthriscus sylvestris*, from Reigate, England, Sept. 1900; conidiophore bearing a single conidium, and conidia.

FIG. 2. Conidial stage of *E. polygoni* DC. on *Heracleum sphondylium*, from Reigate, England, Oct. 1900, two conidiophores, each bearing a single conidium and conidia.

FIGS. 3–6. *Microsphaera euonymi* (DC.) Sacc. on *Caragana frutescens*, from Russia (in herb. Jaczewski); 3–5, apex of three appendages of the perithecium; 6, ascus and ripe ascospores.

FIG. 7. Conidia of *E. polygoni* DC. on *Sisymbrium Alliaria*, from Kew, England, Oct. 1900.

FIG. 8. Conidial stage of *E. polygoni* DC. on *Delphinium hybridum*, from Kew, England, Sept. 1900; two conidiophores, each bearing a single conidium, and conidia.

FIG. 9. Germinating conidium of *E. polygoni* DC. on *Delphinium hybridum* in a drop of water, showing the formation of an appressorium at the point where the germ-tube came in contact with the cover-glass.

FIG. 10. Apex of an appendage of the perithecium of "*Microsphaera Myoschili* Neger" (=*M. alni* (Wallr.)) on *Myoschilos oblongum*, from the Andes, Argentine Republic (ex herb. Neger.)

FIG. 11. Apex of an appendage of the perithecium of *M. alni* (Wallr.), on *Rhamnus cathartica*, from Brandenburg, Germany (Rehm. Ascomycet. no. 1117).

FIG. 12. Ascus and ripe ascospores of "*Erysiphe Fricki* Neger" (=*E. polygoni* DC.), on *Geum Chiloënse*, from the Argentine Republic (ex. herb. Neger).

FIG. 13. Lobed haustoria of *E. galeopsidis* DC. on *Tagetes minuta*, from Lincoln, Argentine Republic (ex. herb. Spegazzini), × 670.

FIGS. 14, 15. Tri- and tetrasporous asci of *Phyllactinia corylea* (Pers.) Karst., on *Fraxinus Ornus*, from Saxony (Rabenh. Fung. eur. no. 1056).

FIGS. 16, 17. Apex of two (partly immature) appendages of *Microsphaera alni* (Wallr.) on *Berberis vulgaris*, from Russia (Jacz. Kom. Tranz. Fung. ross. exsicc. no. 337 b., sub *M. berberidis*).

PLATE 10

Penicillate cells of the perithecium of *Phyllactinia corylea* (Pers.) Karst., from examples from different parts of the world.

FIGS. 1–6. "*P. clavariaeformis* Neger," on *Embothrium coccineum*, from the Argentine Republic (ex herb. Neger); 6, ascus and ripe ascospores of same.

FIGS. 7–9. "*P. Antarctica* Speg.," on *Ribes Magellanicum*, from Lion Range, nr. Gregory Bay, Patagonia (ex herb. Spegazzini).

FIGS. 10–12. *P. Antarctica* Speg.," on *Ribes Magellanicum*, from Patagonia (ex herb. Dr. Rehm).

FIG. 13. On *Adesmia* sp., from the Argentine Republic (ex herb. Spegazzini).

FIGS. 14–15. On *Excoecaria* sp., from Paraguay (ex herb. Spegazzini).

FIGS. 16–18. On *Alnus serrulata*, from South Carolina, U. S. A. (Rav. Fung. amer. exsicc. no. 624, in herb. Kew).

FIG. 19. On *Carpinus Americana*, from Illinois, U. S. A. (Herb. Kew).

PLATE 11

Penicillate cells of the perithecium of *Phyllactinia corylea* (Pers.) Karst., from examples from different parts of the world.

FIG. 1. On *Quercus*, from the United States (Herb. Kew).

FIGS. 2-5. On *Catalpa syringaefolia* from South Carolina, U. S. A. (Roumeg. Fung. select. exsicc. no. 4756, in herb. Kew).

FIG. 6. On *Corylus Americana*, from Illinois, U. S. A. (Herb. Kew).

FIG. 7. On *Corylus Avellana*, from Surrey, England.

FIG. 8. On *Corylus Colurna*, from Copenhagen, (Herb. Kew).

FIGS. 9, 10. On *Betula alba*, from Germany (Herb. Kew).

FIG. 11. On *Alnus* sp. from Germany (Fckl. Fung. Rhen., no. 704, in herb. Kew).

FIGS. 12, 13. On *Alnus glutinosa*, from France (Herb. Kew).

FIG. 14. On *Cornus Mas*, from Italy (Sacc. Myc. Ven. no. 625, in herb. Kew).

FIGS. 15, 16. On *Paulownia imperialis*, from Japan (Herb. Kew).

FIGS. 17, 19. On *Magnolia Yulan*, from Japan (Herb. Kew).

FIGS. 20, 21. Bulbous base of an appendage of *P. corylea;* 20, in a turgescent condition; 21, on loss of turgescence, × 300 (from the drawing given by Neger (**54**, *f.* 14.

FIG 22. Ascospores from an example of *Podosphaera oxyacanthae* (DC.) de Bary, on *Crataegus Oxyacantha*, from Italy. The figures are copied from drawings made by Dr. Spegazzini on the specimen in his herbarium (see p. 84).

(To be concluded.)

Development of the Embryo-sac and Embryo of Castalia odorata and Nymphaea advena*

By Melville Thurston Cook

(With Plates 12 and 13)

The systematic position of the Nymphaeaceae has long been an unsettled question, since the family presents some characters of both monocotyledons and dicotyledons. The purpose of this study was to reach some satisfactory conclusion as a result of observation on the development of the embryo-sac and the embryo. *Castalia odorata* Dryand, and *Nymphaea advena* Soland, were selected and the study has shown that they differ in very few and minor points in their development. Since beginning these investigations, Lyon has published "Observations on Embryogeny of Nelumbo" (9) in which he reaches the conclusion that it is a true monocotyledon in which the single cotyledon bifurcates, thus giving rise to the two fleshy bodies.

The material was killed and fixed in Flemming's osmic-chromo-acetic solution and in chromo-acetic. It was then washed, passed through alcohol, imbedded in paraffine and cut with Minot microtome. The stains used were haematoxylin and iron alum, safranin and gentian violet, and cyanin and erythrosin. The first and second combinations were especially successful. The safranin and gentian violet was especially good for demonstrating the antipodals. A large number of slides were prepared and most of the points figured were observed many times.

Development of the Megaspore and Embryo-sac

The archesporial cell develops from the hypodermis and is easily distinguished from the surrounding cells. In one instance two archesporial cells were observed. The archesporial cell enlarges (*fig. 1*) and the first tapetal cell is formed by a transverse division (*fig. 2*). Other tapetal cells are formed in a very irregular manner as a result of the division of the first. Two

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* Contributions from the Botanical Laboratory, Ohio State University.

tapetal cells may be formed by a periclinal wall (*f. 3*) or by an anticlinal wall (*f. 4*) or three may be formed by the formation first of an anticlinal wall followed by a periclinal wall in one cell only, or four may be formed by two periclinal walls followed by one anticlinal in one cell only, or by one anticlinal wall followed by two periclinal walls (*f. 5*).

The formation of the potential and the functional megaspores was not observed but many cases of the growth of the functional megaspore and degeneration of the potential megaspores were observed (*f. 6–9*). In one case two well-developed functional megaspores were observed lying side by side (*f. 10*).

The embryo-sac is perfectly straight and develops rapidly, enlarging principally in the direction of its longer axis, the greater growth being towards the micropyle at the expense of the tapetal cells (*f. 11–13*). An abundance of starch usually appears in the developed megaspore and persists throughout the two- and four-celled stages (*f. 9, 11, 12*). The antipodal cells are very small and disappear about the time of the conjugation of the polar nuclei (*f. 13*). In only one instance were they observed to persist until the beginning of the formation of the endosperm.

With the formation of the endosperm nucleus the egg apparatus becomes very distinct (*f. 14, 15*). The synergids are quite apparent and at least one of them persists for a very long time (*f. 23, 28*).

Shortly after the conjugation of the polar nuclei (*f. 13, 14, 15*) and fertilization of the egg (*f. 16*) the endosperm nucleus divides and a very delicate but definite wall is formed across the sac (*f. 16, 17*) similar to that described by Schaffner for *Sagittaria* (**12**).

The upper nucleus thus formed moves toward the embryo and rapidly forms the endosperm (*f. 17* and *text fig. 1*). This end of the sac enlarges rapidly and becomes filled with endosperm (*f. 21*) which persists until the embryo is fully formed but the cell walls gradually become thinner and the protoplasm gradually disappears as the embryo approaches maturity.

The other cell formed by the division of the endosperm nucleus grows towards the chalazal end of the ovule, forming a tube by the absorption of the nucellus and leaving in its trail a long string of protoplasm reaching back to the endosperm which never enters this tube (*f. 17, 18, 19* and *text fig. 1*). The formation of this tube is in the axis of the ovule, where the nucellus cells are slightly elongated and have very thin walls. These cells are absorbed very readily, the fragments along the sides of the tube usually being very few and very small. The nucleus reaches the chalazal end of the ovule about the time the embryo is in quadrant stage (*text fig. 1*). Upon reaching the chalazal end of the ovule the end of the tube enlarges, the cell making a corresponding enlargement and then degenerating (*f. 20, a, b*). This process is complete when the embryo and endosperm are in the stage represented by *f. 21*.

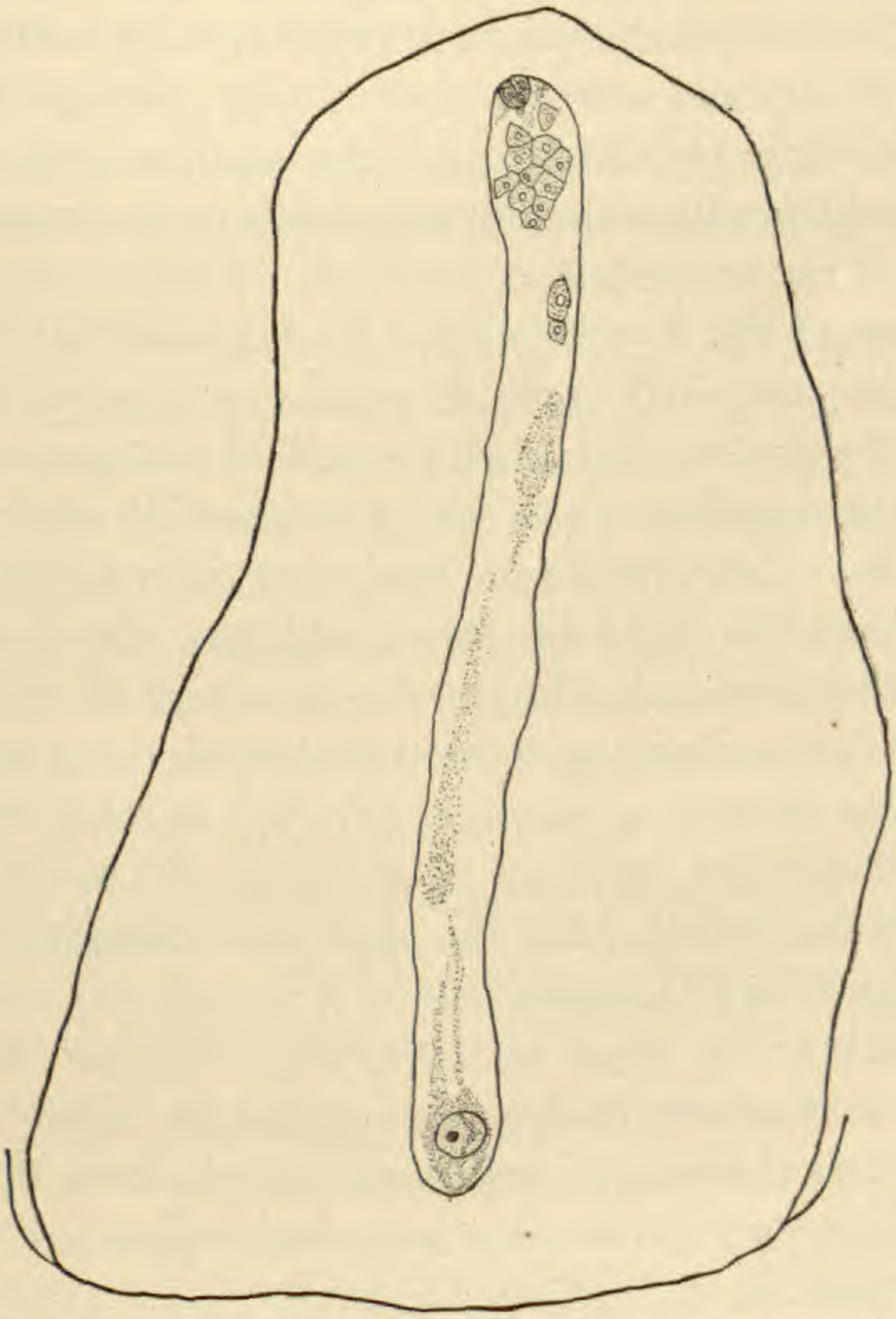

FIG. 1. Tube formed by lower endosperm nucleus. Three-celled embryo and endosperm in upper end of tube, lower endosperm nucleus in lower end of tube. Fig. 19 drawn from same section.

Hegelmaier, in his "Untersuchungen über die Morphologie der Dikotyledonen-Endosperms" (7), describes four types of endosperm development which he designates as: (1) "Allseitig-pheripersche" (*e. g., Adonis, Caltha, Cotoneaster, Malva, Hibiscus*). (2) "Peripherisch-simultanen" (*e. g., Bocconia, Scabiosa,, Euphorbia*). (3) "Einseitig peripherischen" (*e. g., Trigonella, Phaseolus, Fagopyrum*). (4) "Endogene" (*e.g., Eranthis*). In the Nymphaeaceae we apparently have a type intermediate between the third and fourth with greater resemblance to the third type, but differing from it in the appearance and activity of the lower endosperm nucleus.

The physiological significance of this nucleus presents a very interesting problem which should be considered in connection with the function of the antipodals.

In the case of the Ranunculaceae as described by Coulter (**1**) the very large antipodals indicate some very important function which is emphasized by Campbell's study of *Sparganium simplex* (**5**) in which he describes a very great increase in the number of antipodal cells. Lloyd's researches on *Vaillantia hispida* (**10**) seem to throw some light on this problem. He describes the behavior of the antipodals, the third and lowest of which form a haustorium which projects back into the disintegrating megaspores and apparently bearing a nutritive relation to the embryo-sac. Guignard in his recent paper on *Naias major* (**6**) describes two of the antipodals degenerating and the upper one enlarging long after the fertilization of the öosphere.

Chamberlain in his paper on *Aster Novae-Angliae* (**3**) describes and figures a peculiar enlargement of the lower antipodal and believes that one of the nuclei represents an oösphere, thus emphasizing Strasburger's view that the antipodal region is homologous with the prothallium of the Gymnosperms.

Whatever may be the physiological or morphological significance of the antipodals in the plants to which we have just referred and whatever it may have been in the past we find many plants to which Strasburger's view cannot be applied.

In many cases the antipodals are very small and without function but we frequently find other structures which are apparently performing a similar function to that described by Lloyd for *Vaillantia hispida* (**10**). In *Lilium Philadelphicum* (**2**) Coulter describes an enlargement of the sac with the three disorganizing antipodals in a small caecum-like structure. Riddle (**11**) in her studies on *Alyssum macrocarpum* describes a decided enlargement of the sac, and an increase in the endosperm with a very pronounced accumulation of endosperm cells in the antipodal region, usually obscuring the antipodals which are very small and apparently functionless.

In Schaffner's studies of *Sagittaria variabilis* (**12**) we have a condition very nearly that found in the Nymphaeaceae. The endosperm nucleus divides and a wall is formed across the sac; the lower part of the sac does not enlarge greatly as in the Nymphaeaceae and the antipodals persist but the nuclei resemble very closely those I have described for the Nymphaeaceae.

We find further evidence on this point in the papers on *Potamogeton* by Wiegand (**15**) and by Holferty (**8**). Wiegand describes for *P. foliosus* (**15**) a sac of seven nuclei, three forming the egg apparatus and three the antipodals and one very large nucleus which he calls the fourth antipodal and states that a little later it divides into two and that a wall forms across the sac at this point, separating the two nuclei thus formed. He furthermore states that the upper of these two new nuclei divides forming the endosperm, the lower remaining undivided. Holferty describes *P. natans* (**8**) as forming the normal eight-celled sac and the polar nuclei as fusing in the normal manner.

From these two papers it seems possible that Wiegand failed to observe the conjugation of the polar nuclei and that the division of the fourth large antipodal was really a division of the endosperm nucleus as in *Sagittaria* and the Nymphaeaceae.

It seems unreasonable to suppose that the antipodals are without physiological significance in those plants where they are prominent. In the Ranunculaceae, in *Sparganium*, and in *Vaillantia* the antipodals appear to furnish nourishment for the embryo. The peculiar haustorial development of the antipodal of *Vaillantia*, the enlargement of the lower antipodal in *Aster*, the accumulation of endosperm in the antipodal region of *Alyssum*, and the large lower nucleus formed by a division of the endosperm nucleus in *Sagittaria* and the Nymphaeaceae show a resemblance which I believe indicates similar physiological functions. The mere enlargement of the sac of *Lilium* and many other plants may accomplish the same result by absorption of the surrounding cells of the nucellus.

A very pronounced sclerification was developed in the inner part of the epidermal cells just before maturity of the embryo-sac (*f. 6–9, 11–13, 16*). These cells separated readily from the underlying cells of the nucellus and from each other; often the microtome knife would tear them loose and pressure upon the cover-glass of a fresh preparation was usually sufficient to separate them. Although fertilization was observed but once (*f. 16*) and then the path of the pollen tube could not be traced, I am inclined to believe that it occurs in the usual manner.

DEVELOPMENT OF THE EMBRYO

The embryo becomes very prominent (*f: 16*) and divides by a transverse division which is usually oblique (*f. 22, 23*). This is followed by the formation of a quadrant (*f. 23*) and an octant (*f. 24*), the embryo retaining its spherical form. In one instance a distinct twelve-celled embryo (*f. 25*) was observed. The formation of the octant is not always regular and the divisions following this are very irregular, especially in *N. advena*, but the embryo retains its spherical condition until fully half developed and becomes free in the sac (*f. 26, 29*). The free spherical condition corresponds to the condition observed in *Nelumbo* by Lyon (9).

In one case polyembryony (*f. 27*) was observed and was apparently due to the splitting of a very young embryo, since the embryo may typically be said to have two or four basal cells, while in one case of polyembryony each embryo showed one distinct basal cell.

When well advanced there is an increased activity in the division of the cells on the side of the embryo farthest from the micropyle (*f. 29, c*). This is the first appearance of the cotyledon the growth being forward and lateral, the edges being slightly curved so as to form a sort of elongate tray with the main spherical part of the embryo placed at one end (*f. 30, 31*).

A few cells next to the micropyle, probably the original basal cells, show increased activity shortly after the first appearance of the cotyledon growth and eventually forms the suspensor which projects towards the micropyle as a short cone-like organ, but does not become attached to the walls of the embryo-sac (*f. 29, s, 32, s*) and does not appear to be of any great value.

The cotyledon was not observed to bifurcate (*text fig. 2*), as Lyon describes for *Nelumbo* (9), although embryos older than

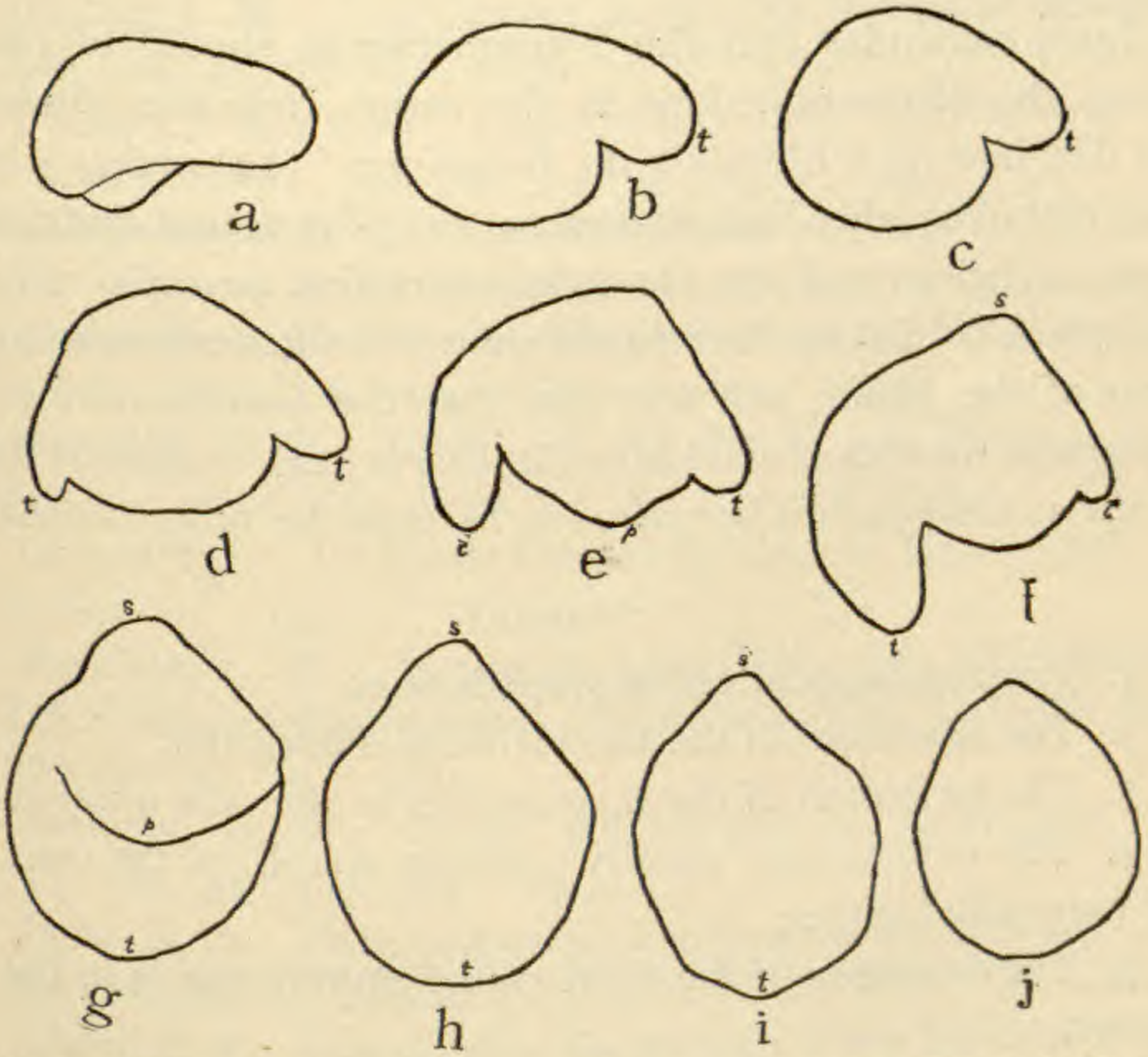

FIG. 2. Outline drawings from series of sections of single embryo of *N. advena* showing relation of parts. *s*, suspensor; *p*, plumule; *t*, cotyledon.

those figured were examined. Soon after the appearance of the suspensor there is an increased activity of the remaining spherical part of the embryo, resulting in the formation of a plumule (*f. 31, plum.*). This agrees with *Nelumbo* (9) as described by Lyon. The primary root is formed by an increased activity of cells between the suspensor and plumule (*f. 31, r*) and also agrees with *Nelumbo* as described by Lyon.

The embryo in its development cannot be said to show a marked resemblance to any of the monocotyledonous plants to which we might suppose it to be related. Aside from the suspensor it compares fairly well with *Lilium* and *Erythronium*. However, the development of the embryo-sac bears a striking resemblance to *Potamogeton*, *Naias*, and *Sagittaria*. The formation of tapetal cells and of megaspores is very similar to that described by Holferty for *Potamogeton* (**8**) and Campbell for *Naias* (**4**). The first division of the definitive nucleus and the formation of the wall across the sac is the same as observed by Schaffner in *Sagittaria* (**12**).

Lyon concludes that the Nymphaeaceae should be classified among the Monocotyledons in the series Helobiae (Naiadales). Van Tieghem in "Elements de Botanique" (**14**) makes a special class including the Nymphaeaceae and Gramineae between the Monocotyledons and the Dicotyledons which he calls "Liorhizes Dicotylees." Taking into consideration the general anatomy and habits of the plants, and the fact that the formation of a lower endosperm nucleus is similar to *Sagittaria* (**12**), it appears that the Nymphaeaceae should be placed in or near the order Naiadales.

SUMMARY

1. The archesporial cell is hypodermal.
2. The formation of the tapetal cells is irregular.
3. The formation of the megaspores is after the usual manner.
4. The embryo-sac usually contains starch in the one-, two-, and four-celled stages.
5. The formation of the eight-celled embryo-sac is in the usual manner.
6. At least one of the synergids persists for a very long period.
7. The antipodals are very small and disappear early.
8. The endosperm nucleus divides and a wall is formed across the embryo-sac between the two nuclei. The upper forms true endosperm, the lower a tube extending to the chalazal end of the ovule for absorbing the cells of the nucellus.
9. The embryo is at first spherical and later forms a single cotyledon.
10. The suspensor is late in forming and apparently without function.
11. The family Nymphaeaceae should be placed in or near the order Naiadales.

The writer wishes to express his thanks to Professor J. M.

Coulter and Dr. Charles J. Chamberlain, of the University of Chicago, for valuable suggestions in the first part of the investigation, and to Professor J. H. Schaffner, of the Ohio State University, for very valuable assistance in the later studies.

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Explanation of Plates

PLATE 12

Castalia odorata (except Fig. 16 which is *C. Zanzibariensis*).

FIG. 1. One archesporial cell.

FIG. 2. One archesporial cell and one tapetal cell formed by a periclinal wall.

FIG. 3. Archesporial cell and two tapetal cells formed by periclinal wall.

FIG. 4. Archesporial cell and two tapetal cells formed by anticlinal wall.

FIG. 5. Archesporial cell and four tapetal cells.

FIG. 6. Functional megaspore and three dissolving megaspores and two tapetal cells

FIG. 7. Functional megaspore and dissolving megaspores and tapetal cells.

FIG. 8. Functional megaspore and dissolving macrospores and tapetal cells.

FIG. 9. Functional megaspore and dissolving megaspore and tapetal cells. Starch in functional megaspores.

FIG. 10. Two functional megaspores. (Missing nucleus was in next section.)

FIG. 11. Two-celled embryo-sac containing starch.

FIG. 12. Four-celled embryo-sac containing starch.

FIG. 13. Eight-celled embryo-sac Conjugating polar nuclei. Degenerating antipodals.

FIGS. 14, 15. Mature embryo-sac with egg apparatus and endosperm nuclei.

FIG. 16. Fertilized egg and pollen tube. First division of the endosperm nuclei. The two nuclei separated by a wall.

FIG. 17. Separation of the two nuclei after division of the definitive nucleus. Fertilized egg and one synergid.

FIG. 18. Lower nucleus formed by division of definitive nucleus about one-third way down ovule.

FIG. 19. Lower nucleus (from text figure 1).

FIG. 20*a*. Lower nucleus in the enlarged end of the tube. Nucleus degenerating.

FIG. 20*b*. Same as 27*a*.

PLATE 13

Nymphaea advena (except Figs. 21–24, which are *C. odorata*).

FIG. 21. Upper end of tube enlarged and containing embryo and endosperm. Age corresponds to Fig. 20.

FIG. 22. Embryo of three cells. One synergid.

FIG. 23. Embryo of four cells. One synergid.

FIG. 24. Embryo of eight cells.

FIG. 25. Embryo of twelve cells. (The other three cells were found in the next section.)

FIG. 26. Spherical embryo.

FIG. 27. Double embryo.

FIG. 28. Spherical embryo. One synergid.

FIG. 29. Spherical embryo showing beginning of cotyledon (*c*) and suspensor (*s*)

FIG. 30. Embryo showing spherical part of embryo and the cotyledon.

FIG. 31. Embryo showing cotyledon, two leaves of plumule (*plum.*) and root (*r*).

FIG. 32. Section from same embryo as 31 showing suspensor (*s*).

New and noteworthy Northwestern Plants—VI

By C. V. Piper

Antennaria Hendersoni sp. nov.

Loosely tufted, bearing at base ascending stolon-like branches 3–6 cm. long; whole plant covered with a closely matted white tomentum, which becoming slightly looser on the stem: flowering stems erect, 20–35 cm. high: basal leaves crowded, narrowly oblanceolate, not petioled, acute and often curved at tip, 15–30 mm. long, 3–4 mm. broad; cauline leaves scattered, linear-oblanceolate, acute, gradually reduced upward: heads numerous, rather loosely corymbed; involucre 5–6 mm. high, woolly below; bracts pale, sometimes slightly brownish at base, the white papery tips rather obtuse and somewhat lacerate, the inner ones twice as long as the outermost: pappus white.

Mt. Adams, Wash., Aug. 6, 1892, *L. F. Henderson, 2290* in part; pistillate plants only.

The species here proposed is clearly not referable to any hitherto recognized from the Cascade Mountains and does not agree with any described Rocky Mountain species. It is nearest perhaps to *A. nardina* Greene.

Antennaria leucophaea sp. nov.

Whole plant silvery with a closely appressed tomentum, apparently tufted, the woody base bearing leafy surculose stolons 3–4 cm. long: flowering stems leafy to the inflorescence, erect, 8–14 cm. high: leaves numerous, sessile, linear or linear-oblanceolate, acute, 2–5 cm. long, the lowest with broader somewhat scarious partly sheathing bases: heads in a single dense cluster or corymbed: involucre oblong-cylindric, woolly only at the base, 5–7 mm. high; bracts in several series, linear-lanceolate, acute or acutish, scarious, brownish except the white tips: pappus white: male plant unknown.

Klickitat, Wash., May 15, 1882, *Thomas Howell* (type); Little Klickitat Valley, Wash., May, 1880, *Suksdorf, 283*. (The locality and number of the Suksdorf specimen are open to question as it is mounted with specimens of *A. lanata* Greene, the one label being apparently a combination of two original ones.) Both collections are in the Gray Herbarium.

In the Synoptical Flora the Howell specimen was referred to *A. luzuloides* T. & G. from which the brown involucre and stoloniferous habit clearly separate it. It is probably nearest *A. stenophylla* Gray but is larger in every way besides being stoloniferous.

Madia ramosa sp. nov.

Annual, erect, 25–30 cm. high, loosely branched above, finely hirsute throughout, stipitate-glandular except at the base: leaves few, alternate, or the lowest opposite, only 2–5 pairs below the inflorescence, all sessile, linear, acute, 2–4 cm. long: inflorescence a loose cyme: heads solitary and lateral or 2–4 in terminal clusters, the lateral heads sessile or nearly so; heads oblong or narrowly ovate, flattened, 7–10 mm. long: disk-flowers 1–4, yellow; ray-flowers wanting, rarely 1–2, the ligule very short: akenes 5 mm. long, curved, broadest near the apex, mostly carinate on one face.

Blue Mts., Walla Walla county, Wash., *Piper, 2451*, Aug. 2, 1896 (type).

Sterile mountain ridges 5,000 ft. alt. Eastern Oregon, *Cusick, 1789*, Aug., 1897.

A close ally of *M. glomerata* Hook., differing essentially in its much smaller size, glandular pubescence, sparse leafiness and loose inflorescence.

CACALIOPSIS NARDOSMIA **glabrata** var. nov.

Differs from the typical form as follows: leaves larger, 10–60 cm. in diameter, green above from the first, at length becoming glabrous beneath also: petioles relatively longer, 20–60 cm. long: heads smaller, less than 20 mm. high (20–25 mm. in the type): corolla shorter, about 15 mm. long; corolla-lobes proportionately longer, one half the length of the broader part of the tube (only one fourth the length of the broad part of the tube in the type): akenes 4 mm. long (4–7 mm. in the type).

The types of *C. nardosmia* Gray are from Sonoma, Humboldt and Mendocino counties, California. All of the Washington specimens differ from the Californian in the particulars pointed out. No specimens have been seen from Oregon.

Klickitat county, *Suksdorf*, 1883 (type in the Gray Herbarium). Klickitat River, *Flett, 1104*. Simcoe Mts., Howell. Stevens Pass, *Sandberg & Leiberg, 564*. Roslyn, *Whited, 425*. Without locality, *Vasey, 252*.

MENTHA ARVENSIS **lanata** var. nov.

Size and habits of var. *Canadensis* Briquet (*M. Canadensis* L.), but the calyx, stem, petioles and often the whole under side of the leaf-blade densely lanate-pubescent.

Specimens examined:

WASHINGTON: Parrotts P. O., *Lake & Hull, 603*, Aug. 5, 1892 (type in the Gray Herbarium). Wilson Creek, *Lake & Hull*, Aug. 5, 1892.

IDAHO: Kootenai county, *J. H. Sandberg*. Mud Lake, Kootenai county, *Sandberg, MacDougal & Heller, 734*. "Fort Colville to Rocky Mts.," *Lyall* in 1861.

CALIFORNIA: Santa Barbara, Sept., 1882, *Mrs. R. F. Bingham;* Clear Lake, Aug. 16, 1882, *Pringle*.

Synthyris schizantha sp. nov.

Rootstocks short, creeping: radical leaves reniform-orbicular, 5–7-nerved, indistinctly lobed, doubly dentate, glabrous above, pubescent beneath, especially on the veins, 5–12 cm. broad; petioles exceeding the blades, pubescent: flowering stem pubescent, 20–25 cm. high, bearing a pair of nearly sessile ovate-orbicular leaves, 2–3 cm. long, just below the inflorescence: raceme 4–6 cm. long in flower, rather dense, viscidly pubescent; bracts lanceolate, entire or the lower ones laciniately few toothed at apex, 5–8 mm. in length, about as long as the pedicels: calyx-lobes subequal, lanceolate and entire, or those of the lower flowers often toothed or even laciniately cleft: corolla blue, 5–6 mm. long, the subequal lobes all deeply cleft into narrow divisions: ovules about 3 in each cell: fruit not seen.

Baldy Peak, Olympic Mts., Wash., July 24, 1897, *Frank N. Lamb, 1343*.

A handsome species nearest related to *S. reniformis* Benth. The pubescence is apparently clammy viscid. On account of the peculiar corolla, some slight modifications in the generic characters are necessitated.

LOMATIUM MACROCARPUM **artemisiarum** var. nov.

Differs from the type essentially in its pubescence but otherwise quite as variable. In the typical form the pubescence is tomentose, especially in the inflorescence. In the variety here proposed there is no trace of this tomentose character, the plant being everywhere puberulent with short erect hairs.

This is the common form in the sage-brush of the Columbia Valley. The following specimens have been examined, all from Washington: Pasco, *Piper*, *2976*, May 26, 1899 (type). North Yakima, *Henderson*, *2509*, *2511*, *2574*, all collected May 25, 1892, Prosser, *Henderson*, *2510*, May 26, 1892. Crab Creek, *Sandberg & Leiberg*, *243*, June 19, 1893. Without locality, *Vasey*, *308*.

The Vasey specimen is about 40 cm. tall with carpels 20–24 mm. long; the other specimens are 10–20 cm. tall with carpels 10–12 mm. long.

LOMATIUM MACROCARPUM **semivittatum** var. nov.

Ultimate leaf segments very narrowly linear or filiform: fruit narrowly winged, the dorsal ridges low; no oil-tubes on the dorsal side, 2–6 on the commissural side.

OREGON: Hood River, May 24, 1886 and Aug. 6, 1883, *Henderson*, *397* (type); Hood River, *Mrs. Barrett*, *71*.

WASHINGTON: West Klickitat County, *Suksdorf*, *279*.

This form differs from *L. macrocarpum* essentially as above. It may be a distinct species as all of the specimens of the typical form or of the preceding variety that we have examined have dorsal oil tubes. The Henderson specimens were referred by Coulter and Rose to *P. bicolor* Wats. in the Revision of the North American Umbelliferae. It resembles that species only in foliage.

Astragalus Whitedii sp. nov.

Hoary pubescent throughout, the erect or ascending stems 40–50 cm. high, simple or sparingly branched: leaflets 5–7 pairs, oblong or obovate, truncate or emarginate at apex, acute at the nearly sessile base, 5–10 mm. long, the pubescence similar on both faces; stipules small: peduncles mostly exceeding the leaves: racemes short, few (5–7)-flowered: calyx cylindric campanulate, the pubescence blackish, the short teeth one fourth as long as the tube: corolla yellowish-white, twice as long as the calyx: pods linear, cartilaginous, 1-celled without sutural intrusions, 2.5–3 cm. long, acute, rather turgid, sparsely pubescent, curved into a semicircle, the stipe-like base as long as the calyx.

Colockum Creek, twenty miles southeast of Wenatchee, Wash., May 17, 1901, *K. Whited*, *1353*; also young flowering specimens from the same station, collected in 1899.

An interesting new species of the § *Podo-sclerocarpus*, nearest related to *A. speirocarpus* Gray and *A. Gibbsii* Kell. It is a pleasure to name it after its enthusiastic discoverer.

ASTRAGALUS CYRTOIDES Gray, Proc. Am. Acad. **6**: 201

A careful examination of the type of this plant, collected on the Clearwater River, Idaho, by Spalding, shows it to be without question *A. collinus* Dougl. and not *A. Gibbsii* Kellogg. The specimens are in young flower.

The fruiting specimens from Carson City, Nevada, *Anderson*, which Dr. Gray referred in Proc. Am. Acad. **6**: 525 to his *A. cyrtoides*, are true *A. Gibbsii* Kell.

Philadelphus confusus sp. nov.

P. Gordonianus Bot. Calif. Not Lindley.

Shrub, 2–4 m. high, much branched above; bark pale, flaky: leaves ovate, acute or acuminate, rather thin, dentate or rarely entire, sparsely pubescent, 2–5 cm. long; petioles short: panicles 4–10-flowered, the lower one or two pairs of flowers in the axils of ordinary leaves: flowers odorous: calyx-lobes triangular-ovate, acute or acuminate, not twice as long as the tube, pubescent on the tips and margins within: petals pure white, oblong, 1.5–2 cm. long: styles united for two-thirds their length: stigmas rather broadly dilated: pods rather more than half inferior.

The common *Philadelphus* occurring from northern California to British Columbia west of the Cascade Mts. We have seen only two specimens from east of the Cascade Mts. that we would refer to *P. confusus*, namely: *Sandberg, Heller & MacDougal, 253*, Hatwai Creek, Idaho; *H. E. Brown*, July 16, 1896, Cañon City, Oregon.

As the type of *P. confusus* we would designate *Allen, 221*, collected on Tum Tum Mountain, Wash., Aug. 13, and Sept. 17, 1896.

The species differs from *P. Lewisii* Pursh essentially in its relatively shorter calyx-lobes, and the styles being united for two-thirds their length, whereas in *P. Lewisii* they are united only half their length.

P. Gordonianus Lindley is a synonym of *P. Lewisii* as indicated not only by Lindley's figure and description but by authentic cultivated specimens from Lindley in the Gray Herbarium. The type was grown from seeds collected by Douglas "along the banks of the Columbia."

Douglas, however, collected *P. Lewisii* also as shown by a specimen in Herb. Gray. There can be no doubt as to the identity of *P. Lewisii* as the type in the herbarium of the Philadelphia Academy is in fine preservation. It was collected by Lewis, "on the waters of Clark's River," July 4, 1806. Dr. Elliott Coues says this means "Hellgate River, between Missoula, Mont., and the mouth of Big Blackfoot River, in Missoula county, Montana."

P. Lewisii ranges from the east slope of the Cascade Mts. of Oregon, Washington and British Columbia eastward to western Montana. We have not seen any specimen of it from west of the Cascade Mountains.

New Species of Uredineae—II

BY J. C. ARTHUR

The following species of Uredineae have come to light, for the most part, from material kindly sent me by various collectors and students. In some cases they proved to be entirely unrepresented in my herbarium, but in other cases they had been known for some time, yet in too fragmentary condition to permit of description. Collections of what appear to be common species but upon unusual hosts often prove, when studied in connection with large series, to be new or otherwise interesting forms. Collections from previously unexplored regions generally well repay careful study, even if at first sight they seem to contain nothing new. All the species of this paper, except one from India, are from various parts of the United States. Thanks are due and are hereby extended to the several persons who contributed the material herein cited, as well as other material used for comparison during the study.

Uromyces Rickerianus sp. nov.

I. Aecidia more hypophyllous than epiphyllous, in dense clusters; substratum scarcely thickened; peridia pale, low, erose; aecidiospores globose to oblong, 16–22 × 18–26 μ; wall thin, minutely verrucose, appearing smooth.

III. Teleutosori at first intermixed with the aecidia, especially on the petioles, elliptical, reaching 4 mm. in length, long covered by the delicate, gray epidermis, at length pulverulent, chocolate-brown; teleutospores dark brown, globose to oblong, somewhat irregular, 20–25 × 23–35 μ, wall medium thick, apex not noticeably thickened, both apex and base rounded, pedicel colorless, fragile, very short.

On leaves of *Rumex Geyeri* (Meisn.) Trel., Teton Pass, Wy., July 13, 1901 (*Elmer D. Merrill* and *E. N. Wilcox*, no. 1217, comm. by P. L. Ricker).

The aecidia of this species bear a striking resemblance to those of *Puccinia phragmitis*, but have a little thinner and smoother wall, and are a trifle smaller; the gross appearance is about the same. The species is named in recognition of the interest taken in plant rusts by Mr. P. L. Ricker, of the Bureau of Plant Industry, Washington, D. C., who has listed the Uredineae of Maine, and is now studying collections from the western United States.

Uromyces rottboelliae sp. nov.

X. Amphisori hypophyllous, oblong, prominent, soon naked, chestnut-brown, ruptured epidermis noticeable; amphispores obovate-globose, 18–25 × 25–30 μ, wall thick, 3 μ, golden brown, finely and closely tuberculate, pores 4, equatorial, pedicel colorless, delicate, about the length of the spore, semi-persistent.

III. Teleutospores globoid, of about the size and color of the amphispores, side wall about 2 μ thick, apex much thickened (8 μ), broad and almost truncate, base rounded, pedicel colorless, delicate, about the length of the spore, persistent.

On *Rottboellia speciosa* Hack. Jaunsar, Northwest Himalayas, India, 7,000 ft. alt., October, 1894 (*J. F. Duthie*, comm. by P. L. Ricker). This species was detected upon specimens in the phanerogamic herbarium of the U. S. Department of Agriculture by Mr. P. L. Ricker. It is notable for being the first Old World species observed possessing amphispores, so far as the writer knows. The amphisori have the gross appearance of teleutosori, the spores being dark colored and persistent. True uredospores were not seen, unless a few spores from parasitized sori were such; they differed from the amphispores only in having thin, yellow walls. Nor were teleutosori seen, the spores described being scattering ones from amphisori. In North America amphispores are known in *Puccinia vexans* Farl., and in a number of other species, but in none belonging to the genus *Uromyces*.

Puccinia tosta sp. nov.

O, I. Spermogonia and aecidia unknown.

II. Uredosori amphigenous, small, brownish yellow, soon naked, ruptured epidermis inconspicuous; uredospores globose, 20–30 μ in diameter, wall brownish yellow, thin, about 1.5 μ, closely and minutely tuberculate, pores 6 or more, scattered.

III. Teleutosori amphigenous, prominent, round or oblong, blackish brown, early naked, ruptured epidermis not visible; teleutospores globoid to oblong, 20–30 × 30–40 μ, rounded at both ends, slightly if at all constricted, side walls medium thick, apex thickened, 5–10 μ, pedicel thick, firm, tinted, once to twice the length of the spore, or longer.

On leaves and sheaths of *Sporobolus cuspidatus* (Torr.) Wood, Spirit Lake, Iowa, March, 1884 (*J. C. Arthur*), which is taken as the type, Aberdeen, S. D., Sept. 7, 1897 (*David Griffiths*), and Callaway, Neb., Oct. 2, 1901 (*J. M. Bates*, no. 2028). Also on *Sporobolus utilus* Torr., Las Vegas, N. M., Oct. 5, 1901 (*T. D. A. Cockerell*, comm. F. S. Earle), and Cochise, Ariz., Oct., 1900 (*David Griffiths*), and on *Sporobolus asperifolius* (N. & M.) Thurb., Billings, Mont., Aug., 1898 (*Williams & Griffiths*, comm. David Griffiths).

A rather common species in the semi-arid parts of the West, heretofore confused with other species of *Puccinia* on *Sporobolus*, more particularly with *P. sporoboli* Arth. The teleutospores are much shorter and more rounded than in *P. cryptandri* E. & B. and *P. vilfae* A. & H., and much shorter, broader, and the two cells more nearly equal in size than in *P. sporoboli* Arth. The uredospores of the four species are even more unlike, and are readily distinguished. In *P. sporoboli* they are echinulate, pores more than 4 and scattered; in *P. cryptandri* they are echinulate with 4 equatorial pores; in *P. vilfae* they are tuberculate, with wall colorless, apex thickened and pores obscure; and in *P. tosta* they are tuberculate with wall colored, pores more than 4 and scattered. The form on *S. asperifolius* is somewhat divergent, but not markedly so in the specimen examined. The host of the two specimens recorded as on *S. utilus* is sometimes called *S. repens* Presl., but it is possible that neither name is correctly used for this grass, a very common form in the Southwest.

Puccinia tosta luxurians var. nov.

II. Uredospores slightly larger than in the species, more strongly tuberculate, almost echinulate, wall thicker, about 2 µ.

III. Teleutosori elongated, in part linear with acute ends; teleutospores larger, oblong, 27–32 × 43–55 µ.

On *Sporobolus airoides* Torr., Andrews, Ore., Aug., 1901 (*Griffiths & Morris*, comm. David Griffiths), which is taken as the type, and on same host, Billings, Mont., Sept., 1898 (*Williams & Griffiths*, comm. David Griffiths). In both gross and minute characters this form on *S. airoides* differs somewhat from the previously described species, but for the most part the differences appear to be what might come from a more luxuriant development. Nevertheless the degree and uniformity of divergence make it seem the better course to keep this form by itself for the present. The wisdom of the course will be shown when a larger series of specimens can be examined and cultures made.

Puccinia aspera Dietel & Holway, sp. nov.

III. Sporen auf beiden Seiten der Blätter und an den Blattstielen, bisweilen Verkrümmungen hervorbringend, rundlich, gross, nackt, pulverig, kastanienbraun; Teleutosporen elliptisch oder oblong, in der Mitte schwach eingeschnurt, an beiden Enden abgerundet, an der Basis bisweilen verschmälert; Epispor am Scheitel nicht oder nur wenig verdickt, gelbbraun, von groben unregelmässigen Warzen rauh, 30–42 × 18–24 μ; Stiel hinfällig.

On *Saxifraga Mertensiana* Bong., Mt. Paddo, Wash., 7,000 ft. alt., Aug. 17, 1897 (*W. N. Suksdorf*, no. 537). This species resembles *Puccinia Jueliana* Diet., but has much larger and more pulverulent sori, and somewhat larger and slightly rougher spores. The description and part of the type specimen were transmitted to the writer by the authors of the species.

Puccinia turrita sp. nov.

III. Teleutosori amphigenous, rounded, .5–1 μ in diameter, early naked, chestnut brown; teleutospores elliptical or oblong, slightly abstricted, 20–24 × 37–48 μ, base rounded, apex acute or obtuse, very coarsely and irregularly tuberculate, especially at the apex, pedicel delicate, fugacious.

On *Saxifraga bronchialis* L., Manitou, Colo., Aug. 13, 1888 (*E. W. D. Holway*). The spores of this species are much rougher than those of *P. aspera* D. & H.; they remind one of the roughness of the teleutospores of *Phragmidium subcorticium* Wint. The four saxifrage species, *Puccinia Pazschkei* Diet., *P. Jueliana* Diet., *P. aspera* D. & H., and *P. turrita*, form a series, the spores of all being nearly of the same size and general shape, but showing an increasing roughness of the surface, and shortening of the pedicel. They appear to be distinct species, however, and not merely variations of one form. The indications are that all four species are without aecidia and uredospores, but this can not be stated positively.

Puccinia adenostegiae sp. nov.

III. Teleutosori caulinicolous, round or united into effused masses, early naked, cinnamon-brown, ruptured epidermis inconspicuous; teleutospores oblong, 15–22 × 45–67 μ, slightly constricted at the middle, apex obtuse, acute or sometimes acuminate, much thickened, base scarcely narrowed, side walls thin, pedicel delicate, somewhat tinted, as long as the spore or shorter.

On *Adenostegia pilosa* (A. Gray) Greene (*Cordylanthus pilosus* Gray), foothills near Stanford, Cal., Jan. 1, 1902 (*LeRoy Abrams*, comm. F. S. Earle). As many as three fourths of the spores in this collection, which was made in mid-winter, and therefore on dead stems, had germinated. The species appears to belong to the leptopuccinia group.

Uredo panici sp. nov.

Chiefly hypophyllous; sori oblong, intercostal, brownish yellow, early naked, ruptured epidermis inconspicuous; spores oval or globoid, 24–28 × 26–37 μ, wall thin, golden yellow, closely and conspicuously echinulate, pores more than 4, scattered.

On *Panicum amarum* Ell., Longboat Key, Fla., April 27, 1900 (*S. M. Tracy*, no. 6598), on Hog Island, Fla., Nov. 26, 1901 (*S. M. Tracy*, no. 7292, comm. F. S. Earle). The latter collection, which is accompanied by flowers of the host, is taken as the type. This uredo from its general appearance undoubtedly belongs to some *Puccinia* or *Uromyces*, although not a teleutospore could be discovered. The spores are larger than in any North American species inhabiting *Panicum* now known; the size of the spores, character of the surface, and arrangement of the pores, easily distinguish it.

Uredo cephalanthi sp. nov.

Sori mostly hypophyllous, small, irregularly bullate, distributed without order, pale, long covered by the epidermis; spores small, at first pedicellate, obovate-globose, 16–20 × 20–26 μ, wall thin, about 1 μ, closely and minutely echinulate, pores obscure, seemingly 4 and equatorial.

On *Cephalanthus occidentalis* L., Palmetto, Fla., Nov. 30, 1901 (*S. M. Tracy*, no. 7288, comm. F. S. Earle).

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Studies on the Rocky Mountain Flora—VIII

By Per Axel Rydberg.

Stanleya arcuata sp. nov.

Perennial with a ligneous caudex, 4–10 dm. high, perfectly glabrous ; stem light green and shining, in age straw-colored : leaves entire or the lower with short and broad lobes, lanceolate, long-petioled, thick, 5–12 cm. long ; pedicels rather short, in fruit, about 1 cm. long : sepals yellow, linear about 15 mm. long ; petals yellow ; blades 7–8 mm. long, broadly elliptic, almost as long as or at least two thirds as long as the claw : pods 7–10 cm. long, strongly arcuate, and spreading.

This species is nearest related to *S. integrifolia*, but is taller, more shrubby, with narrower leaves and broader petals. *S. pinnata* (Pursh) Britton, with which both have been confused, has hairy leaves, most of which are deeply pinnatifid, and the blades of its petals are linear oblong and only one third or one half as long as the claws. *S. arcuata* grows in dry regions from Wyoming to Nevada and south to Colorado and Arizona ; probably also in California.

Nevada : Unionville Valley, 1868, *S. Watson, 105* (type in herb. Columbia University).

Stanleya canescens sp. nov.

Stout perennial .5–1 m. high ; stem light green, finely puberulent or glabrate, terete : leaves grayish puberulent, the upper entire and oblanceolate, 5–7 cm. long ; the lower pinnatifid with oblong lateral lobes and a large oval or elliptic end-lobe : raceme dense, pedicels short, in fruit 1 cm. or less long, divergent : sepals linear, about 12 mm. long ; blades of the yellow petals linear-oblong, about half as long as the claw : pods arcuate, spreading, 5–7 cm. long.

This is nearest related to the preceding, differing in the puberulent leaves, which are shorter and broader and more inclined to be pinnatifid.

Utah : Frisco, 1880, *M. E. Jones, 1809* (type in herb. N. Y. Bot. Garden).

Arizona : Fort Verde, 1887, *E. A. Mearns ;* Verde River, 1883, *H. H. Rusby ; Mexican Boundary Survey.*

Thelypodium macropetalum sp. nov.

A glabrous perennial, 4–6 dm. high: basal leaves oblanceolate or spatulate, short-petioled, 2–5 cm. long: lower stem-leaves oblong, obtuse, sessile, with rounded auricles at the base, 5–6 cm. long; upper leaves lanceolate-sagittate, acute; pedicels in fruit about 1 cm. long, divaricate: sepals about 5 mm, long, purplish with white margins; petals purple, spatulate, long-clawed, nearly three times as long as the sepals: pods 4–5 cm. long, ascending or erect and somewhat incurved.

This is related to *T. sagittatum* (Nutt.) Heller and *T. paniculatum* A. Nelson. From the former, it differs in the smaller leaves, the rounder auricles, the erect, not reflexed nor spreading pod; and from the latter by the much longer petals. It grows at an altitude of 1,000–1,200 m.

UTAH: Farmington, 1881, *M. E. Jones, 1841* (type in herb. N. Y. Bot. Garden).

IDAHO: Soda Springs, 1892, *Isabel Mulford.*

Thelypodium Utahense sp. nov.

Annual or biennial: stem 4–6 dm. high, sparingly pubescent below; leaves all lanceolate in outline, 5–10 cm. long, lanceolate, glabrous; segments broad and crowded, oblong-lanceolate to triangular: pedicels very short, in fruit scarcely more than 1 mm. long: sepals oblong, about 2 mm. long: petals spatulate, almost twice as long, white: pod about 3 cm. long, strongly reflexed.

This is probably nearest related to *S. reflexum* Nutt., which is decidedly hispid on the stem and the veins of the leaves and has much narrower leaf-segments. It grows at an altitude of about 600 m.

UTAH: St. George, 1880, *M. E. Jones* (type in herb. N. Y. Bot. Garden); 1877, *E. Palmer, 28.*

Lepidium Jonesii sp. nov.

Lepidium montanum var. *alyssoides* Jones, Zoe, **4**: 266. 1893. Not *L. alyssoides* A. Gray. 1849.

Perennial with a short woody caudex: stems 2–3 dm. high, glabrous, branched, glabrous: basal leaves pinnatifid with linear acute divisions; stem-leaves similar or the upper entire, narrowly linear: racemes rather short and dense; pedicels in fruit 6–8 mm. long, spreading: sepals oblanceolate, obtuse; petals white, much exceeding the sepals; blade broadly obovate: pod acutish, oval in outline, about 4 mm. long and slightly over 2 mm. wide, glabrous, reticulate, only slightly wing-margined above, retuse; style about twice as long as the width of the wing margins.

This species is in some respects intermediate between *L. alyssoides* and *L. montanum.* In the former only the lowest leaves are pinnatifid, the pod is more rounded and the style is shorter, scarcely longer than the width of the wing-margin. It is closer related to *L. montanum*, differing mainly in the longer and narrower leaf-segments, having a more persistent base and being less pubescent.

UTAH: St. George, 1880, *M. E. Jones, 1636* (type in herb. N. Y. Bot. Garden); Price, 1900, *S. G. Stokes;* southern Utah, 1874, *C. C. Parry, 18.*

NEVADA: Trinity Mountains, 1868, *S. Watson, 120.*

✓ **Lepidium elongatum** sp. nov.

Annual: stem branched near the base, about 3 dm. high, glandular pruinose above: basal leaves spatulate or oblanceolate, about 4 cm. long, coarsely toothed or somewhat pinnatifid with short lobes; stem leaves oblanceolate, tapering into a short petiole, entire or with a few small teeth, 3–4 cm. long, acutish: racemes elongated, at the ends of the branches, in fruit 1 dm. or more long: sepals oblong or oblanceolate, acute, thin and whitish; petals minute, linear-oblanceolate, one half to two thirds as long as the sepals or lacking: pods nearly orbicular, about 3 mm. broad, usually broadest a little above the middle, wing-margined and deeply retuse at the apex, glabrous or slightly pruinose: stigma sessile.

This species is nearest related to *L. apetalum* and *L. ramosissimum.* From the former it differs in the branching near the base, the more entire leaves, the somewhat larger pod and the petals which are generally present; and from the latter in the longer racemes, in the lack of the small axillary racemes characteristic to that species and a different pod. In *L. ramosissimum* this is broadest below the middle. *L. elongatum* grows on rocky hilltops.

WASHINGTON: Almata, 1896, *A. D. E. Elmer, 21* (type in herb. N. Y. Bot. Gard.).

IDAHO: About Lewiston, 1896, *A. A. & E. Gertrude Heller, 3008.*

Thlaspi Nuttallii

Thlaspi cochleariforme Nutt. Journ. Acad. Phila. **7**: 13. 1834. Not DC. 1821.

This species has been merged in *T. alpestre*, but none of our American forms belong to that species. *T. Nuttallii* is intermediate between *T. parviflorum* A. Nelson and *T. glaucum* A. Nelson, having larger flowers than the former and smaller than the latter. The pod is obovate, rounded at the apex with a narrow sinus. In *T. glaucum* the sinus is broad and open.

Roripa clavata sp. nov.

Biennial, tall, perfectly glabrous: stem 6–10 dm. high, simple up to the inflorescence: leaves lyrate-pinnatifid, 5–10 cm. long, more or less auricled at the base; lobes 4–8 pairs, oblong to ovate, obtuse or acute, broadly dentate: inflorescence branched; petioles in fruit 5–10 mm. long, divaricate: petals spatulate, about 3 mm. long, exceeding the sepals: pod 10–12 mm. long, 2.5–3 mm. thick, decidedly clavate, obtuse, strongly curved; style nearly 1 mm. long.

This may have been included in Watson's *Nasturtium terrestre* var. *occidentale*; but the name *occidentale* cannot be used as there is already another older *Roripa occidentalis* Greene. It is not, however, *Roripa Pacifica* Howell, which is supposed to be a synonym of Watson's variety, for that species is described as being slightly pubescent and having pods which are acute at both ends, while in *R. clavata* the pod is almost truncate at the apex.

WASHINGTON: Hogeman, Chehalis county, 1897, *Frank H. Lamb, 1221* (type in herb. N. Y. Bot. Gard.); West Klickitat county, 1885, *W. M. Suksdorf*.

OREGON: Sauvie's Island, 1888, *T. Howell, 1333*.

BRITISH COLUMBIA: Port Henry, 1889, *John Macoun*.

IDAHO: Near Hope, Kootenai county, 1892, *Sandberg, MacDougal & Heller, 1029*, at least in part.

Roripa Underwoodii sp. nov.

Biennial, divaricately branched, even near the ground, perfectly glabrous; stems 2 dm. or more high: leaves 3–5 cm. long, lyrately pinnatifid, thin; lobes oblong, obtuse; the terminal one elliptic to broadly oval, sinuately toothed; petioles short, winged and conspicuously auricled at the base: racemes numerous: pedicels short, in fruit scarcely more than 4 mm. long, diverging or even reflexed: sepals bright orange, obtuse; petals light yellow, scarcely equalling the sepals and not quite 1 mm. long: fruit (immature) 5–6 mm. long, slightly thicker at the base, abruptly contracted into a minute style, not .5 mm. long.

In general appearance, this species resembles most *R. palustris*, but it is more branched with divaricate branches, has much shorter pedicels, rather longer and more tapering pod and not half as long style. From *R. obtusa*, it differs in the shape of the leaves, which are less dissected, the shorter style and general habit. The type grew at an altitude of 3300 m.

COLORADO: Red Mountain, south of Ouray, 1901, *L. M. Underwood, 299a.*

Roripa integra sp. nov.

Biennial, glabrous: stems few, strict, branched above; basal leaves not seen as they are fallen off in the type specimen; stem-leaves spatulate or rhombic spatulate, 1–2 cm. long, not auricled at the base, entire or slightly sinuate: racemes slender, lax: petals 1.5 mm. long, scarcely exceeding the sepals; pedicels 1–3 mm. long, ascending: pod about 8 mm. long, somewhat curved: style about 5 mm. long.

The type specimen is labelled *Nasturtium palustre* var., but it is not closely related to this species. It is nearer *R. obtusa*, but differs in the entire leaves; the more tapering and more curved pod, the erect habit and the short style. It grows at an altitude of about 2700 m.

UTAH: Wasatch Mountains, 1869, *S. Watson, 64*, in part (type in herb. Columbia University).

Lesquerella arenosa (Richards).

Vesicaria arenosa Richardson, Frankl. Journ. App. 743.

Lesquerella Ludoviciana var. *arenosa* S. Wats. Proc. Am. Acad. **23**: 252.

This is amply distinct from *L. Ludoviciana* (DC.) S. Wats. or *L. argentea* (Pursh) MacM., by the more slender ascending stems, the shorter leaves, the oblanceolate, instead of linear stem-leaves and the comparatively larger and often somewhat ellipsoid pod. The range given in the Synoptical Flora should be extended to the Black Hills of South Dakota and northeastern Wyoming.

Lesquerella Shearis sp. nov.

Perennial with a large rosette of basal leaves; stems several, ascending, 1–2 dm. high, densely stellate: basal leaves 3–4 cm. long; blades broadly oval or ovate, entire or slightly angular denticulate; stem leaves oblanceolate, about 2 cm. long, subsessile: raceme many-flowered; pedicels in fruit bent S-shaped: pods erect, densely stellate, 7–8 mm. long, acute, compressed above; septum elliptic in outline: style about as long as the pod.

This species differs from *L. curvipes* A. Nelson in the broad basal leaves, the elliptic instead of ovate outline of the septum and the longer style. It grows along creek banks at an altitude of about 2000 m.

COLORADO: Idaho Springs, 1895, *C. L. Shear, 3269* (type in herb. N. Y. Bot. Gard.); also at the same locality, *P. A. Rydberg*.

Physaria brassicoides sp. nov.

A tufted perennial with a large and dense rosette of basal leaves and a thick taproot: basal leaves large, with winged petioles; blades almost orbicular in outline, sinuate-dentate, 2.5–5 cm. in diameter: stem leaves small and few, spatulate: flowering stems about 1 dm. high, ascending: flowers numerous: fruit almost obcordate, acute at the base, deeply divided above; cells inflated, rounded pyriform, 8–10 mm. long and 5–8 mm. in diameter: style about 5 mm. long.

This species resembles most *P. didymocarpa* in habit, but differs in the smaller fruit, which is not at all cordate at the base but on the contrary usually acute, and in the larger basal leaves which form a large rosette, 7–10 cm. in diameter and having some resemblance to a young cabbage-head. It grows in crevices of magnesian rocks in cañons and badlands.

NEBRASKA: Cañon south of Scott's Bluffs, 1891, *Rydberg*, 24.

Cardamine acuminata (Nutt.)

Cardamine hirsuta β acuminata Nutt.; T. & G. Fl. N. Am. **1**: 85. 1838.

This species has been variously referred to *C. hirsuta*, *C. oligosperma*, and *C. Pennsylvanica*. It is probably nearest related to the last, but the lower part of the stem is hairy and the pod has an evident style over 1 mm. long. It ranges from the Mackenzie River to British Columbia, south to California and Wyoming.

Cardamine multifolia sp. nov.

Stem about 2 dm. high, very leafy, lower part hirsute: leaves 4–6 cm. long glabrous; leaflets 7–13, oblong to oblong-obovate or oval, entire or sinuate-dentate; the terminal one larger and obovate: flowers numerous: petals spatulate, about 2.5 mm. long; pedicels ascending, about 8 mm. long: pod erect, about 2 cm. long and .75 mm. wide.

This is perhaps closest related to *A. parvifolia* L., but is more leafy, has shorter and broader leaf-segments and erect pods, and the plant is less diffusely branched.

IDAHO: Beaver Cañon, 1895, *P. A. Rydberg*.

UTAH: Wasatch Mts., 1869, *S. Watson, 80*, in part.

Sophia brevipes (Nutt.)

Sisymbrium canescens ζ (*brevipes* Nutt. MSS.) Torr. & Gray, Fl. N. Am. **1**: 92. 1838.

Sisymbrium Hartwegianum Fourn. Rech. Auct. & Tax. Fam. Cruc. & Gen. Sisymb. 66, in part. 1865.

Sisymbrium incisum var. *Hartwegianum* S. Wats. Bot. Calif. **1**: 41.

The plant described by Dr. Watson in the Botany of California and by Dr. Robinson in the Synoptical Flora (p. 139) is I think without doubt the var. *brevipes* of Torrey and Gray's flora. Probably also Bourgeau's plant, cited by Fournier, belongs here; but I think that it is very doubtful that Hartweg's plant, which must be regarded as the type of *S. Hartwegianum* Fourn., could be the same.

Sophia Californica (T. & G.)

Sisymbrium canescens ε (*Californicum*) T. & G. Fl. N. Am. **1**: 92. 1838.

This species is characterized by the large flowers, the sparingly stellate and often glandular-puberulent stem, the uniserial linear pod and once or twice pinnatifid leaves. The segments of the lower leaves are broad and obtuse, those of the upper linear to oblong. Its range extends from Montana to Washington south to California.

Sophia viscosa sp. nov.

Biennial, 5–10 dm. high: stem, at least the upper part, decidedly glandular or viscid-villous: leaves obovate or oblanceolate in outline, 3–10 cm. long, twice pinnatifid, densely pubescent; primary divisions of the lower leaves ovate and obtuse; those of the upper lanceolate and acute; secondary divisions oblong acute or obtuse, often few-toothed: inflorescence usually much branched; pedicels in fruit 8–12 mm. long: sepals yellowish, 1–15 mm. long, oblong; petals bright yellow, spatulate, about 2 mm. long: pod (in the specimens seen not fully developed) over 1 cm. long and less than 1 mm. wide: seeds uniserial.

This is perhaps nearest related to *S. incisa* (Engelm.) Greene; but differs in the dense viscid pubescence of the stem, the pubescent leaves and deeper divided primary segments. It grows among rocks and on grassy slopes.

IDAHO: Beaver Cañon, 1895, *C. L. Shear, 3029* (type in Herb. N. Y. Bot. Garden) and *3031*.

WYOMING: Trout Lake, 1899, *Aven & Elias Nelson, 5848;* Head of Pole Creek, 1895, *Aven Nelson, 1321*.

Sophia leptophylla sp. nov.

Stems 5–7 dm. high, sparingly glandular: leaves very thin, dark green, only once pinnate; segments of the lowest leaves rounded; those of the middle lanceolate and somewhat incised; the upper segments entire: pedicels slender, in fruit 5–8 mm. long, spreading: petals bright yellow, about 1.5 mm. long: pod linear, 8–10 mm. long, much less than 1 mm. wide, torulose, spreading, arcuate, curved up, uniserial.

This is nearest related to *S. incisa* (Engelm.) Greene, but differs in the less incised leaves and horizontal curved pod. It grows at an altitude of about 2000 m.

COLORADO: Foothills, Larimer county, 1895, *Crandall & Cowen, 55* (type in herb. N. Y. Bot. Gard.).

WYOMING: Antelope Basin, Albany county, 1900, *Aven Nelson, 7466;* Centennial Hills, 1895, *1686*.

Smelowskia Americana

Hutchinsia calycina Hook. Fl. Bor. Am. **1**: 58. 1834. Not Desv. 1814.

Smelowskia calycina Gray, Proc. Acad. Philad. 1863: 58. Not C. A. Mey. 1831.

While in Europe last summer, I looked up the Asiatic type of *S. calycina*, and this differs considerably from ours especially in the long villous pubescence.

Draba brachystylis sp. nov.

Perennial with a taproot: stems several, decumbent or ascending with divergent branches, 1–1.5 dm. high, hirsute: basal leaves oblanceolate or spatulate, 1.5–2 cm. long, hirsute with branched hairs; stem leaves few, oblong or lanceolate, sessile: pedicels short, in fruit 2–5 mm. long, spreading: pod oblong, finely stellate, 8–12 mm. long, ascending: style very short, almost obsolete.

The type sheet of this species is labeled *Draba Carolina* var. *micrantha*, but the plant evidently is a perennial and nearest related to *D. streptocarpa;* but differs in the divergently branched stem, stellate pod and the almost obsolete style. It grows at an altitude of about 3000 m.

UTAH: Alta, Wasatch Mts., 1879, *M. E. Jones, 1357* (type in herb. N. Y. Bot. Gard.).

Draba decumbens sp. nov.

Perennial with a taproot, a short cespitose caudex and a large rosette of basal leaves: stems decumbent, 1–2 dm. high, sparingly pubescent, few-leaved; basal leaves broadly spatulate, entire, 2–4 cm. long, finely grayish stellate, rather thick; stem leaves ovate to ovate-lanceolate, sessile, entire, 1–2 cm. long: calyx sparingly villous; petals pale yellow, about 4 mm. long: pedicels very short, in fruit 2–4 mm. long: pod oblong, 8–15 mm. long, densely pubescent, usually twisted: style about 1 mm. long.

This is a member of the *D. aurea* group, and distinguished from all the North American species by its decumbent stems, large, thickish entire basal leaves.

COLORADO: Gray's Peak, 1895, *Rydberg* (type in herb. N. Y. Bot. Gard.).

Draba Macouniana sp. nov.

Annual, almost scapose: stems ascending or decumbent, less than 1 dm. high, glabrous and shining; basal leaves numerous, broadly spatulate or obovate, 5–10 mm. long, finely stellate, rather thick; stem leaf usually one, oval, obtuse, 5 mm. long: petioles in fruit spreading, 6–8 mm. long: petals white, less than 3 mm. long: pod oblong-linear, erect, about 1 cm. long and 2 mm. wide: style obsolete.

This species is nearest related to *D. crassifolia*, but differs in the whiter flowers, and the broad and short basal leaves, which are finely stellate, not hirsute ciliate. The type grew at an altitude of about 2000 m.

British Columbia: Summit of Rocky Mountains, 1890, *John Macoun* (type in herb. Columbia University).

Draba Parryi sp. nov.

Annual, perfectly glabrous, except a few cilia on the petioles: stems several, usually less than 1 dm. high, scapiform or rarely with a stem leaf: basal leaves numerous, linear or narrowly linear-oblanceolate, 1.5–2.5 cm. long; pedicels spreading, in fruit 5–8 mm. long: flowers small; petals scarcely 2 mm. long, white or light yellow: pods erect, oblong, 5–8 mm. long, 1.5–2 mm. wide, glabrous: style obsolete.

This is closely related to *D. crassifolia* but the latter has broader leaves, which are more or less hirsute on the surface and distinctly ciliate on the margins.

Colorado: Foot of Gray Peak, 1872, *E. L. Greene* (type in herb. Columbia University); 1872, *C. C. Parry;* Cameron Pass, 1896, *C. F. Baker.*

Wyoming: Telephone Mines, 1900, *Aven Nelson, 7879.*

Draba cana sp. nov.

Perennial with a taproot and short cespitose caudex, whole plant densely grayish stellate; stem 1–2 dm. high, often branched: basal leaves numerous, oblanceolate or spatulate, 1–1.5 cm. long, entire or minutely but sharply toothed, densely stellate; stem leaves lanceolate to ovate, about 1 cm. long: racemes many-flowered; pedicels short, nearly erect, in fruit 2–3 mm. long: flowers small; petals white, about 3 mm. long: pod linear-oblong, 6–8 mm. long, densely pubescent: style about 5 mm. long.

This has gone under the name of *D. incana*, but the latter is much less densely stellate and has a glabrous, much broader pod. I have seen only one specimen of true *D. incana* from this continent, and it was collected in Labrador. Most of those under this name belong to *D. cana*, which ranges from Labrador to the Yukon Territory, south in the mountains to Colorado. The following is regarded as the type.

Alberta: Morley, foothills of the Rocky Mountains, 1887, *John Macoun* (herb. Columbia University).

Draba McCallae sp. nov.

Perennial with a cespitose base, whole plant sparingly stellate but green: stems several, simple, about 3 dm. high: basal leaves spatulate, 10–18 mm. long, entire or nearly so; stem leaves ovate, about 1 cm. long, sharply dentate or entire: raceme elongated; pedicels slender, in fruit about 1 cm. long, erect: petals white, 4–5 mm. long: pod (in the specimen not fully developed) ovate, densely but finely pubescent, much shorter than the pedicels: style 0.75 mm. long.

This species belongs also to the *D. incana* group, but differs from that species in the elongated peduncle, long pedicels, short pubescent pod and large petals.

Alberta: Valley below Mt. Aylmer, 1899, *W. C. McCalla, 2267* (type in herb. N. Y. Bot. Gard.).

Draba Columbiana sp. nov.

Perennial; with a cespitose base, sparingly and finely stellate and ciliate on the margin of the leaves: stems slender, about 2 dm. high, simple: basal leaves many, oblanceolate, 10–15 mm. long, denticulate or entire; stem leaves ovate to lanceolate, about 1 cm. long denticulate: raceme elongated, pedicels slender, ascending, 5–7 mm. long in fruit: flowers small; petals slightly over 2 mm. long, white: pods linear-oblong, finely pubescent, over 1 cm. long, style very short.

This species resembles much the preceding in habit, but the flowers are much smaller and the pods longer.

BRITISH COLUMBIA: Revelstoke, 1890, *John Macoun* (type in Herb. Columbia University).

Geranium Pattersonii sp. nov.

Cespitose perennial with a thick root and short caudex: stems ascending or diffuse, 2–4 dm. long, densely glandular villous with long spreading hairs, petioles of the basal leaves 5–10 cm. long, also glandular villous; blades reniform in outline, about 3 cm. broad, glandular villous on both sides, deeply 5–7-cleft; lobes broadly obovate-cuneate, 3-toothed; teeth broadly ovate, abruptly short-acuminate: stem leaves similar, but short-petioled or the uppermost subsessile: pedicels and calyx glandular long-villous; the former in fruit 1.5–2 cm. long: sepals in fruit about 8 mm. long, oval with a short bristle-tip about 1 mm. long: petals obovate about 1 cm. long, light purple, or rose color, with darker veins: style in fruit about 2 cm. long, glandular-pubescent; beak about 4 mm. long: carpels pubescent: seeds finely reticulate.

This species is perhaps nearest related to *G. Parryi* (Engelm.) Heller, but is lower, more densely glandular, has broader and shorter lobes to the leaves and their teeth are broadly ovate, abruptly acuminate, instead of lanceolate. The general habit is perhaps more like *G. caespitosum* James, but in that species the lower part of the stem is grayish-pubescent with short reflexed hairs. *G. Pattersonii* is a subalpine plant growing at an altitude of 2500–3000 m.

COLORADO: Gray Peak, 1895, *P. A. Rydberg* (type in herb. N. Y. Bot. Gard.); foot of Pikes Peak, 1896, *C. L. Shear, 3702;* mountains, near Empire, 1892, *H. N. Patterson, 177* and *176* in part; North Cheyenne Cañon, 1896, *Ernest A. Bessey;* also 1845. *Freemont, 61.*

Geranium strigosum sp. nov.

Geranium Richardsonii Wats. King's Rep. **5**: 49, in part. 1871. Not Fisch & May.

Erect perennial with a short thick rootstock: stem 4–8 dm. high, finely reflexed strigose; petioles of the basal leaves 2–5 dm. long, also sparingly strigose; blades reniform in outline, 7–12 cm. in diameter, finely strigose on both sides, deeply 7-cleft; divisions rhombic in outline, 3-cleft and toothed; teeth lanceolate, acute; stem leaves similar, but short-petioled; stipules linear-lanceolate, long-attenuate: inflorescence open, glandular pubescent: sepals densely glandular, oval, about 8 mm. long; bristle tips 1.5–2 mm. long; petals broadly obovate, rose color or light violet, strongly purple-veined: style in fruit about 3 cm. long, beak about 6 mm.: seeds reticulate.

This is nearest related to *G. viscosissimum*, but the corolla is lighter in color and the pubescence is different, being decidedly reflexed, strigose, not at all glandular, except on the inflorescence. It grows in the valleys to an altitude of perhaps 2700 m.

WYOMING: Copperton, 1901, *F. Tweedy, 4591* (type in herb. N. Y. Bot. Gard.); Big Horn Mountains, 1900, *3647.*

UTAH: City Creek Cañon, 1880, *M. E. Jones. 1871;* Parley's Cañon, 1901, *S. G. Stokes;* Black Rock and Uintahs, 1869, *S. Watson, 204.*

Oxalis Coloradensis sp. nov.

Perennial with a slender rootstock: stem slender, erect, 1–2 dm. high, sparingly villous; leaves digitately ternate; petioles 2–4 cm. long, sparingly villous: leaflets broadly obcordate, glabrous, 8–12 mm. long: peduncles very slender, about 5 cm. long: inflorescence cymose, but often reduced to 2–3 flowers; pedicels sparingly strigose: sepals 4–5 mm. long, oblong: petals yellow, 6–7 mm. long: pod cylindric with a conical apex, 12–15 mm. long, 2.5–3 mm. wide, glabrous.

This is nearest related to *O. cymosa* Small and *O. Brittoniae*, but differs from the former in the blunter sepals, the appressed pubescence of the pedicels and the glabrous pod, and from the latter in the simpler habit, the longer glabrous pod and paler and larger leaves. It grows in grassy valleys at an altitude of 1800–2500 m.

COLORADO: Sangre de Christo Creek, 1900, *Rydberg & Vreeland 5920* (type in herb. N. Y. Bot. Gard.); Foothills, Larimer county, 1895, *J. H. Cowen* (mixed with *O. stricta* L.).

Lupinus Scheuberae sp. nov.

Perennial; stem 4–6 dm. high, sparingly strigose or almost glabrous, slender: petioles of basal leaves about 1 dm. long; leaflets 7–8, oblanceolate, 5–7 cm. long, acute and mucronate, green, glabrous above, sparingly appressed pubescent beneath; stipules lanceolate, attenuate; stem leaves similar but shorter petioled: racemes 1–1.5 dm. long, not dense; bracts lanceolate, 7–8 mm. long, deciduous: flowers 10–12 mm. long: calyx densely white silvery puberulent, strongly gibbous above; lower lip lanceolate, fully twice as long as the triangular-ovate upper lip: corolla dark purple but lighter and almost white towards the base; banner slightly longer than the wings, silky puberulent on the middle of the back: pod densely white silky with appressed hairs, 2–4-seeded.

This is nearest related to *L. pseudoparviflorus*, but differs in the somewhat larger flowers, the strictly appressed white pubescence on the calyx and pedicels, the gibbous, but not spurred calyx, and the broad and short upper lip of the latter. It grows in woods at an altitude of 2,000–2,400 mm.

MONTANA: Garnet county, 1901, *Mrs. Emma Ware Sheuber, 135* (type in herb. N. Y. Bot. Gard.).

WYOMING: Copperton, 1901, *Frank Tweedy, 4216.*

Lupinus spathulatus sp. nov.

Lupinus parviflorus S. Wats. King's Rep. **5**: 1871. Not Nutt.

Perennial: stem 8–10 dm. high, glabrous or sparingly strigose above, leafy; stipules narrowly lanceolate, attenuate: petioles 3–5 cm. long; leaflets about 7, spatulate or broadly oblanceolate, about 4 cm. long, mucronate, those of the lower leaves obtuse, those of the upper more acute, glabrous above, finely puberulent beneath; raceme elongated, about 2 dm. long, many-flowered: flowers subverticillate; pedicels about .5 cm. long, as well as the calyx, pubescent with short spreading hairs; bracts lanceolate, attenuate, deciduous, longer than the buds; calyx gibbous at the base; lower lip lanceolate, about twice as long as the short ovate upper one: corolla dark blue, with lighter keel; banner glabrous, rounded and shorter than the wings.

This has been confused with *L. parviflorus*, which it closely resembles, differing mostly in the shape of the calyx; the lower lip in that species is only slightly longer than the upper and the banner is larger and less rounded. The type grew at an altitude of 2400 m.

UTAH: Wasatch Mountains, 1869, *S. Watson, 225* (type in herb. Columbia University).

Lupinus flavescens sp. nov.

Perennial: stem about 3 dm. high, appressed pubescent with rather long hairs: stipules lanceolate, densely hairy: petioles often over 1 dm. long, appressed silky; leaflets about 7, oblanceolate, 3–4 cm. long, appressed silky on both sides: inflorescence short; bracts lanceolate, early deciduous; pedicels 8–10 mm. long, as well as the calyx densely pubescent with short, spreading hairs: calyx gibbous at the base; its lips almost equal in length, both about 8 mm. long: corolla 12–14 mm. long, pale yellow; banner with a darker spot, glabrous.

The type has been known as *L. sulphureus* and was included therein questionably by Watson; but differs in the larger, paler flowers, and the longer lips of the calyx, and the longer pubescence.

IDAHO or MONTANA: Medicine Clay Prairies, *Wyeth* (type in herb. Columbia University).

Lupinus lucidulus sp. nov.

Perennial: stem 5–6 dm. high, branched above, finely silky strigose, especially the upper portions, leafy; stipules minute, ovate, acuminate: petioles 3–5 cm. long; leaflets 7–8, linear-oblanceolate, silky and silvery on both sides, about 3 cm. long: raceme 1–2 dm. long, lax: flowers scattered; pedicels and calyx densely pubescent with short strictly appressed silky hairs; lower lip of the calyx about 5 mm. long, lanceolate, almost twice as long as the short ovate upper one: corolla yellow or light pink; banner slightly exceeding the wings, with a few short hairs on the back, with a darker spot, about 8 mm. long: pods densely silky pubescent.

This species is nearest related to *L. sulphureus*, but differs in the more silvery pubescence, the smaller flowers and the appressed pubescence of the calyx and pedicels. The type grew at an altitude of 1900 m.

WYOMING: Spread Creek, 1897, *F. Tweedy, 271* (type in herb. N. Y. Bot. Garden).

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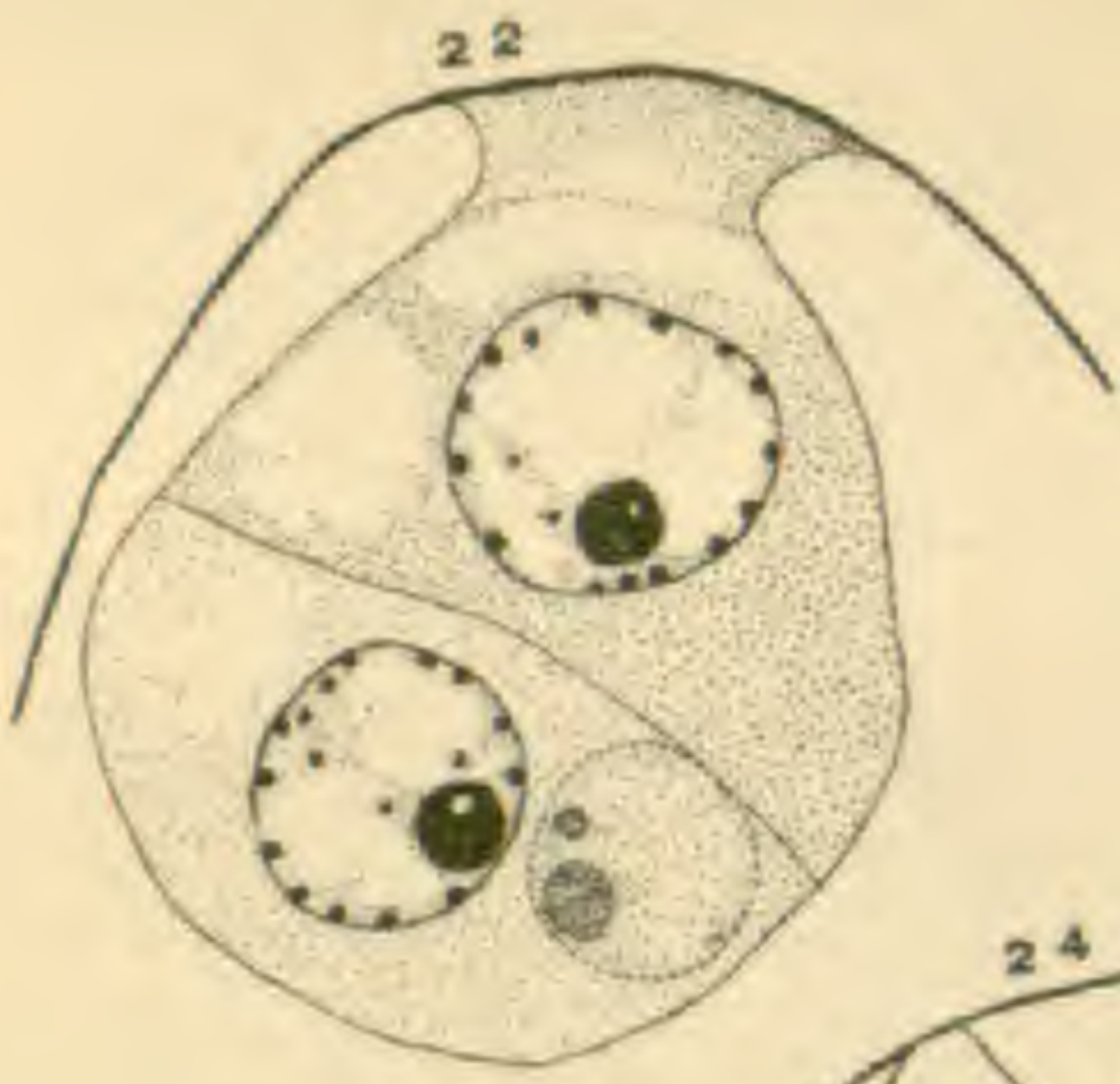

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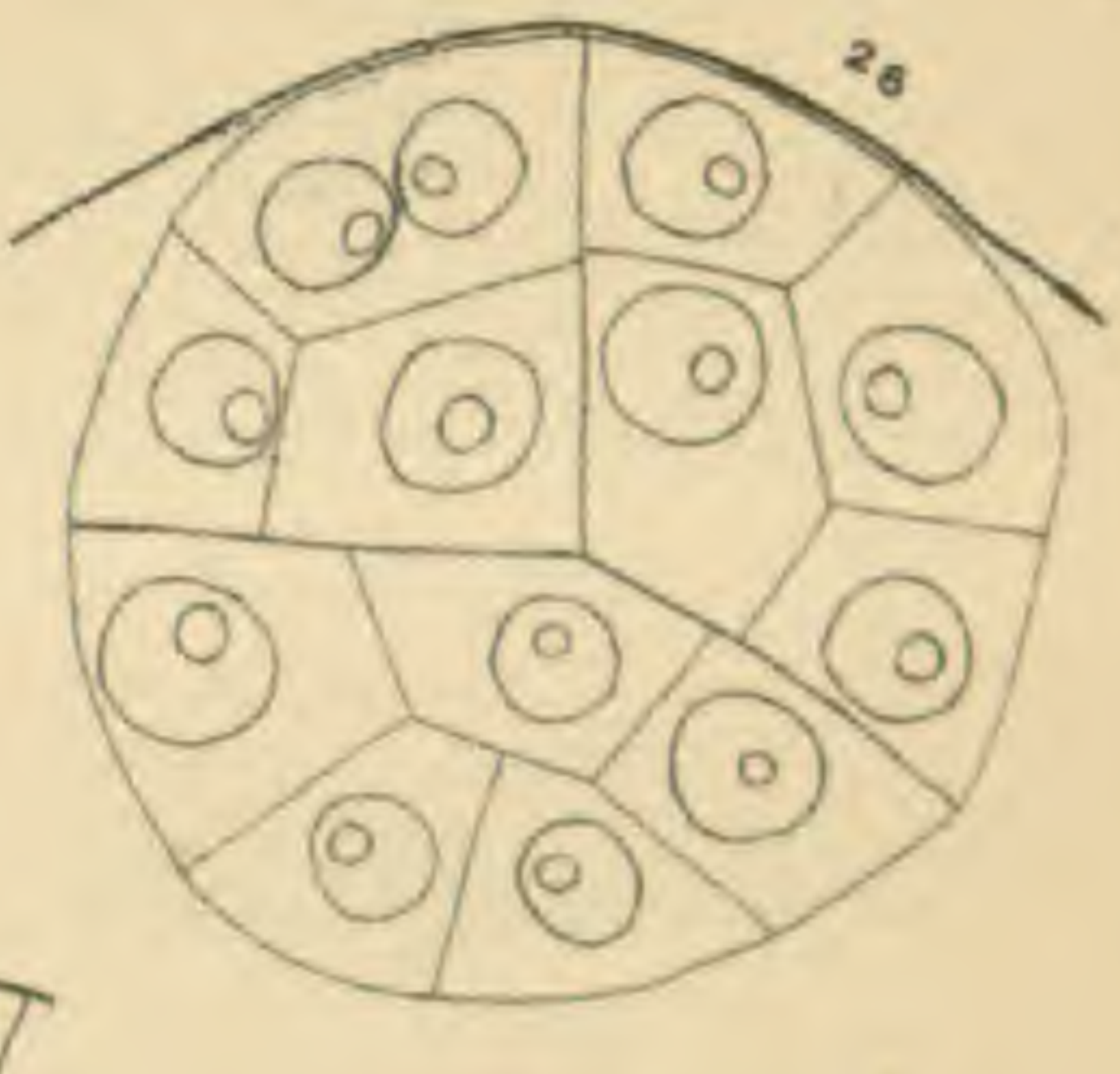

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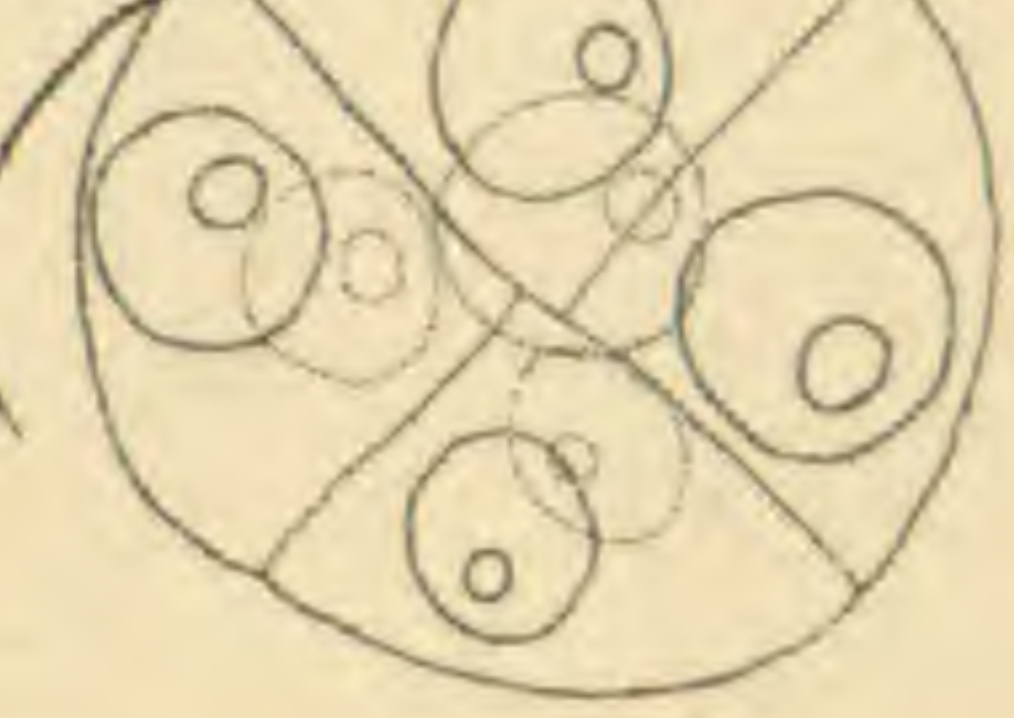

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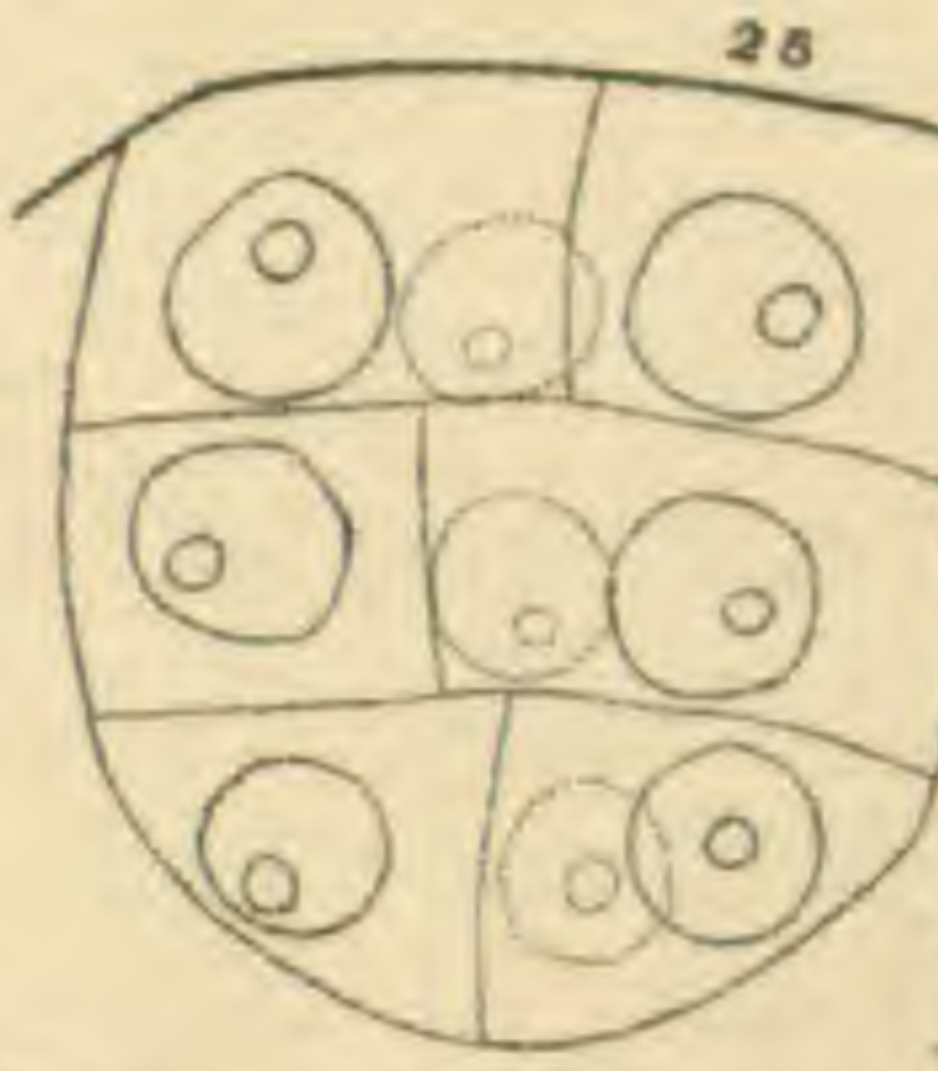

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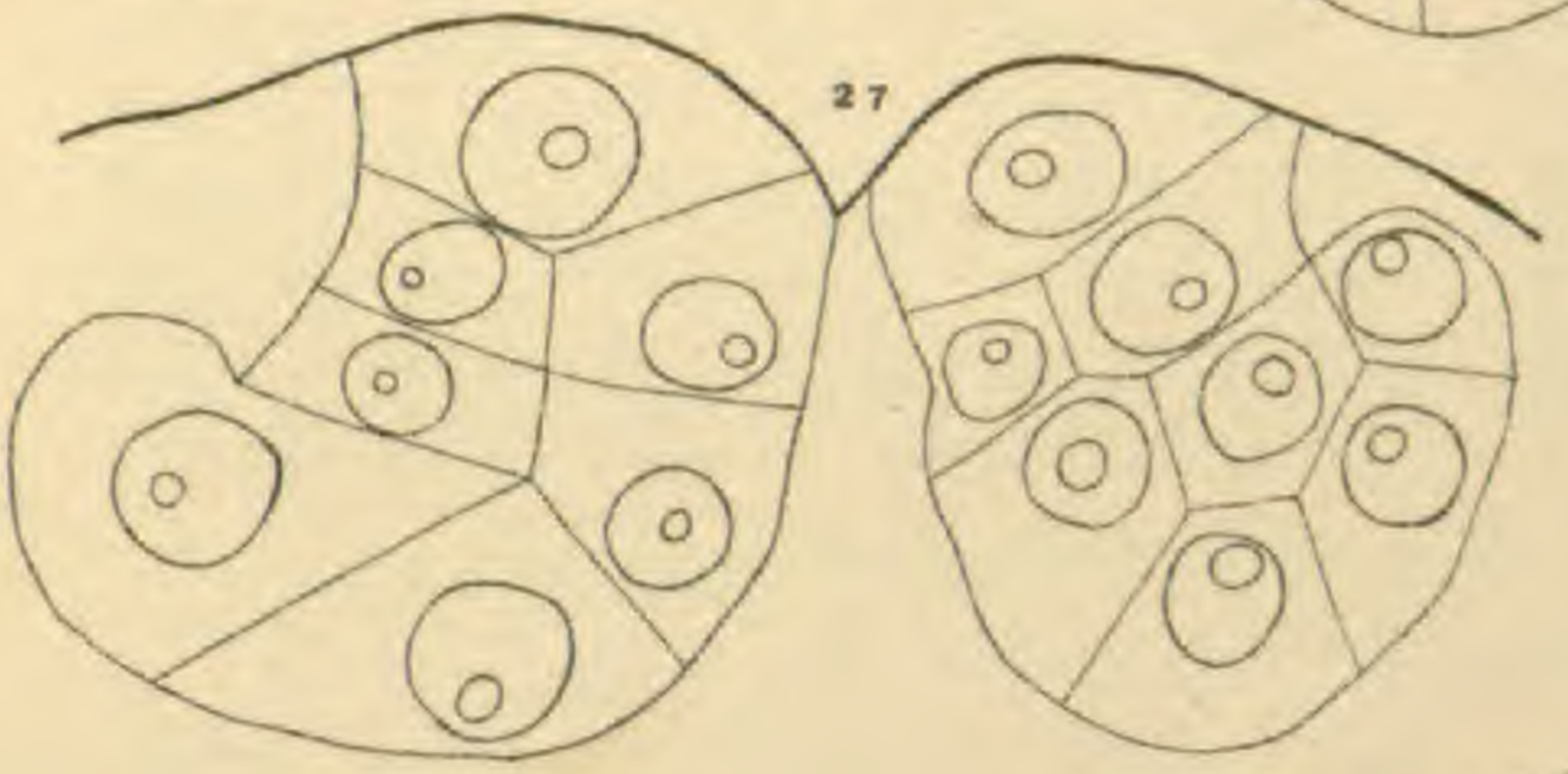

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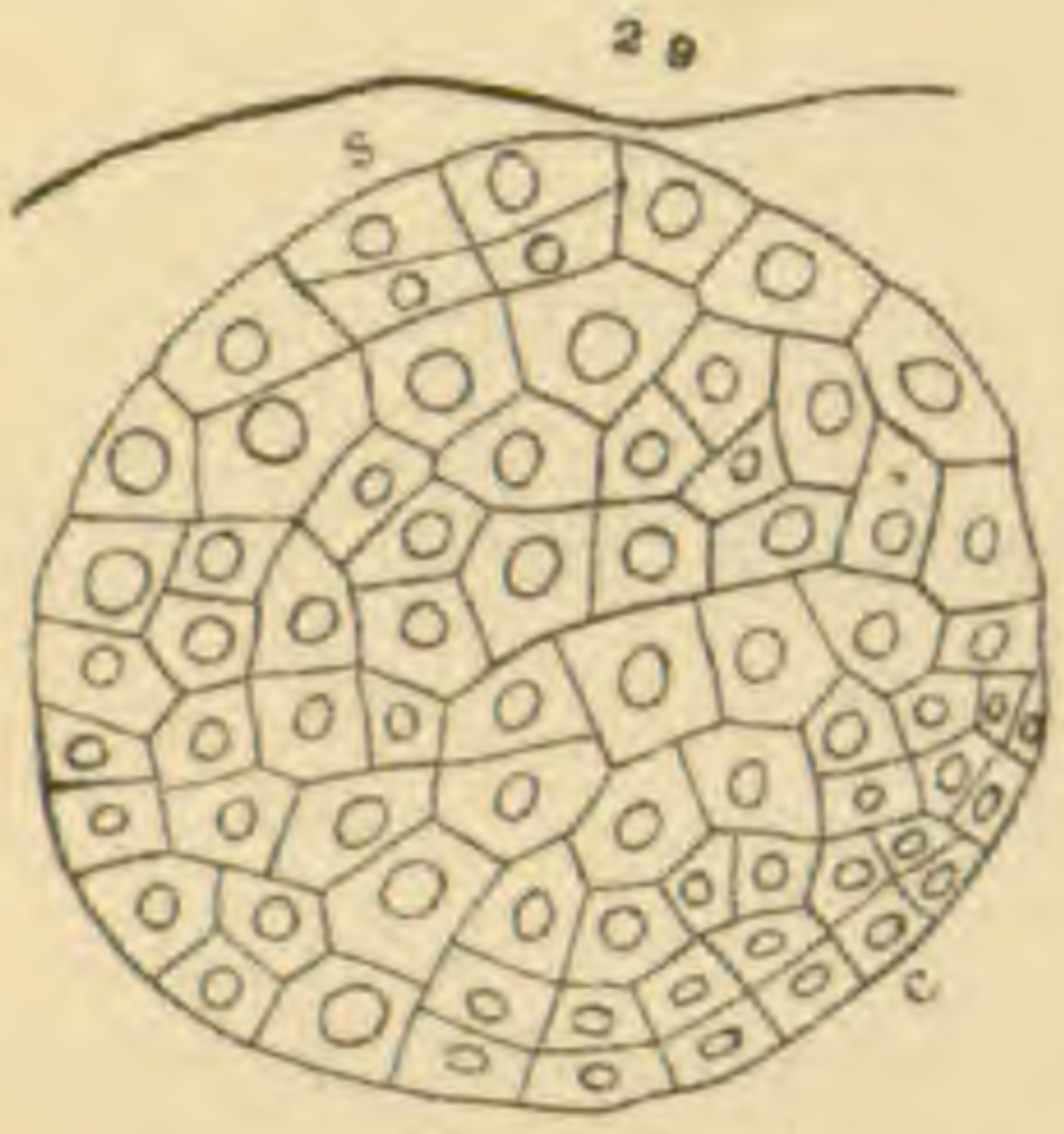

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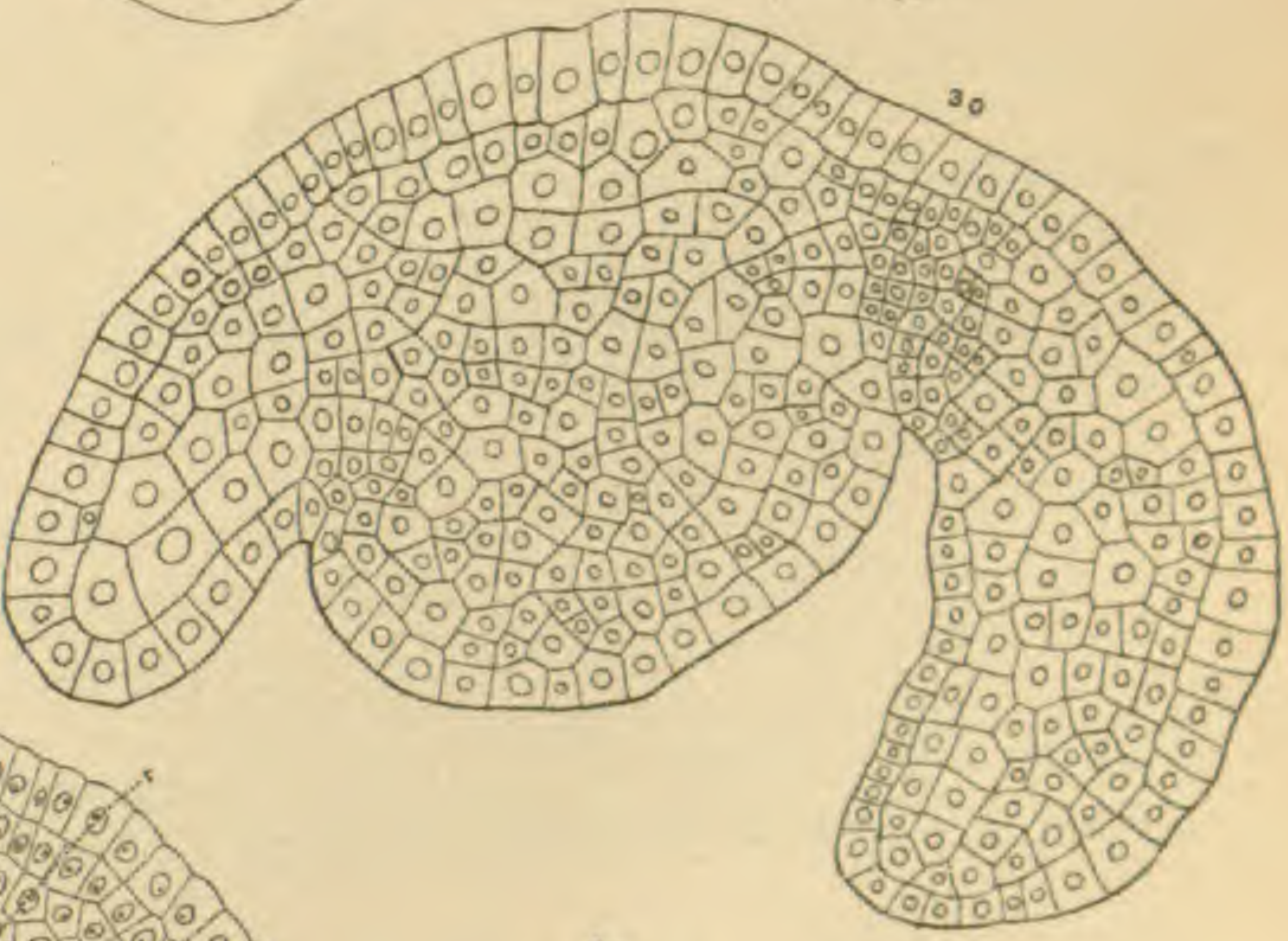

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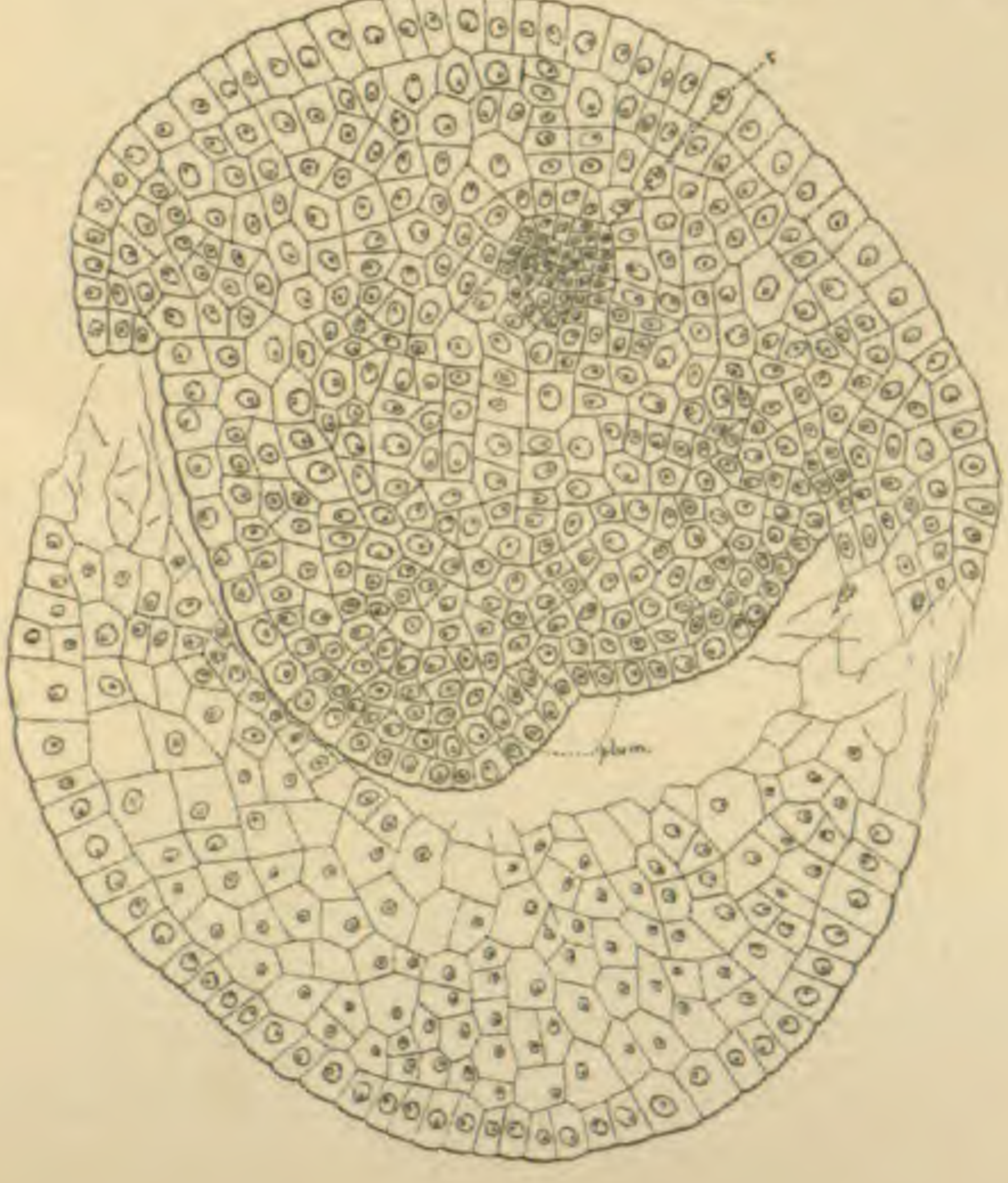

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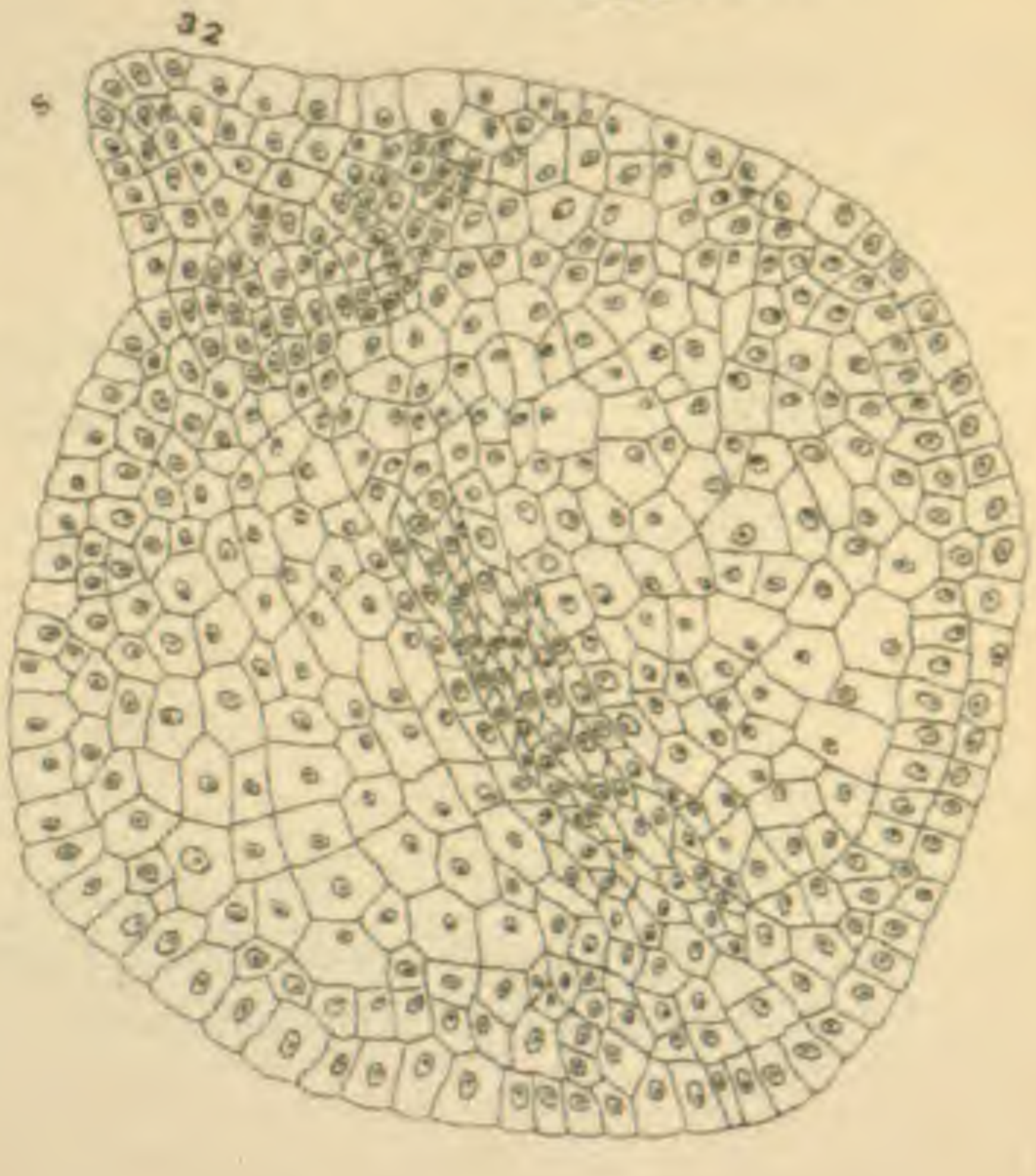

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VOL. 29 No. 5

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MAY 1902

The Nidulariaceae of North America*

BY V. S. WHITE

(WITH PLATES 14–18)

The members of the family Nidulariaceae are small fungi, seldom attaining a height of 15 mm., the average height being from 5–7 mm. The ripe sporophores are usually more or less regularly cup-shaped, containing from 10–20, or in some species, more, lenticular seed-like bodies, which are analogous to the chambers of the gleba in the other chief groups of the gastromycetes; these bodies are usually known as sporangioles or peridiola, while the cup is known as the peridium.

They are widely distributed, as will be shown in the following pages, and several of the species are fairly common, appearing principally in wet weather, in late summer and autumn, often per-

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*This revision of the family was made possible by the large amount of material found at the New York Botanical Garden, principally forming part of the Ellis collection, and by additional material furnished by Professor L. M. Underwood, from his own private collection. Professor F. S. Earle and Professor C. H. Peck also kindly loaned specimens. Thanks are due to Professor G. F. Atkinson, of Cornell University, for the loan of three drawings of *Nidularia Alabamensis* made by Mr. H. Hasselbring, and for a specimen of this same species; to Professor Farlow, of Harvard University, for kindly allowing specimens of *Cyathus pallidus* Berk. & Curt. and *Cyathus Wrightii* Berk., to be examined and sketched; to Mr. Stewardson Brown, of the Philadelphia Academy of Science, for his courtesy in facilitating the examination of Schweinitz's specimens nos. 2211–2220; to Miss Anna Murray Vail, Librarian of the New York Botanical Garden, for help in tracing references; to Mr. E. S. Salmon, for looking up some data at Kew, England, and most especially to Professor L. M. Underwood, under whose direction the work was undertaken.

[Issued 26 May]

sisting through the winter months. They grow on manure, sticks, shavings, dried herbaceous plants, and *Crucibulum crucibuliforme* is frequently found on old pieces of sacking. On a certain old board walk at Lakewood, N. J., this last species was found by the hundred growing in regular series between the joints of the boards. A further study of the plants will probably show that they are far more common and widely distributed than is at present thought, for they are likely to escape detection owing to their small size and inconspicuous coloring,.

The order Nidulariales comprises but one family, the Nidulariaceae. Until quite recently this family was considered by De Toni * and others to include the genera *Cyathus*, *Crucibulum*, *Nidularia*, *Thelebolus*, *Dacryobolus*, *Sphaerobolus*, *Polyangium* and *Atractobolus*, the last two included as doubtful genera. Fries † included besides the three first mentioned genera, *Arachnion* Schwein. *Myriococcum* Fries, and *Polyangium* Link. The two latter genera are certainly out of place here, *Myriococcum* belonging under the Perisporiales,‡ and *Polyangium* is not mentioned by either Saccardo or Fischer. In Fischer's revision of the family in 1899, he places *Arachnion* Schwein.§ under "Doubtful Genera" in the Sclerodermataceae; for *Sphaerobolus* Tode he establishes a separate family; *Thelebolus* is placed under the Ascobolaceae, and *Dacryobolus* and *Atractobolus* are included in the same family but as doubtful genera.

This leaves only the three genera, *Cyathus* (for which there is an earlier form of the name, *Cyathia*) *Crucibulum*, and *Nidularia*, in this family. Concerning the last genus a question already raised by Otto Kuntze presents itself in regard to the correct name, since Roth's *Granularia* || antedates Fries and Nordholm's *Nidularia* ¶ by over a quarter of a century. Roth's description and figure of *Granularia pisiformis* place this genus on a certain footing, and there can be no hesitation in answering the above question. Recently some

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* Saccardo, Syll. Fung. 7: 28. 1887.

† Syst. Myc. 2: 296. 1822.

‡ Saccardo, Syll. Fung. 1: 29. 1882.

§ Engler & Prantl, Nat. Pflanzenzenfam. 1^{1**}: 339. 1899.

|| Ust. Ann. Bot. 1: 6. *pl. 1. f. 1.* 1791.

¶ Syn. Gast. 2. 1817–18.

plants resembling *Crucibulum* in habit [*] have been described under *Nidularia* which differ so much in the peridial structure and character from the type of the genus, with the exception of not having the sporangioles attached to the inner wall of the peridium, that it seems best to establish another genus in order to simplify as much as possible the arrangement of the family. It was ardently desired to retain the name *Nidularia*, but unfortunately it has been found impossible to do this as all seven of the species which Fries [†] gives under his section *Nidularia* conform to the type of *Granularia*, so the name *Nidularia* must pass into synonymy.

It is interesting to note that Corda [‡] included only *Nidularia* and *Cyathus* under the Nidulariaceae. Nees noted a resemblance between this family and *Polysaccum*, but the latter genus is included by Fischer [§] under the Sclerodermataceae as *Pisolithus* Alb. & Schwein.

Although the members of this family have been mentioned in nearly all works treating of fungi from the time of Clusius, 1601, little was known of their structure and life habits until 1842, when Schmitz [||] wrote a short paper on *Cyathus*, and two years later the brothers Tulasne,[¶] instigated by this first effort to continue the study of these interesting plants, prepared their treatise on the organization and fructification of the Nidulariaceae, which, with the supplementary work of Sachs,[**] Eidam [††] and Brefeld,[‡‡] forms the foundation of our exact knowledge of this group of fungi.

The American species have never been monographed, and even the mention of plants belonging to this family has been comparatively infrequent.

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[*] Under *Crucibulum* De Bary (Comp. Morph. 321) calls attention to the fact that he was unable to find a funiculus in some peridioles but says "the coil always showed a small point which answers to it." In the specimens referred to this genus there was absolutely no trace or rudiment and it would be impossible even in young sporangioles to determine to which side they had been attached.

[†] Anleit. 103. 1842.

[‡] Syst. Myc. **2**: 300. 1823.

[§] *L. c.* 338.

[||] Ueber Cyathus. Linnaea, **16**: 141. *pl. 6, 7.* 1842.

[¶] Ann. Sci. Nat. III. **1**: 41–107. *pl.* 1844.

[**] Bot. Zeitung, 833–845, 849–861. 1855.

[††] Cohn's Beitr. z. Biol. **2**: 221–245. 1876.

[‡‡] Bot. Mitt. über Schimmelpilze, **3**: 176–180. 1877.

For a long time the Nidulariaceae seemed to be a bone of contention among various botanical writers, in the fact of their apparently differing from other fungi in having true and visible seeds.* In 1688 Camerarius published a dissertation "de Fungo calyciformi seminifero," setting forth his ideas on the subject and claiming that these fungi had seeds. Marsigli in 1713, on the contrary, tried to exclude what he calls "these simple plants" from the fungi, no fungi having true seeds as these plants seemed to have. In 1714 Tournefort was also inclined to exclude them from the fungi, but Ant. de Jussieu in 1728, denied these propositions, and claimed emphatically that fungi have seeds like true plants. Forty years later fungi were still being classed outside of the vegetable kingdom, particularly so because the sporangioles of *Cyathus* were never seen to germinate. Necker in 1783 wanted to make an intermediate kingdom to consist of the fungi, and Pico five years later, said that he had absolutely proved that the nature of these productions was purely animal. In 1791, Bulliard incontestibly proved that all fungi have seed, but he called the sporangioles of *Cyathus* seeds, and added "that they seem somewhat out of proportion to the size of the fungus." Hoffman says "potius capsa seminalis quam semen ipsum"—"they are less seeds than capsules filled with seeds," while Micheli said that the spores are hard to see with a good magnifying glass.

These fungi have had several popular names, probably owing to their quaint and attractive appearance. Besides the well-known name of "bird's-nest fungi," as far back as 1724 they have been "called in Worchestershire cornbells, where they grow plentifully,"† and in Lincolnshire "we find that a kind of fungus like a cup or old-fashioned purse with small objects inside is called a 'fairy purse' and we presume that the small objects represent the fairies' cash."‡

Synopsis of the Genera of the Nidulariaceae

Sporangioles attached to the inner wall of the peridium.

Peridium composed of three layers; spores mixed with filaments. I. CYATHIA.

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* Most of what follows in this paragraph is translated and adapted from Tulasne's monograph, pages 54–56, as several of the works referred to were unfortunately unobtainable.

† Ray, Syn. Ed. 3, 2: 20. 1724.

‡ Friend, Flower Lore, 34. 1889.

Peridium composed of one homogeneous layer; spores not mixed with filaments.
II. CRUCIBULUM.

in part

Sporangioles not attached to the inner wall of the peridium.
Peridium thick, opening by a regular definite mouth. III. NIDULA. = Nidularia
Peridium thin, rupturing irregularly. IV. GRANULARIA. = Nidularia in Par

I. CYATHIA P. Br., Civ. and Nat. Hist. Jamaica, 78. 1756

Cyathus Hall. Stirp. Helvet. 3: 127. 1768

Peridium composed of three distinct but closely connected layers. Mouth at first closed by a membrane (epiphragm), usually white, opening at maturity; sporangioles flattened, umbilicate beneath, attached to the inner wall of the peridium by a complex elastic cord (funiculus), and with thick horny filaments intermixed with the spores.

Clusius,* in 1601, made the first mention of a *Cyathia* under the name of fungus minimus *ανώνυμος*, and described it in Latin, the following being a free translation of the entire paragraph: "Moreover this fungus, which I will call anonymous, is very different from the preceding ones, and I consider it to be the smallest of all, for it is barely half an inch high. In the fall a great many grow, without petiole, on wooden boards away from dust and sand. They have the color of cinders or are of a lifeless color. The shape, which is so small, appears to be undeveloped, scarcely as large and as thick as the top of a little finger. Sometimes they grow alone or when in numbers two, three or four adhering together, and when ripe, they throw off the top part and appear full of a viscous juice, and of seeds which are about the size of the seeds of cyclamen, but have the outline of small fungi and are apparently cinder-colored. There is no doubt that this fungus grows in Italy, for I remember that a friend of mine sent me, once upon a time from there, some of these seeds, dried and with a certain strange name, asking me if I could find out what they were. For there are certain characters who endeavor to catch and buy praise from the ignorance of others."

There seem to be no intermediate references to this plant until 1671, when Bauhin † mentioned "Fungus minimus lignelis tabellis areolarum hortorum adnascens." Mentzel,‡ in 1682 first figured

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* Rar. Plant. Hist. cclxxxvii. 1601.

† Pinax, Lib. X., Sec. 5, no. 39, 374. 1671.

‡ Ind. Nom. Plant. Univ. *pl. 6.* 1682.

a plant which was, without doubt, *Cyathia lentifera.* Loeselius,[*] and Marsilius,[†] made passing references to this same species, and in 1729 Micheli [‡] described and figured two species, citing one from the above-mentioned writers, and the second from Ray,[§] Dillenius [‖] and Vaillant, [¶] the latter species being unquestionably *Cyathia striata.* Linnaeus,[**] in 1753, gives under his section "Acaules" of the genus *Peziza*—*Peziza campanulata lentifera,* first referring to Hortus Cliffortianus (1737) where we find that the only species of *Peziza* which he gives, and to which he refers what is evidently a *Cyathia* is not a *Peziza* in the modern sense, but the first known type of *Cyathia;* and the only proof that he knew what a *Peziza* really was, is his reference to Dillenius'[††] work published in 1719, in which a true *Peziza* is figured. Dillenius divided the *Pezizae* into two sections: (1) *Membranacei et tenuiores*—the true *Pezizae,* and (2) *Duriores calyciformes, seminiferi putati,* under which head he gives *Peziza calyciformis lentifera laevis* (our *Cyathia lentifera*) and *Peziza calyciformis lentifera hirsuta*" (our *Cyathia hirsuta*).

The genus *Cyathus* was founded in 1768 by Haller, twelve years after *Cyathia* P. Br., and since that time many species have been described from nearly all parts of the world. Fischer[‡‡] states that there are forty-two known species.

From our own country not many species have been described. Schweinitz was the first to mention these plants; in 1818 he named ten species, but not all of them are to be referred to the genus *Cyathia.* In 1869 Berkeley & Curtis[§§] described *Cyathus pallidus* from Cuba, also reporting *Cyathus intermedius, Cyathus Montagnei, Cyathus limbatus, Cyathus Poeppigii, Cyathus microsporus,* and *Cyathus Lesueurii* collected by Wright from the same island. Berkeley,[‖‖] in 1873, described from Connecticut, *Cyathus Wrightii,*

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[*] Flor. Prus. 98. 1703.

[†] Dissert. Gen. Fung. 17. *pl. a.* 1714.

[‡] Nov. Plant. Gen. 222. *pl. 102. f. 1, 2.* 1729.

[§] Syn. **3**: 21. 1704.

[‖] Giss. 196. 1719.

[¶] Bot. Paris. 57. *pl. 11. f. 4, 5.* 1727.

[**] Sp. Pl. **2**: 1180. 1753.

[††] *l. c.*

[‡‡] Engler & Prantl, Nat. Pflanzenfam. 1^{1**}: 328. 1899.

[§§] Jour. Linn. Soc. **10**: 346. 1869.

[‖‖] Grevillea, **2**: 34. 1873.

which has not since been reported. *Cyathus rufipes* was described in 1897 by Ellis & Everhart[*] from Kansas, and the next year Hennings,[||] described *Cyathus niveotomentosus* from California.

The following summary will show the distribution of the known species of *Cyathia*:

EUROPE, 7 species: *C. complanata*, *C. deformis*, *C. fimetaria*, *C. hirsuta*, *C. lentifera*, *C. subiculosa*, *C. umbrina*.

ASIA, 6 species: *C. emodensis*, *C. Hookeri*, *C. intermedia*, *C. minima*, *C. Montagnei*, *C. sulcata*.

AFRICA, 5 species: *C. affinis*, *C. dasypus*, *C. pallida*, *C. hirsuta*, *C. lentifera*.

AUSTRALIA, 9 species: *C. Baileyi*, *C. desertorum*, *C. fimicola*, *C. intermedia*, *C. stercorea*, *C. Montagnei*, *C. pezizoides*, *C. pusio*, *C. lentifera*.

NEW ZEALAND, 3 species: *C. Colensoi*, *C. Novae-Zelandiae*, *C. similis*.

NORTH AMERICA, 11 species: *C. intermedia*, *C. lentifera*, *C. melanosperma*, *C. Berkleyana*, *C. rugisperma*, *C. rufipes*, *C. hirsuta*, *C. stercorea*, *C. pallida*, *C. Wrightii*, *C. fragilis*.

CUBA, 7 species: *C. intermedia*, *C. Montagnei*, *C. pallida*, *C. limbata*, *C. Poeppigii*, *C. Berkleyana*, *C. stercorea*.

SOUTH AMERICA, 12 species: *C. ambigua*, *C. dasypus*, *C. limbata*, *C. microspora*, *C. Montagnei*, *C. plicata*, *C. Poeppigii*, *C. Puiggarii*, *C. scutellaris*, *C. hirsuta*, *C. lentifera*, *C. Gayana*.

Synopsis of the Species of Cyathia

Peridium sulcate-striate within.
Spores large, more than 35 μ long. 1. *C. Poeppigii.*
Spores small, less than 8 μ long. 2. *C. Berkleyana.*
Spores of medium size, 12–20 μ long.
Peridium sparingly clothed with short fasciculate hairs without. 3. *C. intermedia.* ×
Peridium thin, shaggy-tomentose without. 4. *C. hirsuta.* = striatus ×
Peridium very tough and brittle, rough tomentose. 5. *C. dura.* ×
Peridium faintly striate near the mouth, not sulcate within. 6. *C. Montagnei.*
Peridium smooth within, not sulcate.
Spores large, more than 40 μ long. 7. *C. melanosperma.* ×
Spores small, less than 15 μ long.
Sporangioles darkish; margin of peridium straight.
Peridium smooth or nearly so. 8. *C. pallida.*
Peridium strigose-tomentose. 9. *C. rugisperma.* +
Sporangioles light colored; margin of peridium often recurved. 10. *C. lentifera.* = vernicos
Spores of medium size, 15–30 μ long.
Peridium with a red felt-like mycelial bulb at base. 11. *C. rufipes.* +
Peridium with a thick bulb of whitish mycelium. 12. *C. Wrightii.* +
Peridium scarcely thickened at the base. 13. *C. stercorea.* +

[§] Bull. Torrey Club, 24: 125. 1897.

[†] Hedwigia, 37: 274. 1898.

1. **Cyathia Poeppigii** (Tul.)

Cyathus Poeppigii Tul. Ann. Sci. Nat. III. **1**: 77. *pl. 4. f. 23–25; pl. 5. f. 3–4.* 1844.

Peridia slender, goblet-shaped, 7–12 mm. high, 5–7 mm. wide at the top, about 1 mm. at the base of the stem, dark chocolate-brown, the outer surface somewhat shaggy, peeling, leaving a comparatively smooth, deeply and closely striated surface, corresponding with the deep inner striations, the inner surface brown, somewhat lighter colored than the outer surface, somewhat shiny, deeply striate; mouth minutely fimbriate; sporangioles blackish, flattened, dull, 2–2.5 mm. in diameter; funiculus long; spores 38–45 μ long, 18–22 μ in diameter, very thick-walled, granular within, oblong and often slightly curved. (*Pl. 14. f. 1–4.*)

Growing singly and in groups on manure and wet ground.

ST. CROIX (Danish West Indies): *A. E. Ricksecker.*

This species was originally described from Cuba and French Guiana; it is easily distinguished from the other striated species of *Cyathia* by its unusually large spores, and by its deeply and closely striated outer surface.

2. **Cyathia Berkleyana** (Tul.)

Cyathus microsporus β Berkleyanus Tul. Ann. Sci. Nat. III. **1**: 74. 1844.

Peridia small, cup-shaped, 5–8 mm. high, 5–7 mm. wide at the top, very much narrowed and rounded at the base, brownish outside and somewhat shaggy; mouth finely fimbriate, the inner surface of the peridium shiny, grayish-brown, lighter colored than the outer, coarsely striate; sporangioles small, 2 mm. in diameter, shiny, nearly black, flattened; spores small, 6–8 μ long, 4–6 μ wide, somewhat thick-walled, hyaline. (*Pl. 14, f. 5–7.*)

On decayed stems of coarse herbaceous plants.

JAMAICA: *Cockerell.*

This species was originally described from Brazil; it somewhat resembles small specimens of *Cyathia hirsuta*, but it differs from that species in the texture of the outer coat, which is much less shaggy and thick, and in the much smaller spores.

3. **Cyathia intermedia** (Mont.)

Nidularia intermedia Mont.; Sagra, Hist. Phy. Pol. Cuba, 321. 1838–42.

Cyathus intermedius (Mont.) Tul. Ann. Sci. Nat. III. **1**: *72. pl. 4. f. 4–7.* 1844.

Peridia cup-shaped, not rounded at the base, 7–9 mm. high, 6–8 mm. wide at the top, 1–2 mm. at the base, lightish brown, clothed with fine hairs which grow in clusters, the tips of several of which join together in little outwardly curved tufts, thin and showing the inner sulcate markings through in the older peridia; inner surface brown, shiny, sulcate-striate; the mouth straight, not flaring, clothed with a circle of short stiff bristles; the sporangioles about 2 mm. in diameter, flattened, blackish, depressed beneath, somewhat angular with a short attachment; spores hyaline, 12–18 μ long, 6–9 μ wide, thick-walled. (*Pl. 14. f. 8–10; pl. 18. f. 18.*)

Growing in loose soil and on decaying wood.

[CUBA: *Ramon de la Sagra.*]

DELAWARE: Faulkland, *Commons.*

This species was originally described from Cuba; it differs from *Cyathia hirsuta* in the character of the tomentose outer covering of the peridium, and in the shorter and more rudimentary attachment of the sporangioles to the inner peridial wall.

4. **Cyathia hirsuta** (Schaeff.)

Peziza lentifera β Linn. Sp. Pl. **2**: 1180. 1753.

Peziza sessilis campanulata villosa Scop. Fl. Carn. 57. 1760.

Peziza prima Schaeff. Fung. Bav. et Palat. Icon. **2**: *pl. 178.* 1763.

Cyathus hirsutus intus striatus Hall. Stirp. Helvet. **3**: 127. 1768.

Peziza cyathiformis Scop. *p. p.** Fl. Carn. **2**: 486. 1772. [Ed. 2.]

Peziza hirsuta Schaeff. Fung. Bav. et Palat. **4**: 124. 1774.

Peziza striata Huds. Flor. Ang. 634. 1778. [Ed. 2.]

Peziza hirsuta Batsch, Elench. Fung. 127. 1783.

Nidularia striata With. Bot. Arrang. **3**: 446. 1792 [Ed. 2]; Sibth. Fl. Ox. 393. 1794; Fries. Syst. Mycol. **3**: 298. 1822; Schwein. Trans. Amer. Phil. Soc. **4**: 252. 1834.

Cyathus striatus Willd. Fl. Berol. 399. 1787; Hoffm. Veg. Crypt. fasc. **2**: 33. *pl. 8. f. 3.* 1790; Pers. Syn. Meth. Fung. 237. 1801; Nees, Syst. 140. 1817; DC. Fl. Fr. **2**: 269. 1805; Tul. Ann. Sci. Nat. III. **1**: 67. 1844.

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*As the first cited reference under the description of this species belongs to *C. lentifera* this name cannot be taken up for this species.

Peridia 10–15 mm. high, 8–10 mm. wide at the top, 2–4 mm. at the base, usually straight trumpet-shaped, very gradually spreading toward the top; outer surface of the peridium dark brown, shaggy fibrillose; inner surface brown or grayish-brown, shiny, striate-sulcate for about one half the height of the peridium, becoming smooth at the base; mouth densely clothed with a circle of stiff regular bristles; sporangioles darkish, 2 mm. in diameter, shiny, depressed beneath, and somewhat angular from the pressure of one upon the other; spores 12–18 μ long, 6–9 μ wide, thick-walled, hyaline, somewhat crescent-shaped. (*Pl. 14. f. 11–14; pl. 18. f. 1–6.*)

Growing singly and in clusters, on sticks, bark, etc.

EXSICC.: Ellis, North American Fungi, 729.

NEW YORK: *Underwood, Tooke, Clinton, Brown, Murrill;* MAINE: *Harvey;* CONNECTICUT: *White;* PENNSYLVANIA: *Gentry, Lloyd;* OHIO: *Lloyd, James;* GEORGIA: *Underwood;* ALABAMA: *Earle;* IOWA: *Langlois;* WISCONSIN: *Williams;* INDIANA: *Underwood;* MONTANA: *Anderson, no. 601;* COLORADO: *Bethel;* WASHINGTON: *Suksdorf;* CANADA: *Dearness;* PUERTO RICO: *Underwood & Griggs;* MEXICO: *Egeling.*

Tulasne* has given an account of the development of this species from which the following is freely translated:

The young plants arise on the thick felt-like mycelium in the shape of small cylindrical jelly-like masses. They are at first white and smooth, gradually changing to a brown color and their surface becomes somewhat scaly. The three coats which compose the peridium are indicated at this stage, when the outer brownish scaly portion begins to form itself into the outer coat, while the walls of the white glutinous inner substance become differentiated from the fruiting portion into a very thin membrane which encloses these parts, a thin portion of the glutinous membrane remaining between these two coats welding them together and so forming the triple peridial wall. It is now that the sporangioles begin their growth, gradually absorbing the surrounding substance into themselves, so that when the plant is mature and gradually opens, the sporangioles alone remain within the cup attached to the sides of the peridium by means of a funiculus of a complicated structure. The sporangioles are in most

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* Ann. Sci. Nat. III. 1: 50–54. *pl. 3; pl. 4. f. 1–3; pl. 8. f. 1–12.* 1844.

cases composed of three parts, namely, of a thick and usually dark colored coat, a light hyaline thickly interwoven portion which bears the basidia, which in their turn bear the spores. The center part is composed of innumerable spores mixed with branching filaments. The walls of the spores are very thick, these spores having long been separated from their basidia. The funiculus is composed of three parts; the lower portion is variable as to length and thickness, its lower extremity is expanded and attached to the peridium; the upper portion is more regular in shape and is attached by its upper extremity to the sporangiole; it is rather swollen in the center, in which portion there is enclosed a long and slender filet composed of innumerable hyaline, interwoven filaments, which can be drawn out if great care is used in the process and forcibly distended without breaking, according to Tulasne to a length of 12 cm. These two parts are joined by a much narrower and shorter portion to which Tulasne gives the name of "filet médian."

4a. CYATHIA HIRSUTA **infundibuliformis** var. nov.

Peridia 1.5–18 cm. high, funnel-shaped, 1–2 cm. wide at the top, 1.5–2 mm. at the base, 4–5 mm. in the center where the peridium is contracted; outer surface of the peridium brownish, coarsely shaggy-tomentose; inner surface dull brownish, clearly striate, but not below the contraction; mouth minutely fimbriated; sporangioles dull brownish, 2 mm. in diameter, flattened; spores 8–12 μ wide, 14–17 μ long, thick-walled, hyaline. (*Pl. 14. f. 15.*)

Growing singly on leaves and moss.

MONTANA: Sheridan, *Fitch.*

This variety differs from the type in the definite funnel-shape of the peridium, and in the nature of the tomentum, and to a less degree in the size of the spores. Further material may necessitate a different treatment.

5. **Cyathia dura** sp. nov.

Peridia flaring trumpet-shaped, 8–13 mm. high, 8–12 mm. wide at the top, 2–4 mm. at the base, brownish-gray outside, rough, shaggy, and very tough and brittle; inner surface whitish, dull, and marked with rather wide shallow striations; mouth recurved, ragged and much split, but not fimbriate; bases of the peridium contracted and in some specimens there is a thick felty brown mycelial band adhering; sporangioles dull grayish, oval or rounded, 2.5 mm. long, 1.5 mm. wide; spores 14–18 μ long, 8–10 μ wide, hyaline and thick-walled. (*Pl. 14. f. 16–19.*)

COLORADO: Denver, *Bethel, 8.*

This species differs from all others seen in the character of the peridium, which is very thick, hard and brittle.

6. **Cyathia Montagnei** (Tul.)

Cyathus Montagnei Tul. Ann. Sci. Nat. III. **1**: *70. pl. 4, f. 9–11.* 1844.

Peridia 8–10 mm. high, 6–9 mm. wide at the top, 2–3 mm. at the base, spreading, cup-shaped, reddish-brown outside, closely woolly-tomentose, but not shaggy, rather thin; inner surface grayish, dull, faintly striate close to the top, not sulcate; mouth at first curved inwards, then straight, but not recurved, closely and very minutely fimbriate; sporangioles 2 mm. in diameter, grayish, black, somewhat lighter beneath, dull, flattened, angular; spores 15–18 μ long, 8–12 μ wide, thick-walled, granular, hyaline. (*Pl. 14. f. 20–22.*)

On the ground and on decaying wood and chips.

YUCATAN: *C. F. Millspaugh*, 787; [CUBA].

This species was originally described from Brazil; it is readily distinguished from the preceding species: (1) By the faint and only partial striae of the upper part of the inner surface of the peridium, and (2) By the woolly tomentose, and not shaggy nature of the outer coat.

7. **Cyathia melanosperma** (Schwein.)

Nidularia melanosperma Schwein. Trans. Am. Phil. Soc. **4**: 253. 1834.

Cyathus melanospermus (Schwein.) De Toni; Saccardo, Syll. Fung. **7**: 42. 1887.

Peridia cup-shaped, clustered, 5–7 mm. high, 5–6 mm. wide at the top; the outer surface brownish and very shaggy; the inner surface smooth, shiny, dark gray; mouth straight and slightly fimbriate; sporangioles black, flattened, about 2 mm. wide; spores large, 45–55 μ long, 18–45 μ wide, very thick-walled, granular within, hyaline. (*Pl. 15. f. 1–4.*)

Gregarious on the earth.

PENNSYLVANIA: Bethlehem, *Schweinitz*.

The above description is based on Schweinitz's original specimens, which are still in good condition at the Philadelphia Academy of Sciences. This appears to be a rare species, as it is known only from its original collection. It differs from all the following species of *Cyathia*, which have a smooth inner surface, in having a fimbriate mouth, though Schweinitz in his original description notes that it has a smooth mouth, but he writes that *Nidularia stercorea* has a fimbriate mouth, which is contradicted by his own specimens.

8. **Cyathia pallida** (B. & C.)

Cyathus pallidus B. & C. Jour. Linn. Soc. **10** : 346. 1869.

Peridia 4–8 mm. high, 5–7 mm. wide at the top, about 2 mm. at the base, slender urn-shaped, slightly expanded at the top and contracted at the base, thin and membranous, fawn-colored outside, and minutely shaggy ; inner surface light lead-colored, smooth, shiny ; mouth entire or torn but not fimbriate, sometimes slightly striated ; sporangioles 2 mm. in diameter, flattened, the edges very thin, and thicker in the middle, darker above than below, shiny as if frosted, and under high magnification showing a network of delicate rugose wrinkles ; spores 5–9 μ long, 5–7 μ wide, hyaline, thick-walled, oval-pointed or nearly round, pale yellow in the mass. (*Pl. 15. f. 5–7.*)

Growing on decayed wood.

CUBA : *Wright ;* PUERTO RICO : Coamo Springs, *Underwood & Griggs.*

The above description is based on the co-types of this species in the Curtis collection at Harvard University.

9. **Cyathia rugisperma** (Schwein.)

Nidularia rugisperma Schwein. Trans. Am. Phil. Soc. **4** : 253. 1834.

Cyathus rugispermus (Schwein.) De Toni ; Saccardo, Syll. Fung. **7** : 42. 1888.

Peridia somewhat obconic, sharply contracted at the base, 5–8 mm. high, 4 mm. wide at the top ; outer surface lightish fawn-colored, strigose-tomentose, becoming nearly smooth when mature ; inner surface darkish brown, smooth, and shiny ; mouth incurved in the young peridia, and completely covered by the tomentose outer covering ; sporangioles black, flattened, roundish, 1–1.5 mm. in diameter ; spores 10–14 μ long, 8–10 μ wide, somewhat granular and thick-walled, hyaline. (*Pl. 16. f. 3–6.*)

Growing singly on bits of shaving and fibrous matter.

PENNSYLVANIA : Bethlehem, *Schweinitz.*

The above description is based on the original specimens. Schweinitz, in his description of this species, says: "Sporangiis non nitentibus, sed superficie reticulato-rugosa," but no such markings were noticeable.

This is a pretty little species, and is known only from its original collection.

10. **Cyathia lentifera** (L.)

Peziza lentifera α Linn. Sp. Pl. **2**: 1180. 1753.

Peziza sessilis campanulata laevis Scop. Fl. Carn. 57. 1760.

Peziza tertia Schaeff. Fung. Bav. et Palat. Icon. **2**: *pl. 180.* 1763.

Cyathus sericeus intus laevis Hall. Stirp. Helvet. **3**: 127. 1768.

Peziza cyathiformis Scop. *p. p.* Fl. Carn. **2**: 486. 1772 [Ed. 2].

Peziza sericea Schaeff. Fung. Bav. et Palat. **4**: 125. 1774.

Peziza lentifera Huds. Fl. Ang. **2**: 633. 1778 [Ed. 2].

Peziza Olla Batsch, Elench. Fung. 127. 1783.

Nidularia vernicosa Bull. Champ. **1**: 164. *pl. 488. f. 1.* 1791.

Cyathus laevis Hoffm. Veg. Crypt. fasc. 2: 31. *pl. 8. f. 2.* 1792.

Coccigrue à lentilles Paulet. Tr. des Champ. **2**: 406. *pl. 187. f. 7–12.* 1793.

Nidularia campanulata With. Bot. Arrang. **3**: 445. 1792 [Ed. 2]; Sibth. Fl. Ox. 393. 1794; Fries, Syst. Myc. **2**: 298. 1822.

Cyathus Olla Pers. Syn. Meth. Fung. 237. 1801.

Cyathus vernicosus DC. Fl. Fr. **2**: 270. 1805; Tul. Ann. Sci. Nat. III. **1**: 81. *pl. 5. f. 14–23.* 1844.

Nidularia plumbea Pers. Champ. Comest. 110. 1818.

Nidularia fascicularis Schwein. Trans. Am. Phil. Soc. **4**: 253. 1834.

Cyathus campanulatus Corda, Anleit. lxxx. *pl. D. f. 42 (19–23).* 1842.

Peridia 8–12 mm. high, 5–15 mm. wide at the top, 2–7 mm. at the base, campanulate, the edge often recurved and expanded; outer surface lightish brown or grayish-yellow, almost smooth, sometimes having a few tow-like fibers attached which give it a slightly roughened appearance; inner surface smooth, whitish or lead-colored, shiny; mouth entire, often ragged and split; sporangioles light-colored, 2–3 mm. in diameter, flattened beneath; spores 8–15 μ long, 6–10 μ wide, thick-walled, hyaline. (*Pl. 15. f. 8–13.*)

Plants sessile, or sometimes stalked, growing singly or in clusters on the earth, on dry chips, twigs, etc.

NEW YORK: *Underwood;* MAINE: *Harvey, Bartle;* CONNECTICUT: *White;* PENNSYLVANIA: *Martin;* ALABAMA: *Earle;* INDIANA: *Underwood;* KANSAS: *Bartholomew, 1032;* COLORADO: *Ravenel;* UTAH: *Harkness;* CALIFORNIA: *Orcutt, Baker;* TEXAS: *Young;* PUERTO RICO: *Goll.*

11. **Cyathia rufipes** (Ell. & Ev.)

Cyathus rufipes Ell. & Ev. Bull. Torrey Club, **24**: 125. 1897.

Peridia very slender, obconic, .8–1.5 cm. high, 3–6 mm. wide at the top, 1–1.5 mm. at the base, outer surface lightish brown or tow-colored, very shaggy tomentose, and with a quantity of reddish-brown mycelium adhering at the base, forming a felt-like tuft; inner surface smooth, dark gray, shiny; sporangioles 2 mm. in diameter, dark, almost black, shiny, depressed beneath; spores 25–29 μ long, 18–22 μ wide, thick-walled, granular within and hyaline. (*Pl. 15. f. 14–16.*)

On old sods, "growing head downward."

KANSAS: *Bartholomew;* NEBRASKA: *Bates.*

This species is readily distinguished from the other species of *Cyathus* with a smooth inner surface by its very slender elongated shape and its light densely tomentose peridium, besides the characteristic feature of the red felt-like mycelial tuft at the base, from which the species derives its name.

12. **Cyathia Wrightii** (Berk.)

Cyathus Wrightii Berk. Grevillea, **2**: 34. 1873.

Peridia rather large, cup-shaped, 1.2–1.8 cm. high, .5–1.2 cm. wide at the top, contracted somewhat at the base, then bulbose, the bulb composed of mycelium and adhering earth; outer surface darkish brown, very rough, shaggy and encrusted with earth; inner surface smooth, shiny, darkish; mouth entire, not fimbriate though the fine hairs circle up about it; sporangioles dark, 1.5–2 mm. in diameter, shiny, flattened; spores 22–25 μ long, 15–18 μ wide. (*Pl. 16. f. 7–9.*)

CONNECTICUT: Growing singly on earth, *C. Wright.*

This species is not known to have been reported since the original collection. The above description of external characters is based on the cotypes at Harvard University. The spores were not seen; the measurement being taken from some mss. notes on *Cyathus* by Massee, made from the type of *C. Wrightii* at Kew. De Toni gives the measurement in Saccardo as "15 μ long by 10 μ wide."

13. **Cyathia stercorea** (Schwein.)

Nidularia stercorea Schweinitz, Trans. Am. Phil. Soc. **4**: 253. 1834.

Cyathus Lesueurii Tul. Ann. Sci. Nat. III. **1**: *79. pl. 5. f. 5–13.* 1844.

Cyathus Lesueurii, var. *minor* Tul. *l. c.* 80.

Cyathus stercoreus (Schwein.) De Toni; Saccardo, Syll. Fung. **7**: 40. 1888.

Peridia slender, campanulate, sessile or with an elongated slender base, .5–1.5 cm. high, 4–8 mm. wide at the top, 1–3 mm. at the base; outer surface brownish fawn-colored, the young plants being strigose with a copious covering of shaggy hairs, which gradually disappear, leaving the mature peridium almost smooth, or marked with circular depressed zones; inner surface smooth, shiny, lead-colored, somewhat darker toward the base; the mouth entire or at first appearing fimbriate from the surrounding hairy covering, but not ciliate-fimbriate; sporangioles blackish-lead-colored, smooth, shiny, 2 mm. in diameter, depressed beneath; spores 25–30 μ long, 20–25 μ wide, thick-walled, hyaline, granular within. (*Pl. 15. f. 17–20; pl. 16. f. 1, 2.*)

Growing on manure, bits of wood, etc.

EXSICC.: E. & E. Fungi Columbiani, 644 (as *Cyathus vernicosus*); Ravenel, Fungi Amer. Exsic. 473 (as *Cyathus vernicosus*), 474 (as *Cyathus Lesueurii*); Ravenel, Fungi Car. Exsic. 3: 73 (as *Cyathus campanulatus*); Ellis, N. A. Fungi, 1308 (*Cyathus vernicosus*); Shear, N. Y. Fungi, 316.

PENNSYLVANIA: *Schweinitz;* NEW YORK: *Underwood, Shear, Brown, Vail;* MASSACHUSETTS: *Ellis, Knight;* MAINE: *Harvey;* NEW JERSEY: *Ellis;* DELAWARE: *O. S.;* SOUTH CAROLINA: *Ravenel;* VIRGINIA: *Murrill;* IOWA: *Langlois;* INDIANA: *Underwood, Arthur;* OHIO: *Morgan, Lloyd;* ALABAMA: *F. S. Earle & C. F. Baker*, Tuskegee, *Carver;* KANSAS: *Cragin, 273;* COLORADO: *Baker;* NEBRASKA: *Williams;* NEW MEXICO: *F. S. Earle & E. S. Earle Cockerell;* CANADA: *Dearness, 1149.*

This species varies very much as to size, shape and smoothness of the peridium, which facts have been rather misleading, but such different types have been found in specimens from one locality from the short, strigose, sessile or bulbose form to the slender, almost smooth, elongated form—that there can be no question as to their being in reality but one species. Tulasne does not mention Schweinitz's *Nidularia stercorea*, and his species *Cyathus Lesueurii* from New Orleans was presumably described without knowledge of the preceding species. His variety *Cyathus Lesueurii* var. *minor* from Carolina, closely resembles small forms of *Cyathia stercorea.*

CYATHIA (?) sp.

Peridia cup-shaped, clustered, 4–6 mm. high, 3–5 mm. wide at the top, 2 mm. at the base; outer surface lightish brown, nearly smooth, or minutely fibrous; inner surface smooth, very dark brown, almost black, shiny; mouth entire or slightly ragged, but not fimbriate; sporangioles black, shiny, angular beneath, rounded above, 1 mm. in diameter, showing no trace of any attachment, numerous; spores 20–30 μ long, 18–24 μ wide, thick-walled, granular within, hyaline. (*Pl. 16. f. 16, 21, 22.*)

No mention as to habitat.

The specimens on which the above description is based were sent to Mr. Ellis by Professor E. Bethel (no. 9) from Denver, Colorado, and were named *Cyathus vernicosus.* They consist of four or five groups of from two to five plants in each. The peridial wall is triple and the structure of the sporangioles is much as in *Cyathia*, the spores being also intermixed with thick horny filaments as in that genus; but there is no trace whatever of any attachment either on the under surface of the sporangioles or on the inner surface of the peridium. The specimens are all mature, so it is impossible to know what the nature of the young peridia was, but the sporangioles are still in the peridia, filling them completely, even with the margin quite unlike anything seen belonging to the genus *Cyathia.* It is very possible that a genus standing in the same relation to *Cyathia*, as *Nidula* does to *Crucibulum*, will eventually have to be established to accommodate these forms, but the material and data are not sufficient to justify taking such a step at present.

SPECIES INQUIRENDA

CYATHUS NIVEO-TOMENTOSUS P. Henn. Hedwigia, **37**: 274. 1898

Sparsis: peridio obconico-cyathiformi, crassiusculo papyraceo primo operculo albo tecto, sessili vel substipitato, extus niveo sericeo, dense tomentoso, margine integro, crasso, 3–5 mm. alto, 4–5 mm. lato, intus albo-flavescente; sporangiolis innumeris, lentiformibus, planis, tenue tunicatis, cinnamomeis, sericeis, 1–1.2 mm. diametro; sporis ellipsoideis, obtusis, intus granulatis, hyalinis, 7–8.5 × 4.5–5.5 μ, episporio hyalino, tenui, levi.

CALIFORNIA: Potter Valley. On decaying wood (Sept. 1894). *Purpus.*

The original description is quoted, as no specimens of this species were seen, and until more material has been collected it is difficult to decide with any degree of certainty just where it belongs. The author adds that this species appears to be related to *Cyathia pallida.*

II. CRUCIBULUM Tul. Ann. Sci. Nat. III. **1**: 89. 1844

Peridium composed of a single, homogeneous, though sometimes layered, felt-like membrane, which is at first continuous over the mouth, forming a sort of epiphragm; sporangioles more numerous than in the preceding genus, and the funiculus is much less complex, consisting of a little bundle of elastic filaments gathered closely together in a very thin, hardly noticeable outer covering, the upper end of which is attached to a nipple-like protuberance on the under surface of the sporangiole, and the lower end is attached to the inner wall of the peridium; there are no filaments intermixed with the spores.

Although the genus *Crucibulum* was not founded until 1844, for nearly a century and a half plants belonging to it have been known and unmistakably figured. Ray[*] in 1696, in a list of plants collected by D. Samuel Doody, mentions "Fungus seminifer minor," which he figured in 1724.[†] Micheli, five years later, gave a good figure of *Crucibulum crucibuliforme.* As early as 1697 Boccone[‡] figured this plant, under the name of "Fungus *σπερματιας* calyculatus," but does not seem to give it more than this passing notice. Gleditsch,[§] Schaeffer,[||] Scopoli,[¶] Hudson,[**] Hoffman[††] and others made mention of this plant, under various names, but

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[*] Syn. 333. 1696. [Ed. 2.]

[†] Ray, Syn. 20. *pl. 1. f. 2 b, c.* 1724. [Ed. 3.]

[‡] Mus. Fis. *pl. 301. f. 1.* 1697.

[§] Meth. Fung. 138. *pl. 4.* 1753.

[||] Fung. Bav. et Palat. Icon. **2**: *pl. 179.* 1761; **4**: 125. 1774.

[¶] Flor. Carn. **2**: 486. 1772. [Ed. 2.]

[**] Flor. Ang. **2**: 634. 1778. [Ed. 2.]

[††] Vegt. Crypt. fasc. **2**: 29. *pl. 8. f. 1.* 1790.

not until 1801, was the present generic name employed by Persoon *—even then only to denote a species—*Cyathus Crucibulum.*

Schweinitz was the first to report *Crucibulum crucibuliforme* from this country under the name of *Nidularia Crucibulum.* He also described another species, *Nidularia juglandicola* which though retained as a good species of *Crucibulum* by De Toni,† proves to be a form of *Crucibulum crucibuliforme*, slightly larger and more flaring, but otherwise similar to the type species. Though the genus as represented by *Crucibulum crucibuliforme* is comparatively common and widely distributed, it is interesting to note in contrast with the genus *Cyathia*, which is very prolific of species, that only one other species has been described, viz., *Crucibulum simile* Massee ‡ from New Zealand and Australia, and even this is said to resemble *Crucibulum crucibuliforme* closely.

Bulliard § says that there are two varieties of *Crucibulum* both of which he figures, one glabrous, almost as smooth inside as out, the other smooth inside but somewhat tomentose on the outside, and always larger and more yellow than the first. It has been noticed in examining quite a number of specimens from different localities that those collected in one place often vary greatly in size and color, and in the nature of the tomentose outer surface of the peridium. Cooke,‖ in 1879, described a variety which he calls *lanosum*, and which De Toni says might possibly be Bulliard's second variety (figured on *pl. 40*) but as Cooke described it as "paler than in the usual form" this disposition cannot be correct.

1. **Crucibulum crucibuliforme** (Scop.) = vulgare

Peziza sessilis campanulata (b) Gled. Meth. Fung. 138. *pl. 4.* 1753.

Peziza secunda Schaeff. Fung. Bav. et. Palat. Icon. **2**: *pl. 179.* 1763.

Peziza lentifera Oeder, Fl. Dan. **2**: 9. *pl. 105.* 1763; not Linnaeus.

Peziza crucibuliformis Scop. Flor. Carn. **2**: 486. 1772 [Ed. 2]; Schaeff. Fung. Bav. et Palat. **4**: 125. 1774.

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* Syn. Meth. Fung. 239. 1801.

† Saccardo, Syll. Fung. **7**: 44. 1888.

‡ Grevillea, **19**: 93. 1891.

§ Champ. **1**: 165. *pl. 40* and *pl. 488.* 1809.

‖ Grevillea, **8**: 58. 1879.

Peziza laevis Huds. Fl. Ang. 634. 1778. [Ed. 2.]

Cyathus cylindricus Willd. Fl. Berol. 399. 1787.

Cyathus crucibuliformis Hoffm. Veg. Crypt. fasc. 2, 29. *pl. 8. f. 1.* 1790.

Nidularia laevis Bull. Champ. **1**: 164. *pl. 448. f. 2. pl. 40.* 1791; With. Bot. Arrang. **3**: 446. 1792 [Ed. 2]; Sibth. Fl. Ox. 393. 1794.

Cyathus Crucibulum Pers. Syn. Fung. 238. 1801; Nees, Syst. 140. *pl. 13. f. 133.* 1817.

Cyathus laevis DC. Fl. Fr. **2**: 269. 1805.

Nidularia Crucibulum Secret. Mycogr. Suisse, **3**: 378. 1833; Schwein. Trans. Am. Phil. Soc. **4**: 253. 1834.

Nidularia juglandicola Schwein. Trans. Am. Phil. Soc. **4**: 253. 1834.

Crucibulum vulgare Tul. Ann. Sci. Nat. III. **1**: 90. *pl. 6. f. 9–24. pl. 7. f. 1. pl. 8. f. 13–17.* 1844.

Crucibulum juglandicolum De Toni; Sacc. Syll. Fung. **7**: 44. 1888.

Peridia 5–10 mm. high, 5–10 mm. across at the top, 4–7 mm. at the base, cylindrical-campanulate, base truncate or but slightly contracted; outer surface dirty cinnamon or grayish fawn-color, young plant minutely velvety tomentose, becoming smoother with age; the inner surface smooth, shiny and whitish; mouth entire, firm and even, sometimes slightly contracted, sporangioles pale ochraceous, becoming whitish, 1.5–2 mm. in diameter, very numerous and crowded, flattened beneath; spores hyaline, elliptic, 8–10 μ long, 4–6 μ wide, smooth, some thick-walled. (*Pl. 16. f. 10–15; pl. 18. f. 7–13 and 16.*)

Plants gregarious or single on twigs, old bagging, chips, etc.; common and variable.

EXSIC.: Ellis, N. A. Fungi, no. 728; Ravenel, Fungi Amer. Exsic. no. 139.

NEW YORK: *Underwood, Clinton, Jelliffe;* MAINE: *Harvey;* CONNECTICUT: *Underwood, White;* MASSACHUSETTS: *Underwood, Underwood & Seymour, 941;* NEW JERSEY: *Ellis, White;* PENNSYLVANIA: *Haines, Everhart;* ALABAMA: *Underwood, Earle;* VIRGINIA: *Underwood;* KENTUCKY: *Underwood;* INDIANA, *Underwood;* KANSAS: *Cragin, 490;* OREGON: *Carpenter;* MONTANA: *Reynolds;* COLORADO: *Bethel, Underwood & Selby;* WASHINGTON: *Suksdorf.*

The following is extracted and translated from Tulasne's more extended description of this species: The inner white evanescent pellicle is a remnant of the mucilaginous matter which fills the cup in its early stages. The sporangioles are accumulated in large numbers in a space apparently too small to contain them. They are covered with a thick fibrous coat which can be peeled off, and when deprived of this the sporangiole is black and of a horny consistency. It is composed of two parts, a thick and much interwoven darker outer part, and an inner hyaline portion composed of irregularly shaped filaments taking the place of basidia and forming a hymenium of which the surface is nearly uniform. The rest of the inner substance is composed of the spores without any filaments, which fact distinguishes these sporangioles from some of those belonging to species of *Cyathia*. The funiculus of *Crucibulum* is much more simple than that of *Cyathia hirsuta*, being composed of a little bunch of elastic filaments gathered closely together in a very thin, transparent outer covering, which is hardly noticeable, and of an equal filet, about 2–3 mm. long, which expands itself at the base into the inner wall of the peridium.

III. **Nidula** gen. nov.

Peridium composed of a single homogeneous, but layered membrane which is at first continuous over the mouth much as in *Crucibulum;* sporangioles very numerous, at first immersed in a glutinous substance, very closely packed, entirely filling the central cavity and in no way attached to the peridium wall; no filaments intermixed with the spores.

Peridium shaggy-tomentose; sporangioles light-colored, 2 mm. wide.
1. *N. candida.*

Peridium minutely tomentose; sporangioles dark-colored, barely 1 mm. wide.
2. *N. microcarpa.*

1. **Nidula candida** (Peck)

Nidularia candida Peck, Reg. Rep. **45**: 24. 1891.

Peridia 6–15 mm. high, 6–15 mm. wide at the top, 5–10 mm. at the base, cylindrically cup-shaped, somewhat truncate at the base; outer surface white, becoming dingy with age, thick, felt-like, shaggy-tomentose; inner surface smooth, at first snowy white, becoming brownish with age, somewhat shiny; mouth entire, firm, somewhat spreading but not recurved; sporangioles 1.5–2 mm. in diameter, light grayish fawn-colored, very thin, flattened, both surfaces perfectly even, angular, but not depressed; spores 6–10 μ long, 4–8 μ wide, globose to elliptic, hyaline, somewhat granular, thin-walled. (*Pl. 16. f. 17–20.*)

Growing singly on twigs, moss, etc.

WASHINGTON: Olympia, *Henderson*, *Suksdorf.*

BRITISH COLUMBIA: *Macoun, 107.*

2. **Nidula microcarpa** Peck, sp. nov.

Peridia 4–6 mm. high, 4–5 mm. wide at the top, 3–5 at the base, subcylindrical; outer surface whitish, or pale grayish-yellow, minutely tomentose, firm; inner surface smooth, with a thin brownish shiny layer formed by the drying of the glutinous inner substance; mouth entire, straight and firm; sporangioles very numerous, lenticular, covered with a thick fibrous outer coat, which peels off, as in *Crucibulum crucibuliforme*, when dry rugosely wrinkled, becoming smooth when moistened, reddish-brown, .5–1 mm. wide; spores 6–9 μ long, 4–6 μ wide, broadly elliptic or subglobose, hyaline, thick-walled. (*Pl. 17. f. 1–6; pl. 18. f. 14, 15, 17.*)

Growing on wood, and on the ground.

CALIFORNIA: *W. R. Dudley.*

MONTANA: Columbia Falls, *R. S. Williams.*

2a. NIDULA MICROCARPA **rugispora** var. nov.

Crucibulum rugisporum E. & E. in herb.

Peridia 3–5 mm. high, 3–6 mm. wide at the top; outer surface yellowish-white, with a rather thin close tomentum; inner surface smooth, whitish or brownish, somewhat shiny; mouth recurved, and spreading, and minutely lacerate, fimbriate; sporangioles very numerous, reddish-brown, rugose when dry, barely 1 mm. wide, flattened, subrotund; spores broadly elliptic, hyaline, slightly thick-walled, 6–9 μ long, 4–7 μ wide, slightly larger than in the foregoing species. (*Pl. 17. f. 7–9.*)

Growing on dead twigs.

WASHINGTON: Skamania county, alt. 3,000 ft., *Suksdorf, 510.*

Though this variety closely resembles the species it differs in the mouth characters and in the somewhat larger spores.

IV. GRANULARIA Roth, Ust. Ann. Bot. **1**: 6. *pl. 1. f. 1.* 1791

Nidularia Fries & Nord. Symb. Gaster. 2. 1817–18.

Peridium composed of a single homogeneous rather thin closed membrane, or a thin, closely interwoven layer of branched filaments, opening more or less irregularly by the breaking away or falling to pieces of the walls at maturity, having no true epiphragm: sporangioles enveloped in mucus and not attached in any way to the inner surface of the peridium.

The history of the genus *Granularia*, though not as long as that of the first two genera belonging to this family, appears to have become more involved and complicated, very probably owing to the fact that the species of *Granularia* are as a rule, rarer, and less conspicuous than the species of *Cyathia* and *Crucibulum*. Micheli * in 1729 figured "*Cyathoides scutellatum*," which is unquestionably a true *Granularia*, and the reason why this species has since been placed under *Cyathus* by Roth † and later by Tulasne, it hard to understand. Micheli, in writing of this genus, says "[fructus] vel prope centrum, vel ad circumferentiam brevissimo pediculo seu umbilicali funicolo firmantur," but of the figure of three sporangioles of "*Cyathoides scutellatum*" only one has a short lateral attachment, and that much shorter than in the figures of the sporangioles of the three other species represented. Fries ‡ says of his second division, which contains true *Granularia*, that the sporangioles have no umbilicus or umbilical thread, but are attached by the margin. Tulasne writes that notwithstanding these authorities, the lateral position of a funiculus seems very problematical in the genus *Cyathia*, and that the sporangioles of the specimens of *Granularia* which he has studied do not adhere any more by the edge than by any other point, either to the mucilage in which they are immersed or to the peridium. This idea must have arisen from the fact that the mucus contiguous to the walls of the peridium dries up a little quicker than that in the center of the cup and for this reason, several sporangioles appear to be fixed by their outer margin, while they are still loose in the center of the cup. But this does not explain why "*scutellaris*" has been made a species of *Cyathia*.

No other writer seems to have mentioned this plant after Micheli until 1791, when Roth described a new genus *Granularia*, as follows: "Fungus subrotundus, granis mucilagine immersis

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* Nov. Pl. Gen. 222. *pl. 102. f. 4.* 1729.

† Roth, Cat. Bot. 1 : 237. 1797.

‡ Syst. Myc. 2 : 300. 1822.

farctus," with one species *Granularia pisiformis*, which he fully describes and figures. This is unquestionably a *Nidularia*, as this genus was called until Otto Kuntze restored *Granularia* to its proper place in 1891. Roth [*] himself described and figured two species six years later under the name of *Cyathus farctus*, and *Cyathus scutellaris*; it is possible that these belong to our genus *Nidula*, but with the imperfect descriptions it is difficult to determine. It is very evident that they are not species of *Cyathia*.

Bulliard,[†] in 1780 made the first mention of the name *Nidularia*, but he referred it to figures which have been unquestionably proved to be *Cyathia lentifera* and *Crucibulum crucibuliforme*. Sibthorp [‡] also employed this name for *Cyathia lentifera*, *Cyathia hirsuta* and *Crucibulum crucibuliforme*. In 1817 Nees [‡] described and figured *Nidularia granulifera*, but although he gives a colored plate, it is difficult to form a correct idea of his plant. Two years later Ehrenberg [||] described and figured *Nidularia globosa* which he says resembles *Cyathus farctus* Roth and *Cyathus deformis* Willd.[¶] but agrees with neither. About this time, 1818, Schweinitz described from North Carolina *Cyathus pulvinatus*, which, though unfortunately none of the original material remains except some of the wood on which it grew, is evidently a true *Granularia* and is a fairly common species in our own country, and the only clear and definite one of the whole tangled thread of the present history.

The family Nidulariaceae was established by Fries in 1822. Under the section "*Nidularia*," he gives seven species, five of which are the above-quoted ones of Nees, Schweinitz, Roth, Ehrenberg and Willdenow; the last one, *Nidularia denudata* Fr. & Nordh. [**] appears from the description to be a true *Granularia*, while the third species which he gives as *Nidularia farcta* he refers to Ray's [††] no. 21, which is the first mention of *Crucibulum crucibuliforme*.

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[*] Cat. Bot. 1: 237. *pl. 7. f. 2.* 1797.

[†] Herb. Fr. *pl. 488.*

[‡] Flor. Ox. 393. 1794.

[§] Syst. Pilze. 139 note. *pl. 13. f. 133c.* 1817.

[||] Sylv. Myc. Berol. 16, 28. *f. 8.* 1819.

[¶] Ust. Bot. Mag. 2: 14. *pl. 3. f. 8.* 1788.

[**] Symb. Gaster. 4. 1817–18.

[††] Syn. 20. *pl. 1. f. 2.*

Fischer* in writing of *Nidularia* says that there are sixteen known species, but though De Toni † gives eighteen from all parts of the world, it is more than probable that several of these are either synonyms of other species or belong to other genera. Tulasne gives eleven species, to nine of which he adds "non vidimus"! the remaining two being new species—*Nidularia australis* from Chili, South America, and *Nidularia Duriaeana* from LaCalle, Algeria (Mauritania). From America several additional species have been described, namely, *Nidularia Alabamensis* Atk. ‡ from Alabama, which we have reduced to *Granularia pulvinata*, and *Nidularia rubella* E. & E. § from New Jersey. This last species is very uncertain, in fact it may not belong to this family at all, as the sporangioles are quite different in texture from those of all the other species, and have never been found to contain any spores, being filled with small pieces of amorphous hyaline matter. It is hard to believe that the plants are in an immature condition as the peridial walls have in some specimens almost entirely disappeared. The only remaining species of *Nidularia* which has been described in this country is *Nidularia candida* Peck which has been referred to the preceding genus. Two heretofore unpublished species of *Granularia* complete our present list: *Granularia castanea*, a herbarium species of Ellis & Everhart, under the name of *Nidularia castanea*, from New Jersey found in 1883, and *Granularia rudis* Peck, from California.

Synopsis of the Species of Granularia

Sporangioles numerous, small (1 mm. or less in diameter).	
Peridium tubercular, pulverulent.	1. *G. pulvinata.*
Peridium only slightly tubercular, not pulverulent.	2. *G. castanea.*
Sporangioles few, larger (2 mm. or more in diameter).	3. *G. rudis.*

1. GRANULARIA PULVINATA (Schwein.) Kuntze, Rev. Gen. Pl. 2: 855. 1891

Cyathus pulvinatus Schwein. Fung. Car. Sup. 51. 1818.

Nidularia pulvinata Fries, Syst. Myc. **2**: 301. 1822; Schwein. Trans. Am. Phil. Soc. **4**: 253. 1834.

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[*] Engler & Prantl. Nat. Pflanzenfam. 1^{1**}: 326. 1899.

[†] Saccardo. Syll. Fung. **7**: 28. 1888;—**9**: 265. 1891;—**11**: 156. 1895;—**14**: 256. 1899.

[‡] Bull. Cornell Univ. (Science) **3**: 23. 1897.

[§] Bull. Torrey Club, **11**: 18. 1884.

Nidularia Alabamensis Atk. Bull. Cornell Univ. (Science) **3**: 23. 1897.

Peridia subspherical, sessile, 2–10 mm. wide, 2–9 mm. high, reddish-brown or dirty cinnamon-colored, at first very floccose-pulverulent, gradually becoming smoother with age, dehiscing irregularly or not at all; peridium thin and rather brittle, tuberculose; inner surface is shiny, smooth, brownish; sporangioles very numerous, darkish brown, barely 1 mm. in diameter, somewhat angular and depressed; spores hyaline, thick-walled, 6–10 μ long, 4–7 μ wide. (*Pl. 17. f. 10–16, 20; Pl. 18. f. 19.*)

Plants gregarious, rarely singly on wood.

NEW YORK: *Ellis, Fairman, Kupfer*; LOUISIANA: *Langlois*, 2666 and 1821; CONNECTICUT: *White;* MAINE: *Harvey;* ALABAMA: Auburn, *Atkinson.*

The floccose pulverulent appearance of the surface of the peridium is caused by the innumerable ends of the filaments which compose the peridium protruding above the main structure, soon becoming broken or eroded. This is a very characteristic feature which renders this species easily recognizable.

Atkinson (*l. c.*) describes *Nidularia Alabamensis*, which undoubtedly belongs here substantially as follows: Peridia spherical, sessile, reddish-brown, roughened, 4–5 mm. in diameter, irregularly dehiscing by the breaking into fragments of the upper portion exposing the sporangioles which completely fill it; no "rooting" threads; sporangioles lenticular, shiny, dark or blackish-brown, barely 1 mm. in diameter, corrugated, hard, filled with a whitish pulpy material which is composed of stout irregular flexous or blanched knotty strongly tuberculose threads with which the spores are mixed; the spores are obovately hyaline, 4–6 × 3–4 μ.

On decaying wood.

ALABAMA: Auburn, July, 1890.

2. **Granularia castanea** (Ell. & Ev.) sp. nov.

Nidularia castanea Ellis & Everhart in herb.

Peridia small, elongate-globose, or subspherical, sessile, sometimes confluent, .5–2 mm. long, 0.5–1 mm. high; peridial walls very thin, and brittle at first, pale yellowish fawn-colored, gradually as the plant matures becoming grayish, and somewhat tuberculose from the inner pressure of the sporangioles, dehiscing irregularly, the outer covering often breaking away completely, leaving the sporangioles seated alone on the wood, barely visible without magnification; sporangioles yellowish-brown, very numerous, crowded, circular, flattened above and below, barely 0.25 mm. in diameter, even or slightly creased under high magnification; spores subglobose, hyaline, thick-walled, 4–7 μ long, 3–6 μ wide. (*Pl. 17. f. 17–19; pl. 18. f. 20.*)

Gregarious on wood.

NEW JERSEY: Newfield, July, 1883. *Ellis.*

3. **Granularia rudis** Peck sp. nov.

Peridia hemispherical or subglobose, sessile; outer covering thin, smooth, fragile when dry, cellular, rather gelatinous when moist, yellowish-brown with a faint greenish tint; indehiscent or the peridial walls gradually breaking away; sporangioles few, irregular, angular or compressed, 2–2.3 mm. in diameter, blackish or greenish tinted; spores broadly elliptic or subglobose, hyaline, 7–9 μ long, 6–8 μ broad. (*Pl. 17. f. 21–23.*)

On decaying wood.

CALIFORNIA: *W. R. Dudley.*

The material from which this species is described is very scanty, but the specific features are so individual, and they differ so much from any known species of *Granularia* that it has been decided to include it in the present revision. It differs from all known species in the gelatinous cellular and greenish texture of the peridium, and in the large angular sporangioles, only a few being contained in each peridium.

SPECIES INQUIRENDA

NIDULARIA RUBELLA Ell. & Everh. Bull. Torrey Club, **11**: 18. 1884.

The following table will show the present known distribution of the family in North America:

	Canada.	Maine.	Massachusetts.	Connecticut.	New York.	New Jersey.	Pennsylvania.	Delaware.	Virginia.	South Carolina.	Georgia.	Alabama.	Louisiana.	Ohio.	Indiana.	Kentucky.	Wisconsin.	Iowa.	Nebraska.	Kansas.	Texas.	New Mexico.	Colorado.	Utah.	Montana.	Washington.	Oregon.	California.	British Columbia.	Cuba.	Puerto Rico.	St. Croix.	Jamaica.	Mexico.
Cyathia dura.																							+											
C. lentifera.		+		+	+		+					+			+					+	+		+	+				+			+			
C. limbata.																														+				
C. intermedia.								+																					+					
C. melanosperma.							+																											
C. Berkleyana.																														+			+	
C. Montagnei.																														+				+
C. pallida.																														+	+			
C. Poeppigii.																														+		+		
C. rugisperma.							+																											
C. rufipes.																			+	+														
C. stercorea.	+	+	+	+	+	+	+	+	+	+		+	+	+	+			+	+	+		+	+							+				
C. striata.	+	+		+	+		+				+	+		+	+		+	+	+				+		+	+				+			+	
C. Wrightii.				+																														
Crucibulum crucibuliforme.		+	+	+	+	+	+		+	+		+			+	+				+			+		+	+	+							
Nidula candida.																										+			+					
N. microcarpa.																									+	+		+						
Granularia pulvinata.		+		+	+							+	+																					
G. castanea.						+																												
G. rudis.																												+						

Explanation of Plates

The figures on Plates 14, 15, 16 and 17 were drawn one quarter larger than indicated. Those on Plate 18 were made twice the size. The microscopic details were drawn with a camera lucida and reduced on the same scale, as above noted.

PLATE 14

FIG. 1. *Cyathia Poeppigii*, nat. size. 2. The same, enlarged about three times after moistening. 3. Single peridium in dry condition. 4. Spores, × 335. 5. *Cyathia Berkleyana*, nat. size. 6. Peridium of same, enlarged three times. 7. Spores, × 335. 8. *Cyathia intermedia*, nat. size. 9. Peridia, enlarged twice, one in dry condition, the other after expanding when moistened. 10. Spores, × 335. 11. *Cyathia hirsuta* nat. size. 12. Group, enlarged about three times. 13. Spores, × 335. 14, 15. *Cyathia hirsuta infundibuliformis*, enlarged about three times. 16. *Cyathia dura*, nat. size. 17, 18. Peridia, enlarged twice. 19. Spores, × 335. 20. *Cyathia Montagnei*, nat. size. 21. Peridium, enlarged twice. 22. Spores, × 335.

PLATE 15

FIG. 1. *Cyathia melanosperma*, nat. size. 2. Single peridium, nat. size (after moistening). 3. Single peridium, enlarged about three times. 4. Spores, × 335. 5. *Cyathia pallida*, nat. size. 6. Mature and young peridia, enlarged twice. 7. Spores, × 335. 8. *Cyathia lentifera*, nat. size. 9, 10, 11, 12. Different specimens showing character of growth and shape, enlarged twice. 13. Spores, × 335. 14 *Cyathia rufipes*, nat. size. 15. Peridia, enlarged twice. 16. Spores, × 335. 17. *Cyathia stercorea*, nat. size. 18, 19. Different specimens showing character of growth and shape, enlarged about three times. 20. Spores, × 335.

PLATE 16

FIGS. 1, 2. *Cyathia stercorea*, showing additional types and characteristics, enlarged twice. 3. *Cyathia rugisperma*, natural size. 4. Peridia enlarged twice. 5. Spores, × 335. 6. Spores, × 585. 7. *Cyathia Wrightii*, natural size. 8, 9. Peridia, enlarged twice. 10. *Crucibulum crucibuliforme*, natural size. 11. Section of sporangiole, × 50. 12. Group of peridia, enlarged twice. 13. Spores, × 335. 14. Group of peridia from the Schweinitz specimens of *Crucibulum juglandicolum*. 15. Spores from the same, × 335. 16. *Cyathia* (?) sp., natural size. 17. *Nidula candida*, natural size. 18, 19. Peridia, somewhat enlarged. 20. Spores and filament, × 335. 21, 22. Spores of *Cyathia* (?) sp., × 335.

PLATE 17

FIG. 1. *Nidula microcarpa*, nat. size. 2. Peridia, enlarged twice. 3. Section-enlarged about five times. 4. Sporangiole showing torn outer covering, enlarged about twenty-five times. 5. Sporangiole still in its ~~outer covering,~~ enlarged twelve times. 6. Spores, × 335. 7. *Nidula microcarpa rugispora*, nat. size. 8. Peridium, enlarged three times. 9. Spores, × 335. 10. *Granularia pulvinata*, nat. size, reduced from drawing by Mr. Hasselbring of *Nidularia Alabamensis* Atk. 11. *Granularia pulvinata*, nat. size. 12. Peridia, enlarged three times. 13. Spores and filaments, × 335. 14. Very old peridia, the walls of which have almost completely fallen away. 15. Spores. × 585. 16. Spores, × 335. 17. *Granularia castanea*, nat. size. 18. Group of peridia, enlarged twice. 19. Irregular peridia, having grown together, enlarged twice, 20. Spores of *Granularia pulvinata*, × 335 (*Nidularia Alabamensis* Atk.). 21. *Granularia rudis*, enlarged twice. 22. Spores, × 335. 23. Sporangioles, × 15.

PLATE 18

FIGS. 1–6. *Cyathia hirsuta*. 1. Sporangiole, showing attachment, enlarged about fifteen times. 2. Spore, × 390. 3. Spores and filaments, × 215. 4. Threads of outer coating of sporangiole, × 215. 5. Nodose filaments of the funiculus, × 390. 6. Portion of the funiculus, × 110. 7–13. *Crucibulum crucibuliforme*. 7. Sporangiole, × 15. 8. Sporangiole, with the outer coat peeling off. 9. Small portion of a section of a sporangiole, × 215. 10, 11. Spores of young specimen, × 390. 12. Spores of fully mature specimen, showing contraction of inner substance, × 390. 13. Small portion of the ends of the filaments of the thin membrane covering the mouth of the immature specimen, × 315. 14. Spores of *Nidula microcarpa*, × 390. 15. Lateral portion of outer coat of the sporangioles of same, × 215. 16. Small portion of the outer coat of the sporangiole of *Crucibulum crucibuliforme*, × 215. 17. Section of a sporangiole of *Nidula microcarpa*, × 110. 18. Fascicular hairs from the outer covering of the peridium of *Cyathia intermedia*, × 15. 19. Small portion of the peridial wall of *Granularia pulvinata*, × 215. 20. Sporangioles of *Granularia castanea*, when devoid of peridial covering, × 110.

Notes on American Hepaticae

By Marshall A. Howe

I. CEPHALOZIA CONNIVENS

Cephalozia connivens (Dicks.) Lindb. Proc. Linn. Soc. **13**: 190. 1872. Kritisk Gransk. Mossorna Dill. Hist. Musc. 38. 1883. Spruce, On Cephalozia, 46. 1882. Lindb. & Arn. Sv. Vet.-Akad. Handl. **23**^{5}: 20. 1889. Kaalaas, Nyt Mag. 165. 1893.

Jungermannia connivens Dicks. Fasc. Pl. Crypt. Brit. **4**: 19. *pl. 11. f. 15.* 1801.

Cephalozia multiflora Lindb. Act. Soc. Sci. Fenn. **10**: 501. 1875. Musc. Scand. 4. 1879.

This species has been much confused with its near relative *Cephalozia lunulaefolia* Dumort. (*C. media* Lindb., *C. multiflora* Spruce) both in Europe and America, but is very distinct as was first well pointed out by Spruce (*On Cephalozia*, 39. 1882). The plant may be readily distinguished from *C. lunulaefolia* by the large leaf-cells (35–90 μ, while only 25–50 μ in *C. lunulaefolia*), by the long-ciliate perianth-mouth, by the perianth-wall being unistratose throughout, and by being autoicous. The specimens distributed by Sullivant under the name of *Jungermannia connivens* in Musci Alleghanienses (no. 246) belong with *C. lunulaefolia* so far as we have been able to see them, and the same is true of no. 57 of Austin's Hepaticae Boreali-Americanae, issued as *Cephalozia connivens*. In 1896, Professor Underwood, in his review of "The Genus *Cephalozia* in North America" (Bull. Torrey Club, **23**: 381–394), placed *Cephalozia connivens* under "Species dubiae et inquirendae," remarking that it was likely to occur northward. In October, 1898, the writer of the present notes announced* at a meeting of the Torrey Botanical Club the discovery of the genuine *Cephalozia connivens* on the grounds of the New York Botanical Garden, supposing this to be the first collection of the real *C. connivens* in America. The species was soon found in several other places in the neighborhood of New York, and this has led to an

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*Bull. Torrey Club, **26**: 24. 1899.

examination of the specimens of *Cephalozia* in the accessible herbaria with the result that we are now able to cite seventeen North American specimens of the true *Cephalozia connivens*, showing a coastwise range from Prince Edward Island to Florida, and an extension inland as far as London, Ontario.

The specimens cited may be arranged as follows:

PRINCE EDWARD ISLAND: *J. Macoun*, June 27, 1888, no. 139 (a little only, mixed with *C. lunulaefolia* and *Kantia trichomanis*). ONTARIO: London, *J. Dearness* (in herb. Underwood, comm. in 1889 as no. 1). RHODE ISLAND: Providence, from Olney collection in Chapman herbarium; also, in same herbarium, a second specimen from Rhode Island, without locality. CONNECTICUT: on the ground in wet woods, Westville, *A. W. Evans*, November 29, 1890. NEW YORK: in a tamarack swamp, Syracuse, *L. M. Underwood*, April, 1888; Staten Island, *Mrs. E. G. Britton*, February 14, 1892; on the top of a decayed hemlock stump near Bronx River, New York Botanical Garden, *M. A. Howe*, September 21, 1898, with *Odontoschisma sphagni;* on bank of a stream in a boggy wood, Freeport, Long Island, *M. A. Howe*, October 17, 1898; on margin of a swamp, Richmond, Staten Island, *M. A. Howe*, October 23, 1898; Sayville, Long Island, *F. E. Lloyd*, March 5, 1899. DELAWARE: on ground in woods, Wilmington, *A. Commons*, March 12, 1890; in herb. Columbia University. NORTH CAROLINA: Salem, *Schweinitz*, in herb. Torrey (labelled *Jungermannia bicornis* by Schweinitz). SOUTH CAROLINA: Summerville, *C. G. Dubois*, April, 1889. FLORIDA: Lisbon, *L. M. Underwood*, January, 1891 (distributed from U. S. National Herbarium as no. 1217); Port Orange, *F. C. Straub*, February 23, 1895 (no. 207 in herb. Underwood)—also in same locality, March, 1895, mixed with *Telaranea* and a minute *Lepidozia* in Hepaticae Americanae, no. 180. BERMUDA: Devonshire Marsh, *M. A. Howe*, July 4, 1900.

Lindberg appears to have been the first to have combined the specific name *connivens* (Dicks.) with the generic name *Cephalozia*, although at the outset he attributed the binomial to Dumortier. Dumortier however persisted even in his "Hepaticae Europae" in keeping the species under *Blepharostoma* and seems never to have written *Cephalozia connivens*. The synonymy of the species is confused, owing partly to the fact that is was not until 1881 and 1882 that Lindberg and Spruce began to distinguish, in their published works at least, between the true *Cephalozia connivens* and *C. lunulaefolia*, and owing furthermore to some uncertainties attending the determination of *Jungermannia multiflora* of Hudson (Fl. Angl. 431. 1762). The question of interpreting correctly Hudson's *J. multiflora*, difficult at best, is needlessly complicated by Dr. Spruce (*l. c.* 40) by quoting the 1778 edition of Hudson's Flora Anglica, where a supposed synonym from Linné's Mantissa is introduced, though the original 1762 edition without the Linnaean synonym is all that needs to be considered. The original *Jungermannia multiflora* seems to have been founded wholly upon a plant described and figured by Dillenius (Hist. Musc. 481. *pl. 69. f. 4.* 1741). As noted already by Hooker, Spruce, and Lindberg, the figures given by Dillenius point strongly to *Cephalozia bicuspidata.* It is quite impossible to believe that they were drawn from specimens of *C. connivens* and Dillen's words "*per lentem vero perangusta*" in describing the leaves could not well apply to this species, yet Lindberg in 1875 (Act. Soc. Sci. Fenn. **10**: 501), after determining the specimen in the Dillenean herbarium bearing the corresponding name and number from the Historia Muscorum to be the *Jungermannia connivens* * of Dickson, brought forward for this species Hudson's name *multiflora.* Finally,† however, interpreting this "Lichenastrum multiflorum exile foliis angustissimis" of Dillenius by the figure and description, Lindberg considers it a synonym of *Cephalozia bicuspidata* (L.) Dumort., which seems to us the most reasonable course in the matter. Lindberg at the same time most unwarrantably interprets *Jungermannia multiflora* Huds. in the light of additions made by Linnaeus nine years after its original publication and shifts the specific name *multiflora* to *Lepidozia setacea* (Web.) Mitt. It is clear that if *Jungermannia multiflora* Huds. (1762) can be justly treated as a synonym of *J. bicuspidata* L. (1753) it should always remain a "dead name."

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* This determination, it may be noted, was made several years before the distinctions between the true *C. connivens* and *C. lunulaefolia* (*C. media* Lindb.) were recognized in print, at least, yet the statement that the Dillenian specimen is "*C. connivens* (Dicks.) Lindb.," was repeated by Lindberg in 1883, two years after his publication of *C. media.*

† Kritisk Gransk. Mossorna Dill. Hist. Musc. 38. 1883.

II. TELARANEA

TELARANEA Spruce, Trans. and Proc. Bot. Soc. [Edinb.] **15**: 365. 1885. [As a synonym.] Schiffn.; Engl. & Prantl, Nat. Pflanzenfam. **1**^{3}: 103. 1895.

The genus *Telaranea* has points of contact with *Lepidozia*, *Blepharostoma*, and *Arachniopsis*, and if generic rank is denied to it, might be incorporated with any one of the three with almost equal justice. To the *Micro-Lepidozia* section of the genus *Lepidozia* its affinity is perhaps especially close, yet, according to prevailing conceptions of genera among the Hepaticae, it seems a rather violent proceeding to include it in a generic group the historical type of which is *Jungermannia reptans* L. *Telaranea* diverges from *Lepidozia* in its delicate, filmy, conferva-like habit and in the division of the leaves very nearly or quite to the base, the segments being never more highly connate than through half the altitude of the basal cell and usually for a considerably less distance; the leaf-segments are capillary, of a single row of cells unless at the very base, the place of the basal cell being often occupied by a pair of cells side by side. From *Blepharostoma*, *Telaranea* is probably best distinguished by the disparity in size between leaves and underleaves and by the more pinnate branching. The archegonia, though usually borne on short postical branches as in *Lepidozia* and *Cephalozia*, are sometimes terminal on the main stem or lateral branches as in *Blepharostoma*.

In its filmy habit and delicacy of structure *Telaranea* is suggestive of *Arachniopsis* Spruce, but the latter genus represents a still further departure along the same lines from the *Lepidozia* type. In *Arachniopsis* the branches are all postical in origin, the underleaves are entirely wanting or are now and then to be recognized only in a most rudimentary form, and the leaves never have more than two segments which are wholly free at the base and consist of a single series of cells throughout.

The species and varieties to be arranged under the genus are, so far as we know them, as follows:

1. **Telaranea nematodes** (Gottsche)

Jungermannia nematodes Gottsche, Hepaticae Cubenses Wrightianae.

Cephalozia nematodes Aust. Bull. Torrey Club, **6**: 302. 1879.

Lepidozia chaetophylla Spruce, Trans. and Proc. Bot. Soc. [Edinb.] **15**: 365. 1885.

Lepidozia nematodes Spruce, *l. c.* 366.

Telaranea chaetophylla Spruce, "Mst. nov. gen." *l. c.* [as synonym]. Schiffn.; Engl. & Prantl, Nat. Pflanzenfam. **1**^{3}: 103. 1895.

Lepidozia chaetophylla tenuis Pearson, Christ. Vid.-Selsk. Forhandl. 1886^3: 9. 1886. Evans, Bull. Torrey Club, **20**: 308. 1893.

Blepharostoma nematodes Underw. Bull. Torrey Club, **23**: 383 (footnote). 1896.

Spruce in comparing his *Lepidozia chaetophylla* with *Lepidozia nematodes* (Gottsche) emphasizes the flaccidity of the latter as a distinguishing character and this indeed appears to be about the only difference of importance to be detected between Wright's Cuban plant and those from South America distributed by Spruce as *Telaranea chaetophylla* (Hepaticae Spruceanae: Amazonicae et Andinae). Wright's specimens revive quite imperfectly on being soaked out with water, but there is such a range of variability in this respect in different parts of a single tuft and even of different parts of a single plant, both in the Cuban and South American specimens that we are not inclined to give much weight to this character. We therefore agree with our friend Mr. Pearson (*l. c.*) in believing that the two forms represent a single species. We would, however, differ from Pearson in retaining for this species the oldest published name *nematodes.* The specific name *nemoides* given earlier by Taylor to another plant now recognized as a *Lepidozia* seems sufficiently different both to the eye and ear to prevent confusion.*

In both the Cuban and South American plants the archegonia are usually borne on a short postical branch, rarely at the end of the main axis or of an elongated branch. In 1886, Pearson (*l. c.*) identified a specimen from Natal, South Africa, with Gottsche's Cuban species, which he renamed *Lepidozia chaetophylla tenuis.*

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*The remark is attributed to Spruce (Pearson, *l. c.*) that *nemoides* and *nematodes* differ only in case-ending. It seems to us that the two words are equally nominative in form but that Taylor's name *nemoides* is an etymological monstrosity on account of his failure to use the true stem of the Greek noun in constructing the adjective.

Through the courtesy of Mr. Pearson we have been able to examine this South African plant, and like him, can find no reasonable grounds for distinguishing it from the American specimens alluded to. *Telaranea nematodes*, then, may be said to be found in a fairly typical condition in South America and South Africa as well as in Cuba, and to this range is now to be added Bermuda, where sterile plants were collected by the writer in Devonshire Marsh, July 4, 1900, growing in company with *Cephalozia connivens* and *C. divaricata*. In addition to this more or less typical form, illustrated by the specimens and descriptions cited, the species presents itself also in two forms which we think are sufficiently marked to receive varietal names. These are:

1a. **Telaranea nematodes Antillanum** (Besch. & Spruce)

Blepharostoma Antillanum Besch. & Spruce, Bull. Soc. Bot. France, **36**: clxxxiii. 1889.

Archegonia terminal on main stem, a lateral branch, or elongated postical branch, rarely on a short postical branch; leaves and perianth rather rigid.

Le Gommier, Gaudeloupe, *Ed. Marie*. In a specimen of the Guadeloupe plant kindly communicated by M. Bescherelle we find on a single individual all the various modes of bearing archegonia described above. The leaves, described by the authors as 4-parted, we find much more frequently 3- and 2-parted. It seems as impossible to separate this plant specifically from *Lepidozia chaetophylla* Spruce as it is to distinguish satisfactorily between the latter and Gottsche's *Jungermannia nematodes*. So far as we know, the identification of *Blepharostoma Antillanum* with *Jungermannia nematodes* was first made by Professor Schiffner (Engl. & Prantl, Nat. Pflanzenfam. **1**^{3}: 105. 1895).

1b. **Telaranea nematodes longifolia** var. nov.

Leaves more rigid than in type and more widely spaced, 0.4–0.8 (rarely 0.9 mm.) long, leaf-cells 2–4½ times as long as broad.

Collected by the writer on humus in a swampy wood in company with *Sphagnum*, *Pallavicinia Lyellii*, and *Cephalozia catenulata*, Freeport,* Long Island, New York, October 17, 1898

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* This Freeport plant was listed by Dr. Smith Ely Jelliffe in his Flora of Long Island (48. 1899) under the name *Blepharostoma nematodes*.

(type specimen in herb. N. Y. Botanical Garden). Also, Florida, *John Donnell Smith*, 1877; *C. F. Austin*, March, 1878; *F. C. Straub*, March, 1895; Brunswick, Georgia, *C. F. Austin*, April, 1878.

The Long Island specimens agree essentially with those from Georgia and Florida, though the latter make a slightly closer approach to the Cuban plant. The Long Island station is therefore a noteworthy northward extension of the known range of a plant which has heretofore figured in papers on North American Hepaticae as coming only from a limited region of the South. The archegonia in these United States specimens, so far as we have observed, always occur on a short postical branch. The leaves are 5–8 cells long; the underleaves are 3- or 2-parted, their prongs of 2 or 3 cells each, incurved at the apices. All are autoicous. In the original *Jungermannia nematodes*, collected in Cuba by Wright, the leaves are 0.25–0.5 mm. long, 4–6 cells high, the cells being 2–3 times longer than broad.

The variety *longifolia* often gives the impression of being two or three times the size of the Cuban plant, but we have been unable to find any reliable structural characters to serve for a specific separation. The form of the perianth seems quite variable in all conditions of the species, but is often broader in the var. *longifolia* than in the type.

No. 180 Hep. Am., issued as *Blepharostoma nematodes*, is referable to *Telaranea nematodes longifolia*; it is mixed with *Cephalozia connivens* and with a minute *Lepidozia*, probably a reduced form of *L. setacea*.

Telaranea bicruris (Steph.)

Lepidozia bicruris Steph. Hedwigia, **24**: 166. *pl. 3.* 1885.

BRAZIL: São Francisco, *Ule*.

This plant, though a close relative of *T. nematodes*, seems entitled to specific distinction, differing in the almost invariably 2-parted leaves, in the frequent continuation of the stems into leafless flagella (rare in *T. nematodes*) and in the simpler ♀ bracts. It is described by Stephani as dioicous, though apparently he had not seen ♂ plants. We have been unsuccessful in attempts to find antheridia in the specimen kindly communicated by Herr Stephani, and it certainly may be suspected that dioicism is to be added to its distinguishing characters. All the perianths seen are on very short postical branches.

III. ARACHNIOPSIS

Arachniopsis diacantha (Mont.)

Jungermannia diacantha Mont. Ann. Sci. Nat. IV. **5**: 349. 1856.

Arachniopsis coactilis capillacea Spruce, On Cephalozia, 85. 1882; Trans. and Proc. Bot. Soc. [Edinb.] **15**: 356. 1885.

Leaves mostly rigid, composed of 4–6 cells, these 4–7 times as long as broad.

PERU: *Weddell, Spruce.*

Jungermannia diacantha Mont. is represented in the Montagne herbarium, now preserved in the Muséum d'Histoire Naturelle of Paris, only by two small sterile fragments fastened to pieces of mica. This original material, which we have seen through the courtesy of Mons. Hariot, agrees perfectly, so far as it goes, with the specimen from Mt. Campana, Peruvian Andes, distributed by Spruce as *Arachniopsis capillacea* in his "Hepaticae Spruceanae: Amazonicae et Andinae." Montagne's description of the leaves as "spiraliter 5/1 circa caulem dispositis" was evidently an error, due, it may be, to a torsion of the stem.

Arachniopsis confervifolia (Gottsche).

Jungermannia confervifolia Gottsche, Hepaticae Cubenses Wrightianae.

Cephalozia confervifolia Aust. Bull. Torrey Club, **6**: 302. 1879.

Arachniopsis coactilis Spruce, On Cephalozia, 85. 1882. Trans. and Proc. Bot. Soc. [Edinb.] **15**: 355. *pl. 13.* 1885. Excluding var. *capillacea.*

Leaves often flaccid, composed of 6–14 cells, these 2–3 times as long as broad.

CUBA: *Wright;* SOUTH AMERICA: on the tributaries of the Amazon, *Spruce.* We have little hesitancy in considering *Arachniopsis coactilis* Spruce a synonym of the Cuban *Jungermannia confervifolia* Gottsche. The latter is more flaccid, showing a relation to the South American specimens somewhat analogous to that described above as existing between *Jungermannia nematodes* Gottsche and *Lepidozia chaetophylla* Spruce. The Cuban plant is autoicous and in structural characters is essentially identical with the typical *A. coactilis.* Vestiges of underleaves are occasionally met with in both and in both the leaf is sometimes reduced to a single prong.

The specific separation of *Arachniopsis confervifolia* from *A. diacantha* is possibly open to question, yet in the light of available specimens the two appear distinct. *Arachniopsis coactilis filifolia* Spruce, judging from specimens distributed as *Arachniopsis filifolia* in Hepaticae Spruceanae, seems to us less entitled to specific rank.

Arachniopsis confervifolia resembles *Telaranea nematodes* in outward appearance, but is easily distinguished by the characters alluded to above under *Telaranea.* It is to be expected that *Arachniopsis* will be found to occur within the limits of the United States.

IV. RICCIA CAMPBELLIANA

Herr M. Heeg, of Vienna, has kindly called our attention (*in litt.*) to the close resemblance between the Californian *Riccia Campbelliana* M. A. Howe (Mem. Torrey Club, **7**: 26. *pl. 91. f. 1–15.* 1899) and the Mediterranean *Riccia macrocarpa* Levier (Bull. Soc. Bot. Ital. 1894: 114. 1894). The similarity is indeed very striking as is evident from specimens of *R. macrocarpa* which we owe to Dr. Levier, but *R. macrocarpa* appears to be uniformly dioicous as originally described by Levier and as described again by Stephani (Bull. Herb. Boiss. **6**: 343. 1898), while *R. Campbelliana* is uniformly monoicous; and the areolae of the outer face of the spores of *Riccia macrocarpa* are more perfect than in *R. Campbelliana.* In view of these differences the claim of *Riccia Campbelliana* to specific rank seems defensible for the present at least. The species has recently been collected by Dr. Walter R. Shaw at Claremont, Los Angeles County, Cal., thus extending its known range about two hundred and fifty miles southward.

Concerning some West American Fungi

By David Griffiths

This writing is intended to supplement the information supplied on some conventional herbarium labels recently distributed, and to call attention more in detail to certain species which appear to the author to have hitherto escaped the attention of mycologists. All species described are being liberally distributed so that the determinations may be easily verified.

Tilletia externa sp. nov.

Fructification of fungus occurring between the seed coats of the ovary where a black powdery mass of spores is formed surrounding the entire ovary, in some cases, but always more abundantly developed on the upper half, and often not appearing on the lower half at all. Spores black in mass, dark fuscous when viewed singly by transmitted light, very variable in size and shape, subglobose to elliptical, or irregular and angular, 10–13 μ × 18–23 μ or the subglobose spores 17–21 μ in diameter, the contents granular; epispore thin, smooth, surrounded by a hyaline envelope 2–2½ μ in thickness. (Fig. 1.)

Affecting ovaries of *Carex filifolia* Nutt. (305) * on Burnett's Ranch near Buffalo, Wyo., Aug. 1898 (Williams & Griffiths). The fungus was especially abundant and destructive in this locality on high dry knolls at an altitude of about 4000 feet.

Tilletia Earlei sp. nov.

Fungus producing its spores usually in the next to the upper internode of the culm, transforming the parenchymatous tissue within and between the vascular bundles into a light brown powdery mass of spores which finally ruptures the tissue between the bundles producing long fissures a centimeter to a decimeter in length, the edges of the fissure recurving so as to expose and distribute the mass of spores; culms usually much swollen and otherwise distorted and separated from the sheath. Spores light brown in mass but only very slightly tinted when viewed singly, globose, evenly covered with very coarse tubercles and surrounded

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* All figures used in this manner refer to the serial numbers of West American Fungi.

by a hyaline envelope about 2μ thick; epispore rather thin but often appearing thick on account of the tubercles, 13–18μ in diameter. (Fig. 2.)

Affecting the culms of *Agropyron occidentale* Scribn. (311), Aberdeen, S. D., August 10, 1896. The host grew on ground heavily fertilized with refuse from the city on high and dry banks of the Moccasin a short distance below the mouth of a sewer. The species is easily recognized by its method of attack as well as by its color which is more like that of some of the species of *Sorosporium* which affect the Compositae. It was very destructive to the host during 1896, '97 and '98 in this very circumscribed area of not over an acre in extent. There were square rods where the host grew to the exclusion of almost all else, having every culm

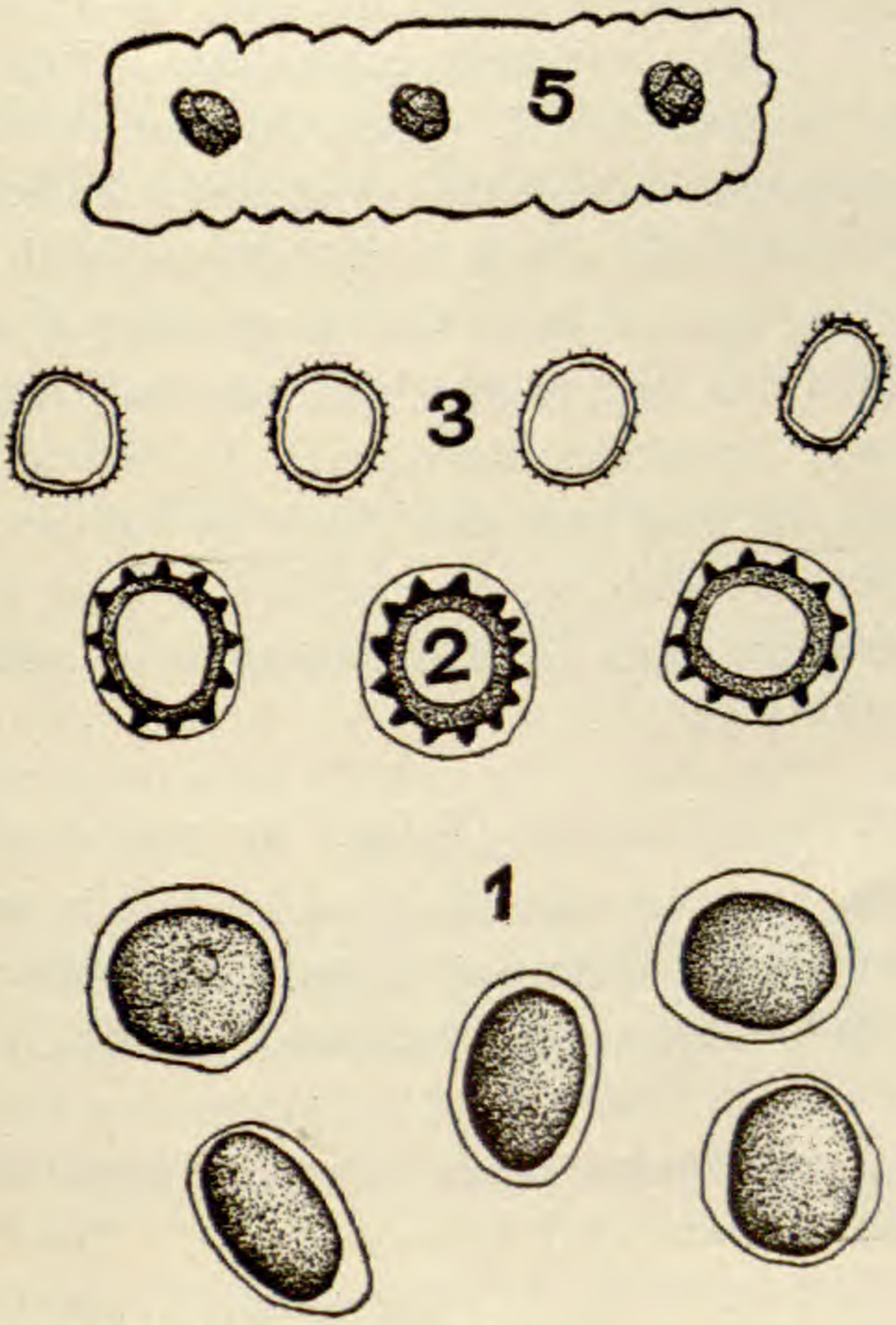


FIG. 1. Spores of *Tilletia externa*. × 630.
FIG. 2. Spores of *Tilletia Earlei*. × 630.
FIG. 3. Spores of *Ustilago elegans*. × 630.
FIG. 5. Spores of *Sorosporium Williamsii*, and outline of the cylindrical spore mass. × 730.

affected and no seed whatever produced. During five years' collecting it was observed in no other locality, although the host is one of the most common of the prairie grasses and often found in similar situations.

Ustilago elegans sp. nov.

Fructification of fungus occurring within the upper or within the second or third leaf sheath which becomes much enlarged and does not open until the maturity of the parasite which occupies its entire interior. Spores subglobose, angular or often elongated with a small central rather indistinct nucleus, 10–13 μ in diameter; epispore about 1 μ thick, minutely echinulate. (Fig. 3.)

On *Chloris elegans* H.B.K. (309) Cochise, Ariz., Oct. 1900. The method of attack, while similar in all cases studied in the field, presents a great variation which is coördinated with the vigor of the plant. On the general mesa the plants affected with the smut were not usually over one to two and one half inches tall with all but the lower internodes destroyed. In the railroad ditches, however, where the host was stimulated by the accumulation of water, the upper internode together with the head was ordinarily affected. Sometimes both of these methods of attack are to be found in the same plant.

USTILAGO HYPODYTES (Schw.) Fr. and its allies

These culm smuts are exceedingly abundant in many portions of the West on a great variety of hosts. My collections contain them on the following: *Stipa spartea* Trin. (3), *Stipa viridula* Trin., *Stipa occidentale* Thurb. (236), *Agropyron occidentale* Scribn. (234), *Elymus condensatus* Presl. (233), *Elymus striatus* Willd. (201), *Distichlis spicata* (L.) Greene (235). The first of these, collected at Canton, S. D., is referred to *U. minima* Arth. the others to *U. hypodytes* although the author is inclined to the opinion that future cultural and inoculation experiments will result in a segregation of species. Field observations in the Northwest during the past ten years point strongly to such a conclusion. One of the above forms may often be found attacking every individual of a certain species within certain areas while other hosts upon which some of the forms occur may within the same area be entirely unaffected. Notable instances of this have been observed in several localities. At Brookings, S. D., in 1892, 1893 and again in 1896 *Stipa viridula* was almost completely prevented from making seed in a certain locality while *Agropyron occidentale* in actual contact with it was entirely unaffected. In 1896 and 1897 at Aberdeen, S. D., the same grasses were observed growing together, but in this instance the *Agropyron* was smutted while the *Stipa* was entirely free. In the vicinity of Billings, Mont., in 1900 smutted plants of *Elymus striatus* and *Agropyron occidentale* were both growing with *Stipa viridula* in different situations, but the latter was entirely unaffected. During the past summer *Elymus condensatus* was very badly smutted at Quinn River Crossing, Nev. *Distichlis spicata* growing about its base was entirely unaffected. In another locality in the same general region where the hosts bore the same relation to each other *Distichlis* was badly smutted while *Elymus* was perfectly free from the disease. In one locality, near Andrews, Oregon, they were both found smutted growing side by side.

There are slight differences in spore characters in some of these forms, but they are too slight to warrant the establishment of species upon them. The spores of the forms on *Stipa occidentale* are a trifle larger than any of the others while the form on *Distichlis* has spores with somewhat thicker walls and more restricted central area. The form on *Agropyron occidentale* from Billings, Mont., has the epispore much darker than any of the others. These differences are trifling of course, but when emphasized by the above field observations their importance is magnified very much. It might be added that these differences are fully as great as those which led to the establishment of *U. funalis* E. & E. on *Eriocoma cuspidata*.

USTILAGO MINOR Norton

This species is very abundant and destructive all through southern Arizona. There appears to be in my material a slight difference in the size of the spores of all collections of *Bouteloua oligostachya* whether from Montana or Arizona. All collections on this host are, therefore, referred to *U. filifera* Nort. (217 and 217*a*). *U. minor*, as represented in my collections from Arizona, occurs on *Bouteloua polystachya* (220), *B. aristidoides* (218), *B. eriopoda* (219), *B. bromoides* (227), and *Pappophorum Wrightii* (224). It is very destructive to all of these species and may be commonly found anywhere from the high mountains to the river bottoms. Its method of attack and the extent of injury done are very variable and apparently correlated with the vigor of the host which is dependent in turn upon the supply of moisture and the fertility of the soil. On fertile soil so situated as to receive an abundance of moisture in the vicinity of Cochise, plants of *B. polystachya* with scarcely a leaf or node unsmutted were but little if any reduced in size; but plants of the same species growing on sandy land near Wilcox were reduced to a small rosette of pustules on the surface of the ground, not over three fourths of an inch in diameter, while the length of culm here averaged about five inches. Similar differences were observable in its method of attack when growing on *Bouteloua aristidoides* in the Santa Cruz valley near Tucson.

USTILAGO MULFORDIANA E. & E. AND TILLETIA FUSCA E. & E.

It is strange that these two species have not found their way into herbaria more abundantly than they have, for there are no fungi more plentiful in many portions of Montana, Wyoming, Idaho and Oregon than these two species. The writer has also collected the former in the Santa Rita Mountains in southern Arizona.

It is also rather strange that the two species should be so commonly associated in the Northwest. They have been seen associated together at Sheridan, Wyo., Billings, Missoula and Kalispell, Mont., and Ontario, Ore. At both Billings and Missoula an abundance of plants were found affected by both species. They invariably, of course, select different culms for their fructification. The first species destroys the upper portion of the culm within the enlarged leaf sheath. The latter allows an apparently normal development of all portions of the host except the ovary which is very much enlarged. The host of both species is *Festuca octoflora* Walt. Professor F. S. Earle has compared some of my material with the type of *U. Mulfordiana* in the herbarium of the New York Botanical Garden and reports that the hosts also appear to be the same.

USTILAGO ARISTIDAE Peck

This species is very destructive to *Aristida Scheideana* in Arizona, where it has been observed in several localities, but always on the same host. Examination of herbarium specimens of the grass shows that the fungus is widely distributed throughout the Southwest. Its persistently tectate condition is very noticeable in all the specimens examined. The author made a large collection (214) in the Santa Catalina Mountains, in Arizona, in Nov. 1900. In the following April, when the locality was visited again, the fungus (*214a*) appeared to be as perfectly preserved as it was five months before. Large herbarium specimens of the host have been seen with every seed destroyed by the smut, but notwithstanding the vast amount of handling, none of them were ruptured.

Professor Norton reports that the fungus causes a shortening of the awns of *Aristida purpurea* in Kansas. Such is not the case with the host mentioned above for there is apparently no modification of any portion of the plant except the ovary.

Sorosporium bigeloviæ sp. nov.

Fungus attacking and destroying the inflorescence especially, but involving also the bracts and often the upper leaves of the branches. The florets become transformed into a globular mass filled with light brown spores and surrounded by a thin pellicle consisting of the modified involucral covering. The leaves become very much swollen especially near the base, the whole interior being transformed into a mass of spores. Spore masses very variable, elongated globular or polygonal and containing 2–6 spores (usually only 3 or 4) commonly 13–21 μ in diameter but often as high as 25–30 μ. Spores globular, globose or compressed and polygonal, 7–10 μ in diameter; epispore thick, distinctly tuberculate and of light straw color. (Fig. 4.)

On *Bigelovia* (399) Tucson, Arizona, Nov., 1900. This was the most common fungus to be found in the Santa Cruse valley near Tucson during the fall and winter of 1900. But, while this is true, it is very likely to be overlooked because the attack of the smut is not at all conspicuous. In one locality north of the city a dense growth of the host along a fence row for a distance of at least ten rods produced almost no seed. Some plants had nearly all the flower heads formed but destroyed, while others had their growth arrested by the abundant fructification of the fungus in the bases of the upper leaves.

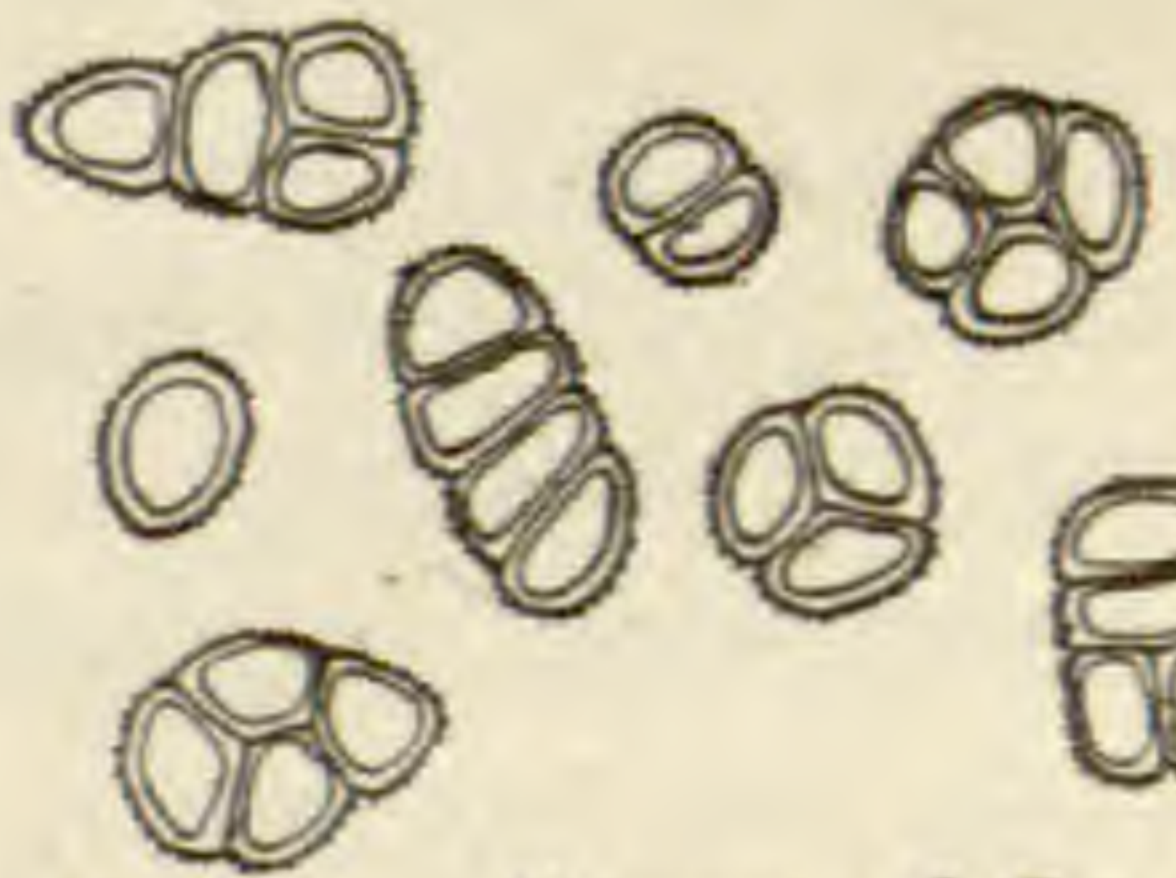


FIG. 4. Spores of *Sorosporium bigeloviæ*. × 115.

Sorosporium Williamsii sp. nov.

Fungus producing its spores in the peripheral tissues of the culm of the host within the leaf sheath, transforming them into a black powdery mass and preventing the fructification of the host, the upper node being usually but little developed; two to four nodes are commonly involved; spore mass very loosely united, containing many spores, cylindrical, straight or curved, 65–100 μ × 20–30 μ, scarcely distinguishable at maturity; spores fuscous, subglobose or angular, 5–7 μ in diameter; epispore comparatively thin, smooth, but fissured by a few deep grooves which in optical section often appear to divide it into four approximately equal segments. (Fig. 5.)

Attacking the sheathed culms of *Stipa Richardsonii* Link. (306), Big Horn Mts., Wyo., August 12, 1896 (T. A. Williams & David Griffiths). The species has been collected but once, but it was very abundant and destructive in this place, a large pine clearing at an altitude of about 8000 feet on one of the tributaries of the North Fork of Clear Creek. In habit and gross appearance it is identical with *U. hypodytes* and *U. minima.* The markings of the spores, however, readily separate it from these species even in the over-ripe condition when the spore masses have been broken up.

Gymnoconia riddelliae sp. nov.

Spermogonia hypophyllous, scattered, prominent, honey-yellow, abundant, producing globular hyaline sporidia 2–3 μ in diameter. Aecidia amphigenous, but more abundant below, scattered, circular, oval, or irregular and often confluent over large areas, lilac-purple turning to light brown when dry; spores globular to slightly ovate, 7–8 μ in diameter, epispore smooth and thin. Uredosori amphigenous but more numerous below, circular, small, 0.5 mm. in diameter, long covered by the unruptured epidermis which forms minute whitish spots not noticeable except under a lens; uredospores subglobose or angular and often broadly ovate, 26–29 μ × 20–24 μ, light brown when mature, the epispore thick, finely and evenly tuberculate; teleutospores produced in the same sori as the uredospores and appearing about the time that the epidermis ruptures, the two being mixed for some time, but as the teleutospores develop the sori become enlarged, black and very conspicuous; teleutospores cuneate to elliptical, 38–50 μ × 20–24 μ, broadly rounded or pointed above and conspicuously constricted at the septum, epispore smooth, strongly thickened above, the pedicel hyaline, quite persistent, two to three times the length of the spore. (Fig. 6.)

On leaves and stems of *Riddellia Cooperi* Gray (378, 378*a* and 378*b*), Tucson, Arizona, Nov. 1900. This is a very common species with an interesting distribution. It may be collected at almost any season of the year, but is most conspicuous during the rainy season when the host is in a vigorous growing condition. It is found in situations where the host receives the most moisture and the writer has never collected it on the dryer portions of the mesas. On the contrary, he has seen it usually in shallow washes which receive the drainage waters from higher altitudes. It was especially conspicuous during 1900 and 1901 on the government range reserve at the mouth of a culvert under the railroad. The aecidial stage was abundant here in autumn and spring.

Specimens of this species from the collections of Professor Toumey are to be found in some herbaria under *Puccinia tanaceti* DC.

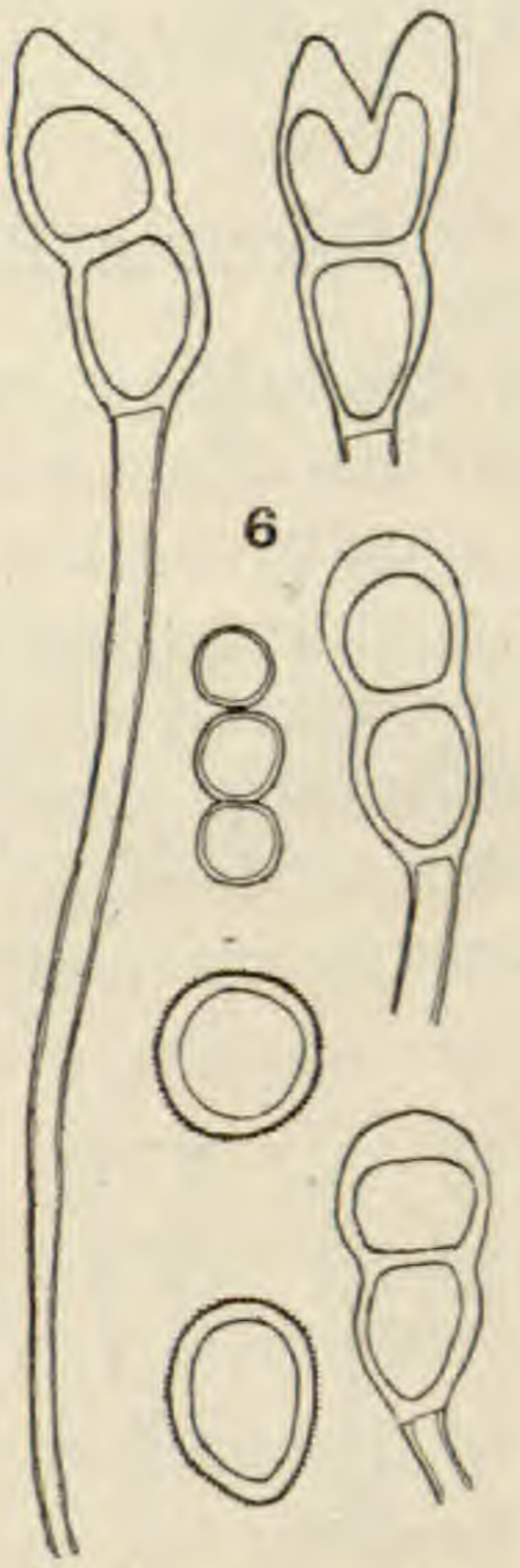


FIG. 6. Æcidiospores, uredospores and teleutospores of *Gymnoconia riddelliae*. All magnified 315 except the aecidiospores which are magnified 500.

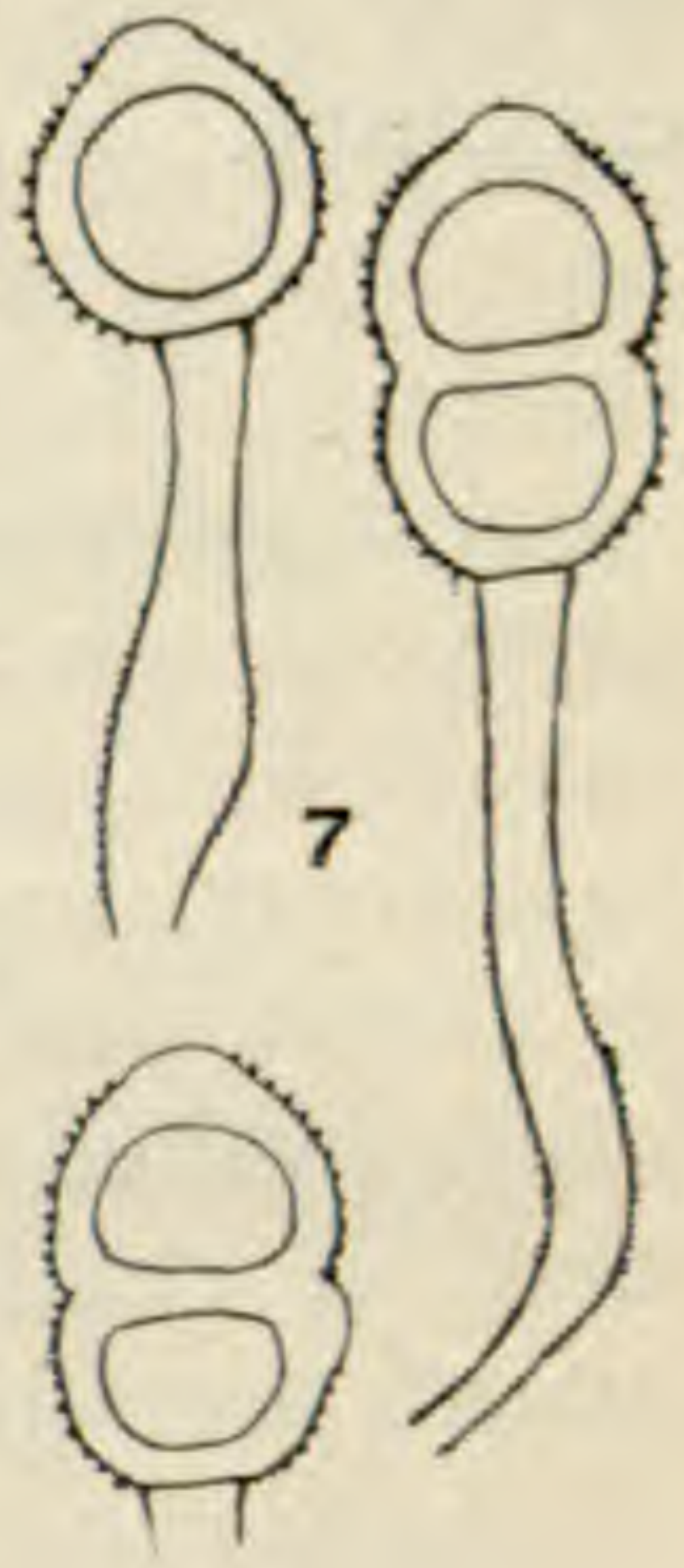


FIG. 7. Teleutospores of *Puccinia bouvardiae*. ×315.

Puccinia bouvardiae sp. nov.

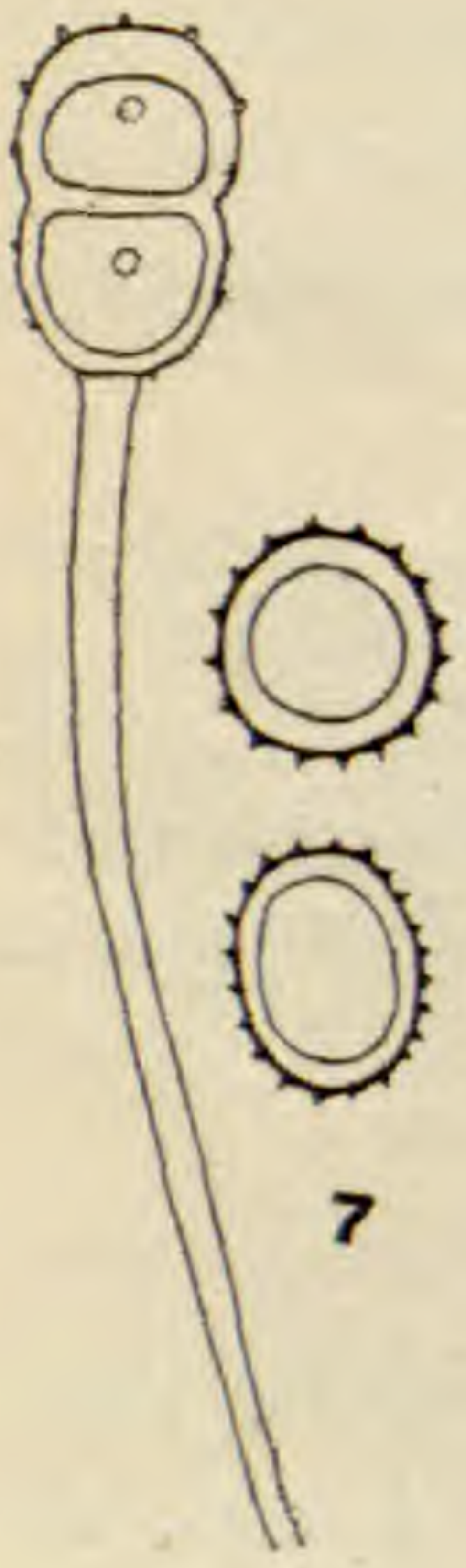
Teleutosori mostly epiphyllous but often found below also, circular, scattered, prominent, black and ragged under a lens, the remains of the ruptured epidermis which is at first prominent soon disappearing; teleutospores broadly elliptical, rounded below, with a yellowish umbonate apiculum above, and often a similar projection on the lower cell immediately below the septum, slightly constricted at the septum, 23–28 μ × 36–46 μ; epispore very thick, dark brown, tuberculate; pedicel broad, hyaline, persistent, crooked, one and a half to two and a half times the length of the spore, roughened and commonly enlarged below the middle. (Fig. 7.)

On *Bouvardia triphylla* Salisb. (394), Santa Catalina Mts., Ariz., Nov. 1900. Apparently not a common species. This in probably the other stage of *Aecideum bouvardiae* D. & H. Associated with it on the same leaves are the remains of a few old aecidia whose spores correspond very well with that species. The aecidial stage is altogether too old however for one to decide with certainty.

Puccinia Burnettii sp. nov.

Persistently epiphyllous, with very large, scattered, conspicuous sori which often attain a length of 2 cm. and a width equal to that of the leaf, usually causing the edges of the leaf to recurve so as to leave the sorus convex; leaf brown below, the ruptured epidermis prominent but not merely cracking open in the center as usual but being pushed off in large shreds as long as the sorus and often 1–2 mm. in breadth; uredospores subglobose to elliptical or ovate, 20–26 µ in diameter, epispore thick, visibly and evenly tuberculate; teleutospores very uniform, elliptical, very slightly if at all wider above than below, rounded above and below, slightly constricted at the septum, 18–23 µ × 28–31 µ, epispore rather thick, sparsely clothed with short hyaline fugacious projections, very slightly if at all thickened above; pedicel hyaline, 2–4 times the length of the spore. (Fig. 7.)

On *Stipa comata* T. & R. (387), on the Burnett ranch near Buffalo, Wyo., Aug. 1898 (Williams & Griffiths). Later the same season it was collected at Billings, Montana, on the same host. Named for Mr. Burnett who first called my attention to this rust.



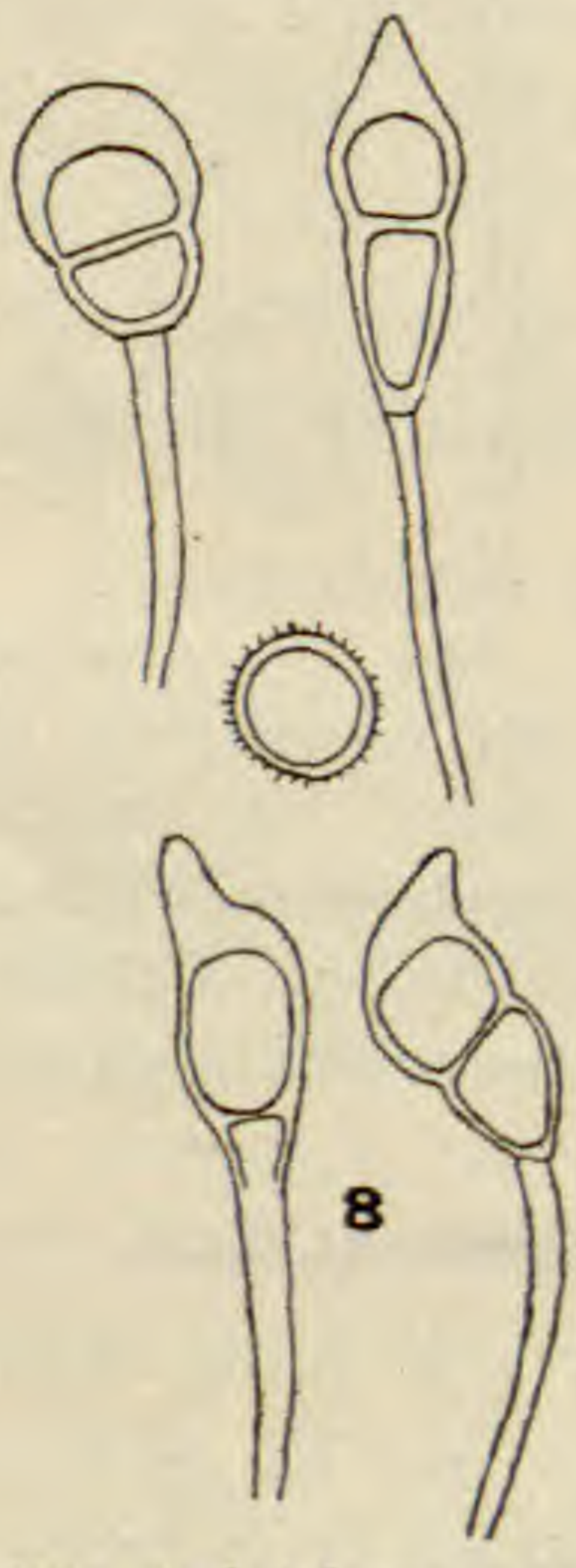


FIG. 7. Uredospores and teleutospore of *Puccinia Burnettii*. × 315.

FIG. 8. Uredospore and teleutospores of *Puccinia micrantha*. × 315.

The species is remarkable for its persistently epiphyllous character and large sori. Even when occurring on the sheaths, as it does very rarely, the sori rupture on the inside and its position is distinguishable by a slight distortion and purplish or brownish coloration on the outside as on the leaf.

Puccinia micrantha sp. nov.

Sori epiphyllous, with both uredo- and teleutospores produced in the same sori which are usually short, linear or circular, scattered evenly over the surface, conspicuous, black, prominent, without visible remains of ruptured epidermis; uredospores subglobose, minutely, rather sparsely but evenly echinulate, 15–17 μ in diameter, the epispore rather thick and prominent in optical section; teleutospores very variable, obovate to oblong-elliptical, very slightly to conspicuously constricted at the septum, the base rounded, the apex broadly rounded or long-pointed, strongly thickened, 13–24 μ × 30–45 μ; pedicel once to twice the length of the spore, hyaline or slightly tinted at the base of the spore. (Fig. 8.)

On living leaves of *Oryzopsis micrantha* (T. & R.) Thurb. (386), Billings, Mont., Sept. 1898 (Williams & Griffiths). This is such a common and familiar species to me that it is with considerable hesitancy that it is given a distinct name. It seems almost impossible that it has not been collected by others; but careful search has not revealed a record of it. It was first collected by Griffiths and Schlosser at Forest City, South Dakota, in 1892 and subsequently in the same locality in 1897 by Griffiths and Carter. Specimens from the first collection are in herbaria of the writer, the agricultural college of South Dakota and the agricultural college of North Dakota. There was also a specimen in the private herbarium of the late Professor T. A. Williams. A large sheaf of the host, all badly rusted, was collected and deposited in the collection of the agricultural college of South Dakota in 1892. It was the intention to have put it up for distribution, but judging from the notes on p. 74 of bulletin no. 40 of that institution it may have been all destroyed except the specimens cited. Professor Bolley, to whom specimens were submitted, reported at the time that the fungus had "characters of its own." Although remembering the specimen, he is unable, owing to removal to new quarters, to find it now.

Aecidium grindeliae sp. nov.

Aecidia usually clustered in brown somewhat thickened areas of the leaf tissue, occurring about equally on both sides of the same spot, each cup forming a distinct papilla having finally a circular or oval or lenticular opening through which the spores escape, the peridium not projecting beyond the raised epidermis of the leaf; aecidiospores globose or angular-compressed, light brown, 20–24 μ in diameter, the epispore thick and very minutely roughened. (Fig. 10.)

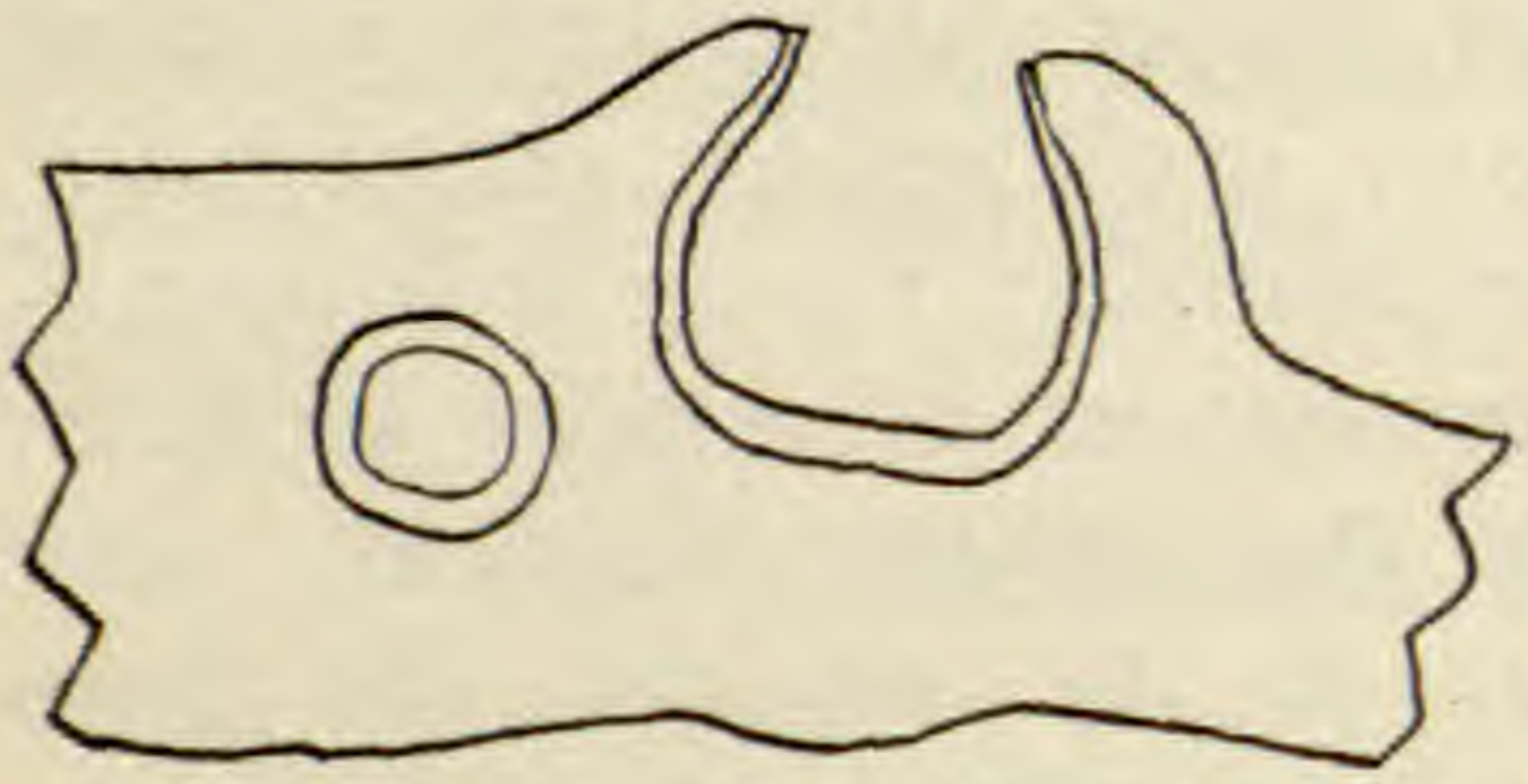


Fig. 10. One spore × 315, and diagram of vertical section of leaf showing outline of cup of *Æcidium Grindeliae.* × 315.

On *Grindelia squarrosa* Dunal. (388), Columbia, S. D., June, 1897. This species, although abundant in the locality and on the date mentioned, is apparently rare in the region.

Aecidium Dakotensis sp. nov.

Spermogonia brown or brown-black under a hand lens, yellow by transmitted light, hypophyllous, evenly scattered, very prominent; aecidia hypophyllous and uniformly scattered often over the entire lower surface, the upper surface being marked by small, circular, brown elevations which mark the position of the aecidia below; pseudoperidium very conspicuously lacerated into broad segments which are strongly recurved; aecidiospores globose or compressed-angular, 15–18 μ in diameter, epispore smooth and while not particularly thick is very conspicuous and often thickened at the angles.

On *Aquilegia Canadensis* L. (389), Big Stone Lake, S. D., June, 1895. Apparently a rare species.

Claviceps ? caricina sp. nov.

Mycelium of the fungus extending throughout the entire substance of the parenchymatous tissue of the center of the culm of the host, and condensing in one to four places into black, longitudinally-striated sclerotia 1.5–5 mm. × 1–5 cm., the interior of which is white, of uniform density and made up of loosely interwoven, colorless, thick-walled and sparingly septate hyphae.

Invariably associated with the above sclerotia are found, in upper portion of the culm, elongated black sori which rupture the epidermis much like a rust and resemble in structure a *Gloeosporium* with hyaline globular spores 1–2 μ in diameter.

On *Carex Nebraskensis* Dewey, Andrews, Ore., Aug. 1901 (Griffiths & Morris). Faithful but unsuccessful attempts have been made to cultivate the sclerotia of this interesting species during the past three months. No one realizes better than the writer that the placing of the species in the genus *Claviceps* is a wild guess, but it seems wise to call attention to the fungus in this way that others may look for it.

On the whole the species is very inconspicuous, but when once seen it can be readily detected afterward. The most noticeable character is the rather early death of the culm while the lower leaves are still green; but this is likely at times to be mistaken for the maturing of the plant. The *Gloeosporium* stage is indistinct until late and really does not become noticeable until the sclerotia have disappeared as described below. Usually the sclerotia are formed in the lower half of the culm and fill its entire vertical section; but they may frequently be formed above the middle and even near the head in close proximity to the *Gloeosporium*-like form above. The method of liberation of the sclerotia is very interesting. The culm is killed, and consequently becomes dry, about the time that the sclerotia are mature. In drying, the sclerotia curve into a segment of a circle, thereby rupturing the tissues and falling to the ground. In searching for the cause of the early drying up of the upper portion of the plant it was these ruptures that first attracted my attention and it was only after a long search that the cause was discovered. The external resemblance of the sclerotia to those of *Claviceps purpurea* is very marked.

Supplementary Notes on the Erysiphaceae

By E. S. Salmon, F.L.S.

(Concluded from page 210)

Excluded or doubtful Species

Erysiphe album Fries, Observ. Myc. 1: 207. 1815. *E. album* Achar.—There is no specimen of this plant in Fries' herbarium at Upsala, but I have seen the single specimen that the Acharian herbarium at Lund possesses. There is, unfortunately, no trace of any fungus now to be found on the leaf mounted on the sheet labeled *Erysiphe album*. As the description given by Fries ("*Erysiphe album*, receptaculo tenuissimo subnullo, capitulis nigris. In foliis *Juglandis* in Helvetia. Nudo oculo ut puncta alba apparet") is altogether inadequate to make identification possible, the name must be allowed to drop.

I have been able, through the kindness of M. P. Hariot, to examine the types contained in the Paris Museum, of the following, published by Mérat, in "Revue de la Flore Parisienne," 459. 1843.

"*Erysiphe lathyri* Mérat.—Granules très fins, spheriques, noirs, rares, sans apparence de filaments basilaires, naissant sous les feuilles du *Lathyrus latifolius* L."

The minute irregularly shaped black bodies on the leaves are not of fungous origin, but are probably the excrementa of some animal.

"*E. saxifragae Sibericae* Mérat.—Le dessous des feuilles de cette plante [*Saxifraga Siberica*] a parfois, en été, des myriades de petits granules noirs, sphériques; d'autres fois, comme cylindroïdes, un peu pënicillés (à la loupe), avec l'apparence d'une membrane ténue, à reflet argenté dans leurs intervalles."

The bodies here described have certainly nothing to do with the Erysiphaceae. They are not, I think, of fungous origin, but appear to be the work of mites.

E. tiliae Mérat.—Les granules sont d'une finesse excessive, peu abondants, noirs, arrondis, et reposent sur des taches blanchâtres, qui décolorent en cel endroit le dessous des feuilles du Tilleul où on les observe. La loupe ne découvre aucun filament basilaire dans cette plante."

The discolorations here referred to are the work of mites, the bodies of which occur on the leaves; the black rounded granules are their excrementa.

Hazslinzky (**27**, p. 182) has described a fungus as follows (I am indebted to Professor A. Mágócsy-Dietz for the translation from the Hungarian).

"*Calocladia bicornis* (Wallr.) *b. rosae* Wallr. Das Mycelium besteht aus sehr spärlichen Fäden. Perithecien zerstreut und nicht zahlreich, mit 7–8 Asci; die Asci mit 7 Sporen Auf den Blättern der *Rosa cinnamomea* in der Umgebung von Eperjes, Königreich Ungarn."

It is impossible from this description to identify the fungus. Wallroth (Ann. Wett. Ges. **4**: 238. 1819) described a species as *Alphitomorpha rosarum*, on *Rosa cinnamomea*, and later (Fl. Crypt. Germ. **2**: 755. 1833) placed it as a variety under "*A. penicillata.*" This plant of Wallroth's has never been identified by later authors.

Roumeguère (**64**) reported in 1880 the occurrence of an *Erysiphe* on *Prunus Laurocerasus* at Tarbes (Hautes-Pyrénées) France, which he named as a new species, *Erysiphe Bertoloni.* The author observed that the leaves of the *Prunus* were abundantly covered in July with *Oidium Passerini* Bertol. fils. The only description given of the *Erysiphe* runs as follows: "Quelques périthéces (fines ponctuations noirâtres), analysés par moi m'out moutré dans chaque conceptacle 4 thèques ovoïdes renfermant 5–7 spores de couleur brune. Je ne peux rapporter cette Erysiphée à aucune espèce connue." It is impossible to say from this description what the fungus was, but the brown spores, if correctly described, preclude it from belonging to the Erysiphaceae. Dr. R. Ferry informed me that no specimen of "*E. Bertolini*" is to be found in Roumeguère's herbarium.

Spegazzini (**79**) had described an *Erysiphe* as a new species under the name of *E. deserticola*, with the following diagnosis: "Amphigena; subiculum submembranaceum canescens arcte adnatum, peritheciis sparsis globosis atris, ascis paucis 2–4-spermis, sporis subcylindricis obtusis. *Hab.* ad folia *Hoffmanseggiae* cujusdam in deserto Valle de Santa Maria, prov. Salta, Jan. 1897.—*Obs.* Subiculum tenue e pulverulento membranaceo-subcrustaceum matrice arctissme adpressum canescens, ex hyphis densissime intertextis tenuibus (3–4 μ crass.) ramulosis septulatis hyalinis efformatum: perithecia pauca sparsa amphigena globoso-depressa (100–150 μ diam.) atro laevia astoma, hyphis basalibus paucis radiantibus radicata, tenui-membranacea, contextu minute parenchymatico e ferrugineo ochraceo; asci pauci ovati v. obovati (50–60 μ long. × 25–35 μ diam.) brevissime stipitati aparaphysati, 2–4-spermi; sporae subcylindraceae (40 μ long. × 12 μ crass.) utrimque obtusissimae e latere (praecipue in parte media) compressae, laeves, hyalinae, tenuiter tunicatae, nubiloso-farctae."

In the specimen sent to me by Professor Spegazzini I was unable to find more than one or two quite immature (yellowish) perithecia. The subpersistent mycelium is of the same appearance and consistency as that commonly found in examples of *E. polygoni* (*e. g.*, in specimens on *Geranium*, *Anemone*, *Polygonum erectum*, *Peucedanum Oreoselinum*, etc.), and there are no characters given in the diagnosis quoted above, except that of the length of the spores, to separate "*E. deserticola*" from this cosmopolitan species.

Although "*Erysiphe euphorbiae* Peck" (= *Microsphaera euphorbiae* Berk. & Curt.) has been twice recorded from Belgium—by Bommer and Rousseau, Bull. Soc. Roy. Bot. Belg. **25**: 169. 1886, and Lambotte, Fl. myc. Belg. Supp. **1**: 90. 1887—it is very improbable that the fungus found really belonged to this North American species. The examples recorded by Bommer and Rousseau occurred on *Euphorbia amygdaloides*. In specimens (now in the Kew herbarium) sent by Mme. Bommer, from "Poix (Belgique), Sept. 1885," on which the record mentioned above was based, no perithecia are to be found. Dr. Lambotte informs me that no specimens exist of the example recorded by him. The description given in Fl. myc. Belg. (*l. c.*), it may be noted, is a repetition of Peck's original diagnosis (Reg. Rep. **26**: 80. 1874), and has therefore probably not been drawn up from characters shown by a Belgian plant. It is quite possible that the "*E. euphorbiae*" of Belgium is *Sphaerotheca euphorbiae* (Cast.). Serbinov (**76**) records "*Erysiphe* (?) *euphorbiae* Peck," on *Euphorbia virgata*, from Russia; I have seen no specimens of this.

Microsphaera diffusa Cooke & Peck has been recorded by Serbinov (**76**) on *Lathyrus pratensis* L. from St. Petersburg, Russia. *M. diffusa* is a North American (United States) species, and the

Russian plant, I am inclined to think, will prove more probably to belong to the European species *M. Bäumleri* P. Magn.

Serbinov (**76**) has described as a new variety of "*Erysiphe lamprocarpa* Lév.," from Russia, the following plant on *Polemonium coeruleum*:

"Var. *polemoniacearum* Serb. Varietas amphigena, mycelio denso, niveo, persistente, peritheciis globosis, maioribus compactius gregariis, appendicibus fuscis, haustoriis partim lobulatis, partim non lobulatis, ascis (5–8) constante bisporis." "Unter dem von Prof. Schmalhausen gesammelten Materiale fand ich bei Bestimmung desselben eine Form auf Blättern von *Polemonium coeruleum* L., welche sehr der *Erysiphe lamprocarpa* (Wallr.) Lév. ähnelt, und sich jedoch durch folgende Merkmale von obiger Art unterscheidet: Die Perithecien sind etwas grösser und sehr dicht gedrängt, die Haustorien bei einigen Exemplaren *non lobulati*, bei anderen *lobulati*, während sei bei *E. lamprocarpa* stets *non lobulati* sind. Nach De Bary sind bei *E. lamprocarpa* 2 oder 3 Ascosporen, bei den von mir untersuchten Formen stets nur 2 Ascosporen."

I have not seen a specimen of this plant; from the description above given it seems to be a form intermediate between *E. cichoracearum* and *E. galeopsidis*.

Serbinov (**76**, p. 23) records finding a species of *Erysiphe* in an immature condition on the leaves of *Betula alba* (*B. verrucosa* Ehrh.), in the neighborhood of St. Petersburg.

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HOST-INDEX

(All records have been personally verified, except in the case of those plants prefixed by *, the authority for these will be found indicated in the list of host-plants given under the species in question.)

Acer opulifolium, palmatum, spicatum Ukuruduense	U. aceris.
*Aconitum variegatum	E. polygoni.
Actinostemma racemosum	E. polygoni.
Adesmia sp.	P. corylea.
*Aesculus Hippocastanum	P. corylea.

Alchemilla Helvetica	S. humuli.
*Alhagi maurorum	E. polygoni.
Alnus incana glauca, viridis	P. corylea.
Amelanchier Asiatica	P. corylea.
Anarthrophyllum rigidum	P. corylea.
*Anemone nemorosa	E. polygoni.
Arabis alpina	S. humuli fuliginea.
*Arctium minus	S. "Castagnei."
*Artemisia maritima Stechmaniana	E. cichoracearum.
*A. serrata	E. cichoracearum.
*Aster sp	E. polygoni.
A. *azureus, *lateriflorus, *Novae-Angliae, *undulatus	E. cichoracearum.
*Ballota nigra	E. polygoni.
Berberis vulgaris	M. alni.
*Betula pumila	M. alni.
*Bidens bipinnata	E. cichoracearum.
B. pilosa	S. humuli fuliginea.
Bowlesia tenera	E cichoracearum.
*Brassica oleracea	E. polygoni.
Bromus mollis, *unioloides	E. graminis.
*Bupleurum linearifolium	S. "Castagnei."
Caesalpinia sepiaria	P. corylea.
*Calamintha Acinos	E. galeopsidis.
C. umbrosa	S. humuli fuliginea.
*Calendula arvensis, *fulgens	E. cichoracearum.
*C. fulgens	S. humuli.
Caragana frutescens	M. euonymi.
*Carpinus Americana	M. alni.
*Catabrosa aquatica	E. graminis.
Celtis *Boliviensis, *Selloviana, Sinensis	U. polychaeta.
C. Sinensis	U. Clintonii.
*Centaurea Babylonica	S. "Castagnei."
C. *Cyanus, pectinata	E. cichoraceorum.
Ceratonia Siliqua	Oidium ceratoniae Comes (see p. 188).
*Cerinthe sp	E. taurica
Chionanthus Virginica	M. alni.
*Cineraria sp	E. cichoracearum.
Clerodendron trichotomum	S. humuli fuliginea.
Cnicus arvensis	E. cichoracearum.
* " "	S. "Castagnei."
*Coreopsis trichosperma	S. humuli fuliginea.
Corylus rostrata Sieboldiana	M. alni (forma).
*Crataegus nigra	P. corylea & P. oxyacanthae.
C. parvifolia	P. corylea.
C. sanguinea, *tanacetifolius	P. oxyacanthae.
Crepis virens	S. humuli fuliginea.
*Cytisus capitatus	E. polygoni.

*C. purpureus	E. cichoracearum.
Delphinium hybridum, Maackianum	E. polygoni.
*Desmodium sp.	P. corylea.
D. podocarpum Japonicum	E. polygoni.
*Dinebra Arabica (cult.)	E. graminis.
*Dipsacus silvestris	E. polygoni.
*Dorycnium herbaceum	E. taurica.
*Echinops sp.	E. polygoni.
*Echinospermum Lappula	E. cichoracearum.
Echium vulgare	E. cichoracearum.
Embothrium coccineum	P. corylea.
*Epilobium obscurum	S. humuli.
*Euonymus Europaeus	"M. euonymi. borealis."
*Eupatorium ageratoides	E. cichoracearum.
Euphorbia sp.	E. cichoracearum.
E. *Cyparissias, palustris	S. euphorbiae.
*E. virgata	"E. (?) euphorbiae" (see p. 304).
Excoecaria sp.	P. corylea.
Fragaria (cult.)	S. humuli.
*Fraxinus oxyphylla	P. corylea.
*Galeopsis Ladanum	E. galeopsidis.
Geranium dissectum	S. humuli.
G. *pratense, *Robertianum	E. polygoni.
Geum Chiloënse	E. polygoni.
G. rivale	S. humuli.
*Hedera Helix	U. salicis (see p. 97).
*Helianthus parviflorus	E. cichoracearum.
*Heuchera Americana	E. polygoni.
*Hieracium umbellatum	E. polygoni.
* " "	E. cichoracearum.
Hoffmanseggia sp.	"E. deserticola" (see p. 303).
*Holcus lanatus	E. graminis.
*Hydrophyllum appendiculatum, *macrophyllum	E. cichoracearum.
*Hypericum tetrapterum	E. polygoni.
*Ilex verticillata	M. alni.
Impatiens Balsamina	S. humuli fuliginea.
Inula Britannica	E. cichoracearum.
*Isopyrum thalictroides	E. polygoni.
*Juglans sp.	P. corylea.
Lamium amplexicaule	E. galeopsidis.
Lathyrus *Clymenum, montanus, *niger	E. polygoni.
L. niger	M. ? Bäumleri.
*L. ochroleucus	E. polygoni.
L. palustris	M. alni.
*L. palustris	E. polygoni.
*L. pratensis	M. diffusa (see p. 304).

L. venosus, *vernus	E. polygoni.
*Leonurus Cardiaca	E. polygoni.
Lonicera hirsuta, Sullivantii	M. alni.
*Lolium perenne	E. graminis.
Lupinus angustifolius	E. polygoni.
*Lycopersicum esculentum	E. polygoni.
Magnolia Yulan	P. corylea.
Marrubium peregrinum	E. taurica.
*Melampyrum silvaticum	E. polygoni.
*Mentha arvensis	E. polygoni.
Microseris tenella	S. humuli fuliginea.
*Milium effusum	E. graminis.
Myoschilos oblongum	M. alni.
*Myosotis sp	E. polygoni.
* " "	E. cichoracearum.
M. *collina, *palustris, *sparsiflora, *stricta	E. cichoracearum.
*Onobrychis Crista-galli	E. polygoni.
Papaver Rhoeas	E. polygoni.
Parietaria *Canadensis, *Judaica	E. cichoracearum.
*Phaseolus vulgaris	E. polygoni.
*Phlomis Herba-venti	E. cichoracearum.
P. tuberosa	E. galeopsidis.
Phtheirospermum Chinense	S. humuli fuliginea.
*Physalis sp.	S. polygoni.
P. Alkekengi	E. cichoracearum.
*Pilea pumila	E. cichoracearum.
*Pisum arvense	E. polygoni.
*Plantago Coronopus	E. cichoracearum.
*P. major	S. "Castagnei."
Pleurospermum Uralense	E. polygoni.
*Poa alpina	E. graminis.
*Polemonium coeruleum	"E. lamprocarpa polemoniacearum" (see p. 305).
*Populus sp.	P. corylea.
P. suaveolens	U. salicis.
*Potentilla collina	S. humuli.
*P. reptans	P. oxyacanthae tridactyla (see p. 85).
*P. Sibbaldi	S. humuli.
Prunus Grayana	P. oxyacanthae tridactyla.
*P. Persica	P. oxyacanthae.
*Pyrus Aucuparia	P. oxyacanthae tridactyla.
*P. communis	P. leucotricha.
*P. Malus	P. corylea.
Quercus cinerea	M. alni extensa.
Q. discolor	M. alni.

Q. glandulifera	S. lanestris.
Q. glandulifera	U. septata.
Q. Kelloggii	P. corylea.
Q. serrata	M. alni.
Ranunculus *nemorosus, *recurvatus	E. polygoni.
*Rhabdosciadium Aucheri	E. polygoni.
Rhus succedanea, vernicifera	U. verniciferae.
Ribes Magellanicum	P. corylea.
Robinia Pseudacacia	E. polygoni.
Rosa *Eglanteria, *fragrans	S. pannosa.
Rubus *Idaeus, villosus	S. humuli.
*Ruta Buxbaumii	? E. taurica (see p. 198).
Salix gracilistyla, multinervis, stipularis	U. salicis.
*Salvia glutinosa	E. cichoracearum.
*S. officinalis	E. galeopsidis.
Saussurea sp.	E. taurica.
Saxifraga punctata	S. humuli fuliginea.
Scabiosa stellata, succisa	E. polygoni.
Scutellaria *lateriflora, *pilosa	E. galeopsidis.
Sedum Telephium purpureum	E. polygoni.
Senecio cineraria	S. humuli fuliginea.
S. *erucifolius, Fuchsii	E. cichoracearum.
S. Muehlenbergii	S humuli fuliginea.
S. *silvaticus, *viscosus	E. cichoracearum.
Sisymbrium officinale	E. polygoni.
*Sium latifolium	E. polygoni.
*Solidago latifolia	E. cichoracearum.
*Sonchus oleraceus	E. polygoni.
Styrax Japonicum	M. alni
Symphytum tauricum	E. cichoracearum.
Syringa vulgaris	M. alni lonicerae.
" "	P. corylea.
Tagetes minuta	E. galeopsidis.
Teucrium Scorodonia	E. galeopsidis.
*Thesium alpinum	E. polygoni.
*Tilia sp.	P. corylea.
T. Miqueliana	U. Miyabei.
*Torilis Anthriscus	E. polygoni.
*Tragopogon pratensis	S. humuli.
Trifolium agrarium, *spadiceum	E. polygoni.
Ulmus parvifolia	U. clandestina.
Urtica urens	E. polygoni.
*Vaccinium Vitis-Idaea	P. oxyacanthae.
*Valeriana officinalis	E. polygoni.
*Valerianella sp.	E. polygoni.
*V. olitoria	E. polygoni.
Verbascum Lychnitis	E. taurica.
" "	E. cichoracearum.
Veronica *Chamaedrys, *orientalis, *spuria	S. "Castagnei."

V. Virginica var. Sibirica	S. humuli.
Vicia *tenuifolia, venosa capitata	E. polygoni.
*Vitis cordifolia	U. necator.
*Willughbya scandens	E. cichoracearum.
*Zinnia elegans	E. cichoracearum.

SPECIES INDEX

(*Synonyms in italics.*)

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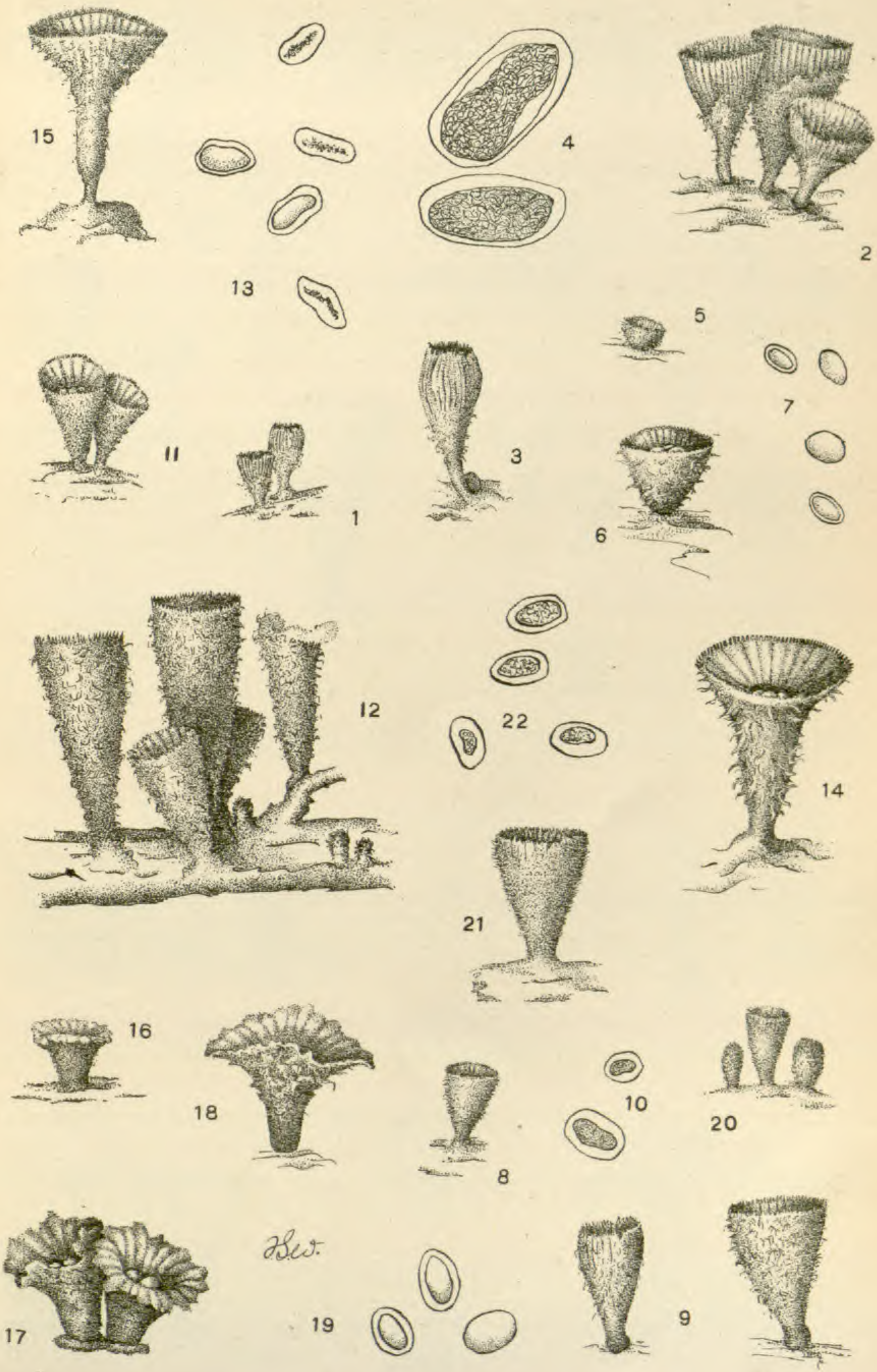

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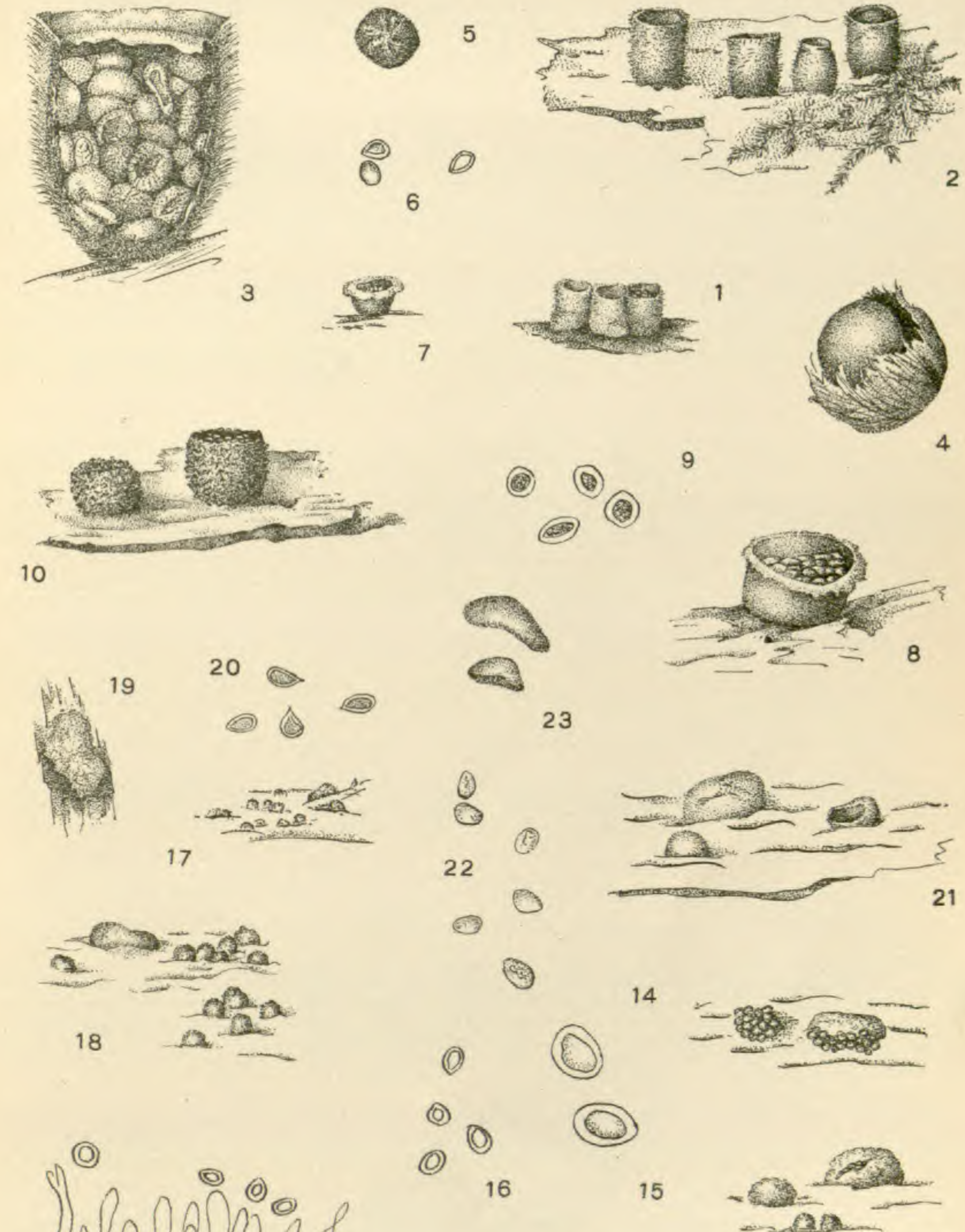
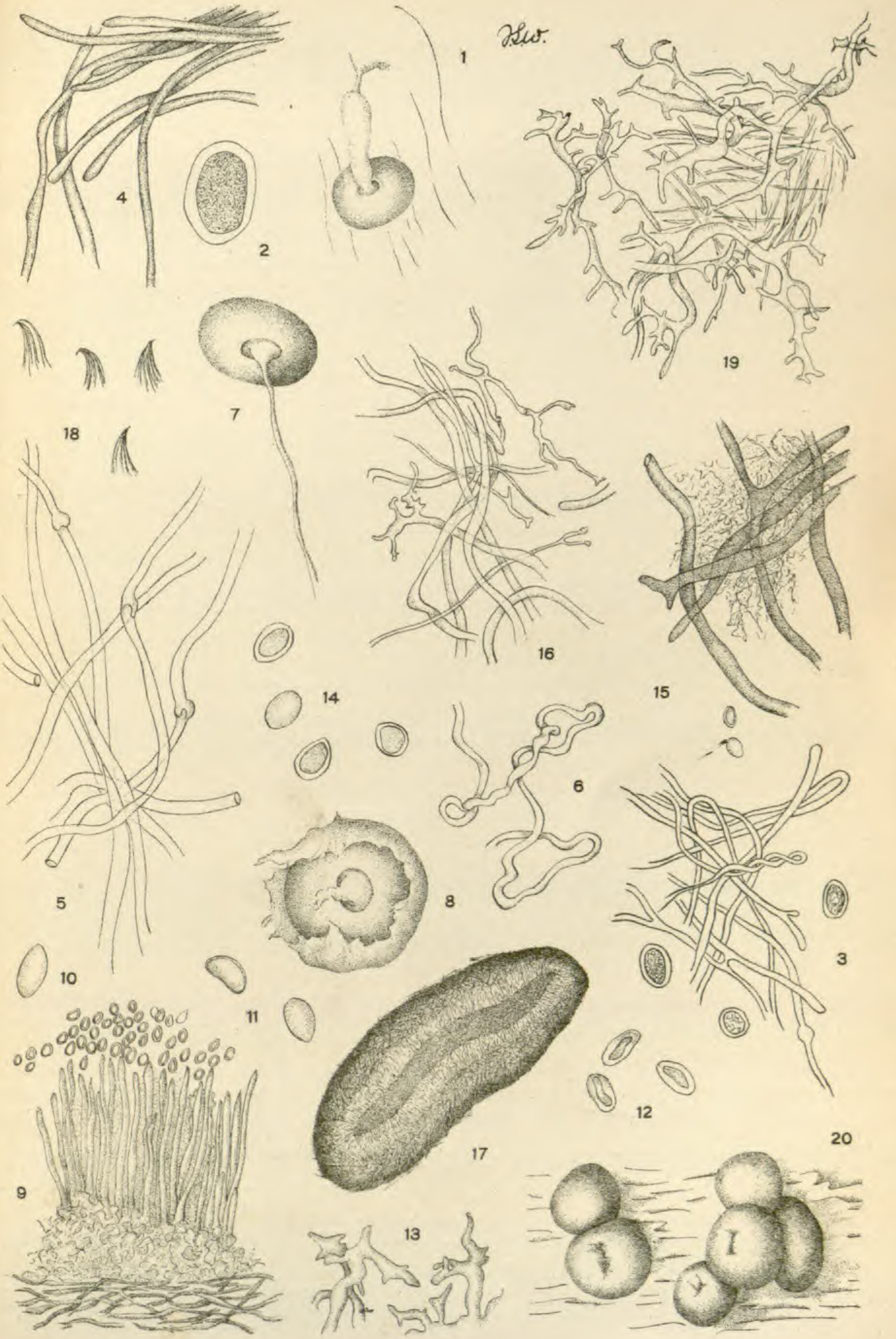
CYATHUS, CRUCIBULUM, NIDULA.



NIDULA, GRANULARIA.



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Memoirs. (See last page of cover.)

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BULLETIN

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TORREY BOTANICAL CLUB

JUNE 1902

Chemical Studies of the Cocoanut with some Notes on the Changes during Germination *

BY J. E. KIRKWOOD AND WILLIAM J. GIES

(WITH PLATE 19)

[From the Laboratory of Physiological Chemistry of Columbia University, and the New York Botanical Garden, New York.]

SYNOPSIS

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* Preliminary accounts of some of the results of this research were given in the Proceedings of the American Association for the Advancement of Science,—: 275. 1900, and in the Proceedings of the American Physiological Society. 1900: American Journal of Physiology, 5: 14. 1901.

The term "coco" appears to be derived from "coc" or "cocus," a local name for the "Indian nut," the fruit of *Cocos nucifera*, given to it on account of a fancied resemblance of the base of the endocarp, with its three circular impressions, to the face of a monkey when it utters a cry having a sound like the word. See *f. 1*, *pl. 19*. The term "cocoa" should be carefully distinguished from "cacao," the product of *Theobroma cacao*, from "coca" the derivative of *Erythroxylon coca*, from "coco," the coco-kola of commerce, and from "cocco" or "cocoa root" (*Colocasia esculenta*).

[Issued 20 June]

I. INTRODUCTION

"Of the whole class of seeds having the character of luxuries rather than of necessaries, the cocoanut is by far the most important to mankind, whether considered as a delicious and nutritious food or as supplying valuable oil and many other articles useful in social life." *

The common cocoanut is derived from *Cocos nucifera*, a species of palm growing in practically all tropical coasts and islands. The cocoa palm grows naturally on the seashore or in its immediate vicinity and does not bear well when at a great distance from salt water. (See analyses, p. 335.) At maturity it has a cylindrical stem about 2 feet in diameter. At its apex the tree carries a tuft of leaves, which are about 12 feet long. These have numerous narrow, rigid and long leaflets. The leaf, which may attain to 20 feet in length, consists of a strong mid-rib, whence numerous long acute leaflets spring, giving the whole the appearance of a gigantic feather. The flowers which produce the nut are yellowish-white. They are arranged in spikes, branching from a central axis, and inclosed with a tough spathe usually a meter or more

FIG. 1. Inflorescence of the cocoanut showing spathe inclosing the spikes, each with numerous male flowers above and a single female flower near the base. $\times \frac{1}{5}$. Winton.

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* Smith: Food, 226. 1873.

in length. Their appearance and arrangement is shown in Fig. 1, on the opposite page. The tree grows to a height of about 60–100 feet and usually bears 80–100 nuts arranged on the tree in bunches of 10–20. It continues to bear during two generations of men.

The fruit is subtriangular-ovoid in form, about 12 inches long and 6 inches broad. It is composed of a thick, fibrous "husk" (exocarp) and thin, hard "shell" (endocarp), containing a white fleshy seed, the "meat" (endosperm), with a thin integument (testa). (See *Fig. 3*, p. 324.) The thick husk is remarkably adapted to the preservation of the seed, whilst the nut is tossed about by the waves until it reaches some shore, it may be, far distant from that on which it grew. While immature the nut is without the solid endosperm, but is filled with a milky fluid. As it ripens, however, the endosperm gradually develops and the milky juice diminishes in quantity. The temperature of this juice when fresh is always comparatively low. (See page 349 for further reference to the parts of the nut.)

FIG. 2. Half-grown cocoanut fruit with calyx, and axis from which the male flowers have fallen. × ⅕. Winton.

Figures 1, 2 and 3 are from cuts loaned to us by Dr. A. L. Winton, who used them lately in the account of his very valuable histological study of "The Anatomy of the Fruit of the *Cocos nucifera*."* We are greatly indebted to Dr. Winton for his kind assistance.

The cocoanut forms the chief food of the inhabitants of Ceylon, the South Sea Islands, the coast of Africa and other tropical coasts and islands.† The flesh is not only eaten as it comes from the tree, both ripe and unripe, but it is also prepared and served in various ways. In India the "copra" is much used as an ingredient of curries. It forms an accessory part of the diet, and is found

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* Winton: American Journal of Science, IV. 12: 265. 1901.

† The cocoanut is agreeable to the taste of various domestic and other animals, and is eagerly eaten by them. The cocoanut-crab (*Birgus latro*, suborder *Macrura*; anomalous form, approaching the *Brachyura* and closely related to the hermit crab) feeds almost entirely on the kernel of the cocoanut. Its powerful claws enable it to easily peel off the husk and open the hard shell.

in many of the confections, of civilized man all over the globe.*

Immoderate use of the fruit, which according to the people of the tropics is highly refrigerant, causes, it is said, rheumatic and other diseases.† The milk is considered an agreeable cooling beverage in the tropics. It has been known for some time that irritation of the mucous membrane of the bladder and urethra is caused by drinking too freely of the cocoanut milk.‡ It is strongly diuretic. Parisi has used the cocoanut therapeutically as an anthelmintic with uniformly satisfactory results.§ He states that the meat of the nut is a powerful *taenicide*, the milk sharing the prop-

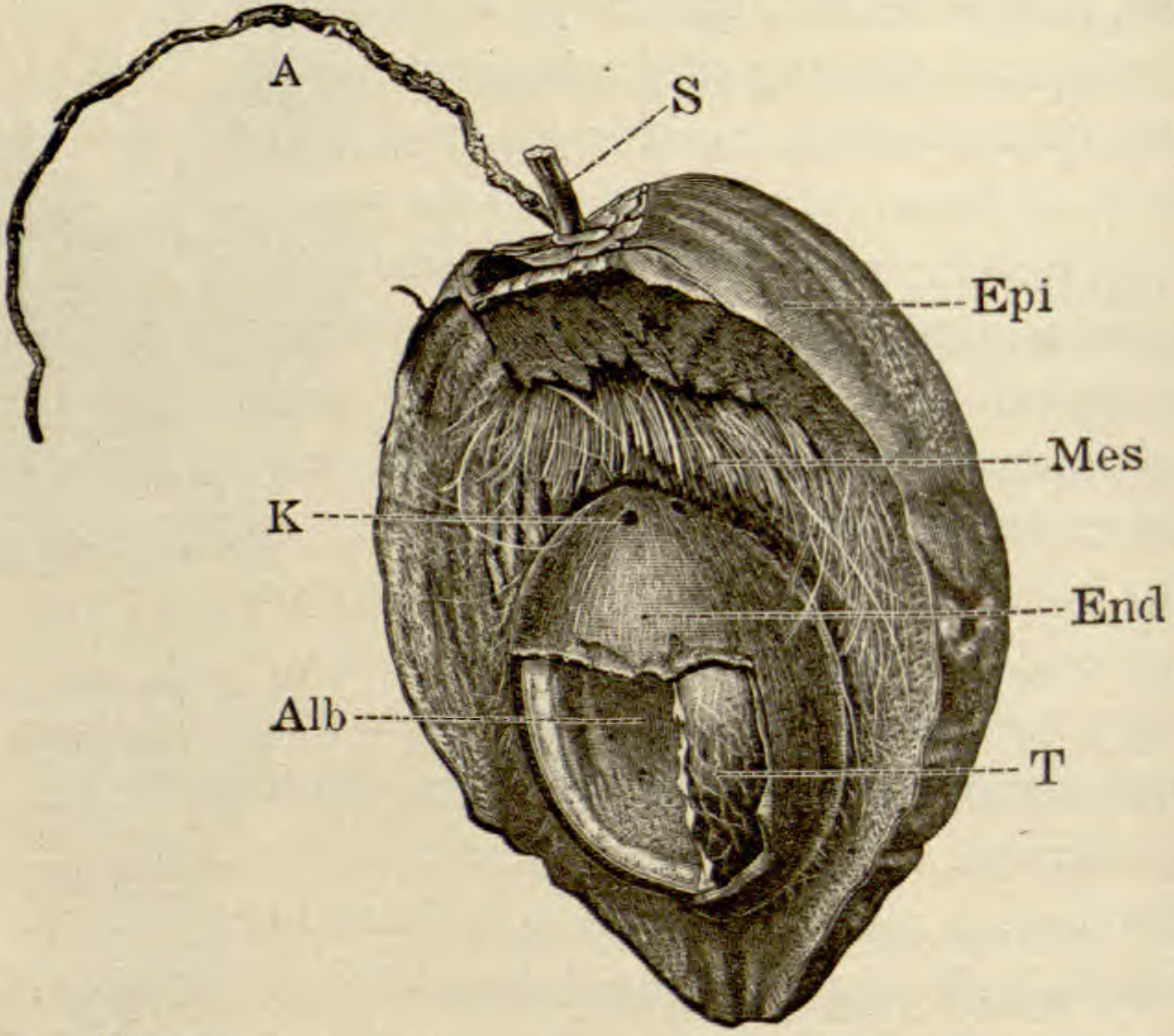

FIG. 3. Ripe cocoanut. *S*, lower part of axis forming the stem; *A*, upper end of axis with scars of male flowers; *Epi*, epicarp; *Mes*, mesocarp with fibers; *End*, endocarp or hard shell; *T*, portion of testa adhering to endosperm; *Alb*, endosperm surrounding cavity of the nut; *K*, germinating eye. × 1/5. Winton.

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* In the Annals of the New York Academy of Science, 13: 490, 1900–1901, the following may be found: "Dr. Gies in answer to a question stated that the food content of the cocoanut is small." This answer is quoted incorrectly. The question referred to the *nitrogenous* food content. It was stated on that occasion that the "content of *proteid* food-stuff is small." See page 340.

† Pavy: A Treatise on Food and Dietetics physiologically and therapeutically considered, 488. 1878.

‡ Curtis: Annals of the New York Academy of Sciences, 13: 490. 1900–1901.

§ See Liebreich: Encyklopaedie der Therapie, 1: 744. 1896.

erty.* The cocoanut has been used as a vermifuge in India for probably forty generations by the beef eaters of that country and is there well known as a means of expelling the flat worm.† The small, green and immature nut is grated fine for medicinal use, and when mixed with the oil of the ripe nut becomes a healing ointment.

The fibrous husk (coir) is widely used for the construction of ropes, brushes, bags, matting, etc. The compact fleshy edible portion (copra), closely lining the hard shell and which is entirely fluid or gelatinous when young, contains a large proportion of fat, which is extracted and used for various commercial purposes, such as the manufacture of fine soaps and candles and frequently as a substitute for butter. Cocoanut oil and resin melted together yield a substance capable of being used with success in filling up the seams of boats and ships, and in tropical countries for covering the corks of bottles as a protection against the depredations of the white ant. A quart of the oil may be obtained from six to ten nuts. The hard shell is easily polished and lends itself to the formation of various utensils and ornaments. It also has a high fuel value.

Although considerable is known of the constituents of the cocoanut, of its nutritive value and commercial uses, little has been done to ascertain the nature of the changes which the nut undergoes during germination. At the suggestion of Dr. MacDougal we have undertaken such a study, more especially from the chemical standpoint, and although our work in this particular connection has not been quite as fruitful as we had hoped it might be, our results are not without some interest.

II. CHEMICAL COMPOSITION OF THE UNGERMINATED COCOANUT

Before beginning our work on the germinating seed we felt it desirable to make ourselves thoroughly familiar with the chemical qualities of the ungerminated nut. This seemed all the more desirable because of the incomplete as well as the disconnected chemical data thus far recorded in this connection. This purpose was accomplished in a large number of analyses of numerous

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* United States Dispensatory, 1619. 1899.

† American Journal of the Medical Sciences, 67 : 281. 1889.

samples. We record the more important of these results, with comparative data from the work of others, on the following pages.

Most of the nuts subjected to the analyses referred to farther on were furnished to us for this work by Hon. Wm. Fawcett and the United Fruit Co., who sent them in their husks from Jamaica. They were ripe, fresh and of about the average size. A few determinations were made with material from nuts bought in the markets in this city—source unknown, though doubtless of West Indian origin. These were of ordinary size, appeared to be ripe and fresh, and gave essentially the same analytic results as those obtained directly from Jamaica.*

We wish at the outset of this paper to thank Dr. MacDougal not only for the supply of material with which he favored us, but also for the suggestions which led us to undertake this work and for the kind encouragement he has given us from the beginning.

PROPORTIONS OF MILK, ENDOSPERM AND SHELL IN THE HUSKED NUT.—The weights and proportions of the main parts of the nut without its husk were carefully ascertained in special observations, as well as incidentally in other experiments.† The milk was removed as indicated on page 328. The empty nut was quickly broken with a hammer, the endosperm and germ, with the thin seed coat, carefully and promptly removed with a knife, and the fresh moist parts weighed at once. The results given on the opposite page were obtained in this connection.‡

The only results recorded on these gross relationships that we have been able to find were those obtained in a single experiment by v. Ollech, and those by Bachofeu.§ The parts of a single cocoanut, except the milk, were dried in the air by v. Ollech.‖

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* A few showed signs of deterioration, such as "popping" on opening, free acid in the milk, etc. These were, of course, discarded.

† The weight of the fibrous husk varies considerably, as the amount of moisture increases by absorption or decreases by evaporation. The weights of the other parts are ordinarily not subject to such fluctuations.

‡ The weights of the germ and the thin seed coat enveloping the endosperm were included with the latter.

§ See also Berzelius: Lehrbuch der Chemie. Translated by Wöhler, 7: 533. 1838.

‖ v. Ollech: Quoted by König, Die menschlichen Nahrungs- und Genussmittel, etc., 2: 495. 1893.

FRESHLY IMPORTED NUTS (FROM JAMAICA).

Number.	Weights in Grams.				Percentage of total Weight of husked Nut.			Milk.	
	Fruit without Husk.	Shell.	Endosperm with Germ and Integument.	Milk.	Shell.	Endosperm with Germ and Integument.	Milk.	Vol. c.c.	Specific Gravity.
1	845	255	437	153	30.2	51.7	18.1	150	1018
2	771	198	379	194	25.7	49.2	25.1	190	1017
3	658	168	371	119	25.5	56.4	18.1	117	1020
4	718	199	351	168	27.7	48.9	23.4	164	1019
5	597	152	327	118	25.5	54.8	19.7	113	1022
6	463	127	251	85	27.4	54.2	18.4	83	1019
7	622	195	334	93	31.3	53.7	15.0	90	1023
8	563	144	329	90	25.6	58.4	16.0	87	1027
9	633	166	374	93	26.2	59.1	14.7	90	1027
10	530	156	282	92	29.4	53.2	17.4	90	1021
11	637	150	363	124	23.5	57.0	19.5	121	1024
12	497	144	267	86	29.0	53.7	17.3	85	1014
13	538	162	283	93	30.1	52.6	17.3	90	1021
14	413	123	256	34	29.8	62.0	8.2	33	1030
15	511	158	309	44	30.9	60.5	8.6	43	1037
16	578	190	320	68	32.8	55.4	11.8	67	1016
17	568	142	350	76	25.0	61.6	13.4	74	1026
18	495	140	293	62	28.3	59.2	12.5	60	1024
19	813	221	392	200	27.2	48.2	24.6	194	1021
20	758	208	393	157	27.4	51.9	20.7	150	1022
21	584	148	339	97	25.4	58.0	16.6	94	1028
Aver.	609	169	333	107	27.8	55.2	17.0	104	1023

NUTS FROM THE MARKET (NEW YORK CITY).

1	1070	250	558	262	23.4	52.2	24.4	254	1018
2	1009	251	506	252	24.9	50.1	25.0	246	1015
3	728	202	417	109	27.7	57.3	15.0	106	1027
4	800	226	450	124	28.2	56.3	15.5	120	1026
5	688	191	385	112	27.8	56.0	16.2	110	1015
6	565	131	316	118	23.2	56.0	20.8	116	1017
7	639	210	382	47	32.9	59.8	7.3	46	1024
8	638	210	311	117	32.9	48.8	18.3	115	1017
9	480	125	304	51	26.0	63.3	10.7	48	1034
10	561	158	307	96	28.2	54.7	17.1	92	1024
11	733	204	414	115	27.8	56.5	15.7	110	1024
12	762	176	380	206	23.1	49.9	27.0	202	1020
Aver.	722	194	394	134	27.1	55.1	17.8	130	1021

They represented the following proportions of the total weight, which was 1,133 grams :

Fibrous Husk.	Shell.	Endosperm with Germ.*	Milk.
30.45 per cent.	19.59 per cent.	37.78 per cent.	12.18 per cent.

Of the total weight of the husked nut, which, by calculation, must

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* Including, doubtless, the seed coat as well.

have been 788 grams, the percentages of the parts were (calculated by us):

Shell.	Endosperm with Germ.	Milk.
28.17 per cent.	54.32 per cent.	17.51 per cent.

These results, it will be observed, harmonize closely with the averages of our own determinations.

The data obtained by Bachofeu in this connection will be found in the table on page 335.*

COMPOSITION OF THE MILK.—The milk was poured from the nut through an opening made in the "eye" of the fertile carpel (see page 350) with a cork-borer. Extraneous matter could easily be kept out of the milk by this procedure and, besides, the fluid could be obtained when desired in a perfectly fresh, unevaporated condition.

The milk was found to be faintly turbid and opalescent in each case, and always contained a few oil globules and occasionally crystalline matter. It was acid in reaction to litmus although, as shown by lacmoid, no free acid was present in the normal fluid. The reaction is due to acid phosphate. Both alkali and earthy phosphate are present. The latter can be precipitated, in part at least, on boiling. An abundant precipitate of phosphate is obtained when the milk is made alkaline. The average specific gravity, determined with the aid of a hydrometer, was, as already noted on page 327, 1,023 and 1,021. The average specific gravity of the mixed milk of 15 nuts not included in the table on that page was 1,023. Of eight additional nuts not referred to there, and examined at another time, the figures for the mixed milk were 1,022.

The milk reduces Fehling's and Nylander's solutions and it ferments. It contains some monosaccharide which, from the characters of the phenylosazone derivatives, appears to consist of either dextrose or galactose, probably of both. Disaccharide in the form of cane-sugar is also present in good quantity, as might be inferred from the sweet taste of the milk.

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* Results having some relation to these are given by Atwater: Report of the Storrs (Conn) Agricultural Experiment Station, 123. 1899. Hammerbacher (Landwirtschaftlichen Versuchs-Stationen, etc., 18: 472. 1875) found that the endosperm of two nuts weighed 835.8 grams; the milk, 303.95 grams. See also, pages 331 and 356.

On standing the milk turns sour, becomes thicker, and has much the odor and physical appearance of soured cow's milk. The milk ferments readily. As it does so the acidity increases with a production of acid from the sugar. Alcohols are also produced in the process. The distillate from the fermented milk has an agreeable taste and an alcoholic odor.*

Chlorides are prominent with phosphates among the inorganic substances of the milk. It contains only a very small quantity of proteid, coagulating above 80° C., and also traces of a proteose-like body. Very faint biuret and xanthoproteic reactions were obtainable with the fresh fluid. A snow-white precipitate consisting in part of earthy phosphate is obtained on warming the milk on the water-bath at 70° C. The filtrate from this product when boiled yields a delicate turbidity of coagulated proteid which becomes flocculent on addition of a slight excess of acetic acid. The filtrate from this coagulum gives only a very faint biuret reaction. Cocoanut milk is said to contain malate of lime.†

GENERAL COMPOSITION OF THE MILK

No.	Milk Used.		Percentage of Fresh Milk.				Percentage of Solids.	
				Solid Matter.				
	Specific Gravity.	Grams.	Water.	Total.	Organic.	Inorganic.	Organic Matter.	Inorganic Matter.
1–*a*	1019	28.815	95.52	4.48	3.98	0.50	88.84	11.16
b		27.280	95.43	4.57	4.05	0.52	88.60	11.40
2–*a*	1020	25.403	95.28	4.72	4.27	0.45	90.58	9.42
b		27.837	95.44	4.56	4.14	0.42	90.70	9.30
3–*a*	1022	30.382	94.73	5.27	4.78	0.49	90.57	9.43
b		28.528	94.62	5.38	4.90	0.48	91.02	8.98
4–*a*	1016	25.958	95.73	4.27	3.88	0.39	90.81	9.19
b		25.823	95.65	4.35	3.96	0.39	90.92	9.08
c		26.298	95.68	4.32	3.91	0.41	90.57	9.43
5–*a*	1021	29.416	95.11	4.89	4.47	0.42	91.38	8.62
b		29.467	95.23	4.77	4.36	0.41	91.39	8.61
c		24.667	95.24	4.76	4.35	0.41	91.31	8.69
6–*a*	1024	23.119	95.44	4.56	3.82	0.74	83.68	16.32
b		23.886	95.33	4.67	3.92	0.75	84.04	15.96
7–*a*	1028	22 540	94.80	5 20	4.18	1.02	80.38	19.62
b		26.690	94.94	5.06	——	——	——	——
8–*a*	1027	28.722	95.02	4.98	4.21	0.77	84.45	15.55
b		28.409	94.97	5.03	4.26	0.77	84.69	15.31
Aver.	**1022**	**26.847**	**95.23**	**4.77**	**4.21**	**0.56**	**88.47**	**11.53**

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[*] Cocoa beer, containing 3.4 per cent. "Extractive," has been made by Calmette: Chemisches Centralblatt, 2: 394. 1894.

[†] Harley and Harley: Proceedings of the Royal Society of London, 43: 464. 1887–88.

On evaporation to a small volume on a water-bath the fresh milk becomes darker in color, takes on an odor characteristic of sugar syrups and looks not unlike molasses. Cane-sugar crystallizes from it in abundance on cooling.

The analytic data given on page 329 were obtained in our study of the general composition of the perfectly fresh milk of the Jamaican nuts.*

Percentage results in this connection had been obtained previously as follows:

Water.	Solids.	Organic Matter.	Inorganic Matter.	Nitrogenous Substance.	Fat.	Nitrogen-free Extractives	Carbohydrates.
91.50†	8.50	7.31	1.19	0.46	0.07	6.78	—
91.37‡	8.63	7.50	1.13	0.38	0.11	—	7.01§

These results were obtained with milk from nuts grown in the eastern hemisphere. The milk from the Jamaican nuts appears, as we have seen, to contain less solid matter, both organic and inorganic. This difference is emphasized by Hammerbacher's¶ observations on the specific gravity of cocoa-milk. He describes the milk as a colorless, slightly opalescent fluid with a specific gravity at 20° C. of 1044.** The milk from two nuts weighed 303.95 grams. From the nitrogen-free extractive substance in 77.8 grams of milk contained in a third nut, 0.8504 gram of dextrose was obtained. When milk was warmed with dilute sulphuric acid an odor of volatile fatty acid became perceptible. A crystalline barium salt was prepared from the distillate of the acidified milk which was found to consist of barium propionate.

The milk contains a small amount of diastatic ferment and also oxidase.†† We were unable to detect any other enzymes.

The following results were obtained by van Slyke‡‡ in his comparative studies of the milk of six *unripe* nuts and of one ripe one:

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* The methods of analysis used for this and similar purposes, throughout our work, were those commonly employed in the laboratory. See Vandegrift and Gies: American Journal of Physiology, 5: 287. 1901.

† Hammerbacher: Landwirtschaftlichen Versuchs-Stationen, etc., 18: 472. 1875.

‡ König: Menschlichen Nahrungs- und Genussmittel, etc., 2: 308. 1893. See also Bizio: Pharmaceutisches Centralblatt, 756. 1833.

§ Including 4.42 per cent of cane-sugar. See page 328.

¶ Hammerbacher, *loc. cit.*

** See our large number of determinations of specific gravity on page 327. Also references on pages 328 and 329.

†† Hunger: Journal of the Society of Chemical Industry, 20: 1030. 1901.

‡‡ Van Slyke: Chemisches Centralblatt, 1: 595. 1891. Compare with results on page 329.

Constituents.	Milk of unripe Nuts.							Milk of ripe Nut.
	1	2	3	4	5	6	Average 1–6.	
Weight in grams. . .	230.5	378.6	347.0	383.7	350.0	330.0	336.6	109.6
Specific gravity . . .	1,024.6	1,023.0	1,022.3	1,023.0	1,022.1	1,021.5	1,022.8	1,044.0
Water (per cent.)	94.37	94.48	94.59	94.89	95.27	96.43	95.01	91.23
Total solid matter (%)	5.63	5.52	5.41	5.11	4.73	3.57	4.99	8.77
Inorganic substance.	0.575	0.635	0.675	0.611	0.658	0.602	0.626	1.06
Glucose	4.58	3.83	3.45	4.06	4.36	3.56	3.97	Trace.
Cane-sugar . . .	Trace	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	4.42
"Albuminoid" . .	0.120	0.126	0.114	0.205	0.140	0.095	0.133	0.291
Fat . .	0.084	0.100	0.138	0.131	0.145	0.120	0.120	0.145

The chief chemical differences induced by growth, as indicated by the above results, are an increase in the proportion of solid matter, including ash, fat and nitrogenous substance. Glucose almost entirely disappears from the milk of the ripe nut, cane-sugar replacing it—a fact evidencing synthetic production of disaccharide from monosaccharide.

Hammerbacher, believing that the endosperm develops directly from the milk, determined the quantitative relationships of the saline matters contained in each part from the same nut. He gives the following as his percentage results :

	Ash of the Milk.	Ash of the Endosperm.[*]
Potassium,	55.200	43.882
Sodium,	0.728	8.392
Calcium,	3.679	4.628
Magnesium,	6.606	9.438
Chlorine,	10.373	13.419
Phosphoric acid,	20.510	16.992
Sulphuric acid,	5.235	5.091
Silicic acid,	——	0.500
	102.331	102.342
Minus oxygen for chlorine,	2.338	3.024
	99.993	99.318

The above results indicate a particular increase of the content of sodium chloride in the ash of the developing endosperm and a corresponding decrease of potassium phosphate. See pages 322 and 335. The amount of silicic acid in the endosperm is also noteworthy. See page 335.

ENDOSPERM. *General Composition.*—The pure white kernel

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[*] Compare with results of Bachofeu's analysis, given on page 335. Our own results were the same as these qualitatively. See also Schaedler Technologie der Fette und Oele des Pflanzen- und Thierreichs, 840, 1892, who found 3.60 per cent. of iron in the ash of the endosperm in addition to the above constituents.

or "meat" of the nut is fibrous in structure, closely lines the shell, is from 1 to 2 cm. thick, and contains a very large proportion of fat. It is the part used most frequently for dietetic purposes. It possesses a characteristic and pleasant odor and is very agreeable to the taste. The endosperm cells do not contain starch granules, but fat needles and proteid lumps are present in them. The proteid particles are partly crystalline.*

After the kernel has been finely divided in a meat chopper, the resultant hash may be subjected to increasing pressure, when an oily juice is obtained from it. The filtrate from this turbid mixture has a higher specific gravity than the milk of the nut, is acid in reaction, reduces Fehling's solution, contains a dextrin-like body and the milk salts, gives the proteid color reactions, yields coagulable proteid, and on dilution with water becomes turbid from precipitated globulin.

GENERAL COMPOSITION OF THE ENDOSPERM

No.	Endosperm used.	Percentage of fresh Endosperm.				Percentage of Solids.	
	Grams.	Water.	Solid Matter.			Organic Matter.	Inorganic Matter.
			Total.	Organic.	Inorganic.		
1–*a*	8.467	47.70	52.30	51.19	1.11	97.88	2.12
b	9.728	42.10	57.90	56.79	1.11	98.09	1.91
c	10.900	46.60	53.40	52.34	1.06	98.01	1.99
2–*a*	11.885	48.31	51.69	50.65	1.04	98.01	1.99
b	12.151	48.90	51.10	50.01	1.09	97.87	2.13
c	11.707	52.29	47.71	46.61	1.10	97.69	2.31
3–*a*	8.762	43.90	56.10	55.20	0.90	98.39	1.61
b	8.185	47.73	52.27	51.20	1.07	97.95	2.05
c	8.923	46.31	53.69	52.71	0.98	98.18	1.82
4–*a*	11.511	47.89	52.11	51.05	1.06	97.97	2.03
b	9.501	46.90	53.10	52.05	1.05	98.02	1.98
c	9.244	47.50	52.50	51.43	1.07	97.96	2.04
5–*a*	8.942	42.80	57.20	56.17	1.03	98.21	1.79
b	9.312	43.79	56.21	55.21	1.00	98.23	1.77
6–*a*	10.214	50.30	49.70	48.68	1.02	97.95	2.05
b	10.624	48.70	51.30	50.28	1.02	98.02	1.98
7–*a*	10.746	42.21	57.79	56.83	0.96	98.34	1.66
b	10.142	39.60	60.40	59.46	0.94	98.45	1.55
Aver.	10.052	46.31	53.69	52.66	1.03	98.07	1.93

The data given above were obtained for general composition of the endosperm immediately after the nuts were opened.†

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* See pages 342 and 352.

† The methods were the same as those employed with the milk. The thin seed-coat was trimmed off and the pieces of kernel cut into small, thin pieces with a knife. The material was taken from all parts of the nut.

Comparison of the averages given on the opposite page may be made with the following previously recorded results for the fresh endosperm from nuts of eastern origin : [*]

FRESH ENDOSPERM				DRY ENDOSPERM	
Water.	Total Solids.	Organic Matter.	Inorganic Matter.	Organic Matter.	Inorganic Matter.
46.64	53.36	52.39	0.97	98.20	1.80

The agreement is seen to be very close.

By reason of the dietetic and commercial values of the various constituents of the endosperm of the cocoa fruit, numerous products of the kernel have been made and analyzed. The air-dried endosperm, or so-called "copra," is shipped in large quantities from the tropics. Cocoa-oil is obtained from the copra by various methods in countries distant from the tropics, the solid residues remaining after extraction serving various purposes. This residue makes up the so-called "cocoa-cake" obtained in the process of expressing the oil at various degrees of temperature. It is also ground into "cocoa-meal." In both forms, the residual substance

Products Analyzed.	Water.	Total Solids.	Organic Matter.				In-organic Matter.
			Nitrogenous Substance.	Fat.	N-free Extractive.	Crude Fiber.	
Air-dried endosperm or copra.[†]	5.81	94.19	8.88	67.00	12.44	4.06	1.81
Endosperm, perfectly dried.[‡]	——	100.00	10.29	67.35	15.11	5.42	1.83
Endosperm, free from fat and water.[‡]	——	100.00	31.49	——	46.25	16.69	5.57
"Cocoa-cake." [§]	10.30	89.70	19.70	11.00	38.70	14.40	5.90
"Cocoa-meal." [‖]	11.12	88.88	17.94	10.88	35.34	17.40	7.32
"Cocoa-meal," after extraction of oil. [¶]	4.55	95.45	23.20	1.85	64.45		5 95

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[*] Hammerbacher : Landwirtschaftlichen Versuchs-Stationen, etc., 18 : 472. 1875. See also Bizio : Pharmaceutisches Centralblatt, 757. 1833.

[†] König : Menschlichen Nahrungs- und Genussmittel, etc., 2 : 652. 1893. Also p. 308.

[‡] Hammerbacher : Landwirtschaftlichen Versuchs-Stationen, etc., 18 : 472. 1875.

[§] Dietrich und König : Zusammensetzung und Verdaulichkeit der Futtermittel; 2 : 1031. 1891.

[‖] Dietrich und König : *ibid.*, 1 : 725.

[¶] Schaedler : Technologie der Fette und Oele des Pflanzen- und Thierreichs, 624. 1892. (*a*) For references to digestibility and nutritive value of cocoa-cake see results of experiments on pigs and sheep given by Dietrich and König, 2 : 1031, 1036, 1040, 1123. (*b*) Compare above results with the table for general composition on the opposite page.

is used as food for cattle and as a fertilizer, having special value in both these connections.* It is sometimes also used illicitly as a food adulterant.

The analytic percentage results on page 333 have been reported by various agricultural chemists for such products from nuts grown in the eastern hemisphere.

The following summary of facts connected particularly with food value was given several years ago by Woods and Merrill: †

	Refuse.	Water.	Proteid.	Fat.	Total carbohydrates.	Ash.	Fuel value per pound; calories.
Edible portion,	——	14.1	5.7	50.6	27.9	1.7	2,986
As purchased,	48.8	7.2	2.9	25.9	14.3	.9	1,529
Without milk, as purchased,	37.3	8.9	3.6	31.7	17.5	1.0	1,872
Cocoanut milk, as purchased,	——	92.7	.4	1.5	4.6	.8	97
Shredded cocoanut,	——	4.3	6.5	63.7	24.1	1.4	
Shredded cocoanut,	——	2.8	6.0	51.0	39.0	1.2	
Edible portion,	——	5.8	8.9	67.0	16.5	1.8	
Cocoanut milk,	——	91.5	.5	.1	6.8	1.2	

Through the kindness of Dr. MacDougal we have been able to examine an account of "The cocoanut and plant vitality" in the Bulletin of the Botanical Department of Trinidad (July, 1900, p. 249). Reference is therein made to the report of Bachofeu in the Queensland Agricultural Journal for April, 1900. Bachofeu says: "Though there exist several analyses of parts of the cocoanut, no one seems to have undertaken the task of getting a complete analysis made with the view of ascertaining the actual demand made by the cocoanut upon the mineral constituents of the soil."

The results obtained by Bachofeu for a single nut are so complete, and so general in their interest and application that we quote, on page 335, his general summary in its entirety. ‡

Bachofeu's results indicate that sodium chloride and potassium phosphate are the chief inorganic matters drawn upon in the development of the cocoanut—chemical data in harmony with the fact

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* v. Knieriem: Chemisches Centralblatt, 2: 672. 1898.

† Woods and Merrill: Bulletin, Maine Agricultural Experiment Station, No. 54; 81. 1899.

‡ The analyses were made in Ceylon. Native nuts were used.

that the cocoa palm does not thrive away from the coast or where salt is lacking in the soil. See second table, page 331.

BACHOFEU'S ANALYSIS OF THE COCOANUT

	Husk.	Shell.	Kernel.	Milk.
Total weight in lbs.	2.702	0.546	0.875	0.593
" " in per cent.	57.28	11.59	18.54	12.58
* Moisture in per cent.	65.56	15.20	52.80	——
* Dry matter in per cent.	34.44	84.80	47.20	——
Pure ash in per cent., containing viz:	1.63	0.29	0.79	0.38
Silica, SiO_2.	8.22	4.64	1.31	2.95
Oxide of iron and alumina, $Fe_2O_3Al_2O_3$.	0.54	1.39	0.59	Trace.
Lime, CaO.	4.14	6.26	3.10	7.43
Magnesia, MgO.	2.19	1.32	1.98	3.97
† Potash, K_2O.	30.71	45.01	45.84	8.62
Soda, Na_2O.	3.19	15.42	——	——
† Potassium chloride, KCl.	——	——	13.04	41.09
Sodium chloride, NaCl.	45.95	15.56	5.01	26.32
Phosphoric acid, P_2O_5.	1.92	4.64	20.33	5.68
Sulphuric acid, SO_3.	3.13	5.75	8.79	3.94
	100.00	99.99	99.99	100.00
† Containing total potash, K_2O.	30.71	45.01	54.05	34.54
* Containing nitrogen, N.	0.137	0.100	0.504	——

Thus of the more important ingredients of the soil 1,000 nuts remove the following:

In Lbs.	Husk.	Shell.	Kernel.	Milk.	Total Lbs.
Nitrogen, N.	3.7017	0.5460	4.4100	——	8.6577
Phosphoric acid, P_2O_5.	0.8456	0.0735	1.4053	0.1279	2.4523
Potash, K_2O.	13.5255	0.7127	3.7362	0.7783	18.7527
Lime, CaO.	1.8234	0.0991	0.2143	0.1674	2.3042
Sodium chloride, NaCl.	20.2375	0.2464	0.3563	0.5431	21.4233

Fat.—The striking chemical characteristic of the endosperm is its large content of oil. This may readily be extracted with fluids like ether. It can also be obtained in large proportion by pressure, particularly at the tropical temperatures. The fat has the consistence of butter in northern countries and possesses, when fresh, a fragrant and characteristic odor and an agreeable taste. It is snow white, sometimes cream-colored and readily crystallizes in large rosettes from the molten condition or from its alcohol or ethereal solutions. These crystals closely resemble those of palmitic acid. They melt at about 20–23° C., and congeal again several degrees below the melting point. They are fairly soluble in cold alcohol. Although cocoa-fat differs somewhat in composition in different countries, it has been found that the variations are comparatively slight. The temperature at which the oil is expressed influences these variations by increasing or decreasing the proportion of fats melting only at higher temperatures. These facts account for the variations in the figures given for melting point. Its specific gravity is 0.9+.

On heating to about 170° C., the oil gives off the odor of lactic acid; at a temperature of 300° C. acrolein may be detected. On long-continued heating with nitric acid the following dibasic acids are formed: succinic, adipic, pimelic, suberic and azelaic. Nitrocaproic acid is also formed.[*] The oil is very soluble in all of the well-known fat solvents. It contains some free fatty acid, but consists chiefly of glycerides of caprylic, lauric, myristic and palmitic acids.[†] Glycerides of caproic and capric acids are present in appreciable quantity; also a trace of stearin and some olein.[‡] The fat dissolves readily at a comparatively low temperature in an equal quantity of glacial acetic acid. Such a solution becomes turbid at 40° C.[§] By reason of its content of lower fatty acid radicles cocoa-oil has a high saponification value. Cocoa-oil is particularly resistent to the hydrating effect of superheated steam.[||]

The following data were obtained for the percentage fat-content in the fresh endosperm. The method of determination used was Dormeyer's:[¶]

	1	2	3	4	5	6	7	Gen'l Average.
Fresh endosperm, *a*.	38.27	40.01	36.71	35.10	34.60	38.90	38.60	
b.	36.14	40.54	35.02	34.90	34.10	40.70	38.40	
Average,	37.20	40.28	35.87	35.00	34.35	39.80	38.50	37.29

The ether extracts containing the oil were free from lecithin

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[*] Schaedler: Technologie der Fette und Oele des Pflanzen- und Thierrichs, 843. 1892.

[†] The presence of palmitin (tri) is doubted by Ulzer: Chemisches Centralblatt, II: 1143. 1899.

[‡] The so-called "cocinic acid" or "cocostearic acid" derivable from "cocin" or "cocinin" is, like the latter, a mixture. The former is a mixture of some of the above fatty acids; the latter of their glycerides. See Oudemans: Chemisches Centralblatt, 192. 1861.

[§] Valenta. Quoted by Vaubel: Physikalischen und chemischen Methoden quantitativen Bestimmung organischer Verbindungen, 1: 162. 1902.

[||] Klimont: Journal of the Society of Chemical Industry, 21: 126. 1902.

[¶] Dormeyer: Jahresbericht über die Fortschritte der Thier-Chemie, 26: 42. 1896. The fresh tissue was finely divided and weighed, then dried to constant weight at 100–105° C., and all of it extracted with anhydrous sulphuric ether. The usual amounts of tissue were used.

and could be almost entirely saponified. Hammerbacher * in the saponification of 25 grams of the pure oil obtained the following results :

	Grams.	Per Cent.
Fatty acids convertible into *insoluble* lead salts,	15.1488	60.595
Fatty acids convertible into *soluble* lead salts,	9.5282	38.113
Glycerin,	0.5596	2.238
Total,	25.2366	100.946

The excess in weight of products is explained by the addition of hydroxyl groups in the cleavage of the triglycerides. König had previously found the glycerin content of cocoa-fat to be 2.08 per cent. Hammerbacher therefore concludes : "It follows from these results that this vegetable fat consists in greatest part of *free* fatty acid."

That there is some error in this conclusion, however, is evident from the results of later work. Benedikt † reports the glycerin content of cocoa-oil to be 13.3–14.5 per cent. Crossley and Le Suer found that the content of *free* fatty acid in terms of oleic acid varied between 2.50 and 8.86 per cent.‡

Stellwaag || studied the fat extracted from cocoa cakes. This oil was rancid, of course. He found the quantity of *free* fatty acid to be only 9.84 per cent. The fat from the ether extract melted at 23° C. The saponification figure was 244.4. The extract contained 81.14 per cent. of neutral fat. The amount of unsaponifiable matter was 0.51 per cent. The molecular weight of the fatty acids was given as 207.¶

Studied through the oleo refractometer of Amagat and Jean, cocoa-oil is found to rotate to the left like an animal fat.**

The composition of cocoa-oil as determined by König †† is :

C.	H.	O.
74.15 per cent.	11.73 per cent.	14.12 per cent.

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* Hammerbacher : Landwirtschaftlichen Versuchs-Stationen, etc., 18 : 472. 1875.

† Benedikt und Zsigmondy : Chemiker Zeitung, 9 : 975. 1885.

‡ Crossley and Le Suer. Quoted by Hopkins : Oil-Chemists' Handbook, 38, table iv. 1900.

|| Stellwaag : Landwirtschaftlichen Versuchs-Stationen, etc., 37 : 135. 1890.

¶ See also König, Menschlichen Nahrungs- und Genussmittel, etc., 2 : 389. 1893.

** Blyth : Foods, Their Composition and Analysis, 359. 1896.

†† König : *loc. cit.*, 2 : 385. See also, Brandes, Pharmaceutisches Centralblatt, 751. 1838.

The following facts regarding cocoa-oil have been compiled from various sources. They may be compared with similar data for other fats and oils given in the standard works of König, Staedeler, Lewkowitsch and others:

A. The heat of combustion of cocoa-oil is 9,066 small calories per gram.* It is as low as that of any other fat; slightly lower than butter. This is due to the fact that it contains a large proportion of fatty acids of low molecular weight.

B. Melting point is at 24° C. Congealing temperature is 22–23° C. Fatty acids from it melt at 24.6° C. They congeal at 19° C.†

C. Saponification value = 257.3–268.4‡

D. Iodine number = 9.0–9.5; same for its fatty acids = 8.5–9.0.§

E. Specific gravity = 0.9115 at 40° C.||

F. Acid value = 9.95–35.21.

G. Reichert-Meissl figure = 7.4; Hehner = 88.6–90.5.

H. Barium figure (König-Hart) = 117–120.

I. Molecular weight of the mixed fatty acids = 196–211.

The use of cocoa-fat and other cheap vegetable oils as a substitute for butter among the poorer classes has been increasing. Cocoa-fat is better adapted for cooking than for table use. It is frequently employed as an adulterant of ordinary butter. Prepared cocoa-fat makes a fairly good substitute for common butter. The fresh material becomes rancid after a time, because of its accumulating content of free fatty acid resulting from bacterial agency. Volatile acids are formed. Its tendency to rancidity is not as great, however, as that of animal fats. The fatty acid present in the fat to begin with can easily be removed with insoluble basic compounds, such as magnesia. By this means

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* Merrill. Quoted by Sherman and Snell: Journal of the American Chemical Society, **23**: 166. 1901.

† König: Menschlichen Nahrungs- und Genussmittel, etc., **2**: 322. 1893.

‡ König: *Ibid.*

§ Benedikt. Quoted by Vaubel: Physikalischen und chemischen Methoden quantitativen Bestimmung organischer Verbindungen, **2**: 235. 1902.

|| Values given after E–I inclusive are quoted by Hopkins: Oil-Chemists' Handbook, 38, table iv. 1900. See also Lane: Journal of the Society of Chemical Industry, **20**: 1083. 1901.

a "butter" is made from this oil which has the merit of enduring hot climates without becoming rancid. This product has been recommended for military and naval uses.*

Among the prominent commercial products is the cocoa-butter made in Mannheim, Germany.† König‡ found this product to have the following percentage composition :

Water.	Solids.	Organic Matter.	Inorganic Matter.	Fat.	Fatty Acid.	Nitrogenous Substance.
0.15	99.85	99.848	0.002	99.848	trace.	trace.

It has been stated that cocoa-butter is not very easily digested and that it does not agree with sick people.§ The recent researches of Bourot and Jean,‖ however, show that a specially prepared cocoa-butter melting at 31° C. and containing only a trace of free fatty acid, is quite as easily and completely digested as ordinary butter.¶

We have already alluded to some of the commercial uses to which cocoa-fat is put. Soaps made from it combine with or hold an unusual amount of water while still retaining special hardness, one pound of the oil yielding three pounds of soap.** It is thus well adapted for the preparation of toilet soaps. The soaps made from cocoa-oil are characterized by great solubility in salt solution and can be precipitated from such fluid only by the addition of a very large excess of salt. The so-called "marine" or "salt water soap" has the property of dissolving as well in salt water as in fresh water and is made of cocoa-oil and soda.††

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* Rusby : Reference Handbook of the Medical Sciences, 3 : 164. 1901.

† See Leffman and Beam : Select Methods in Food Analysis, 182. 1901.

‡ König : Menschlichen Nahrungs- und Genussmittel, etc., 2 : 309. 1893. See also Schaedler, Technologie der Fette und Oele des Pflanzen- und Thierreichs, 1340. 1892.

§ Liebreich : Encyklopaedie der Therapie, 1 : 744. 1896.

‖ Bourot und Jean : Jahresbericht uber die Fortschritte der Their-Chemie, 26 : 58. 1896. See also v. Knieriem, Chemisches Centralblatt, 2 : 672. 1898.

¶ "Cocoanut cream," a dietary product much used in the tropics, is made by grating the endosperm and squeezing through cloth the fluid from the finely divided material. In a warm climate the resultant mixture contains much oil and is a very delicious accessory food. Besides the oil, the "cream" contains chiefly carbohydrate and proteid. See page 332 for references to similar fluid obtained from the endosperm by pressure in our own experiments.

** Ebermayer : Physiologische Chemie der Pflanzen, 344. 1882. See also Joss, Pharmaceutisches Centralblatt, 449. 1834.

†† See Schaedler, Technologie der Fette und Oele des Pflanzen- und Therreichs, 1178–1188, 1892, where may be found the results for percentage composition of the sodium soap, given at the bottom of the next page :

The harder fats of the oil make excellent candles. They are used also as constituents for suppositories and related therapeutic products. Medicinally the oil is employed repeatedly as a substitute for lard, olive oil and cod-liver oil. It is also made the chief substance by bulk in various salves and in cold cream, pomade and similar cosmetic preparations. In ointments and cerates it is especially valuable because of its ready absorption when rubbed on the surface of the body; further, it takes up an unusual amount of water—a useful quality when it is desired to apply saline solutions externally. It shows little tendency to produce chemical changes in substances with which it may be associated.

Crude Fiber and Carbohydrates.—Cellulose is a prominent constituent of the endosperm. Associated with the fibrous elements is a polysaccharide, present in comparatively large quantity. This substance is only slightly soluble in water, is insoluble in alcohol, but readily soluble in salt solution. It is precipitated along with globulin when saline extracts of the kernel are dialyzed (page 341). The gum is readily transformed into sugar by the action of diastase or ptyalin.

The fluid pressed from the finely divided endosperm contains a slight amount of reducing sugar—dextrose. Galactose appears to have been identified also.* Cane-sugar is also present.

The following results were obtained in our determinations of the percentage content of crude fiber in the fresh tissue: †

	1	2	3	4	5	General Average.
Fresh endosperm, *a*	3.96	3.20	2.98	3.40	2.78	
b	4.21	3.80	3.12	3.52	2.98	
Average,	4.08	3.50	3.05	3.46	2.88	3.39

Proteids.—That the meat of the cocoanut contains at most only a very small amount of proteid matter is seen at a glance from the following percentage results for content of nitrogen.‡

Water.	Fatty Acid.	Sodium Oxide (combined).	Sodium Oxide (free).	Other Salts.	Residue.
58.74	32.82	4.26	1.50	2.26	0.42

See also the Dispensatory of the United States of America, 1899: 1619, for references to objectionable chemical qualities of some cocoa-soaps.

* Green: Soluble Ferments and Fermentation, 100. 1899.

† Determinations were made, after the fresh weighed material had been dried and thoroughly extracted with ether, by the method adopted by the Association of Official Agricultural Chemists: Bulletin, Division of Chemistry, U. S. Department of Agriculture, 46: 26.

‡ In these determinations the Kjeldahl method was employed.

	1	2	3	4	5	6	7	General Average.
Fresh endosperm, *a*	0.657	0.734	0.806	0.738	0.766	0.776	0.701	
b					0.740	0.781	0.756	
Average,	0.657	0.734	0.806	0.738	0.753	0.778	0.729	0.742

The fresh endosperm contains an average of 0.74 per cent. of nitrogen which, multiplied by the usual factor, 6.25, would indicate 4.63 per cent. of "albuminoid." Some of this nitrogen, however, is undoubtedly closely associated with the fibrous elements. Much of it probably is in the form of nitrogenous extractive.* Some of the nitrogenous substance is soluble in 95 per cent. alcohol.

The proteid present in the endosperm appears to consist chiefly if not exclusively of globulin and proteose (globulose ?), the globulin predominating in quantity.† We have made several samples of cocoa globulin by the method used by Osborne for the preparation of edestin—in general as follows : ‡ The kernel was run through a hashing machine and the finely minced substance freed from fat by repeated extraction in ether for several days. The ether adherent to the tissue was evaporated at room temperature and the ether-free tissue then extracted in 10-per-cent. salt solution for 24–48 hours. The saline extract was then filtered off and globulin thrown from its solution either by the dilution process, by dialyzing for several days in running water, or by treatment with ammonium sulphate to complete or half-saturation. The deposit of globulin resulting thereby always contained an appreciable amount of gummy carbohydrate. The carbohydrate admixture was eliminated by subjecting the deposit to the action of diastase or ptyalin for 24–48 hours, in the presence of thymol at 45° C. in neutral fluid, during which time it was transformed into soluble reducing sugar.§ The globulin residue left behind after this treatment was

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* The factor 6.25 is here too large, also, because the proteids present contain about 18 per cent. of nitrogen. See pages 343 and 344. Stutzer found that, of the total nitrogen of cocoa-cakes, from 1.8 to 6.9 per cent. was contained in non-proteid substance. Quoted by Dietrich and König : Zusammensetzung und Verdaulichkeit der Futtermittel ; 2 : 987, 1380. 1891.

† The amount of nucleoproteid must be very slight.

‡ Osborne : See various papers in the Journal of the American Chemical Society since 1894.

§ Similar difficulty was experienced by Osborne, who got rid of the gum by repeated dialysis and precipitation with ammonium sulphate. Journal of the American Chemical Society, 17 : 429, 539. 1895.

further purified by re-solution and re-precipitation. For quantitative analysis some of the final product was washed in water, alcohol and ether, and dried at 100°–105° C. to constant weight.

Sometimes the globulin prepared in this way was both crystalline and amorphous. At other times it was entirely crystalline. Triangular, hexagonal and rhombohedral forms were frequently seen, although octahedra predominated.* The crystals so closely resemble those we have repeatedly made from hempseed and linseed by the same method, and are so like those given by Osborne for edestin,† that we felt satisfied from the beginning our globulin would prove to be of the edestin type. Careful study of the reactions of the substance convinced us of this fact, for it gives all of those attributed to edestin by Osborne.

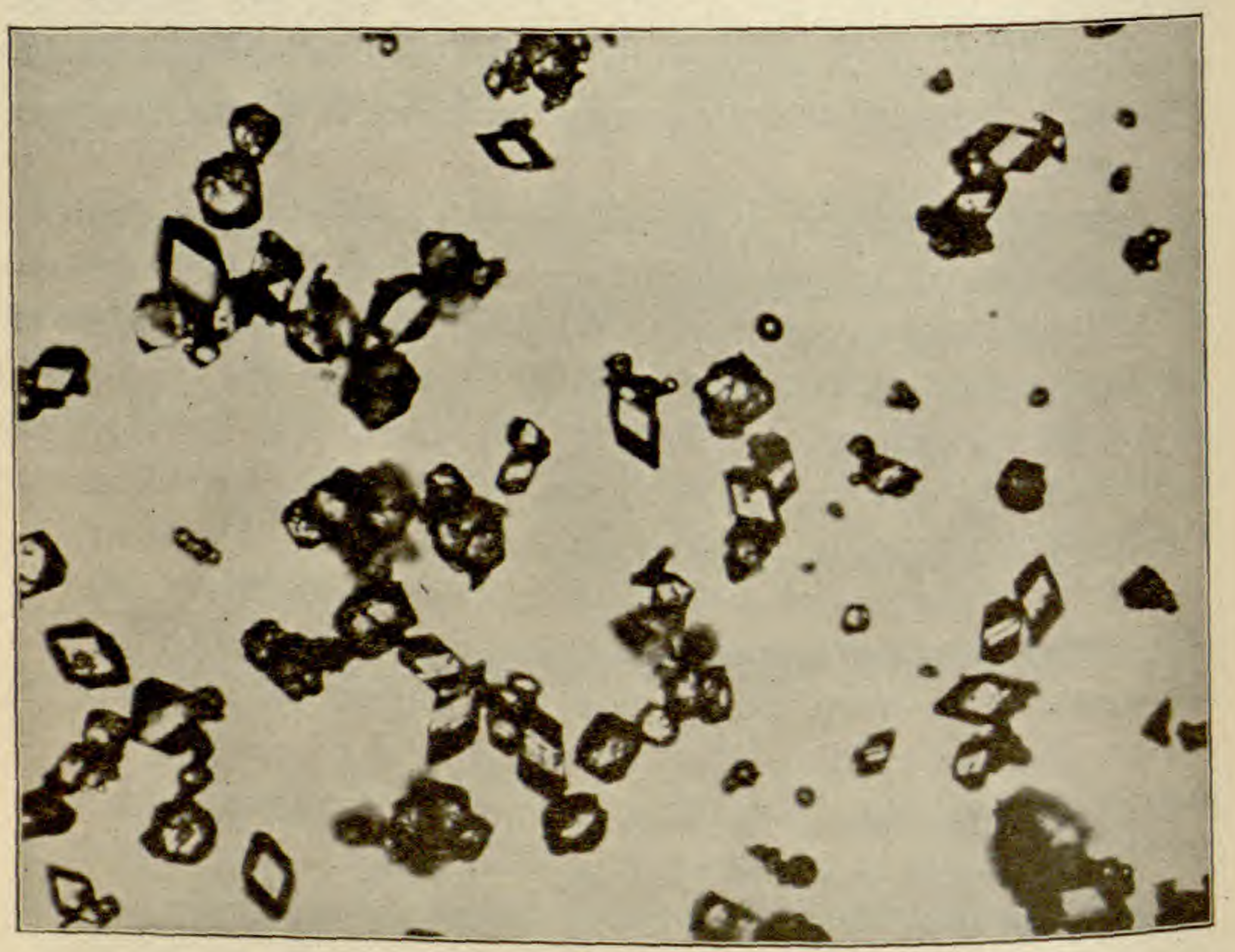

FIG. 4. Crystals of cocoa edestin.

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* The large proportion of gum extracted by the saline solution made it difficult not only to prepare the proteid in pure form but to obtain it quantitatively. Besides, the edestin passed in part into an insoluble modification during the manipulations. An appreciable loss resulted, therefore, in each preparation. We obtained as much as 25 grams of the purified product from the kernels of twelve nuts.

† Osborne: Journal of the American Chemical Society. See also his paper on crystalline vegetable proteids in the American Chemical Journal, 14: 28. 1893.

On the opposite page we give a microphotographic view of edestin crystals from our second preparation Although not the purest, we have selected this preparation for this purpose because its crystals are mostly rhombohedra. These forms rarely occur in abundance in edestin precipitates, octahedra being more commonly obtained. Most of the larger masses among the crystals shown here are "rounded" octahedra; not in perfect focus because they are thicker than the rhombohedra. The smaller particles consist of globular matter and crystal pieces.

The crystals given in *Fig. 4* were photographed for us by the writer's colleague, Dr. Edward Leaming, who cordially gave us the benefit of his large experience. We wish here again to extend to Dr. Leaming our sincere thanks for his valuable assistance.

That the substance under discussion is edestin is further shown by the results of analysis. We append our results for nitrogen content, as determined by the Kjeldahl method, calculated for ash-free substance:

PERCENTAGE OF NITROGEN IN COCOA EDESTIN

Preparation.	1	2	3	4	5
Analytic results.	17.87 17.77 17.79	17.85 17.96 17.91	17.66 17.69 17.78	18.14 18.21 18.18	18.23 18.20 18.28
Average.	17.81	17.91	17.71	18.18	18.24
Ash.	0.41	0.13	1.12	1.90	1.84

Preparations 1, 2 and 3 contained amorphous material, possibly some of the gummy matter referred to on page 342, in spite of our efforts to completely remove it. Preparations 4 and 5 were obtained from 1 and 3 by further treatment with diastase and by recrystallization by dialysis from 10-per-cent. salt solution. They were practically wholly crystalline.

The above results show that the globulin separated from the cocoanut by the methods here employed is edestin.*

This same proteid of the cocoanut was examined by Ritthausen, † who termed it conglutin without really identifying it with that substance. His analyses gave it a content of nitrogen of 17.87–17.91 per cent. Chittenden and Setchell ‡ referred to it by

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* The edestin from barley contains 18.10 per cent. N. That from maize 18.12 per cent.; from rye, 18.19 per cent.; wheat, 18.39 per cent. Osborne: Journal of the American Chemical Society, 17: 547. 1895.

† Ritthausen: Jahresbericht über die Fortschritte der Thier-Chemie, 10: 18. 1880.

‡ Chittenden and Setchell: Quoted by Chittenden, Digestive Proteolysis, 32. 1895.

the name of phytovitellin. The composition they gave for it is in general accord with that of edestin (nitrogen content = 18.40 per cent.), and as they obtained it partly crystallized in octahedra, Osborne * has lately suggested that the substance is edestin. The results we have obtained confirm Osborne's deduction.

The proteose to which we have already alluded was obtained from the globulin filtrate. The latter was freed from traces of globulin by the coagulation method, the hot filtrate evaporated to a small bulk on the water-bath and the proteose precipitated and purified by the usual method. † About four grams were obtainable from fifteen nuts. The product contained both proto and deutero forms. Some heteroproteose was also detected in the products formed on dialysis and a trace of dysprotose was obtained.

The following results for nitrogen content in the ash-free substance were obtained by the Kjeldahl method:

PERCENTAGE OF NITROGEN IN COCOA PROTEOSE

Preparation.	1	2	3	General Average.
Analytic results.	18.67 18.50 18.58	18.48 18.46 18.40	18.57 18.61 18.54	
Average.	18.58	18.45	18.57	18.53
Ash.	1.71	1.08	1.21	1.33

These results differ only slightly from those reported by Chittenden and Setchell.‡ This difference may be explained by the fact that mixtures of proteoses have been analyzed in each case by Chittenden and Setchell, and by us. Their preparation of proteose contained 18.25 per cent. of nitrogen.

In his volume entitled Digestive Proteolysis, Chittenden gives the analytic results for eleven different proteids and the proteoses derived from them (page 67). For seven of these the nitrogen of the corresponding proteose is somewhat higher than that of the original proteid. Analysis of our own preparations has shown the percentage of nitrogen to be greater in the proteose than in the globulin, a result in accord with the majority rule just noted.

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* Osborne: Journal of the American Chemical Society, 18: 13. 1896.

† MacDougal: Practical Text-book of Plant Physiology, 164. 1901.

‡ Chittenden and Setchell: Quoted by Chittenden, Digestive Proteolysis, 32. 1895.

There appeared to be only a very slight amount of an albumin in our extracts—a coagulable substance which was not precipitated from its neutral solution when the latter was half-saturated with ammonium sulphate.*

Osborne's methods of extracting glutenin and gliadin † in dilute alkali and acid, and in dilute alcohol, after the removal of globulin, proteose and albumin as above described, gave mere traces of proteid substances in solution, derivatives, doubtless, of the proteids already referred to, which perhaps had not been completely removed from the residual tissue ; or possible nucleoproteid.

Peptone could not be detected in any of our extracts.‡

Ash.—Composition is referred to on pages 331 and 335. Qualitatively our results were the same as those there given.

Enzymes.—Water, salt solution and glycerin each failed to extract appreciable quantities of either proteolytic or adipolytic enzymes from the endosperm of the fresh, ungerminated nut, although an active amylolytic ferment was extracted by all of these fluids. The large quantities of fat and fatty acid in the endosperm suggest that an emulsifying ferment may be present. This, however, may be localized in the germ, increasing to physiological quantity and activity only in the process of germination (see page 358). The proteoses present in the endosperm seem to imply the presence of a proteolytic ferment. Possibly, however, the proteoses represent a residue from which the globulin was derived by reverse process.§

We have already referred to the fact that oxidase has been detected in the milk. Traces of it are also contained in the endosperm.

Average Composition.—The average results of our analyses of the endosperm are summarized in the following table, which presents the data obtained for the composition of the fresh tissue and the dry solid matter derived from it (constant weight at 100–105° C.).

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* Cohnheim : Chemie der Eiweisskörper, 150. 1900.

† Osborne and Campbell : American Chemical Journal, 15 : 392. 1893.

‡ Small quantities of non-proteid nitrogenous substances were detected by Ritthausen : Chemisches Centralblatt, 230. 1880. Compare, also, with recent results respecting proteoses obtained by Bokorny : Chemisches Centralblatt, 1 : 1167. 1902.

§ See recent papers in the Zeitschrift für physiologische Chemie by Schulze and Kutscher and their associates.

PERCENTAGE COMPOSITION OF THE ENDOSPERM

Constituents.	Fresh Endosperm.	Dry Endosperm.[*]
Water.	46.31	
Solids.	53.69	
Inorganic matter.	1.03	1.93
Organic matter.	52.66	98.07
Fat (substance soluble in ether).	37.29	69.45
Crude fiber (cellulose).	3.39	6.31
Proteid $(N \times 5.5)$[†]	4.08	7.60
Soluble carbohydrate, non-nitrogenous substance, extractive, etc. (by difference).	7.90	14.71
Nitrogen.	0.742	1.382

The previous results obtained by Hammerbacher[‡] for the fresh endosperm from nuts of eastern origin were as follows:

Water.	Solids.	Inorganic Matter.	Organic Matter.	Fat.	Crude Fiber.	Proteid.	Non-nitrogenous Extractive.
46.64	53.36	0.97	52.39	35.93	2.91	5.49	8.06

COMPOSITION OF SHELL AND HUSK.—We have already alluded to some of the uses to which the shell and husk of the cocoanut are put by reason of the chemical and physical qualities they possess. Some facts regarding their chemical composition were given in the table on page 335.

The following percentage results of elementary analysis of the powdered shell were obtained by Baumhauer;[§] all samples having finally been thoroughly extracted in alcohol and ether, and then dried at 120°–150° C.:

	Cocos nucifera.				*Cocos lapidea.*	
	1. Extracted in boiling water.	2. Extracted in boiling water, dilute alkali and acetic acid.	3. Extracted in boiling water, concentrated alkali and acetic acid.	4. Extracted in alkali and in chlorine water.	5. Same treatment as 1.	6. Same treatment as 4.
C.	52.99	47.19	46.27	43.72	52.20	44.20
H.	5.88	6.09	5.81	6.11	5.80	6.24
Ash.	1.43	——	1.00	——	0.22	0.55

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[*] According to Dietrich and König (König, Menschlichen Nahrungs- und Genussmittel, etc., 1: 612. 1893) the *air-dried* substance contains the following in percentage of the total dry weight:

Total Substance Soluble in Water.	Proteids Soluble in Water.	Sugar (Sugar-Yielding Substance).
15.16	2.27	9.25

[†] The factor 5.5 is used because the proteids of the endosperm contain 18 per cent. of nitrogen. See references in this connection on page 341, footnote.

[‡] Hammerbacher: Landwirtschaftlichen Versuchs-Stationen, etc., 18: 472. 1875.

[§] Baumhauer: Pharmaceutisches Centralblatt, 601. 1844.

Nitrogen was detected in small amount in the powders which had not been treated with alkali. The alkaline extracts contained substance, precipitable by acetic acid, with the following percentage composition: From *Cocos nucifera*, C = 50.04, H = 5.81, ash = 4.45; from *Cocos lapidea*, C = 52.15, H = 5.93, Ash = 1.00.

Tromp de Haas and Tollens * were able to show the presence of a large amount of pentosane (xylan) in the endocarp, the powdered material yielding an abundance of xylose on hydration in 4 per cent. sulphuric acid. Mannose was absent from the acid solution from which the xylose had been crystallized. After xylan had been completely removed from the shell-powder by the above method, dextrose was derived from the residue on treatment with sulphuric acid in the usual manner.

In his very complete histological studies of the cocoanut, Winton † recently called attention to the fact that both the husk and shell contain a brown substance which is quickly changed to a reddish color by caustic potash, but is unaffected by alcohol, ether or any of the specific reagents for proteids, fats or resins. He also states that no immediate effect is produced by ferric chloride solution, but on long standing the color is changed to olive green. Winton has pointed out the presence of minute silicious bodies among the fibers of the husk.

Winton, Ogden and Mitchell ‡ give the following percentage data for the composition of the shell:

Water,	7.36	Alcohol extract,	1.12
Solids,	92.64	Reducing matters calculated as starch,	20.88
Organic matter,	99.46		
Inorganic matter,	0.54	Starch,	0.73
Soluble in water,	0.50	Crude fiber,	56.19
Insoluble in HCl,	0.00	Nitrogen,	0.18
Ether extract,	0.25	Albuminoid (N × 6.25),	1.13
Non-volatile,	0.25	Quercitannic acid,	1.82
Volatile,	0.00		

During germination the shell remains unaltered. The husk soon begins to decay. See page 351.

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* Tromp de Haas and Tollens: Chemisches Centralblatt, 2: 359. 1895.

† Winton: American Journal of Science, IV. 12: 265. 1901. Facts are also given regarding the use of powdered cocoa-shell and the husk as adulterants of ground spices.

‡ Winton, Ogden and Mitchell: Report of the Connecticut Agricultural Experiment Station, 2: 210. 1898.

COCOANUT PEARLS.—Within the nut there is occasionally found a small stony substance of a bluish white color, a kind of vegetable bezoar, called in India *calappa*, which is eagerly purchased by the Chinese, who ascribe great virtues to it as a sort of amulet to preserve them from diseases. The cause of its formation in the nut is unknown.

According to Harley and Harley [*] these pearls, like those of molluscan origin, appear to consist almost entirely of calcium carbonate, with water and organic matter in smaller proportion. Riedel, quoted by Harley and Harley, states that in 1886, while in North Celebes, he found a pearl in the endosperm of the cocoanut. One such a pearl was pear-shaped in form and 28 mm. long.

We are greatly indebted to Dr. D. Morris, Imperial Commissioner of Agriculture for the West Indies, for the following very interesting quotation from a letter to Dr. MacDougal:

"More than two hundred years ago Rumph, an eminent botanist in the East, sent as a present to the Grand Duke of Tuscany a ring in which a cocoanut pearl had been set. Further, Rumph himself described cocoanut pearls in his great work with considerable minuteness and gave illustrations of two of them. One was perfectly round, the other was oval or egg-shaped. * * * Travelers in the Philippine Islands have heard of cocoanut pearls, but seldom or ever have seen them. The natives, it is said, keep "cocoanut stones" as charms against disease and evil spirits. The rajahs, we were told, highly prized them and wore them as precious stones. It was only a few years ago that real cocoanut pearls were at last brought to England. One is now at the Museum at the Royal Gardens at Kew, brought by Dr. Hickson. It is almost egg-shaped, perfectly white, and composed almost entirely of carbonate of lime. It has, in fact, a somewhat similar composition to the pearl of the oyster, and yet there is little doubt it is a purely vegetable product." [†]

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[*] Harley and Harley: Proceedings of the Royal Society of London, 43: 464. 1887–88.

[†] "Besides these cocoanut pearls," quoting further from Dr. Morris' letter to Dr. MacDougal, "Rumph describes what he calls 'Melate' pearls taken from the flowers of a Jasmine; and a 'Champake' pearl taken from the flower of a Michelia. If we had not already seen the pearl of the cocoanut it would have been impossible to believe that there were such things as Jasmine and Michelia pearls * * * Of their composition, mode of occurrence and true nature we have yet to learn." See the article by Harley and Harley referred to above.

See also, on the subject of cocoanut pearls, the Proceedings of the Boston Society of Natural History, 1861 and 1862; The Tropical Agriculturalist, 1887; Nature, 1887.

III. CHANGES IN THE COCOANUT DURING GERMINATION

The nuts for our studies of the changes occurring during germination were obtained fresh, fully developed and with their husks still on them, directly from Jamaica. Immediately after their arrival at the New York Botanical Garden they were imbedded in earth until they were nearly covered. The earth was kept saturated with water and a tropical temperature was maintained. These conditions closely approximated those attending normal germination.

MORPHOLOGICAL CHANGES.—Nearly four months elapsed before the shoots began to appear through the husks, the fibers of the husk having been pressed aside in their upward progress. At this stage the stem of the shoot was an inch or more in diameter at the "root-crown," sharply tapering toward the point of penetration at the surface of the husk. As the growth proceeded it seemed to gradually become more and more rapid, and by the end of a year the plants had attained the height of two or three feet, with a stem about an inch in diameter throughout most of its length. By this time the part of the husk under the earth had decayed considerally; it became softer and more porous, and several stout roots had developed through it and penetrated the soil to the depth of a foot or more.*

The appearance of the nuts and their plants at this period of their growth is shown in the cut on page 350. Unless otherwise stated, the chemical analyses reported farther on were made of the parts at this stage of their development.

It may not be amiss, in describing the morphological changes induced in the nut during the process of germination, to also briefly review, at the same time, the more important facts regarding structure of the nut as it exists in the ungerminated condition.

The entire fruit is, strictly speaking, intermediate between a nut and a drupe — a "drupaceous nut." The outer covering,

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* For facts regarding germination and cultivation see Bailey: Cyclopedia of American Horticulture, 1: 341–343. 1900. Also, Wittmack, L.: Die Keimung der Cocosnuss. Ber. d. deut. bot. Ges. 14: 145. 1896.

FIG. 5. Germinating cocoanut at the end of a year, showing plumule and roots, with husk little altered except where it was in contact with the earth.

usually removed before the nut appears upon the market, is a thick fibrous layer comprising the exocarp, the epicarp consisting of a smooth, thin, tough coat of a brownish or grayish color. (See pp. 323 and 324). The endocarp, or what is commonly known as the shell of the nut, is composed of three carpels whose lines of fusion are always apparent. The nut lies in the husk with the end containing the "eyes" toward the pedicel. Each carpel contains an "eye," so-called, and under one of these three eyes, the softest, is the germ imbedded in the endosperm. The fertile carpel may be recognized from the fact that it has the greatest degree of divergence between the longitudinal fusion lines of the carpels. The true integuments of the ovule are reduced to a thin brown coat closely adhering to the abundant endosperm.

The embryo is a cylindrical body about 8 mm. in length lying below one of the natural openings of the endocarp and in a line perpendicular to the exterior surface of the endosperm. When germination begins the embryo elongates and, having pushed through its thin coverings, begins to enlarge at both ends. From the outer end arises the plumule and the roots; the inner end is an extension of the true cotyledon and is developed into a special absorbing organ. See *pl. 19*.

The absorbing organ is of a soft spongy texture and all through it are the ramifications of vascular strands which converge to the narrow "neck," which connects the absorbing tissue with the stem. The cotyledon, and by this term, hereafter, we shall mean the part of that structure specialized for absorption, can attack only the part of the endosperm to which it is contiguous. In the earlier stages of growth this absorption is confined to the part nearest the young shoot, which we may hereafter refer to as the proximal end of the nut. Finally, however, the cotyledon fills the entire cavity of the nut and somewhat thins the endosperm distally, also.

The milk may persist in the nut until the cotyledon has almost filled the cavity. After germination has proceeded for some time the milk becomes insipid to the taste, and contains fragments of cellulose and large drops of floating fat. In nuts in which germination has continued for a year the cotyledon has entirely filled the cavity, but usually there is still left a third to a half of the endosperm undigested. This residual portion in normal cases is little affected, except that it is softened superficially, and to the taste suggests nothing different from the meat of the ordinary ungerminated nut.

In its natural development the roots of the plant soon take firm hold of the soil and, long before the endosperm is completely absorbed, junction between the shoot and the absorbing organ is broken, the husk decays and the plant enters an independent career. Neither the husk nor the shell appears to serve any other than passive mechanical function, and only the constituents of the endosperm and milk, so far as the nut is concerned, nourish the young plant before it finds in the soil the elements provided there in abundance for its growth to maturity.*

In our microscopic studies, particularly of the cotyledon, pieces of the fresh part were "fixed" in a mixture of glacial acetic acid (⅓) and 70% alcohol (⅔). After remaining in this fluid for a few hours the pieces were transferred to 70% alcohol and later to 85% alcohol, in which they were kept. Sections were cut with a razor and mounted in glycerin. Treated with iodine, such sections of the cotyledon showed an abundance of starch in all cells except those of the outermost layer or epidermis. This outer layer stained yellow with iodine. That it contained an abundance of oil was shown by its deep black reaction with osmic acid. Large globules of oil are, however, distinctly visible in the epidermis under the microscope without the aid of osmic acid. Oil may also be found in the subepidermal layers, but it rapidly diminishes in quantity as the distance from the outside increases and as the starchy deposit accumulates. Needle-like crystals may be very readily found in the epidermal cells. These resemble crystals of tripalmitin, but the fact that so much oil appears in globules, and that the breaking down of fats must occur to a large extent in these cells, would suggest that they are palmitic acid rather than the fat itself.

The above facts make it appear that the starch is formed indirectly at least from the oil.† See references under enzymes, pages 345 and 358.

See *pl. 19* for drawings of parts mentioned above.

CHEMICAL CHANGES.—The following summary gives briefly the effects of germination on the individual nuts examined:

I. *Not Analyzed.*—A. Development had proceeded for nearly six months. The plumule protruded six inches above the husk. Roots had developed through the husk—two were about a quarter of an inch in diameter. The stem was very thick at the "root-

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* Note references on page 357 to the functions of the husk in holding water and possibly furnishing nutrient matter in its decay.

† Ebermayer: Physiologische Chemie der Pflanzen, 347. 1882.

crown" ; sharply tapered to the point of surface penetration. The fibers about the stem were tightly pressed together. The neck of the absorbing organ was very woody and fibrous in character. Absorption of the endosperm at the proximal end was quite marked; distal portion undiminished. Milk cavity largely filled by the absorbing organ. A small space at the distal end remained, containing viscid white material full of large oil globules; quantity less than 10 c.c.—doubtless concentrated milk. It was strongly acid in reaction from acid phosphate, reduced Fehling's solution, gave only a faint biuret reaction and was free from starch. The inner surface of the endosperm in the distal portion was soft, having the consistency of lard.

The weight of the whole shoot, minus the roots, in the fresh condition was 28.1 grams. Dry, the weight was 4.25 grams or 15.1 per cent. of the fresh substance, indicating a presence of 84.9 per cent. of water in the original plant.

B. This nut, although germinating for the same period of time, was not quite as far advanced as the previous one, having shoots that were just emerging from the husk. The stem was thicker, however. In most respects its internal condition was exactly the same as that of the first. The fluid in the distal cavity was less in quantity, not as turbid, contained less oil—otherwise was the same as that of the previous nut.

The weight of the entire plumule was 38.8 grams. Dried, it weighed 5.75 grams. Thus it contained 14.8 per cent. of solid matter and 85.2 per cent. of water.

II. *Analyzed.*—1. Growth continued for eight months. The cotyledon entirely filled the cavity. About half of the endosperm was absorbed; practically all of that proximally except a thin layer. The distal residue of endosperm appeared to be normal in taste and appearance except on the surface, where the soft layer previously referred to—one fourth the entire thickness—could again be seen. The outer surface of the cotyledon, that part in contact with the endosperm, was much corrugated; the whole organ, solid but spongy, sweet and agreeable to the taste, pyriform. In the tables on page 354 and 355 the results of our analyses for this nut are indicated by the numeral 1.

GENERAL COMPOSITION OF THE PARTS OF THE GERMINATED COCOANUT

Parts of the Nut and its Plant.		Percentage of fresh Tissue.				Percentage of Solids.	
		Water.	Solid Matter.			Organic Matter.	Inorganic Matter.
			Total.	Organic.	Inorganic.		
I. *Cotyledon.*							
A. Central, vascular portion :	*a*—1	89.10	10.90	99.14	0.86	92.07	7.93
" " "	*b*—1	87.71	12.29	99.10	0.90	92.25	7.75
" " "	*c*—2	91.62	8.38	99.00	1.00	88.10	11.90
" " "	*d*—2	91.41	8.59	99.11	0.89	89.71	10.29
" " "	*e*—3	88.99	11.01	99.20	0.80	92.77	7.23
Central, between center and surface :	*f*—3	86.07	13.93	98.94	1.06	92.36	7.64
Average.		**89.15**	**10.85**	**99.08**	**0.92**	**91.21**	**8.79**
B. Outer, corrugated portion :	*a*—1	84.95	15.05	98.69	1.31	91.30	8.70
" " "	*b*—2	82.79	17.21	98.93	1.07	93.85	6.15
" " "	*c*—3	80.83	19.17	98.26	1.74	90.93	9.07
Outer portion—neck :	*d*—3	78.98	21.02	98.58	1.42	93.24	6.76
Average.		**81.89**	**18.11**	**98.62**	**1.38**	**92.33**	**7.67**
II. *Residual endosperm.*							
C. Proximal portions after much absorption :	*a*—2	19.09	80.91	99.13	0.87	98.92	1.08
	b—3	23.42	76.58	99.16	0.84	98.90	1.10
Average.		**21.25**	**78.75**	**99.15**	**0.85**	**98.91**	**1.09**
D. Medial portions :	*a*—1	31.65	68.35	99.03	0.97	98.58	1.42
	b—1	30.36	69.64	99.06	0.94	98.65	1.35
	c—2	28.68	71.32	99.25	0.75	98.95	1.05
	d—3	25.77	74.23	99.23	0.77	98.96	1.04
Average.		**29.12**	**70.88**	**99.14**	**0.86**	**98.78**	**1.22**
E. Distal, normal portion :	*a*—3	**46.08**	**53.92**	**99.02**	**0.98**	**98.12**	**1.82**
III. *Stem of the plant.*							
F. Base, "root crown," with petioles at lowest parts :	*a*—1	86.21	13.79	98.95	1.05	92.37	7.63
	b—1	86.51	13.49	98.70	1.30	90.38	9.62
	c—2	85.15	14.85	98.84	1.16	92.06	7.94
	d—3	84.31	15.69	98.68	1.32	91.60	8.40
Average.		**85.55**	**14.45**	**98.79**	**1.21**	**91.60**	**8.40**
G. Parts above the base, with more petioles :	*a*—2	82.47	17.53	98.80	1.20	93.20	6.08
	b—3	79.87	20.13				
Average.		**81.17**	**18.83**				
IV. *Petioles.*							
H. Alone, or with young leaves :	*a*—1	83.63	16.37	98.57	1.43	91.27	8.73
	b—1	82.55	17.45	98.63	1.37	92.15	7.85
	c—3	82.13	17.87	98.75	1.25	93.01	6.99
	d—3	82.17	17.83	98.63	1.37	92.34	7.66
Average.		**82.62**	**17.38**	**98.65**	**1.35**	**92.19**	**7.81**

GENERAL COMPOSITION OF THE PARTS OF THE GERMINATED COCOANUT.—*Continued*

Parts of the Nut and its Plant.	Percentage of fresh Tissue.				Percentage of Solids.	
	Water.	Solid Matter.			Or-ganic Matter.	Inor-ganic Matter.
		Total.	Or-ganic.	In-organic.		
V. *Leaves.*						
I. Mature or nearly so: *a*—1	74.66	25.34	98.35	1.65	93.49	6.51
b—1	71.99	28.01	98.10	1.90	93.20	6.80
c—2	72.60	27.40	98.34	1.66	93.93	6.07
d—2	72.51	27.49	98.41	1.59	94.19	5.81
e—3	68.45	31.55	97.96	2.04	93.52	6.48
f—3	70.65	29.35	98.39	1.61	94.52	5.48
Average.	**71.81**	**28.19**	**98.26**	**1.74**	**93.81**	**6.19**
J. Very youngest: *a*—3	**87.22**	**12.78**	**98.50**	**1.50**	**86.67**	**13.33**
VI. *Roots.*						
K. Short, not developed outside of husk, with soft tips: *a*—1	87.08	12.92	98.46	1.54	88.09	11.91
b—2	89 89	10.11	98.67	1.33	86.89	13.11
c—2	86.41	13.59	98.43	1.57	88.44	11.56
d—3	87.46	12.54	98.83	1.17	90.70	9.30
Average.	**87.71**	**12.29**	**98.60**	**1.40**	**88.53**	**11.47**
L. Parts of longer roots, taken near the stem: *a*—1	77.92	22.08	98.80	1.20	94.59	5.41
b—2	82.65	17.35	98.85	1.15	93.34	6.66
c—3	81.09	18.91	98.50	1.50	92.09	7.91
d—3	79.47	20.53	98.77	1.23	94.00	6.00
Average.	**80.28**	**19.72**	**98.73**	**1.27**	**93.51**	**6.49**
M. Parts of longer roots, taken outside the husk: *a*—1	81.70	18.30	97.94	2.06	88.76	11.24
b—1	84.64	15.36	98.47	1.53	90.05	9.95
c—2	82.79	17.21	98.40	1.60	90.74	9.26
Average.	**83.04**	**16.96**	**98.27**	**1.73**	**89.85**	**10.15**

2. This nut represented germination after ten months and was essentially like the preceding in all respects. The roots were thicker and a number of good sized ones had not yet proceeded through the husk. Their ends were soft and watery, rounded and blunt. Analyses of this nut are referred to in the tables on pages 354–355 by the numeral 2.

3. Essentially the same as No. 2, both in stage of development and conditions of parts, although the time of germination was about two months longer. Analyses of the parts of this nut are referred to in the tables on pages 354–355 by the numeral 3.

4. This nut had germinated for just about a year. The follow-

ing weights of the fresh parts were very carefully taken; the data for nitrogen were determined by the Kjeldahl method.*

	Weight in Grams.	Percentage of Total Weight.	Percentage of Nitrogen.
Cotyledon,	196	28.1	
Central part,			0.14
Cortical layer,			0.31
Endosperm,	155	22.2	
Distal portion,			0 65
Proximal portion,			0.93
Shell,	161	23.0	
Stem,	16	2.3	
Lower part,			0.70
"Root crown,"			0.53
Roots,	41	5.9	
Inside of husk,			0.27
Outside of husk,			0.54
Petioles and young leaves,	58	8.3	0.29
Petioles,			0.39
Old leaves and petioles,	71	10.2	0 45
TOTAL WEIGHT,	698		
Shell and contents,	512	73.4	
Whole plant,	186	26.6	
Cotyledon and endosperm,	351	50.3	

The tables on pages 354–355 give all our results for general composition of the parts of the germinated nut.† Numerous deductions may be drawn from these results, as to growth and metabolism.

The central part of the cotyledon, with its vascular network, contains more water and less solid matter than any other part of the germinated nut. The proportion of solid substance in it increases toward the corrugated epithelium, being greatest in the "neck," where the structure is fibrous and woody.

That the absorbing organ completely takes up the milk is very evident from the way it fills the cavity and from its own composition, but it is likewise apparent from our results that water is also with-

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* The husk was not weighed because it was decayed underneath and water-logged. Nitrogen was not determined in the shell because its substance remains unaltered during germination.

† The methods of determination were the same as those used previously. The roots, outside of the husk, which had been in the wet soil, were hurriedly rinsed with water to remove inorganic matter then wiped dry with a towel and at once cut into thin cross sections for analysis.

drawn from the residual endosperm, this absorption being greatest at the proximal end of the nut, where absorption was begun in the first place, and least at the distal end, where it had hardly commenced. The roots also are seen to have absorbed considerable moisture.

The lowest part of the stem contains almost as little solid matter and is nearly as watery as the cotyledon. The percentage of water in the stem diminishes as the distance away from the "root crown" increases. The watery condition of the lower part of the stem is increased, doubtless, by the fact that the surrounding husk is impregnated with water, thus favoring direct absorption by osmosis and at the same time preventing evaporation from the surface of the growing tissue.

The amount of solid matter in the petioles is also comparatively slight, little more than in the lower part of the stem. In the leaves the water is greatest in the youngest, as would be expected; least in the oldest—those most exposed to the air.

The roots at the tips are soft and watery, but the older they become the more solid matter they develop and the more woody material they accumulate.

In the distribution of the inorganic matter in the fresh parts it is noticeable that the proportion of saline substance increases with a decrease of water and *vice versa*, as in the cotyledon, in the residual endosperm and throughout the plumule. This condition is such as might be expected. The relation of the inorganic to the organic matter in each part, however, is variable. The substance of the cotyledon and the stem contains a greater proportion of salts than that of the endosperm and the leaves, the roots likewise holding a fairly large amount of saline matter. The substance of the endosperm contains least of all, from which fact it is quite clear that the inorganic matter of the plumule has been absorbed, not only by the cotyledon from the milk, but also by the roots from the fluid in the husk and the surrounding earth.

At the beginning of germination the inorganic matter and water of the milk are doubtless sufficient for the changes that occur, the organic matter coming chiefly from the endosperm. Some time before the cotyledon fills the milk cavity and completely absorbs the milk, the roots have begun to take water and inorganic matter from the fluid in the husk—possibly also organic substance from the disintegrating husk fibers—and thus they absorb new nourishment from a large supply. Growth of the plumule is consequently favored. The plumule soon reaches such a height and development as to enable it to make increasing contributions to the plant metabolism from the gaseous products the air affords. By this time the whole growth has become practically independent of the reserve material of the seed.

ENZYMES.—We made only a few preliminary studies of enzyme distribution. Extracts were made in water, dilute salt solution and glycerin. The indicators used in nearly all the experiments were prepared from the materials in the nut itself.

The extracts of the cotyledon were acid to litmus (phosphates), though, as indicated by lacmoid, they contained no free acid. Diastatic ferment was found to be distributed in abundance in all parts of the cotyledon. Oxidase was also present. Only the very slightest proteolytic action was manifested by the cotyledon extracts, even when they were obtained in particularly concentrated form. In some experiments the results were entirely negative, however. Cellulose-dissolving and fat-splitting enzymes were not detected in either the cotyledon or the residual endosperm, although we cannot be sure that in our few experiments they have not escaped us.* Germination progresses so slowly that possibly some of the enzymes are present in only very minute quantity at any one time—in such amount, perhaps, as to be undiscoverable by the methods commonly employed for ferment detection. We did not examine the parts of the plumule in this connection.

At this point, before we were able to come to any very definite conclusions as to the enzymes present and before we could determine the distribution of proteids, fats, carbohydrates, etc., in the parts of the plant, we were obliged to discontinue our work. The writer hopes to extend these experiments on the germinated cocoanut to a consideration of related problems of nutrition.

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* See our references to enzymes on page 345. Lipase seems to have been found in the germinating cocoanut by Lumia: Jahresbericht über die Fortschritte der Thier-Chemie, 28: 724. 1898.

Explanation of Plate 19

FIG. 1. An end view of the cocoanut, without its husk, showing the three carpels and the "eyes." The fertile carpel is the one included in the largest angle.

FIG. 2. A sectional view through the end of an ungerminated nut, with its husk removed, showing the form and location of the germ imbedded in the endosperm (under the micropyle). The shell is indicated by the heavy outline.

FIG. 3. Another sectional view similar to that of Fig. 2 showing development of the absorbing organ after germination had proceeded for a few weeks. The incipient stem and roots are to be seen. The cotyledon has enlarged within and without the shell.

FIG. 4. A longitudinal section through the whole nut somewhat to the side of the median line. It shows the nut imbedded in its fibrous husk and the conditions found after germination had gone on for about five months. The absorbing organ has filled about two thirds of the cavity of the nut but has absorbed comparatively little of the endosperm. The stem has proceeded upward through the husk, the roots downward through the husk into the soil. The leaves have been cut off above the husk. (See page 350 for appearance of full plumule.)

FIG. 5. A section through the layer of the cotyledon normally in contact with endosperm, showing the corrugated, villiform arrangement of the absorbing epithelium. This section having been treated with osmic acid shows the localization of the fat globules.

FIG. 6. A section through that part of the cotyledon given in Fig. 5. This section, treated with iodine, shows the localization of starch.

FIG. 7. A few cells from the absorbing epithelium of the cotyledon after enlargement. This figure shows the large clear oil globules and the darkly staining starch grains in the subepidermal cells. The crystals seen in most of the cells appear to consist of fatty acid, possibly palmitic.

FIG. 8. Enlarged starch granules from subepidermal cells.

Some Observations on Transpiration

CARLTON C. CURTIS

Variations in the rate of transpiration have been observed almost from the beginning of physiological research. These irregularities present a most puzzling problem since they appear in the results obtained by any method that may be employed to demonstrate the phenomena of transpiration and notwithstanding the fact that the external conditions may be apparently uniform and constant, I have been interested to take note of the records that have been made from year to year, when this subject comes up for experimentation in the laboratory with a view to determine whether there is any rhythm to be found in the fluctuations, and if so, whether this is related to the tension of fluids in the stem. In other words, to find out in what degree transpiration might be connected with the vital phenomena of the plant.

The table on the following page illustrates the character of the fluctuations and these examples are presented since they were obtained under as constant conditions as could be expected with natural light.

The amount of transpiration is expressed in milligrams obtained by hourly weighings beginning in the morning and running through the day, and below each series is given the changes of temperature and humidity while on the right hand of the table is noted the character of the day.

The intensity of the light may account in a certain degree for the maxima of the curves coming near the middle of the day although there was no apparent variation in the amount of illumination at that time of day. However, there are minor fluctuations in the curves quite independent of the slight variations of the climatic conditions and the light intensities and they are as likely to be at variance with any perceptible changes as in keeping with them. These irregularities may result in the rise or fall of the rate for a short period or again they may extend over longer periods. They are quite as appearent in the consecutive readings of potometers and especially in the device of Darwin's where a shoot

I. TRANSPIRATION CURVES IN DAYLIGHT

	6 A.M.	7	8	9	10	11	12	1 P.M.	2	3	4	5	6	
ABUTILON THOMPSONI	160	243	316	366	504	602	643	715	686	636	646	641	304	Cloudy with
Temperature	24				25			25.5		25		24		rain from 11
Hygrometer	24				25			21		23		23		to 5.
KALANCHOE GLAUCESCENS	12	22	28	32	36	48	64	57	39	34	36	26	18	Cloudy.
Temperature	26						27		28		27			
Hygrometer	30						28		26		28			
ANTHOLIZA AETHIOPICA	91	100	98	102	118	127	173	180	166	133	124	132	119	Snowing.
Temperature	20				21	22				21		19		
Hygrometer	33				30	30				34		36		
ACALYPHA HISPIDA	59	56	52	96	243	220	304	328	354	168	108	84	108	Raining,
KLEINIA FICOIDES	8	6	7	10	20	24	39	58	73	62	29	27	20	
Temperature	19		19			20		21				21		cl'ring 3.30
Hygrometer	55		54			52		50				48		but cloudy.
STACHYS GRANDIFLORA	26	30	40	74	67	84	120	115	99	99	60	36	39	Cloudy.
Temperature	17							17.5				17.5		
Hygrometer	42			44				43				46		
FICUS INFLECTA	81	91	136	82	63	195	244	229	239	150	62	57	50	Very dark
Temperature	19			20								21		in forenoon
Hygrometer	42			38								36		becoming foggy.

is sealed to a test-tube and the loss in weight is viewed with a horizontal microscope or in Gardner's experiment where the transpiration stream of a small shoot is viewed under a microscope. In both of these latter cases the transpiration rate can be examined in short intervals of time and we have a magnified view, so to speak, of the process. In all these methods the irregularity of the rate is the striking phenomenon. It is ever fluctuating and without apparent reason. It is exceptional to find consecutive readings that show a fixed ratio of increase or decrease. In the above table while the hourly weighings furnish singular irregularities they give an imperfect idea of the endless series of changes that are constantly going on.

In the curve found for *Abutilon*, the acceleration though continuing for eight hours (a very exceptional curve) increases very irregularly, *i. e.*, by 83 mg. 73, 50, 38, 98, 41, 72, and then declines by 29, 50, rises again by 11 and finally declines by 5.337—the last evidently a light effect. In the case of *Kleinia* and *Acalypha* an irregular decline follows for three hours when the rate for *Kleinia* accelerates for six hours and then declines, while in the case of *Acalypha* there is a rise for two hours followed by a decline for one hour, then a rise for three hours, then a decline for three hours, then a rise for one hour. The succeeding hour, not given in the table, showed a further decline, *i. e.*, 96 but still in excess of the rate at 5 o'clock. I was able to verify the character of these fluctuations during the summer of 1901 at the N. Y. Botanical Garden and it gives me pleasure to acknowledge the facilities for conducting the work that were placed at my disposal.

It would seem that these variations can only very indirectly be connected with external conditions and the facts would appear to warrant the conclusion that the phenomena here recorded are the expression of the vital processes at work in the plant. It should be said that in all the experiments recorded in this paper that care was taken to select thrifty potted plants and the jars were placed in large tin cans, the mouths being closed with tin covers and sealed with beeswax mixture after the manner suggested by Darwin. In this way a considerable volume of air was at the disposal of the roots and would serve to keep the plant in normal condition for some time. It was necessary to make the weighings exactly at the end of the hour if the various measurements were to be of any value. It is apparent how imperfect a knowledge of the transpiration rate or how misleading may be the results when observations are taken at long or irregular intervals or for a short period and from such data drawing conclusions as to the rate.

For the purpose of comparison a number of experiments were conducted under more uniform conditions. The records found in Table II. were obtained in the dark room where the plants were exposed to an electric light of 900 candle power hung at a distance of 4 m. from the balance. The dark room was sufficiently light-tight to permit the handling of the most sensitive photographic plates without injury. When necessary the humidity was controlled in a degree by sprinkling the floor and the temperature rarely varied more than one degree. In this and the preceding table where the record of two plants are given at the same time two separate balances were used to avoid a possible error due to distributing the plants in moving them. Baranetsky's contention on this point has something of merit. Certainly with the most careful manipulation the operator runs a very considerable risk of disturbing the delicate balance in the plant and in a continued series of observations it is at least questionable whether the results obtained in this manner may always be relied upon. The plants in these experiments were usually placed in the dark room over night or for two or three hours before using. This permitted an adjustment to the conditions obtaining in the room and eliminated such after effects as have been noted by Schwendener and Sorauer. Buds and young leaves were cut off in many of the cases cited about one week before the experiment; in other instances such parts were sealed with a mixture of beeswax, tallow and linseed oil and then bound with sheet rubber. The interesting results obtained by Hoehnel on the relative transpiration rate of young and old leaves and similarly by Wiesner on the transpiration of developing stems and also of Sorauer on the relation of the formation of chlorophyll to the transpiration, renders it necessary in arriving at any conclusion as to what the plant is really doing to exclude such factors as may introduce variations that would furnish misleading results or more probably quite nullify the value of the observations. As will be seen the measurements show an unmistakable curve characterized by minor fluctuations but demonstrating a grand curve with a maximum in the forenoon or near the middle of the day. In several instances I have noticed that transpiration was more active earlier in the day than was found in the first table. This may be due to the fact that the electric current was not turned on till 7 o'clock and the escape of the excess of intercellular vapor in the following hours overbalanced the normal transpiration under the feeble illumination. I regret that it was impossible to secure the curve for 24 hours under constant illumination. However, it will be seen that the curves for 12 hours bear a resemblance to the irregular daily curve of growth determined by Sachs. The absorption curves given by Vesque, also the curves of fluid tensions in the stem determined by Detmer and the periodicity of the exudation of fluids from cut stems, all show variations in keeping with the records set forth in Table II. It is interesting to note that these curves correspond in the main with those found in Table I. and show the same erratic character. Every plant appears to possess an individuality that becomes evident in these continued irregularities. In fact it has never been my experience to secure two measurements from the same plant that showed similar fluctuations, although special attention was given to placing them under the same conditions for two or more days between the tests.

While there may not necessarily be a constant relation between absorption, exudation and tension of fluids and the phenomena of growth, nevertheless, analogy and the general harmonizing of the ratios of these various rhythms with the curves of transpiration would seem to point unmistakably to the dependence of the latter process upon the vital activities of the plant. The marked irregularities in the rate are of special significance in this regard. As had been said they cannot be connected with any minor variations of the light, temperature or humidity—at least this statement would apply to many of the experiments where the instruments would show no appreciable fluctuations for hours at a time. Furthermore these results would naturally be expected where we consider Pfeffer's work on the energy of the cell. So many factors enter that the secretion and excretion are constantly

II. TRANSPIRATION CURVES UNDER ELECTRIC ILLUMINATION

	8 A.M.	9	10	11	12	1 P.M.	2	3	4	5	6	7
EUONYMUS JAPONICUS	38	67	105	167	116	82	110	108	92	89	72	
PELARGONIUM ZONALE	53	42	54	56	66	49	48	52	46	40	42	34
Temperature	25		26	27			26				25	
Hygrometer	28		30	28			31				30	
GARDENIA JASMINOIDES	27	36	57	60	65	60	63	55	33	38		
JUSTICIA ELEGANS	216	214	248	235	269	270	210	228	214	150		
Temperature	20		20.5				21		20.5			
Hygrometer	32		30				29		30			
FUCHSIA SPECIOSA	45	40	42	45	53	52	44	45	46	42		
AUCUBA JAPONICA	25	48	67	40	60	50	45	38	30	27		
Temperature.	22			21.5		22		22				
Hygrometer	37			36		36		38				
ACALYPHA HISPIDA	176	182	184	210	194	182	176	177	147	141	138	
Temperature	23				23					23.5		
Hygrometer	51				50					52		
FICUS ELASTICA	126	134	143	170	145	116	106	98	110	93		
Temperature	20		21				22					
Hygrometer	46		46		48		47					
SPARMANNIA	7	24	23	26	31	26	24	24	12	16		
Temperature	24.5				25				24.5			
Hygrometer	37				35				35			

subject to variation. Saturation, tension of gas, salts, food contents, metabolic processes, conditions of growth, all, acting independently of outward conditions, have in a degree a controlling influence on the cell activity and the expression of this complex interaction is found in the fluctuations. It is not intended to imply that transpiration is a purely physiological phenomena. The position of Nägeli is the only rational one—all physiological processes are dependent upon chemical and physical laws and every vital phenomenon goes on in accordance with these laws. This statement of Nägeli's made in 1861 would almost seem prophetic in the light of the knowledge on this subject of vital phenomena held to-day. We are accustomed to look upon the phenomena of transpiration as a purely physical process, largely, no doubt, because it is so intimately associated with the factors that govern evaporation. However, in this consideration we overlook the fundamental character of the physiological processes involved in transpiration and that are of the highest importance in growth, development and gaseous exchange. And it may be pointed out that the manner of action of light upon transpiration is by no means a settled problem, aside from the fact that it is intimately associated with the activities of the cell. Certainly the behavior of plants in light and darkness and the reaction of etiolated, chlorophylless and green plants to light would be difficult to explain on a purely physical basis. Again the after effects attending variations of illumination indicate interactions of a physiological character. If the vaporization of water in the plant is of a mechanical nature, having for its purpose the diffusion of the meager supply of salts required by the plants, then the process is not in keeping with the exceptional economy illustrated in the activities of the plant. It appears as rather remarkable when we consider the devices for the distribution of the slowly diffusing organized products, that the plant never hit upon an adaptation that would provide it with this relatively minute quantity of salts without putting it to the expenditure of so much energy. This supposition certainly ranks transpiration as perhaps the most wasteful operation in the vegetable kingdom.

The most variable factor in the external conditions of the experiments mentioned above was the variation in the percentage of moisture. The temperature would remain constant for long periods but the humidity was subject to more considerable variations. I was interested to observe what results would follow changes of humidity. A rise of a few per cent. had no effect that could with certainty be recognized. The following figures will illustrate the result when the humidity was changed at 11 o'clock from 36 to 44.

III. EFFECT OF MOISTURE

	10 A. M.	11	12	1	2	Temp.	Hygrm.	Time.
Aucuba Japonica,	167	164	136	167	108	18.5	37	10
Richardia Africana,	142	138	135	112	106		36	11
Opuntia camnessa,	5	7	0	4	3		44	12
Begonia metalica,	98	117	93	80	70	19	44	1
Cycas revoluta,	70	70	37	29	20		44	2

The result of this very considerable change is unmistakable and is apparent in the increased irregularities of the curve. The variation in *Opuntia* is in keeping with what might be expected from a plant of so pronounced adaptive character. It should be stated, however, that the curves of several cacti, obtained under fairly uniform conditions, were very uneven. These results are such as to warrant the conclusion that no serious error was being introduced through the fluctuations of the hmidity.

A few measurements are given in Table IV., of the transpiration of plants in the dark. Occasionally there is apparent a rhythm corresponding to the daily periodicity, but on the other hand it not unfrequently happens that there may be an irregular decline from the start or the curve may be characterized by a rise or fall without reference to the period of the day. I have noticed on several occasions that pronounced maxima may be found early in the morning—between 5 and 9 o'clock.

Manifestly little importance is to be attached to the results obtained under such conditions inasmuch as they represent the work performed under practically pathological conditions and the results throw little light upon the real action of the plant. While the rate becomes more uniform as Kohl and Wiesner have pointed out there is also to be noted a marked decline and the plant is less responsive to the stimuli of light, all the phenomena, in fact, point to a cessation of the activities. The tissues become congested and it is apparent

IV. ABSENCE OF LIGHT

	6 A.M.	7	8	9	10	11	12	1 P.M.	2	3	4	5	6
FICUS INFLECTA,	58	71	64	52	53	96	70	110	68	54	56	48	
Temperature,	17.5		18						18.5				
Hygrometer,	51		50						49				
FICUS ELASTICA,		286	255	247	280	294	270	265	266	247	223	203	166
		17.5					17.5			18			18
		40					41			40			39
GARDENIA JASMINOIDES,		32	34	30	49	48	46	40	44	38	32	36	34
Temperature,		19.5			20		19.5	20.5				21	
Hygrometer,		37			37		38	37				36	
NERIUM OLEANDER,		53	60	57	59	83	75	64	62	56	45	40	
Temperature,		20	21					21			21		
Hygrometer,		46	45					44			44		
ACALYPHA HISPIDA,		90	88	84	68	76	85	93	119	86	78	80	84
Temperature,		18			19			20			20		
Hygrometer,		38			37			36			36		
JUSTICIA ELEGANS,	210	190	164	135	198	167	170	195	166	174	192	213	184
Temperature,	18				19					195			
Hygrometer,	36				36					33			

that this must lead to a disarrangement of the operation of the vital processes. I was particularly interested to note that the leaves in many cases decidedly changed their positions. They often appeared to flag as if from the loss of water. They were, however, perfectly rigid and the changed turgor tensions had caused the curvature of the petioles. In other instances the edges of the leaf turned strongly upwards. This was particularly the case in *Begonia* while in *Fuchsia* many of the leaves bent down, forming a half circle and in so rigid a leaf as that of *Ficus* a lateral twisting of the leaves was sometimes to be seen.

The amount of water transpired is rather surprising in view of the fact that we usually consider the stomata as closed in the dark. Very few authors have maintained that the contrary condition is the case. Considering the ratios that have been found by Garreau and others between the dorsal and ventral surfaces of leaves it appears impossible that the cuticular transpiration could equal the volume recorded in the table. Only one instance has been noticed where the plant seemed to have the power of closing the stomata. In the case of *Cycas revoluta* brought into the dark room at 7.45 a. m. weighings were made hourly from 12.45 on with the following results: loss of 7 mg., 25, then gained for four hours 3, 2, 3, 2, loss 2, 7, gain 2, 4, 2, 0, 2. Temp. 21 to 19, Hygrm. 32 to

36. Six days later the same plant, having been returned to the green house, gave from 10.10 a. m. these readings: gain 0, 6, 2, loss 4, 7, 4, 8. Temp. 22 to 23.5, Hygrm. 32 to 30. The changes in the temperature and humidity were not corollated with the fluctuations. The gain in weight may be due to a precipitation similar to that noted by Volken in certain plants.

I was interested to make some further investigations upon the relations between cuticular and intracellular transpiration. The results will be found in Table V. The stems and petioles of plants from which the immature leaves had been removed a week previous were carefully sealed with wax mixture and the transpiration rate determined in the dark for three hours. Then the under surface of the leaves were rubbed with the wax so as to thoroughly plug the stomata and then coated with a further coat of the wax. The figures indicate that the stomata were closed. This wax mixture, referred to above, seems to me to offer a much better sealing mixture that the commonly employed shellac preparations which may react upon the living cells.

V. CUTICULAR AND INTRACELLULAR TRANSPIRATION

	9 A. M.	10	11	12.30 P. M.	1.30	2.30	3.30	4.30	5.30
FICUS ELASTICA,	70	76	107	4	7	9	12	10	10
Temperature,	18.8			19.5			19		
Hygrometer,	50			52			48		
FICUS ELASTICA,		163	175	6	4	11	10	12	12
Temperature,		22						23	
Hygrometer,		48						45	
FICUS ELASTICA,	37	38	43	4	8	10	10	6	8
Temperature,	19.5			19			20		
Hygrometer,	47			46			43		

In the cases under consideration, where the diffusion owing to the nature of the leaf must be at a minimum, the results would appear to warrant the conclusion that the stomata are sufficiently open to permit diastomic transpiration during the night. The work of Blackman in demonstrating the slow diffusion of CO_2 through the cuticular membrane of leaves, likewise that of Morren in reference to the absorption of SO_2 are suggestive of a similar action for vapor gas. It would also be difficult to understand how respiration may in all cases be effected at night by diffusion. I have not been able to demonstrate that the stomata were open by actual observation under the microscope but the rapid closing of the stoma in the case of plants standing in the shade suggests that possibly the balance between the tensions is so delicate that the least disturbance of the equilibrium, as in making the sections for examinations, may bring about the closing. It is also possible that, owing to the activity of the secreting cells and the accumulation of intracellular water, the stomata may open at varying periods and after the escape of the vapor close again. The rise in the rate after some one or more hours is perhaps due to the increase of water in the epidermal walls, induced by the turgor tensions. The work of Wiesner on the relative permeability of dry and moist membranes certainly points to such a conclusion. Comes has also demonstrated that the amount of water transpired from the two surfaces of the leaf when acting separately may be so increased that the total amount given off may exceed the normal transpiration of the leaf. The relatively large amount of water transpired in the third example after the sealing may be due to the quicker and stronger response in turgor tensions, thus bringing about a more rapid saturation of the epidermal membrane and there may also be an interaction on the stomatal apparatus.

Another feature of transpiration that emphasizes the intimate relation existing between the process and the vital action of the plant is the periodicity to be seen in the opening and closing of the stomata. Darwin has recently shown that the stomata have acquired the habit of opening more readily in the morning under the influence of light than in the afternoon. This is very strikingly shown in the experiments that are recorded in table VI.

The plants were given one hour illumination at various hours in the forenoon, indicated by the larger type, and for the same length of time in the afternoon. In the two last measurements the electric light was used. I have not a sufficient number of experiments at hand to warrant a conclusion as to the hour when the greatest response may be obtained and, owing to the very uncertain quality of the light from day to day as well as the influence of after effects, this would be a difficult if not impossible task. The results show in a very striking manner that there is a pronounced periodicity in the stomata of the plants under consideration. The stomata appear to open quicker and wider in the

VI. PERIODICITY OF THE STOMATA

IV.

	9 A. M.	10	11	12	1 P. M.	2	3	4	5	6	7
GERANIUM ZONALE,	56	60	*107*	78	67	49	44	*64*	46	40	
GERANIUM ZONALE,	60	68	*128*	78	80	62	45	*96*	55	36	
Temperature,	23					23.5			23		
Hygrometer,	47					47			49		
GERANIUM ZONALE,	19	23	24	*68*	46	28	24	*49*	28	25	23
Temperature,	25				24.5				24		
Hygrometer,	36				32				32		
GARDENIA FLORIDA,		48	*75*	65	62	32	40	*65*	40	27	30
JUSTICIA ELEGANS,		306	*568*	460	322	302	270	*302*	275	255	217
Temperature,		22.5						22		21.5	
Hygrometer,		48						51		53	
FUCHSIA SPECIOSA,	50	*103*	84	48	58	58	53	*71*	50	48	
Temperature,	20					21			20		
Hygrometer,	56					54			55		
AUCUBA JAPONICA,	43	43	*48*	44	46	43	42	*44*	40	40	
Temperature,	19.5							19.5			
Hygrometer,	59							58			
JUSTICIA ELEGANS,			196	175	180	*210*	176	167	150	*154*	136
Temperature,			20.5		20			19.5			
Hygrometer,			43		43			44			

morning. At least this might be inferred from the volume transpired and the reverse is true in the afternoon. Of interest also is the relation of the after effect. The volume for one or more hours following the period of illumination in the morning is in excess of the volume preceding the period of illumination. In the afternoon this relation may not hold good or there may be a slight excess in the volume following illumination over that of the preceding period. While the periodicity would assist in bringing about this relation it is evident that under the conditions of experimentation it could not produce so constant a rhythm.

One feature of this work that has been constantly before me is the extreme sensitiveness of the plant and the consequent necessity for the greatest care in avoiding the introduction of disturbing influences. Burgerstein's suggestion that transpiration phenomena, when possible, should be studied by weighing would appear to promise the most trustworthy results. When we consider the complex relations existing in the plant and their varied reaction to external conditions it would appear that much of the work that had been done upon this subject had been prosecuted under exceptionally brutal conditions. Devices which employ shoots or portions of the plant are of great value for demonstrations rather than as a means for the exact determination of actual processes. This remark may also apply to the measurements obtained by condensation or absorption of vapor. Work conducted under so artificial and unusual conditions can only give uncertain results.

SUMMARY

On cloudy and stormy days when the intensity of the light is quite uniform or at least not in keeping with the time of day, the transpiration curve shows a pronounced maximum near midday and it is also characterized by minor fluctuations that occur independently of climatic changes.

An illumination of an electric light of 900 candle-power under uniform external conditions demonstrated a periodicity in the transpiration of several plants that corresponds in the main with the curves determined on cloudy days. The harmonizing of the rhythms of absorption, exudation and tension of fluids and the rate of growth is suggestive of the vital character of transpiration.

Variations of a few per cent. in the humidity of the atmosphere produced no change in the amount of transpiration that could be determined with certainty. An increase of 8 per cent. resulted in a marked drop in the rate.

The curve in the dark sometimes was in keeping with the rhythm found under constant illumination but more frequently it is characterized by variations quite out of keeping with the periodicity of light. There is evidently a cessation of the vital action of the plant and the retarding of the rate together with its more pronounced regularity is in keeping with the loss of tone manifest in the plant.

The very considerable volume transpired in the dark indicates that the stomata may be sufficiently open to allow the escape of vapor. This may be brought about in connection with the interchange of the gases in respiration or possibly by the independent action of certain stomata that are especially affected by the increased turgor tensions or vapor tensions of intercellular transpiration. Only in the case of *Cycas revoluta* did the amount of transpiration appear in keeping with the ratios determined for cuticular transpiration.

This supposition became more manifest when the stems and petioles of several plants of *Ficus elastica* were sealed and the rate of transpiration in the dark was measured for three hours after which the stomatal surfaces were sealed and the rate of cuticular transpiration was determined for four hours. This amounted to from 3.6 to 10 per cent. of the former volume.

The physiological character of transpiration is also indicated by the periodicity of the opening and closing of the stomata. They are more responsive to the stimulus of light in the morning than in the afternoon and the more considerable physiological activity in the morning is manifest in the more pronounced after-effect following the illumination in the forenoon.

Forcible Discharge of the Antherozoids in Asterella Californica*

By George J. Peirce

In January, 1901, I had a considerable number of male plants of *Asterella Californica* * on a plate under a bell-glass in the laboratory. The laboratory was moderately warm, the air fairly dry; the soil under the bell-glass was damp, the air moist. On removing the bell-glass to examine the plants more closely, I was presently surprised to see slight puffs of what looked like smoke coming from the sods. I scrutinized the material thinking there must be a puff-ball in it, but could see none. On the contrary, the little puffs of smoke came from different places over the plate and, on looking carefully, I thought they must come from the groups of antheridia. I held a glass slide over the plate, caught a puff or two on it, and examined it under the microscope. What I saw were great numbers of the antherozoids of this liverwort sticking to what had been the lower surface of the slide. I tried this again several times with the same result—the antherozoids were forcibly projected above the surface of the plant. The slides were held from five to ten centimeters above the plants, but I made no exact measurements at that time, for I was not sure that what I had seen was not a wholly unusual phenomenon, possible only under the unnatural conditions prevailing in the laboratory. The plants had been in the laboratory for some time—two weeks, possibly longer—on a table six feet from the window. They were average plants when I brought them in, but they had not developed in the laboratory so fast as plants which I had left undisturbed out of doors. It was impossible for me to test the plants out of doors for they were already too old to discharge any more antherozoids, so I was obliged to stop work on the matter for this reason.

From Professor D. H. Campbell, of this university, and Dr. M. A. Howe, of Columbia University, I learned that what I had seen was new, not hitherto recorded in the literature with which they are familiar and which is quite unknown to me, and I deter-

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* This plant has also been known as *Fimbriaria Californica*.

mined to watch the plants out of doors as well as in the laboratory during the following season.

On January 20 of this year (1902) I thought the plants of *Asterella Californica* were in proper condition for testing whether they do or do not discharge their antherozoids under the conditions prevailing out of doors, and I set some glass slides to catch antherozoids if any should be expelled. A word may be said as to the weather and the place, as well as the manner and the result, of my experiment. The rains came early this season, in October and November, the season being ahead of the average when December began. There was no more rain to speak of till January 18. On December 11 the weather became decidedly cooler and remained cool, with frequent white frosts at night for weeks. There have been heavy dews and heavy fogs at night, some of the fogs being so heavy as to wet the streets enough to make the surface sticky. The days had been sunny as a rule, but there had been little growth and development among plants. In consequence, *Asterella* is not so far along as usual at this time. The bank where *Asterella* grows is sandy, steep, more or less covered with grass, shrubbery, mosses and liverworts, about half a mile from this university, and faces northeast, receiving little direct sunshine. On the morning of January 18 I was struck by the dryness of the soil there compared with last year. We had 20 mm. of rain the following afternoon and night; the sun shone brightly and the air was warm on the 19th. The plants were then in perfectly normal, healthy condition on the morning of the 20th, after a night of heavy dew and comparative mildness.

The sun was shining brightly, the air was rapidly growing warmer, as I set my slides at various distances from male plants of *Asterella*. The slides had been cleaned and numbered, and were held in place by wire holders thrust into the soil. The slides did not touch the plants and were in various positions, some horizontal, others oblique or vertical, corresponding to the positions of the plants. Slide no. 1 was 2–3 cm. from a patch of young *Asterella* growing on a vertical part of the bank. Other slides were nearer, others much further from the plants, from 0.5 cm. to 15 cm. I put out the first slides at 10.15 a. m., the last one at 11. At 4.30 p. m. I took a microscope out to the bank and looked at some of the slides, but it was too late to examine all and the light was uncertain at best. Slide no. 1 had some dead antherozoids sticking to it. I did not see any on the other five slides examined. I put no. 1 back and brought the other five with me for more careful examination in the laboratory. The day had been warm and sunny, the air was much dryer during the day than at night, and there was some breeze throughout the day (a circumstance which might account for there being no antherozoids on any slides except no. 1). By seven o'clock in the evening it had begun to rain, and it rained gently for three hours.

There was white frost on the lowlands on the morning of January 21, but none on my bank. At 9.30 I took a microscope out again. Slide no. 1 had water on it, making a ridge along the lower edge on the side next the bank. I carefully took the slide out of the wire holder, turned it flat so that the water spread over the upper surface, and put it on the microscope. There were *Asterella* antherozoids in considerable numbers—a dozen in one field of Leitz objective VI and ocular 3—swimming about in the water. These antherozoids could have come upon the slide only as did those dead ones found on it the afternoon before, by being forcibly projected from the antheridia imbedded in the plants. It is evident, then, that the antherozoids are expelled when the plant is under perfectly natural conditions, and that what I saw a year ago was not a laboratory phenomenon merely.

From the conditions prevailing when I first saw the expulsion of these antherozoids, I thought the mechanics of the process might be as follows: that the walls of the antheridia and the adjacent tissues of the plant give up water in comparatively dry air faster than the contents of the antheridium can; that pressure develops which finally exceeds the resistance of the wall of the antheridium; that this breaks suddenly and the antherozoids are thus thrown out through the openings of the cavities in which the antheridia lie. This hypothesis seemed to be strengthened by my finding antherozoids in the afternoon, after a day of comparative dryness following a night when the dew was heavy. But the occurrence of antherozoids on the slide which was out all night and during a rain does not favor this view. The number of antherozoids on this was decidedly larger, perhaps because the time of exposure was longer (about three times as long), perhaps because the antherozoids did not fall off the wet slide as they might from a dry one, perhaps because the breeze was gentler or different in direction, etc. The main thing is the occurrence of antherozoids on the slide under two sets of conditions very different from each other. The mechanics of expulsion cannot be such as I at first thought.

Having proved that *Asterella* expels its antherozoids out of doors under natural conditions and not merely in the laboratory, I decided to bring plants in for further study. So many things may act as disturbing influences out of doors—the wind, rain, animals, etc.—that no satisfactory tests of the distances to which the antherozoids may be thrown are likely to be made out of doors without a great expenditure of time and trouble. I brought a considerable number of male plants of somewhat different ages into the laboratory, arranged them on a plate, fastened to the edge of the plate wires holding slides at different heights above the plants, and covered the whole with a bell-glass, first taking care that the plants were thoroughly wet. On the afternoon of the following day I found a few antherozoids on one slide about seven centimeters above the plants. On the morning of the next day but one there were grayish spots on three slides, five to seven centimeters above the plants. These spots I feared were excrementitious matters from some insect but proved on examination to be extensive masses of antherozoids in the slime in which they are discharged. This slime consists presumably of the gelatinized walls of the mother-cells of the antherozoids together with whatever protoplasmic matters remain and degenerate in the mother-cells. The slime is very important in contributing to the expulsion of the antherozoids.

I put the slides on higher holders and waited another twenty-four hours, again watering the plants before putting the bell-glass over them. Much to my astonishment, on the following morning, one of the slides, fourteen centimeters above the plants, had a series of spots on it as shown in *Fig. 1*. This figure is a tracing, moderately exact as to the shape and size of the spots and exact as to their number and arrangement, made on thin paper from the stained preparation on the slide. These spots certainly suggest fly-specks, but examination with the microscope proves them to be masses of antherozoids. I again put fresh slides on holders still higher, but I caught no antherozoids on these highest slides. Any one of these possibilities may account for this, namely: the plants may have stopped forming antheridia and have emptied all those already made, or none may have been ready to burst while the slides were up, or the slides may have been between instead of in the path of expelled antherozoids, or the slides may have been just too high to catch any. Certainly the antherozoids caught on the slide fourteen centimeters above the plants would have gone considerably higher if they had not been caught. The highest slides I put in place were about 21 cm. above the plants. One may say, then, that *Asterella* can throw its antherozoids, under favorable conditions, to a vertical height of 14–20 cm.

The spots made on the slide by the discharged antherozoids are dense or thin, close together or scattered, according as the slide receives the discharge from the antheridium before or after the discharge spreads out. The outlines of the spots represent cross-sections of the discharge at the height of the slide. In *Fig. 1* there are so many spots that two or three plants must have discharged their antherozoids upon the one slide. The outlines of the spots even under the microscope are very sharp, the antherozoids are held together in very compact masses, the slime serving as the matrix. On some slides, instead of such dense spots, there is an immensely larger number of smaller spots, visible only under the microscope. These spots consist (*Fig. 2*) of a considerable number of antherozoids in a thin layer of slime. The slime layer varies somewhat in thickness in different parts of the spot. From my slides it is obvious that the antherozoids are discharged while enclosed in slime, that the main mass of slime breaks up during its flight into smaller ones, these again dividing perhaps, and that finally the antherozoids fall again to the ground in little groups, the enclosing slime dissolving in the dew or rain, on the surface on which they fall, thus liberating the antherozoids. The antherozoids thereupon swim off, swimming then for the first time although they may have been carried far on the breeze which also helped to break up the discharge from the antheridium. The slime, holding the antherozoids together in little groups, is distinctly beneficial in so doing. It is a protection, besides, in keeping the antherozoids from drying and stiffening, as such minute bodies would surely do unless enclosed in a matrix which holds water more effectively than protoplasm. That there is always slime about the antherozoids till they fall on a wet surface is shown by my dry slides. That the slime dissolves, thus liberating the antherozoids, which thereupon swim away, is shown by my wet slide out of doors.

Antherozoids on the slide, whether singly or in patches, may be fixed and stained by the methods applied to staining cover-glass preparations of bacteria. I tried several methods, of which Fischer's * for staining cilia was the most successful. Of course, this method is not recommended for the cytological study of the antherozoids. I recommend it only for the purpose of demonstrating perfect antherozoids, ciliated and enclosed in thin slime, which have been caught on slides.

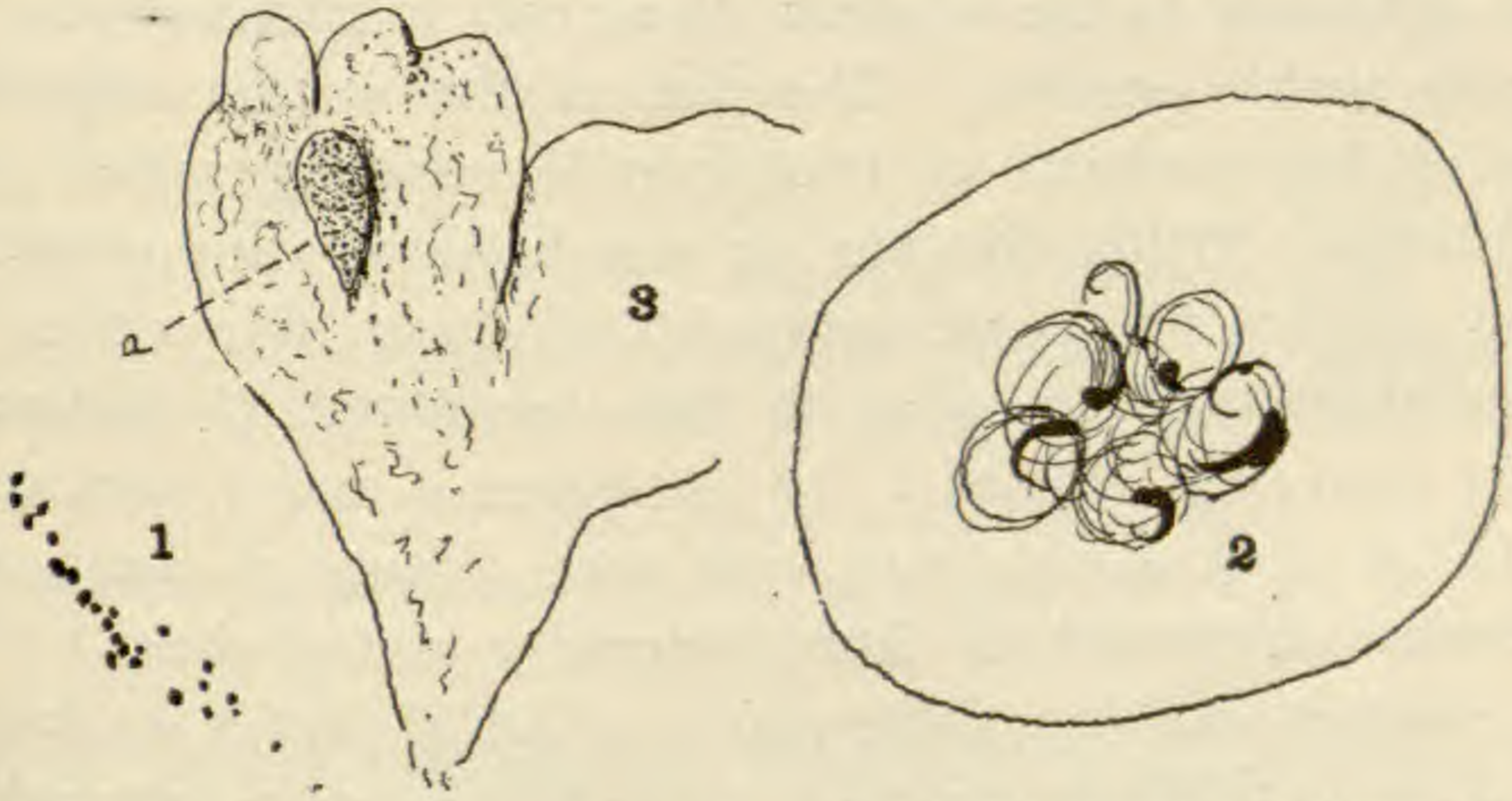

FIG. 1. A tracing of spots formed on slide by discharge of antherozoids from antheridia 14 cm. below.

FIG. 2. A very small spot, showing ciliated antherozoids and slime in which they are imbedded, × 755. Leitz drawing-prism.

FIG. 3. Sketch of male plant of *Asterella Californica*, showing cushion (*a*) in which antheridia develop, × 3.

We come back now to the mechanics of expulsion. The discharges which I have seen take place or have caught on the slides, have occurred only when the soil and the plants were full of water. Not only the tissues of the antheridia, but the surrounding vegetative tissues were turgid. Given an abundant supply of water in

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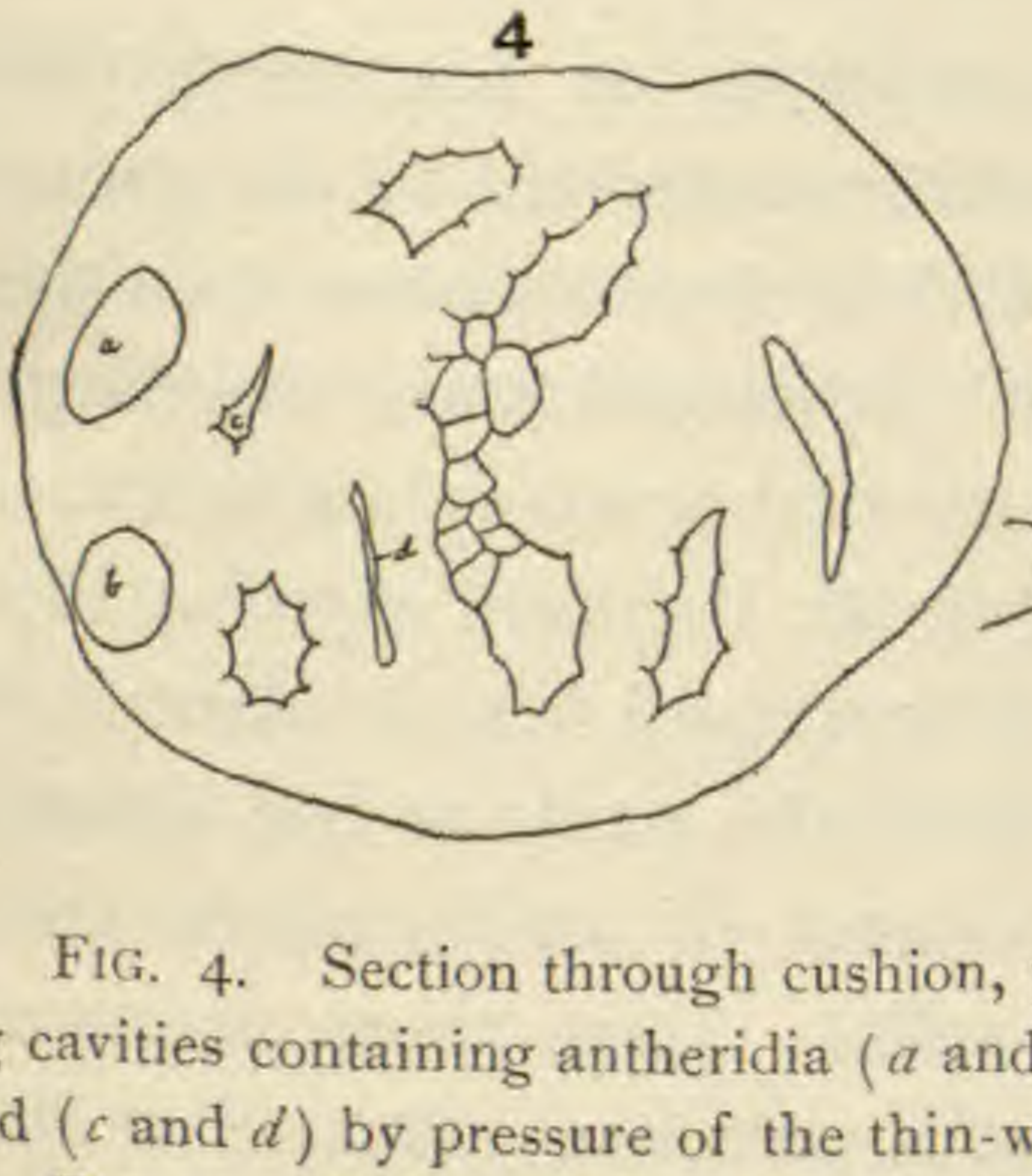
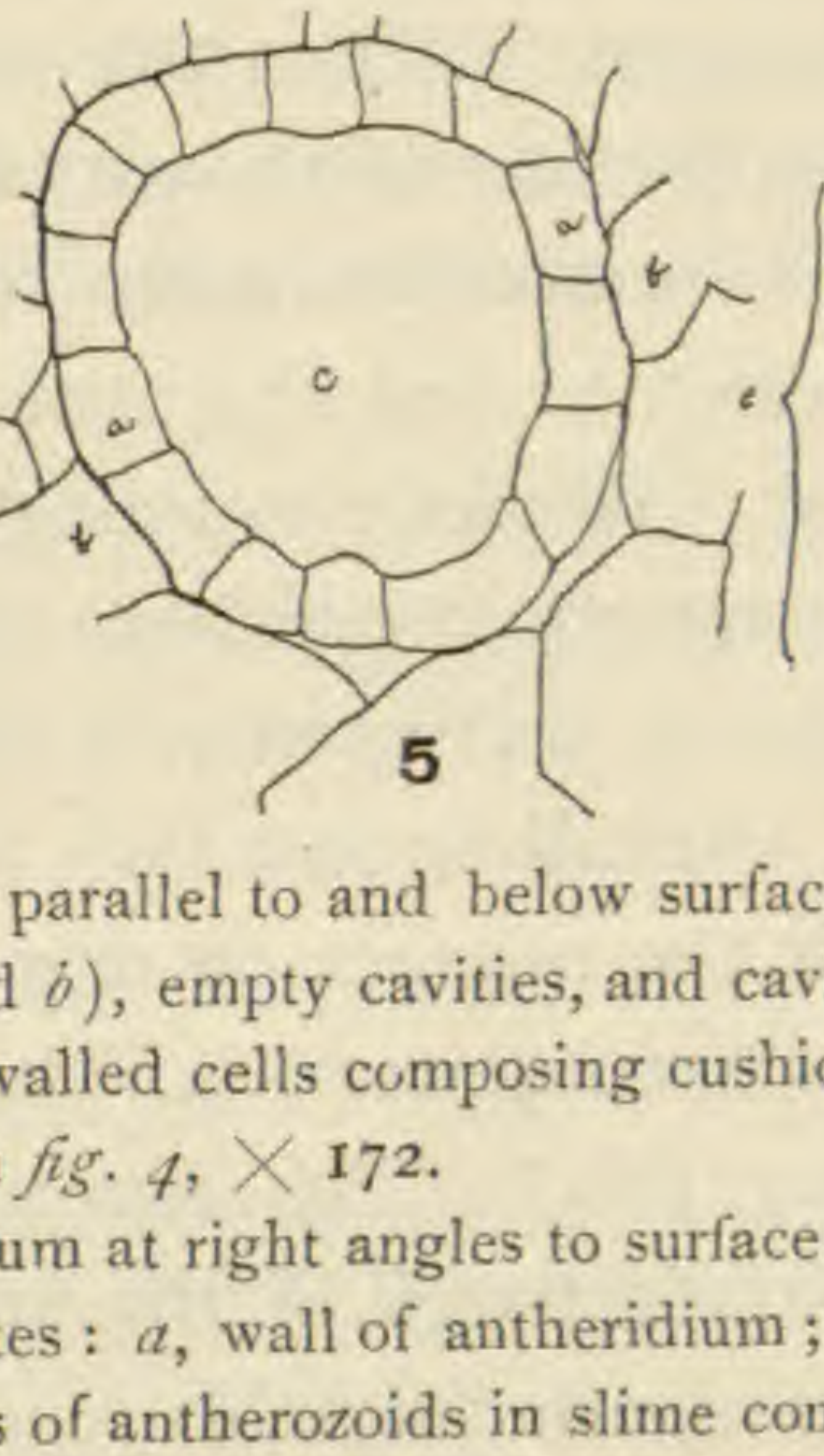
* Jahrb. wiss. Bot. 27 : 82. 1895.

the soil, turgidity will always develop. The structure of these turgid parts demands a moment's notice. The antheridial patches of *Asterella*, as shown in *fig. 3*, are somewhat raised above the general surface of the thallus. The tissue composing and underlying this elevation is very different from that elsewhere. A section through one of these antheridial patches parallel with and below the surface of the thallus, shows that the thallus is composed in the main of moderate sized cells, containing many chlorophyll grains and with small intercellular spaces between, while the part of the thallus where the antheridia are consists of much larger cells, with far fewer chlorophyll grains, cell-walls no thicker, and (when the tissue is full of water) there are no intercellular spaces. The distribution of these tissues is plain to the naked eye, for the part under or among the antheridia appears quite colorless compared to the adjacent tissue rich in chlorophyll. *Fig. 4* shows such a section. The part of the section outside the bounding line consists of chlorophyll-containing rather small-celled tissue. Within the line one sees holes of various sizes and shapes between which are comparatively large, thin-walled cells pressed close together owing to their turgidity. (I sectioned a thallus from very wet soil.) In the spaces *a* and *b* were antheridia, in the other spaces there were none. Some of these spaces are nearly obliterated, as those lettered *c* and *d* show. *Fig. 5* is an enlarged drawing of the part *a* of *fig. 4*, that is, a cross section of an antheridium enclosed in the turgescent nearly colorless tissue of the cushion. The cells forming the wall of the antheridium are shown in outline (*a*), the adjacent and closely pressing vegetative cells are only partly shown (*b*), while the blank central portion (*c*) represents the mass of antherozoids enclosed in slime, forming the greater part of the antheridium. *Fig. 6* is a longitudinal section of an antheridium, a section at right angles to the surface of the thallus, similarly lettered. All the sections are free hand, and the one shown in *fig. 6* does not show in quite true proportions the opening of the chamber in which the antheridium lies. The tissue within the bracket *d* is composed of comparatively small cells, rich in chlorophyll, the tissue bracketed *e* is composed of large cells, comparatively poor in chlorophyll, and capable of great changes in volume. It is precisely this comparatively colorless tissue in which the antheridia are imbedded which furnishes much of the force by which the antherozoids are ejected.

The mechanism effecting the ejaculation of the antherozoids consists of two parts—*first*, of the shiny, water-absorbing matrix consisting of gelatinized mother-cells and thin walls, in which the antherozoids lie and which fills and distends the ripe antheridium still enclosed by the single layer of peripheral cells; *second*, the thin-walled, large-celled, water-absorbing tissue composing the cushion, in chambers of which the antheridia develop. These two, the tissue and the slime, expand in opposite directions as they absorb water, the one tending to decrease, the other to increase, the size of the chambers containing antheridia. The two pressures would tend to offset each other and would affect nothing if they met on all sides of the antheridia. The chambers in which these lie, however, are open above and are covered by the chlorophyll-containing, smaller-celled, and more rigid tissue indicated by *d* in *fig. 6*. Hence the antheridia are distended in all directions, upward as well as otherwise, and are compressed from all sides, *except from above*. The distending and compressing strains finally result, under these considerations, in the rupture





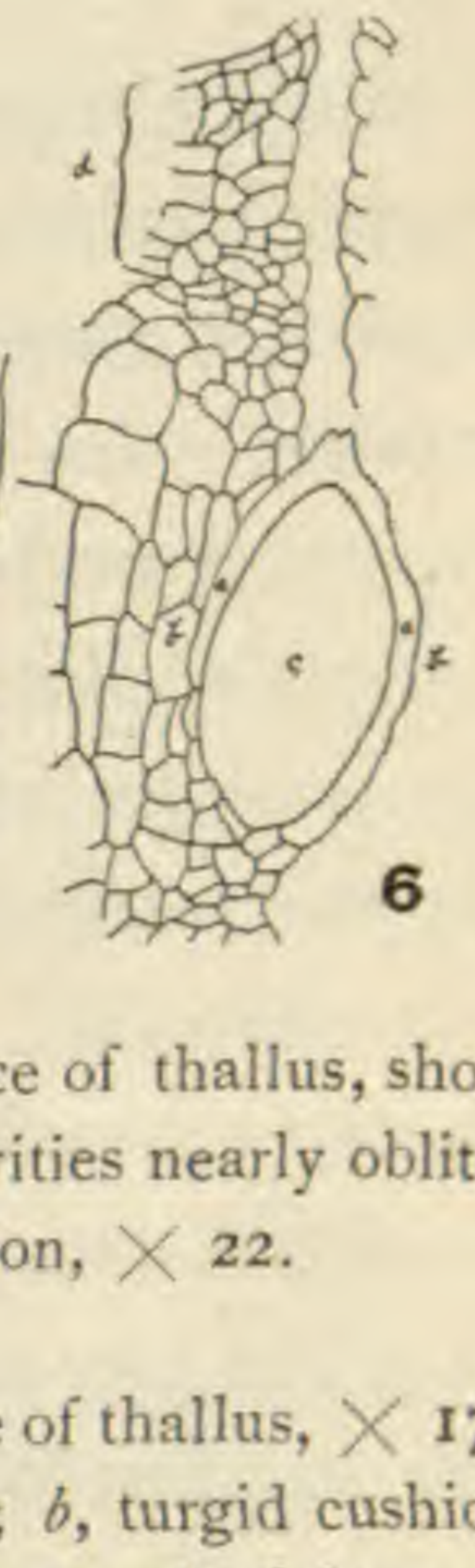


FIG. 4. Section through cushion, parallel to and below surface of thallus, showing cavities containing antheridia (*a* and *b*), empty cavities, and cavities nearly obliterated (*c* and *d*) by pressure of the thin-walled cells composing cushion, × 22.

FIG. 5. Enlarged drawing of *a* in *fig. 4*, × 172.

FIG. 6. Section through antheridium at right angles to surface of thallus, × 172.

The lettering in *figs. 5 and 6* denotes: *a*, wall of antheridium; *b*, turgid cushion-tissue compressing antheridium; *c*, mass of antherozoids in slime composed of degenerated walls and contents of mother-cells. This absorbs water and distends antheridium; *d*, solid chlorophyll-containing tissue, with opening of chamber; *e*, water-absorbing turgescent cushion-tissue. The figures were drawn with Leitz drawing-prism.

of the antheridium and the discharge of its contents through the mouth of the chamber, the total force expanding itself all in one direction with the astonishing result just described.

The distance to which antherozoids will be thrown will depend on the one hand upon the turgidity of the antheridia and of the vegetative parts of the plant, and on the other hand upon the position of the plant and upon the wind. The antherozoids may be thrown violently against nearby objects, leaves, branches, etc., when the force was sufficient to have carried them much farther if the plants had only been growing in more open places. But the main external influences are wind and water. The wind may blow the antherozoids back upon the parent plant or take them far away, dropping them near female plants or scattering them where there are none. When the antherozoids fall to the ground they must swim the rest of the way if they are to accomplish their purpose. An enormous number of antherozoids are discharged from each antheridium, and there are several or many antheridia on each male plant. Without counting at all, I should say that there appear to be about equal numbers of male and female plants, and that the number of archegonia is about the same as the number of antheridia. At all events the number of antherozoids enormously exceeds the number of egg-cells. Since these plants are dioecious, cross fertilization is all that is possible. But what does the plant pay for this? The dioecism of this species is coupled with the forcible discharge of the male elements. These may or may not be transported by this means nearer to the female elements which they must reach by swimming and with which they must fuse if they are to be useful.

It would be interesting to know whether other dioecious liverworts have this same habit. I hope next year to test other plants for this phenomenon, but I do not wish by this statement to reserve the field to myself.

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January 31, 1902.

Taxodium distichum and related Species, with Notes on some geological Factors influencing their Distribution

BY ROLAND M. HARPER

Observations on the genus *Taxodium* in the field during three or four seasons have led me to the conclusion that there are at least two well-marked species in the southeastern United States. Most authors who have written on the subject have considered the genus to be represented in that region by a single species, but some have admitted the existence of a variety in addition.

The genus was founded by L. C. Richard in 1810, with a single species, the *Cupressus disticha* of Linnaeus; and the number of living species in the world has since been variously regarded as from one to three, excluding species which are now referred to *Sequoia* and *Glyptostrobus*.

Before discussing the relationships of the two southeastern species it will be well to give their principal synonymy, which is as follows:

TAXODIUM DISTICHUM (L.) L. C. Richard, Ann. Mus. Par. **16**: 298. 1810

Cupressus disticha L. Sp. Pl. 1003. 1753. Type locality: "Virginia, Carolina."

Schubertia disticha Mirbel, Mem. Mus. Par. **13**: 75. 1825.

Taxodium imbricarium (Nutt.)

Cupressus disticha β imbricaria Nutt. Gen. **2**: 224. 1818.

Type locality: "From Florida to North Carolina, in swamps and ponds more remote from the sea."

Taxodium ascendens Brong. Ann. Sci. Nat. **30**: 182. 1833. Type locality North American, but not specifically given.

T. distichum var. *imbricarium* Sarg. Sylva N. A. **10**: 152. 1896.

The latter form of the name was used by H. B. Croom in his Plants of New Bern (now Newbern), N. C., in 1837, by M. A. Curtis in his flora of North Carolina in 1867, and by Wood & McCarthy in their Wilmington (N. C.) Flora in 1886, but does not seem to have been properly published until it was taken up by Professor Sargent. Synonyms for these two species which are purely horticultural or of doubtful application are here omitted.

The principal objection to the recognition of the latter species as distinct seems to have been its supposed intergradation with *T. distichum.* Elliott,[*] writing a few years after Nuttall, says of *T. imbricarium:* "This is a small tree growing in pine-barren ponds. It produces its knobs (exostoses) more abundantly than the large variety; and on its lower branches the leaves are frequently imbricated after the manner of the junipers. But on the upper branches the leaves are often expanded and distichous. It is perhaps only a stunted variety, growing in an unfavorable soil."

Seventy-two years later Professor Sargent[†] remarks: "No one unfamiliar with the fact that branches of the two forms occasionally appear on the same individual would imagine that the cypress trees with erect or pendulous thread-like branches and closely appressed acerose leaves belong to the same species as those with spreading distichous branches and flat leaves."

Dr. Mohr's observations on *Taxodium* in his "Plant Life of Alabama"[‡] are of interest as being among the latest published. On page 117, in speaking of the mesophile and paludial forests of the lower division of the coast pine belt, he says: "Groves of the pond or upland cypress just mentioned—a variety closely connected with the type by intermediate forms—cover the shallow pine-barren ponds and semi swampy woods of a poor, sandy soil destitute of vegetable mold. This form of the cypress in the size and quality of its wood is greatly inferior to the typical cypress of the alluvial swamps, and is at once recognized by the leaves, which are closely appressed to the deciduous annual shoots. By this peculiarity of the foliage a check to excessive transpiration is provided during the time of drought, when the sandy soil is laid bare to the sun and its supply of water is failing."

On page 325 he says of the same plant: "Of smaller size than the species, with the leaves reduced in size and closely adpressed to the deciduous branchlets, thus imparting to the tree a strikingly

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[*] Bot. S. C. & Ga. **2**: 643. 1824.

[†] Sylva N. A. **10**: 152. 1896.

[‡] Contr. U. S. Nat. Herb. **6**: 1901.

peculiar aspect. This character, however, is not constant, and the variety can scarcely be maintained, the same individual producing during the earliest stages of growth and on vigorous adventitious shoots leaves of the ordinary form. This form passes freely into the species where the soil conditions are more favorable."

But, notwithstanding the opinions of these eminent botanists, it seems to me that the intergradation is more apparent than real, and that this idea may have arisen from a too hasty generalization of observed facts. It is true that young shoots of *T. imbricarium* often bear branchlets with distichous leaves (perhaps indicating its descent from an ancestral form which resembled *T. distichum* of the present day), but on the typical *T. distichum* I have seen only one kind of branchlets.

The opinions of Nuttall and Croom, both of whom seem to have been very acute observers, are more favorable to my view of the distinctness of the two species under consideration.

Nuttall, in the original description of *T. imbricarium*, says: "Leaves subulate, partly imbricated in four ranks, deciduous; nuts larger, chestnut colored." * * * "A smaller tree than the preceding, often producing fruit at a height of three feet from the ground."

Croom, in his flora of Newbern above mentioned, says (page 48): "*Taxodium distichum.* * * * Elliott expresses the opinion that the variety *imbricarium* of Nuttall is only this species in a starved condition, as it is commonly found in pine-barren ponds. But in some instances (20 miles above New Bern) I have seen large trees of this variety, and, in one instance, I observed it growing by the side of the common variety, and in the same soil."

The differences between the two species will now be considered more in detail. These differences are of several kinds, not only structural but ecological as well.

The most conspicuous structural difference, as noted by most of the authors just quoted, is in the form and position of the leaves and the branchlets which bear them. In *T. distichum*, as is well known, the leaves are two-ranked on the branchlets, widely spreading, and in the same plane, making each leafy branchlet resemble a pinnate leaf (to which it is indeed analogous); and the branchlets spread approximately horizontally, bringing the surfaces of the leaves likewise into a horizontal position. In *T. imbricarium*, on the other hand, the leaves are normally more or less appressed to the branchlets, which have lost their dorsiventral character. The branchlets have been described by Professor Sargent and others as "erect or pendulous," and from a herbarium specimen it would usually be impossible to ascertain which of these two positions they had assumed in life. But they would be much more correctly described as normally erect, occasionally somewhat spreading, very rarely (never in perfect specimens) drooping. It is interesting to note that the leaves and branchlets of the two species of the allied genus *Sequoia* differ in much the same way.

I have not noticed any difference between the fruits of the two species, but Nuttall says of *T. imbricarium* "nuts larger," and Endlicher * probably following Nuttall, says of *T. ascendens* Brong., "seminibusque majoribus."

The difference in size, mentioned by some authors, does not appear to be constant, as remarked by Croom. In Georgia, where both species are abundant, *T. imbricarium* often attains as large a size as *T. distichum*, but the former probably begins to fruit at a smaller size (though perhaps not at an earlier age, as it is said to be of slower growth).

One characteristic difference, which does not seem to have been noted before, is found in the enlargement at the base of the trunk, which is usually more abrupt in *T. imbricarium* than in *T. distichum*. In Coffee county, Georgia, I have walked entirely around a specimen of *T. imbricarium* on its enlarged base, a feat which would be impossible with any specimen of *T. distichum* I have ever seen. Furthermore, the enlargement of the trunk of *T. distichum* is approximately conical, with its greatest slope at or below the surface of the ground (or water, as the case may be), while that of *T. imbricarium* is conoidal, with its greatest slope some distance (a few inches to a foot or two) above the ground. In the many thousands of individuals of *T. imbricarium* which I have seen I have never observed any deviation from this character. The longitudinal ridges traversing this enlargement are usually quite sharp and prominent in *T. distichum*, and rounded

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* Syn. Con. 69. 1847.

or almost wanting in *T. imbricarium.* The same differences are often observable in cultivated specimens.

The general appearance of the trunk of *T. distichum* is well shown in figure 48 of Schimper's Pflanzengeographie, which is a full page half-tone reproduction of a photograph taken by Dr. H. J. Webber in Florida,* also by plate 8 and figure 30 of Professor N. S. Shaler's paper on the fresh-water morasses of the United States in the Tenth Annual Report of the U. S. Geological Survey, and by plate 73 in Mr. Kearney's recent paper on Dismal Swamp,† which is the same as Professor Shaler's plate 8.

Plate 68 of Mr. Kearney's paper illustrates very well the character which I have just assigned to *T. imbricarum,* and plate 9 of Professor Shaler's paper, which was evidently photographed at about the same time and place, shows the same thing, though less distinctly. By comparing these plates with the illustrations of *T. distichum* just cited, the difference is readily seen. Nothwithstanding the fact that this species is not mentioned by Mr. Kearney in his paper (and he has since told me that he is not acquainted with it), I am confident that his plate 68 and Professor Shaler's plate 9 represent the true *Taxodium imbricarium.* I find no other record of the occurrence of *T. imbricarium* in Virginia than these two illustrations, but Croom found it near Newbern, N. C., which is only about 100 miles from Lake Drummond, Virginia, where the photographs in question were taken.

Whether the knees afford any diagnostic characters or not I am unable to state at present. Elliott mentions those of *T. imbricarium* as being more abundant than those of *T. distichum,* but this may not be universally true. Professor Shaler (in the paper above cited) and perhaps other authors, have noted that *T. distichum* cannot live with its knees under water during the summer. This is probably not true of *T. imbricarium,* for I have seen it in midsummer in ponds and creeks where no knees were visible, at least at the ordinary stage of water. The knees of *T. imbricarium* probably never become so large as those of *T. distichum.*

Physical tests show an appreciable difference in the wood of the two species. Dr. Filibert Roth, in one of the publications of

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* The same photograph is reproduced in Coulter's "Plant Relations," as Fig. 91.

† Contr. U. S. Nat. Herb. 5: 321–550. *pl. 65–77. f. 51–90.* 6 N. 1901.

the U. S. Department of Agriculture,* although not regarding the two forms as specifically or even varietally distinct, has tabulated the results of many tests which show that the wood of the "pond-cypress" is both heavier and stronger than that of the better-known plant.

Turning now to ecological characters, the leaf-galls may be considered next. The leaves of both species are frequently more or less infested with galls, and as far as I have observed the galls on the two species appear to be different. Whether they are caused by the same or different insects I do not know; this is a matter which deserves further investigation.

In regard to habitat, it seems to be the prevailing opinion that *T. distichum* is confined to river swamps and *T. imbricarium* to pine-barren ponds. This, however, is not always the case. The largest specimens of *T. imbricarium* I have ever seen are in southeastern Georgia, in deep-flowing water of creeks which never dry up, and yet they maintain their essential characters perfectly. Here the species is to all outward appearances growing under practically the same conditions which prevail in the rivers and creeks which *T. distichum* inhabits. The habitat of the latter is also somewhat variable, including lime-sinks as well as river-swamps. Some say that *T. imbricarium* grows in poorer soil, but this also is liable to many exceptions, to say nothing of the difficulty of defining accurately what constitutes a poor soil.

In view of all these well-marked and constant differences, and others to be mentioned later, it seems to me that *Taxodium distichum* and *Taxodium imbricarium* can no longer be consistently treated otherwise than as distinct species. They are certainly as distinct as *Lycopodium lucidulum* and *L. porophilum*, *Juniperus Virginiana* and *J. Barbadensis*, *Pinus palustris* and *P. heterophylla*, and a hundred others which might be mentioned.

During my investigations of the flora of Georgia in 1900, I discovered a most remarkable relation between the habitats of these two species of *Taxodium* and the geological formations, on which I have based a new theory of their distribution. This theory has so far been fully substantiated by observed facts in almost every case, and the few apparent exceptions to it which have been

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*Circ. Div. Forestry, 19: 22. 1898.

noted will probably disappear on closer investigation. It may be briefly stated as follows:

Taxodium imbricarium always grows over the Lafayette formation; Taxodium distichum never.

Furthermore, *T. imbricarium* seems to occur only on Lafayette which is overlaid by a thin deposit of the Columbia formation, and *T. distichum* is often, if not usually, found on the Columbia also, but where this formation is absent it may grow directly on the older strata.

The Lafayette and Columbia formations have been thoroughly discussed by W J McGee,* but a brief outline of them here may be of interest to those who have not time to read the one hundred and seventy-five quarto pages of his monograph.

The Lafayette, the older of the two, is (at least throughout most of the region in which *Taxodium imbricarium* occurs) a deposit of sandy clay, reddish or yellowish in color, varying considerably in thickness, lying unconformably on the mesozoic and cenozoic strata over a vast area of the coastal plain of the eastern United States. It is supposed to have been laid down just before the Glacial period of the North, during a submergence of the coastal plain estimated to have lasted about 60,000 years.

The Columbia formation, in the region under consideration, consists almost entirely of sand. It is supposed to have been deposited during a much shorter period of submergence of the coastal plain contemporaneous with or subsequent to the glacial period. It is always above the Lafayette where the two come in contact, and is rarely too thick for the roots of trees to penetrate through it into whatever strata may be beneath.

In a general way the terrane of the Lafayette may be said to coincide with the present coastal plain from Maryland to Texas, extending up the Mississippi Valley to Illinois, with the following exceptions. It is not known to cover any portion of Florida except the extreme north, the peninsula having perhaps been too far off shore during the Lafayette submergence to receive any of these sediments. Neither is this formation known to extend to the present shore line at any point.

During a period of elevation succeeding the Lafayette submer-

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* Ann. Rep. U. S. Geol. Surv. 12^1: 347–521. *pl. 32–41. f. 28–72.* 1891.

gence the larger rivers of the coastal plain cut their channels entirely through the Lafayette deposits into the older strata below, and in most of the resulting gorges the Columbia sands were subsequently deposited.

Like the Lafayette, the Columbia covers a large part of the coastal plain, extending from Long Island to Mexico, and up the Mississippi and Ohio rivers to Indiana. In the Middle and South Atlantic States it covers the whole country near the coast, but usually does not extend up to the inland edge of the coastal plain like the Lafayette. In southwestern Georgia and Alabama, however, it is mostly confined to the river valleys, the divides here having been above the sea during the Columbia submergence. In Texas, while the main body of the Columbia only covers the seaward portion of the coastal plain, long narrow arms of this formation extend several hundred miles up the larger rivers, far beyond the inland edge of the costal plain. Similar extensions are found in Arkansas and the Indian Territory. On the peninsula of Florida the Columbia formation has not been traced south of latitude 28°.

The geographical distribution of our two species of *Taxodium* is intimately related to that of the two geological formations just mentioned, as will now be shown.

The range of *T. distichum* is given by Professor Sargent* as follows: "From southern Delaware * * * southward near the coast to the shores of Mosquito Inlet and Cape Romano, Florida, through the coast region of Gulf States to the valley of the Devil River in Texas, and through Louisiana and Arkansas to southeastern Missouri, eastern Mississippi and Tennessee, western and northwestern Kentucky, southern Illinois, and Knox county in southwestern Indiana."

The range thus given of course includes that of *T. imbricarium* also, but according to my theory *T. distichum* would be confined to the comparatively small but widely distributed area from which the Lafayette formation is absent, such as near the coast, along the larger rivers, and on the peninsula of Florida.

Among the extreme points of the range of *T. distichum* may be mentioned the following:

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* Sylva N. A. 10: 153. 1896.

Dr. Hollick* has reported its occurrence near Newark, N. J., but is not certain that it is indigenous there. This locality is near the extreme northern limit of the Columbia formation, and about 200 miles from any known area of the Lafayette. The occurrence of *T. distichum* at this point therefore does not conflict with my theory. The Lafayette formation is also unknown in Delaware, which is the northernmost state in which *T. distichum* is undoubtedly indigenous at the present time.

Dr. Gattinger, in his Flora of Tennessee (pages 25 and 32 of the 1901 edition), mentions its occurrence along the Tennessee River, which, according to Dr. McGee's map of the Lafayette and Columbia formations (plate 38 of his monograph above cited), has cut through the Lafayette and is now lined by deposits of Columbia throughout most of its course through the western part of the state.

Dr. Mohr† says of the range of *Taxodium distichum* in Alabama: "This tree is found throughout the State," but this statement is probably to be taken with some qualification. Among the particular localities mentioned by him is the Tennessee River; and although the Columbia formation is not known to extend up this river into Alabama, the *Taxodium* might well do so, as it is not necessarily confined to this formation.

The occurrence of *T. distichum* in Knox county, Indiana, has been discussed by John S. Wright.‡ In Garden and Forest (**3**: *7. f. 2*) for January 1, 1890, there is a good half-tone engraving of an Indiana cypress swamp.

An interesting station for *T. distichum* in Texas was discovered in 1894 by Mr. A. A. Heller, who collected it along the Guadalupe River at Kerrville, at 1600 feet altitude.§ One of his specimens from this locality is in the Columbia University herbarium. Kerrville is beyond the known area of the Columbia formation, but it is noteworthy in this connection that this formation extends farther inland and higher above sea level along the rivers of Texas than anywhere else. According to Mr. Heller's report, Kerrville

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* Ann. Rep. State Geol. N. J. 1899: 181. 1900.

† Contr. U. S. Nat. Herb. **6**: 46. 1901.

‡ Proc. Ind. Acad. Sci. 1897: 172–175. 1898.

§ *Cf.* Contr. Herb. F. & M. Coll. **1**: 9. 1895.

is "situated in a limestone formation." On investigation I find that this formation is lower Cretaceous. Professor W. L. Bray, of the University of Texas, to whom I wrote for further information about the range of *T. distichum* in that state, informs me that it occurs on almost every stream in the Cretaceous area of Texas and probably on all on the Rio Grande Plain, also in all the bayou country of east Texas, north to the Indian Territory line. Dr. Havard, in his "Report on the Flora of Western and Southern Texas," * mentions several stations for this species in the extreme southern part of the state.

The southeastern limit of *T. distichum* has been placed by Professor Sargent at Mosquito Inlet (about lat. 29°) on the east coast and at Cape Romano (about lat. 26°) on the west coast of Florida, but Dr. Small, who has recently been in southern Florida, tells me that it extends down the east coast to Miami (which is farther south than either locality mentioned by Professor Sargent) and is common in the Everglades near by. This is considerably beyond the known area of the Columbia formation, but still farther from the Lafayette.

In Georgia, to which state my field work on this genus has been confined, I have seen *T. distichum* on the Oconee River in Montgomery county, on the Ocmulgee in Dodge and Wilcox, on the Flint in Sumter, Dooly, Dougherty and Decatur, on the Ochlocknee in Thomas, on the Chattahoochee River and Sowhatchee Creek in Early, on Lime Creek in Sumter and Gum Creek in Dooly, on Muckalee Creek in Lee and Kinchafoonee in Lee and Terrell, on Spring Creek in Decatur, Ichawaynochaway in Calhoun and Chickasawhatchee in Dougherty; from all of which points the Lafayette formation is known or believed to be absent. I have also observed this species in a few scattered localities away from the rivers in Sumter, Lee and Dougherty counties (from which localities the Lafayette may be inferred to be absent, though we have as yet no direct evidence that such is the case), and in lime-sinks near the Flint River in Dooly county. Other botanists have collected or observed it along the Savannah and Altamaha rivers; and it doubtless extends from all the points just mentioned down each river nearly or quite to its mouth.

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* Proc. U. S. Nat. Mus. 8: 504. 28 S. 1885.

The range of *T. imbricarium* is not so well known, as comparatively little attention has been paid to this species. Although it appears to be much more abundant than *T. distichum* in most of the states in which it grows, most botanists who have observed it have probably considered it identical with that species, and therefore made no especial note of it. It is not even mentioned in any edition of Chapman's "Flora of the Southern United States."

Professor Sargent * says of the range of this species: "The acerose form * * * is not uncommon in South Carolina, in northern Florida, and in the neighborhood of Mobile, Alabama." It has also been reported from North Carolina by Nuttall, Croom and others, and is very abundant in Georgia, where it perhaps reaches its best development. The evidence in favor of its occurrence in Virginia has already been given. Outside of these six states I find no record of it.

T. imbricarium is common wherever the conditions of soil and topography are favorable for its development, in those portions of the coastal plain where both the Lafayette and Columbia formations are present, away from the coast and larger rivers. It seems to approach nearest to the coast in North Carolina, where Wood and McCarthy have recorded a station for it in their Wilmington Flora,† in a swamp about six miles from the ocean, in New Hanover county. In Chatham county, Georgia, I noticed last June that it extended to within twelve miles of Savannah on both the Central of Georgia and Georgia and Alabama Railways. These two railroads run almost perfectly straight through the county, and at the points mentioned they are about a mile apart. On consulting Mr. McGee's map I found that these localities are just at the coastward edge of the Lafayette formation, thus furnishing additional evidence in support of my theory.

Of the inland limit of *T. imbricarium* little is known. In the eastern part of Georgia I have seen a few specimens as far up as Millen, 78 miles from Savannah, and in the western part it is abundant in certain spots as far up as the southeastern corner of Sumter county, 200 feet above sea-level, 180 miles west of Savannah and about 125 miles north of the Gulf of Mexico. Here it

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* Sylva N. A. 10: 152, in footnote.

† Jour. Elisha Mitchell Sci. Soc. 3: 123. 1886.

extends to the inland edge of the Oligocene strata. Croom * has reported it from Hartford, Ga. (a settlement, now extinct, which was near the Ocmulgee River in Pulaski county, about opposite the site of the modern town of Hawkinsville), which is about the same distance from the Atlantic coast as that last mentioned.

Between these limits *T. imbricarium* is very abundant in Georgia; and I will here give its observed distribution in the state somewhat in detail, as it is on these observations that my theory of its distribution is chiefly based.

East of the Ogeechee River it is abundant in the wet pine-barrens of Chatham and Effingham counties, and is sparingly represented around Millen, in the southern corner of Burke. West of the Ogeechee, in Emanuel and the upper part of Bulloch, I have seen it only in creeks and small rivers, where, as before mentioned, it attains a considerable size. Traveling westward along the Georgia and Alabama Ry., I saw it last July at many points in the pine barrens of Tattnall, Telfair, Dodge, Wilcox and Dooly counties, extending to within eight or ten miles of Cordele. Between Cordele and the Flint River the Columbia formation seems to be absent, and *Taxodium imbricarium* likewise. Farther south it occurs in wet pine-barrens or in small sluggish pine-barren streams in Worth, Berrien, Coffee, Ware and Appling counties. In the upper part of Coffee county, as for instance in the vicinity of Douglas, it grows also in creeks as in Bulloch.

In Sumter it seems to be confined to a number of shallow ponds about three miles from the Flint River in the southeastern corner of the county, where the Lafayette and Columbia formations overlap a short distance. Southward from there, it is very abundant in Lee county, and occurs in Dougherty, Calhoun, Mitchell, Miller, Early, and the northern parts of Thomas and Decatur, in the terrane of the Lower Oligocene. Throughout this part of the state its usual habitat is in shallow pine-barren ponds which sometimes dry up in summer, which it occupies to the exclusion of other trees. But in Thomas and Decatur counties (east of the Flint River) I have seen it in permanent ponds several hundred acres in extent and probably five or six feet deep, con-

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* Am. Jour. Sci. **28**: 166. 1835.

taining a luxuriant growth of various Nymphaeaceae and other strictly aquatic plants.

At every point where *Taxodium imbricarium* has been observed all the indications are that both the Lafayette and Columbia formations are present, though of course I have been able to actually verify this only in comparatively few cases.

The cause of the preference of these two species of *Taxodium* for different superficial formations is as yet unknown, but the comparative imperviousness of the Lafayette clays doubtless has something to do with it.

If my theory is absolutely correct, these two species would never be found together. One or two exceptions to this have been noted. On July 13, 1901, I found both species together in a swamp in the pine-barrens in the northeastern part of Lee county, Georgia. But it is noteworthy that the specimens of *T. distichum* appeared stunted and unhealthy, while those of *T. imbricarium* were of the usual size and appearance. One explanation of their occurrence together might be that the seeds of *T. distichum* had been brought there in some manner and that the trees had managed to grow in spite of the unfavorable environment. I did not notice any fruit on these specimens of *T. distichum*, and the species is perhaps not reproducing itself at this locality. A similar or analogous state of affairs may prevail at the locality in North Carolina mentioned above, where Mr. Croom observed both species growing together.

It might be remarked here that there has been some difference of opinion among geologists as to whether the Lafayette formation extends beneath the Okefinokee Swamp in southeastern Georgia. If my theory is true this question could easily be settled by a determination of the species of *Taxodium* inhabiting the swamp. So far as I know no botanist has yet penetrated this vast swamp, but there can be no doubt that it contains at least one of the species of *Taxodium*, for cypress timber is said to be one of its principal resources, and the chief cause of the destruction of the swamp which is unfortunately now in progress.

In addition to the influence of the Lafayette and Columbia formations on the distribution of these two species, the older underlying strata also seem to have a considerable influence. For instance, both species seem to grow only over calcareous substrata. *T. distichum* is almost entirely restricted to the Cretaceous and later formations of the coastal plain, but if Dr. Mohr's report of its occurrence on the Tennessee River in Alabama is correct, it there extends beyond the inner edge of the coastal plain into the Palaeozoic region. In Georgia it does not seem to extend even as far inland as the Cretaceous, but probably neither the topography nor the chemical composition of the rocks in the Cretaceous region of Georgia are adapted to either species of *Taxodium*, for the country is quite hilly, with few swamps or ponds, and the rocks are mostly argillaceous.

The habitat of *T. imbricarium*, so far as underlying formations are concerned, seems to be still more restricted than that of *T. distichum*. I do not know of its occurrence on strata older than Tertiary, and it may not extend farther inland than the Oligocene division of the Tertiary.

The difference between *T. distichum* and *T. imbricarium* may be of comparatively ancient origin, for fossils resembling both species are found in the Cretaceous and Tertiary strata of North America and Europe. Some of the fossil species of *Taxodium* with spreading leaves are referred to our living species *T. distichum*, but those with appressed leaves are usually referred to the related genus *Glyptostrobus*, which seems to be represented among living plants only by a single Asiatic species. More will be said of this genus later.

But if both of our species of *Taxodium* have existed since Cretaceous times, the question will naturally arise, what were their respective habitats before the Lafayette period, and also during that period, when the present coastal plain was all submerged? I am not prepared to answer this question completely, but would suggest as a partial solution that *T. imbricarium* has been evolved from the ancestors of *T. distichum* since the Lafayette period, and for this reason the two species are not yet as completely differentiated as are those of more ancient origin. The occurrence of distichous spreading leaves on the branchlets of the young shoots of *T. imbricarium* would seem to substantiate this view, for young shoots are usually supposed to show ancestral characters.

It seems to be a well-established fact that *T. distichum* grew as far north as Greenland in Miocene times. With the advance of the ice-sheet during the Glacial period it was probably driven southward into Mexico, where the same species or a closely related one exists to-day. In the meanwhile the deposition of the Lafayette formation had taken place, and with the retreat of the ice our *Taxodium* doubtless migrated northward and eastward until it occupied its present territory. It was probably during this migration over the newly deposited Lafayette that the differentiation into two species took place, and *T. imbricarium* was evolved.

Some of the authors quoted at the beginning of this paper have mentioned the occurrence of forms intermediate between *T. distichum* and *T. imbricarium*. These might be of two kinds: first, individuals bearing branchlets of both kinds, and second, individuals all of whose leaves are intermediate in form and position.

The first case has been already discussed, and seems to present no difficulty. Individuals of the second kind also exist, and may perhaps even represent a distinct species. Such an intermediate form is probably what Brongniart * described as *Taxodium microphyllum*, and Parlatore † as *T. distichum β microphyllum*, so that names are not lacking for it. The only locality cited by Parlatore for his variety is Louisiana, while the typical *T. imbricarium* is not known west of Alabama. This may be an indication of the progressive differentiation of the species as the genus migrated eastward along the Gulf coast after the Glacial period.

In Georgia I have seen this intermediate form only in and near the Ogeechee River, at Millen, Ogeechee, Rocky Ford and Meldrim. What the relations of the Lafayette and Columbia formations are at these points I have not yet determined.

There is another supposed species of *Taxodium* in Mexico, *T. mucronatum* Tenore, of which comparatively little is known. Most of the accessible information about it has been summed up by Professor Sargent,‡ who is inclined to believe that "it may prove to be a mere geographical form of our tree." Professor Bray, in writing to me of the range of *T. distichum* in Texas, expresses the opinion that this species as it passes into Mexico

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* Ann. Sci. Nat. 36: 182. 1833.

† DC. Prodr. 16: 441. 1868.

‡ Sylva N. A. 10: 150. 1896. Gard. & For. 10: 451. July 17, 1897.

becomes "Sonorized," as several other species do, and is another thing. It is possible that *T. distichum* intergrades with *T. mucronatum* as suggested by Professor Bray. The two species are scarcely distinguishable in the herbarium, the characters by which they are separated being mostly phaenological. Mr. Heller's specimens from Kerrville, Texas, seem to resemble the latter as much as they do the former, at least in their visible structural characters.

One other point now remains to be considered, namely, the relation between *Taxodium* and *Glyptostrobus*. The latter genus was founded by Endlicher (Syn. Con. 69) in 1847, with two species, *G. heterophyllus* and *G. pendulus*, said to be natives of China. (He enumerates also in the same work three species of *Taxodium*.) In 1880 this genus was united with *Taxodium* by Bentham and Hooker (Gen. Pl. 3: 429). Eichler, in his treatment of the Coniferae in Engler and Prantl's Natürlichen Pflanzenfamilien, keeps the two genera apart, but considers the reasons for so doing scarcely sufficient. This subject has recently been more fully discussed by Dr. M. T. Masters,* who gives very good reasons for considering the two genera distinct. I have seen only one specimen of *Glyptostrobus* (*G. heterophyllus*, in the Columbia University herbarium) myself, but its appearance suggests that its leafy branchlets might not fall off with the leaves as in the case of *Taxodium*. This point is not mentioned by the authors just cited, and I have no means of verifying it at present.

But the question of the identity of *Taxodium* and *Glyptostrobus* is not of such immediate interest to us as the relation of *Taxodium imbricarium* to *Glyptostrobus pendulus*. These were both mentioned by Endlicher in his Synopsis Coniferarum who seems to have had no suspicion of their similarity, but they have been regarded as identical by some authors, and this is probably the case. Professor Sargent treats them as identical in his Sylva of North America (**10**: 152. 1896), and in Garden and Forest (**10**: 451) for July 17, 1897, writes as follows: "The tree which in the United States and Europe is almost universally called *Glyptostrobus pendulus*, is really a juvenile [*sic*] form of the *Taxodium* of the Southern States, *Glyptostrobus* being a south China genus

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* Jour. of Bot. **38**: 37–40. Feb. 1900.

with a single species, which has possibly never been brought to the United States, and which would not be hardy in this part of the country" [Massachusetts]. "It is a comparatively small tree in its native swamps, and, in spite of its southern home, is hardy in New England, where it is one of the most distinct and beautiful of the pyramidal conifers. The proper name for this tree is *Taxodium distichum*, var. *imbricarium*."

In front of the main building of the Department of Agriculture in Washington there are two trees of this species one labeled "Chinese Water Pine, *Glyptostrobus pendulus*, China," and the other the same except that it is called *G. Sinensis.* Scattered about the parks of the city are many similar specimens, as well as some of *Taxodium distichum.* Although they are rather pyramidal in shape, unlike *Taxodium imbricarium* in its native habitat, they have the appressed leaves and erect branchlets of that species, and seem to differ only in their peculiar shape, which is probably only the result of long cultivation under unnatural conditions. The only specimen of "*Glyptostrobus pendulus*" in the Columbia University Herbarium is from a tree cultivated in Philadelphia, and on the back of the sheet is written a note to the effect that it came from a seedling of *Taxodium distichum.*

In the Gardener's Chronicle (III. **26**: 489. *f. 161*) for December 30, 1899, there is a figure of one of these cultivated specimens growing in England, and it is there contrasted with *Glyptostrobus heterophyllus*, its identity with *G. pendulus* evidently being taken for granted.

The question might now arise: Are there really two species of *Glyptostrobus* in Asia? Apparently not; for no flora of China or Japan to which I have had access contains any reference to *G. pendulus*, and it is most likely that Endlicher described this species from a cultivated specimen, and erred in crediting it to China. A number of horticultural names which have been given to this cultivated plant may be found in Sargent's Sylva, among the synonyms of *Taxodium imbricarium.*

COLLEGE POINT, N. J.

New Plants from Wyoming, XIV

By Aven Nelson

Eriophorum ocreatum

Culms growing singly, from the corm-like crowns of the short slender rhizomes, the base sheathed in old leaf bases, subterete, finely striate, smooth, slender, 2–3 dm. high : sheaths 2–3, 2–3 dm. long, all blade-bearing ; blades folded-channelled, obscurely roughened on the margins, broadly linear, rather rigid, short, 5–10 cm. long, tapering to a triangular point, leaves of the involucre 2–4, the longer usually erect and surpassing the inflorescence : spikelets 3–6, subumbellate, the longer-peduncled drooping : scales oval or ovate, obtuse or scarious-lacerate, brown, not obviously veined : bristles numerous, glistening-white, 4–6 times as long as the scales : akene broadly obovate, obtuse, dark brown (nearly black).

This species is most nearly allied to *E. polystachyon* L., but is readily distinguished from it by its more slender habit, shorter and fewer leaves, generally fewer and larger heads, longer and more glistening-white bristles, very different scales and akene. In its few, long-vaginate, short leaves, and in its akene it reminds one of *E. vaginatum* L. In its slender culm which often greatly surpasses the uppermost leaf it suggests *E. gracile* Koch. It is probably a rare plant as thus far I have seen but two collections of it. The type was secured in an open, grassy, subalpine park in the Medicine Bow Mountains, Lincoln Gulch, August 8, 1900, no. 8014.

Hemicarpha aristulata (Coville)

Hemicarpha micrantha aristulata Coville, Bull. Torrey Club, **21** : 36. 1894.

Annual, glabrous, culms few to several, erect, 8–15 cm. high, filiform or capillary, exceeding the capillary leaves : involucral leaves 2–3, unequal, 5–20 mm. long : spikes 2 (sometimes but 1), ovoid, 3–5 mm. long : scales rhombic, acuminate, the body nearly 1 mm. long, scarious-margined, some of the margins turning brown, with a green midrib and inconspicuous nerves ; the acumination green, subulate, somewhat spreading, nearly as long as the body of the scale or in the lower ones exceeding : sepal large, as long as the ovule, obtuse or even with a truncate or toothed apex : filament barely exceeding the ovule : style short, its branches inconspicuously if at all barbellulate: akene obovoid, shorter than the body of the scale.

The above description had been drawn before I was aware of Mr. Coville's variety of *H. micrantha* Vahl, which does not appear in Heller's recent Check-list of North American plants. After carefully considering all that appears in Mr. Coville's excellent and complete discussion of the genus I am still of the opinion that the plant deserves specific rank. Besides the characters pointed out by Mr. Coville which separate it from *H. micrantha*, decided differences in size and form of the floral structures are to be noticed. The following collection greatly extends the range of this species. It was found in a moist, sandy cañon, altitude 2000 m., in company with *Cyperus inflexus*. Halleck cañon, Albany county, July 4, 1900, no. 7428.

Juncus saximontanus

J. xiphioides montanus Engelm. Trans. Acad. Sci. St. Louis, **2**: 481; Bot. Calif. **2**: 290.

As there is a variety *montanus* of *J. Balticus*, this plant, which seems well to deserve specific rank as well as a separate name within the genus, may take the above as indicating its center of distribution.

Trifolium scariosum

Densely caespitose, silvery or cinereous-pubescent throughout, becoming greener and more glabrate with age; the caudex freely branched and clothed with the dead petioles; stemless or nearly so: leaves crowded on the crowns; the leaflets narrowly linear-oblong, widest at the middle and tapering gradually to each end, 1.5–2.5 cm. long, sessile or nearly so; the petioles slender, from twice to several times as long as the leaflets: peduncles surpassing the leaves, like the leaves prostrate-spreading or ascending: the adnate portion of the stipules broad, sheathing, scarious-margined; the free portion linear-acuminate, reduced to merely the greenish midrib, less than 1 cm. long: involucre usually (always?) present, of several very unequal scarious-margined linear-lanceolate segments: heads globose, rather few-flowered: calyx-tube short, narrow-campanulate; its teeth linear, unequal, exceeding or often twice as long as the tube, purple as is also the upper portion of the tube: corolla purple, fading in drying; the standard broadly elliptic, equaling and enclosing the wings which exceed the keel petals: pod 6-ovuled, fewer seeded: the style slender, as long as the pod.

I propose this species as a segregate from *T. dasyphyllum* T. & G. That species was described from James's collections from "Summit of the Rocky Mountains." Specimens from similar situations agree with the original in the brownish pubescence, the absence of an involucre (usually so at least), and the subequal calyx teeth. *S. scariosum* is a larger plant with whiter, more permanent pubescence, a conspicuous scarious involucre, the segments of which are marked by a green midrib. Its petals are uniformly reddish-purple or shading to violet when fresh, while the petals of *T. dasyphyllum* differ in color from each other, the standard being whitish or ochroleucous, barely tinged with purple, the wings and tip of the keel a deep purple hue. The latter, as already stated, occurs in alpine stations while *T. scariosum* occurs at middle elevations, mostly on very stony slopes in the foothills. It is often found on naked ledges where the roots find no soil except in the crevices. Probably not very rare, at least is not in southeastern Wyoming. No. 7270, Laramie Hills, June 20, 1900, is taken as the type.

This seems so strangely characterized that one may venture to name it in the absence of mature fruit. The inflorescence in appearance is much like that of *A. Canadensis*, but of course it cannot even be placed in the same section.

I have met with this plant but once and then it was found in the greatest abundance in the sand dunes of the Red Desert, at the base of Steamboat Mt., Sweetwater county, collected June 9, 1900, no. 7051.

MERTENSIA CILIATA **longipedunculata**

Size of the species, stems more freely branched, stem and branches few-leaved, terminating in long naked peduncles: calyx lobes oblong, subacute, ciliate-margined.

This variety is very common along the streams of eastern Wyoming and apparently occurs at lower altitudes than the species. No. 7321, Chug Creek, Albany county, June 30, 1900, as well as many earlier collections represent it.

Mertensia coriacea

Very leafy from base to summit, tufted, the numerous glabrous stems assurgent, 2–3 dm. long: leaves thick, coriaceous, smooth on both faces except for the flat-topped papillae on the upper surface and on the margins (these are probably the pustulate bases of deciduous hairs); root-leaves numerous, oblong or elliptic, mostly obtuse, 4–8 cm. long, on somewhat shorter petioles; the lower stem-leaves oblanceolate or broadly spatulate, obtuse, tapering into a short petiole, passing into sessile ovate leaves upward; those of the inflorescence crowded, from lanceolate to broadly ovate, acute, 3–5 cm. long: flower-clusters terminal and in the axils of the upper leaves, crowded even in the fruit: calyx-lobes triangular-lanceolate, subciliate, from ⅓ to ½ as long as the tube; of the corolla, somewhat enlarged in fruit: corolla tube 5–6 mm. long, the very villous ring ⅓ its length from the base, the crests in the throat and the 10-toothed ring at the base evident; limb funnelform, only slightly spreading, usually exceeding the tube; the orbicular lobes less than half its length: filaments inserted in line with the crests, membranous, spatulate, as broad or broader than the somewhat longer anthers: seeds 2–3 mm. long, ovate, coarsely rugose.

I have sought in vain for any near ally for this truly alpine species. It was collected about the summits of the Medicine Bow Mts., Albany county, Wyoming, Aug. 1, 1900. It occurred in the rock-slides, mostly in the vicinity of snow banks. The type no. is 7870.

Mertensia coriacea dilatata

Very similar, leaves less coriaceous: inflorescence more open and less leafy: sepals lance-linear, longer (especially in fruit): filaments shorter, dilated, mostly broader than the anthers.

This variety is readily distinguished from the species in the field but less readily in the dried state when the texture of the leaves is not so evident. In herbarium specimens the greater leafiness, especially of the inflorescence, and the broader sepals of the species in contrast with the opener and less leafy inflorescence and the narrower sepals of the variety are the most obvious points of distinction. The habitat of the variety is in general the same as that of the species and it was secured at the same time; no. 7844.

Mertensia coronata

Tufted, from large friable roots: stems glabrous, shining, assurgent, 2–4 dm. long: leaves numerous, large for the plant, smooth below, minutely scabrous above (the hairs very short and curved and sometimes early deciduous from the small pustulate bases); the radical on petioles 2–3 times as long as the oblong, mostly obtuse blades (5–10 cm. long); the lower stem-leaves similar, tapering into short petioles, the upper ovate-lanceolate, subacute, sessile: flower-clusters terminal and axillary, at length open-paniculate among the large floral leaves: calyx cleft nearly to the base, the lobes triangular-lanceolate, sparingly ciliate, more than half as long as the corolla-tube: corolla tube rather broad, about 5 mm. long, not noticeably hairy within near the base; limb a little shorter than the tube; the lobes suborbicular, abruptly dilated from the rounded sinus: stamens inserted a little below the conspicuous crown of crests in the throat; filaments as long as the anthers, dilated, as broad or broader than the anthers which do not equal the lobes of the corolla.

Probably somewhat related to *M. papillosa* Greene and in some points to *M. foliosa* A. Nelson, but not very closely to either. It seems to be confined to the Leucite formations of south-central Wyoming, occurring among the rocks on the buttes of the Leucite Hills. Collections as follows: Sweetwater county, June 9, 1900, no. 7071 (type); Steamboat Mt., same county and date, no. 7072; N. Vermillion Creek, July 24, 1897, no. 3593.

CASTILLEJA ANGUSTIFOLIA **dubia**

The woody caudex short, giving rise to few or several, slender, simple, ascending or erect stems, 2–3 dm. high: pubescence sparse, cinereous, consisting of fine puberulence and some white, soft hairs: the body or axis of the leaf linear, 3–5 cm. long, 3–5 mm. broad, usually with 1 or 2 pairs of widely divergent linear lobes which are one third to one half as long as the leaf: bracts shorter, the blade and lobes relatively broader and tending to become scarious, decidedly yellowish or at the summit bright yellow: calyx about 2 cm. long, equally cleft to nearly one third its length: corolla scarcely longer than the calyx; the galea and tube subequal; lip almost wanting, not noticeably saccate, truncate and short-toothed.

C. angustifolia Don. is really a species of the far Northwest Its history and characters are well set forth by Mr. M. L. Fernald in Erythea, **6**: 46. In the specimens cited, two from Wyoming are included which possibly are similar to those now before me. While it seems possible that the variety here proposed might properly be constituted a species, yet, as Mr. Fernald's description is drawn, I find no good differences except the yellow color, scantier pubescence (especially in the inflorescence), shorter corolla and sparser leafiness and the longer more open spike in the variety.

Collected by Elias Nelson in the Indian Grove Mts., July 18, 1898, no. 4898a; by L. N. Goodding at Medicine Bow, June 19, 1901, no. 43.

Plantago nitrophila

Allied to *P. Rugelii* but coarser and larger; rootstock short, with a great number of thick fibrous roots: leaves 1 dm. or more in length, mostly oval, sometimes nearly orbicular, obtuse or obtusish, entire or crenately dentate, the 5–7 nerves extending into the pubescent petiole which generally equals or exceeds the thick blade: scape proper about equaling the leaves, whitish with soft crinkly hairs: spike equaling the scape, simple or with 2 or more short spikes from the lowest foliar bracts, moderately thick, crowded: bracts proper ovate, subacute, scarious-margined, keeled and closely appressed, shorter than the mature fruit: sepals nearly orbicular, overlapping each other, scarious with a green midrib, but little more than half as long as the bracts: capsule ovate, 3–4 mm. long, circumscissile near the base: seeds 7–10 in each cell, oblong-elliptic, obscurely wing-angled and delicately reticulated, dark brown.

Readily distinguished from *P. Rugelii* by its coarse leaves, heavy petioles, thick spike, shorter and thicker capsules, the different bracts and sepals, the reticulated seeds as well as the pubescence and larger size of the plant. It is indigenous on wet, grassy saline banks throughout the state but not frequent or plentiful. The type is no. 8417, from an alkali creek bog, near Manville, Converse county, Wyoming, July 17, 1901.

Helianthus Utahensis (D. C. Eaton)

Roots fleshy, fascicled or variously branched from the gnarled central shaft, mostly fusiform, often nearly 1 dm. long: stems generally solitary, simple below, branched above, 1 m. (more or less) high, glabrous, striate: leaves opposite, 7–15 cm. long, all lanceolate, the uppermost narrowly so, only the midrid conspicuous, green, with short sparse incurved hispid hairs which sometimes arise from a slightly pustulate base, sparsely ciliate on the short petiole: heads terminating the many slender, ascending or divaricate branches: peduncles pubescent, slender; those from the lower axils often much elongated: involucre hemispherical; its bracts linear-lanceolate, white-ciliate-pubescent on the margins, 10–15 mm. long, the loose acuminate tips often reflexed: rays usually 14–18, 25–30 mm. long, narrowly oblong: disk yellowish-brown, 1 cm. high and fully as broad; chaff oblong, acute, pubescent on the brownish tip: akenes oblong, brown, 4 mm. long, nearly as long as the corollas; pappus of 2 linear-lanceolate awns as long as the akenes.

That this is the *H. giganteus Utahensis* Eaton, Bot. King. Expd. 169, I have no longer any doubt. Unfortunately a few specimens have been distributed under another name as a new species. Dr. Rydberg suggested that it might be the above and a comparison since, by the writer, with the type deposited in the National Herbarium confirms that suggestion. Dr. Gray in the Synoptical Flora made it a variety of *H. Californicus* DC., to which indeed it is more closely related. The two are, however, abundantly distinct.

H. Utahensis, very curiously, occurs frequently in herbaria as *H. giganteus* but for what reason is hard to guess. In habit and mode of branching it more nearly resembles *H. Nuttallii* T. & G.

It is common in the middle Rocky Mountains, occurring mostly on sandy stream banks. Some collections of it are: 1578, Laramie Peak, Aug., 1895; 684, Muskrat Creek, July, 1894; Laramie, Oct., 1894; 6757, Yellowstone Park, Aug., 1899; 8135, Granger, Aug., 1900.

CORRECTION

Gnaphalium exilifolium.

G. angustifolium A. Nelson, Bull. Torrey Club, **26**: 357; not *G. angustifolium* Lam. Encyc. **2**: 746.

The Genus Eritrichum in North America

BY WILLIAM F. WIGHT

Although four different forms under this genus have been recognized in North America, there seems to have been much misapprehension, in regard to some of them at least, as to their relationship to the European *E. nanum* and to each other. A fruiting specimen of one of the Alaskan species not hitherto described has also recently been collected, making a complete description possible, and it is thought that the descriptions given below would therefore be desirable. The author wishes to express acknowledgments to Mr. Frederick V. Coville and Dr. J. N. Rose for criticisms and suggestions in the preparation of the paper, to Mr. F. A. Walpole for the drawings of the nutlets and to Professor Robinson, of the Gray Herbarium, for the loan of material.

The North American species are separable into two main groups, the section *Eueritrichium* of DC.* with four species, *E. aretioides*, *E. argenteum*, *E. Chamissonis* and *E. splendens*, and a second section not before recognized with two representatives, *E. Howardi* and *E. elongatum*. The first section has fruit with a toothed border which is characteristic of *E. nanum*, the type of the genus, figured by Gurke,† while the two last named species have fruit with a marginal ridge-like elevation. These are not referable to the section *Amblynotus* DC.‡ represented by a single species, *E. obovatum* DC., which does not even appear to be congeneric with any of the species under consideration since it differs in having fruit without teeth or any trace of a marginal border, and is convex on the dorsal side instead of flat or with a slight central ridge, as is the case with typical *Eritrichum*.

ERITRICHUM Schrad.

Eritrichum Schrad. Comment. Goetting. **4**: 186, 1820, based on *Myosotis nana* Vill.

Eritrichium Gaudin, Fl. Helv. **2**: 4. 1828.

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* DC. Prodr. **10**: 125. 1846.

† Gurke, in Engler and Prantl, Die natürlichen Pflanzenfamilien, 4^{3a}: 108. *f. 43. E.* 1894.

‡ DC. *l. c.* 128.

Synopsis of the Species

Dorsal surface of the nutlet margined with a ridge-like elevation, but without a toothed border.

Leaves with a fine and rather loose or spreading pubescence; dorsal surface of the nutlets smooth or rather hispidulous; flowers 4–6 mm. in diameter. 1. *E. elongatum.*

Leaves with a dense and closely appressed pubescence; dorsal surface of the nutlet papillose and hispid with short bristly hairs; flowers 7–9 mm. in diameter. 2. *E. Howardi.*

Dorsal surface of the nutlet with a border of subulate or triangular teeth.

Leaves with closely appressed, strigose pubescence; flowers in dried specimens 9–13 mm. in diameter. 3. *E. splendens.*

Leaves with rather loose, villous or hirsute pubescence; flowers in dried specimens 4–7 mm. in diameter.

Dorsal surface of the nutlet ovate; teeth of the border about half the length of the body of the nutlet; flowers 4–6 mm. broad.. 4. *E. argenteum.*

Dorsal surface of the nutlet nearly circular in outline, the teeth of the border as long as the body of the nutlet; flowers 5–7 mm. broad.

Flower cluster usually raised on a distinct, sparingly leafy stalk, commonly 2–5 or sometimes even 12 cm. high. 5. *E. aretioides.*

Flower cluster sessile among the terminal leaves of the stem. 6. *E. Chamissonis.*

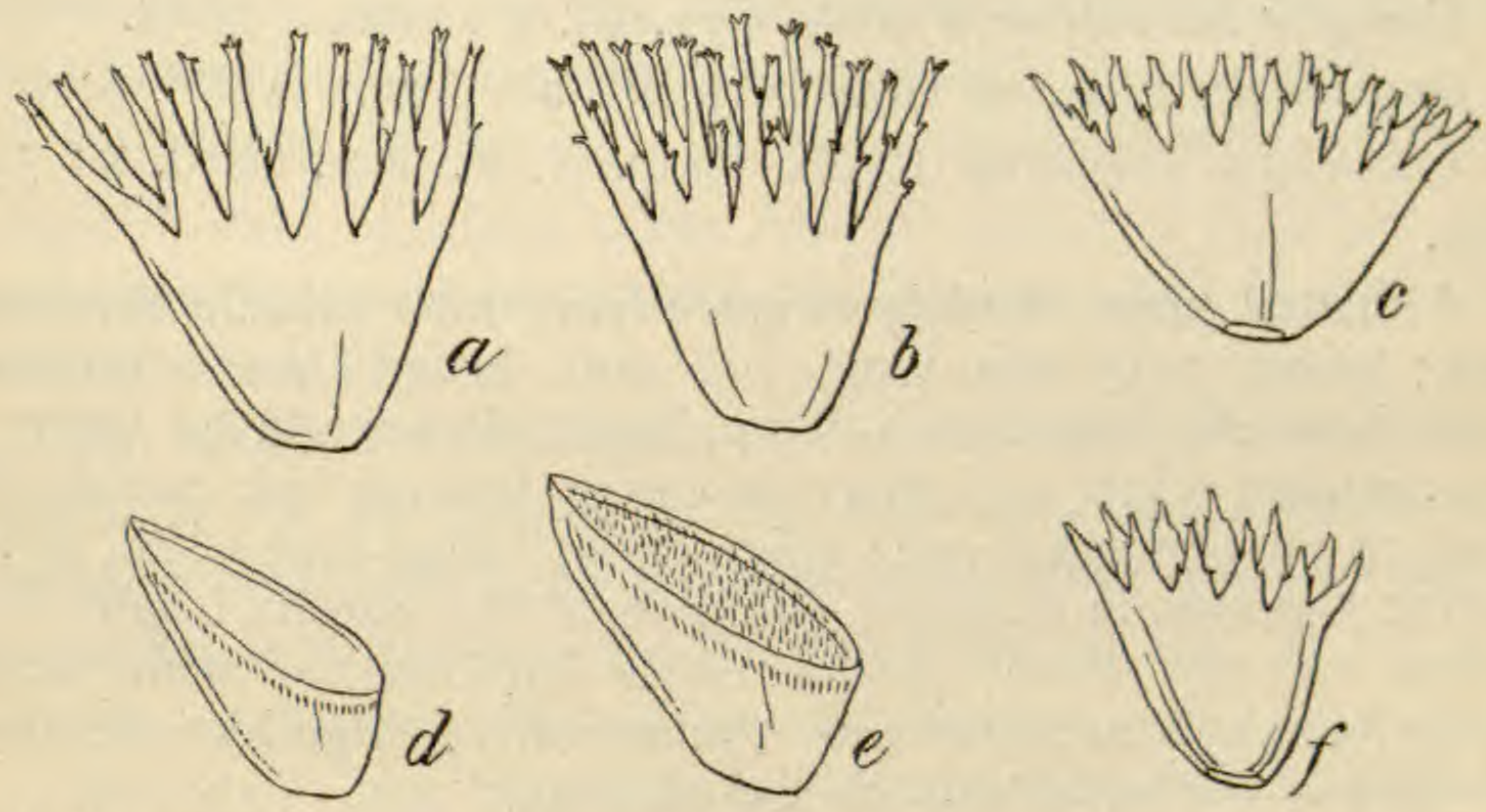
1. **Eritrichum elongatum** (Rydb.)

Eritrichum aretioides elongatum Rydb. Mem. N. Y. Bot. Gard. **1**: 327. 1900.

A low and tufted or matted plant in external appearance very closely resembling *E. argenteum*, but the pubescence commonly rather more loose and spreading and seldom with a silvery appearance; the closely overlapping leaves 5–8 mm. long, 1.5–2 mm. broad, oblanceolate, acute or obtuse, those on the flowering branches linear or oblong-linear; flowering branches 1–6 cm. long; flower cluster raceme-like or more or less compact: calyx lobes linear: corolla 4–6 mm. in diameter, its limb bright blue: nutlet usually shining, about 2 mm. long on the inner angle, the dorsal surface usually smooth, very rarely with a few minute bristles, margined by a rather sharp, ridge-like elevation, but without a toothed border.

Two plants are cited by Dr. Rydberg, one collected June 26, 1897, in the Spanish Basin, Montana, by Rydberg and Bessey (no. 4891) and the other collected in 1883 in the Belt Mountains, Montana, by Scribner (no. 173); the type, however, is not indicated and the first named plant is therefore here designated as such, a duplicate of which, in fruit, is in the United States National Herbarium.

This plant, briefly described by Dr. Rydberg as a variety of *E. aretioides*, differs from both the true *aretioides* and the Rocky Mountain plant hitherto identified as such in the nutlets not having a toothed border, but instead a ridge-like margin which allies it to *E. Howardi*. A description of the nutlets was omitted in the original description, although well-developed nutlets were found on the plant in the United States National Herbarium collected by Rydberg and Bessey (no. 4891). It differs from *E. Howardi*, its nearest relative, in being a smaller plant, and in its oblanceolate leaves, its spreading pubescence and its smaller flowers. A plant of alpine or subalpine distribution in northern Colorado, Wyoming and western Montana to eastern Oregon.



Nutlets of *Eritrichum*, × 10. *a*, *E. aretioides*; *b*, *E. chamissonis*; *c*, *E. splendens*; *d*, *E. elongatum*; *e*, *E. Howardi*; *f*, *E. argenteum*.

Specimens have been examined as follows:

COLORADO: Alpine Ridges, Middle Park, 1861, *C. C. Parry*; Gray's Peak, 11,000–14,000 ft. alt., 1885, *H. N. Patterson, 109*.

WYOMING: Head of Big Goose Creek, Big Horn Mountains, 1893, *Frank Tweedy, 43*; Dome Lake, 1896, *Aven Nelson, 2433*.

MONTANA: Belt Mountains, 9,000 ft. alt., 1883, *F. L. Scribner, 173*; 6–7,000 ft. alt., 1887, *R. S. Williams, 1078*. Park county, 1889, *Frank Tweedy*. Spanish Basin, Gallatin county, 5–6,000 ft. alt., 1897, *Rydberg & Bessey, 4891*. Old Hollowtop, near Pony, about 9,000 ft. alt., 1897, *Rydberg & Bessey, 4890*. Bald Mountain, 10,000 ft. alt., 1880, *Sereno Watson, 245*.

IDAHO: Pleasant Valley, June 25–30, 1871, *G. N. Allen;* June 25–30, 1871, *Thos. C. Porter.*

OREGON: Summits of the Wallowa Mountains, 1886, *Wm. C. Cusick, 1430.* Subalpine ridges of the Wallowa Mountains, near the lake, 1899, *Wm. C. Cusick, 2268.*

2. ERITRICHUM HOWARDI (Gray) Rydb.

Cynoglossum Howardi Gray, Syn. Fl. **2**^{1}: 188. 1878.

Omphalodes Howardi Gray, Syn. Fl. **2**^{1}: 423. 1886.

Eritrichum Howardii Rydb. Mem. N. Y. Bot. Gard. **1**: 327. 1900.

A matted plant, densely strigose-hairy with closely appressed hairs; leaves 7–13 mm. long, 1–2 mm. broad, linear-spatulate, acute, flowering branches 1–6 cm. high: flower cluster more or less compact when on a short flowering branch, but raceme-like when on an elongated one: calyx lobes linear-lanceolate, acute: flowers 7–9 mm. in diameter, the limb of the corolla bright blue: nutlets with the dorsal surface either papillose or with minute bristly hairs and margined with a rather sharp ridge-like elevation, the sides of the nutlet smooth and shining.

E. Howardi is distributed in the mountains of western Montana, and has been collected in the Cascade Mountains in Washington. It was originally described from material collected by Winslow J. Howard in the "Rocky Mountains in Montana."

Specimens have been examined as follows:

MONTANA: Without special locality, "about 1866," *Winslow J. Howard.* Mt. Helena, 1883, *Wm. M. Canby, 242.* Helena, May 1, 1886, *R. S. Williams;* June, 1888, *F. D. Kelsey.* Yogo, Belt Mountains, July 25, 1888, *R. S. Williams.* Park county, 1889, *Frank Tweedy.*

WASHINGTON: Cascade Mountains, 1882, *Frank Tweedy, 130.*

3. **Eritrichum splendens** Kearney, sp. nov.

A strigose-hairy herb, the caudex much branched and forming a mat of numerous short, sterile, leafy shoots, and of fewer elongated flowering ones which attain a height of from 4–13 cm.; lower leaves narrowly oblanceolate, 1.5–2 cm. long, 2–3 mm. broad, tapering to a slender petiole, the upper leaves on the flowering stems sometimes linear or oblong-linear, sessile, the upper surface less hairy than the lower: racemes few-flowered, the lower peduncles elongated at least in fruit: calyx lobes oblong, obtuse or broadly acute: corolla large, the limb bright blue, its lobes broadly obovate, the tube about equalling the calyx; dorsal surface of the nutlet slightly hispid or tuberculate, the teeth of the border two thirds as long as the body of the nutlet and with bristly points on their margins and apex, the bristles at the apex sometimes showing a tendency to become glochidiate.

Type specimen in the United States National Herbarium, collected July 9, 1901, on Old Man Creek, a tributary of the Koyukuk River, Alaska, by W. C. Mendenhall.

E. splendens differs from all other species herein noted in its larger flowers, and from other Alaskan species in its larger leaves and closely appressed, strigose pubescence, and in the shorter teeth of the nutlet.

Mr. Kearney's description was from plants in flower only, collected by G. M. Stoney in the Jade or Baird Mountains. A specimen with both fruits and flowers has since come to hand and is now taken as the type for the above description.

The specimens examined are as follows:

ALASKA: Old Man Creek, July 9, 1901, *W. C. Mendenhall*, Jade or Baird Mountains, August 2, 1885, *G. M. Stoney*.

4. **Eritrichum argenteum** sp. nov.

A low and rather densely villous plant of several short, sterile branches forming a tuft or mat 2 or 3 cm. high, this often exceeded from 1–5.5 cm. by the flowering branches; the pubescence commonly silky and shining or silvery in appearance: leaves on the sterile branches closely overlapping, oblanceolate or oblong, obtuse or acute, 5–10 mm. long, 1.5–3 mm. broad, those on the flowering branches sometimes linear or linear-oblong and usually less villous than the lower ones: flower cluster compact when sessile among the leaves at the end of a branch or raceme-like when borne on an elongated branch: calyx lobes linear, densely villous: flowers in dried specimens 4–6 mm. in diameter, the limb of the corolla bright blue: nutlets with a dorsal border of triangular teeth, these distinctly visible in the young nutlets soon after pollination and even discernible under a low power of the compound microscope as soon as the flower is fully open; teeth when mature about half the length of the body of the nutlet distinctly connate at the base and bearing minute bristles on their margins and apex.

Type specimen in the United States National Herbarium, collected July 31, 1895, among rocks above timber line, at an elevation of 12,000 feet, on a mountain northwest of Como, Colorado, by Crandall and Cowen (no. 36).

E. argenteum hitherto identified as *E. aretioides*, differs from both the Alaskan plants with villous pubescence, which are its nearest relatives, in the following characters; from *E. Chamissonis* in its smaller leaves and its usually somewhat elongated flowering branches, and from both *Chamissonis* and *aretioides* in its more silvery pubescence, its more villous calyx, its smaller flowers and the shorter teeth of the nutlets; it differs from other Rocky Mountain species in having nutlets with a toothed border, and has a more southern range, occurring on the high mountains of central Colorado and northeastern Utah.

The specimens examined are as follows:

COLORADO: Rocky Mountains, Lat. 39°–41°, 1862, *Hall & Harbour, 440.* Near Boulder City, "alpine," 1873, *H. N. Patterson, 26.* Mountain northwest of Como, 12,000 ft. alt., 1895, *Crandall & Cowen, 36I.* Gray's Peak, 12,000 ft. alt., June 19, 1873; *J. M. Coulter*, 1872; 12–13,000 ft. alt., *A. Gray*, July 18, 1892, *C. S. Crandall.* Saddle House, Pikes Peak, 12,500 ft. alt., 1896, *F. H. Knowlton, 16.* Central Colorado, 13,000 ft. alt., 1873, *John Wolf.* Without special locality or date, *E. Palmer.*

UTAH: Uinta Mountains, 12,000 ft. alt., 1869, *Sereno Watson, 849.*

5. ERITRICHUM ARETIOIDES (Cham.) DC.

Myosotis aretioides Cham. Linnaea, **4**: 443. 1829.

Eritrichum aretioides DC. Prodr. **10**: 125. 1846.

Eritrichum nanum aretioides Herder, Act. Hort. Petrop. **1**: 535. 1871–1872.

Omphalodes nana aretioides Gray, Proc. Am. Acad. **20**: 263. 1885.

A tufted or matted plant of numerous sterile branches with overlapping leaves and fewer elongated sparingly leafy ones bearing a compact flower cluster at the end, the sterile branches 3–5 cm. high, the flowering ones exceeding these from 2–5 or even 12 cm., the whole plant villous with a rather loose or spreading pubescence; leaves of the sterile branches 5–12 mm. long, 1–2.5 mm. broad, oblanceolate or the upper ones sometimes nearly linear, acute, or the lower ones rarely obtuse, those on the flowering branches linear or oblong-linear, obtuse or acute: calyx lobes oblong, acute or broadly acute: flowers in dried specimens 5–7 mm. in diameter, the limb sky-blue: nutlets about 1.5 mm. long on the inner angle, the teeth of the dorsal border about as long as the body of the nutlet, more or less connate at the base and bearing minute bristles on their margins and apex.

A beautiful plant growing on sandy or gravelly soil near the shore from St. Lawrence Island and Port Clarence to Cape Lisburne in Alaska, and on Herald Island, St. Lawrence Bay, Kayne Island and Kamchatka, in Siberia. The original description was based on specimens from St. Lawrence Island and St. Lawrence Bay.

Specimens have been examined as follows:

ALASKA: Port Clarence, 1899, *Coville & Kearney, 1970; 1901, F. A. Walpole, 460, 532, 984.* Cape Riley, July 5, 1894, *James F. White.* Reindeer Station, July 3, 1894, *James F. White.* Cape Thompson, 1881, *John Muir.*

SIBERIA: Herald Island, 1881, *C. L. Hooper.* Whalen, July 18, 1894, *James F. White.* Kayne Island, 1853–56, *C. Wright.*

6. ERITRICHUM CHAMISSONIS DC.

Eritrichum Chamissonis DC. Prodr. **10**: 125. 1846.

Eritrichum nanum Chamissonis Herder, Act. Hort. Petrop. **1**: 535. 1871–72.

Omphalodes nana Chamissonis Gray, Proc. Am. Acad. **20**: 263. 1885.

Very closely resembling the preceding but rather more densely villous, and the flower cluster sessile among the leaves at the ends of the branches, the latter however sometimes elongated 1 or 2 cm. in fruit; the closely overlapping leaves about 10 mm. long, 2–3.5 mm. broad, oblanceolate, but the lower portions covered by the successively overlapping leaves and the exposed portion obovate to ovate, obtuse or broadly acute: flower cluster compact: calyx lobes oblong, obtuse; flowers in dried specimens 5–7 mm. in diameter, the limb of the corolla sky-blue: nutlets about 1.5 mm. long on the inner angle, the teeth of the dorsal border as long as the body of the nutlet, more or less connate at the base and bearing rather strongly marked bristles on their margins and apex, those at the apex showing a tendency to become divergent or sometimes even slightly recurved.

A common plant on St. Paul Island, Alaska, and also collected on the main land at Port Möller, Alaska Peninsula. It was originally described from specimens collected at St. Lawrence Bay, Siberia, and Kamchatka.

Specimens have been examined as follows:

ALASKA: St. Paul Island, August 3, 1891, *J. M. Macoun;* 1895, *True & Prentiss, 40, 68;* 1890, *Wm. Palmer, 139;* August 7, 1891, *C. Hart Merriam;* without date, *Kusmischscheff;* without date, *H. W. Elliott;* Port Möller, July, 1890, *C. H. Townsend.*

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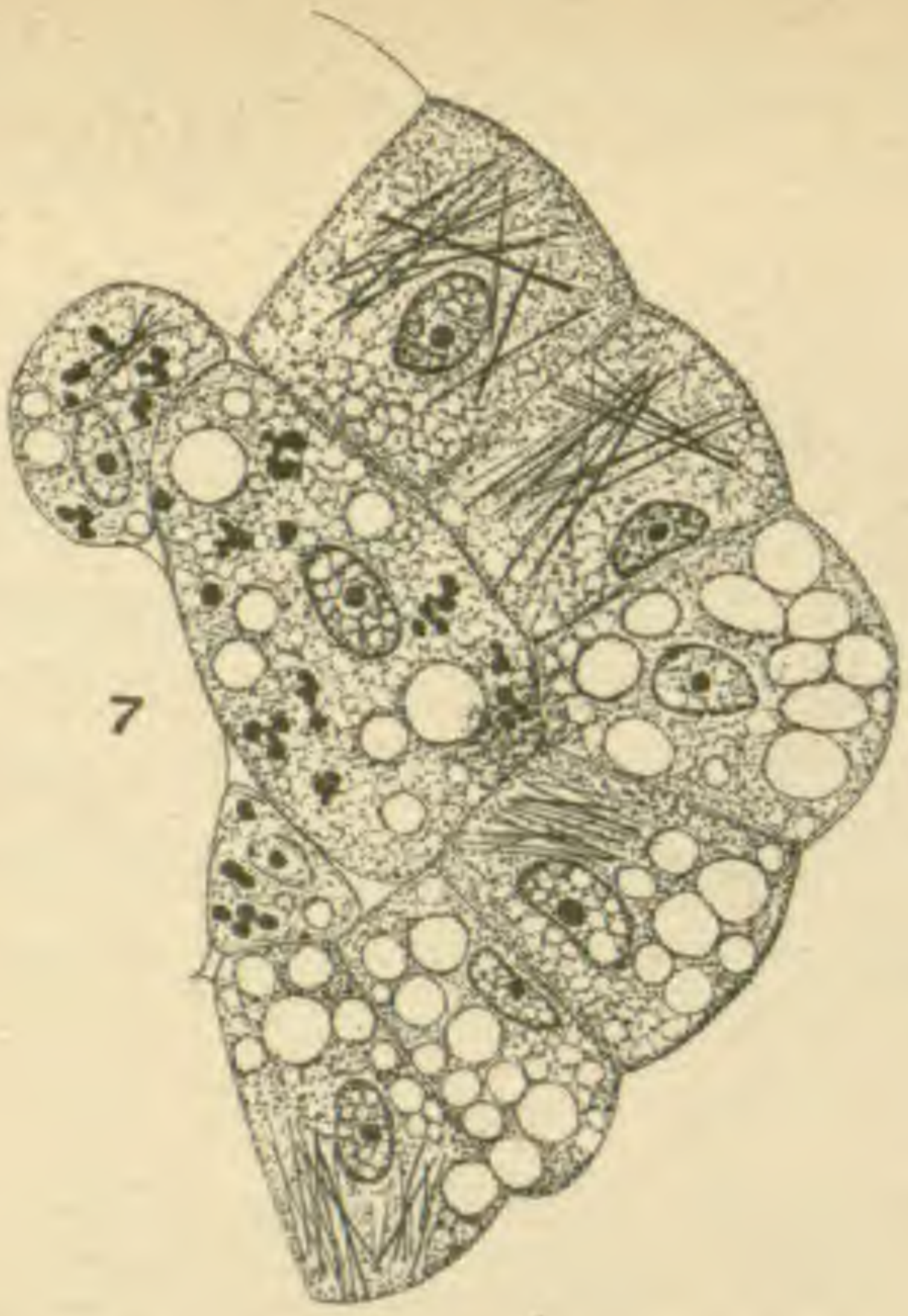
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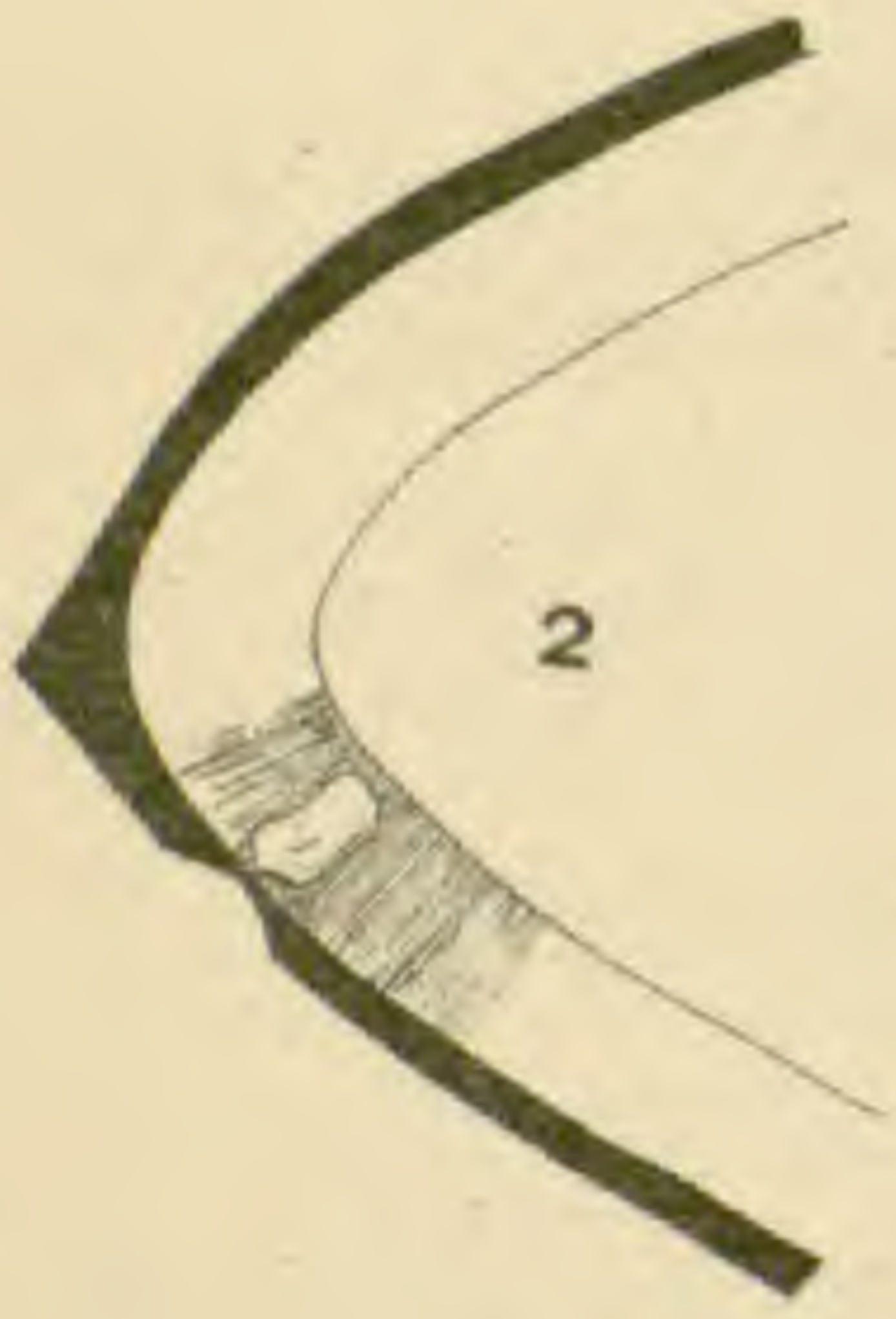
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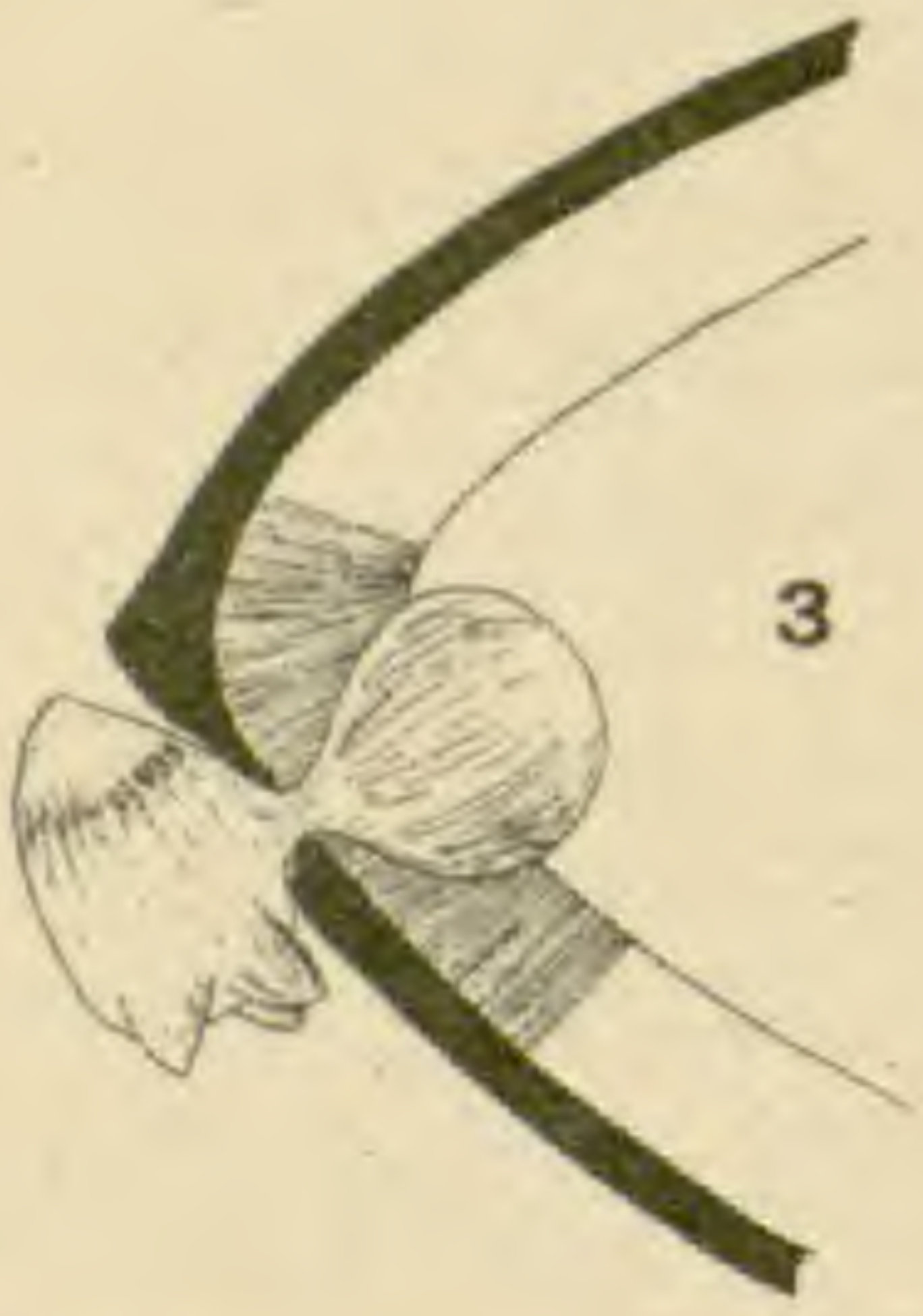
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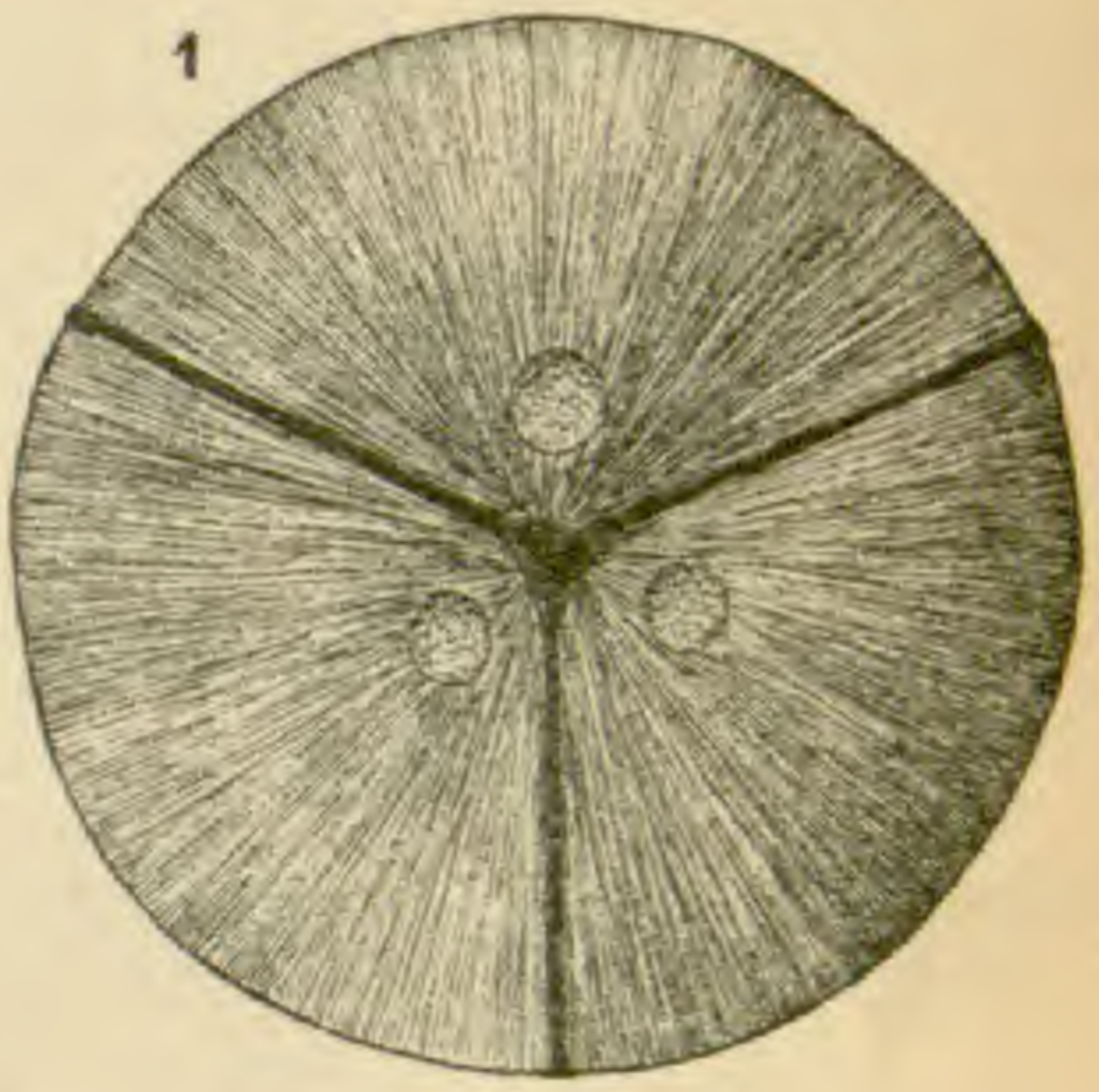
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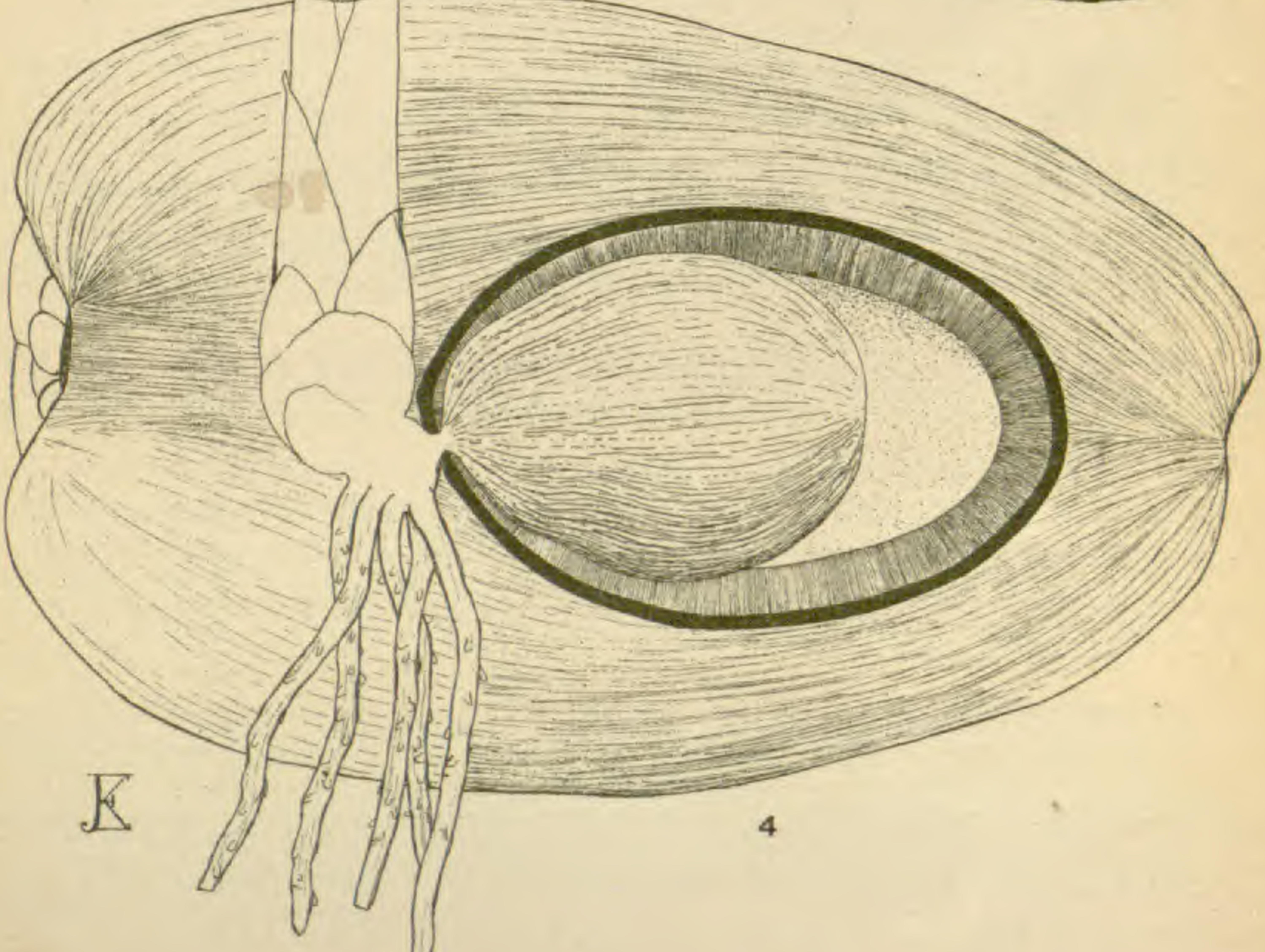
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Memoirs. (See last page of cover.)

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JULY 1902

Cytological Changes accompanying the Secretion of Diastase

BY JOHN CUTLER TORREY

(WITH PLATE 20)

From the chemical standpoint, a large amount of work has already been done on the secretion of diastase in the Gramineae. For these researches we are principally indebted to Morris and Brown. These authors have determined with great care the cells concerned in its formation, the amount secreted and its method of attack on the endosperm. Many botanists, too, have described and figured the pitting and ultimate dissolution of the starch grains in the endosperm during the progress of germination. No serious attempt, however, has been made to determine the nature and sequence of the changes occurring in the diastase-secreting cells during the elaboration of the enzyme. This paper, accordingly, embodies an attempt to throw some light on the following questions:

1. In what part of the diastase-producing cells is the ferment produced? Is it in the nucleus or in the cytoplasm?

2. How soon after the beginning of germination is diastase secreted? Is it formed intermittently or is it a continuous secretion?

Little attention has been paid to the action of the enzyme on the endosperm, except in so far as it gave evidence that diastase had been discharged from the cells.

As maize has been found to be in many ways more favorable for study than barley, it has largely furnished the material for the present paper. The latter, however, has been of value from a comparative standpoint. I take pleasure in acknowledging my

[Issued 25 July]

indebtedness to Professor Francis E. Lloyd for the suggestion of the research and kindly criticism during its progress.

Methods.—The seeds were soaked over night in water to soften the coats, and were then placed between layers of filter paper in a moist chamber. The embryos at different stages of growth were cut from the grain together with that part of the endosperm in immediate contact with the scutellum. The first series was made at time intervals. The embryos were fixed approximately every 12 hours for two days, and then at 24-hour intervals. This was found to be unsatisfactory as the rate of growth in different seeds varied greatly, and thus the chances of obtaining a sequence of stages was lessened. Accordingly, a series from the beginning of germination to five days was secured with the rate of growth as a guide, and without reference to time intervals. The length of the radicle and plumule served as an indicator. The best fixation was effected by the use of sublimate acetic 2 per cent., or of alcoholic acetic (70 per cent. alcohol 2 parts and glacial acetic acid 1 part). Flemming's fluid caused excessive blackening. Iron haematoxylin proved to be by far the most satisfactory stain, either alone or followed by Congo red as a counter stain. Auerbach's method, also, was of some value. The sections were cut for the most part 5 μ in thickness.

I. DESCRIPTION OF SEED. (PL. 20, F. 1)

Without entering upon a description of the various seed coats, a kernel of corn may be said to consist of two distinct elements—the endosperm and the embryo. The former occupies the larger part of the seed and partly clothes the adjacent embryo. The latter is on the furrowed flattened side of the kernel. It is thickest at the end attached to the cob, and gradually slopes to a point reached at about four fifths the length of the grain. Between the axis of the plantlet and the endosperm there is a thickened shield-like expansion of the hypocotyl, supposed by many to be the homologue of the cotyledon, and known as the scutellum. This is the special organ of absorption. The endosperm consists of large cells filled with starch grains imbedded in a matrix of proteid matter. Several layers of crushed and empty cells separate these well-filled cells from the scutellum. As these cells have been emptied by the pressure of the growing scutellum during the development of the seed, we find them most numerous where the scutellum is thickest. Directly adjoining the flattened empty cells is the epidermal layer of the scutellum, the cells of which manufacture the "diastase of secretion."

These secretory cells are found at every point where the scutellum is in contact with the endosperm. At the region of the tip this secretory epithelial layer dips down at frequent intervals into the scutellum. The convolutions so produced secure a larger surface of secretion where there is greatest need for the enzyme; for the endosperm is thickest at this point and in front of the embryo. Immediately below the epithelial cells are the large loosely arranged isodiametric cells of the scutellum. The larger cells are near the central part of the scutellum. Here, too, the cell walls are thicker than at the periphery. The young shoot itself, is closely connected with the lower central portion of the scutellum. From the hypocotyledonary part there proceeds into the scutellum a branch of the vascular system which soon divides into two parts. One of these runs directly upward, and the other toward the tip of the scutellum. They both give rise to many small branchlets, but none of these find their way into the heel of the scutellum.

The diastase-secreting cells are columnar, and at the beginning of germination are about three times as long as broad (*f. 2*). The bases of the cells rest on the scutellar parenchyma, and their ends are in close apposition to the endosperm. The cell walls are extremely thin and delicate, thus permitting a free osmotic interchange. The protoplasm in early stages is finely reticulated, but becomes somewhat coarser as germination progresses. The nucleus varies greatly in its position. Although it is found as a rule near the center, it may not infrequently occur at the base or near the outer end of the cell. It is slightly elliptical with its long dimension parallel to that of the cell. The nuclear wall is very delicate. The chromatin, in the form of small granules, lies scattered in the linin network. The large, deeply staining nucleolus always lies in a vacuole. Two such nucleoli very commonly occur. Although as a rule round, a knot like projection is sometimes present. The cells in the central part of the scutellum are especially heavily loaded with nutritive matter, which consists, for the most part, of aleurone grains and oil globules. In corn, even at the beginning of germination, starch grains are commonly found in these cells. In barley, such grains, according to Morris and Brown, are not present in the scutellum until the endosperm shows signs of depletion. Nearly all the starch grains, wherever found, are cracked because of the dehydration of the resting period.

II. ORIGIN OF DIASTASE

1. *Previous Accounts.*—It will be sufficient, for our present purpose, to point out the following pertinent facts in regard to diastase, which have been established principally through the researches of Morris and Brown.*

(*a*) There are two varieties of diatase.—One is an amylohydrolytic enzyme occurring in buds, leaves and other regions, which acts on the transitory starch grains found in the cells of these tissues. It does not act on starch paste nor pit starch granules, but dissolves them evenly.

The other is the enzyme secreted by the columnar epithelial cells in the seeds of the Gramineae. This dissolves starch paste and corrodes starch granules.

The former has been called by Morris and Brown the "diastase of translocation" and the latter the "diastase of secretion."

(*b*) This diastase of secretion begins to be formed soon after the beginning of germination and continues until the endosperm is depleted.

(*c*) The first evidence of the formation of the ferment is the appearance of granules in the columnar epithelial cells of the scutellum.

(*d*) Soon after the appearance of these granules the cells walls of the endosperm nearest the scutellum begin to be dissolved and the contained starch grains show evidence of pitting.

(*e*) Concomitant with the above-mentioned phenomena starch grains appear in the cells of the scutellum immediately below the secreting epithelial cells.

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* For a detailed description of the work that has already been done on the origin of diastase and its action on the endosperm, the reader is referred to the original papers or to the chapter on Diastase in Reynold Green's Fermentation.

(*f*) If a small quantity of cane sugar is added to the starch, the latter is protected in a remarkable manner. There is no sign of pitting of the starch grains as long as any sugar remains unabsorbed by the embryo. "Thus the secretion of active diastase by the epithelium may be regarded to some extent as a starvation phenomenon."

(*g*) Lastly, in addition to the starch-dissolving enzyme (amylohydrolyst), there is present in the growing plantlet a cellulose-dissolving enzyme (cytohydrolyst). Both these enzymes are secreted by the columnar ("absorptive") epithelium.

2. *Observations.*—In previous accounts of the secretion of diastase, the statement that the epithelial cells at the beginning of germination are filled with granules seems to be the nearest approach to an accurate description of its origin. This is true as far as it goes. I have attempted to trace these diastase granules to their ultimate origin and I think that there is evidence for the conclusion that in corn and barley and probably in all the Gramineae, "diastase of secretion" arises in the nucleus of the epidermal cells of the scutellum.

My earliest preparations of corn are sections of a kernel that had been soaked in water just long enough to soften the outer coats. The protoplasm of the columnar cells is found to be much shrunken owing to the dry condition of the resting seed. The nuclei for the most part stain very deeply, either wholly, or in several places, although here and there are nuclei which are clear. By the use of a high power this dark staining matter is seen to be distinctly granular (*f. 2*). It stains fully as intensely as chromatin. These granules are often collected in little bunches. Sometimes a string of them lie about the vacuole of the nucleus. The granules seem to arise along the course of the linin network, for many of them may be seen scattered throughout the reticulum. Even at this early stage the nucleus is often so packed with granules that it stains a uniform black and the granular constitution of the mass is shown only by its corrugated edge. In cases where the epidermal cell is double, *i. e.*, where there is an inner and an outer cell, the nuclei of both produce these granules.

Passing now to a kernel that has been placed a little longer in conditions favorable to germination, we find the cytoplasm filled with these granules and the nucleus empty. Cells that are in an intermediate condition make it clear how this change has taken place. A careful examination of a heavily loaded nucleus will often show a row of granules in the shape of a fine knotted thread extending from the black staining mass in the nucleus through the nuclear membrane and out into the cytoplasm of the cell. There may be several of these threads varying in thickness, but always composed of distinct granules (*f. 3*). Sometimes a thread ends in the cytoplasm in a bunch of granules. As a rule the breaks in the nuclear wall, through which the granules find a point of exit, are very minute, but, in later stages especially, they may be quite extensive (*f. 6*).

In the majority of cases these ruptures seem to be brought about by the constantly increasing size of the mass of granules. Since these granules are present in many nuclei in great abundance before germination has begun, the conclusion is inevitable that they were formed before the resting period. On the other hand, it is no less probable that no diastase is secreted from the cell until the beginning of germination, or, to use Matthew's term, up to that time there is merely "hylogenesis." It is worthy of note, however, that the processes going on at the beginning of germination are a direct continuation of those brought to a stop in the developing embryo by the resting period.

An examination of these same columnar cells in a grain that has been placed under conditions favorable for germination for about 18 hours shows a very striking change in their organization. They are so greatly swollen that they are now at least three times their former size (*f. 4*). The nuclei are for the most part entirely devoid of granules. These have become scattered throughout the cytoplasm, in all probability by virtue of the circulation of the cell sap. Many of the granules have increased considerably in size but the large ones are not restricted to any particular region of the cell. This increase in size of the granules lends color to the theory that a "prozymogen" is formed in the nucleus which becomes an active ferment only after certain elements have been added to it from the cytoplasm.

The nuclei themselves are distorted and in some cases the swelling has been so violent that the delicate nuclear wall is ruptured and the nucleolus, vacuole and all, is ejected. The absorption of water by the diastase-secreting cells has, without doubt, caused their swollen condition. This condition, however, is very transitory, for at the end of the first day of germination we find these cells only slightly larger than they were before it occurred. After 24 hours the cells have not only regained their original size, but, in most instances, have also lost their granules. Certain cells are to be found here and there in which the granules are massed together at their ends nearest the endosperm, but otherwise the cytoplasm and nuclei are entirely destitute of them- At the end of the first day, too, the endosperm shows evidence of the action of an enzyme. The solvent action, at this stage, is con. fined to the cell walls just outside the diastase-secreting epithelium and to the proteid matter between the starch granules. The coincidence of the disappearance of the dark staining granules from the cells that secreted them, and the dissolution of a part of the endosperm, is a strong proof of the diastatic character of the former. By this time the radicle has broken through the coleorhiza and projects for about 1.5 to 2 mm. from the seed.

At the beginning of the second day of germination the diastase-secreting cells are in a resting condition. There is no increase in size and the nuclei and cytoplasm are clear. The solvent effect of the diastase secreted during the first day is now more apparent. Not only are the cell walls in the neighborhood of the epithelium broken down, but the starch grains themselves are pitted. The method of attack of the diastatic enzyme on starch grains has been frequently described and nothing was observed which calls for special mention.

At the end of the second day the epithelial cells again begin to show signs of activity, and the second period of secretion is inaugurated. Dark staining granules have appeared once more in some of the nuclei. These granules steadily increase in quantity until, as before, they completely fill the nuclei. The cytoplasm, however, remains clear of them, and there is no increase in size of the cells themselves until some time during the third day. After about 72 hours of germination, groups of the diastase-secreting cells increase once more threefold in size and the cytoplasmic reticulum is filled with granules precisely as during the first day (*f. 5*). All the cells, at a given time, are by no means at the same stage in the elaboration of the enzyme. This is especially the case after the first day. We may say, nevertheless, that the first and second periods of secretion are separated by an interval of from 36 to 48 hours. By this time the plumule has broken through, and the radicle is an inch and a quarter in length. The scutellar cells show now a notable increase in the number and size of the starch grains that they contain. This is of course due to the fact that, by virtue of the solvent action of diastase, the starch of the endosperm is being transported and stored up in the scutellum, where it serves as food for the growing plant. The usual reduction in size follows the swollen condition, and is accompanied by a collecting of the granules at the tips of the cells, and finally by a discharge of the enzyme into the endosperm.

From now on until the complete depletion of the endosperm and the final degeneration of the scutellum there are no sudden changes in the size of the secreting cells. There seems, on the other hand, to be a gradual, but steady, increase in size with a continual production of diastase by each cell independently of the others. During the fourth day the nuclei of many cells became filled again with granules and on the fifth these may frequently be seen breaking through the nuclear membrane and collecting at the tips of the cells directly, without at first becoming scattered through the cell (*f. 6*). At the end of 11 days there are signs of degeneration in some of the epithelial cells. These consist of an abnormal swelling and vacuolization of the cytoplasm, most noticeable at the ends of the cells towards the scutellum. After the lapse of 22 days the cytoplasm is very scanty and ragged. The cells have also become very greatly elongated. They are now at least three and a half times their length at the beginning of germination. The cell walls are thick and stratified. The nuclei still stain very darkly and are probably producing a ferment for the dissolution of what is left of the cell walls of the endosperm. The starch grains have completely disappeared from the endosperm and the scutellar cells are mere skeletons (*f. 7*). The time given, at which various changes in the diastase secreting cells occur, is merely approximate and varies greatly according as the conditions are more or less favorable for growth.

A sufficient number of stages in germinating barley have been studied to make it clear that we have the same series of phenomena here during the secretion of diastase as in maize. The granules arise in the nucleus, they find their way into the cytoplasm, and immediately after their disappearance from the cell we note the action of an enzyme on the endosperm. The collecting of the diastase granules at the tip of the cell nearest the endosperm is especially noticeable in barley (*f. 8*).

Although the iron haematoxylin stain is one of the most useful ones for cytological purposes, there is a common source of error in its employment, which should be carefully guarded against. It has a tendency to stain in a very deceptive way any precipitates that may be present in the cell. Such precipitates are easily mistaken for natural metabolic products. Accordingly Auerbach's method was used as a precautionary measure. It is interesting to note that those stages of the nuclei which stain an intense black with iron haematoxylin, also stain very deeply with methyl green; whereas the nuclei with granule-filled cytoplasm stain very lightly with methyl green. This is another proof that matter is ejected from the nuclei at the same time that granules appear in the cytoplasm.

3. *Comparative.*—Very few examples of secreting cells in plants have been studied with any degree of care. The results of Huie and Schniewind-Thies, accordingly, are of especial interest in this connection. Miss Lily Huie ('96) found that during secretion in *Drosera* the basophile cytoplasm was depleted. The basophile chromatin increased in the meantime greatly in extent, and, after ejection from the nucleus, gave rise to new basophile cytoplasm. After long-continued secretion the basophile cytoplasm was entirely replaced by a scanty eosinophile cytoplasm. It was not determined whether the nuclear, or nucleolar chromatin, was the primary product of the metabolism. In diastase-secreting cells the cytoplasm is not so directly concerned in the formation of the secretory product as appears to be the case in *Drosera*. The only evidence of the possible activity of the cytoplasm in the former is the increase in size of some of the granules scattered through it. Schniewind-Thies ('97), who has made a very thorough study of the nectar cells in a number of plants, finds that,

as a rule, at the height of secretion these cells are much swollen. The nucleus becomes greatly enlarged and distorted, often sending out pseudopodial processes. As a general rule there is a loss of staining power in the nucleus during secretion. In the end the cytoplasm is much shrunken and the nucleus and nucleoli completely disappear. The nectar begins to appear at the end or just outside the end of the cell. In this case the nucleus seems to play a very active rôle and bears a strong resemblance to the behavior of the nucleus during the secretion of diastase. In both there is a final disappearance of the nucleus after the cell has exhausted itself by its long-continued secretions. In both also there is a swelling of the cell during the formation of the secretion. It seems not unlikely that this swelling is brought about by osmosis set up by some substance secreted within the cell at this time. The diastase, being of a proteid nature and consequently of high molecular weight, would not be, even if in solution, as active osmotically as other less complex substances, as for instance, organic salts or acids, which, De Vries has shown, exercise a strong osmotic attraction when present in the cell. Nevertheless the swelling takes place when the nucleus has become completely filled with these granules. A possible explanation of this phenomenon may be that some organic acid is formed during the great metabolic activity of the cell. The fact that diastase, in order to be especially effective as a ferment, must be dissolved in a liquid with a distinct, but not too strong acid reaction, lends support to this hypothesis.

A comparison of the secretory processes in plants with those in the animal kingdom, where the literature is much more complete, is certainly of interest. Mathews ('99) has studied the secreting cells of the pancreas very carefully. He describes the pancreas cell as divided into two zones, a granular inner and a striated outer. The fibrils of the outer zone arise in the chromatin and end in the cytoplasm of the inner (granular) zone. "The chromatin has, then, formed a highly complex substance probably a nucleo-albumin (the cell thread or fibril) which splits into at least two constituents, one of which forms the granules, and the other a reticulum. The granular substance is perhaps further altered and ultimately forms the zymogen." The interesting fact from a comparative standpoint is that, whereas in diastase-secreting cells the ferment is found directly by the nucleus, in the pancreatic cell the nucleus does not play an active rôle, but indirectly controls the zymogenesis. Nevertheless, in both cases the *nucleus* is the ultimate source of the zymogen granules. Mathews, in agreement with Nussbaum, arrives at the rather sweeping conclusion that the changes in the nuclei of the secreting cells are passive, the nuclei taking no active part in secretion or in zymogenesis. The active part taken by the nucleus in the production of the diastase granules certainly forms a very evident exception to this generalization and is a point in favor of the views of Heidenhain, Korschelt and others, who consider that the changes in position and size of the nuclei during secretion are signs of functional nuclear activity.

There is considerable evidence that chromatin is the synthetic substance of the nucleus and in the elaboration of the metabolic products acts somewhat in the manner of a ferment. In other words it brings about the union of certain elements without entering into the synthesis itself, or becoming changed in its chemical nature. Mathews thinks that the fact of the cell threads ending in the chromatin points to this conclusion. The secretion or rather the hylogenesis of diastase seems to be a case exactly to the point, as here the process is strictly intranuclear. Pekelharing ('95) and Halliburton ('95), working from another viewpoint, have demonstrated that fibrin ferment is a nucleo-proteid, a form of chromatin. That the amylolytic granules, while in the nucleus, stain in the same manner and with the same intensity as chromatin, indicates that they have something in common with the fibrin-ferment. According to Macallum the nuclei of the pancreatic cells have much to do with the formation of the enzyme. His experiments lead him to the conclusion that the chromatin elaborates a substance which he calls prozymogen. This finds its way into the cytoplasm and, combining with certain elements, forms the granules of the enzyme; certainly a very good description of the sequence of stages in the diastase cell.

The wide-spread occurrence of granules in secreting cells is worthy of note. Green ('99) giving quite a number of examples in which this is the case. In the mucous glands of the frog's tongue there is a clear protoplasmic zone and a granular zone; a serous glandular cell is filled with granules during the resting period; a like phenomenon is seen in the pepsin-secreting cells. According to Ward,* during the secretion of rhamnase by *Rhamnus infectorius* granules appear.

In animal tissues the secretions are, as a rule, intermittent, but in plant tissues, according to Green, they are prolonged and probably only to a slight degree intermittent. This he explains by the fact that, in the animal, digestion is continually repeated, whereas in plants the utilization of reserve materials is a continuous and very gradual process. During the first three or four days, however, in the case of maize and probably all the Gramineae there is clearly an intermittence in the secretion of the enzyme.

The active part taken by the nucleus in secretion in plants, at least, is in complete harmony with the view that it is the metabolic center of the cell. Verworn, in his General Physiology, cites a number of instances in which the nucleus takes an active part in the nutrition and growth of the cell. Although, as he observes, the presence of a membrane generally necessitates the exchange of liquids between nucleus and protoplasm, yet many observers, among them Fromman and Auerbach, "have observed on the part of the nucleus a direct ingestion and extrusion of granules and flakes." The ejection of granules from the nucleus of the diastase-secreting cell is another case to the point.

A general review of the literature on secretion in plants and animals leads one to the conclusion that in the two cases we have a different state of affairs. In both the nucleus is the ultimate source of the secretory product but in plants it is far more directly concerned than in animals; in the one it is active and in the other passive.

GENERAL CONCLUSIONS

1. In the Gramineae "diastase of secretion" arises in the nucleus of the epidermal cells of the scutellum. For:

(*a*) At the beginning of germination the nuclei contain dark staining granules, but there are few or none in the cytoplasm.

(*b*) At this same stage, through very small breaks in the membranes of the heavily loaded nuclei, granules are beginning to exude in small streams.

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* Green, R., Soluble Ferments and Fermentation, 379.

(*c*) These granules at first spread through the cell but later collect at the end of the cell next to the endosperm, where they are ultimately dissolved.

(*d*) Immediately after their dissolution the first destructive action of a ferment in the cell walls and inter-starch matrix of the endosperm is to be observed.

(*e*) Soon starch grains appear in greater abundance in the scutellar cells.

2. Zymogenesis begins in the nuclei before the advent of the resting period.

3. At some time during the first and third days of germination the diastase-secreting cells swell to three or four times their original size.

4. During the first and third days there are "waves" of secretion, so that this process may be described as intermittent. From that time on, until the final exhaustion of the cells, the secretion is more continuous. (It has been shown by Hansteen * that an accumulation of diastase unless removed will inhibit the further secretion of that substance by the scutellum and it would seem that the behavior of the secreting cells as above described is due to this fact.)

5. The secreting cells begin to degenerate about the tenth day.

6. It is highly probable that the chromatin takes an active part in the zymogenesis.

7. The nucleus is in this case very clearly the metabolic center of the cell.

8. There is a marked difference in secretory processes in plants and animals.

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* See Pfeffer's Physiology of Plants (English translation), p. 580.

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Explanation of Plate 20

FIG. 1. A somewhat diagrammatic view of a section of a kernel of corn, showing the general relationship of the plantlet, the scutellum, and the endosperm: *end*, endosperm; *ep*, secreting epithelium of scutellum; *pl*, plumule; *r*, radicle; *sc*, scutellum with the vascular tissue. × 4.

FIG. 2. Diastase-secreting cells before the beginning of germination: *end*, endosperm; *ep*, diastase-secreting cells; *d*, diastase granules; *n*, nucleus; *sc*, scutellar cells; *st*, starch grains. × 795.

FIG. 3. Shortly after the beginning of germination: *d*, diastase granules. × 795.

FIG. 4. The same cells the latter part of the first day of germination. The firs period of secretion: *d*, diastase granules; *n*, nucleus. × 795.

FIG. 5. The condition of the cells after about three days of germination; corrosion of starch grains; *st*, starch grains; *d*, diastase granules. × 795.

FIG. 6. Diastase-secreting cells during the fifth day of germination. × 795.

FIG. 7. The extremely elongated diastase-secreting cells after about twenty-two days of germination. × 795.

FIG. 8. The corresponding cells of barley during secretion of the enzyme. The seeds had germinated about two days. × 795.

All figures except the first were drawn from camera outlines.

A historical Review of the proposed Genera of the Hydnaceae

By Howard J. Banker

The family of the Hydnaceae is distinguished from all other families of the Basidiomycetes by the fact of the hymenial surface being developed in the form of subulate or awl-shaped spines or teeth. This characteristic renders it comparatively easy to distinguish most members of the group. Yet there are species that grade insensibly into related families, so that it is impossible to draw hard and fast lines here as much as in any part of the plant world; thus through the genera *Sistotrema* and *Irpex* we may pass by a natural transition to the family Polyporaceae, or, choosing a different route, we may make the transition just as naturally through the genera *Phlebia* and *Merulius*; on the other hand we may pass with equal ease to the Thelephoraceae through *Grandinia* and *Thelephora*, while the transition to the Clavariaceae is not likely to prove any more difficult.

The earliest reference we have to a plant of the hydnaceous type appears to have been by Bauhin, in 1651, in his Historiae Plantarum Universalis, **3**: 828. As the reference is brief I quote it in full as a matter of curiosity, and as giving the historical origin of this group of plants:

"Fungus paene candidus prona parte erinaceus. Raro naturae miraculo parte prona pro membranulis innumeris veluti aculeis muricatus, erinaceum in memoriam revocat, unde ex argumento nomen imposuimus." It is entirely probable that the plant thus referred to was *Hydnum repandum*.

For the next century the group received little attention from botanists, and at the publication of the Species Plantarum in 1753 but four plants had become distinguished in botanical literature. During the past century and a half the group has grown to quite ample proportions, constituting the distinct family Hydnaceae and embracing more than 450 species as recognized in Saccardo's Sylloge Fungorum. From this material numerous genera have been proposed with more or less substantial claims to validity. It is the purpose of this paper to review these claims chiefly from a historical standpoint, believing it will serve to clear the air for a more critical study of generic relationships in this family. Before entering upon this discussion it will be proper to state the most important principles by which it is proposed to determine the historical status of a generic name.

This much vexed question is still in a very unsettled state, but it does not seem advisable to take up the space of this paper by a full discussion of the principles here adopted. In general they will be found to conform closely to those set forth by Professor L. M. Underwood in his paper "A Review of the Genera of Ferns proposed prior to 1832." *

1. Only generic names established in Linnaeus' Species Plantarum, 1753, or later are considered.†

2. No generic name is considered as established unless it is: (*a*) Associated with one or more previously described species which are referred to with sufficient directness as to be recognizable, or (*b*) Associated with some species which is described for the first time at the publication of the name itself. Generic names founded with no hint of a species with which the name can be permanently associated will not be considered as holding any priority rights against names capable of being anchored to definite species (*cf.* Underwood, *l. c.*).

3. Whenever a genus is established under a new generic name the name will be considered as permanently associated with the first-named species in the genus. This does not constitute such "first-named species," the *type* of the genus in any sense that involves the primary meaning of that term.‡ Nevertheless, the distinct designation of some other species as the "type" of his genus by the author will be considered a sufficient ground for an exception to the above rule.

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* Mem. Torrey Club, **6**: 250.

† This rule, laid down by the Rochester convention, compels us to ignore the older and more appropriate name *Erinaceus* for the leading genus of the family.

‡ This is the key to my modification of Underwood's rules. I have sought to avoid every expression that seemed to involve the idea of "type species," believing there is an ambiguity in the conception to which is to be attributed much of the controversy that rages about this term. Moreover it does not seem to me possible to determine the true biological type of any genus in the present state of our knowledge.

As this paper is not intended to be a criticism of nomenclature it is not necessary to present further rules or to discuss the details of this subject. Therefore, with these principles as a guide, we will examine the genera which have been proposed in this family.

1. HYDNUM L. Sp. Pl. 1178. 1753

The genus was founded on four species, namely *H. imbricatum, repandum, tomentosum*, and *Auriscalpium* in the order named. It is to be observed that all these species, the only members of the family known to Linnaeus, are stipitate forms. The form *Hydna* was first used. In Flora Lapponica, 368, 1737, Linnaeus published the genus *Hydna* with two species which, from the descriptions there given and from his own citations in Sp. Pl. **2**: 1178. 1753, are clearly *H. imbricatum* and *H. Auriscalpium* respectively. In Genera Plantarum, 327, also published in 1737, he publishes the genus *Hydna* without naming any species but cites "*Erinaceus* Dill." Now Dillenius, Catalogus Plantarum circa Gissam nascentium 188, *pl. 1*. 1719, figures and describes but one species which is evidently *H. repandum.* Linnaeus also clearly so understood it, for in Sp. Pl. **2**: 1178 under *H. repandum* he cites "Flora Suecica, 1098," and in the last-named reference he cites again "Dill. giss. 188." It may therefore be considered an open question whether we are to regard *H. imbricatum* or *H. repandum* as the species with which the generic name is to be permanently associated, that is, to constitute the so-called "type." The technical decision must turn upon the determination whether the "Flora Lapponica" or the "Genera Plantarum" both of which bear the date 1737, was published first. But this is a laborious quibbling over trifles. Linnaeus originated the genus himself, and it is evident from his lists that *H. imbricatum* ever stood foremost in his mind as the leading representative of his genus. In his Systema Naturae, 32. 1740, he changed the form of the name to *Hydnum.* Therefore the generic name *Hydnum* belongs permanently to *H. imbricatum* and becomes the proper name of the genus to which that species is referred.

2. SISTOTREMA Pers. Neues Mag. für die Bot. 1: 108. 1794

The genus was founded on *S. confluens* Pers. (= *Hydnum sublamellosum* Bull.) and *S. cinereum* Pers.

3. HERICIUM Pers. Neues Mag. für die Bot. **1** : 109. 1794

This genus was established on *Hydnum coralloides* Schaef., a single species and is not *Hericium* of Fries, *q. v.*

4. ODONTIA Pers. Neues Mag. für die Bot. **1** : 110. 1794

This genus was established on *O. ferruginea* Pers. and *O. nivea* Pers. and is not the *Odontia* of Fries, *q. v.*

5. XYLODON S. F. Gray, Nat. Arr. Brit. Pl. **1** : 649. 1821

This name was first given to a subgenus of *Sistotrema* by Persoon in Syn. Fung. 552. 1801. It included *Odontia quercina* Pers. and six other species. Gray made it a genus of his family of the Sistotremideae with the species *Sistotrema quercina* Pers. and *S. digitatum* Pers. It has since been treated, when recognized, as a genus of the Polyporaceae, where it presumably belongs. It has been included here only to make the historical discussion of the family complete.

6. DENTINUM S. F. Gray, Nat. Arr. Brit. Pl. **1** : 650. 1821

The genus was founded on *Hydnum repandum* L. and *H. rufescens* Pers.

7. AURISCALPIUM S. F. Gray, Nat. Arr. Brit. Pl. **1** : 650. 1821

The genus was based on *Hydnum Auriscalpium* L., a single species.

8. STECCHERINUM S. F. Gray, Nat. Arr. Brit. Pl. **1** : 651. 1821

This genus was established on *Hydnum Daviesii* Sow. (= *H. ochraceum* Pers.*), *H. gelatinosum* Pers. and *S. quercinum* Gray (= *Hydnum erinaceus* Bull.). In his Key, on page 597, Gray uses the form *Stecherina* but, as he quotes Micheli for the source of the name, it is evident that the form used in the text is the correct one.

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* Gray quotes *Hydnum ochraceum* Pers. as a synonym. *H. Daviesii* was figured and named by Sowerby in Eng. Fungi, 15. 1797. The same species was described under the name of *H. ochraceum* by Persoon in Obs. Myc. **1** : 73. 1796, and he quotes as reference "Gmel. Syst. Nat. Linn. **2** : 1440." The copy of Gmelin in the Library of the New York Botanical Garden is dated 1796 and on page 1440 is given "*H. ochraceum* Pers." but without any reference, the preceding species, however, is given as "*H. mucidum* Persoon fung. ined." It is evident, therefore, that *H. ochraceum* Pers. was first published in Gmelin, Syst. Nat. Linn. **2** : 1440, at least as early as 1796, but Pritzel's Thesaurus gives 1791, as the date of Gmel. **2**. In this case, however, this difference in date is not important as even the later establishes Persoon's priority. It would be a matter of interest to know the ground of Pritzel's earlier date.

9. PHLEBIA Fr. Syst. Myc. 1: 426. 1821

The genus was founded on *Merulius merismoides* Fr. with three other species.

10. RADULUM Fr. Syst. Orb. Veg. 81. 1825

This genus was established on *Hydnum pendulum* (= *Sistotrema pendulum* Alb. & Schw.) with three other species. That the species, simply named as *Hydnum pendulum* by Fries, in this instance is really *Sistotrema pendulum* of Albertini and Schweinitz is made unquestionably evident by a comparison of the text in Systema Orbis Vegetabilis, 81, with the text in the Conspectus Fungorum, 261. Fries himself always cites the Elenchus Fungorum, 149. 1828, as the place where he established the genus. But this must be regarded as a different genus having the same name, for, curiously enough, in the latter work, he describes a totally different species and evidently a new one under the name of *pendulum*. *Cf. Irpex* below.

The name *Radulum*, however, is untenable, being excluded by *Radula*, established as a genus of the Jungermaniaceae, by Dumortier in Comment. Bot. Obs. 112. 1822.* I propose, therefore, for the name of this genus **Tylodon** † based on **T. Friesii** (= *Radulum pendulum* Fries, Elenchus Fungorum, 149. 1828; not *Radulum pendulum* Fries, Syst. Orb. Veg. 81. 1825.)

11. IRPEX Fr. Elench. Fung. 142. 1828

This genus was first published by Fries in Syst. Orb. Veg. 81. 1825; but without naming any species. In the Elenchus, 142, ten species are mentioned under *Irpex*, *I. pendulus* standing first. This species is clearly our old friend of the *Radulum* discussion, *Sistotrema pendulum* Alb. & Schw., as may be seen by a comparison of Elench. Fung. 142, with Syst. Myc. 1: 413. A more curious confusing of names it would seem could hardly be found in the work of a great systematist.

The genus stands on the border line between the Hydnaceae and the Polyporaceae and is thrown now to the one side and now to the other by the varying judgment of mycologists.

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* *Cf.* M. A. Howe, Hepaticae and Anthocerotes of California, Mem. Torrey Club, 7: 157, note.

† From τύλη, a knot or callus, and ὀδούς.

12. HERICIUM Fr. Syst. Orb. Veg. 88. 1825

The name was published in the above work without any species being given, but a reference is made to Syst. Myc. **1** : 409. 1821, "Hydna Gomphi." In the latter work, under the section Gomphi, four species are described : *Hydnum Caput-medusae*, *H. hystrix*, *H. echinus* and *H. ramularia* ; we must therefore regard these as representing *Hericium* Fr. That the genus, moreover, is distinct from *Hericium* Pers. is positively established by Fries' own comment in Syst. Orb. Veg. 88. "Cum *Hericio* Pers., cujus typus *H. coralloides* * * * non commutandum." In Hym. Eur. 617. 1874, Fries retains only two of the original species, *H. hystrix* and *H. echinus*, while a wholly new species stands at the head of the list, *H. Notarisii.* Although the name is untenable, it does not seem wise to propose a new one until the validity of the species composing it is more thoroughly established.

13. ODONTIA Fr. Epicrisis, 528. 1836–8

Fries based this genus on five species of which *Hydnum barba-Jovis* Bull. stands first, but of one of the following species, *O. fimbriata*, he says "typus generis." Fries first published the name in Obs. Myc. 149. 1815, as a subgenus of *Hydnum* with three species ; *Hydnum pinastri* Fr. standing first and *fimbriata* not being mentioned.

Fries' name of *Odontia*, however, is preoccupied by *Odontia* Pers., which evidently stands for a very different group. I, therefore, propose the name **Etheirodon** * based on **E. fimbriatum** (= *Odontia fimbriata* Fries, Epicrisis, 528).

The Friesian groups of *Hericium* and *Odontia* are the ones commonly known by these names and not the older genera of Persoon. The discussion of the above four genera well illustrates the loose methods of nomenclature formerly in vogue.

14. GRANDINIA Fr. Epicrisis, 527. 1836–8

This genus was established on *G. polycocca* Fr. with six other species.

15. KNEIFFIA Fr. Epicrisis, 529. 1836–8

This was established on *Thelephora setigera* Fr. (= *Th. aspera* Pers.).† The name is untenable, having been used by Spach in

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* From *ἔθειρα*, a tuft of hair, and *ὀδούς*, tooth.

† Bull. Torrey Club, **25** : 631. 1898.

Hist. Nat. Veg. **4**: 373. 1835, for a genus of the Epilobiaceae. For this reason Underwood proposed the name *Kneiffiella* in Bull. Torrey Club, **24**: 205. 1897. The next year P. Hennings independently proposed precisely the same name, Die nat. Pflanzenf. **1**^{1**}: 139. 1898. But this name was found to be untenable, having been used by Karsten for another genus of the Hydnaceae, Krit. Ofv. Finlands Basids. 371. 1889. Underwood then proposed the name *Pycnodon*, Bull. Torrey Club, **25**: 631. D. 1898. But this name had been anticipated four months previously by Saccardo, who had published the name *Neokneiffia* in his Tab. Com. Gen. Fung. 11 Aug. 1898. Nunc requiescat in pace!

16. MUCRONIA Fr. Summa Veg. Scand. 329. 1849

The genus was based on *Hydnum calvum* Alb. & Schw., a single species. The name was found to be preoccupied by Bentham for a genus of the Polygonaceae, Trans. Linn. Soc. **17**: 419. 1837. Fries himself, therefore, changed the name to *Mucronella*, Hym. Eur. 629. 1874.

17. GRAMMOTHELE Berk. & Curtis, Jour. Linn. Soc. **10**: 327. 1869

The genus was established on *G. lineata* with three other species.

18. MUCRONELLA Fr. Hym. Eur. 629. 1874

This name was proposed as a substitute for *Mucronia* (*q. v.*) and is, therefore, based on *Hydnum calvum* Alb. & Schw.

19. SARCODON Quel. Clavis Hym. 195. 1878

This genus was established on *Hydnum imbricatum* L. with eighteen other species. The name is clearly a direct synonym of *Hydnum* L.

20. CALODON Quel. Clavis Hym. 196. 1878

Quelet established this genus on *Hydnum suaveolens* Scop. with twenty-one other species.

21. DRYODON Quel. Clavis Hym. 198. 1878

The genus was founded on *Hydnum umbellatum* March. with seven other species including *Hydnum coralloides* Schaef. on which Persoon had based his genus *Hericium*. *Dryodon* Quel. must, therefore, be considered a synonym of *Hericium* Pers.

22. PLEURODON Quel. Clavis Hym. 198. 1878

The genus was established on *Hydnum occidentale* Paul. with seventeen other species.

23. HYDNUM Quel. Clavis Hym. 200. 1878

Quelet published this name with thirty-one species, all resupinate in form, not one of which we have any reason to suppose was known to Linnaeus. No law of nomenclature would seem to justify one in regarding such a group as *Hydnum* L.* *Hydnum* Quel. must be considered as a distinct idea from *Hydnum* L. and the name, therefore, preoccupied by Linnaeus.

In a later work, the Enchiridion Fungorum, 1886, Quelet has wholly ignored any such genus as *Hydnum;* the species of his own genus of that name being referred almost bodily to the genus *Odontia* Pers., and the name of the family itself being changed from Hydnaceae to Erinaceae.

24. AURISCALPIUM Karst. Medd. Soc. Faun. et Fl. Fenn. **5**: 27. 1879

This name was published with *A. vulgare* (= *Hydnum Auriscalpium* L.) and two other species. It is a direct synonym of *Auriscalpium* Gray, *q. v.*

25. HYDNELLUM Karst. Medd. Soc. Faun. et Fl. Fenn. **5**: 27. 1879

This genus was founded on *Hydnum suaveolens* Scop. with eighteen other species. The name is a synonym of *Calodon* Quel. *q. v.*

26. GLOIODON Karst. Medd. Soc. Faun. et. Fl. Fenn. **5**: 28. 1879

The genus was established on *Hydnum strigosum* Sw. with two other species.

27. FRIESITES Karst. Medd. Soc. Faun. et Fl. Fenn. **5**: 27. 1879

The genus was established on *Hydnum coralloides* Scop. (= *H. coralloides* Schaef.) and *H. caput-ursi* Fr., so the name is a synonym of *Hericium* Pers.

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* Karsten has performed the same sort of nomenclatural gymnastics by publishing the genus *Hydnum* with five resupinate species and then added the star feature of quoting the name of the genus as "*Hydnum* Linn."! *Cf. Hydnum* page 438.

28. CREOLOPHUS Karst. Medd. Soc. Faun. et Fl. Fenn. **5**: 27. 1879

This genus was based on *Hydnum corrugatum* Fr. and three other species.

29. CALDESIELLA Sacc. Michelia, **1**: 7. 1879

This genus was established on *C. Italica*, a single species, and placed in the Gasteromyceteae. Saccardo transferred it afterward to the Hydnaceae in Sylloge Fungorum, **6**: 477 and conveys an impression of uncertainty as to its true status in his account.

30. ACIA Karst. Medd. Soc. Faun. et Fl. Fenn. **5**: 28. 1879

The genus was founded on *Hydnum fusco-atrum* Fr. with thirty other species. The name is untenable, as it is preoccupied for a genus of the Rosaceae, by Schreber, Gen. Plant. **2**: 458. 1791.

31. LOPHARIA Kalch. & MacOwan, Grevillea, **10**: 58. 1881

The genus was published with *L. lirillosa*, a single species.

32. TYRODON Karst. Rev. Myc. **3**: 19. 1881

The genus was founded on *Hydnum repandum* L. and *H. rufescens* Pers. and is, therefore, a direct synonym of *Dentinum* Gray. Karsten evidently has had no knowledge of Gray's work which has been sadly neglected even by Gray's own countrymen.

33. PHELLODON Karst. Rev. Myc. **3**: 19. 1881

This genus was established on *Hydnum nigrum* Fr. with two other species.

34. CLIMACODON Karst. Rev. Myc. **3**: 20. 1881

The genus was established on *Hydnum septentrionale* Fr., a single species.

35. LEPTODON Quel. Ench. Fung. 191. 1886

The genus was based on *Hydnum occidentale* Paul. with eight other species. In accordance with the rules laid down, this name must be regarded as a synonym of the author's own genus *Pleurodon.* We have less compunction in the rigid application of our rule in this case, since there is no evidence that Quelet was governed by any rules whatever in his own work.

36. ODONTINIA Pat. Hym. D'Eur. 147. 1887

The genus was established on *Hydnum denticulatum* Pers. with four other species.

37. PHAEODON Schroet. Krypt. Flora Schlies. **3**: 458. 1888

The genus was established on *Hydnum tomentosum* * Schrad. with eight other species. *H. tomentosum* Schrad. is the same as *Odontia ferruginea* Pers., and hence *Phaeodon* Schroet. must be treated as a synonym of *Odontia* Pers.

38. GRANDINIA Schroet. Krypt. Fl. Schles. **3**: 450. 1888

This genus was based on *Odontia crustosa* Pers. with *G. alutacea;* it is to be regarded as equivalent to *Grandinia* Fr.; otherwise the name is untenable.

39. KNEIFFIELLA Karst. Finlands Basids. 371. 1889

The genus was established on *Hydnum barba-Jovis* Bull., a single species.

40. SCLERODON Karst. Finlands Basids. 360. 1889

The genus was established on *Hydnum strigosum* Sw., a single species. Karsten quotes *Gloiodon* in the above reference as a synonym of *Sclerodon.* But the rules of priority compel us to regard *Sclerodon* as a direct synonym of *Gloiodon.*†

41. AMAURODON Schroet. Krypt. Fl. Schles. **3**: 461. 1889

This genus was founded on *Sistotrema viride* Alb. & Schw. a single species.

42. THWAITESIELLA Massee, Grevillea, **21**: 2. 1892

The genus was based on *T. mirabilis* (= *Radulum mirabile* B. & Br. Jour. Linn. Soc. **14**: 61. 1875). A single species. Patouillard has demonstrated that the genus is identical with *Lopharia* Kalch. & MacOwan and should be regarded as a synonym of the latter.‡

43. ASTERODON Pat. Bull. Soc. Myc. **10**: 129. 1894

The genus was established on *A. ferruginosum,* a single species.

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* This name is untenable, having been used by Linnaeus for a stipitate species in Sp. Pl. **2**: 1178. 1753.

† This is a case that would seem to justify a method of residues in the determination of "types." But it seems to us a very exceptional case.

‡ Bull. Soc. Myc. France **11**: 13. 1895.

44. GRANDINIELLA Karst. Hedwigia, **34**: 8. 1895

The genus was founded on one species, *G. livescens.*

45. HYDNELLUM Karst. Hedwigia, **35**: 173. 1896

The genus was founded on *Kneiffia subtilis* Karst., a single species. The name is untenable, having been used by Karsten himself as the name of a mesopous genus in this same family, a synonym of *Calodon* Quel.

46. HYDNOCHAETE Bres. Hedwigia, **35**: 287. 1896

This genus was established on one species, *H. badia.*

47. HYDNOCHAETE Peck, Reg. Rep. **50**: 113. 1897

The genus was established on *H. setigera*, a single species. The name is preoccupied by Bresadola as above.

48. KNEIFFIELLA Underw. Bull. Torrey Club, **24**: 205. 1897

49. KNEIFFIELLA Henn. Die nat. Pflanzenf. **1**^{1**}: 139. 1898

50. NEOKNEIFFIA Sacc. Tab. Com. Gen. Fung. 11. 1898

51. PYCNODON Underw. Bull. Torrey Club, **25**: 631. 1898

The above four names were successively proposed as substitutes for *Kneiffia* Fr. *q. v.* *Neokneiffia* prevails.

52. HYDNOCHAETELLA Sacc. Tab. Com. Gen. Fung. 11. 1898

This name was proposed as a substitute for *Hydnochaete* Peck and is therefore based on *H. setigera* Peck.

53. ECHINODONTIUM Ellis & Everh. Bull. Torrey Club, **27**: 49. 1900

This genus was established on the single species, *Fomes tinctorius* E. & E.

SUMMARY

To sum up then, we have the following names for the genera of the Hydnaceae with their synonyms. It is probable that several of these will be reduced to synonymy when a proper arrangement of the groups is obtained.

Names free to be used are in full face; synonyms in Roman; the species with which the generic name is to be permanently associated follows the date in Italics.

Acia Karst. 1879, name preoccupied.
Amaurodon Schroet. 1889. *Sistotrema viride* Alb. & Schw.
Asterodon Pat. 1894. *A. ferruginosum* Pat.
Auriscalpium S. F. Gray, 1821. *Hydnum Auriscalpium* L.
  Auriscalpium Karst. 1879. *A. vulgare* Karst. = *Hydnum Auriscalpium* L.
Caldesiella Sacc. 1879. *C. italica* Sacc.
Calodon Quel. 1878. *Hydnum suaveolens* Scop.
  Hydnellum Karst. 1879. *Hydnum suaveolens* Scop.
Climacodon Karst. 1881. *Hydnum septentrionale* Fr.
Creolophus Karst. 1879. *Hydnum corrugatum* Fr.
Dentinum S. F. Gray, 1821. *Hydnum repandum* L.
  Tyrodon Karst. 1881. *Hydnum repandum* L.
Dryodon Quel. 1878 = Hericium.
Echinodontium Ell. & Ev. 1900. *Fomes tinctorius* Ell. & Ev.
Etheirodon gen. nov. *Odontia fimbriata* Fr.
  Odontia Fr. 1836–8. *O. fimbriata.*
Friesites Karst. 1879 = Hericium.
Gloiodon Karst. 1879. *Hydnum strigosum* Sw.
  Sclerodon Karst. 1889. *Hydnum strigosum* Sw.
Grammothele Berk. and Curt. 1869. *G. lineata.*
Grandinia Fr. 1836–8. *G. polycocca.*
Grandiniella Karst. 1895. *Gr. livescens.*
Hericium Pers. 1794. *Hydnum coralloides* Schaef.
  Dryodon Quel. 1878. *Hydnum umbellatum* March.
  Friesites Karst. 1879. *Hydnum coralloides* Schaef.
Hericium Fr. 1825; name untenable.*
Hydnellum Karst. 1879 = Calodon.
Hydnellum Karst. 1896; name preoccupied.
Hydnochaete Bres. 1896. *H. badia.*
Hydnochaete Peck, 1897 = Hydnochaetella.
Hydnochaetella Sacc. 1898. *Hydnochaete setigera* Peck.
  Hydnochaete Peck, 1897. *H. setigera.*
Hydnum L. 1753. *H. imbricatum.*
  Sarcodon Quel. 1878. *Hydnum imbricatum* L.
Hydnum Quel. 1878; name preoccupied.

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* The species are doubtful and do not warrant a substitution.

Irpex Fr. 1828. *Sistotrema pendulum* Alb. & Schw.
  Radulum Fr. 1825. *Sistotrema pendulum* Alb. & Schw.
Kneiffia Fr. 1836–8 = Neokneiffia.
Kneiffiella Karst. 1889. *Hydnum barba-Jovis* Bull.
Kneiffiella Underw. 1897 = Neokneiffia.
Kneiffiella Henn. 1898 = Neokneiffia.
Leptodon Quel. 1886 = Pleurodon.
Lopharia Kalch. & MacOwan 1881. *L. lirillosa.*
  Thwaitesiella Massee 1892. *Radulum mirabilis* B. & Br.
Mucronella Fr. 1874. *Hydnum calvum* Alb. & Schw.
  Mucronia Fr. 1849. *Hydnum calvum* Alb. & Schw.
Neokneiffia Sacc. 1898. *Thelephora aspera* Pers.
  Kneiffia Fr. 1836–38. *Thelephora aspera* Pers.
  Kneiffiella Underw. 1897. *Thelephora aspera* Pers.
  Kneiffiella Henn. 1898. *Thelephora aspera* Pers.
  Pycnodon Underw. 1898. *Thelephora aspera* Pers.
Odontia Pers. 1794. *O. ferruginea.*
  Phaeodon Schroet. 1888. *Odontia ferruginea* Pers.
Odontia Fr. 1836–8; name preoccupied.
Odontinia Pat. 1887. *Hydnum denticulatum* Pers.
Phaeodon Schroet. 1888 = Odontia Pers.
Phellodon Karst. 1881. *Hydnum nigrum* Fr.
Phlebia Fr. 1821. *Merulius merismoides* Fr.
Pleurodon Quel. 1878. *Hydnum occidentale* Paul.
  Leptodon Quel. 1886. *Hydnum occidentale* Paul.
Pycnodon Underw. 1898 = Neokneiffia.
Radulum Fr. 1825 = Tylodon.
Sarcodon Quel. 1878 = Hydnum.
Sistotrema Pers. 1794. *Hydnum sublamellosum* Bull.
Sclerodon Karst. 1889 = Gloiodon.
Steccherinum S. F. Gray, 1821. *Hydnum ochraceum* Pers.
Thwaitesiella Mass., 1892 = Lopharia.
Tylodon gen. nov. *T. Friesii.*
  Radulum Fr. 1830. *R. pendulum* (*cf.* page 440).
Tyrodon Karst. 1881 = Dentinum.
Xylodon S. F. Gray, 1821. *Sistotrema quercina* Pers.

CALIFORNIA, PA.

Mycological Notes and new Species

BY C. L. SHEAR

FUSICLADIUM FASCICULATUM C. & E. Grevillea, **6**: 88. Mr. 1878

A careful study and comparison of authentic specimens of this species, issued by Ellis in North American Fungi no. 545, with *Scolecotrichum euphorbiae* Tracy & Earle, Bull. Torrey Club, **23**: 209. May 1896, as represented in the herbarium of the Department of Agriculture by specimens marked "type material" and sent by Tracy and Earle shows that they are the same species. Both are on stems and leaves of *Euphorbia*. The form on stems, N. A. F. 545, appears more effuse than that on leaves, Fungi Col. 380, which is identical with the Tracy & Earle material. The conidia vary considerably in size. The effuse form, N. A. F. 545, has conidia 9–16 × 5–7 μ. Tracy & Earle's specimen has somewhat larger conidia, varying from 13–22 × 6–8 μ. As pointed out by Tracy & Earle this is not a typical *Scolecotrichum* in the sense in which the genus is defined by Saccardo. What the typical *Scolecotrichum* of Kunze & Schmit, Myc. Heft **1** : *pl. 1. f. 5.* 1817, is does not, however, seem very clear. It is a monotypic genus, the authors having referred to it only one species, *S. virescens*, which is rather indefinitely described and poorly figured. Unless specimens of the type are extant it is doubtful whether the genus can stand.

The plant under discussion belongs however, to the group to which this generic name is at present applied rather, than to *Fusicladium* and unless there is an older tenable name should be designated **Scolecotrichum fasciculatum** (C. & E.).

LACHNUM ENGELMANNI Tracy & Earle, Pl. Bak. **1**^{1}: 25. 1901

An examination of this species as represented by type material (no. 1058 Baker, Earle & Tracy on *Picea Engelmanni*, La Plata Mts., Colo.) seems to indicate that it is identical with *Peziza* (*Dasyschyphae*) *arida* Phill. Grevillea, **5**: 117. *pl. 89. f. 13.* 1877.

We have had no opportunity to examine type material of Phillips' species, which was collected by Harkness & Moore on pine bark in the Sierra Nevada mountains, but his description and plate agree so closely with these specimens and with other material determined by Ellis and Rehm that there seems little doubt about the matter. Ellis issued the species (no. 1246 N. A. F. on bark of *Abies Menziesii* from Colorado) as *Peziza fuscosanguinea* Rehm, but Dr. Rehm does not regard it as his species. The typical plant, so far as agreement with Phillips' description and figure goes, was issued by the writer in F. Col. no. 1414. It was collected in the Powder River Mountains of eastern Oregon, growing abundantly on the bark of recently cut pines. The plant is rather frequent on bark of various dead conifers in the West, especially in subalpine regions.

Cryptoporus gen. nov.

Cryptoporus Peck as a section of *Placodermei* of the genus *Polyporus*, Bull. Torrey Club, **7**: 104. Oct. 1880.

The type of the genus is **Cryptoporus volvatus** (Peck). *Polyporus volvatus* Peck, Rep. N. Y. St. Mus. **27**: 98. *pl. 2. f. 3–6.* 1875.

Three varieties were described by Professor Peck, only one of which appears to us of varietal importance, **Cryptoporus volvatus Torreyi** (Ger.). *Polyporus volvatus Torreyi* Gerard, Bull. Torrey Club, **7**: 104. *f. 1–3.* O. 1890.

This fungus is so different from any other *Polyporus*, especially in the thick volva-like extension of the margin of the pileus which covers the pores with the exception of a small circular aperture, as to deserve in our opinion generic rank. Professor Peck, *l. c.*, has given a very full description of the fungus to which we need only add the following extension of range and new hosts:

Vicinity of Washington, D. C., on *Pinus Virginiana*, collected by the late G. H. Hicks, also by the writer.

Grand Lake, Colorado, on *Pinus contortus Murrayana*, no. 1107, Shear & Bessey.

Blue Mountains, Oregon, on undetermined conifer, collected by the writer, 1899.

Secotium Arizonicum Shear & Griffiths sp. nov.

Peridium subglobose to subpyriform, pale yellowish-white, smooth, 2–4 cm. high × 1.5–3 cm. in diameter, rather thin and fragile when dry, sessile or occasionally very short stipitate, rupturing more or less irregularly in longitudinal slits from the apex; columella not well developed, usually not reaching the apex of the peridium; gleba composed of closely anastomosing thin plates forming more or less elongated longitudinal cells, pale sulphur yellow when dry, becoming slightly brownish at maturity; spores spherical or subspherical, pale creamy white, smooth, guttulate, 8–12 μ diam., frequently with a very short pedicel.

Type no. 1630, D. Griffiths, mesa near Tucson, Arizona, Sept. 1900. Type material also distributed in Griffiths, West American Fungi, no. 323.

This species seems more nearly related to *S. Warnei* Pk. than any other known species. It differs, however, in its much smaller size, different mode of dehiscence and lighter colored peridium and gleba, as well as in the poorly developed columella which appears to but rarely, if ever, reach the apex of the peridium and is sometimes almost or quite lacking.

Scleroderma pteridis sp. nov.

Peridium globose or depressed-globose, sessile, sordid white or faintly yellowish, irregularly squamose, fibrose-radicate, 3–6 cm. diameter; wall 3–8 mm. thick, separating from the gleba in drying; gleba firm, somewhat indistinctly areolate, purplish-brown; columella none; spores irregularly globose, purplish-brown, roughened with short spines, 6–8 μ diameter.

Growing attached to dead rhizomes of *Pteris aquilina* in the side of a recent excavation, two to four feet below the surface and embedded in the earth.

Type no. 1115 collected by the writer, wagon road near Baker Creek, six miles west of McMinnville, Oregon, July, 1899.

The plant seems most nearly related to *Scleroderma Geaster*. None of the specimens were entirely mature so that the method of dehiscence is uncertain; but the peridium is much thicker and the spores smaller and lighter colored than in *S. Geaster*. The plant is remarkable on account of its subterranean habit and its connection with the rhizomes of *Pteris*.

Cucurbitaria celtidis sp. nov.

Perithecia .35–.5 mm. in diameter, densely gregarious or subcespitose, covering continuous areas of dead branches, erumpent or partially immersed in the bark, depressed globose, carbonaceous, somewhat granular roughened, frequently partially collapsed, provided with a papilliform ostiolum; asci cylindric, short-stipitate or subsessile, 140–180 × 16 μ; sporidia uniseriate, overlapping somewhat, hyaline at first then yellowish and finally dark brown, with 3–5 transverse septa and one longitudinal septum, slightly constricted at the septa, 24–27 × 8 μ; paraphyses branched above, equally or exceeding the asci and about 3 μ in diameter.

Type material, no. 383, collected by the writer on dead branches of *Celtis occidentalis*, Osborne, Kansas, March, 1894. The plant is scarcely a typical *Cucurbitaria* and was at first referred to *Teichospora*, but I have referred it to the former genus in deference to the opinion of Dr. Rehm to whom specimens were submitted.

Fusicladium robiniae sp. nov.

Hypophyllous or sometimes amphigenous; spots reddish-brown, usually numerous, scattered, .5–1.5 mm. diam., circumscribed by a darker, reddish-brown, slightly elevated line; tufts of fertile hyphae small, rather dense, arranged in small groups; hyphae light chestnut-brown, slightly flexuous, irregular toward the apex, mostly non-septate, 100–130 × 2–3.5 μ diam.; conidia clavate-fusiform, light-brown, uniseptate, very slightly constricted, one cell slightly larger than the other, 20–30 × 4–5 μ.

On living leaves of *Robinia pseudacacia*, Glen Sligo near Takoma Park, D. C. Type material, no. 935, Mr. & Mrs. C. L. S., May 3, 1899, deposited in herbarium U. S. Dept. of Agriculture, and to be distributed in Fungi Columbiana, Century XVII.

The affected leaves soon turn yellow and fall. The fungus proved quite destructive to the foliage on several trees in the locality mentioned.

Illosporium conicolum E. & E. sp. nov.

Sporodochia yellowish-rose color, minute, 75–80 μ diameter, globose and sessile by a short, stipe-like base; conidia globose-conic, hyaline, 6–8 μ diam., forming a continuous superficial layer borne on obscure, short, thick, conglutinated hyphae hardly distinguishable from the conidia.

Issued in Ellis & Everhart, Fungi Columbiana, no. 1497. On scales of pine cones (*Pinus Virginiana*), Takoma Park, D. C., December, 1899, and March, 1902. C. L. Shear. The above description is supplied by Mr. Ellis.

Allied to *Illosporium coccinellum* Cooke.

Phragmidium Andersoni sp. nov.

I. and II. not seen. III. Sori amphigenous, slightly pulvinate, yellowish, scattered, sparse or abundant, 200–400 μ diameter; teleutospores oblong-cylindric, densely tuberculate-roughened, nearly black and opaque when mature, 60–75 × 32–34 μ, 2–4-septate; septa convex; apex with a small, blunt, nearly hyaline papilla which is occasionally obscure; pedicel colorless, 60–105 μ long, the lower half with an oblong or elliptical rugulose roughened fistulose enlargement 15–20 μ diameter.

Type material no. 319 Griffiths, West American Fungi on *Potentilla fruticosa*, Big Horn Mts., Wyoming, Williams & Griffiths, August, 1898. Other specimens examined: No. 137 Anderson, Parasitic Fungi Mont. Upper Sand Coulee, Mont., August, 1888, on *Potentilla fruticosa* Myc. Herb. Dept. of Agriculture and no. 319a Griffiths, West Amer. Fungi. Collected on same host by C. L. S. & E. A. Bessey, no. 988, near Grand Lake, Colo.; also no. 1201 Merrill & Wilcox, Jackson, Wyo., 1901. This was first collected, so far as I know, by my late lamented friend, F. W. Anderson, whose name I have associated with it. It appears quite different from any of the species heretofore described on *Potentilla* but seems related to *P. rubi*, especially in the character of the pedicel.

Aecidium atriplicis sp. nov.

Spermagonia not seen.

Pseudoperidia hypophyllous, thickly and mostly evenly scattered over the surface, .5–1 mm. long, 240–320 μ diameter, closely surrounded at the base by the ruptured epidermis; margin coarsely crenate-dentate; cells mostly irregularly pentagonal, 20–30 μ diameter, densely reticulate-ridged, appearing densely and minutely papillate with low magnification; spores smooth, yellowish, irregularly globose, 20–24 μ diameter.

On leaves of *Atriplex Nuttallii*, Montrose, Colo. Type no. 975, C. L. S., July, 1897. Type material, Griffiths, West American Fungi, no 321. The fungus attacks almost or quite every leaf of the plants affected, making them dwarfed and stunted so that they produce little or no inflorescence. The leaves are about normal in appearance on the upper surface, but slightly thickened and below the normal in size.

Aecidium zephyranthis sp. nov.

Spermagonia sordid yellowish, occupying circular yellowish spots 1–2 mm. in diameter; spermatia globose or subglobose, 2–3 μ diameter.

Pseudoperidia amphigenous, crowded in 1–4 irregular circular series about the spermagonial spots, short with white torn edges, 200–300 μ diameter, cells irregularly quadrangular or pentagonal, 21–35 μ diameter, closely reticulated, appearing densely and minutely papillate under ordinary magnification; spores yellowish, smooth, irregularly globose, 18–25 μ diameter.

On leaves of *Zephyranthes* sp. near Tlalpam, Valley of Mexico, Mexico, Dr. J. N. Rose, no. 5478, July 15 ,1901. With a $\frac{1}{8}$- or $\frac{1}{6}$- in. objective the cells of the pseudoperidia appear papillate but with a $\frac{1}{12}$- oil immersion the surface is seen to be densely reticulate-ridged.

Diatrypella rimosa sp. nov.

Stromata scattered or somewhat gregarious, erumpent, mostly elliptical, sometimes suborbicular, white within, 1–3 mm. long mostly 2 mm., slightly constricted at the base, closely surrounded by the ruptured epidermis and a black circumscribing line which reaches to the wood leaving a whitish scar when the bark is removed; disk plane or slightly convex, nearly smooth except for the slightly prominent indistinctly 4-sulcate ostiola, transversely rimose; perithecia 5–15, monostichous, ovate or angular by mutual pressure; asci elongate-clavate, long-stipitate, paraphysate, 90–135 × 6–7 μ (p. sp. 60–70 × 6–7); paraphyses numerous, slender, multiguttulate, longer than the asci; sporidia numerous, yellowish-brown in mass, slightly curved, 5–7 × 1.5 μ.

Type material on *Alnus* sp., Wallowa Lake, Oregon, no. 980, C. L. S., 1899, distributed in Griffiths, West American Fungi, no. 320. Apparently most nearly related to *D. discoidea alni* Cooke. but differs in having the surface of the disk almost pure black, the ostiola less conspicuous and not so distinctly stellate, and also in its rimose character.

From *D. tocciaeana* it differs in the form and color of the stroma, the stroma being contracted at the base instead of enlarged. From *D. verrucaeformis* it differs in its more regular, smoother, darker and rimose stroma and less conspicuous and less regular ostiola as well as in the measurements of the asci.

Pleomassaria magnoliae sp. nov.

Perithecia gregarious, seated on the inner bark and permanently covered by the slightly pustulate epidermis, depressed spherical or sublenticular, thick-walled, coriaceo-carbonaceous, 600–800 μ diam., with a small conical ostiolum which just pierces the epidermis; asci clavate, very short-stipitate, 8-spored, 195–230 × 55–60 μ; paraphyses filiform; sporidia inordinate, mostly massed near the apex of the ascus, oblong-ovate, constricted below the middle, at first hyaline and 3–6-septate, then olivaceous and muriform-septate, finally deep brown, enclosed in a hyaline envelope, 66–78 × 21–23 μ exclusive of envelope.

On dead *Magnolia obovata*, cultivated on grounds of the Dept. of Agriculture from China and Japan, March 12, 1902. Type material, C. L. S. no. 1035 and Fungi Col. Century XVII.

Associated with *Camarosporium magnoliae* Shear of which it may be the mature form.

Camarosporium magnoliae sp. nov.

Perithecia same as in *Pleomassaria magnoliae* but slightly smaller; sporules subglobose to clavate, at first hyaline, becoming deep olive-brown and densely muriform-septate at maturity, subsessile, body elliptic with a short basal prolongation which is 2–3-septate, 100–112 × 28 μ; paraphyses rather stout, septate, 45–70 × 7–8 μ.

On dead *Magnolia obovata* associated with *Pleomassaria magnoliae*, U. S. Dept. of Agriculture Grounds, Washington, D. C., March 12, 1902, C. L. S., no. 1034.

Members of this genus have been regarded as pycnidial forms of *Pleomassaria* but this has not been demonstrated by cultures so far as I know. The perithecia of the two forms described above are so nearly identical that it seems probable that the asci are developed in the same perithecia as the sporules.

Haplosporella rhizophila sp. nov.

Stromata .5–1.5 mm. in diam., gregarious or crowded, erumpent, pulvinate-verrucose, deep brownish-black, carbonaceous, somewhat pulverulent, rather regular in outline and somewhat contracted at the base which is closely surrounded by the bark; cells of the stroma 2–10, monostichous, very irregular in size and shape, partitions membranous, composed of light olivaceous hyphae; ostiola inconspicuous, plane or slightly prominten; sporules oblong-elliptic, frequently inequilateral, deep olivaceous, brown, 15–21 × 6–8 μ, usually uniguttate; sporophores less than the length of the sporules; paraphyses abundant in mature plants, very variable in length but much exceeding the spore, 2–2.5 μ in diameter.

Type on dead, exposed roots of *Ulmus* sp., Lincoln, Neb., no. 981. C. L. Shear, March 30, 1895. Type material deposited in the Myc. Herb. U. S. Dept. of Agriculture.

In a poorly developed condition the stroma is very small and almost simple, suggesting *Sphaeropsis* but examination shows that this is an abnormal, aborted state. The cells of the stroma do not all appear to be entirely distinct but some seem to connect with each other. The spores of this are almost identical with those of *Sphaeropsis ulmea* Ell. & Barth. with type material of which I have been able to compare it through the kindness of Mr. Bartholomew. There is no resemblance between the two plants in other respects however.

PESTALOZZIA GUEPINI **vaccinii** subsp. nov.

Sporules elliptic to oblong-elliptic, somewhat inequilateral. usually 4-septate, 21–24 × 8–9 μ. the three central cells dark colored, usually guttulate with the septum below the upper one darker colored than the others; apical setae 3–4, 22–35 μ long; basal seta 6–12 μ. The fungus forms no spots on the leaves but develops evenly over the surface of the yellow fallen leaves, apparently preferring the lower surface.

Type no. 1146, on dead leaves of *Vaccinium macrocarpon* kept in a moist chamber in the laboratory for about a week. Plants from which the leaves were taken were collected at Parkdale, N. J., by the writer.

This plant has apparently been referred heretofore to *P. guepini*, Desm. Ann. Sci. Nat. Bot. 2d Ser. 3: 182. *t. 4. f. 1–3.* 1848. It agrees fairly well in many respects with the description and figures of that species but differs decidedly from the specimens issued in the exsiccatae at hand. Hosts are given by Desmazierès (*l. c.*) as follows: "Habitat in foliis siccis Camelliae et Magnoliae" and his Pl. Crypt. fasc. XXII. is cited as containing a specimen. Specimens on *Camellia Japonica* from three different collections (no. 150 Briosi & Cavara, Fun. Par. Pia. Col. no. 974; Saccardo Myc. Ven. and an unnumbered specimen from G. W. Clinton, Buffalo, N. Y.) agree well with each other and are well represented by the figure accompanying Briosi & Cavara's specimens.

The spores are however quite different from those figured by Desmazierès. The leaf figured by him appears to be that of *Camellia* rather than *Magnolia*, but the spores may possibly have been figured from the specimen on *Magnolia* to which he refers in his description.

No. 553 Rav. Fun. Amer. on persimmon (*Diospyros*) and 526 E. & E. N. A. F. on *Camellia Japonica* were distributed under this name but the material in the Department herbarium is old and poor, showing no spores.

Whichever may prove to be the type of Desmazierès' species, we believe the plant we have is sufficiently characteristic to deserve recognition as a variety at least. The fungus appears abundantly on apparently healthy leaves after they have been dampened and kept in a moist chamber for a week or ten days.

Plectrothrix gen. nov.

Sterile hyphae creeping, scanty; fertile, erect scattered with more or less irregularly arranged spinose branches near the apex; conidia globose, hyaline, borne singly on the tips of the branches.

This appears most nearly related to the genus *Monosporium* Bon., as treated by Saccardo, but differs in the much simpler fertile hyphae with the peculiar spur-like branches, to which the name refers. The type of the genus is

Plectrothrix globosa sp. nov.

Evenly effused or slightly tufted; sterile hyphae, scanty, hyaline or subhyaline or subhyaline, septate; fertile hyphae, erect, evenly scattered over the matrix or sometimes in small groups, 3–5-septate, hyaline or slightly colored toward the base, 250–350 × 3–4 μ, apex acute with 3–9 short, conical or spur-like branches, which are usually not longer than the diameter of the spores; the lower sometimes prolonged and dichotomous at the tip; conidia globose, hyaline, 15–20 μ diam., contents homogeneous.

On leaves of *Vaccinum macrocarpon* kept in a moist chamber in the laboratory, Dept. of Agriculture, Washington, D. C. Type material no. 1108, C. L. S. in Myc. Herb. U. S. Dept. Agriculture. This fungus followed regularly the appearance and maturity of *Pestalozzia guepini vaccinii* on cranberry leaves kept in a moist chamber from one to two weeks.

BUREAU OF PLANT INDUSTRY, U. S. DEPT.
AGRICULTURE, WASHINGTON, D. C.

Studies in North American Discomycetes. II. Some new or noteworthy Species from central and western New York

BY ELIAS J. DURAND

My studies in the Discomycetes extending over several years have brought to light many interesting forms which it is my plan to discuss in this and future papers. Many of these undoubtedly represent undescribed species, while others present such interesting features of already known species that notes upon them will, it is hoped, lead toward a better understanding of our discomycete flora. I wish especially to acknowledge my indebtedness to Dr. H. Rehm, whose work upon the Discomycetes of central Europe will long remain a model for workers elsewhere; and of whose kindly assistance and critical opinions, always so freely extended, I have constantly availed myself.

ASCOBOLUS ATRO-FUSCUS Phil. & Plow. Grevillea, **2** : 186. *pl. 24. f. 1.* 1874

A. viridis Boud. Ann. Sci. Nat. V. **10** : 217. *pl. 5. f. 4.* 1869. (Not Currey.)

A. carbonicola Boud. Bull. Soc. Bot. Fr. **24** : 310. 1877.

Phaeopezia Nuttallii E. & E. N. A. F. no. 2908. (Nomen ined.)

EXSICC.: Phil. Elv. Brit. no. 47 ; E. & E. N. A. F. no. 2908.

Ascomata scattered, sessile, at first spherical and closed, later expanding, becoming orbicular, flattened and scutellate, sometimes contorted, often attached to the substratum by white mycelial threads, 1–10 mm. in diameter; when fresh yellow or greenish-yellow, but in drying and at maturity the disk becomes yellowish-brown, finally dark chestnut or almost black, and papillate from the projecting asci. The exterior usually remains yellowish-brown and furfuraceous, with the margin slightly inrolled. Excipulum parenchymatous throughout, composed of irregularly rounded cells of variable size, 15–50 μ in diameter, the ectal ones projecting from the surface in groups. Hypothecium rather sharply differentiated, cells small, not more than 10 μ in diameter. Hymenium about ⅓ the total thickness of the cup at the base. Asci clavate-cylindrical, apex rounded and blue with iodine, 150 × 12–15 μ; spores

8, brown, minutely verrucose, broadly elliptical, 18–25 × 9–15 μ; paraphyses numerous, longer than the asci, hyaline, septate, filiform, curved or circinate, sometimes irregularly knobbed at the apex, imbedded in a greenish-yellow jelly.

On burnt wood and soil, New York, *Durand*, nos. 984, 985, 994, 992; W. Virginia, *Nuttall.* Reported also from California, on dung, *Harkness & Moore*, and from Nebraska, on wet sandy ground, *Clements.*

This species was described from specimens collected in England, on charcoal beds. It has been found elsewhere in similar situations in France, Germany and Switzerland. In September, 1900, it was my good fortune to find numerous plants of this species growing in a burnt-out swamp, near Canandaigua, N. Y. The ascomata were in all stages of development, and were attached to burnt wood and adjacent burnt soil. The above description was drawn from fresh plants. I have compared the specimen in N. A. F. no. 2908 with that in the Elv. Brit. no. 47, in my herbarium, and find them identical.

DETONIA FULGENS (Pers.) Rehm; Rab. Krypt. Flora, **1**^{3}: 1269. 1896

Peziza fulgens Pers. Myc. eur. **1**: 241. 1822.

Pseudoplectania fulgens Fckl. Symb. Myc. 324. 1869.

Otidella fulgens (Pers.) Sacc. Syll. Fung. **8**: 99. 1889.

Barlaea fulgens (Pers.) Rehm, Rab. Krypt.-Flora, **1**^{3}: 930. 1894.

Plants usually solitary but occasionally clustered, nearly sessile or with a short thick stem, attached by a yellowish mass of mycelial threads to the soil which it binds together. Ascomata cup-shaped, bowl-shaped, or rarely spread out flat, usually with the margin slightly incurved, commonly regular but often contorted or split at the margin, 0.5–2.5 cm. in diameter; disk clear yellow or orange-yellow, externally yellow at first but becoming greenish, finally yellowish-olive, smooth or pruinose. Excipulum entirely parenchymatous, cells small, the cortical ones rounded, 10–20 μ in diameter, the medullary ones elongated and irregular, showing their hyphal origin. Hymenium about ¼ the total thickness of the cup below. Asci narrowly clavate-cylindrical, apex rounded, not at all blue with iodine, 125–150 × 9–10 μ; spores 8, uniseriate or subbiseriate, hyaline, smooth, globose, 5–8 μ in diameter. Paraphyses slender, filled with orange granules above.

Fine specimens of this beautiful species were collected at Ithaca during the week of May, 1901 (Herb. Cornell, no. 5807). The locality was low warm beech woods, where the plants grew on the bare soil among leaves, or in clumps of moss, or rarely on fragments of rotten wood.

Saccardo established the genus *Otidella* for this species on account of its irregular form and spherical spores. In other words it was a spherical-spored *Otidea*. An examination of fresh material shows that the irregularity of mature plants is certainly not sufficiently constant or peculiar to serve as a basis for generic distinction.

Good illustrations are given by Cooke, Mycogr. *pl. 53. f. 209;* by Gillet, Disc. franc. *pl. 38;* and by Weberbauer, Pilze Nord-Deutschl. *pl. 3. f. 1.*

Hitherto reported from this country only from Deerfield, Mass., and Yosemite Valley, Cal., *Harness & Moore.*

CIBORIA LUTEOVIRESCENS (Rob.) Sacc. Syll. Fung. **8**: 206. 1889

Peziza luteovirescens Rob. Ann. Sci. Nat. III. **8**: 188. 1847.

Peziza pallidovirescens Phil. Grevillea, **6**: 24. 1877.

Hymenoscypha luteovirescens (Rob.) Phil. Man. Brit. Disc. 121. 1887.

EXSICC.: Phill. Elv. Brit., no. 122.

Plants solitary, stipitate; ascomata plane with a slight margin, waxy-membranous, about 2 mm. broad, narrowed below to a long, slender, flexuous stem, 0.5–2 cm. long, tapering downward; whole plant greenish-sulfur-yellow when fresh. Cortex parenchymatous, cells rounded or polygonal, 12–15 µ in diameter. Medullary portion composed of slender hyphae loosely interwoven. Flesh of the cup greenish-yellow when crushed. Asci clavate-cylindrical, apex rounded, becoming deep blue with iodine, 135–145 × 9–10 µ; spores 8, obliquely uniseriate, hyaline, continuous, smooth, elliptical, occasionally slightly unsymmetrical, 12–16 × 5–6 µ; paraphyses filiform, slightly thickened above, somewhat longer than the asci.

On partly buried petioles lying on the ground among leaves under beech trees, Churchville, N. Y., October 26, 1901.

My plants agree with Phillips's specimens in every way except that the cups are smaller. This was also true of the German specimens described by Rehm. The length of the stem varies with the depth under ground of the petiole from which it springs. If the latter is on the surface the stem may be very short.

Not previously reported from America.

Ciboria sulfurella (E. & E.) Rehm, *in litt.*

Helotium sulfurellum E. & E. Bull. Torrey Club, **10**: 98. 1883.

EXSICC.: Ellis, N. A. F., no. 1275.

Plants solitary, stipitate, ascoma at first vitelline- or sulfur-yellow, but on drying the disk becomes dark ochraceous, finally dark chestnut-brown or almost black, at first globose and closed, then expanding and becoming plane with a slight margin, waxy-membranous in texture, 1–4 mm. in diameter; exterior yellow, becoming chestnut, paler than the disk, furfuraceous and longitudinally striate; stem 1 mm. to 3 cm. long, slender and flexuous, tapering downward, darker and thinly tomentose below; cortex parenchymatous, cells about three times as long as broad, those of the sides and margin of the cup rounded, about 10 μ in diameter; medullary portion of the stem and cup of slender, loosely interwoven hyphae; tomentum of slender threads, 4 μ in diameter. Asci evenly clavate, apex slightly narrowed, rounded, becoming pale blue with iodine, 75–90 × 8–10 μ; spores 8, obliquely uniseriate or irregularly biseriate above, hyaline, smooth, continuous or possibly becoming --septate at maturity, elliptical, navicular, 9–15 × 4–6 μ; paraphyses filiform. Flesh of the cup chestnut-brown when crushed.

On partly buried petioles of *Fraxinus*, West Chester, Pa.; not uncommon in central and western New York, in autumn, occurring in moist woods, ravines and swamps where the host abounds. (Herb. Cornell, nos. 5635, 5716). In my experience the species is confined to ash petioles, but Clements reports it as growing on dead limbs in Nebraska.

Ciboria sulfurella is a very distinct species, resembling *C. luteovirescens* in form, size and habit, but differing in the color, in the strongly furfuraceous exterior and smaller asci. There is never any shade of green about the present species, but the ochraceous and chestnut tones are the ones most often met with. The color of the crushed flesh is quite different in the two species.

Ciboria Americana sp. nov.

Plants solitary, stipitate; ascomata cup-shaped, usually becoming plane, or with the margin reflexed and umbilicate, thin, waxy-membranous, pale cinnamon to brown, 3–10 mm. in diameter;

stem 2–10 mm. long, slender, darker below, with the exterior of the cup delicately furfuraceous. Cortex very thin, of polygonal cells, 8–10 μ in diameter, projecting in groups from the sides of the cup and upper part of the stem making the exterior furfuraceous. Toward the base of the stem the cells are prolonged into short hairs, 4 μ in diameter. Hypothecium parenchymatous, cells rounded, 6–10 μ in diameter. Medullary part of the stem and cup of slender hyphae loosely interwoven. Asci clavate, usually curved, about 75 × 9 μ, apex rounded, not blue with iodine; spores 8, biseriate, hyaline, smooth, continuous, eguttulate, elliptical or ovate-elliptical, slightly unsymmetrical, 9–12 × 4–5 μ; paraphyses filiform.

On the inside of decaying involucres of *Castanea vesca*, lying on the ground among leaves. Not uncommon in Coy Glen and Enfield Ravine, in the vicinity of Ithaca, N. Y., October, 1901. (Herb. Cornell, nos. 7942 and 7950, the latter the type.)

This species resembles *Ciboria* (or *Rutstroemia*) *echinophila* (Bull.) Sacc. in size, color, habit and habitat, but differs from it in the smaller spores (in the latter "12–22 × 4–5 μ," Phillips; "16–21 × 5 μ," Massee), which are not strongly curved, and which never, so far as observed, become septate. *C. echinophila* has been reported in America only by Schweinitz, from Bethlehem, Pa., and his specimen may possibly have belonged to the present species. It may be that *C. Americana* will prove to be the American representative of the European *C. echinophila*.

Sclerotinia smilacinae sp. nov.

Plants scattered on gregarious, long-stipitate; sclerotia small, 1–2 mm. in diameter, irregularly spherical, aggregated and sometimes coalesced into a thin crust-like mass 1–2 cm. in diameter; ascoma fleshy-leathery, closed and spherical at first, expanding to cup-shaped, finally becoming campanulate, usually with a depression in the center, sometimes contorted or irregular, .75–3 cm. in diameter, bright cinnamon-brown, externally smooth; stem 2–6 cm. long, 2–3 mm. thick, tapering downward, somewhat tomentose below. Cortex parenchymatous, cells irregular, 10–30 μ in diameter; hypothecium and medullary portion composed of slender hyphae loosely interwoven. Asci narrowly cylindrical, apex rounded, slightly blue with iodine, 120–140 × 6–8 μ; spores 8, obliquely uniseriate, hyaline, continuous, biguttulate, smooth, narrowly elliptical, 12–15 × 4–5 μ; paraphyses scarce, filiform, but little thickened above.

Attached to decaying rhizomes of *Smilacina racemosa*, buried in rich humus, Fall Creek, Ithaca, N. Y., May 13, 1901 (Herb. Cornell, no. 5945).

The plants are usually aggregated, a half-dozen springing from a single rhizome. The sclerotia are so small as to be easily overlooked, and seem ridiculously small for so large a plant.

The spores germinate readily in nutrient agar made up with a decoction of *Smilacina* rootstocks. The spores do not become septate at germination. One or two germ-tubes are produced which branch profusely but do not throw off conidia. Cultures on agar and on sterilized rootstocks produced the minute sclerotia in great numbers.

This species resembles *S. tuberosa* (Hedw.) Fckl. very closely, but differs in the sclerotia, which in the latter are large and tuberous, in the method of germination of the spores and in the host plant. The latter species is said to grow always in connection with the rhizomes of *Anemone nemorosa.*

CYATHICULA MARCHANTIAE (Sommf.) Sacc. Syll. Fung. **8**: 307. 1889

Peziza marchantiae Sommf. Sup. Fl. Lap. 295. 1826.

Ascomata solitary, turbinate, sessile or with a short, thick stem substance fleshy-waxy, thin, translucent, pallid-white usually with a pale lilac tint, 0.5–2 mm. in diameter; disk plane or saucer-shaped, the margin ornamented with ciliate teeth composed of bundles of narrow cells. Excipulum parenchymatous, cells polygonal, 15–18 μ in diameter. Asci clavate-cylindrical, not conspicuously narrowed below, apex rounded, not blue with iodine, 60–75 × 6–8 μ; spores 8, 1–2-seriate, hyaline, contiguous, smooth, ovate-elliptical, 8–10 × 4 μ, minutely 2-guttulate; paraphyses filiform, flexuous, exceeding the asci.

On living *Marchantia polymorpha*, Six-mile Creek, Ithaca, N. Y., November 3, 1901 (Herb. Cornell, no. 8513).

The ascomata usually spring from the margin of the thallus, or sometimes from the summits of the gametophores. One cannot, of course, be certain that this is Sommerfelt's species, but it corresponds fully with the brief description given in Saccardo's Sylloge. This in connection with the peculiar habitat renders it quite probable that ours is the form Sommerfelt had in mind. If this is true we have the interesting fact of the occurrence, in New

York State, of a species which has not been found before since its original discovery, in northern Europe, more than sixty years ago.

LACHNUM INQUILINUM (Karst.) Schroet. Krypt.-Fl. Schl. 3^2: 96. 1893

Helotium inquilinum Karst. Myc. Fenn. I. 147. 1871.

Lachnella inquilina Karst. Rev. Monog. 132. 1885.

Trichopeziza inquilina (Karst.) Sacc. Syll. Fung. 8: 424. 1889.

Pezizella inquilina (Karst.) Rehm, Rab. Krypt.-Fl. 1^3: 675. 1892.

Ascomata scattered or gregarious, each with a short but distinct stipe, at first spherical and closed, later becoming plane with the margin upturned, when dry cupulate with the margin inrolled, 0.3–0.5 mm. in diameter, entirely white, but old specimens often becoming brownish, clothed externally with a thick coating of white hairs; hairs short, not more than 50 μ long, 3–4 μ thick, hyaline, rarely septate, more or less irregularly curved or flexuous, the tips uncinate, obtuse, smooth or granular; asci clavate, narrowed at the tips which are not blue with iodine, 35–45 × 5–6 μ; spores 8, biseriate, hyaline, continuous, smooth, clavate-cylindrical, 8–10 × 2 μ; paraphyses abundant, scarcely exceeding the asci, lanceolate-acute at the tips, 3 μ wide at the broadest part, hyaline, septa not seen.

On decaying stems and rootstocks of *Equisetum hyemale*, lying on the ground in wet places, Ithaca, N. Y., April, May and Nov. (Herb. Cornell, nos. 1041, 5836 and 8457); London, Canada, Aug. (Dearness, 2323 !).

This is distinguished among the white species of the genus by the character of the external hairs. These are sometimes so short as to be easily overlooked, but in well-developed specimens collected in the spring they are quite prominent. Their irregular flexuous character and curved tips are peculiar. Not before reported from America.

Dermatella hamamelidis (Peck) Durand

Patellaria hamamelidis Peck, Rep. **33**: 32. *pl. 2. f. 7–10.* 1880.

Lecanidion hamamelidis (Peck) Sacc. Syll. Fung. 8: 800. 1889.

Dermatella hamamelidis E. & E. Proc. Phil. Acad. Sci. **45**: 149. 1893. (as n. sp.)

EXSICC.: E. & E. N. A. F., no. 2634.

Ascomata scattered or gregarious, originating beneath the epidermis but soon breaking through and becoming apparently sessile on the surface, 0.3–0.5 mm. in diameter, the whole plant dark reddish-brown, the disk plane scarcely margined; excipulum minutely parenchymatous, brown. Asci broadly clavate, narrowed below to a short stout base, apex rounded, not blue with iodine, 65–110 μ × 15–20; spores 8, irregularly biseriate, at first hyaline and continuous, finally becoming yellowish and three-septate, smooth, oblong-elliptical or oblong-fusiform, usually somewhat inequilateral, 15–21 × 4–6 μ; paraphyses filiform, longer than the asci, the tips yellowish and cohering to form an epithecium.

On a bark of dead limbs of *Hamamelis Virginiana*, New York, *Peck*, *Fairman*, *Durand* et al. (Herb. Cornell, nos. 923, 5808 and 7938); Penn., *Ellis*; W. Virginia (*Nuttall*).

Specimens may be collected almost any month in the year, but the best fruiting material is to be found in the late autumn. I have compared specimens authenticated by Dr. Peck as *Patellaria hamamelidis* Pk., with the specimen of *Dermatella hamamelidis* E. & E. in the N. A. F., no. 2634, also with material from Dr. Fairman determined by Ellis, and find that the three represent a single species. The continuous spore is multiguttulate. The first septum is near the middle. This is followed by one in each half simultaneously, or one half may be septated long before the other. A section shows clearly the erumpent habit of the ascomata.

BOTANICAL LABORATORY,
CORNELL UNIVERSITY.

New or noteworthy North American Grasses

By F. Lamson-Scribner and Elmer D. Merrill

Agrostis occidentalis sp. nov.

A rather stout, caespitose, glabrous perennial, about 12 dm. high, with numerous linear leaves, open lax panicles and awnless spikelets. Culms glabrous; sheaths shorter than the internodes; ligule about 4 mm. long, obtuse, somewhat lacerate; leaf blades plane, 2–3 dm. long, 3–4 mm. wide, scabrous on both surfaces. Panicles exserted, about 1.5 dm. long; common axis and branches scabrous, the latter fasciculate at the nodes, spreading or ascending, naked below, flower-bearing above. Spikelets pale green; empty glumes subequal, lanceolate, acuminate, strongly aculeolate-scabrous on the keel, 3.5–4 mm. long; flowering glume 2.5–3 mm. long, acute and minutely 4-toothed at the apex, bearing at the base a tuft of hairs one fourth to one half as long as the glume. Palea wanting.

Type specimen collected by C. L. Shear, no. 1644, in a moist glade, McMinnville, Yamhill county, Oregon, July 20, 1899.

This species in habit resembles *Agrostis virescens* H.B.K., but is at once distinguished by its awnless flowering glumes.

Elymus velutinus sp. nov.

A caespitose, densely pubescent, ashy-gray perennial about 8 dm. high, with numerous basal leaves, densely flowered spikes and long-awned flowering glumes. Culms minutely pubescent or puberulent throughout; nodes puberulent, sheaths shorter than the internodes, densely pubescent with short hairs; ligule about 1 mm. long, densely pubescent; leaf-blades linear-lanceolate, firm, flat or with somewhat incurved margins, 1–1.5 dm. long, 5–8 mm. wide, densely and softly pubescent with short hairs throughout. Spike about 10 cm. long, the spikelets slightly exceeding the internodes, and two at each node; empty glumes nearly equal, linear-lanceolate, long-acuminate-awned, 1.5–2 mm. wide, about 15 mm. long, including the awn, very strongly scabrous on the nerves; flowering glumes about 9 mm. long, scabrous, bearing a stout scabrous awn about 2 cm. in length. Palea about equaling the glume, scabrous, ciliate on the margins.

Type specimen collected at Deep Creek, San Bernardino Mountains, California, no. 2056, L. Abrams, July 30, 1901.

A most distinct species with apparently no closely related forms in North America. It is at once recognized by its ashy-gray color, due to the short dense pubescence, its very scabrous, relatively broad outer glumes and scabrous long-awned flowering glumes.

Elymus cinereus sp. nov.

A rather stout, tufted perennial, about 10 dm. high, densely short-pubescent throughout, giving the whole plant an ashy-gray appearance. Culms stout, nearly glabrous where protected by the sheaths, elsewhere densely short-pubescent; nodes pubescent; sheaths shorter than the internodes, densely pubescent, ligule thin, truncate, 2 mm. long, densely short-pubescent; leaf-blades firm, involute, 2–3 dm. long, about 5 mm. wide, densely short-pubescent on both surfaces. Spike about 15 cm. long, densely flowered, rachis puberulent. Spikelets usually two at each node, 3–4-flowered, empty glumes subequal, subulate, scabrous throughout, 10–15 mm. long, flowering glumes lanceolate, acuminate, scarcely awned, 9–10 mm. long, rather prominently strigose-pubescent throughout. Palea nearly equaling the glume, scabrous, ciliate on the margins.

Type specimens collected by C. A. Purpus, no. 6050, dry plains, Pahrump Valley, Nevada, May–October, 1898.

This species in aspect resembles *Elymus velutinus*, the pubescence of the two species being nearly the same but in other respects is not closely related to that species. Its most prominent distinguishing characters are its subulate empty glumes, which are never more than 0.5 mm. wide, and awnless flowering glumes. It is evidently related to *Elymus triticoides* Buckl., although that species is glabrous, or at least not at all pubescent.

ERAGROSTIS AMABILIS Wright & Arn. in Hook & Arn. Bot. Beechy's Voy. 251. 1841

This very distinct and beautiful species was found rather abundantly along moist roadsides, at two stations in Florida, Lloyd's and Live Oak, 65 miles apart, by Mr. A. H. Curtis, no. 6898, September 12, 1901. How has this grass a native of India become established in northern Florida? *Eragrostis amabilis* is known to florists as a desirable ornamental grass and is cultivated for ornamental purposes in the United States and it was suggested that its appearance in Florida might be explained from this fact, and that it was an escape from cultivation. Regarding this point Mr. Curtiss writes as follows: "I cannot believe *Eragrostis* *amabilis* an escape from cultivation, for in the 'cracker' country where it was found, nothing but most common things are cultivated. At Lloyd's where it is well established along roads in low grounds, there is only a dinner house and a couple of stores. It is possible that the grass may have been grown at the so-called Experiment Station at Lake City, 22 miles east of Live Oak, but it is doubtful."

This species is apparently well established in northern Floirad and should certainly be recognized as a constituent of the flora of that region.

Festuca Elmeri sp. nov.

A weak, caespitose, pale green perennial, 6–8 dm. high, with long, linear, thin leaves and lax panicles. Culms glabrous. Sheaths slightly shorter than the internodes, strongly striate, the lower ones crowded and marcescent, the upper ones minutely scabro-pubescent between the striae ; ligule a very short minutely ciliate ring ; leaf-blades 2–3.5 dm. long, 2–3 mm. wide, plane, striate, nearly glabrous beneath, minutely scabrous or scabro-pubescent on the nerves above, especially the upper ones. Panicles 1–2 dm. long, pale green, the axis glabrous, the branches scabrous, ascending, naked below, flower-bearing at and above the middle, the lower ones often 1 dm. long. Spikelets 7–9 mm. long, 3- or 4-flowered ; empty glumes unequal, the first about 2.5 mm. long, linear-lanceolate, acute, the second 3–4 mm. long, obtuse, both slightly ciliate on the hyaline margins above ; flowering glumes about 5 mm. long, exclusive of the awn, lanceolate acuminate, prominently 5-nerved, rather strongly scabrous, cleft at the apex, forming two sharp teeth about 1 mm. long bearing between them a slender scabrous awn about 4 mm. in length. Palea very narrow, acuminate, 2-keeled, slightly exceeding the glumes.

Type specimen collected by A. D. E. Elmer at Stanford University, Santa Clara county, California, no. 2101, April, 1900, also secured by Le Roy Abrams from the same locality, no. 1646, May 14, 1901.

This species resembles *Festuca Jonesii* Vasey, in its habit of growth and in its very thin leaves, but is distinguished from that species by its very short ligule, much narrower leaves, more unequal empty glumes, and rather strongly scabrous flowering glumes.

KOELERIA BRACHYSTACHYS DC. Hort. Monsp. 120. 1813.

This European species was found at Pensacola, Florida, by S. M. Tracy, June 1, 1901, and we also have a specimen from King's Valley, California, collected by Mrs. R. M. Austin, July, 1882. By some European authors it is reduced to *Koeleria phleoides*, but although closely related to that species we believe it to be valid, being distinguished by its glabrous spikelets. In *Koeleria phleoides* the glumes are prominently pilose.

SCLEROPOA RIGIDA (Linn.) Griseb. Spicil. Fl. Rumel. **2**: 431. 1844

Poa rigida Linn. Amoen. Acad. **4**: 265. 1759.

Festuca rigida Kunth. Enum. **1**: 392. 1833.

This European species was introduced at Charleston, S. C., early in the nineteenth century, as it was considered by Elliott in his Sketch of the Botany of South Carolina and Georgia 1: 164. 1817.* It has also been found at Mobile, Alabama, on ballast, by Dr. Chas. Mohr, and at Fort Morgan, Alabama, by S. M. Tracy, no. 7212, April 27, 1901, and should, we believe, be considered as a constituent of the flora of the southern United States.

Sitanion marginatum sp. nov.

A densely caespitose, bright green glabrous perennial, 2–3 dm. high with short, usually spreading leaves, rather short spikes, and broad empty glumes. Ligule short, membranaceous; leaf-blades linear-lanceolate, the basal ones 5–9 cm. long, those of the culm shorter, glabrous beneath, scabrous on the rather prominent white, cartilaginous margins. Spikes 3–6 cm. long, exserted, rarely partly enclosed in the upper sheath. Spikelets crowded; empty glumes lanceolate, 1–1.2 mm. wide, about 5 mm. long, acuminate into a spreading awn about 1.5 cm. long; flowering glumes glabrous, about 7 mm. long, bearing an awn similar to that of the empty glumes.

Type specimen, no. 334 E. D. Merrill and E. N. Wilcox, collected on bare open slopes, Teton Mountains, above Leigh's Lake, Wyoming, July 26, 1901, altitude about 3,300 m.

A peculiar species very similar in habit to *Sitanion glabrum*, J. G. Smith, but on account of its relatively broad empty glumes must be placed in the section *Elymoides* in relation with *Sitanion*

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*Cir. U. S. Dept. Agr. Div. Agros. 29: 11. 1901.

planifolium to which it is not closely related. Its distinguishing characters are its habit of growth, lanceolate empty glumes, glabrous flowering glumes, and prominent cartilaginous leaf-margins.

Trisetum Congdoni sp. nov.

A caespitose, erect, rigid perennial 2–3 dm. high, with erect or ascending rigid leaves, and exserted, ovate, densely-flowered panicles 4–5 cm. long, 1.5 cm. in diameter. Culms minutely puberulent. Ligule ovate, hyaline, 2–3 mm. long; leaf blades 4–5 cm. long, 2–3 mm. wide, glabrous beneath, scabrous above, flat or somewhat involute toward the apex. Panicles slightly purplish, common axis pubescent, the short branches densely flowered, spikelets mostly 2-flowered; empty glumes narrowly lanceolate, glabrous except on the scabrous keels, acuminate, 1-nerved, the first about 6 mm. long, the second 8 mm. long; flowering glumes 6 mm. long, very strongly scabrous throughout, lanceolate, acuminate, cleft at the apex, and terminating in two slender teeth about 1 mm. long; awn inserted somewhat above the middle, spreading, scabrous, 7–8 mm. long. Palea equaling the glume.

Type specimen collected by J. W. Congdon, Shadow Lake Trail, Mariposa county, California, 1899.

This species is readily distinguished from forms of *Trisetum subspicatum* by its rigid leaves, peculiar panicles, narrow empty glumes, very scabrous longer flowering glumes and longer awns.

New Species of Nemophila from the Pacific Coast

By Alice Eastwood

(With Plate 21)

Nemophila Brandegei sp. nov.

Stems branching, erect, sparingly retrorsely pubescent. Leaves generally 5-lobed, with rounded, entire or occasionally lobed, mucronate divisions, clothed with appressed pubescence, denser and finer on the lower surface, somewhat pustulate on the upper; petioles broad, dilated at base, ciliate on the margins especially at the base, about as long as the blade: peduncles 3–5 times as long as the leaves, erect in flower, recurved spreading later: calyx 7 mm. long, with lanceolate-subulate acute divisions extending almost to the base; auricles narrowly linear, about half as long as the divisions of the calyx: corolla 3.5 cm. across, blue with dotted lines in the throat, paler at base; tube hairy within, destitute of appendages but with a double line of fine hairs between each filament: divisions obcordate, almost twice as long as the tube: filaments as long as the tube: anthers ovate-acuminate, dark brown: style divided almost to the middle, hairy below the lobes; ovary sparingly hairy: no fruit. (*Pl. 21, f. 1.*)

This was collected near Japato, Fresno county, California, by Mr. T. S. Brandegee, March 26, 1893. This is one of the largest flowered species of *Nemophila* and in general appearance approaches *N. insignis.* The general habit of the plant, the much larger flowers, the difference in the inner part of the corolla tube all mark it as a distinct species. It is with pleasure that I name it in honor of Mr. Brandegee who has done so much for the herbarium of the California Academy of Sciences and for the Botany of the Pacific Coast.

There are two forms on the same sheet, one much more luxuriant than the other. The flowers in both are similar, though those of the larger specimen may be a little larger. This specimen is not complete, so the others have been taken as the type.

Nemophila macrocarpa sp. nov.

Stems long, decumbent, weak, branching, more than 30 cm. long, ribbed, glabrate near the base, retrorsely pubescent above; internodes generally exceeding the leaves: leaves 3–5 lobed, with linear-subulate subfalcate mucronate divisions: petioles about as long as the blade and as broad as the divisions: flowers on long, slender peduncles, which exceed the leaves and the internodes, in bloom from the earliest axils; flowering calyx 7–9 mm. long, with triangular-subulate lobes, veiny, pubescent on the outer surface, glabrous within, ciliate on the margin: auricles linear, about half as long as the divisions, both increasing in length with age: corolla rotate-campanulate, white with dotted lines of blue-black radiating from the base, 2 cm. across, with rounded obtuse divisions a little longer than the tube; appendages as figured: stamens with filaments as long as the tube; anthers ovate-acuminate: style not divided to the middle, hairy below: capsule oblong-orbicular, 6 mm. long: seeds dark brown, with some scales on the rough, tuberculated surface; calyptra prominent. (*Pl. 21, f. 2.*)

This was collected by Will Price in Humboldt county. There are two specimens, one collected at Jarnagan, July 1, 1890, the type, the other fragmentary, from Kneeland Prairie collected, June 30, 1890.

Nemophila Johnsoni sp. nov.

Stems low, densely and closely branching from the base, almost caespitose, branching also above, sparingly hispid with downwardly appressed hairs, leafy with the internodes shorter than the leaves: leaves opposite, with the blades as long as the broad ciliate petioles, together 1–3 cm.; divisions 5–7, entire or lobed, mucronate, pubescent with appressed hairs which are more numerous on the upper surface and inclined to be pustulate at base on older leaves. Peduncles 3 or 4 times longer than the subtending leaves, sparingly hispid with spreading or reflexed hairs: calyx 4 mm. long, with the triangular-subulate lobes extending almost to the base, veiny, finely appressed pubescent on both sides, ciliate on the margin; auricles narrowly linear, almost half as long as the divisions: corolla rotate-campanulate, 1 cm. long, pale blue, with darker dots radiating in lines from the center: divisions two thirds the entire length, obcordate, hairy on the tube and with two denser lines of hairs between the filaments: filaments filiform, longer than the tube of the corolla; anthers black, sagittate, 1 mm. long: style divided to below the middle, the lower part and ovary hispid with white hairs: capsule becoming 5 mm. in diameter: immature seeds scaly, the calyptra prominent. (*Pl. 21, f. 3.*)

This was sent to me by Mr. A. J. Johnson, of Astoria, Oregon, in whose honor it is named. He reports it as growing on wet rocks at the head of tide water, on the Umquaw River, Coos county, Oregon.

Nemophila diversifolia sp. nov.

Stems decumbent, 15 cm. high, branched from the base and above, with slender, weak, angled stems, canescently hirsute with fine white spreading hairs; lowest leaves opposite, with generally five petiolulate, 2–3-parted divisions, the ultimate lobes rounded and obtuse; upper leaves lobed, generally unequal, 1–3 lobes on one side, three or none on the other, cuneate at base, tapering to a short petiole: flowers on slender peduncles which are shorter than the leaves, generally recurving in fruit: divisions of the calyx oblong-linear, acute, appressed hairy on both sides, margined by long and short cilia; auricles short, narrow: corolla open-campanulate, 3 mm. long, lobed half way with obtuse, orbicular divisions, 2.5 cm. wide; appendages at base triangular-attenuate, overlapping: filaments as long as the corolla tube: anthers linear-oblong: style divided one-third, lower part hairy: ovary globular, clothed with spreading hairs: capsule purple-spotted on lower part, flattened-globular: seeds immature. (*Pl. 21, f. 4.*)

This belongs to *Section V. in the groups of small-flowered *Nemophila*, though the lower leaves are those of Section VI. It is nearest to *N. inaequalis* Eastwood. It was collected by Mr. J. G. Congdon below Mormon Bar, Mariposa county, May 28, 1901. The type is in the Herbarium of the California Academy of Sciences.

Nemophila decumbens sp. nov.

Stems many from the base, branching dichotomously above with numerous weak branches, decumbent or supported on other plants, clothed with few fine recurved bristles; internodes about as long as the alternate leaves: leaves thin, variously lobed and divided, scarcely two alike; the lowest with petiolulate orbicular divisions: the uppermost oblanceolate, entire; the others 2–5-lobed with the lobes generally broad, mucronate at apex, all cinereous with upwardly appressed hairs: petioles of lower leaves wing-margined, shorter than the blades; upper leaves almost sessile: peduncles capillary, becoming recurved: upper ones longer than the subtending leaves, lower ones shorter: calyx with thin, veiny divisions 3.5 mm. long, 1.5 mm. wide, hispid externally, and slightly so on the inside near the apex, the bristles on the margins rather short; auricles short, acute, deeper green than the sepals: corolla rotate-campanulate, white with purple dots in lines; divisions broad, obovate, retuse, as long as the tube, thin hispid ex-

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* Bull. Torrey Club, **28**: 240. 1901.

ternally; appendages at base thin, attached by the long side, the free part unequally triangular: filaments as long as the tube of the corolla inserted a little above the base; anthers oblong: ovary hispid; style divided more than half, slightly hispid at base: seeds 3–4: capsule corrugated, pitted; the calyptra flat, soon falling.

This was collected by Mrs. Katherine Curran (Mrs. Brandegee) on Mt. Diablo, 1883.

A CORRECTION

The name *Nemophila inconspicua* proposed by me (Bull. Torrey Club, **28**: 144. 1901) is preoccupied, there being an earlier *N. inconspicua* Henderson. For my species I would substitute the name **Nemophila pratensis.**

Explanation of Plate 21

FIG. 1. *Nemophila Brandegei* Eastwood. All parts of this are enlarged to twice the natural size except the leaves which are outlined from actual leaves.

FIG. 2. *Nemophila macrocarpa* Eastwood. Corolla and calyx twice the actual size; leaf the actual size; appendage at base of corolla five times the size.

FIG. 3. *Nemophila Johnsoni* Eastwood. Calyx and corolla twice the actual size; leaves the actual size.

FIG. 4. *Nemophila diversifolia* Eastwood. Calyx and corolla twice the actual size; *d*, *c*, *e*, *f*, *g*, outlines from actual leaves.

Trichomanes radicans

By Elizabeth G. Britton

Having come to the conclusion that *Poterophora Donnellii* Wolle, originally described as a fresh-water alga, is a filamentous prothallium of a species of *Trichomanes,* collected on trunks of trees in Florida by J. Donnell Smith, we have been somewhat surprised to learn that the only record for any species of this genus in Florida is a doubtful one. Chapman, in all three editions of his Southern Flora, states that *T. Petersii* had been sent to him among mosses from Pensacola, Florida, without stating the habitat or name of collector. As the first leaves of both *Vittaria lineata* and *Campyloneuron phyllitidis* might readily be mistaken for a small species of *Trichomanes,* there is some doubt as to whether this statement is correct. No specimens occur in Chapman's original herbarium now in the Columbia University collections, and at Biltmore no further information can be obtained from Chapman's later herbarium. Meanwhile I have made a curious set of discoveries, and confirmed the opinion held by most students of North American ferns that the species known in our text-books as *Trichomanes radicans* is quite distinct from the species originally described by Swartz.

Trichomanes radicans as collected by Swartz was from Jamaica, where it grew closely clinging to trees in the forest, and climbed by a long tomentose rootstock; the fronds were sparse, on stipes 1–3 inches long, margined by the decurrent tissue of the leaf, which is ovate-lanceolate, sub-tripinnate, and dark green. The rachis was partially margined. Leaflets patent, alternate; pinnules alternate, pinnatifid; lobes linear, apex bipartite and obtuse. Urceolate fructification subpedicellate, scarcely exserted, the lobes laciniate, membranous, cylindric. Columella long setaceous.

Compared with *T. scandens* L., he says it differs in the place where it was found, the angular rachis, which is not black; the laciniate ends of the lobes not bifid, and the shorter columella.

This comparison raises the question as to what *T. scandens* L. is, and here too we find a diversity of opinion, most authors having followed the English school in taking as the type the specimen in the Linnaean herbarium; whereas the Germans have gone to the original plates cited by Linnaeus, of pre-Linnaean authors, and taken that as the type.

The Linnaean description is as follows:

8. TRICHOMANES *scandens* frondibus supradecompositis; foliolis alternis, pinnis alternis oblongis serratis.

"Adiantum scandens ramosissimum, laciniss retusis dissectum." Plum. fil., 76 t., 93. 1705.

"Darea ramosissima scandens." Pet. fil., 102, t. 12, fig. 5. 1712. Habitat in America.

If the type is Plumier's figure on plate 93, of his Tractatus Filicibus Americanus, 1705, it must be noted that this is a folio volume and the rhizome and part of one frond only is figured, yet it more than filled the plate with the upper part omitted, and the stipe of one frond is over a foot long, so that the fronds must have been two and a half feet long, with pinnae six to eight inches long, pinnate-pinnatifid, with linear lobes. In his description he says the rhizome is very long and stout, and that it is completely covered with dark fibers which cling closely to the bark of trees, like the ivy. The whole plant is remarkable for its great spread, being very long and branching, and giving rise to a great number of leaves, alternating on the stem, which, though delicate, are nevertheless stout; the stipes are naked, black and shining like ebony, and about as long as the leaf; the pinnae are alternate, about half a foot long, with alternate pinnules, which are about one inch long and are deeply cut into narrow, linear lobes, bearing the cup-shaped sporangia, with a membranous lid and the black bristle about a line long.

The type locality is south of Leogano, Santo Domingo, in dense forests climbing on trunks of trees.

The second Linnaean reference to Petiver's Pteridographia is simply a copy of a portion of Plumier's plate with the descriptive phrase cited by Linnaeus.

Hooker and Baker, in the Synopsis Filicum state that "Van den Bosch refers *T. scandens* L. to *T. Kunzeanum* Hook., "but that *T. scandens* of the Linnaean herbarium is described by them on another page." They recognize *T. Kunzeanum* as a variety of

T. radicans. We feel that the plant of the Linnaean herbarium should be restudied, as well as the type of *T. radicans*, which must be at Stockholm. This would probably necessitate the study of all the species which have been reduced to synonyms of one or the other, such as *T. macroclados* Kunze, *T. Lindeni* Presl, *T. Mexicanum* V. d. B., etc. For it is quite certain that the specimens in our collection which have come from various sources, include a great jumble of species from the West Indies, Central and South America and the United States. Hooker and Baker say that *T. radicans* is a "very widely diffused and variable plant,"—and from the list of localities cited by them we do not doubt this would be true of their specimens so-called.

It is quite certain, however, that our species from the Southern States is quite distinct, in spite of the fact that Eaton in his Ferns of North America says "the name proposed by Sturm, and published with a long description by Van den Bosch, is wholly superfluous." We feel that he is mistaken, and that it must be known as *Trichomanes Boschianum* Sturm. (Van den Bosch. Syn. Hymen. 160. 1868.)

This was recognized by Salomon in his nomenclator of the vascular cryptogams in 1883, but such has been the conservatism of North American botanists, that since Dr. Gray in 1852 referred the species discovered by Peters to *T. radicans*, it has gone by this name in spite of the fact that it is totally unlike any other specimens so-called.

Liriodendron Celakovskii Velen.

By Edward W. Berry

In 1881 Professor Velenovsky found a leaf in the Cretaceous Clays, near Kuchelbad, in Bohemia, which he subsequently described * under the above name. Following is his description: "Das Blatt im Umrisse rundlich, seicht dreilappig, der Mittellappen nicht viel länger als die seitlichen, vorne seicht ausgerandet, die seitlichen ebenfalls ausgerandet oder beinahe abgerundet. Der Primarnerv gerade, nicht zu stark, zur Spitze merklich verdunnt; in der oberen Hälfte desselben entspringen noch 2–3 Paare von starkeren Secundarnerven. Beiderseits des Mittelnerven entspringen am Grunde noch 2 Basalnerven, von denen der obere etwa in der Mitte seiner Länge noch ein langes Secundarastchen abzweigt, die feinere nervation ist unkenntlich. Der Blattstiel etwa 2 cm. lang, gerade, am Grunde stark."

This leaf is of considerable interest as it is the only specimen of Cretaceous age in Europe which has been referred to *Liriodendron*, the balance of the European species appearing in the later Tertiary (Oligocene, Miocene, and later) and greatly resembling the existing tulip-tree. A critical comparison convinces the writer that this leaf is in no wise related to *Liriodendron*, and the result seems worthy of publication inasmuch as it limits the known introduction of this genus into Europe to the Oligocene, and suggests that this introduction may have been from the northwest through Heer's *Liriodendron Procaccinii* of the Eocene (or at the very latest Oligocene) of Greenland and Iceland. This species in turn is the logical descendant from forms similar to those found in the Amboy Clays and related strata from New Jersey to Martha's Vineyard.

Velenovsky is positive enough that his identification of this leaf is correct and he compares it to those forms of *Liriodendron Meekii* from Nebraska. While the two leaves are much the same size, *Liriodendron Meekii* is oblong in its general outline while this

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* Die Fl. der Boehm. Kreideform., Beiträge zur Palaeont. des Oesterreich-Ungarus und des Orient. E. v. Mojsisovics und M. Meumayr, 3 : 18 (43), *pl.* 6 (14), *f.* 2. 1884.

leaf is orbicular. *Liriodendron Meekii* is almost perfectly fiddle-shaped; the apical lobes are not convergent; the lateral sinuses are in the basal half of the leaf, and are quite decided; the lateral lobes are basal and directed nearly laterally; the secondaries are numerous, and the venation so far as known is that of *Liriodendron*. *Liriodendron Celakovskii* is, on the other hand, a typically trilobed leaf with palmate venation, although the sinuses are shallow and the lobes not particularly well marked; the sinuses are in the apical half of the leaf and are directed downward, while the venation is quite different from that of the former species, with few, and much curved secondaries.

The genus *Cissites* which was originally proposed by Heer to include leaves presumably allied to *Cissus*, has been made to include a variety of forms with more or less resemblance to *Vitis*, *Platanus*, *Sassafras*, *Liriodendron*, etc., by later authors. It is with some of these that Velenovsky's leaf shows a decided similarity.

Lesquereux, in discussing his *Cissites obtusilobus*,* notes its resemblance to *Liriodendron Celakovskii*, the venation being however strikingly different.

A *Cissites* which resembles this leaf is *Cissites salisburiaefolius*, Lx. which† species has been referred successively to *Populites* and to *Sassafras*; in fact it resembles some of the obtuse varieties of *Sassafras cretaceum* "so called" very much. It is a somewhat larger leaf than *Liriodendron Celakovskii* and more decidedly trilobed; in some of Lesquereux's specimens which lack the decurrent base the venation is very similar to that of *Liriodendron Celakovskii*.

Another species of *Cissites* which resembles this leaf is Lesquereux's *Cissites Harkerianus*. The two leaves are exactly the same size; the outline is the same, except for the slightly notched apex of *Celakovskii* and the somewhat decurrent base of *Harkerianus*. The venation is similar in the straight primaries and few greatly arched secondaries. ‡

Another species of analogous appearance is *Hedera platanoidea* Lx. His figure of this species (*pl. 3, f. 5*) resembles *Liriodendron*

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* Fl. Dakota Group, 161.

† Am. Jour. Sci. 46: 94. 1868.

‡ See especially Cret. & Tert. Fl. *f. 3*.

Celakovskii considerably in both size and outline, except for the unnotched apex; the secondaries are more nearly straight, however, and there are no additional veins below the lateral primaries.

Comparing *Liriodendron Celakovskii* with the existing *Liriodendron Tulipifera* we note that, while the outline is not dissimilar from numerous *L. Tulipifera* leaves in my possession, the wide petiole enlarged at the base is widely different. The venation is decidedly different from any form of *Liriodendron*, living or extinct, which I have seen. It is most decidedly palmate, three veins which may be called primaries and two lateral secondaries branching from the summit of the petiole at the extreme base of the leaf blade. The primaries are straight and the lateral ones run directly to the tips of the obtuse lateral lobes. In *L. Tulipifera* what answers to these primaries are seldom straight, do not form such an acute angle with the midrib, and in 99 per cent. of the leaves examined do not run directly to the tips of the lobes, but branch and become more or less obliterated.

The disposition of the tertiary system in the region of the sinus is different; in *L. Tulipifera* a secondary generally runs toward the sinus, forking and striding it.

In *L. Tulipifera* the secondaries are more numerous and branch from the midrib at approximately regular intervals, nor do they ascend in sweeping curves as in *L. Celakovskii.*

The base in *L. Tulipifera* is not straight, but usually decurrent in the smaller leaves, and more or less obcordate in the larger. It would not be difficult to find additional analogues of the leaf in question, and while the writer's knowledge is far to limited to assign *Liriodendron Celakovskii* to its proper place, it would seem to be more nearly related to that somewhat heterogeneous assemblage included in *Cissites.* At least this seems to accord more nearly with its natural affinity than its reference to *Liriodendron*, and we may repeat in conclusion that it is not related to *Liriodendron*, which is the point of emphasis in the foregoing note.

PASSAIC, N. J.

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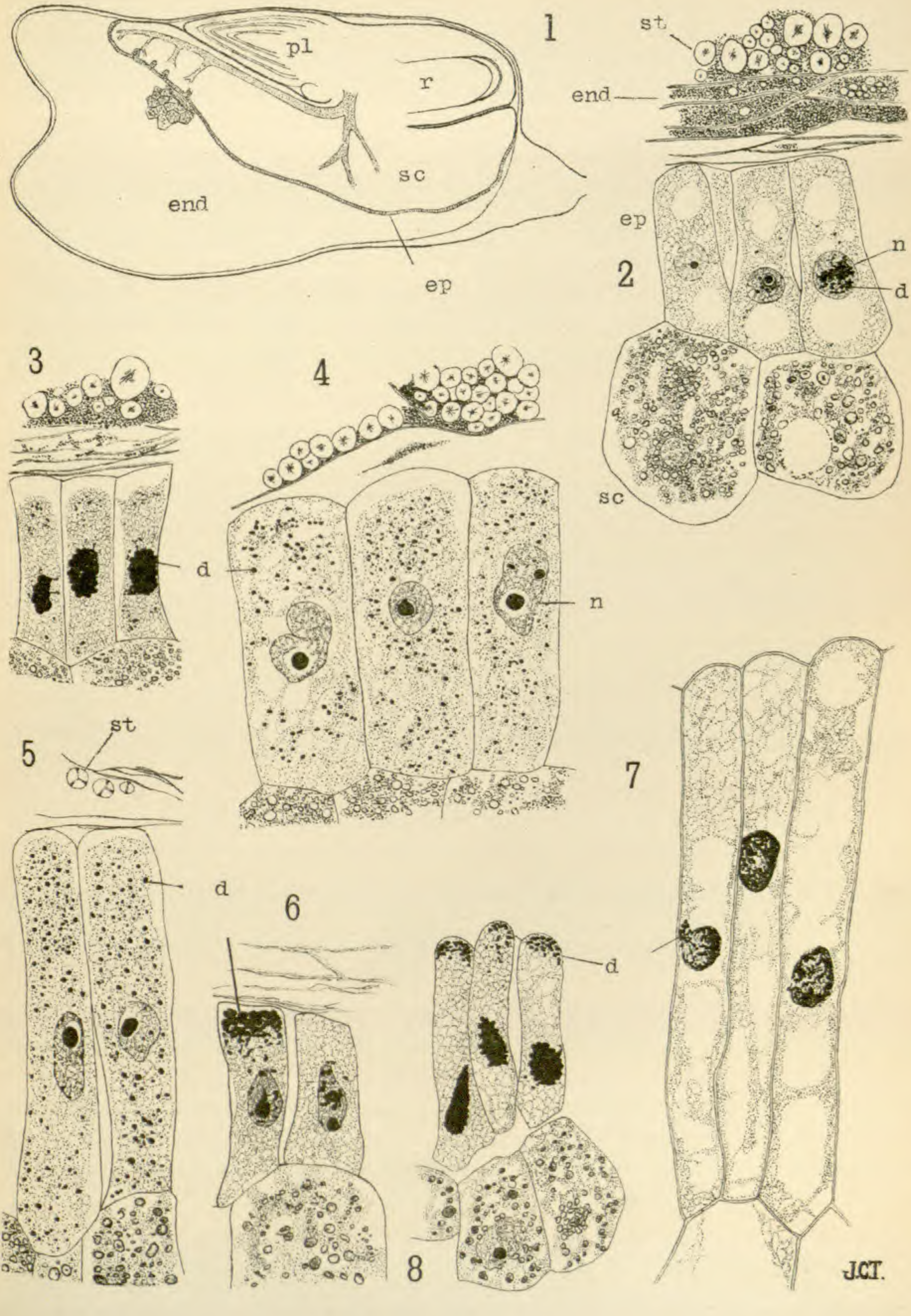

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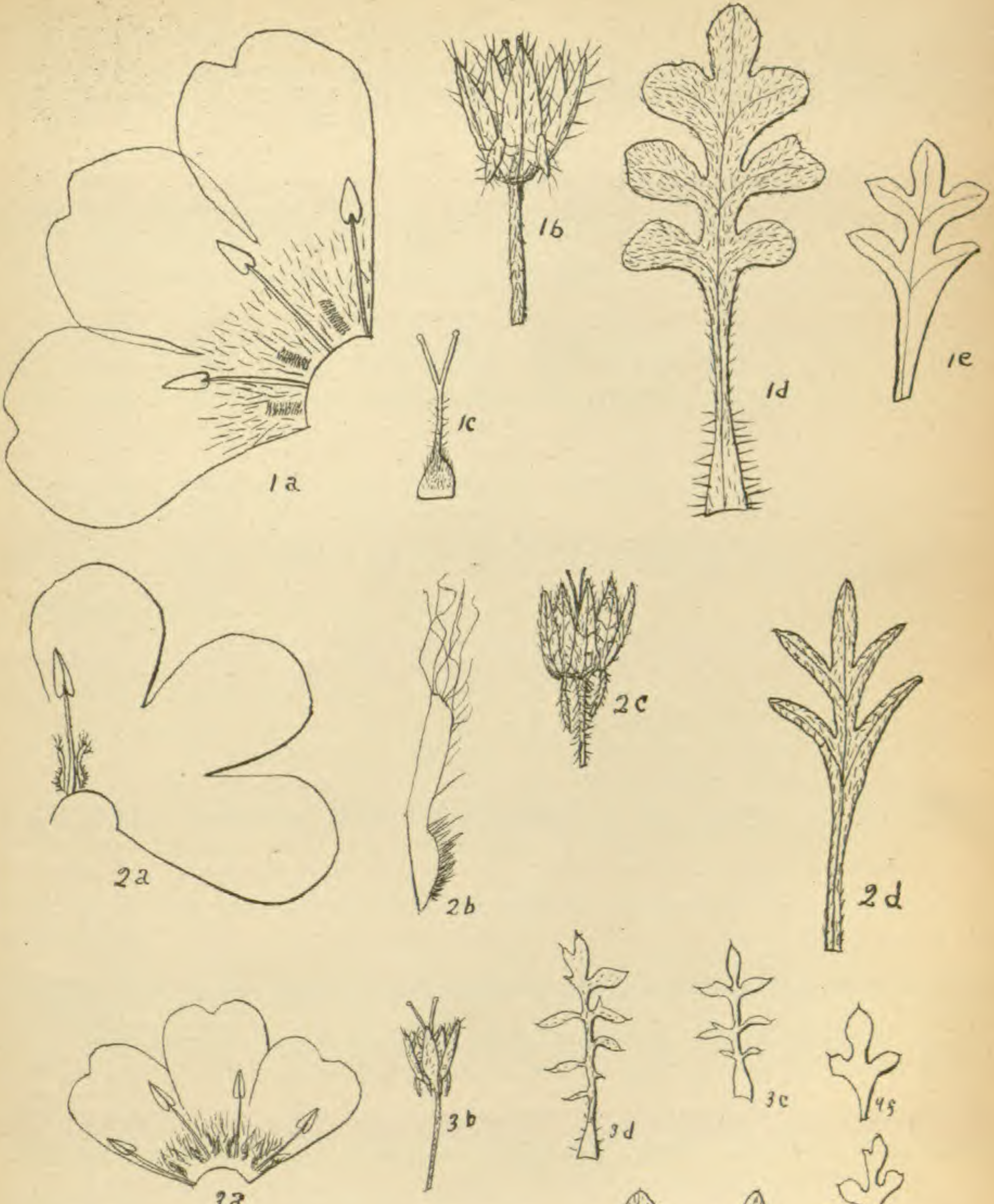

1. Nemophila Brandegei. 2. N. macrocarpa. 3. N. Johnsoni. 4. N. diversifolia.

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Memoirs. (See last page of cover.)

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BULLETIN

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TORREY BOTANICAL CLUB

AUGUST 1902

The Origin of Asplenium ebenoides

BY MARGARET SLOSSON

The question whether *Asplenium ebenoides* R. R. Scott is or is not a hybrid between *Asplenium platyneuron* (L.) Oakes and *Camptosorus rhizophyllus* (L.) Link has long been a vexed one. In order to ascertain the truth by crossing *A. platyneuron* and *C. rhizophyllus*, I began experiments several years ago which had been suggested by Mr. George E. Davenport.* Partial description of these experiments, together with a discussion of the advantages and disadvantages of various methods of attempting the hybridizing of ferns, has been announced already, † but it is necessary to refer here to the method that Mr. Davenport suggested and which, with slight modification, was at first adopted.

This method consists of dividing prothalli of two species between the archegonial and antheridial regions before fertilization has taken place and planting the archegonial section of a prothallus of one of the species close to the antheridial section of a prothallus of the other, so that antheridia and archegonia come in contact. The idea is that should fertilization subsequently take place it can only be cross-fertilization and the resultant plant a hybrid. It should be said that although the formation of plants of pure species from asexual growth, which sometimes occurs on prothalli, would not be prevented, yet plants arising in this way can be distinguished, according to Dr. Farlow, from plants springing from fertilized archegonia and can, therefore, be detected and removed.

On experimenting, however, two objections to this method were encountered: (1) Nearly all of the sections of prothalli

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* Papers Pres. Boston Meet. (1898), 9. 1899.

† Fernwort Papers (ined.).

[Issued 30 August.]

sent out branches and it appeared extremely probable that on the branches the organs that had been removed were often regenerated. Each of the branches was shaped more or less like a complete prothallus, and many produced plants of pure species borne, as in the normal prothalli, close to a sinus. I did not wish to disturb the cultures sufficiently to make certain, but it is not probable that all, if any, of these plants were the result of asexual growth; (2) Very many of the antheridial sections, though possessing roots when planted, either died immediately or appeared to fade and remain faded for weeks, reviving only by sending out branches. The archegonial sections, on the contrary, though rootless when planted, as a rule quickly produced roots and grew rapidly.

Since there appears to be no way of dividing prothalli that offers any certainty that the organs cut away will not be regenerated, it is evident that in attempting to cross species of ferns that method of dividing and bringing prothalli together is best in which the prothalli offer most quickly facilities for cross-fertilization, in order that it may take place before regeneration of the organs. As antheridial sections that die or fade cannot be said to offer such facilities, in the experiments described further on whole prothalli have been substituted for the antheridial sections. In cutting the archegonial sections the incision has been made transversely close to the sinus of each prothallus in order to make certain of retaining archegonia only on the archegonial sections. Then, discarding the section containing antheridia, the archegonial section of a prothallus of one species has been planted against a whole prothallus of the other species with the lower surfaces of the prothalli pressed close together, in the hope that when antherozoids should be set free on the whole prothallus some would reach and cross-

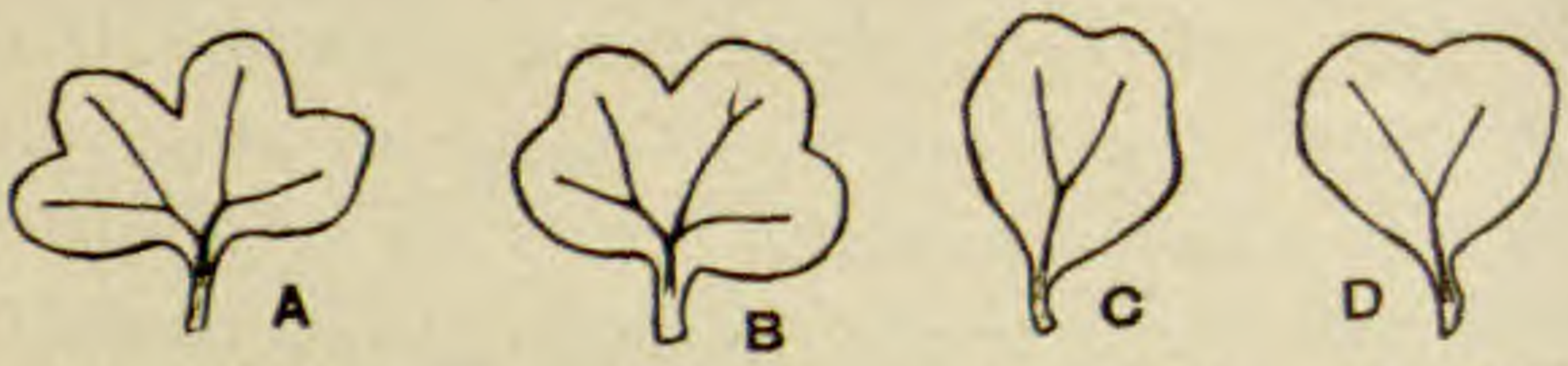

FIG. 1. × 4. The letters in the series uniformly refer to the same plants: *A*, *Asplenium platyneuron*; *B*, hybrid artificially produced; *C*, *Asplenium ebenoides*; *D*, *Camptosorus rhizophyllus*.

fertilize the archegonia on the archegonial section before that section could regenerate antheridia of its own.

It is obvious that in seeking to discover the origin of *A. ebenoides* the removal of organs of *A. platyneuron* or *C. rhizophyllus* is only of use in so far as it may facilitate cross-fertilization, for *A. ebenoides*, while it combines characteristics of these two ferns and hence might be produced by their cross-fertilization, is so distinct from either that it could not possibly be produced by the cross-fertilization of either. For the same reason it could not be produced by the asexual growth of either. Therefore if a plant of *A. ebenoides* should spring from prothalli of *A. platyneuron* and *C. rhizophyllus* that had been planted together and pure cultures had been insured, that plant must be considered proof that *A. ebenoides* is a hybrid between *A. platyneuron* and *C. rhizophyllus.*

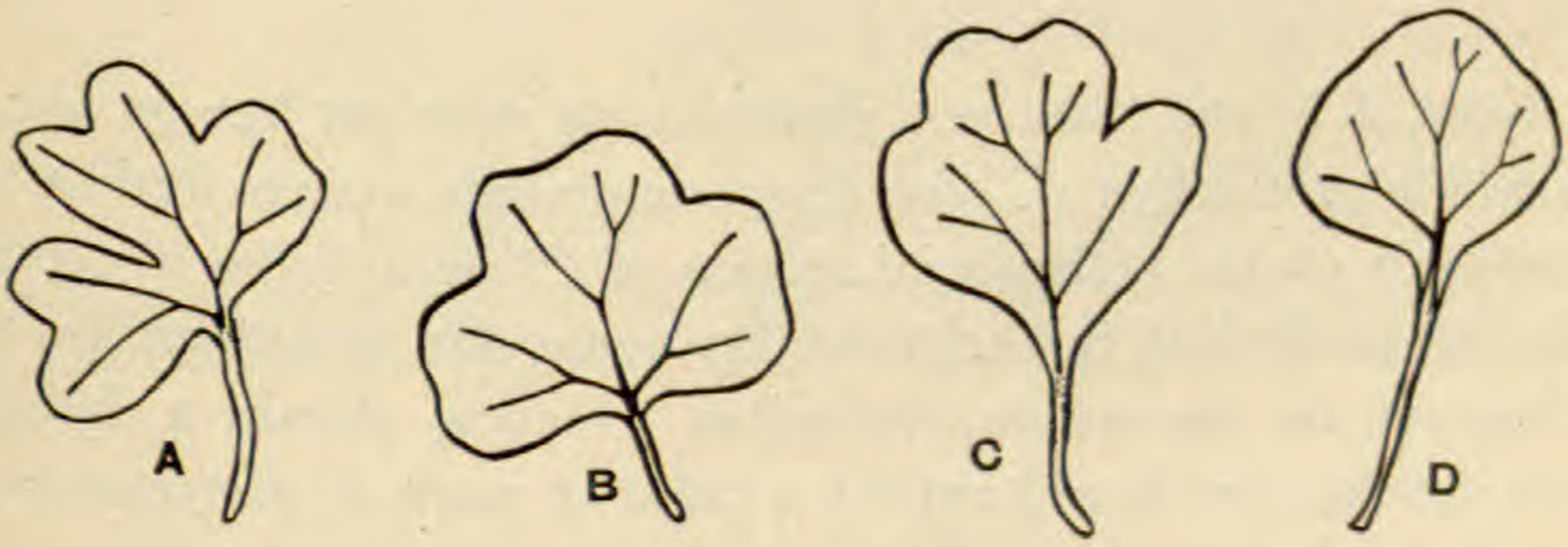

FIG. 2. × 4.

In order to insure pure cultures, in my experiments the prothalli have been raised on sterilized earth in new flower-pots and kept under glass. Lack of success during several years in crossing *A. platyneuron* and *C. rhizophyllus* has not been caused by prothalli of these ferns failing to produce a hybrid when planted together, but by the difficulty in getting prothalli of both ferns in proper condition at the same time in order to plant them together. Almost as soon as that was overcome results followed.

In the winter of 1900–1901 spores of these two ferns sown in separate flower-pots developed prothalli in large numbers. During February and March archegonial sections were cut from the prothalli of *C. rhizophyllus*, planted in a third pot, and a whole prothallus of *A. platyneuron* planted close against each section. In a fourth pot archegonial sections of *A. platyneuron* were planted against whole prothalli of *C. rhizophyllus*. In a fifth pot a few whole prothalli of both ferns were planted against each other. In all about fifty pairs of prothalli were planted.

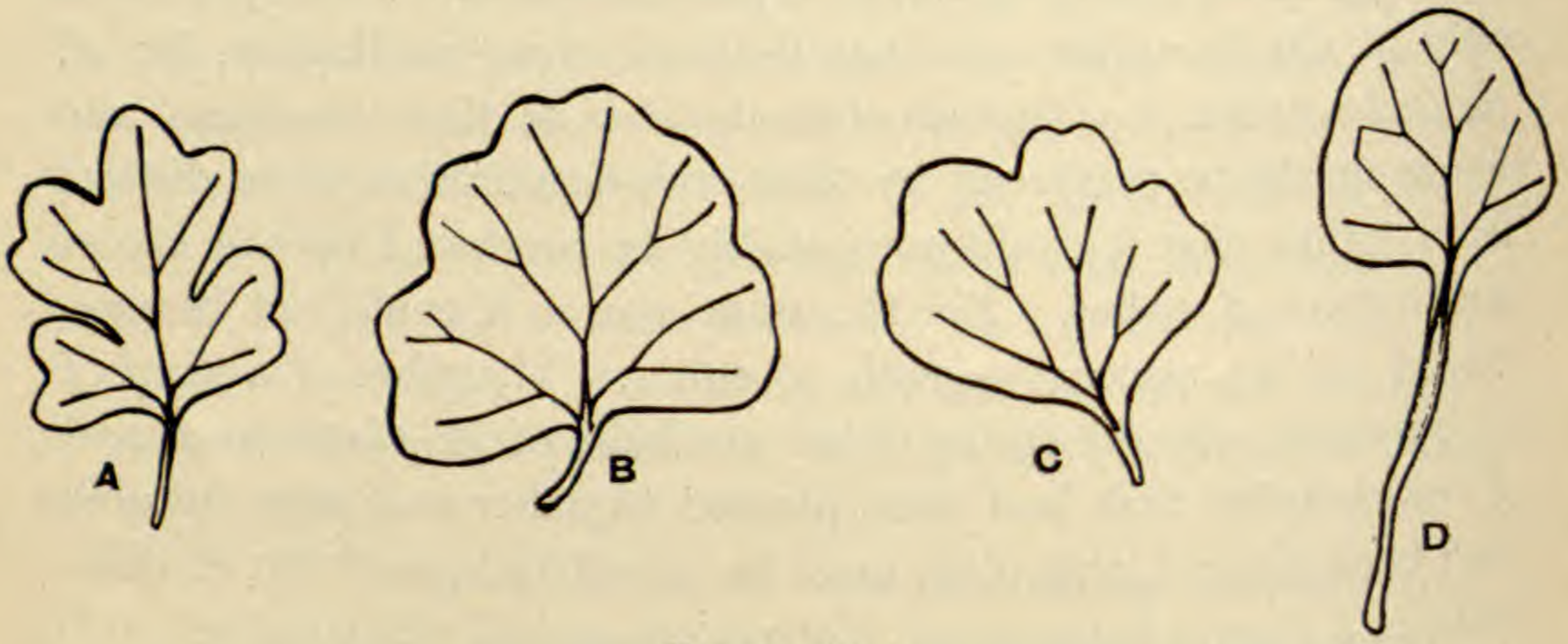

FIG. 3. × 4.

Now, if in the third pot antherozoids were set free on one of the whole prothalli of *A. platyneuron* and some were to fertilize the archegonia on the archegonial section of *C. rhizophyllus* in contact with that prothallus, in all probability some also would fertilize the archegonia on the whole prothallus. Hence, should a hybrid-plant develop, we would expect a plant of pure *A. platyneuron* to

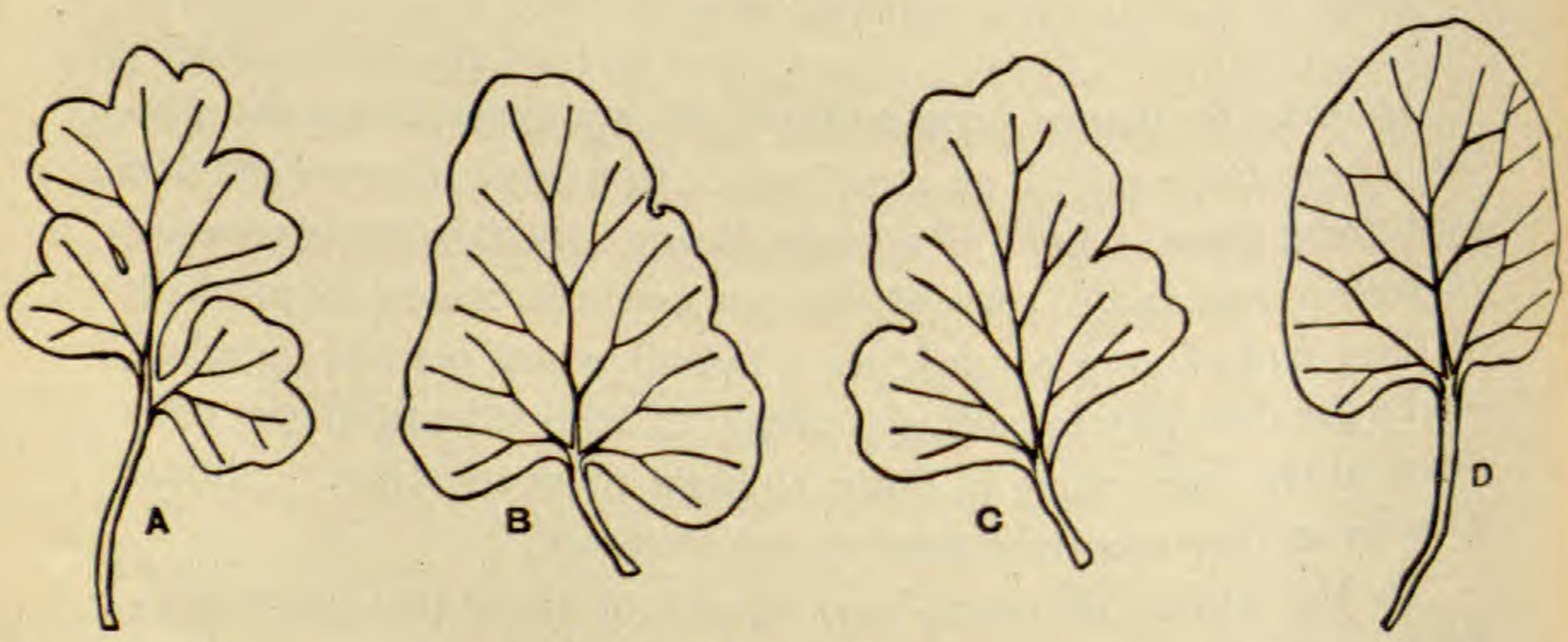

FIG. 4. × 4.

develop at the same time. That is what occurred. In June a plant, unquestionably a hybrid between *A. platyneuron* and *C. rhizophyllus*, and a plant of pure *A. platyneuron* sprang up side by side.* It is probable, then, that this hybrid-plant was produced by archegonia of *C. rhizophyllus* fertilized by antherozoids of *A. platyneuron.* The following September a second hybrid-plant sprang up, but, as in the meanwhile plants both of pure *A. platyneuron* and of pure *C. rhizophyllus* had been produced, the organs cut away had probably been regenerated, hence no conclusions can be formed as to whether this second plant is the result of the same cross as the first or of the reciprocal cross.

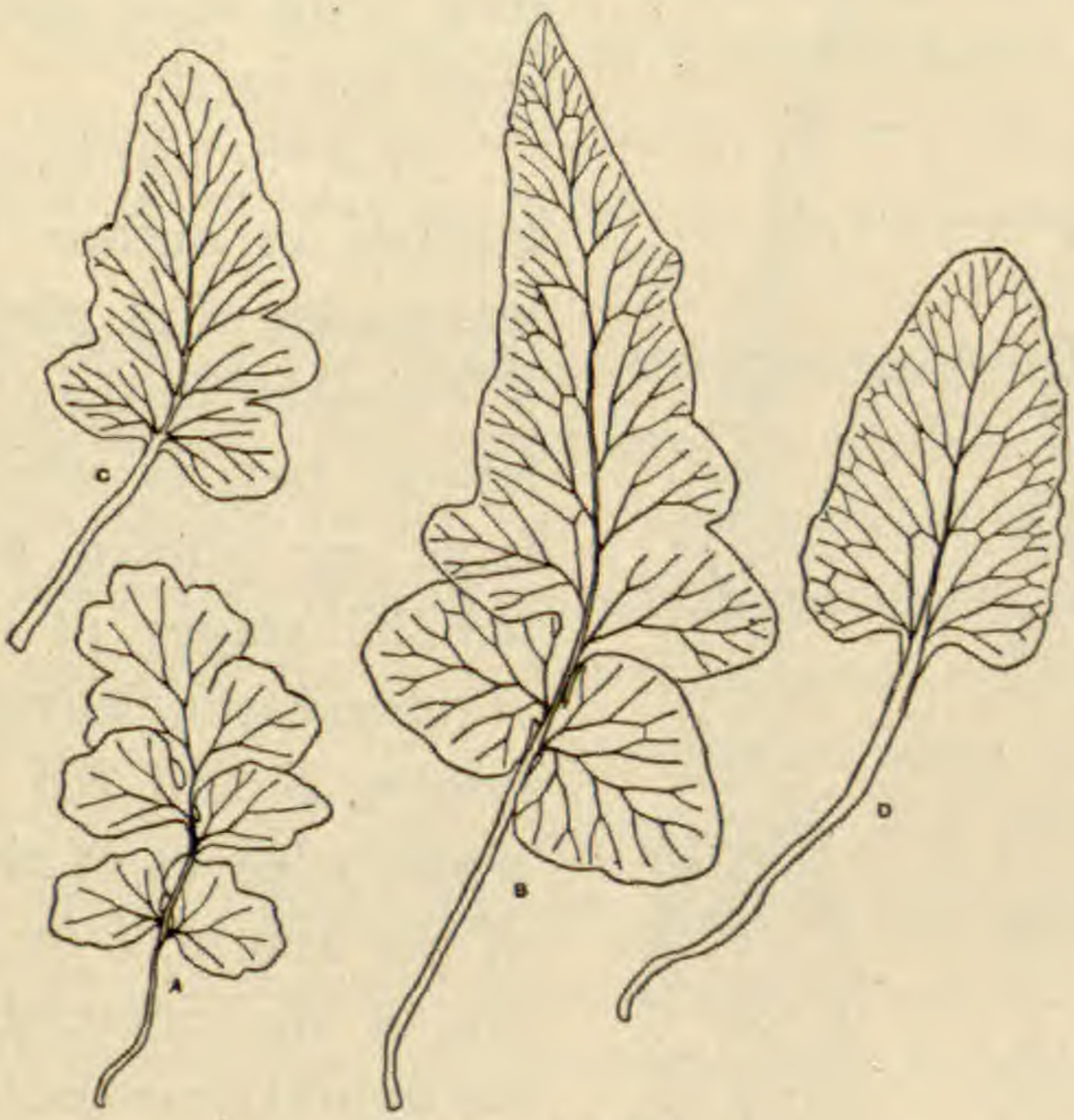

FIG. 5. × 1½.

Shortly before September, from the appearance of plants of pure *C. rhizophyllus* and pure *A. platyneuron* in the fourth pot, it became evident that in that also the organs cut away had probably been regenerated, so for convenience the contents of the fifth pot were transferred to the fourth one. Two hybrid plants sprang up in it soon afterward, about the same time that the second hybrid plant appeared in the pot with the June plant.

The only fact that could lead one to suppose that the hybrid plants in the two pots might represent reciprocal crosses is that in the one containing the June plant the leaves of both plants, when young, were truncate at the base, like leaves of young *A. platy-*

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* In this connection it is interesting to note that a pocket of rock containing a plant of *A. ebenoides*, found by G. A. Woolson in Vermont, contained also a plant of *A. platyneuron.*

neuron, and in the other cuneate, like leaves of young *C. rhizophyllus.* Later, the leaves of all four became cordate at the base, like leaves of mature *C. rhizophyllus.*

There can be no doubt of the hybridity of these four plants: they have shown from the beginning a most curious combination of the characteristics of *A. platyneuron* and *C. rhizophyllus.*

The leaves have varied from suberect to almost decumbent and, though none have taken root, some have rested their tips upon the earth.

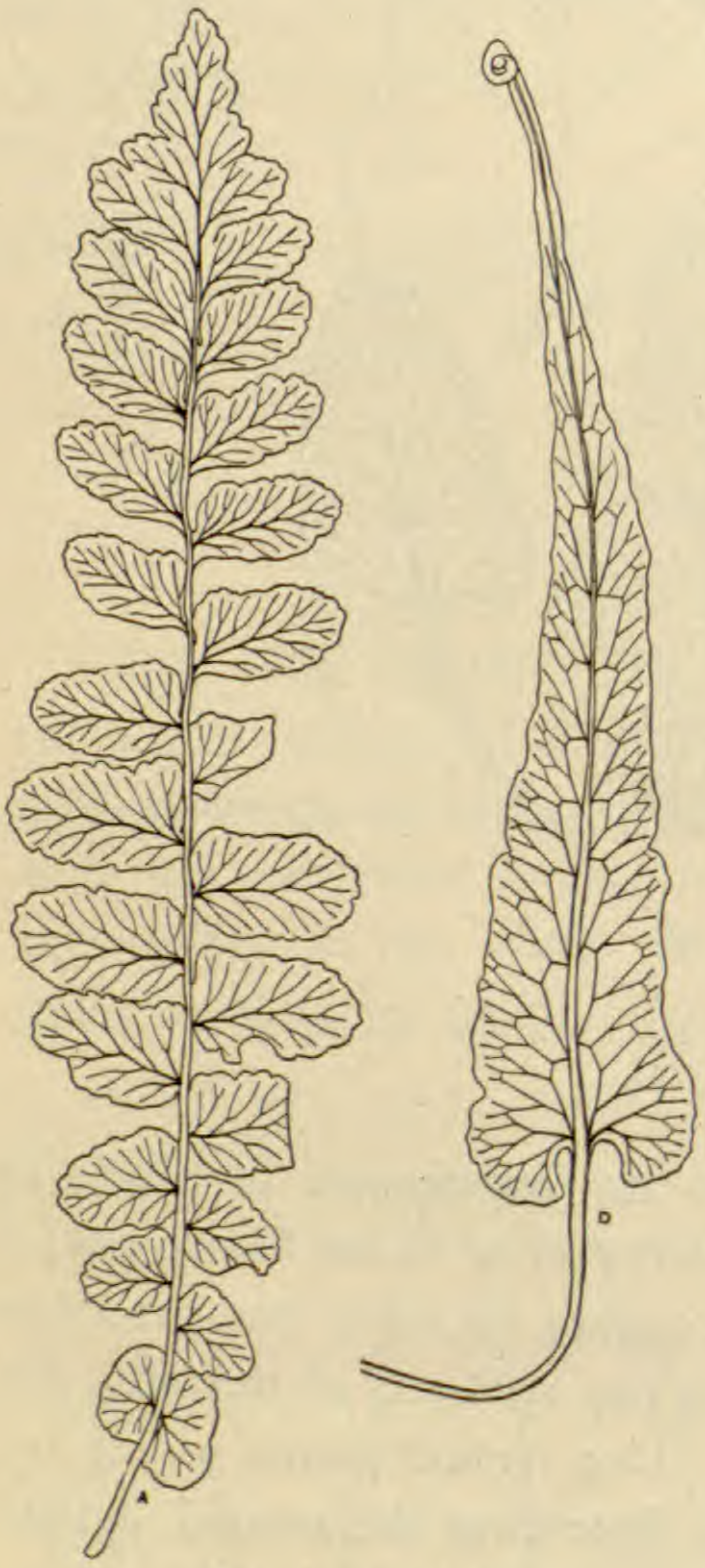

FIG. 6. × 1½.

That the leaf-blades are intermediate in outline between the leaf-blades of *A. platyneuron* and *C. rhizophyllus* may be seen from figures 1–7, in which the three ferns are shown in somewhat parallel stages of development, *A* representing leaves of *A. platyneuron*, *B* and *BB* in *f. 1, 2, 3, 4* and *7* leaves of the June plant of the hybrid, *B* in *f. 5* a leaf, of one of the September plants of the hybrid from the fourth flower-pot, and *D* leaves of *C. rhizophyllus*. The blades of the leaves of the hybrid combine fairly their texture, which is characteristic of *A. platyneuron* but not of *C. rhizophyllus*, with veins forming slightly raised lines on the face of the leaf, which is characteristic of *C. rhizophyllus* but not of *A. platyneuron.* Their color, though a lighter and brighter green than that of *C. rhizophyllus*, suggests it.

In one of the hybrid-plants in each pot the veins have been wholly free, and in the other, especially in the June plant, the veins, though mostly free, have formed a number of areolae.

In all three ferns when very young the petioles are green, but other coloring soon appears at their bases and spreads upward. In *A. platyneuron* this coloring is at first light stramineous and spreads rapidly, involves in time the entire rachis and turns chestnut brown or purplish-ebeneous, sometimes leaving touches of green. In *C. rhizophyllus* it seems to vary from light to dark brown and extends, ultimately, only part way up the petiole. In the hybrid it has been brown from the beginning, has now a dark purplish tinge, and extends some distance up the back of the rachis. The petioles themselves in *C. rhizophyllus* are more or less narrowly winged on the sides, in the hybrid, they are similar, though perhaps more slender, while in *A. platyneuron* they are wingless.

The scales clothing the bases of the petioles in the three ferns are minute, acuminate, and reticulate in reddish-brown on an almost colorless background. In *C. rhizophyllus* they vary from lanceolate to lanceolate-deltoid or are occasionally ovate at base and narrowed suddenly above, and their margins are entire or sometimes bear short cilia. In *A. platyneuron* they are elongate-linear or lance-linear and their margins bear cilia often long and conspicuous. In the hybrid they are more or less intermediate in shape, resembling occasionally the scales of one parent more than those of the other, and their margins are entire or bear cilia varying in length.

On comparing the hybrid plants with a large number of specimens of *Asplenium ebenoides* from Havana Glen, Alabama, and from Virginia, and with photographs of *A. ebenoides* from Virginia, Maryland, and Vermont, I find that the characteristics of the hybrid are, with one exception, characteristics also of *A. ebenoides.* This exception is the manner in which the base of the blade of the leaf varies, at different stages of development, in its resemblance to that of *A. platyneuron* or of *C. rhizophyllus.* As already stated, in two of the plants of the hybrid when young the base of the blade resembled that of young *A. platyneuron* and in the other two that of young *C. rhizophyllus,* while in all four when older it resembled that of mature *C. rhizophyllus.* In young specimens of *A. ebenoides* from Havana Glen, the only young wild plant of this fern I have seen, the base of the blade resembles that of young *C. rhizophyllus,* while in older plants from Havana Glen and elsewhere it resembles in some of the leaves that of mature *C. rhizophyllus* and in others that of mature *A. platyneuron.* But, supposing *A. ebenoides* and the hybrid to have arisen in the same way, for some of the progeny of the same parents to resemble one parent and for others at the same stage of development to resemble the other, is so common an occurrence that no comment is required. From the figures, in which *C* and *CC* represent leaves of *A. ebenoides* from Havana Glen, this varying resemblance of *A. ebenoides* and of the hybrid, at various stages of development, to *C. rhizophyllus* or *A. platyneuron* may be seen. It is especially noticeable in figures 1–3.

Of characteristics possessed by *A. ebenoides* and not by the hybrid I find but two:

1. Possession of sori. The lack of this characteristic in the hybrid is easily accounted for by the age of the plants. The plant are still growing and it is confidently expected that sori will develop upon older leaves.

2. Elongation and attenuation of the pinnae. But this characteristic is either not constant in *A. ebenoides* or else appears in different plants at different stages of development. It is very marked and seems to appear, as a rule, at an early age, in most specimens of *A. ebenoides* from Havana Glen. On the other hand, Dr. Murrill tells me that it did not appear in his plants from Virginia until they had been kept for some time in a greenhouse, in a favorable environment which caused them to develop luxuriantly. In one of his specimens that show no trace of it the blade of the leaf is fully 10.797 cm. long, about a third longer than that of the largest leaf of the hybrid plants, and well fruited. None of the leaves of the specimens of *A. ebenoides* found by Dr. C. E. Waters in Maryland show elongation and attenuation of the pinnae. So the utmost that can be said of the lack of this characteristic in the leaves of the hybrid is that they resemble some leaves of *A. ebenoides* rather than others. How close the resemblance is may be seen by comparing *B* and *BB, f.* 7, which represent leaves of the hybrid, with *C* and *CC, f.* 7, which represent leaves of *A. ebenoides.*

Thus, on comparing with *A. ebenoides* a fern produced by crossing *A. platyneuron* and *C. rhizophyllus*, it is found similar to

A. ebenoides in habit, coloring, texture, form of the leaf, venation, and character of the scales ; in short, it does not possess one characteristic that *A. ebenoides* does not possess at some time in its life history, and, though young, lacks of the characteristics of *A. ebenoides* only the possession of sori and elongation and attenuation of the pinnae, both of which are often absent in *A. ebenoides* at the same age. Surely we have here convincing proof of the origin of *A. ebenoides.*

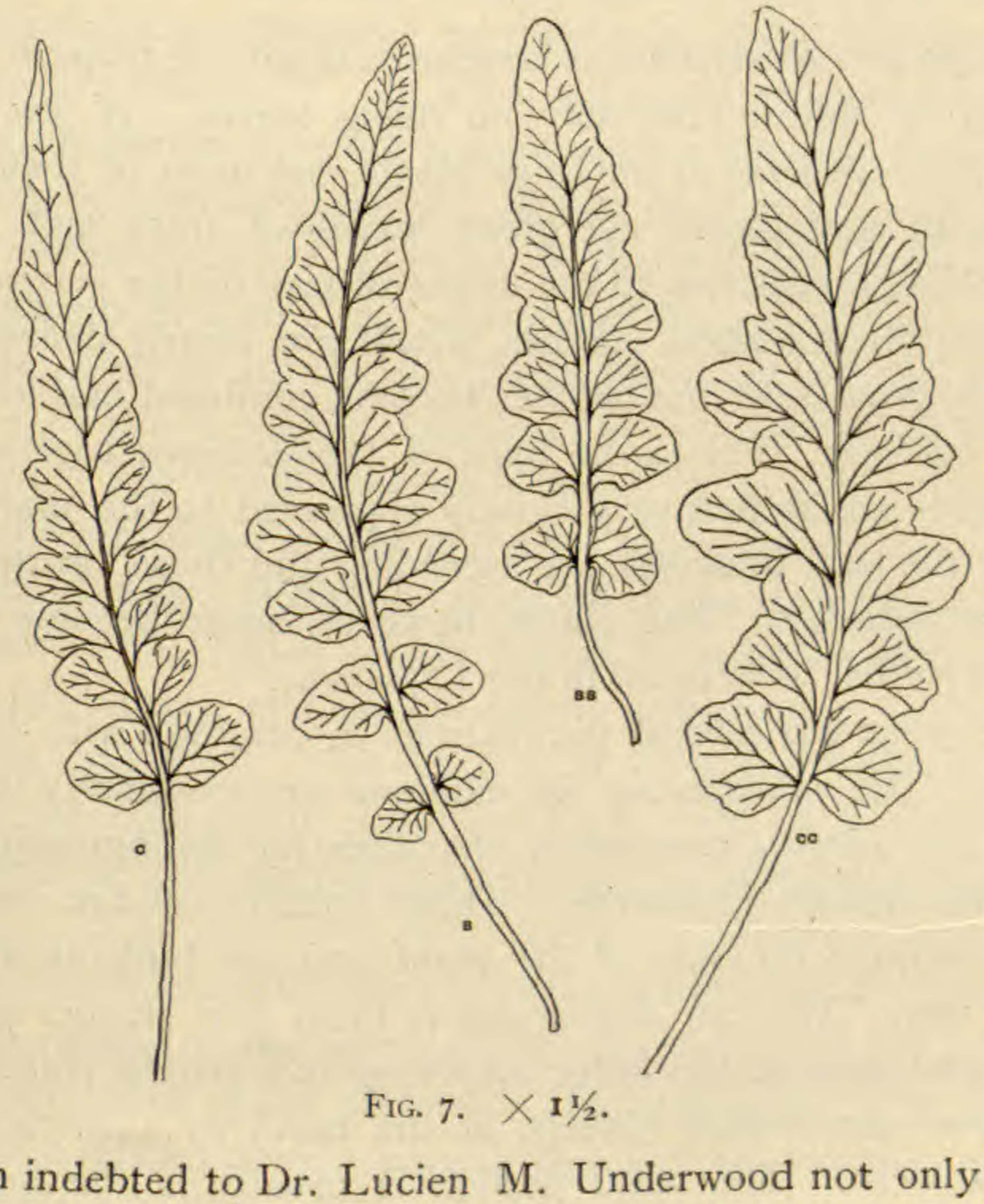

FIG. 7. × 1½.

I am indebted to Dr. Lucien M. Underwood not only for the privilege of examining his collection of specimens of *A. ebenoides* from Havana Glen, but also for many courtesies extended to me in the preparation of this paper ; to Mr. William R. Maxon for a generous number of additional specimens of *A. ebenoides* from Havana Glen ; to Dr. W. A. Murrill for a photograph of *A. ebenoides* from Virginia and the loan of specimens and manuscript notes ; to Dr. H. H. Swift for photographs of *A. ebenoides* from Vermont, and to Dr. C. E. Waters for photographs of *A. ebenoides* from Maryland.

Hepaticae of Puerto Rico

I. THE SPECIES OF LEPTOLEJEUNEA, INCLUDING AN ACCOUNT OF THEIR VEGETATIVE REPRODUCTION

By Alexander W. Evans

(With Plates 23–25)

The genus *Leptolejeunea* is composed of minute tropical species which occur almost invariably on living leaves. A few of the species grow on ferns or on hairy plants, but most of them prefer the smooth and glossy evergreen leaves of trees and shrubs. They confine themselves to the upper surface of the leaves and at first form circumscribed patches, which are clearly defined. As the plants grow older the patches become confluent and lose their distinct outlines. The sterile axes of *Leptolejeunea* together with their leaves are at first very closely appressed to the matrix, but some of the later branches are ascending and those bearing perianths are suberect. The plants, however, never become densely matted together as is usual in the Lejeuneae.

The genus has several peculiarities in common with *Drepanolejeunea.* The underleaves for example are essentially the same in both and afford a convenient character for distinguishing them from other minute Lejeuneae. These underleaves are commonly minute even for the size of the plant and are built up in a very regular way. We can distinguish in them two slender divisions and a basal portion, the latter consisting of a central rhizoid-bearing region surrounded (except at the base) by a single row of marginal cells. The basal portion is usually in the form of a trapezium and is attached to the axis by the shorter of its parallel sides. In some species it is more nearly rectangular and is then abruptly contracted just above the base. From the upper angles of this basal portion arise the two filiform or subulate divisions, which are sometimes composed of a single row of cells throughout and are sometimes two or three cells wide in the lower part. The divisions vary from suberect to widely spreading and in certain species form an angle of 180° or more with each other. In the latter case the upper boundary of the underleaf is a straight or slightly convex line. The number of cells in the basal portion, the number of cells in the divisions and the angle which the divisions form with each other vary within very narrow limits for a given species and are of much value in distinguishing between closely related plants. The rhizoids to which the underleaves give rise are numerous and of the usual type. They consist of simple or branched projections from the median cells of the basal portion and are not themselves divided into cells. The rhizoids secrete a gelatinous substance by means of which they attach the hepatic to its substratum. In a few species of *Drepanolejeunea* an underleaf sometimes develops a small, sucker-like disc, from which the rhizoids develop secondarily. Similar discs occur on the underleaves of *Odontolejeunea* * and also on the first underleaves of the leafy propagula in both *Leptolejeunea* and *Drepanolejeunea.*

In the position of the ♀ inflorescence and in the general characters of the perianth, *Leptolejeunea* also agrees with *Drepanolejeunea.* The ♀ inflorescence is borne on an extremely short branch, which in some species is simple and in others gives rise to a single innovation. With the exception of the perichaetial bracts and bracteoles the leaves on the ♀ branch are abnormally developed or rudimentary, and are commonly reduced to a single side-leaf and an underleaf. The perianth is dilated and sharply five-keeled in the upper part, and the keels, with rare exceptions, extend outward, and often slightly upward, as distinct projections or horns.

The most reliable differences between the two genera are to be found in the shape of the leaves and in the characters drawn from the keels and horns of the perianths. In *Leptolejeunea* the leaves are gradually dilated from a narrow base and are rhombic, ovate, or lanceolate in outline; their apices, although sometimes acute, are scarcely acuminate and are usually plane. In *Drepanolejeunea* the leaves are abruptly dilated from a still narrower base, and are more or less triangular in outline, their apices are long and slender and usually reflexed. In *Leptolejeunea* the keels and horns of the perianth are smooth or nearly so, while in *Drepanolejeunea*, they

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* *Cf.* Spruce, Hep. Amaz. et And. 142. 1884. Also Goebel, Pflanzenbiologische Schilderungen, 1: 161. *f. 66.* 1889.

are rough and often spinose. In *Leptolejeunea* also the leaves are usually ocellate and the inflorescence autoicous, while in *Drepanolejeunea*, the leaves are rarely ocellate and the inflorescence is usually dioicous. It must be admitted, however, that there are species which it is difficult to assign definitely to either genus, and in such cases we must rely upon a combination of characters rather than upon any single generic difference.

Four species of *Leptolejeunea* are now known from Puerto Rico, all of which are widely distributed in the American tropics. The commonest of these is probably *L. elliptica*, which has already been recorded by Stephani.* The range of this abundant species extends through the islands of the Pacific into the East Indian archipelago.

Leptolejeunea exocellata (Spruce)

Lejeunea (Lepto-Lejeunea) exocellata Spruce, Hep. Amaz. et And. 195. 1884.

Pale green, becoming brownish upon drying; stems 0.05 mm. in diameter, closely adherent to substratum, once to thrice pinnate with widely spreading branches but less copiously branched than the preceding species: leaves distant, the lobe widely spreading, plane or nearly so when moist, appressed to substratum, ovate to obovate, 0.45 mm. long, 0.25 mm. wide, attached by a very short, oblique line of insertion, margin entire or nearly so, antical margin not arching across axis, apex obtuse to subacute; lobule oblong-rhomboidal, inflated, 0.14 mm. long, 0.09 mm. wide, keel slightly arched or almost straight, usually continuous with postical margin of lobe, roughened from projecting cells, free margin plane, appressed to basal ocellus of lobe, bicrenulate at the apex, then passing by a straight line or by a lunulate sinus to end of keel: leaf-cells thin-walled, plane or nearly so, averaging 15 μ in diameter at edge of lobe and 19 μ in the middle and at the base, trigones and intermediate thickenings minute but usually distinct, never confluent; basal ocellus, the only one present, 50 μ long, 27 μ wide, projecting postically and forming a cylindrical water-sac with the plane lobule, usually overlapped and almost covered over by adjacent cells of lobe: underleaves distant with erect or

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* Hedwigia, 27: 285. 1888.

obliquely spreading, filiform divisions, each consisting of 3 or 4 cells in a single row, basal portion of underleaf rectangular or tapezoidal, 0.05 mm. long, 0.07 mm. wide, abruptly narrowed at the base, radicelliferous region surrounded by 6 marginal cells, 3 on each side, basal marginal cells curved inward, second marginal cells forming the rounded lower angles of the basal portion, third marginal cells meeting in the middle and giving rise at their junction with the second cells to the filiform divisions of the underleaf: inflorescence autoicous: ♀ inflorescence borne on a very short branch without innovation; leaf at base of branch smaller than ordinary leaves, the lobe ovate to rotund, the lobule reduced to a single row of cells connate with the lobe; underleaf at base of branch broadening from a narrow base, bifid about one half with subulate lobes and a broad lunulate sinus; bracts suberect or obliquely spreading, scarcely complicate, unequally bifid with narrow, long-pointed lobes and lobules, the lobes 0.45 mm. long, 0.07 mm. wide, margin entire; bracteole connate on both sides at the base, linear, shortly bifid with subacute divisions and sinus, margin entire, 0.35 mm. long, 0.07 mm. wide above connate base; perianth somewhat exserted, oblong or obconical from a narrow base, broad at the apex and with a short beak, 0.5 mm. long, 0.45 mm. wide in upper part, terete below, sharply five-keeled above, the keels extending upward and outward as acute or truncate horns, smooth or slightly roughened near the apex: or inflorescence usually occupying a short branch, rarely terminal on a leading branch; bracts usually in 2 or 3 pairs, imbricated, strongly inflated, shortly and subequally bilobed with obtuse divisions, keel crenulate or denticulate from projecting cells; bracteoles present at base of spike, bifid about one half with subulate lobes and obtuse or subacute sinus; antheridia in pairs: mature sporophyte not seen (*pl. 23*).

On living leaves. Between Cayey and Aibonito, *Heller* (568, 569); near Mayaguez, *Heller* (4566 *p. p.*, 4567 *p. p.*); Cayey, *Evans* (70a *p. p.*).

LEPTOLEJEUNEA ELLIPTICA (Lehm. & Lindenb.) Schiffn.

Jungermannia elliptica Lehm. & Lindenb.; Lehmann, Pugillus, **5**: 13. 1833.

Lejeunea elliptica Lehm. & Lindenb.; G. L. & N. Syn. Hep. 403. 1845.

Colura elliptica Trevis, Mem. r. Ist. Lomb. III. **4**: 402. 1877.

Lejeunea (*Lepto-Lejeunea*) *elliptica* Spruce, Hep. Amaz. et And. 194. 1884.

Lepto-lejeunea elliptica Schiffn. Die nat. Pflanzenfam. **1**1^3: 26. 1893.

Pale green, becoming brownish or blackish upon drying; stems 0.04 mm. in diameter, closely adherent to substratum, once to thrice pinnate with widely spreading branches: leaves distant, the lobe widely spreading, plane or nearly so when moist, appressed to substratum, oblong-ovate to oblong-lanceolate, 0.35 mm. long, 0.18 mm. wide, attached by a very short oblique line of insertion, margin entire, antical margin not arching across axis, apex rounded, obtuse or rarely subacute; lobule ovate, inflated, 0.01 mm. long, 0.08 mm. wide, keel slightly arched or almost straight, usually continuous with postical margin of lobe, roughened from projecting cells, free margin plane and appressed to basal ocellus of lobe, bicrenulate at apex, then passing by a lunulate sinus to end of keel; lobule often poorly developed; leaf-cells thin-walled, plane or nearly so, averaging 13 μ in diameter at edge of lobe and 23 μ in the middle and at the base, trigones and intermediate thickenings minute but distinct, never confluent; ocelli 2 to 5 in number, arranged in a median, interrupted line, basal ocellus larger than the others, 45 μ long, 25 μ wide, projecting postically and forming a cylindrical water-sac with the plane lobule, sometimes partially overlapped by adjacent cells of lobe: underleaves distant with widely spreading, filiform divisions, each consisting of 2 or 3 cells in a single row, the cells longer than in *L. exocellata* and with less bulging walls, basal portion broadly rectangular or trapezoidal, 0.04 mm. long, 0.07 mm. wide, abruptly narrowed at the base, radicelliferous region surrounded by 6 marginal cells as in the preceding species but with the second marginal cells sharply angular instead of rounded: inflorescence autoicous or dioicous: ♀ inflorescence borne on a very short branch without innovation; leaf and underleaf at base of branch similar to those of *L. exocellata*; bracts obliquely spreading, scarcely complicate, shortly and unequally bifid, the lobe oblong to obovate, acute to rounded at the apex, sometimes indistinctly apiculate, entire, 0.4–0.5 mm. long, 0.08–0.14 mm. wide, lobule ovate to ligulate, obtuse; bracteole connate on both sides at the base, linear, shortly bifid with obtuse sinus and obtuse or acute divisions, margin entire, 0.25 mm. long, 0.07 mm. wide above connate base; perianth slightly exserted, obconical from a narrow base, broad at the apex and with a short beak, 0.4 mm. long, 0.35 mm. wide, terete below, sharply fine-keeled above, the keels extending upward and outward as acute or truncate horns, smooth or slightly roughened near the apex; or inflorescence usually occupying a short branch, rarely terminal on a leading branch; bracts and bracteoles as in *L. exocellata;* antheridia in pairs: spores oblong, greenish, with a thick, brownish, minutely verruculose wall, averaging 23 μ in short diameter (*pl. 24, f. 1–7*).

On living leaves. First collected by *Sintenis* (45, 136); 14 miles south of San Juan, *Heller* (678, 680); near Mayaguez, *Heller* (4566 *p. p.*, 4567 *p. p.*); Cayey, *Evans* (70a *p. p.*).

L. exocellata and *L. elliptica* are very closely related species. They are not only strikingly similar in appearance but are likely to grow mixed together on a single leaf, and for these reasons they have been much confused by students of the hepaticae. Even Spruce, who first recognized the first species, considered its validity as somewhat doubtful and suggested that it might perhaps be looked upon as a variety of *L. elliptica*.

According to its author, *L. exocellata* may be distinguished from *L. elliptica* by the following differences: the plants are a little larger, their leaves are sometimes narrowed at the base (*i. e.*, obovate-lanceolate) and are constantly *exocellate*, the leaf-cells are more indistinct and with somewhat thickened walls, the infrafloral underleaf is conspicuously pentagonal and bicuspidate, the perichaetial bracts are narrower and the perianth is larger.

Unfortunately several of these differences are not to be relied upon, and this applies particularly to those which concern the leaf-cells. In his full descriptions of the two species in question, Spruce states that the cells of *L. elliptica* are "valde leptodermes," while those of *L. exocellata* are "intus sinuatae, parietibus, subincrassatis." As a matter of fact the cell-walls are very thin in both species but show almost invariably minute and distant trigones and intermediate thickenings. These are a trifle larger in *L. elliptica* than in *L. exocellata*, but the difference is not at all striking. The species of *Leptolejeunea* when dried do not always assume their natural appearance upon the addition of water. Even boiling water is not always effective, and it is sometimes necessary to treat them with potash solution or some similar reagent before we can gain an accurate idea of their cells. This is probably one reason why the cell-structure is not always accurately described.

The absence of ocelli in the leaves of *L. exocellata* is emphasized by Spruce, and it is from this supposed character that the species derives its name. There is present, however, at the base of the lobe a large hyaline cell about three times as long as the neighboring cells. This cell, which would naturally be interpreted as an ocellus, occurs not only in Puerto Rico specimens, but also in South American specimens distributed by Spruce himself. The ocellus is more or less overlapped by the adjacent part of the lobe on the side toward the keel. This part is distinctly convex, and we can see the ocellus clearly only by focussing through the cells which lie over it (*pl., f. 4*). Sometimes the overlapping goes so far that the ocellus looks as if it were a foreign body inside the water-sac, and possibly it has been so interpreted. In reality it takes direct part in the formation of the water-sac. It is not only longer than the neighboring cells, but greater in diameter and projects considerably beyond them toward the substratum. Here it comes into contact with the free edge of the lobule, which remains plane or nearly so (*f. 5*), and in this way a cylindrical sac is formed open only at one end. The capacity of the sac is of course increased by the convexity of the lobe between the ocellus and the keel. A similar ocellus occurs in *L. elliptica*, but it is usually less concealed by overlapping cells. Except for this basal ocellus the leaf of *L. exocellata* is truly "exocellate," and lacks the interrupted row of ocelli, which is characteristic of *L. elliptica*.

The differences in the subfloral underleaves, as noted above, do not seem to be constant. It is sometimes difficult to make out these structures at all on account of the numerous rhizoids which they bear, but when well developed they are essentially alike in the two species.

The remaining differences mentioned by Spruce seem to be trustworthy. It may be added to these that the leaves of *L. elliptica* are usually from 8 to 12 cells broad, while those of *L. exocellata* are from 12 to 15 cells. The underleaves of the latter species also are rounded below instead of angular, and their slender divisions spread less widely and have more bulging cells than in *L. elliptica.*

LEPTOLEJEUNEA STENOPHYLLA (Lindenb. & Gottsche) Schiffn.

Lejeunea stenophylla Lindenb. & Gottsche; G. L. & N. Syn. Hep. 769. 1847.

Colura stenophylla Trevis, Mem. r. Ist. Lomb. III. **4**: 402. 1877.

Lejeunea (*Lepto-Lejeunea*) *stenophylla* Steph. Hedwigia, **29**: 96. 1890.

Leptolejeunea stenophylla Schiffn. Engler's Bot. Jahrb. **23**: 596. 1897.

Pale green, becoming yellowish or brownish upon drying; stems 0.035 mm. in diameter, closely adherent to substratum, irregularly once or twice pinnate with widely spreading branches: leaves distant, the lobe obliquely spreading, plane or somewhat revolute along antical margin, straight or upwardly curved near the apex, lanceolate, 0.5 mm. long, 0.13 mm. wide, somewhat narrowed toward the base and attached by an almost longitudinal line of insertion, margin entire or very slightly crenulate or denticulate from projecting cells, apex acute or short acuminate; lobule ovate, strongly inflated, 0.12 mm. long, 0.09 mm. wide, keel slightly arched, smooth or nearly so, usually continuous with postical margin of lobe, free margin plane or strongly involute too, or including the apex, then lunulate to end of keel, apex formed by a single cell so strongly curved as to almost touch the end of the keel, forming in this way a circular opening into the water-sac; lobule often poorly developed; leaf-cells thin-walled and without trigones, plane or nearly so, averaging 17 x 12 μ at the edge of lobe and 20 x 12 μ in the middle and at the base; ocelli 1 to 4, forming an interrupted median row, scarcely distinguishable from the other cells: underleaves distant, 0.04 mm. long, 0.15 mm. wide, with widely spreading filiform divisions, each consisting of (2 or) 3 cells in a single row, basal portion of underleaf broadly trapezoidal, cuneate at the base, the lateral margins continuous with the divisions, radicelliferous region surrounded by 6 marginal cells: inflorescence dioicous: ♀ inflorescence borne on a very short branch, innovating on one side with a short, simple and sterile innovation; bracts obliquely spreading, scarcely complicate, unequally bifid, the lobe ovate, acute or acuminate, 0.35 mm. long, 0.12 mm. wide, margin irregularly denticulate, lobule varying from sharp-pointed to truncate, 0.17 mm. long, 0.009 mm. wide, margin as in lobe; bracteole more or less connate on both sides at the base, narrowly ovate, 0.35 mm. long, 0.1 mm. wide, bifid about one third with narrow, erect sharp-pointed lobes, and a narrow sinus, margin denticulate; perianth somewhat exserted, obconical, gradually narrowed toward base, 0.6 mm. long, 0.35 mm. wide, broad and truncate at the apex, and very shortly beaked, terete below, sharply 5-keeled above, the keels extending outward as triangular horns, acute to truncate at the apex, smooth or slightly roughened from projecting cells: or inflorescence occupying a short branch or terminal on a leading branch; bracts usually in 6 to 10 pairs, imbricated, strongly inflated, shortly and subequally bifid, the lobe obtusely to acutely pointed, lobule blunter, keel strongly arched, cells in upper part forming a very narrow denticulate wing: bracteoles present at base of spike, small, bifid about one half, with erect-spreading pointed lobes and obtuse sinus: antheridia in pairs: mature sporophyte not seen (*pl. 24, f. 8–16*).

On living leaves. Cayey, *Evans* (70b).

The specimens of *L. stenophylla* from Puerto Rico agree very closely with those distributed in Hepaticae Cubenses Wrightianae. The latter were determined by Gottsche and the determination has since been confirmed by Schiffner. The species has also been reported from Mexico (the type-locality) and from Bolivia.

L. stenophylla is very distinct from the two preceding species. It differs from them in its leaves, which are narrower and much more sharply pointed; in its leaf-cells, which lack local thickenings; in the absence of a large basal ocellus; and in the presence of a subfloral innovation. Its underleaves also are very different in shape and are never angular below their spreading divisions. In its lobule, the apex of which is formed by a single strongly curved cell, the species differs not only from *L. elliptica* and *L. exocellata* but from nearly all the other members of the genus, and approaches in this respect several species of *Drepanolejeunea*.

LEPTOLEJEUNEA HAMULATA (Gottsche) Schiffn.

Lejeunea hamulata Gottsche; Wright, Hep. Cubenses; Schiffn. Engler's Bot. Jahrb. **23**: 587. 1897 (as synonym).

Leptolejeunea hamulata Schiffn. *l. c.*

Brownish-green, growing in thin, irregular patches: stems prostrate, 0.06 mm. in diameter, irregularly pinnate, the branches widely spreading, those bearing propagula microphyllous: leaves distant to contiguous, the lobe obliquely spreading, plane or with slightly revolute margins near the apex, ovate to ovate-lanceolate, distinctly narrowed toward the base, 0.6 mm. long, 0.25 mm. wide, attached by an almost longitudinal line of insertion, margin denticulate except in basal region, the teeth usually projections of single cells, rarely composed of from 1 to 3 cells, antical margin somewhat more convex than postical, apex acute, tipped with a single cell or with 2 superimposed cells; lobule oblong, 0.2 mm. long, 0.14 mm. wide, inflated toward base and along keel, plane and appressed to lobe in outer part, keel slightly arched, forming an almost continuous line with postical margin of lobe, free margin involute toward base, passing beyond apex by a lunulate sinus to end of keel, apex formed by a single, strongly curved cell separated by a slight indentation from the inner part of the free margin; cells of lobe plane or nearly so, averaging 14 μ at the edge, 23 x 13 μ in the middle and at the base, thin-walled throughout or more rarely with indistinct and more or less confluent local thickenings; ocelli indistinct, but present in well-developed leaves, varying in number from 1 to 6, usually 4, arranged in an interrupted longitudinal row, those near the base of lobe measuring 35 x 23 μ, those in outer part averaging 23 x 16 μ: underleaves distant, basal portion trapezoidal in outline, often abruptly contracted at base, 0.05 mm. long, 0.09 mm. wide, marginal cells 6, the second cells more or less bulging, divisions obliquely spreading, 3 or 4 cells long, 1 or 2 cells wide at base, the cells very slightly bulging, cluster of rhizoids sometimes replaced by a sucker-like disc: inflorescence dioicous: ♀ inflorescence borne on a very short branch, innovating on one side with a short, simple and sterile innovation; underleaf at base of branch usually with a sucker-like disc; bracts erect-spreading, complicate, shortly and unequally bifid, the lobe ovate, 0.45 mm. long, 0.2 mm. wide, acute, sharply and irregularly denticulate above the middle: lobule oblong, 0.35 mm. long, 0.1 mm. wide, truncate to acute at the apex, denticulate; bracteole connate on one side, oblong-obovate, 0.4 mm. long, 0.17 mm. wide, bifid about one third with acute divisions and sinus, margin irregularly denticulate or crenulate in upper part; perianth obpyramidal, shortly rostellate, 0.55 mm. long, 0.45 mm. wide at apex, 5-keeled, the keels dilated and truncate in upper part, smooth or nearly so: ♂ inflorescence terminal on a short branch; bracts in 5 to 12 pairs, imbricated, strongly inflated, shortly bifid, the lobe obtuse, the lobule rounded, margins subentire, keel strongly arched, denticulate in outer part; bracteoles limited to base of spike, similar to ordinary underleaves, but smaller and with more erect divisions: antheridia in pairs (*pl. 25*).

On living leaves. Cayey, *Evans* (*71 p. p.*).

The Puerto Rico specimens of *L. hamulata* agree closely with those distributed in Hepaticae Cubenses. Unfortunately they show no perianths and the description of this organ as given above is taken entirely from Schiffner. In all other respects the specimens are well developed.

The close relationship which exists between the present species and *L. stenophylla* has already been commented upon by Schiffner. *L. hamulata* is the larger of the two species and differs also in its broader and less acuminate lobes with sharply denticulate margins. It must be acknowledged, however, that poorly developed specimens are sometimes difficult to determine.

In the original description of *L. hamulata* the lobule is said to be "cylindrico-convolutus apice duobus dentibus validis hamatis conniventibus foramen rotundum includentibus armatus." One of the teeth referred to is evidently the curved cell at the apex of the lobule, the other is apparently the fold at the junction of lobule and lobe. Until the lobule is flattened out by pressure this fold often resembles a tooth in a marked degree. A lobule of this character, although not unusual in *Drepanolejeunea*, is, according to Schiffner, almost unique in *Leptolejeunea*. He emphasizes it in fact as one of the most important differences between *L. hamulata* and *L. stenophylla*. It is evident, however, from a study of the Puerto Rico specimens of the latter species that a *normal* lobule is built up on essentially the same plan as in *L. hamulata*. Unfortunately normal lobules are somewhat unusual and are largely replaced by rudimentary structures in which the true lobular characters are not apparent. In the Cuban specimens normal lobules are still more infrequent but may be demonstrated by careful search.

Aside from their lobules *L. stenophylla* and *L. hamulata* resemble each other closely in their antheridial spikes, in the possession of a subfloral innovation, in their perichaetial bracts and bracteoles and apparently also in their perianths. Most of these peculiarities will distinguish them from *L. exocellata* and *L. elliptica*.

In addition to the ordinary method of reproduction, the four

Puerto Rico Leptolejeuneae exhibit a vegetative reproduction by means of leafy propagula. These arise just behind the leaves in the position usually occupied by normal branches. They are to be looked upon, therefore, as modified branches, the whole of the branch, with the exception of the basal sheath, taking part in the formation of the propagulum. Leafy propagula have already been noted in *Plagiochila* and in various other genera of the Jungermanniceae, but in all cases which have been described they have arisen directly from leaf-cells or more rarely from indefinitely situated axis-cells. Goebel * ascribes the formation of these propagula to the latent power retained by every cell of the liverwort (*i. e.*, of the gametophyte) to develop as if it were a spore — a power which is not made manifest until the plant becomes enfeebled. Propagula of this character are essentially different from those of *Leptolejeunea*, in which the reproductive bodies represent entire branches. The latter, although described for various mosses,† have not before been recorded for any of the leafy hepatics.

The modifications in structure which are exhibited by the propagula of *Leptolejeunea* are in part explicable by their function as reproductive bodies and in part by the peculiar habitat of the species, namely the smooth and glossy surface of evergreen leaves. These modifications are most pronounced in *L. exocellata* and *L. elliptica*, and the propagula of these two species, which are essentially alike, will be considered first. Instead of spreading widely as it would if it were a normal branch, a young propagulum grows toward the apex of the stem, lying above the leaves and parallel with the axis or only slightly diverging from it (*pl. 23, f. 9*). In assuming this position its axis curves abruptly near the base in such a way that the antical surface of the propagulum is turned downward, while the postical surface with its underleaves is turned upward.

The first few leaves and underleaves of the propagulum (*f. 10*) are very different from those borne on ordinary axes. The leaves, although larger than the first leaves of a normal branch, are shorter than typical leaves and are nearly as broad as long. Their

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* Organographie der Pflanzen, 277. 1898.

† Cf. Correns. Unters. über die Vermehrung der Laubmoose durch Brutorgane und Stecklinge. 1899. *E. g.*, *Plagiothecium elegans*, p. 250.

lobes are strongly squarrose and are sometimes completely reflexed, so that they come to lie parallel with the axis and with their apices pointing toward the base of the propagulum. The lobules are very rudimentary and in the reflexed leaves are turned forward, in this way obliterating the keel. The modified leaves, instead of being entire like ordinary leaves, are angular-dentate with from one to three teeth, one being at the apex, and the others (when present) on the outer edge. These teeth often end in the curious rhizoid-like processes (*f. 11*) described by Schiffner * for *Cheilolejeunea versifolia* and for certain other hepaticae, but it is doubtful if they ever assume the function of rhizoids. As we pass from the base toward the apex of the propagulum, we find all gradations between these modified leaves and the ordinary leaves of the species.

The first two underleaves of the propagulum are perhaps even more remarkable than the leaves. They are larger than ordinary underleaves and their divisions often bend inward instead of diverging. The middle cells of the basal portion, which are more numerous than usual, do not produce rhizoids directly but develop instead, a large, orbicular, sucker-like disc (*f. 12*) composed of minute and closely united cells. This disc is entire on the margin and often projects slightly beyond the basal portion of the underleaf.

When a propagulum has developed several pairs of leaves, it becomes separated from the parent plant and develops into a new individual. The separation takes place at its junction with the parent-axis just within the basal sheath. The cells by which it is actually attached are few in number, often reduced apparently to a single one. These cells gradually become shriveled, and it requires very little force to tear them across and set the propagulum free. Probably in nature the force of a shower would be sufficient to bring about this result. It has already been stated that a propagulum, while still attached, lies withits underleaves turned away from the substratum. This position cannot be very stable after separation takes place, because the propagulum would rest on nothing except the edges and apices of its squarrose leaves. Probably here again the force of dripping water is sufficient to over-

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* Engler's Bot. Jahrb. **23** : 598. *pl. 15. f. 4.* 1897.

turn it and at the same time to carry it a short distance away from its parent axis.

By means of the discs on the underleaves, which have the power in common with rhizoids of secreting a gelatinous substance, the propagulum attaches itself firmly to the substratum. Sometimes the attachment is made still firmer by rhizoids which grow out from the marginal cells of the disc (*f. 13*). In the similar discs of *Odontolejeunea* the power of developing rhizoids is possessed by all the cells of the disc, instead of by the marginal cells alone, as in these propagula. When the propagulum has thus established itself, its growing region continues to develop and produces an axis bearing normal leaves and underleaves.

The propagula of *L. stenophylla* are less highly specialized than those of the two preceding species. The branches upon which they are developed usually bear abortive leaves, consisting of a short lobe and an extremely rudimentary lobule, and the growth of these branches is soon arrested by the production of the propagula. In this species the first underleaf is larger than the succeeding ones and shows a well-developed disc. The lobes of the first and second side-leaves are squarrose and more or less toothed and the lobule of the first leaf at least is very rudimentary. The third leaf, however, and sometimes even the second, develop normal lobules, and the fourth and fifth leaves show fairly characteristic lobes.

Leafy propagula of the type just described occur also in several species of *Drepanolejeunea*. Their discovery may likewise be expected in other epiphyllous Lejeuneae and especially in those which do not develop disc-shaped gemmae.

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Explanation of Plates

The figures were drawn by the writer with the aid of the camera lucida. Most of them were prepared for reproduction by Miss Edna L. Hyatt.

PLATE 23

Leptolejeunea exocellata (Spruce) Evans. 1. Stem with two perianths, a ♀ inflorescence and a ♂ inflorescence, postical view, × 47. 2. Cells from middle of lobe, × 425. 3. Cells from apex of lobe, × 300. 4. Cells from base of lobe, showing basal ocellus partially overlapped by adjacent cells, × 400. 5. Transverse section through lobe and lobule, showing basal ocellus, × 300. 6. Apex of lobule, × 300.

7. Underleaf, × 300. 8. Bracts and connate bracteole, × 67. 9. Stems with three young propagula in various stages of development, × 47. 10. Base of an established propagulum, × 47. 11. Apex of one of the first leaves of a propagulum, × 300. 12. Underleaf of propagulum with sucker-like disc, × 360. 13. Marginal cells of disc with rhizoids, × 360. Ten was drawn from a specimen collected by A. A. Heller near Mayaguez (no. 4567 *p. p.*); the other figures were all drawn from specimens collected by the writer at Cayey (no. 70a *p. p.*).

PLATE 24

Leptolejeunea elliptica (Lehm. & Lindenb.) Schiffn. 1. Part of plant with perianth, postical view, × 45. 2. Cells from middle of lobe, enclosing an ocellus, × 400. 3. Cells from base of lobe showing basal ocellus, × 280. 4. Apex of lobule, × 280. 5. Underleaf, × 280. 6. ♀ branch, postical view, × 65. 7. Bracts and connate bracteole, × 65. The figures were all drawn from specimens collected by A. A. Heller near Mayaguez (no. 4567 *p.p.*).

Leptolejeunea stenophylla (Lindenb. & Gottsche) Schiffn. 8. Stem with perianth, postical view, × 45. 9. ♂ inflorescence, postical view, × 45. 10. Cells from middle of lobe, enclosing an ocellus, × 400. 11. Cells from apex of lobe, × 280. 12. Cells from antical margin of lobe, × 280. 13. Apex of lobule, × 280. 14. Underleaf, × 280. 15. Bract and connate bracteole, × 65. 16. Perianth, × 45. The figures were all drawn from specimens collected by the writer at Cayey (no. 70b).

PLATE 25

Leptolejeunea hamulata (Gottsche) Schiffn. 1. Stem with ♀ inflorescence, postical view. 2. Part of stem, antical view. 3. Cells from middle of lobe. 4. Cells from antical margin of lobe. 5. Cells from apex of lobe. 6. Outer portion of lobule. 7. Underleaf. 8. Bract and bracteole. 9. Bract from same involucre. 10. Microphyllous branch showing a propagulum almost ready to become separated and the empty sheath of several older propagula, postical view. 11. An established propagulum, becoming microphyllous in upper part. All the figures are drawn from specimens collected by the writer at Cayey.

The saltatory Origin of Species

BY CHARLES A. WHITE

The following remarks refer to certain noteworthy cases of sudden specific mutation in the genus *Lycopersicum*, and the correlated production of a new horticultural variety of tomato. These remarks will be followed by a comparison of the phenomena referred to with the mutation theory of Professor de Vries and with some of the results of his demonstrative experiments.*

Without reference to the eight or nine other species of tomato that have been more or less satisfactorily recognized by botanists, *Lycopersicum esculentum* has, under American cultivation, become divided not only into a very large number of horticultural varieties, but into at least three distinct groups of those varieties. The varieties, as recognized by gardeners, are mainly, but not wholly, characterized by differences in quality, size and color of the fruit; but the groups are phylogenetic in character and readily recognizable by differences of foliation and inflorescence, and of general habit and relative size of the plants. The color consistence form and size of the fruit, being varietal characters only, are not the exclusive property of any one of these three groups. Two of the groups are known to have originated from the other one; and each one of them embraces a part of the many known varieties. The groups are so distinct from one another, and are characterized by such definite and heritable attributes, that if they had been found in the wild state, no botanist would hesitate to give them new specific names. Their origination under cultivation does not justify one in refusing to apply such names because horticulture does not change the mutative nature of plants. Its nurture and protection give more freedom for normal mutation, as well as for fluctuating and racial variation, than could occur in the wild state. Still, for descriptive purposes in the first part of this article, I will give them the non-systematic name of group,

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* See Volume I. of Die Mutationstheorie. Versuche und Beobachtungen ueber die Entstehung von Arten im Pflanzenreich. Von Hugo de Vries. Leipzig, 1901.

and designate them as the atavic, solanoid and latifoliate groups respectively.

The atavic group embraces those decumbent, more or less diffuse, plants with loose foliage, which represent *Lycopersicum esculentum* as it was first horticulturally known, and which now includes the majority of the most approved fruit-varieties. The solanoid group embraces those plants which are often sturdy and more or less upright in posture, and whose compact, rugose foliage has come to be known as the "potato-leaf." It is because the general aspect of the plants often suggests *Solanum* rather than *Lycopersicum* that this group name is given. The solanoid group embraces a considerable number of varieties, but not so many as does the atavic group. A conspicuous feature of the latifoliate group is the character of its leaves, whose petioles are decurrent and whose leaflets are few in number, broad, flattened, and sometimes have their borders entire. The most characteristic member of this group is the variety known to gardeners as the Mikado. It is also sometimes called Turner's Hybrid, but because it is so conspicuously unlike either of its parent forms I think it really originated in correlation with the specific mutation which produced the latifoliate group, and not by hybridization. Other known members of this group are yet very few. The members of each of these three groups are more or less true to their own seed as regards the characteristics of both group and variety, but the cases of sudden mutation which I am about to describe constitute a special deviation from that rule as do also the cases of original mutation, which produced in correlation with that act, the first varieties of the solanoid and latifoliate groups.

My observations were made while engaged in amateur gardening upon my house-lot in Washington, D. C., and were briefly as follows: In the spring of 1898 I purchased from a dealer in Washington two dozen tomato plants of the Acme variety and transplanted them in my small garden. They produced a uniform crop, both fruit and plants answering in all respects to the reputed characteristics of the Acme, the plants of which variety are typical representatives of the atavic group. I selected seeds from fruit of the best plants of the crop and planted them in the same garden plot in 1899, expecting to grow another crop of Acme tomatoes from them. The seeds germinated promptly and the crop of thirty young plants grew well, but from their first appearance above ground they showed a marked difference from Acme plants. When they had reached the fruiting stage they had developed into typical representatives of the solanoid group, and not of their parent atavic group ; showing that the difference from their parent form was more than varietal in character. Furthermore, every plant of that crop possessed identically the same characteristics, all having shared equally and fully in the mutation. The new form was varietally characterized by an excellent quality of fruit, but it was different in flavor and shade of color from that of the Acme, and ripened earlier than did that of the parent plants. I saved no seed from the fruit of the new variety and therefore supposed it to be lost, as indeed it was.

In 1900 I planted in the same garden-plot Acme tomato seed which I purchased from a seedsman who grew it on a Pennsylvania farm, more than a hundred miles from the place where the seed of my first crop was grown. These seeds also produced a uniform crop of typical Acme plants and fruit. I selected seeds from fruit of the best of that crop of thirty Acme plants and sowed them in my garden in the spring of 1901, and grew in that year also thirty plants from those seeds, again expecting to get a harvest of Acme tomatoes. On the contrary, the result was an exact duplication of my experience of 1899, every plant and every fruit partaking fully and uniformly in the duplicated mutation. *

One naturally inquires whether mutation of any other variety than the Acme would have occurred in my garden, whether it is an inherent quality of that variety to give only one mutative result, and that toward the Solanoid group, and what are the natural and artificial conditions of my garden. I have made no experiments with any other varieties than the Acme and its progeny, the new one, and can therefore only refer to these. The Acme variety is now about twenty-five years old, and has been one of

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* An account of these two mutations of identical character was published in Science for November 29, 1901, but a sufficiently clear distinction between the combined varietal and specific characteristics of the plants resulting from that mutation was not therein made. That statement also was written from a horticultural rather than from a botanical standpoint.

the most stable of the many known varieties of tomato; but of late years it has shown so much tendency to atavic reversion that gardeners are abandoning its cultivation. Possibly that senile decline of varietal characters with which the true specific attributes were long blended, has left the latter with more freedom for mutation. Still, it cannot be supposed that such a condition is the rule for all mutating plants, and it will presently be shown that mutation sometimes occurs in the first generation of a species following its own origin by mutation.

Two dozen plants of the new variety from seed of the second mutation observed by me are now, July 15, 1902, growing vigorously in my garden and bearing characteristic fruit. Every plant is true to seed in both varietal and specific characteristics and the new variety, which I have called the Washington, gives promise of being heritably stable. It shows no tendency to either varietal or specific change, although growing under the same conditions which attend both the mutations which I have described and with which it originated.

There is nothing unusual in the physical conditions and environment of my garden. The soil is clayey, formerly part of a cultivated field, fertilized with stable manure and sodium nitrate, and watered with Potomac water. The seeds were germinated in window boxes, in garden soil, and transplanted on different ground for each year, soon after the spring frosts ceased. I do not know that any other case of mutation has ever occurred in the district which is occupied by the same soil and subject to the same environing conditions.

The new fruit compares favorably with the most approved varieties, and is therefore horticulturally valuable. But that fact is of little importance compared with the biological questions which arise concerning the mutative origin of the plant which bore it. I shall, therefore, in this article make no further reference to the fruit and discuss only the biological significance of the plant-mutation of which it was the joint product. The new variety, however, will be of botanical interest as a demonstration of the heritable character of varieties originating in correlation with specific mutation.

The sudden origination of new plant-forms having hitherto been believed by many persons to be always due to hybridization, I refer to the following facts as proof that there was no cross-fertilization in either of the two cases mentioned, and that the new form is therefore not a hybrid. In neither of the two cases mentioned was any other variety of tomatoes grown with those which I planted, and no other grew in my neighborhood. Wind, or insect cross-fertilization was therefore quite improbable. Because I personally gathered, preserved and planted all my seed and cultivated all my plants, I am sure no substitution of either seed or plants occurred. The fact that in both those cases of mutation every plant of the whole crop partook equally of that act is itself proof that cross-fertilization did not occur. If my Acme plants had received adventitious pollination, or if pollen had reached them from any other flowers than those of their connate crop associates, the results of that cross-fertilization would necessarily have been incomplete as to the whole crop. It would also have been various as to the kinds of hybrids produced had the pollen come from more than one variety. Even if it were credible that the first case of complete mutation of the whole crop might have been the result of cross-fertilization from some unknown source, it would still be too much to believe that exactly the same result could have been produced a second time in successive years by such adventitious means. Therefore the question of hybridity is eliminated.

The origination of this new form was, in both instances, saltatory. It occurred in correlation with the ordinary function of intraspecific reproduction and was therefore accordant with both physiological and phylogenetic law. It did not result from cross-fertilization, and it is therefore assumed to have been a spontaneous result of some not yet ascertained exciting cause, and primarily due to some unknown determinate or predisposing cause.

After I had reached the foregoing conclusion as to the nature of the mutations which I had witnessed, public announcement was made of the publication of Professor de Vries' theory of mutation already referred to, and I at once began a comparison of his theory and observations with my observations which are described in the foregoing paragraphs. This comparison convinced me that my cases of mutation are similar in fundamental character to those described by Professor de Vries, and the brief discussion I shall give them will be in accordance with that conviction. But to illustrate my remarks upon them it is necessary to briefly state the nature of his mutation theory and the methods he has pursued in demonstrating it; and also to show wherein it differs from the generally accepted Darwinian theory. For the sake of brevity these statements are mostly made in epigrammatic form. It is my purpose also, as far as possible, to present this brief sketch of the theory and its demonstration from the author's point of view, albeit in words of my personal choosing.*

The Darwinian theory of the origin of species by natural selection teaches that species have been produced from one another, through lines of genetic descent, by a process of evolutional variation which is immeasurably slow, even in its most accelerated cases; that one of the chief causes of specific change is the competitive struggle for existence to which all organisms are subjected; and that variation is incipient species-building. The enunciation of this theory was a strong and effective plea in favor of the origin of species by the operation of natural law as opposed to the then-prevailing belief that every organic form has arisen by a special act of creation. It has served a grand purpose, especially in establishing the doctrine of evolution on a firm basis, and if its candid and eminent author were now living he would be among the first to welcome any change in it that might prove to be necessary in view of later discovered facts.

The de Vriesian theory of mutation is in entire accord with natural law and also with the doctrine of the evolutional origin of species through lines of genetic descent, but it especially makes a clear distinction between species and varieties and teaches the sudden origination of the former whether they possess more or less strongly marked attributes. It also teaches a far more stable entity of species than one can conceive of who unqualifiedly accepts the Darwinian theory. Professor de Vries logically assumes that the mutation theory is as applicable to animals as to plants, but he has formulated it only with reference to the latter. I shall make

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* A somewhat fuller, but brief, statement of the mutation theory is given by me in the Annual Report of the Smithsonian Institution for 1901. An interesting general sketch of the theory by Professor de Vries is contained in Science for May 9, 1902.

only a similar reference to the theory in following paragraphs, although my former paleontological work suggests a much wider application of it.

The theory begins with a philosophical concept concerning the molecular constitution of the protoplasm of organisms, as set forth in the author's treatise on intracellular pangenesis.* It assumes that the specific attributes of multicellular plants result from the special molecular constitution of their protoplasts, or cell contents; and that these attributes are built up of sharply defined intracellular units, which normally combine in groups. This specific group-combination has much stability, but it is subject to change by sudden, independent action of some unknown determinate cause. That change is the initial step in mutation and consists of the addition, or substitution, of one or more units to an established group and the consequent rearrangement of the units of that group, forming a new one.

Upon the integrity of the groups of units depends the stability of the specific attributes. Their normal tendency to stability is so great that initial group-changes do not occur in the somatoplasts of plants but only in the plasma of certain of their reproductive cells; and they occur there only seldom. Ordinarily, when such a change occurs, it is only in the oöplast of the germ cell of the ovule which is about to originate a new plant. If no change of specific units occurs in the oöplast the case is one of ordinary reproduction. If such a change does occur in the oöplast the case is one of mutation as well as of reproduction, all the cells of the coming plant naturally partaking of the same specific attributes.

It should be here remarked that such cases as the reputed origination of the nectarine from the peach are apparent exceptions to the rule just mentioned. That case being one of ordinary asexual reproduction and if it really was also a case of simultaneous origination of a new species, initial mutative change must have occurred in the plasma of the apical cell of the mutating bud. If mutation may occur in correlation with asexual reproduction, mutative molecular change in pollen cells would seem to be unnecessary in mutating cases of sexual reproduction.

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* See Intracellulare Pangenesis. Von Hugo de Vries. Pp. 212, Jena, 1889.

Mutation is, therefore, the saltatory origination of new organic species resulting from sudden molecular change in their initial protoplasts. The new species is at once such, without preliminary preparation, without intermediary gradation, and without any subsequent addition of attributes. Newly mutated species differ clearly and distinctly, but not widely, from the parent species. Wide differences between species of a genus indicate the death of intervening species. As a rule, mutation occurs, not by, or in connection with cross-fertilization, but in correlation with pure intraspecific sexual reproduction, and nevertheless independently of it. A new and stable specific form is thus produced, but the parent species remains intact. Mutation is, therefore, a strictly phylogenetic process, although plural cases occurring in one and the same mutating species are often randomly divergent in character.

Hybridization occurs in nature, and very often in cultivation, but it is not mutation. Neither is it really phylogenetic in character, but a result of ontogenal miscegenesis, with the groups of molecular specific units unbroken in each parent germinal portion. According to Mendel's law, even fertile hybrids are sooner or later obliterated by the prepotency of one or the other of the parent forms.

Mutation, being a normal process, does not produce monstrosities. The latter are cases of distorted or abnormal ontogeny.

Above all, variation is not mutation, nor are varieties incipient species. Ordinary fluctuating, or individual, variation is an inseparable accompaniment of all plants, and racial variation also widely prevails, but no kind of variation leads to mutation proper.

Mutation, being a result of intracellular molecular change, is necessarily sudden, as is molecular substitution in chemical reaction. One cannot concieve that molecular change could continue in action toward one result through immeasurable time. A species being suddenly produced implies that its normal state is one of at least a considerable degree of stability.

Species being normally stable and only incidentally mutable, a part of the time-existence of each is therefore a mutative, and a part an immutative, period. The immutative period is, as a rule, so very much longer than the mutative period that very few mutable plants exist simultaneously in any flora. Because of these facts, of the great prevalence of fluctuating varieties, and for other reasons, mutation has hitherto usually escaped observation, even by naturalists.

When a new species originates by mutation in the wild state it is at once subject to the usual competitive struggle for existence, even with its parent form. Species not only do not originate by natural selection and the struggle for existence, but they perish thereby; and the number of species which have originated by mutation since the beginning and met an untimely death without having produced any progeny, is doubtless beyond human estimate.

Acting upon the theory which is very briefly stated in the foregoing paragraphs, Professor de Vries formed a systematic plan for discovering and studying mutating plants. He selected from the flora of Holland more than one hundred species and transplanted them in experimental gardens at Amsterdam, where he also sowed seed of those, and many other members of the Holland flora. He also made exhaustive studies of that flora in its wild state. The object of these experiments was not to produce horticultural varieties but to discover plants that were already in their natural mutative period among the multitude that were plainly immutative. He nurtured, protected and artificially pollinated the plants thus growing under his care. In short, he fully supplied their natural wants, gave them much greater advantages of growth and development than the best wild conditions could afford, and relieved them from all the adverse conditions which they necessarily would have encountered in their wild habitat. Meanwhile he eagerly watched them all for any sign of mutation that might occur.

The result was at least one grand success amid a multitude of failures. The failures were not due to the method of investigation, but to the fact that almost all the plants investigated were in their immutative period. The chief case of success was with plants of the American genus *Oenothera*, the so-called evening primroses. One species, *O. Lamarckiana*, proved to be in an exceptionally mutable condition. A few years ago it escaped from cultivation in certain parks in Holland and immediately began a most vigorous multiplication and dispersion in a wild state. Among the abundant original plants thus produced, two new species soon appeared which Professor de Vries believed had originated then and there by mutation from *O. Lamarckiana.* He transferred many of those plants and much of their seed to his experimental gardens and there verified that belief by obtaining a repetition of those two mutations under his direct observation. Furthermore, in the course of a few years of experimentation, he obtained by mutation from *O. Lamarckiana* five other new species, seven in all. A part of these new species proved to be also mutative, adding still other new ones to his list; and all the new ones possessed, from the moment of their origin, well-defined and heritable attributes. These mutations occurred in the progeny of plants which had received intraspecific artificial pollination. Interspecific pollination, or cross-fertilization, was not found to facilitate mutation, and hybridization was not sought for or desired.

In view of the success of Professor de Vries' experiments with *Oenothera*, and the fact that all except one or two per cent. of the species with which he experimented failed to show any sign of mutation; and the further fact that he experimented with only a part of the Holland flora, one infers that the proportion of immutative plants to the mutative may perhaps be as great throughout the plant kingdom as he found it to be in that flora.

Recognizing the fundamental accordance of my observations with those of Professor de Vries, I assume that *Lycopersicum* is, like *Oenothera*, in its mutative period and that *L. esculentum* has given mutative origin to two other species which, in previous paragraphs, I provisionally designated as groups. The fact that these two specific forms differ less from each other, and from their common parent *L. esculentum*, than do some other species from one another, does not affect the validity of the claim that they should also be regarded as distinct species. The facility with which all forms of *Lycopersicum* hybridize with one another also does not affect that claim because of the non-phylogenetic character of hybridization. I shall therefore apply the systematic name of *Lycopersicum solanopsis* to the solanoid group, and the latifoliate group accordingly becomes *L. latifoliatum;* but the atavic group must retain its original name of *L. esculentum.*

While the cases of mutation which I have observed in *L. esculentum*, fundamentally accord with those which Professor de

Vries observed in *Oenothera Lamarckiana*, they present some peculiar features, the chief of which are shown by the following comparisons. In none of his cases do specific attributes seem to have been complicated with varietal characters, unless one should except the case of *O. nanella.* Perhaps a sufficient reason therefor is that most of the species of *Oenothera* have hitherto shown very little tendency toward variation. On the contrary, *Lycopersicum solanopsis* became divided into several varieties soon after its first mutation from *L. esculentum.* I do not know in what variety it first appeared, but in the first of the two subsequent mutations, those which I observed, it appeared in a new variety, the Washington. Furthermore, in the next mutation, which was quite independent of the others, it appeared in the same variety. Indeed, in all the cases of specific mutation of *Lycopersicum* to which I have referred, some one horticultural variety seems to have been a conjunctive vehicle for the introduction of the new species.

The scope of mutative action in *Oenothera* has been given in detail by Professor de Vries, but my observations show that in *Lycopersicum* the scope of that action is different in certain respects. He found mutation in *Oenothera* to act independently and separately upon the germ of each one of a very small number of seeds in an abundant fruitage of a large crop of plants; and that those seeds were usually subject, not to one and the same mutation, but to different specific mutations. I found in *Lycopersicum* that one specific mutation acted completely and uniformly upon the germs of all the seeds, of all the fruits, of every plant of my crop of 1899, and that it acted in precisely the same manner in the crop of 1901. The suddenness of its action in the latter crop especially, is shown by the fact that the Pennsylvania Acme seeds, planted in my garden in 1900, gave a full and uniform crop of true Acme plants; and that it was their seed which mutated so completely upon the same ground in 1901. In view of my repeated experience with the Acme variety one seems to be justified in assuming that the determinate cause of mutation is now latent in every plant of that variety wherever grown, and that it quickly manifests itself when the flowering plants are brought under the influence of a favorable, exciting cause.

Again, Professor de Vries found that some of his newly mutated species of *Oenothera* were themselves immediately mutable. My observations of the mutation from *Lycopersicum esculentum* to *L. solanopsis* seem to indicate that the mutative act was coincident with impending varietal senility in the Acme variety, and that the resulting variety, the Washington, has no tendency to mutate. Doubtless *L. esculentum* originated by mutation from some other pecific form of that genus, but no evidence seems to be obtainables that, although variable, it began to be really mutable until many years after the species became horticulturally known. These facts indicate that in some species the mutative period occurs in one part of their time-existence, and that in other species it occurs in another part of the same.

Some of the observations made by myself in the cases of mutation of *Lycopersicum* are thus seen to be different from any of those made by Professor de Vries in cases of mutation of *Oenothera;* but the facts which we have both observed are not in conflict. Their differences only indicate that the field of investigation which that distinguished botanist has opened in close contact with nature is a very broad one.

SMITHSONIAN INSTITUTION, 15 July, 1902.

New Western Plants

BY ALICE EASTWOOD

I. NEW SPECIES FROM COLORADO AND UTAH

Castilleia scabrida

Stems low, 5–10 cm. high, from a perennial root, leafy, flowering from near the base or half way to the top. Entire plant canescent with a stiff scabrous and hispid pubescence: lower leaves linear-oblong, obtuse, 1–2 cm. long, 2–3 mm. wide, the midrib prominent; upper leaves 3–5-cleft, with spreading divisions, the lower part broad, 3-ribbed; bracts similar to the upper leaves, colored: calyx obliquely gibbous at base, 2.5 cm. long, about equally cleft, hispid especially on the nerves; divisions linear, 6–7 mm. long: corolla with half the galea extending beyond the calyx lobes: lower lip protuberant with acuminate divisions: stamens and style exserted, the latter surpassing the former: capsule ovate-acuminate, 15 mm. long, 8 mm. wide, distending the calyx as it ripens: seeds brown, shining as if varnished, linear-oblong to clavate, scrobiculate.

This was collected at Grand Junction by Mrs. H. C. Long in the spring of 1890. The type is in the herbarium of the California Academy of Sciences.

Lappula gracilenta

Stems erect, 4–6 dm. in height, branching from the base or half way up with slender, spreading branches, hispid throughout with white hairs which are horizontally spreading on the stems and margins of the leaves, appressed on the surfaces of the leaves and calyx, wanting on the corolla: leaves crowded at base, spatulate to oblanceolate, narrowed to a margined petiole of about the same length as the blade, together 2–8 cm. long, about 1 cm. wide, the earliest leaves shorter and broader in proportion: cauline leaves lanceolate, sessile, 6 cm. long, 1 cm. wide, becoming smaller as they ascend, entire or obscurely denticulate along the upper margin: internodes not quite equalling the lower leaves, surpassing the upper ones: bracts generally alternating with the flowers, becoming smaller and linear on the upper part of the racemes: pedicels slender, recurved in fruit: divisions of the calyx extending almost to the base, linear, obtuse, 2–3 mm. long, spreading under the nutlets: corolla blue, with white folds in the throat: divisions obovate, 4 mm. long, 3 mm. wide, twice as long as the short tube: folds in the throat thick, each of 3 wart-like crests, the middle one largest: stamens on short filaments which are concealed by the large anthers, 1 mm. long, inserted below the folds and alternating with them: scales at the base of the corolla tube fleshy, in pairs: style short: stigma capitate: nutlets ovate, 3 mm. long, 2 mm. broad, the surface pubescent and having a few barbed bristles which are .5–2.5 mm. long, generally a long and short one alternating.

This beautiful species grows in the cañons of Mesa Verde in southwestern Colorado where the cliff dwellings are situated. The type specimens were collected by the author in Navajo Cañon, June 7, 1892.

Type in the herbarium of California Academy of Sciences.

Corydalis Wetherillii

Annual or biennial, branched from the base and also above, with slender, erect stems and branches, 10–15 cm. high, glabrous and glaucous: leaves dissected, the lower on long slender petioles, twice-compound with 5 primary divisions on capillary petiolules, secondary divisions fan-shaped, 3–5-parted with ultimate divisions spatulate, entire, or 3-lobed, acute, minute: peduncles axillary from near the base to the top of the stems, 1 mm.–2 cm. long, with 1–3 flowers at summit as well as some abortive ones: bracts linear-acuminute, entire or with a few teeth near the summit: sepals 2, membranous, triangular, scale-like, less than 1 mm. long: corolla 2 cm. long, the spur rounded at base, straight, 4 mm. long: outer petals pinkish, hooded but without dorsal crests: inner yellowish, as long as the outer, with wing-like crests on the back: capsules linear or linear-lanceolate, straight or somewhat curved, 2 cm. long, tipped with the persistent style and disk-like stigma: seeds flattened, orbicular, black, very glossy, 2 mm. in diameter, faintly marked under a 10-diameter lens with a fine quadrangular venation.

This peculiar species was collected near Bright Angel Creek, one of the branches of the Colorado River which comes into the river nearly opposite Hans' Trail. This trail is that taken by tourists who go into the cañon from the Flagstaff side. It is named in honor of Mr. Alfred Wetherill who collected it in the summer of 1897.

The foliage is more finely dissected than in any other species known to me. It is perhaps more nearly related to the group which contains *C. aurea* but it is quite distinct from that or any other known species. The type is in the herbarium of the California Academy of Sciences.

II. TWO NEW SPECIES OF CAMPANULA FROM THE PACIFIC COAST

Campanula stylocampa

Stems slender, erect, about 2 dm. high, simple, purplish, ribbed with scabrous angles, otherwise glabrous. Leaves alternate, oblanceolate to linear, acuminate, 2–3 cm. long, becoming smaller as they ascend, tapering to a sessile base, veinless except for the midrib, revolute and crisped-undulate along the margins, the lowest leaves ciliate at base: flowers solitary, terminating the stems: calyx with narrow, linear-subulate divisions, 8 mm. long, .5 mm. wide, glabrous, revolute and somewhat undulate at base: corolla divided almost to the base; divisions lanceolate, 13 mm. long, 4 mm. wide at base, with cucullate apex and undulate margin: anthers linear, 7 mm. long, on short, narrowly linear filaments 2 mm. long, abruptly widening to an orbicular base, 2 mm. wide, hairy along the margin: ovary urceolate, ribbed, opening under the calyx: style long, exserted, 12 mm., erect at base, then curved like a sickle downwards, 3-cleft at apex when developed: fruit not present.

This unique species of *Campanula* was collected by George Fenwick near Dawson, N. W. Territory, in the summer of 1900.

The specific name arises from the peculiarly curved style in which it differs from all other species of North American Campanulae. Type in the herbarium of California Academy of Sciences.

Campanula Baileyi

Stems from creeping, filiform rootstocks, 6–12 cm. high, slender, simple, erect, glabrous, angled or ribbed, leafy up to the solitary, terminal peduncle. Lowest leaves cuneate or obovate, toothed along the apex, middle stem leaves elliptical-lanceolate, sharply serrate with a few teeth; upper ones more distant, narrowly lanceolate or entire: peduncles at first nodding, becoming erect, about 2.5 cm. long: divisions of the calyx triangular-subulate, acuminate, 1 cm. long, glabrous: corolla blue, 14 mm. long, with divisions 8 mm. long, linear-lanceolate, minutely cucullate at the apex: anthers 6 mm. long, linear, mucronate: filaments broadening from 1 mm., as wide as the anthers, to 2 mm.: style not exserted, as long as the stamens: ovary turbinate, opening just below the divisions of the calyx: fruit not seen.

This was collected by Mr. Vernon Bailey, in the mountains at the head of Canyon Creek, Trinity county, California, August, 1899.

While it is distinct from all other species of *Campanula* it probably comes nearest to *C. linnaeifolia* Gray. Type in the herbarium of California Academy of Sciences.

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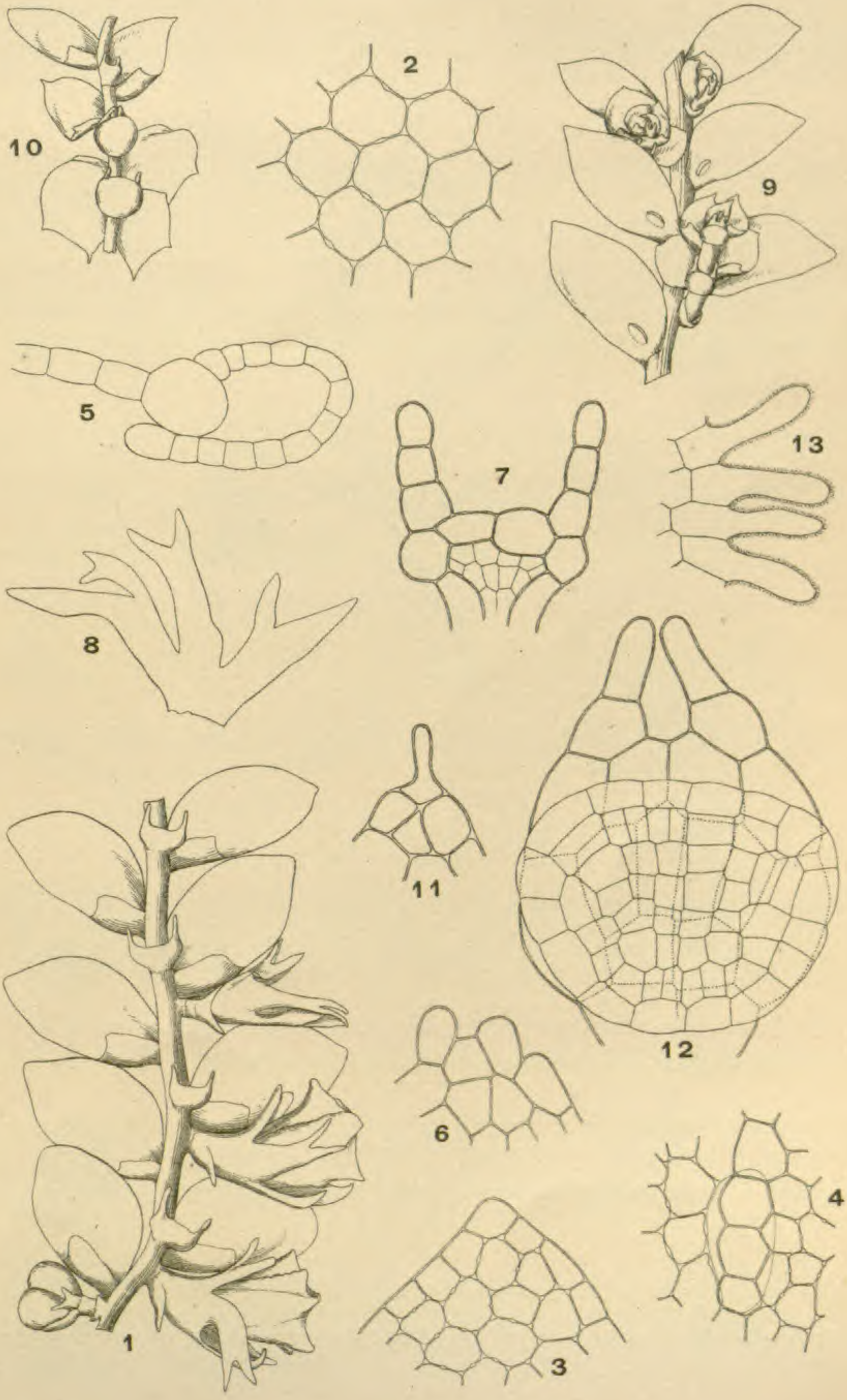

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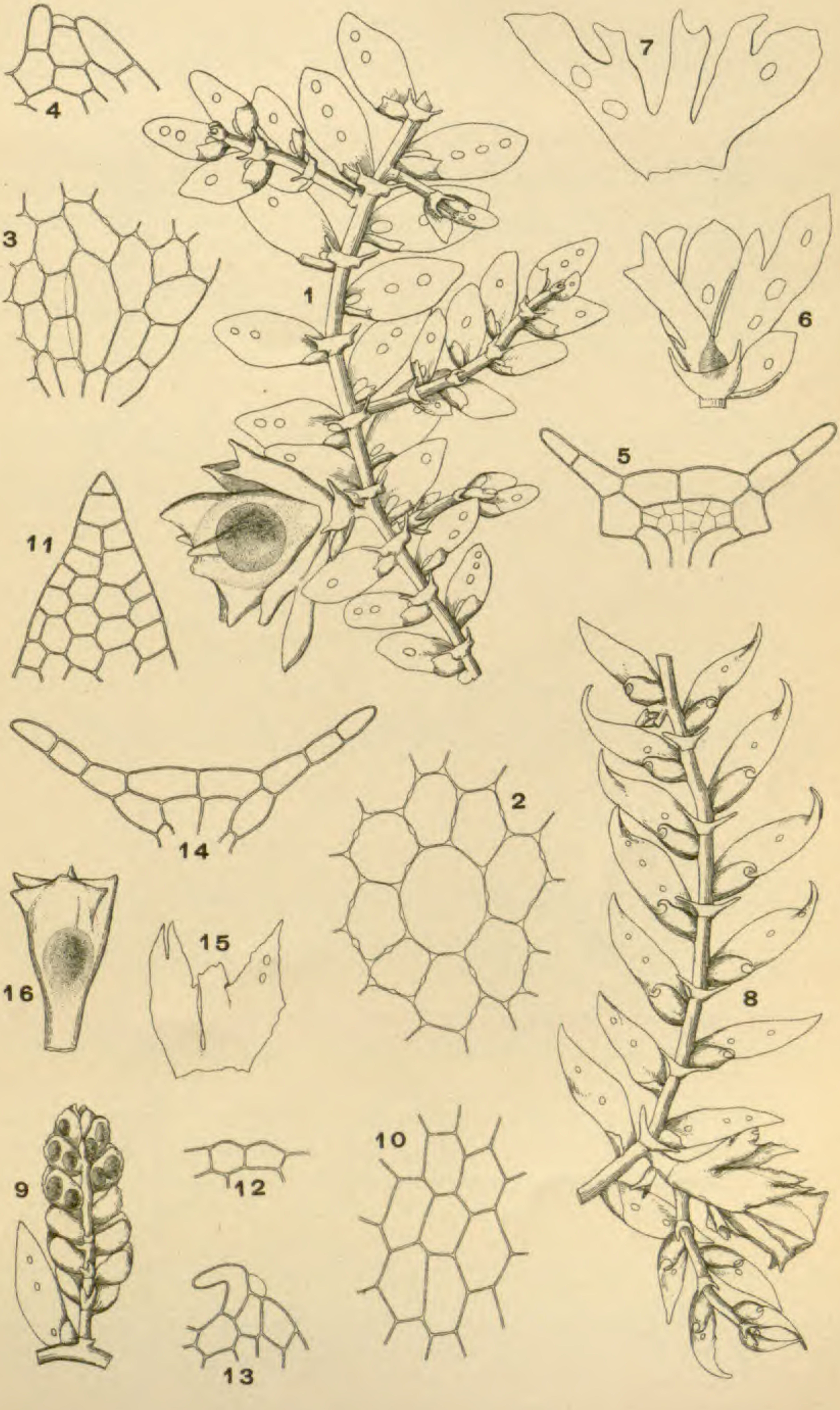

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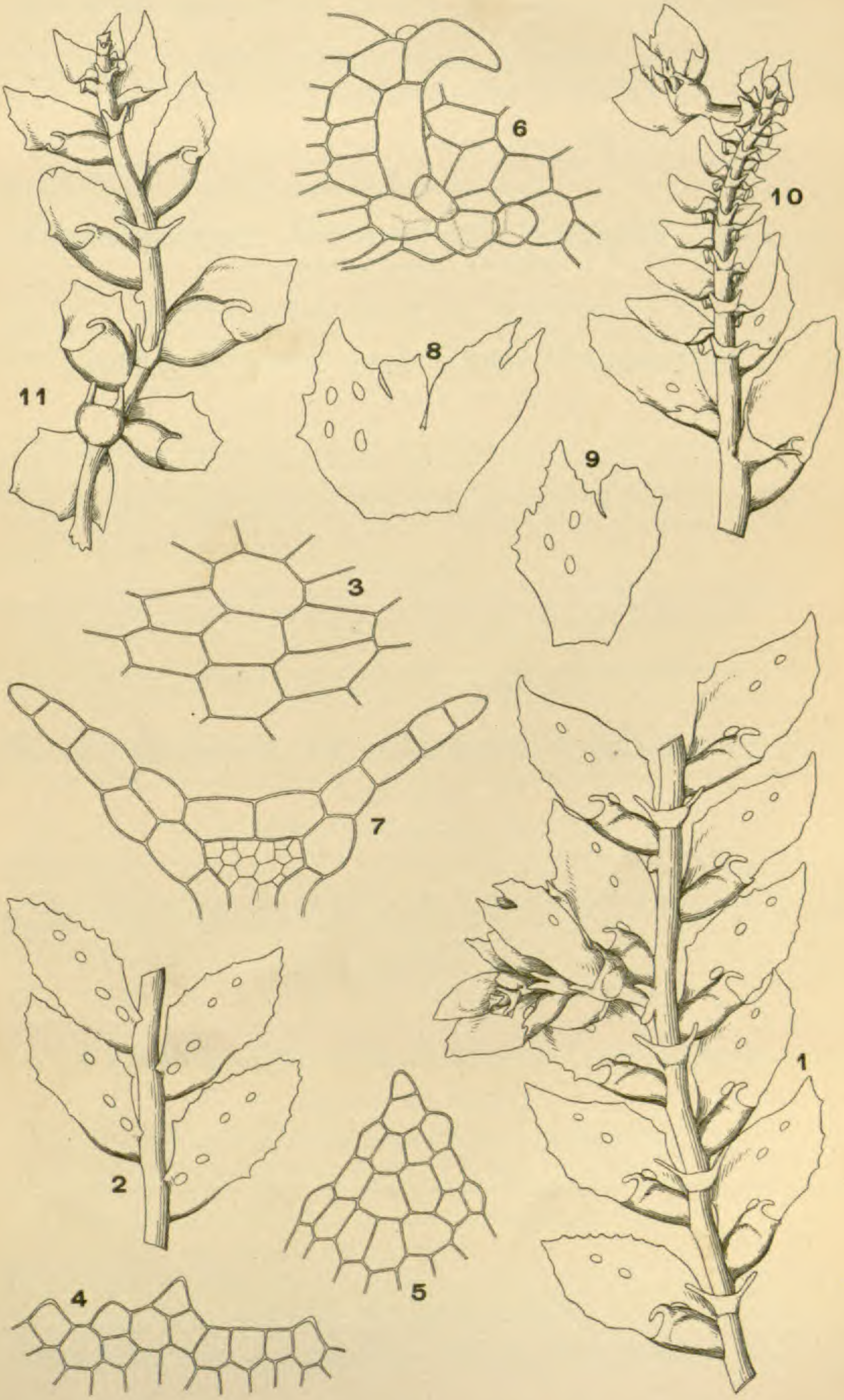

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Memoirs. (See last page of cover.)

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BULLETIN

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TORREY BOTANICAL CLUB

SEPTEMBER, 1902

Notes on the biennial and perennial West American Species of Lappula

BY C. V. PIPER

In describing *Lappula arida* in this journal (28 : 44) I briefly called attention to the value of the fornices or appendages in the throat of the corolla as one means of distinguishing that species from *L. ciliata* (Dougl.) Greene. Indeed it was largely by the character of this appendage that it became clear that the handsome blue-flowered species common about Spokane, Wash., was identical with Douglas' original, an authentic specimen of which is in the Gray herbarium. Douglas' plant was in very young flower, so that it was only by comparing the throat appendages that it became certain that his plant was distinct from *L. arida*. In the course of this examination I was struck with the different forms of the throat appendages, which prove on further study to be very constant and therefore a helpful means of identifying specimens in flower only, as well as of distinguishing species. In describing *L. arida*, the fornices were said to be "not retuse." This is an error, as in all the biennial and perennial American species at least the appendage is notched. Briefly the appendage consists of an obcordate erect or connivent swelling, from the lower ventral face of which projects into the throat a protuberance. The size shape and surface of the appendage, the shape of the protuberance, and the relative dimensions of these parts furnish characters, which though difficult to describe, are found to be very reliable. In endeavoring to clear up the northwestern species, it became necessary to examine a large amount of material. The following results are based on a study of the material in

[Issued 26 September]

the Gray herbarium, of that in the California Academy of Science, and of that in the herbaria of Mr. W. C. Cusick and Professor L. F. Henderson, together with my own. Besides the species here considered there are several more undoubtedly distinct species represented in the Gray herbarium, which owing to incomplete material it was not deemed wise to describe. It is very desirable in the future that collectors endeavor to secure both flowering and fruiting specimens of each species. The great bulk of the material in herbaria is either in flower or in fruit, so that it is often very difficult to determine which goes with which. Belated flowers in fruiting material are unsatisfactory, as they are frequently much smaller than is typical and therefore apt to be misleading.

So far as my experience goes in the field, the color of the flowers, contrary to what might be expected, is very constant. While white-flowered specimens are notoriously common in blue-flowered plants, the present genus seems to be exceptional in this respect.

Owing to the great confusion of material in herbaria, a full list of the specimens examined is given under each species.

Key to the Species

Biennials or perennials; nutlets armed on the margins with free or united flat subulate glochidiate prickles.

I. Back of nutlets unarmed or with short glochidiate prickles; marginal prickles free to the base or nearly so.

Corolla appendages smooth or merely papillate.

Appendages broader than long: protuberance short, broad: flowers blue.

Flowers small, 4–6 mm. broad. 1. *L. floribunda.*

Flowers larger, 8–10 mm. broad. 2. *L. diffusa.*

Appendages as long as broad: the oblong protuberance scarcely projecting: flowers white.

Foliage rather softly pubescent. 3. *L. Hendersoni.*

Foliage harshly papillose-scabrous. 4. *L. trachyphylla.*

Corolla appendages pubescent.

Flowers small, less than 5 mm. broad; appendage about as broad as long, short-pilose, the protuberance very small. 5. *L. pinetorum.*

Flowers larger, 5–12 mm. broad.

Appendage short-pilose.

Flowers white: pubescence rather harsh, mostly appressed except on the lower part of the stem and the leaf-margins. 6. *L. arida.*

Flowers blue: pubescence soft, not appressed. 7. *L. saxatilis.*

Flowers blue: pubescence smooth, very closely appressed except a few bristles on the lower petioles. 8. *L. Cusickii.*

Appendage hirsute, the hairs as long or longer: flowers bluish (or sometimes white?). 9. *L. caerulescens.*

II. Back of nutlets unarmed or with short glochidiate prickles; lateral prickles united for about half their length.

Flowers greenish: corolla-lobes broadest at base; appendage smooth, much broader than long, lunate, the protuberance forming a short blunt tooth. 10. *L. hispida.*

Flowers blue: corolla-lobes suborbicular; appendages short-pilose; protuberance short.

Back of nutlets with glochidiate bristles.

Flowers blue: pubescence fine, appressed. 11. *L. ciliata.*

Flowers blue: leaves bristly, green. 12. *L. setosa.*

Flowers white: leaves bristly, ashy-gray. 13. *L. cinerea.*

Back of nutlets without glochidiate bristles.

Back of nutlets coarsely granulate-scabrous, with central ridge faint or none. 14. *L. ursina.*

Back of nutlets nearly smooth, with a prominent central ridge. 15. *L. scaberrima.*

III. Back of nutlets with glochidiate prickles about as long as the marginal ones.

Corolla white, rotate, the tube not exceeding the calyx; appendage broader than long, short pilose. 16. *L. Californica.*

Corolla blue or pink, short-salverform, the tube longer than the calyx.

Corolla 10–15 mm. broad: appendages very large, one third as long as the corolla lobes; protuberance equally long: pubescence velvety. 17. *L. velutina.*

Corolla 6–8 mm. broad: appendages small, one sixth as long as the corolla-lobes, the protuberance very small: pubescence not velvety. 18. *L. nervosa.*

1. LAPPULA FLORIBUNDA Greene, Pittonia, **2**: 182. 1891

Echinospermum floribundum Lehm. Pugillus, **2**: 24. 1830.

Specimens of this species in fruit are very easily distinguished from fruiting specimens of the following, but flowering specimens are sometimes distinguishable only with difficulty. The only differences which seem to separate the two species in flower are the smaller corollas and denser racemes of *L. floribunda.* According to Cusick, *L. floribunda* is always biennial in duration, *L. diffusa* perennial. So far as fruiting material goes there seem to be but two species, but Dr. Rydberg has segregated a third supposed species, *L. leptophylla* Rydb. (Fl. Mont. 329. 1900), of which I have seen no specimen. It is said to be distinguished from *L. floribunda* by having smaller flowers and thinner leaves. It is very desirable that collectors take careful note in the field as to whether variations in the size of the corolla are correlated with other differences. *L. floribunda* as at present received shows some variation as regards the size of the flowers and also in pubescence.

The following specimens are referred to this species.

WASHINGTON: Yakima Region, July 1883, *Brandegee, 986.*

OREGON: Without locality, 1881, *Cusick, 118.*

CALIFORNIA: Lake Tahoe, *Lemmon;* without locality, 1874, *Lemmon, 734;* Susanville, Lassen county, 2 July 1892, *Brandegee;* Lake City Pass, July, 1892, *Mrs. R. M. Austin.*

IDAHO: Hailey, 22 July 1895, *Henderson, 3195;* Challis Divide, 3 August 1895, *Henderson, 3619.*

NEVADA: Ruby Valley, August 1868, *Watson, 860.*

UTAH: American Fork Cañon, 16 July 1895, *M. E. Jones;* Provo, 8 July 1894, *M. E. Jones, 5594;* Wasatch Mts., July 1869, *Watson, 860.*

ARIZONA: Casnino, August 1883, *Rusby, 746;* Base of San Francisco Mt., September 1884, *J. G. Lemmon & wife.*

COLORADO: Near Dix P. O., 10 July 1898, *Baker, Earle & Tracy, 471;* Golden City, 8 June 1870, *Greene, 306;* Headwaters of Clear Creek, 1861, *Parry, 290;* Estes Park, 8 June 1884, *J. Ball;* Pagosa Springs, July 1899, *Baker, 551;* Canon City, June 1877, *Brandegee;* Clear Creek Cañon, 10 June 1870, *Greene;* Without locality, *Hall & Harbour, 437.*

WYOMING: Yellowstone Lake, 24 August 1899, *A. & E. Nelson, 6647;* Sybille Creek, 8 July 1894, *A. Nelson, 348;* between Sheridan and Buffalo, 15 June–15 July 1900, *Tweedy, 3579.*

MONTANA: Without locality, 3 July 1883, *Scribner, 171;* Glen Creek, 29 July 1899, *A. & E. Nelson, 5561.*

ASSINIBOIA: Crane Lake, 9 June 1894, *Macoun.*

SASKATCHEWAN: Without locality, 1858, *Bourgeau.*

2. LAPPULA DIFFUSA Greene, Pittonia, **2**: 182. 1891

Echinospermum diffusum Lehm. Pugillus, **2**: 23. 1830.

I have followed Dr. Gray in his interpretation of this species and as he compared his materal with the type it is doubtless correct. According to this view Lehmann's characterization of the corolla as white is an error. It is barely possible however that Lehmann's original is a different plant from the one here considered, as there are at least three white-flowered species in the Columbia Basin, whence the type of *E. diffusum* came, viz., *L. Hendersoni*, *L. arida* and *L. Californica*. It is impossible to reconcile either of the first two with the original description of *E. diffusum*, but it is possible that it may prove to be identical with *L. Californica*.

The following specimens have been examined.

BRITISH COLUMBIA: Above Lake Louise, 27 July 1895, *Canby;* Kicking Horse Lake, 11 August 1890, *Macoun;* Lake Louise, 9 August 1898, *J. R. Anderson;* near Banff, 9 July 1891, *Macoun, 676.*

WASHINGTON: Wenatchee Mts., 3 June 1900, *Whited, 1258;* Klickitat River, 27 June 1899, *Flett, 1011;* without locality *Vasey, 420;* near Ellensburg, 21 May 1897, *Piper, 2669;* Blue Mts., 7 August 1897, *Horner, 341;* 11 June 1897, *121.*

OREGON: Near Snake River, 25 May 1898, *Cusick, 1887;* Stein's Mts., 30 June 1898, *Cusick;* without locality, 1879, *Cusick, 614;* Pine Creek, July 1893, *Mrs. R. M. Austin, 121;* Quartz Valley, Lake county, *Mrs. R. M. Austin;* Mt. Ashland, 9 July 1886, *Henderson;* Wallowa River below the Lake, 10 August 1899, *Cusick, 2323;* Powder River Mts., August 1896, *Piper, 2494.*

CALIFORNIA: Cottonwood Creek, White Mts., 13 July 1891, *Coville and Funston, 1811;* Siskiyou Mts., June 1884, *Howell, 219;* Sisson, Siskiyou county, *H. E. Brown, 327;* near Mineral Springs, Tulare county, 4 August 1891, *Coville & Funston, 1484;* Janesville, Lassen county, 29 June 1892, *Brandegee.*

IDAHO: Banks of Kootenai River, 1861, *Lyall.*

UTAH: Thistle, 29 June 1894, *M. E. Jones, 5529;* without locality, 1891, *Mrs. W. C. Dodd.*

MONTANA: Spanish Basin, Gallatin county, 26 June 1897, *Rydberg & Bessey, 4895;* Bridger Mts., 12 June 1897, *Rydberg & Bessey, 4896.*

Echinospermum subdecumbens Parry (Proc. Davenport Acad. **1**: 48) is probably a synonym of *L. diffusa;* at least an authentic specimen in young flower in the Gray Herbarium seems to be referable here. The specimen is from central Utah.

3. **Lappula Hendersoni** sp. nov.

Perennial, erect, 60–80 cm. high, rather sparsely and softly pubescent with appressed hairs, leafy to the top: leaves green, thin, the radical spatulate-lanceolate; cauline lanceolate, attenuate, sessile, gradually reduced upward, the upper ones ciliate with long hairs, the middle ones 5–10 cm. long: flowering branches racemosely arranged: cymes 5–10-flowered: calyx-lobes linear-lanceolate, obtusish: corolla white, 10–12 mm. broad; appendage as broad as long, merely papillate, the protuberance oblong, short, scarcely protruding into the throat: fruit (nearly mature) about 6 mm. long, on longer recurved pedicels; back of nutlets flat, muriculate, bearing a few scattered short glochidiate prickles; marginal prickles flat, of two lengths, free to the base or nearly so, the longer ones equalling or exceeding the diameter of the back; inner face smooth, the oblong scar central.

Clemens Mountain, Yakima county, Washington, 14 June 1892, *L. F. Henderson* (type). Specimen in herbarium Washington State College.

The following specimens are also confidently referred here:

WASHINGTON: Moist shady rocks, Klickitat county, June 1881, *Suksdorf;* Upper Yakima, 1860, *Lyall.*

OREGON: Cliffs along the Columbia River, August 1880, *T. J. Howell;* Deschutes, 1879, *Howell;* "Hood River, Celilo, etc.," June 1886, *Henderson, 88.*

A doubtful specimen is Howell's no. 335, Rooster Rock, Ore., with blue flowers.

The Suksdorf and Henderson specimens have mature fruit. In these the back of the nutlet is more or less convex, with a faint central ridge, muriculate, bearing 10–12 short glochidiate bristles; ventral surface sparsely muriculate, the oblong scar central.

4. **Lappula trachyphylla** sp. nov.

Probably perennial, apparently about 60 cm. high: stem and branches hispid: upper leaves sessile, lanceolate, attenuate-acuminate, 4–5 cm. long, harshly scabrous on both faces with hispid, papillate-based hairs; upper leaves passing gradually into the bracts of the inflorescence: branches 10–15 cm. long, loosely 10–15-flowered: calyx-lobes attenuate, hispid, 4–5 mm. long: corolla white, the tube not exceeding the calyx, the limb 10–12 mm. broad; appendages as broad as long, merely papillose, the protuberances small: pedicels decidedly longer than the fruit: nutlets 5 mm. long, the marginal prickles free to the base; back plane, muriculate, bearing several short glochidiate prickles; ventral side muriculate, the scar central.

A single fragmentary specimen in the Gray herbarium, collected by Winslow J. Howard in Montana. Associated with it are two inflorescences of *L. diffusa.*

5. LAPPULA PINETORUM Greene, Pittonia, **2**: 182. 1891

Echinospermum pinetorum Greene; Gray, Proc. Am. Acad. **17**: 224. 1872.

This species appears from the specimens to be an annual. The following specimens are in the Gray herbarium:

NEW MEX.: Pinos Altos Mts., July and September 1880, *Greene.*

ARIZONA: Santa Rita Mts., 13 July 1881, *Pringle, 349;* North Arizona, 1884, *Lemmon, 3211.*

6. LAPPULA ARIDA Piper, Bull. Torrey Club, **28**: 44. 1901

In addition to the specimens cited in the original description the following are referable here:

WASHINGTON: Without locality, 1889, *G. R. Vasey, 419.*

OREGON: Camp Harney, 26 May 1885, *Howell;* Camp Harney, 1875, *Captain Bendire;* Drew's Valley, Lake county, *Mrs. R. M. Austin 282.* This specimen is referred to *L. arida* with considerable hesitation.

The two following species are very near allies, and further material may compel their reduction. In all three the fornices of the corolla are practically identical.

7. **Lappula saxatilis** sp. nov.

Perennial, about 30 cm. high, rather slender, cinereous throughout with a fine short rather soft pubescence intermixed with some longer hairs, especially on the petioles of the lower leaves and margins of the upper ones: radical and lower cauline leaves oblanceolate, acute, the petioles as long or nearly as long as the blades; upper cauline lance-linear, sessile by broad bases; bracts of the inflorescence leaf-like; branches 6–10-flowered; calyx hispid, the lobes 2–3 mm. long: corolla blue, rotate, about 7 mm. broad; appendages pubescent, broader than long, exceeded by the obovate-oblong protuberance: fruit small, 3–4 mm. long; marginal prickles 4–5 on each side, subulate, glochidiate, slightly united at base; dorsal surface muriculate, bearing a few short glochidiate prickles; ventral surface smooth; scar central.

Rocky sides of cañons, Klickitat River, Wash., 12 June 1885, *W. N. Suksdorf, 592.* Type specimen in Gray herbarium.

Very close to *L. arida*, differing in its smaller blue flowers, softer pubescence, and the smaller fruit without granulations on the ventral side.

8. **Lappula Cusickii** sp. nov.

Perennial, erect or ascending, 15–30 cm. high, the caudex thickly clothed with old leaf bases, the whole plant pale bluish-green with a very closely appressed fine pubescence, except on the petioles where it is hirsute-ciliate: radical leaves lanceolate, acute, 4–8 cm. long, the petioles equaling the blades; cauline leaves linear-lanceolate, acute, all but the lower sessile by broad bases, 2–5 cm. long: inflorescence corymbose, the false racemes 6–8-flowered: calyx-lobes linear, acute, 2 mm. long: corolla blue, 5–6 mm. broad; appendages short pilose, about as long as broad, the protuberance oblong, as long or longer; immature fruit 5 mm. long, the back flat, muriculate, and bearing about 10 short glochidiate bristles; marginal prickles flat, separate and rather distant, all glochidiate, shorter than the diameter of the nutlet.

Logan Mountains, eastern Oregon, 6500 feet altitude, in the shelter of juniper, 1 July 1901, *W. C. Cusick, 2623*.

This species is related to *L. arida*, differing in its smaller blue flowers and the separate marginal prickles of the nutlet.

9. LAPPULA CAERULESCENS Rydberg, Flora Montana, 328. 1900

This species is readily distinguished from any other described species by the long hairs of the corolla-appendages. At least one other undescribed species represented in the Gray herbarium by too scanty material, has a very similar corolla-appendage, so that this character alone can not be entirely relied upon.

The species as here interpreted shows considerable variation as regards pubescence, and in some specimens the flowers are apparently white.

MONTANA: Bridger Mts., 18 July 1897, *Rydberg & Bessey, 4899*.

WYOMING: Mammoth Hot Springs, 30 June 1899, *A. & E. Nelson, 5602*.

UTAH: Salt Lake City, May 1891, *Eastwood;* Salt Lake City, 30 April 1898, *W. Travers;* Salt Lake City, May 1889, *Sarah K. White;* Wasatch Mts., May 1869, *Watson, 860;* Pine Valley, June 1874, *Parry, 172*. In this plant the pubescence is hirsute, and it was included by Dr. Gray under *Echinospermum* *ursinum.* The fornix is exactly like that of the present species, but it is possible that fruiting material may show additional characters.

NEVADA: Battle Mts., June 1868, *Watson, 860;* Humboldt Mts., 27 May 18—, *Beckwith.*

In the original description of this species the fruit was not described. The following are its characters as it occurs on the Nelson specimen above cited:

Nutlets 3 mm. long; marginal prickles of two lengths, free to the base or nearly so, all glochidiate; back plane or with a more or less evident central ridge densely finely muriculate and bearing about ten short glochidiate prickles; ventral surface finely rugose.

10. LAPPULA HISPIDA Greene, Pittonia, **2**: 182. 1891

Echinospermum diffusum var. *hispidum* Gray, Proc. Am. Acad. **17**: 225. 1882.

E. hispidum Gray, Proc. Am. Acad. **20**: 259. 1884.

This species differs from any other which I have examined in having the corolla-lobes broadest at base. The species proper has been collected only by Cusick in eastern Oregon as follows: 1880, rocky hillsides of Pine Creek near the mouth, *855;* 31 May 1898, hillsides near Snake River, *1906;* 15 June 1898, Burnt River, *1906;* without locality, 1885.

The Wilcox specimen referred here by Dr. Gray in the original description belongs to *L. cinerea* as above. The Watson specimen referred here with some doubt in the Synoptical Flora (**2**: 422) is an undescribed species.

11. LAPPULA CILIATA Greene, Pittonia, **2**: 182. 1891.

Cynoglossum ciliatum Dougl.; Lehm. Pugillus, **2**: 24. 1830.

Echinospermum ciliatum Gray, Proc. Am. Acad. **17**: 225. 1882.

The original specimens of this species were collected by Douglas according to the note in Hooker's herbarium, "On the gravelly banks of mountain streams near the head springs of the Columbia"; according to the note in Bentham's herbarium, "Kettle Falls and Spokan River, 1826."

The plant is quite common on the gravelly bluffs of Latah Creek and of the Spokane River within the environs of Spokane, Wash. The following specimens agree exactly with the Douglas specimen in the Gray herbarium.

Spokane, 1 June 1891, *Henderson;* Spokane, 16 May and 2 July 1896, *Piper, 2292;* Hangman Creek, 18 May 1893, *Sandberg & Leiberg, 36.*

The following is a description of the fruit:

Nutlets 5 mm. long; marginal prickles united for about half their length into a wing, all the prickles glochidiate; back plane or usually with a faint central ridge, roughly muriculate and bearing eight or ten short glochidiate prickles; ventral surface smooth, the scar central.

12. **Lappula setosa** sp. nov.

Perennial, 30–60 cm. high, bristly hirsute throughout, without any finer pubescence: radical leaves linear-oblanceolate, obtuse or acute, 6–10 cm. long including the petioles; cauline sessile or nearly so, linear or lance-linear, gradually reduced upwards; calyx-lobe oblong-linear, obtuse, hispid, 3–4 mm. long: corolla bright blue, 12–15 mm. broad, the tube not exceeding the calyx; appendage semicircular, short pilose, the protuberance small: fruit 5 mm. long, the marginal prickles united for one half their length into a wing: dorsal surface nearly plane, granulate scabrous, bearing a few very short glochidiate bristles; ventral surface granulate, the narrowly triangular scar central.

OREGON: Waldo, June 1884, in flower, *Howell, 218.*

CALIFORNIA: Siskiyou Mountains, 17 June 1884, in flower, *Howell;* Snow Mountain, 23 June 1892, in flower, *Brandegee;* Sierra Valley, July 1883 (type), in fruit, *Lemmon.* Specimen in herbarium California Academy of Science.

A well-marked species, easily recognized by its large blue flowers and bristly pubescence.

✓ 13. **Lappula cinerea** sp. nov.

Perennial, erect, 40–60 cm. high, cinereous throughout with appressed pubescence, some coarser hispid hairs intermixed, the larger of which are papillate at base: basal leaves linear or linear-lanceolate, obtusish, 6–10 mm. long; cauline similar, rather few, reduced upwards: inflorescence in fruit loose, the branches 5–20 cm. long: calyx-lobes linear-lanceolate, acute: corolla white, the tube 2 mm. long, the obovate-orbicular lobes 3 mm. long; appendages short-pilose, the crest semicircular in form, retuse at apex, the protuberance on the inner side hemispherical, and separated by a smooth depression from the pilose crest: nutlets 3–4 mm. long, the marginal prickles united at base for about half their length, all glochidiate; dorsal surface with a faint central ridge, muriculate, and bearing 6–12 glochidiate bristles half as long as the marginal ones; inner face smooth, the oblong scar central.

Salmon River bluffs, Idaho, altitude 2500 feet, 2 July 1895, *L. F. Henderson, 3006*. Type in the U. S. National herbarium, no. 231836.

I would also refer here two specimens from Boise, Idaho; one collected by A. Isabel Mulford, July and August, 1892, which in the Gray herbarium specimen is mixed with *L. floribunda;* the other collected June 1881, by *Dr. T. E. Wilcox* and referred by Dr. Gray to *L. hispida*. The fruit of the Wilcox specimen is rather larger than that of the type, being 5 mm. long.

14. LAPPULA URSINA Greene, Pittonia, **2**: 182. 1891

Echinospermum ursinum Greene; Gray, Proc. Am. Acad. **17**: 224. 1882.

No other material has been seen of this species except that which was before Dr. Gray. Fendler 633 from New Mexico referred here by Dr. Gray is very probably a distinct species undescribed. Parry's 172 collected in South Utah in 1874 is a form of *L. caerulescens*.

15. **Lappula scaberrima** sp. nov.

Perennial, erect, 25–50 cm. high: stems softly hirsute below, hispid above: leaves harshly hispid on both faces, the closely appressed short hairs with papillose bases; basal leaves spatulate-oblanceolate, obtuse, petioled; cauline oblong-lanceolate, acutish: branches of the inflorescence with 15–25 rather densely crowded flowers: calyx hispid, the ovate-oblong lobe obtuse: corolla blue, the tube barely exceeding the calyx, the limb 5 mm. broad; appendages broader than long, papillose, the protuberance small: fruit 5 mm. long on recurved pedicels about as long: nutlets with the marginal prickles united into a wing, all glochidiate; back smooth with a prominent heel; ventral surface smooth, the triangular scar central.

Cripple Creek, Colo., 3 August 1897, *Eastwood*, type, in herbarium Cal. Academy of Science.

Above Idaho Springs, Colo., August and September 1874, *Engelmann*.

A species probably nearest related to *L. floribunda.* The united marginal prickles and scabrous foliage easily distinguish it.

16. **Lappula Californica**

Echinospermum Californicum Gray, Proc. Am. Acad. **17**: 225. 1882 (in part).

Perennial, erect, leafy, green, 30–80 cm. high: pubescence fine and sparse, soft below, almost hispidulous above in fruiting specimens: lower leaves oblong-lanceolate, obtuse or acute, the petioles nearly as long as the blades; middle leaves oblong-lanceolate, sessile by broad bases; upper leaves lanceolate or even ovate, sessile or partly clasping, mostly acute: panicle in fruit open, the branches about 6-flowered: corolla white, its tube barely exceeding the calyx; appendage broader than long, puberulent, the protuberance small: nutlets granulate-muriculate on both faces; dorsal face and margin bearing 20–30 glochidiate subulate separate prickles, as long as the diameter of the nutlets, with shorter ones intermixed; scar central, large, ovate-triangular.

The following specimens are referred here.

CALIFORNIA: Mt. Shasta, 6000 ft. alt., 23 August 1881, *Pringle* (type); Mt. Shasta, 5000 ft. alt., 1862, *Brewer, 1416;* Sisson, July 1892, *Brandegee;* near Webber Lake, 1875, *Lemmon, 1204;* Lake Tahoe, *Lemmon, 205.* Both the Lemmon specimens have the prickles of the fruit purple, and the nutlets apparently smooth on the ventral side; Prattville, Plumas county, 2 April 1892, *Brandegee;* Prattville, Plumas county, June 1878, *R. M. Austin.*

OREGON: Near "Three Sisters," 5 August 1881, *Henderson;* Black Butte, Crook county, 19 July 1901, *Cusick, 2680.*

17. **Lappula velutina** sp. nov.

Perennial (or perhaps biennial), tall and stout, 30–90 cm. high, clothed throughout with a dense velvety pubescence: lower cauline and radical leaves spatulate-oblanceolate, acutish, 8–10 cm. long; cauline numerous, mostly sessile by broad bases, oblong-linear or lanceolate, acute or obtuse, gradually reduced upwards, 2–8 cm. long: inflorescence open, the branches 5–10-flowered: calyx densely pubescent, the oblong lobes obtuse: corolla blue or sometimes pink, its tube 5 mm. long, much exceeding the calyx, the limb 10–12 mm. broad; appendages very large and conspicuous, one third as long as the corolla lobes, the deeply cordate crest short-pilose, equalled in length by the oblong protuberance:

fruit 6–8 mm. long, shining, covered all over with subequal glochidiate separate prickles; ventral surface smooth, the scar central.

This is apparently the commonest California species. It is readily distinguished from all others at a glance by its velvety pubescence, its large blue salverform corollas, and the very prominent corolla appendages.

The following specimens have been examined, all from California: General Grant Grove, 20 July 1892 (type in herbarium California Academy of Science), *Brandegee;* General Grant Park, 1–13 July 1899, *Eastwood;* Lake Tahoe, June 1900, *Miss King;* Lake Tahoe, July 1895, *Abraham;* Lake Tahoe, *Lemmon,* Tulare county, June 1896, *Purpus, 1777;* Humboldt county, 1885, *C. C. Marshall;* Amador county, June 1886, *Mrs. Wiley;* Armstrong Station, 13 June 1895, *G. Hansen, 1141;* Summit, Eldorado county, July 1899, *Blaisdell, 96.*

The Cusick specimen was distributed as a new species but on further study it is thought best to refer it here.

It has been a matter of some difficulty to decide upon a type for this species, inasmuch as Dr. Gray confused three very different plants under one name and did not definitely indicate a type either in the published description or in his herbarium. The difficulty is easily understood from his original description which follows:

> "3. Comparatively large-flowered, perennial, with tube of the corolla surpassing the calyx and about the length of the lobes: nutlets of the globose fruit equally armed over the whole surface and margins with long and slender but flattish minutely glochidiate prickles.
>
> "E. CALIFORNICUM. *E. diffusum* Gray, Syn. Fl. (excluding small-flowered specimens which belong to the true *E. diffusum,* and *excl. syn.* Kellog?) not of Lehm. Sierra Nevada, California, from Mount Shasta southward. This was taken for Lehmann's *E. diffusum,* because of his description of the corolla ('Corolla alba? magna, tubus calyce paullo longior sensim ampliatus'); and Californian specimens of the real *E. diffusum* were mixed with it. The original specimens of the latter do not have the exserted tube of the corolla which marks the present species when in blossom, as does the fruit at maturity. It is the *E. nervosum* of Kellog; but neither the leaves nor the sepals are perceptibly nervose (the former not '3–5-nerved' nor the latter '3-nerved'), so that the name would be a false one."

It is perfectly clear that the flower characters of the above description were taken from the specimens *L. velutina* and *L. nervosa* as they alone have salverform corollas. The fruiting characters were drawn from the Brewer and Pringle specimens, perhaps also from the Lemmon specimens. As the flower characters are the most important in separating *L. Californica* and *L. velutina*, and presumably of *L. nervosa* the fruit of which is unknown, one might justly lay stress on this element of the description. This course would either reduce *L. Californica* to a synonym of *L. nervosa*, or compel its use for the other salverform-flowered segregate, *L. velutina.*

The type range as given in the original description, however, points clearly to the Pringle and Brewer specimens as the type as only these Mt. Shasta species were before Dr. Gray. On the whole it has seemed to us best to retain the name *L. Californica* for this Mt. Shasta plant. We therefore designate the Pringle specimen as the type because it is in better condition than the Brewer specimen.

South Sierras, *Bolander, 2784 ;* without locality, *Bridges, 317 ;* without locality, *Grav, 1872.*

18. LAPPULA NERVOSA Greene, Pittonia, **2**: 182. 1891.

Echinospermum nervosum Kellogg, Proc. Calif. Acad. **2**: 146. 1862.

Perennial, erect, leafy, 20–40 cm. high, finely appressed pubescent throughout but green: leaves 3–8 cm. long, oblong-linear or somewhat oblanceolate, acute or obtuse, the upper sessile by broad bases, the lower narrowed into margined petioles: panicle rather narrow: calyx small, 2 mm. long: corolla blue, its tube 4–5 mm. long, much exceeding the calyx, the limb about 6 mm. in diameter: appendage quadrate, minutely pilose, the protuberance very small: fruit not seen.

An apparently authentic fragment of the type is in the Gray herbarium, labelled "Acad. Calif. sent by E. L. Greene." This is matched by several specimens in the herbarium of the California Academy of Sciences as below cited. The plant is clearly different from *L. Californica* and from *L. velutina*, and should easily be recognized by its small salverform corollas with small appendages.

CALIFORNIA: Summit, Placer county, 8–16 June 1898, *Alice Eastwood;* Summit, Placer county, July 1876, *Henry Edwards;* Summit, Placer county, 5 July 1886, *Sonne, 69 ;* Yosemite Valley, May and June 1900, *Bioletti;* without locality, 1872, *Bolander.*

19. **Lappula Cottoni** sp. nov.

Perennial, erect, 40–60 cm. high, pale green throughout with appressed rather harsh white hairs, equally leafy to the top: leaves rather numerous, the radical spatulate, lanceolate, acute, petioled, 10–15 cm. long, the cauline linear or linear-lanceolate, acute, sessile or nearly so by broad bases, 2–5 cm. long: flowering branches racemosely arranged: lower bracts leafy, the upper much reduced: calyx-lobes linear, obtuse or acutish, 2–3 mm. long: corolla yellowish, 6–7 mm. broad, the lobes oval, broadest above the base: appendages broader than long, short pilose, the hemispherical protuberance nearly as long.

North slope of Rattlesnake Mountains, Yakima county, Washington, 11 May 1901, *J. S. Cotton, 360.* Type in herbarium Washington State College.

A species with the aspect of *L. Californica* but with smaller yellowish flowers, very different corolla appendages and more leafy inflorescence.

Some Mt. Desert Fungi

BY V. S. WHITE

The country in the neighborhood of Bar Harbor forms a specially interesting collecting ground for the mycologist because of the quantity of wooded land which remains in spite of the constantly increasing clearings and improvements. The woods are moist and kept in this condition even in very dry weather by numerous springs, underground streams and rivulets.

A system of paths originally begun by some of the first Boston visitors, modeled on that in use about the forests of Thüringen near Eisenach is maintained by the Village Improvement Society. The paths extend many miles in various directions; pocket maps are to be had on which the paths are marked in different colors to correspond with the colors painted upon the trees at short intervals or on occasional signposts; rude arrows formed by forked white birch branches indicate the entrace to these paths and are also placed at points of intersection, so that there can be no danger of going astray or unnecessarily out of one's way except from heedlessness. These paths though kept free from underbrush and occasionally cleared of dead wood, do not interfere with the natural beauty and wildness of the place and render the task of the collector a far easier and pleasanter one than it would otherwise be. The present list of fungi collected in the vicinity of Bar Harbor, Mount Desert, Maine, from 8 July to 15 September 1901, by the writer have been determined principally by Professor Charles H. Peck. Professor F. S. Earle of the New York Botanical Garden, Professor Underwood of Columbia University, Dr. W. A. Murrill of New York, and Mr. H. J. Banker of California, Pa., have also aided the writer in making determinations. Dried specimens with notes and in some cases water-color sketches have been deposited with the New York Botanical Garden. It is hoped that in the future this list may be greatly enlarged as the fungus flora becomes better known. The present list may serve as a preliminary supplement to Rand's Flora of Mount Desert Island from which the fungi were omitted. The one hundred and twenty species marked with an asterisk (*) are not found in Ricker's List of Maine Fungi (April 1902).

Preliminary List of Bar Harbor Fungi

MYXOMYCETES

ARCYRIA NUTANS (Bull.) Grev.

ARCYRIA INCARNATA Pers.

DICTYDIUM CANCELLATUM (Batsch) Macbr.

FULIGO SEPTICA (Link) Gmel. Common.

LEOCARPUS FRAGILIS (Dicks.) Rost.

LYCOGALA EPIDENDRON (Buxb.) Fr.

ASCOMYCETES

Family HYPOCREACEAE

CORDYCEPS ENTOMORRHIZA (Dicks.) Fr. Only one specimen found.

HYPOCREA RUFA (Pers.) Fr. One form.

HYPOMYCES LACTIFLUORUM (Schw.) Tul. On *Lactarius piperatus.* Plentiful.

NECTRIA EPISPHAERIA (Tode) Fr.

Family CHAETOMIACEAE

*CHAETOMIUM OLIVACEUM C. & E.

Family DIATRYPACEAE

DIATRYPA STIGMA (Hoffm.) De Not.

Family XYLARIACEAE

HYPOXYLON COHAERENS (Pers.) Fr. Common.

HYPOXYLON COCCINEUM Bull. Very plentiful.

XYLARIA POLYMORPHA (Pers.) Fr.

Family MOLLISIACEAE

*MOLLISIA MELALEUCA Fr.

Family HELOTIACEAE

HELOTIUM CITRINUM (Hedw.) Fr.

Family PEZIZACEAE

LACHNEA HEMISPHAERICA Wigg.

LACHNEA SCUTELLATA (L.) Sacc.

DASYSCYPHA AGASSIZII (B. & C.) Sacc. Very plentiful in certain localities.

PEZIZA BADIA Pers. Widely distributed.

Family GEOGLOSSACEAE

GEOGLOSSUM HIRSUTUM Pers. Found only once but growing in large quantities.

LEPTOGLOSSUM LUTEUM (Peck) Sacc. Common on moss-grown decayed stumps.

LEOTIA LUBRICA (Scop.) Pers. Very plentiful in damp woods.

BASIDIOMYCETES

Family PUCCINIACEAE

GYMNOSPORANGIUM CLAVIPES C. & P. On *Juniperus Virginiana.*

Family AURICULARIACEAE

AURICULARIA AURICULA-JUDAE (L.) Schroet. Growing in large quantities in certain localities.

Family TREMELLACEAE

TREMELLODON GELATINOSUM (Scop.) Pers. Plentiful.

Family THELEPHORACEAE

CORTICIUM EFFUSCATUM C. & E.

CORTICIUM INCARNATUM (Pers.) Fr. Plentiful.

CRATERELLUS CORNUCOPIOIDES (L.) Fr. Found only once but in large quantity on hard-packed woody path.

*CRATERELLUS LUTESCENS (Pers.) Fr. Common.

STEREUM HIRSUTUM (Willd.) Pr. Plentiful.

STEREUM OCHRACEOFLAVUM Schwein.

THELEPHORA SCHWEINITZII Peck. Growing in large quantities.

Family CLAVARIACEAE.

CLAVARIA CRISTATA Pers. Common.

*CLAVARIA CIRCINANS Peck. Common.

CLAVARIA FUSIFORMIS Sowerby. Fairly abundant.

CLAVARIA INAEQUALIS Müll.

CLAVARIA PISTILLARIS L. Few specimens found.

Family HYDNACEAE.

* HYDNUM ALBONIGRUM Peck. Found only in one locality.

* **Hydnum boreale** Banker, sp. nov. Plant white to greenish, moist; pileus thick, convex, undulate, 12–15 cm. wide; stem short, thick, flattened, the longer diameter three times the shortest (2 cm. by 7 cm.), 7 cm. long; teeth short, 5 mm. long, 0.5 mm. wide, the points rounded and somewhat knobbed when dry, decurrent, brownish with white tips; substance zonate within, the uppermost layer white spongy thick, the lower strata becoming darker, harder, and more compact, in the stem deep lavender color; mycelium purple, persistent; odor unpleasant.

In damp rich soil and leaf mould.

HYDNUM CARBUNCULUS Secr. (= *H. ferrugineum* Fr.) The peppery taste of this species has not been previously noted and is an important character.

* **Hydnum humidum** Banker, sp. nov. Plant yellowish, becoming brown, hygrophanous, pileus irregular, spongy, scrobiculate, 9 cm. or more wide, stem stout, brownish, about 2 cm. long, 1.5 cm. thick; teeth long, 5 mm., brownish with white tips; substance corky, hard when dry and gray like weathered wood but with streaks and spots that appear darker and cartilaginous, which cut as if gummy, zonate internally; odor strong but not unpleasant; taste mild.

In hard-packed wooded path. The fresh plant exudes water freely when pressed between the fingers.

HYDNUM REPANDUM L. Fairly common.

* HYDNUM SCROBICULATUM Fr.

HYDNUM ZONATUM Batch.

Family POLYPORACEAE.

DAEDALEA CONFRAGOSA POLYPOROIDEA Peck. Plentiful.

FAVOLUS ALVEOLARIUS (DC.) Quel. Fairly abundant.

POLYPORUS ADUSTUS (Willd.) Fr.

* POLYPORUS CARPINEUS Sower.

POLYPORUS CARNEUS Nees.

POLYPORUS CHIONEUS Fr.

POLYPORUS CONNATUS Wein.

* POLYPORUS CONFLUENS (A. & S.) Fr. Plentiful.

POLYPORUS ELEGANS (Bull.) Fr. Fairly abundant.

POLYPORUS FOMENTARIUS (L.) Fr.

POLYPORUS LEUCOPHAEUS Mont.

POLYPORUS PERENNIS (L.) Fr.

POLYPORUS PICIPES Fr.

POLYPORUS PERGAMENUS Fr. Very common.

POLYPORUS SCHWEINITZII Fr. Plentiful.

POLYPORUS SCHWEINITZII DUALIS Peck.

POLYPORUS SPLENDENS Peck. (*P. oblectans* of Ricker's list, but that species is not likely American.)

POLYPORUS SULFUREUS (Bull.) Fr.

POLYPORUS VERSICOLOR (L.) Fr. Very common in all localities.

POLYPORUS VAPORARIUS Fr.

LENZITES SEPIARIA Fr.

TRAMETES CINNABARINA (Jacq.) Fr.

* TRAMETES RUBESCENS Fr.

Family BOLETACEAE

BOLETINUS PICTUS Peck. Common in damp places, *Sphagnum*, etc.

* BOLETUS ALBUS Peck. Only one plant seen.

BOLETUS AMERICANUS Peck. Common in damp places.

BOLETUS CHROMAPES Frost. Fairly common but scattered, rarely more than one plant in a locality.

* BOLETUS CYANESCENS Bull. Common.

* BOLETUS EDULIS Bull. Plentiful.

* BOLETUS EDULIS CLAVIPES Peck. Common.

* BOLETUS FELLEUS Bull. Rather scarce.

BOLETUS GRANULATUS ALBIPES Peck. Plentiful.

* BOLETUS MINIATO-OLIVACEUS SENSIBILIS Peck. Common.

* BOLETUS ORNATIPES Peck. Very common in woods.

* BOLETUS PIPERATUS Bull. Common in woods and by roadsides.

* BOLETUS PURPUREUS **fumosus** Peck, var. nov. Pileus convex, velvety, smoky brown, flesh creamy-yellow, changing to bluish-green where wounded; tubes depressed about the stem, yellowish-green, the mouths small, brownish-red, the dissepiments slightly decurrent on the stem, changing to greenish-blue where wounded; stem tapering upward, yellow above, colored like the pileus below, bright yellow within, changing to bluish-green where wounded; spores 10 μ long, 5 μ broad.

Pileus 4–14 cm. broad; stem 4–12 cm. long, 1–2.5 cm. thick at the top, 2.5–5 cm. thick at the base.

Woods. July.

This *Boletus* agrees so closely with *B. purpureus* in all its characters except color that it has seemed best to consider it a mere variety of that species, but future investigation may show it to be a distinct species. It does not appear to have any purple hues in either pileus or stem.

* BOLETUS RUSSELLII Frost. Under pines in dry soil; scarce.

BOLETUS SCABER Frost. Very common and variable.

* BOLETUS SCABER MUTABILIS Peck. Common.

* BOLETUS SCABER NIVEUS Peck. Common.

* **Boletus scabripes** Peck, sp. nov. Pileus thick, broadly convex, firm, dry, glabrous, reddish-brown with a bloom; tubes convex in the mass, adnate or slightly depressed around the stem, brown, with very small round darker mouths; stem stout, equal, solid but spongy within, grayish-white, adorned with numerous small projecting black points; spores oblong, fusiform, 12–15 μ long, 4–5 μ broad.

Pileus about 15 cm. broad; stem about 10 cm. long, 2–3 cm. thick.

Rich soil in woods. July. A fine large species but with a disagreeable taste. The black points on the stem are suggestive of those on the stem of *B. scaber*, but they are smaller and more numerous. In drying the plants become black and exude a black juice with a strong odor.

* BOLETUS SUBGLABRIPES Peck. In damp shady soil; only two plants found.

BOLETUS SUBLUTEUS Peck. Very plentiful all summer.

Family AGARICACEAE

(*Cantharelleae*)

CANTHARELLUS AURANTIACUS (Wulf.) Fr. Plentiful.

CANTHARELLUS CIBARIUS Fries. Common and widely distributed.

* CANTHARELLUS FLAVICEPS Peck.

CANTHARELLUS FLOCCOSUS Schwein. Very plentiful in a few localities.

CANTHARELLUS MULTIPLEX Underw. Two specimens. Specimens attaining a large size, some measuring nearly 17 cm. across.

TROGIA CRISPA (Pers.) Fr. Plentiful in a few localities.

(*Paxilleae*)

* PAXILLUS ATROTOMENTOSUS Fr. Found plentifully in one locality; a very showy fungus.

* PAXILLUS INVOLUTUS (Batsch.) Fr. Plentiful.

* PHELLOPORUS RHODOXANTHUS (Schwein.) Peck. Only two plants found; in widely different localities.

(*Coprineae*)

* COPRINUS ATRAMENTARIUS (Bull.) Fr. Plentiful.

COPRINUS ATRAMENTARIUS SILVESTRIS Peck. Found only in one locality but abundant there.

* COPRINUS PLUMBEUS Peck. A large quantity in damp weather.

(*Hygrophoreae*)

HYGROPHORUS CANTHARELLUS Schwein. Fairly common.

* HYGROPHORUS CHLOROPHANUS Fr. Abundant in restricted localities.

* HYGROPHORUS COCCINEUS Schaeff. In large quantities in damp weather.

HYGROPHORUS CONICUS (Scop.) Fr. Abundant.

HYGROPHORUS MINIATUS Fr. Found once or twice only.

* NYCTALIS ASTEROPHORA Fr. Growing on much-decayed specimens of *Russula* and *Lactarius piperatus*. This is a very strange species, in which the lamellae are almost entirely undeveloped and the entire top of the fungus bears the spores.

(*Lactarieae*)

LACTARIUS AFFINIS Peck. Pale form; plentiful.

LACTARIUS CINEREUS Peck. Only two or three plants found.

LACTARIUS DECEPTIVUS Peck. Plentiful.

LACTARIUS DELICIOSUS (L.) Fr. Fairly common in certain localities.

* LACTARIUS FULIGINOSUS Fr. Plentiful.

LACTARIUS GRISEUS Peck. Plentiful in damp woods.

LACTARIUS HYSGINUS Fr. Plentiful in damp woods.

LACTARIUS INSULSUS Fr. Only one plant seen.

* LACTARIUS MACULATUS Peck. Only two specimens found ; a showy plant.

* LACTARIUS PIPERATUS (Scop.) Fr. Common.

* LACTARIUS SORDIDUS Peck. Found only once but then in large quantities.

LACTARIUS SUBDULCIS (Bull.) Fr. Plentiful and widely distributed.

* LACTARIUS TORMINOSUS (Schaeff.) Fr. Found twice.

LACTARIUS THEIOGALUS (Bull.) Fr. Found in only one locality growing in leaf mould.

LACTARIUS UVIDUS Fr. Only a few plants found, some growing on wood.

LACTARIUS VOLEMUS Fr. Common.

* RUSSULA ADUSTA (Pers.) Fr. Common.

* RUSSULA BREVIPES Peck. Plentiful.

* RUSSULA BASIFURCATA Peck. Found several times.

RUSSULA DECOLORANS Fr. Plentiful and widely distributed.

* RUSSULA EMETICA Fr. Common.

* RUSSULA FINGIBILIS Britz. Only found three times.

RUSSULA FOETENS (Pers.) Fr. Common.

* RUSSULA FRAGILIS (Pers.) Fr. Only a few plants found.

RUSSULA INTEGRA (L.) Fr. Plentiful.

* RUSSULA LUTEA (Huds.) Fr. Found only one.

* RUSSULA MARIAE Peck. Fairly widely distributed.

* RUSSULA NIGRICANS (Bull.) Fr. Found abundantly in a few localities.

* RUSSULA PULCHRALIS Britz. Plentiful in one locality.

* RUSSULA PALUSTRIS Peck. By roadside ; found several times.

RUSSULA PURPURINA A. & S. White-stemmed form ; found only once but in large quantities.

* RUSSULA PUELLARIS UMBONATA Peck. Only one plant found.

* RUSSULA ROSACEA Fr. Abundant.

* RUSSULA SCABRIUSCULA Peck. Apparently scarce.

* RUSSULA SORDIDA Peck. Plentiful.

(*Marasmieae*)

LENTINUS LEPIDEUS Fr.

MARASMIUS ANDROSACEUS (L.) Fr. On hemlock needles after rain in large quantities.

* MARASMIUS CONFLUENS Pers.

MARASMIUS OREADES Fr. Forming large nearly complete fairy rings.

MARASMIUS ROTULA (Scop.) Fr. Plentiful.

* MARASMIUS VITICOLA B. & C. Plentiful.

PANUS STYPTICUS (Bull.) Fr. Common.

(*Agariceae*)

(*Evelatae*. With neither volva nor annulus)

* CLITOCYBE ECTYPOIDES Peck. Plentiful on damp banks.

* CLITOCYBE INFUNDIBULIFORMIS Schaeff. Common.

CLITOCYBE LACCATA Scop. Common.

* **Clitocybe marginata** Peck, sp. nov. Pileus fleshy, rather thick, subcampanulate, becoming convex, obtuse or broadly umbonate, glabrous or nearly so, dry, bay red verging to mahogany color, the margin at first involute, flesh yellow; lamellae narrow, close, decurrent, yellowish, reddish on the edge; stem nearly equal, stout, hollow, glabrous, shining, yellowish marked with reddish longitudinal lines; spores subglobose, 5 μ long, 4–5 μ broad. Pileus 5–8 cm. broad; stem 5–8 cm. long, 6–12 mm. thick. Cespitose; growing around decaying stumps. September.

A peculiar species well marked by the reddish edge of the lamellae, reddish lines of the stem and yellowish flesh of the pileus. It is referable to the second subsection of the Disciformes according to arrangement in *Sylloge Fungorum*.

CLITOPILUS CAESPITOSUS Peck. Found only once but in large quantities.

* CLITOPILUS CARNEOALBUS With. Fairly abundant in certain localities.

* CLITOPILUS PRUNULUS Scop. Very common in meadows.

COLLYBIA ABUNDANS Peck. Growing in large clusters.

* COLLYBIA COLOREA Peck. Growing in large quantities, singly and in clusters.

COLLYBIA DRYOPHILA Bull. Common.

* COLLYBIA FAMILIA Peck. Growing in great quantities over old decaying stumps.

* COLLYBIA PLATYPHYLLA Fr. Common.

COLLYBIA RADICATA Relh. Common and variable.

* COLLYBIA RADICATA FURFURACEA Peck. Found only once; seven or eight fine plants growing about a much-decayed stump.

CREPIDOTUS APPLANATUS Pers. Common.

* CREPIDOTUS MALACHIUS B. & C.

CREPIDOTUS VERSUTUS Peck.

* ENTOLOMA CUSPIDATUM Peck. Growing in large quantities.

ENTOLOMA GRAYANUM Peck. Only a few plants seen.

* ENTOLOMA PECKII Burt. Plentiful.

* ENTOLOMA SALMONEUM Peck. Plentiful.

* ENTOLOMA SINUATUM Fr. One cluster of five specimens found; a fine large species.

* LEPTONIA ASPRELLA Fr. Short-stemmed form; fairly common.

* LEPTONIA GRISEA Peck. Four or five plants found.

* LEPTONIA FORMOSA Fr. Fairly common.

* LEPTONIA SERRULATA (Pers.) Fr. A beautiful species which appears to be rare.

* LEPTONIA SUBSERRULATA Peck. A few specimens found in grass two hundred feet from the beach.

MYCENA CORTICOLA Schum. A beautiful little fungus 2 cm. high, growing on wood; only occasionally seen.

* MYCENA HAEMATOPODA Pers. Plentiful in certain localities.

* NOLANEA CONICA Peck. Appears to be scarce; growing on wood.

OMPHALIA CAMPANELLA Batsch. Growing as usual in large quantities on decaying wood.

* OMPHALIA SCABRIUSCULA Peck. Plentiful.

PANAEOLUS CAMPANULATUS (L.) Sacc.

* PANAEOLUS FIMICOLA Fr. Common after rains.

* PLEUROTUS OSTREATUS (Jacq.) Fr. Plentiful, growing in dense clusters.

* PLUTEUS CERVINUS Schaeff. Very common and variable; a white variety found and also a scaly one corresponding to *Agaricus rigens* Pers.

* PLUTEUS GRANULARIS Peck. Only one plant found.

* PLUTEUS UMBROSUS Pers. Found twice on decaying wood.

* TRICHOLOMA ALBOFLAVIDUM Peck. Plentiful.

TRICHOLOMA ALBUM (Schaeff.) Fr. Growing singly in leaf mould.

TRICHOLOMA DAVISIAE Peck. Plentiful.

* TRICHOLOMA FALLAX Peck. On dead leaves and twigs after rain.

* TRICHOLOMA FUMOSOLUTEUM Peck. Abundant.

* TRICHOLOMA LUGUBRE Peck. Plentiful.

* TRICHOLOMA RUTILANS Schaeff. Appears to be rare.

* TRICHOLOMA VARIEGATUM Scop. Found only twice; a pretty species.

(*Velatae.* Provided with a veil, but no volva)

CORTINARIUS ARMILLATUS (A. & S.) Fr. Fairly abundant.

* CORTINARIUS BERLESIANUS Sacc. & Cub. Only two plants found.

* CORTINARIUS CORRUGATUS Peck. Found twice but in large quantities.

* CORTINARIUS ERRATICUS Peck. Plentiful; growing in large semicircles in damp leaf mould.

* CORTINARIUS MULTIFORMIS Fr. Plentiful.

* CORTINARIUS SIMILARIS Peck. Two plants seen.

CORTINARIUS TORVUS Fr. Plentiful in one locality.

CORTINARIUS VIOLACEUS (L.) Fr. Abundant.

* **Cortinarius Whiteae** Peck, sp. nov. Pileus fleshy, hemispherical, becoming nearly plane with a lobed wavy or irregular margin, dry, glabrous, subpruinose, reddish or brownish-orange verging to tawny; lamellae subdistant, deeply and broadly emarginate, reddish-brown becoming brownish-cinnamon; stem long, equal, solid, fibrous, colored like the pileus, adorned with darker fibrous lines or striations; spores subglobose, 7–8 μ long, 7 μ broad.

Pileus 6–12 cm. broad; stem 7–12 cm. long, 1.5–2 cm. thick.

Woods. August. A large species intermediate between *Dermocybe* and *Telamonia*, related to the former by its dry pileus and to the latter by its general aspect and stout solid stem. It gives me pleasure to dedicate it to its discoverer, a most enthusiastic mycologist from whose specimens, notes, and colored sketch of the fresh plant the description has been derived.

FLAMMULA FLAVIDA Pers. On fallen spruce in large quantities.

* **Flammula granulosa** Peck, sp. nov. Pileus thin, hemispherical, becoming convex, dry, densely squamulose, tawny; lamellae thin, rather broad, subdistant, adnate or slightly decurrent, pale yellow becoming tawny ferruginous; stem fleshy, rather slender, stuffed, glabrous or sometimes minutely squamulose, colored like the pileus; spores elliptic, generally uninucleate, 7–8 μ long, 4–5 μ broad.

Pileus 1.5–3 cm. broad; stem 2.5–3 cm. long, 1.5–3 mm. thick.

Decaying wood. August. This is a small species but easily recognized by the squamules of the pileus which give to its surface a granular appearance similar to that of the pileus of *Lepiota granulosa*. At the base of the stem there is a colored membranous disk by which the plant is attached to its place of growth.

* FLAMMULA SAPINEA Fr. Appears to be scarce.

FLAMMULA SPUMOSA Fr. Plentiful.

* HYPHOLOMA CAPNOIDES Fr. Found only once; growing singly and in clusters.

* HYPHOLOMA HYDROPHILUM (Bull.) Sacc. A single cluster of five or six found in a hollow at foot of maple in decaying wood and leaf mould; spores a rich purple red.

HYPHOLOMA INCERTUM Peck. Plentiful in paths singly or in clusters.

* HYPHOLOMA PERPLEXUM Peck. Plentiful.

* INOCYBE RIMOSA (Bull.) Fr. Two plants found in deep leaf mould in woods.

* NAUCORIA ERINACEA Fr. Only a few plants found.

NAUCORIA SEMIORBICULARIS Bull. Large quantities found in lawn.

* TUBARIA FURFURACEA Pers. A few specimens found in decaying leaves in damp woods; a pretty little species.

(*Annulatae*. Provided with a veil which remains as a permanent annulus; no volva)

* AGARICUS ABRUPTUS Peck. Many very large specimens found.

Agaricus campestris L. Abundant in certain localities.

Armillaria mellea Vahl. Only one cluster found, which is unusual for this species.

* Lepiota illinita Fr. Found in only two localities.

* Lepiota naucinoides Peck. A single plant found in lawn.

* Pholiota agericola Peck. Only two plants found.

* Pholiota caperata Pers. Plentiful.

* Pholiota cerasina Peck. In large clusters on decaying spruce.

* Pholiota squarrosoides Peck. Growing in large clusters; plentiful in certain localities.

Stropharia Howeana Peck. Only a few plants found in rich woods in leaf mould.

Stropharia semiglobata Batsch. Common in lawns.

* Stropharia stercorea Fr. Abundant after rain.

(*Volvatae.* Provided with a volva; usually also with a veil and annulus)

* Amanita crenulata Peck. Only a few specimens found.

* Amanita floccocephala Atk. Three or four plants seen.

Amanita Frostiana Peck. Abundant.

*Amanita mappa Fr. Growing singly in rich soil.

Amanita muscaria (L.) Fr. Abundant.

*Amanita muscaria formosa Gonn. & Rab. Fairly common.

Amanita phalloides Fr. Abundant.

*Amanita rubescens Fr. Abundant.

Amanita spreta Peck. Rare.

*Amanita verna Fr. Fairly common.

*Amanitopsis vaginata (Bull.) Roz. A white variety also found.

*Amanitopsis vaginata fulva (Schaeff.). Common.

*Amanitopsis vaginata **crassivolvata** Peck, var. nov. Pileus broadly convex or nearly plane in the mature plant, subumbonate, glabrous, viscid when moist, widely sulcate striate on the margin, creamy yellow; lamellae broad, close, free, white, sometimes tinged with yellow; stem long, equal, hollow or stuffed with cottony fibers, colored like but a little darker than the pileus, volva very thick, loose, white and woolly; spores globose, 8–10 μ broad. Pileus 7–10 cm. broad; stem 15–20 cm. long, about 2 cm. thick.

In damp soil. Although the sheathed *Amanitopsis* is a very variable species, this large form is so well marked by the very thick felty volva that it seems best to separate it as a variety. It does not closely sheath the base of the stem as in the common form but spreads away above and assumes the shape of a wine glass or goblet.

* AMANITOPSIS VOLVATA (Peck) Sacc. Growing singly; three specimens found.

Family SCLERODERMATACEAE

SCLERODERMA VULGARE Hormen. Appears to be rare.

* SCLERODERMA VERRUCOSUM (Pers.) Bull.

Family LYCOPERDACEAE

BOVISTA PILA B. & C. Common in fields.

BOVISTA PLUMBEA Pers. Common in sandy ground near the ocean.

* GEASTER FORNICATUS (Huds.) Fr. Found in one locality only.

* LYCOPERDON ATROPURPUREUM Vitt.

LYCOPERDON GEMMATUM Batsch. Common.

* LYCOPERDON PECKII MORG.

LYCOPERDON PYRIFORME Schaeff. Common.

LYCOPERDON SEPARANS Peck.

LYCOPERDON SUBINCARNATUM Peck.

LYCOPERDON TURNERI E. & E.

Family PHALLACEAE

* DICTYOPHORA DUPLICATA (Bosc.) E. Fisch. Plentiful in woods in one locality.

* MUTINUS CANINUS (Huds.) Fr. A few specimens only found.

NEW YORK, N. Y., July 1902.

Notes on migratory Plants

By E. J. Hill

It is always instructive to study the incoming and habits of introduced plants. This is especially true of those that have become troublesome weeds or may be such if the conditions favor their development. Some of those to be mentioned may be transient visitors, or if persistent, harmless or acceptable additions to the indigenous flora; others are of a very different character. Those are chiefly noticed which have proved of the most interest, and the list does not claim to be complete. Chicago being so great a railroad center, where cars loaded with grain and stock come from so many places to the westward, and from which dump is taken to outlying districts, provides a region with added facilities for the appearance of foreign plants. Among harmless kinds are the following:

Convallaria majalis, L. In the spring of 1899 this was found in the dune region near Miller, Ind. The conditions were such as would have led to the conclusion that it was indigenous had I not frequently been in the locality for several years before, or had found it more abundantly. It was remote from any dwelling where such a plant might be cultivated, in a hollow among the sand hills. I was looking for *Cypripedium acaule* which grows in the locality in just such depressions, and was surprised to find in one of these, hidden among the jackpines, the lily of the valley. The plants were beginning to bloom, it being the middle of May. In such locations the sands are somewhat moist and the ground considerably shaded. The plant most abundantly associated with it was *Maianthemum Canadense*, and the *Convallaria* was as much at home and seemed as flourishing as these. It would be a puzzle to tell how it came to so wild and little-frequented a spot if introduced, as I suppose it must have been.

Cassia Tora L. This was obtained the same season beside a railroad track at Barrington, Ill., about thirty miles north of Chicago. This is quite a distance north of its ordinary range. The pods were well formed, but it was so late in the season, Sept. 21, that it was doubtful if seeds would ripen.

MENTZELIA NUDA (Pursh) Torr. & Gr. An example of this plant of the western plains was found last summer beside the track of the Santa Fé railroad, just west of this city. This would point to the line of its introduction. The handsome flowers were nearly two inches in diameter.

ERYTHRAEA PULCHELLA (Sw.) Fries. A single specimen of this European plant was detected late in the fall of 1900 among some *Brachyactis angulatus*, an introduction from the West which flourishes along the sides of unpaved streets at South Chicago. Last summer the little centaury plants were observed in great abundance in neighboring pastures and commons of the prairie. It was growing in the short grass like a native to the soil, and had the appearance of having always been there. The soil is sandy, naturally damp or even wet, but now dry for most of the season on account of drainage. It occurred in both dry and moist locations, since the minute seeds are produced in countless numbers. It is well adapted, though an annual, to hold its place and spread rapidly.

LACTUCA PULCHELLA (Pursh) DC. This native of the North and Northwest was found last summer beside a railroad in the western margin of the city. The plants were scattered along the edge of the roadbed for several rods, in a place where it was subject to hard usage, which it seemed to endure well. As it was seeding freely and had this habit, it seemed likely to persist.

BROMUS TECTORUM L. In an article in the Bulletin of the Torrey Club (June, 1899), I reported this as occurring beside a railroad east of Chicago, in the dune region of Indiana. It was first observed in 1897 in a single locality. Since then it has spread extensively and now appears along the road in spots for several miles. In some places the grass forms dense plats covering several square rods, but is mostly confined to ground within the railway inclosures. It flourishes finely in the sand, especially if a little damp, or quite moist in the spring. In such locations it attains a height of 12 to 18 inches. With its nodding panicles it is not an unseemly plant for a railroad wayside. But its rather early fruiting and drying up expose it to fires from passing trains, though the seeds readily renew it annually.

HELIANTHUS PETIOLARIS Nutt. This was mentioned in the same article as growing along railroads both east and west of Chicago. I saw it first in 1897. It keeps its place in localities which it frequented then and has since considerably extended its range. It readily takes root in the dry soil of the railway embankments, sending the root down quite deep for an annual, and from its low habit escapes the destruction that is apt to befall taller plants by the trackmen. As yet it seems confined to such localities.

HELIANTHUS ANNUUS L. The form from the western plains is the one here meant. I noticed it first in 1891, west of the city. It was growing in the dump from stock-cars thrown out in piles along the railway tracks. The following year it was seen growing under similar conditions east of the city. It still continues most abundant in the same kind of habitat, but of late I have met with it in fields, competing with indigenous species more common to such localities, such as *H. grosse-serratus*, *H. giganteus*, *H. doronicoides*. These being perennials keep their ground where the soil is not much disturbed by means of their tuberous rootstocks, plentifully produced, and line the fence-rows and field-borders in cultivated areas. But where the soil has been disturbed, and especially if left unused for a little while, *H. annuus* seems the more agile plant and comes in, to make extensive patches sometimes. The larger leaves and flowers make it a more conspicuous plant than the native kinds, which it equals in height. Sometimes a few clumps or some scattered examples of the garden escape appear among them or in close proximity, and the stems, commonly taller, and the larger flowers, bring them into contrast very effectively. The western sunflower has become a weed, but is so easily destroyed and confined to unused stations that it can hardly be called troublesome.

GRINDELIA SQUARROSA (Pursh) Dunal. Possibly the same cannot be affirmed as to the inoffensiveness of this and the plant next following. The gum-plant was reported as occurring here in 1891, being found at South Evanston, just north of Chicago. Since then it has been found in other localities, generally beside railroads. Last summer I came across it in stations relatively remote from railway tracks, and growing under conditions that led to the thought that it might become an unwelcome denizen of pastures.

These stations were in the southern part of Lake county, Ill., at Lake Zurich and near Barrington. Two considerable patches were seen in pastures and some examples by roadsides. Those found in pastures were the most instructive, and at Lake Zurich were carefully examined, where the patch was of four or five square rods in extent. As the season had been very dry and the land chiefly used for dairying, the cows had cropped the pastures close, taking about everything edible. But the *Grindelia* seemed untouched and flourishing, and being in flower in early September made a fine display of golden yellow amid the parched surroundings. The grass which grew among it had been picked out and nibbled off close up to the stems. The only hint of service was apparently experimental, for some of the plants showed by their branching that the main stem had been taken off at an earlier stage of growth, and the most probable explanation was that the animal had tested something unfamiliar, and finding the gummy, bitter plant unpalatable afterward left it quite alone. If allowed to grow and ripen the seed, as some heads were already mature, a good crop would be furnished for the coming year.

SISYMBRIUM ALTISSIMUM L. As this has been found more common in the vicinity of Jackson Park, the opinion has been expressed that it was introduced to this region at the time of the Columbian Exposition in 1893. But from other collectors I learn of its appearance in the vicinity of Chicago about 1890 at least. It now occurs in various places, sometimes a tall branching weed, as the name indicates, at others low, subglobose, widely branching, of a habit that suggests a good tumble weed. I have seen it chiefly in the latter form, but have not caught it discharging the functions of a tumble weed, which the shape and rather stiff branches would enable it to do if detachable from the ground. Vast number of seeds are produced on these thickly set branches.

MELILOTUS ALBA Desv. The rest of the plants to be noticed are the troublesome kinds, some of long standing, others of more recent introduction. Among those whose behavior has most interested me is the white melilot, the sweet clover of our mothers' gardens. For a dozen or more years I have seen no weed make greater progress in overrunning waste grounds. It seems strange that a plant I knew in childhood as a harmless garden-flower, a bunch of which grew by the side of nearly every farmhouse, should have become so troublesome. I have since seen it flourishing by waysides in localities where it was then known chiefly as a flower, but nowhere in such abundance as it shows here. Acres of the weed can be seen in the waste ground along the drainage canal and railroads running parallel with it, as well as on the débris of the numerous quarries of limestone. City lots whose soil is in any way disturbed are apt to be stocked with it. As it can attain a height of six or seven feet—three or four feet being a common height, and branching freely—it soon overshadows the more humble plants and becomes the one in possession almost exclusively. In richer soil, especially of bottom lands, its most important competitor is the great ragweed, *Ambrosia trifida*, which grows higher and is apt to supplant it. Being often xerophytic in habit it frequents dry localities, such as hard clay hills and banks, rubbish-heaps of limestone chips and intermingled dirt from quarries. It is a common weed between the grassy border of a highway and the well-beaten track, where the ground is sufficiently disturbed to permit its seeds to germinate but not enough used to destroy the plants. It readily takes root on a hilly slope or bank on which the rains cut out gullies, washing away the soil so as to prevent less hardy plants gaining a foothold. Here in a sense it may serve a useful purpose in holding the soil or preparing for other growth.

AMARANTUS BLITOIDES Watson. This is one of our most persistent weeds. As nearly as I can learn it appeared in the vicinity of Chicago early in the seventies. I saw it first in 1875, after it had become well established, but not covering any great area. Since that time it has spread extensively and become common, particularly along waysides and railways. It bears a great deal of trampling, and grows where it is subject to very hard usage, much like the knotgrass, *Polygonum aviculare*. Being prostrate, it cannot be mown down like the white melilot, but must be pulled or dug up. It is now the most common of our amaranths except in cultivated ground, where the tumble-weed, *A. graecizans*, is better adapted to the abrupt and frequent disturbances of soil due to cultivation. The prostrate plant cannot take advantage of the wind for dissemination. It is often quite troublesome in lawns, rooting in any spot where the grass is thin, or at the inner edge of the curbstone, the stems creeping in the grass too low to be reached by the lawn mower, or hanging over the edge and perhaps rooting in the gutter if not disturbed for some weeks. It is not uncommon to find mats in favorable situations with stems three or four feet long.

SALSOLA TRAGUS L. This was reported from this region in 1890 or a little before. I have carefully watched it since first seeing it about that time, for the notoriety it had gained in the Northwest called particular attention to it. During this interval it has spread throughout our area, but is not as conspicuous or hardly as plentiful as it was four or five years ago, since it spread very rapidly at first. It is now a common weed of waste ground, struggling with others found in such associations. No systematic effort has been made to exterminate it so far as I have seen or been able to learn. First appearing most commonly along railroad lines, it shares the lot of other growth removed by the trackmen. Little is seen along country roadsides or in cultivated fields. In some vacant lots not far from my dwelling, where the soil was considerably exposed by the plotting of streets and construction of sewers but not occupied for residence, it became abundant soon after making its appearance there, but has since mostly disappeared. Here it was left to natural conditions and no effort was made to get rid of it. It was a dry, sandy soil, and such grasses as *Festuca tenella* and *Sporobolus vaginaeflorus* and plants of similar habit proved more than a match for it. I do not think it will be the troublesome weed under such conditions of cultivation as prevail in the Atlantic States as we were led to expect, or that eastern farmers need to be much alarmed by the inroad of the Russian thistle. It will add another to the list of weeds to be contended with and take its place among the rest, no more burdensome in some respects than others, mainly troublesome when the leaves and branches become stiff in late summer and autumn, and by its ability to be rolled about by the wind, and lodge in obstructed corners. The individual plants are now on the average much smaller than at first, less branched and more upright in growth, and, consequently, less favorably adapted to rolling. Their form changes as they are crowded by other plants, of which they get the start by their superior ability to spread, but with which they must subsequently contend; or because the plants, when the ground is well stocked with seeds, come up thickly and crowd one another. It is probable, too, that it loses in vigor under less favorable conditions. It stands no chance whatever in maintaining itself against a growth of the common grasses.

LACTUCA SCARIOLA L. I noticed this first in 1885. It was infrequent then, but has since become one of the most common weeds, more generally diffused than *Salsola Tragus.* Its copious pappus permits its easy propagation, and like the dandelion it springs up in pastures and meadows as well as in waste ground. But as stock devour it when tender, little comes to maturity in pastures, but more in meadows and the neglected parts of cultivated fields. Its stiff and rather prickly habit make it more repulsive when grown, but even then the leaves are eaten.

CHICAGO, ILL., April 1902.

Some hymenomycetous Fungi from South America

By Edward A. Burt

In February, 1901, there was sent to me for determination a package of very interesting Hymenomycetes, collected by Professor C. F. Baker in Santa Marta, United States of Colombia, in December, 1898. I am indebted to Professor W. G. Farlow for the privilege of confirming the determinations of some of the species by my comparison with authentic specimens in the Curtis herbarium and to Dr. Lars Romell for his sharing with me several of the species described in his *Hymenomycetes Austro-Americani.*

Lenzites striata Swartz. Nos. 12 and 20. In no. 12 the spores are hyaline, even, inequilateral, 8–9 x 4–4½ μ.

Lenzites repanda (Mont.) Fr. No. 27.

Lenzites Palisoti Fr. No. 29. This specimen has the substance of the pileus slightly darker than in no. 27 and the lamellae slightly darker and more porose-anastomosing. Bresadola, in *Fungi Kamerunenses*, p. xxxv, and Romell, in *Hymenomycetes Austro-Americani*, p. 11, regard *Lenzites repanda* and *L. Palisoti* as but forms of *Lenzites applanata* Fr., a species varying in color and other characters with age.

Polyporus fruticum B. & C. On under side of green coriaceous leaves, no. 19. The fructifications of the specimens sent to me are about 3–5 mm. in diameter — only about one third the diameter of authentic specimens collected in Cuba by Wright (422) but are certainly the same species. The spores, as seen with the microscope in sections, are melleous, even, allantoid or flattened on one side, 3–3.5 x 1.5–2 μ; no setae present in the hymenium.

Fomes carneus Nees. No. 211.

Polystictus arenicolor B. & C. No. 35.

Polystictus flabellum Mont. No. 21. This determination is by Bresadola.

Polystictus hirsutus Fr. No. 210.

Polystictus licnoides Mont. No. 25. Probably this species but immature; the tubes are only barely forming and do not show spores and setae.

POLYSTICTUS MODESTUS Kunze. No. 30. *Polystictus albocervinus* Berk. is a synonym.

POLYSTICTUS NILGHERIENSIS Mont. No. 15. This specimen is paler than the description of this species seems to indicate but agrees well with specimens in the Curtis herbarium from Hillsborough, North Carolina, determined by Berkeley.

POLYSTICTUS SECTOR SCHIZODES B. & C. No. 209.

POLYSTICTUS TRICHOMALLUS Berk. & Mont. No. 18.

POLYSTICTUS UNDIGER (B. & C.) Sacc. No. 28. Described as *Polyporus undigerus* B. & C. in *Fungi Cubenses*, No. 282. The Cuban specimens in the Curtis herbarium, collected by Wright (457), are smaller but certainly the same species.

TRAMETES FIBROSA Fr. No. 13. Has been compared with the specimen in the Curtis herbarium, collected in South America by Spruce (20), which is, perhaps, not specifically distinct from *Trametes hydnoides* (Swartz) Fr.

TRAMETES FUMOSOAVELLANEA Romell (POLYPORUS VERECUNDUS B. & C. ?). No. 212. This agrees in all respects with the authentic specimen of his *Trametes fumosoavellanea* received from Romell but differs from the authentic specimen of *Polyporus verecundus* in the Curtis herbarium, collected in Cuba by Wright, *Fungi Cubenses* (220), in having the tubes stratose—three layers present —in the thickest part of the pileus. The other gross characters are so similar to those of *P. verecundus* and so characteristic that I regard the present collection as probably the older, more fully developed fructification of the same species.

TRAMETES STEPHENSII Berk. ? No. 11. The specimen is sterile.

HEXAGONIA VARIEGATA Berk. No. 23.

LACHNOCLADIUM BRASILIENSE (Lev.). No. 14. *Thelephora Brasiliensis* Lev.

STEREUM ILLUDENS Berk. No. 24. Vertical sections through the pileus show in the hymenium the peculiar branched cystidia, resembling minute bottle brushes, by which the species is best distinguished from the more common *Stereum gausapatum* Fr. and *S. subpileatum* B. & C.

STEREUM PAPYRINUM Mont. No. 26.

MIDDLEBURY COLLEGE, MIDDLEBURY, VT.

Three new Plants from Washington

By J. S. Cotton

Glyceria latifolia

Culms 70–120 cm. high, smooth and glabrous; sheaths usually exceeding the internodes, loosely embracing the culm, rough; ligule 2–3 mm. long, scarious, truncate; leaves 7 or 8, the blades flat, 20–30 cm. long, 6–10 mm. broad, linear, acute, rough on both sides: panicle ample, 20–30 cm. long, open; branches in twos and threes, spreading, ascending, branching from near the middle; lower branches 10–15 cm. long: spikelets 3 mm. long, 4–7- usually 5-flowered; empty glumes 1–1.5 mm. long, obtuse, 1-nerved: flowering glumes 2 mm. long, very broad, distinctly 7-nerved, scabrous; palet equalling the flowering glume.

This species differs from *G. nervata* Trin. in its much larger size and broader more numerous leaves. It also shows some resemblance to *G. Americana* but differs from that species in its smaller more obtuse glumes and in having a much more coriaceous palet.

Specimens examined: Railroad Creek, Okanogan county, *Elmer, 721* (type); Seattle, *Piper;* Seattle, *Smith, 942;* Cascade Mts., *Lyall, 490;* Stampede Pass, 4 Oct. 1892, *Henderson;* West Klickitat county, *Suksdorf, 1136*.

Astragalus Olympicus

Perennial, spreading from a stout woody root, the branches about 20 cm. long, densely ashy pubescent throughout: leaves 2–3 cm. long; leaflets 6–8 pairs, 8–12 mm. long, oblong, subacute; stipules membranaceous, triangular, 4 mm. long: peduncles two to three times as long as the leaves: raceme about 10-flowered: flowers on short pedicels, the bracts linear, acuminate, longer than the pedicels: calyx-tube 7 mm. long, pubescent with white and black hairs intermixed, the teeth nearly as long as the tube, equal, acute: corolla greenish-white, tinged with purple, about 10 mm. long: pod 1-celled, inflated, membranaceous, glabrous, oblong, 20–25 mm. long, 6–12 mm. wide, acute at each end; stipe slightly exceeding the calyx tube; sutures not inflexed.

Olympic Mts., Clallam county, July 1900, *A. D. E. Elmer.* Belonging to the Section *Inflati* and probably nearest related to *A. Suksdorfii* Howell.

Orthocarpus barbatus

Annual, slender, erect, simple or sometimes sparseyl branched above, 10–20 cm. high, minutely pubescent and sparsely hispid: leaves 2–4 cm. long, deeply 5-cleft, the lobes linear-attenuate; uppermost leaves passing into the bracts of the spike: spike 3–5 cm. long, its bracts oblong, acute, 10–15 mm. long, about 7 mm. wide; the lower ones more or less 3–5-cleft, the upper merely 3–5-toothed: calyx sparsely hispid, 9 mm. long, its lobes deeply 2-cleft into subulate teeth; teeth nearly as long as the tube: corolla yellow, 12 mm. long, with a simply saccate lip inconspicuously 3-toothed, and a moderately smaller triangular galea whose tip is straight and surpasses the lip about 1.5 mm. and is densely pubescent; the rest of the corolla nearly glabrous: anthers 2-celled, the cells equal, oblong, and covered with a few long hairs: capsule ovoid, acute, dark brown to blackish.

This species is closely allied to *O. tenuifolius* Benth., but is distinguished by its acute bracts, and its galea which is straight and densely pubescent. The rest of the corolla is nearly glabrous while in *O. tenuifolius* it is finely puberulent. The capsule is broader just below the middle, not elliptical as in *O. tenuifolius.*

Type collected at the junction of Crab and Wilson creeks, Douglas county, 19 June 1893, *Sandberg & Leiberg, 234.*

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Memoirs. (See last page of cover.)

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Notes on a Collection of Cuban Pteridophyta, with Descriptions of four new Species

BY LUCIEN M. UNDERWOOD AND WILLIAM R. MAXON

Early in the present year a party consisting of Messrs. Charles Louis Pollard and William Palmer of the United States National Museum, and Dr. Edward Palmer left Washington on a brief collecting expedition to eastern Cuba. Out of some 425 numbers of plants secured no less than 144 are Pteridophyta. These have been placed in our hands for determination. In the following notes four species — one in each of the genera *Alsophila, Polypodium, Asplenium*, and *Diplazium* — are described as new. Several others, mentioned below as probably undescribed, we have not cared to diagnose at the present time on account of insufficient or sterile material. The other notes are in the nature of comments on rare species and unusual forms or in explanation of nomenclatorial confusion.

Alsophila gracilis sp. nov.

Stipes elongate, slender, deeply triple-grooved on the anterior face, about 7 mm. in the greatest diameter, pale brown, densely armed with short spines; pinnae 30–35 cm. long with 14–16 pairs of deeply pinnatifid pinnae, the lowest 1–2 cm. from the main rachis; pinnules 6–8 cm. long, 1.5–1.7 cm. wide, formed of about 8–13 segments on either side; lower pinnules on short stalks (5 mm. or less) which diminish upward so that the uppermost pinnules are sessile; segments oblong-falcate, coriaceous, smooth on both sides, the margins crenate, incurved; the apex attenuate and crenate; veins mostly once-forked, bearing the globular sori near the middle.

The species is founded upon sheets no. 403248 and no. 403247 in the U. S. National herbarium, representing no. 255

[Issued 31 October]

collected by Charles L. Pollard, Dr. Edward Palmer, and William Palmer in the vicinity of Baracoa, Santiago province, Cuba, February 1–7, 1902. A sheet of the same number in the herbarium of the New York Botanical Garden has a longer portion of the stipe. Both herbaria contain earlier specimens collected in eastern Cuba by Charles Wright and distributed (no. 951) as *Alsophila nitens* J. Sw.

ANEMIA HIRTA SW. ?

Numbers 121 and 401 are well matched by a sheet in the U. S. National herbarium (no. 26037) from Jamaica. They represent what Jenman regarded as the true *Anemia hirta* of Swartz, and are presumably what Swartz had in hand when describing this species. They are, however, scarcely the plant represented by Plumier's plate 157 (which Swartz cites), from Martinique.

ORNITHOPTERIS sp.

The specimens of number 232, though probably representing an undescribed species, are sterile and therefore unsatisfactory for purposes of description.

ELAPHOGLOSSUM APODUM (Kaulf.) Schott

Acrostichum apodum Kaulf. Enum. Fil. 59. 1824.

Elaphoglossum apodum Schott, Gen. Fil. *pl. 15*. 1834.

Acrostichum platyneuron Feé, Mém. Fam. Foug. **2**: 43. *pl. 4. f. 1*. 1844–45; *non* L.

The plants collected as no. 152 are certainly identical with Feé's species, judging from both the admirable plate and description; but we do not feel justified in regarding Feé's species as distinct from the *Acrostichum apodum* of Kaulfuss. Hooker and Greville published (Ic. Fil. **1**: *pl. 99*. 1829), a figure of *A. apodum* which matches several sheets at hand, under this name, as well as the new material (no. 152). Feé recognized *A. apodum* as a distinct species; but Moore in transferring *A. platyneuron* to *Elaphoglossum* (Ind. Fil. 364. 1862), hazards the suggestion "*An E. apodum.*" Whether or not the two are one, the name *Elaphoglossum platyneuron* is not available, for the reason that *Acrostichum platyneuron* Feé is antedated by the Linnaean *Acrostichum platyneuron.*

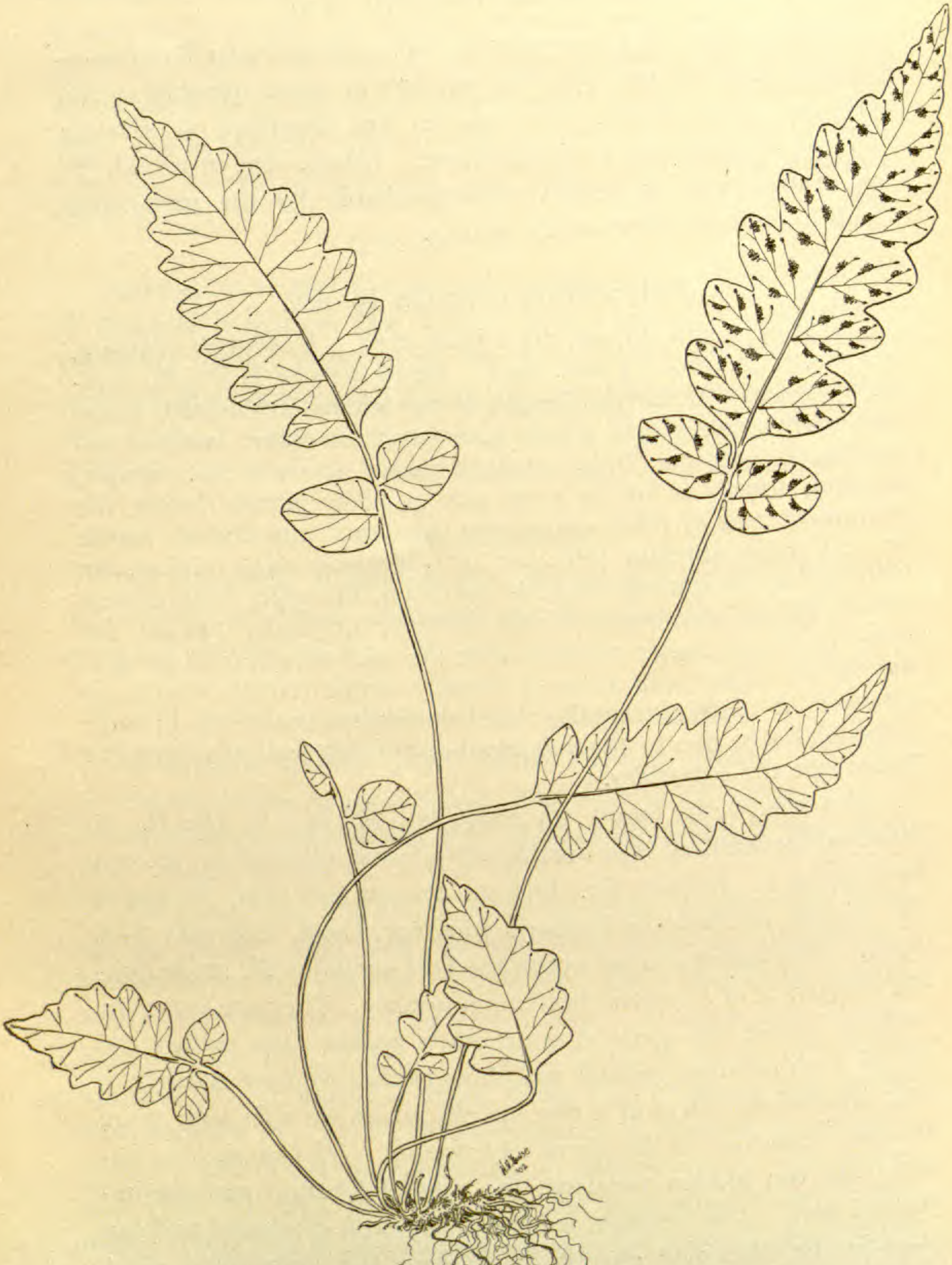
LOMARIOPSIS WRIGHTII Mett.

Of this there are two numbers, both collected near Baracoa — a single sheet of no. 150, but no. 220 in some quantity — and both are quite sterile. The species was described in Eaton's "Filices Wrightianae et Fendlerianae" (Mem. Am. Acad. II. **8**: 195. 1863) and is readily distinguishable by the remarkable abruptly caudate apices of the pinnae.

Polypodium cryptum sp. nov.

Plant of small stature, 10–17 cm. high. Rootstock creeping, 1–2 cm. long, about 5 mm. thick; stipes variable in length, commonly 1.5 to 2 times the length of the lamina, articulated, somewhat pubescent, and of a dull greenish straw color: laminae lanceolate, 4.5–7.5 cm. long, greatest width about 2 cm., simple, pinnately lobed, or for the most part partially pinnate below, the lowermost pair of lobes commonly developed into distinct sessile or very short-stipitate orbicular or orbicular-cordate pinnae, the next pair rarely approaching this condition, the upper lobes merely broad obtuse crenations which decrease gradually toward the tapering obtuse apex; venation free, the midvein of each lobe giving off on either side about 4 usually simple veinlets which are enlarged at their extremities: sori somewhat immersed, broadly elliptical, borne one to the veinlet almost exactly half way from the midve into the extremity.

The species is based on sheet no. 403232 in the U. S. National herbarium, representing specimens collected as no. 231 by Charles L. Pollard, Dr. Edward Palmer and Wm. Palmer in the vicinity of Baracoa, Santiago province, Cuba, February 1–7, 1902. The specimens are not in the best condition for study, having somewhat of a weatherbeaten appearance. They are, however, uniform in size and general appearance, appear quite mature and are of such peculiar general morphology that we have thought it best to describe them as a new species which we refer with more or less hesitation to the genus *Polypodium*. The anomalous features are the hidden venation, the unique lobation and the immersed sori. The venation is indeed very well concealed and can scarcely be discerned except by holding the unmounted plant towards strong light. Only the basal veinlets of the lowermost lobes in the larger fronds fork commonly and these only once or twice, most of the veinlets being simple.



POLYPODIUM CRYPTUM

A majority of the plants have the appearance of being quite glabrous; but careful examination of a more perfect specimen shows that the lower portions of the stipe possess an inconspicuous soft stellate pubescence which becomes more scattering above but is rather noticeable on the midvein and lower veins of the frond, and that the margin of the frond is sparingly ciliate.

GONIOPHLEBIUM PILOSELLOIDES (L.) J. Sm.

To this species we have referred numbers 47, 181 and 182. There is to be observed considerable variation, particularly in the shape of the sterile leaf; but the specimens are undoubtedly all referable to the single species.

CAMPYLONEURON REPENS (L.) Presl.

The need of a critical study of the group to which this species belongs, in connection with the types preserved in European herbaria, permits no closer determination of no. 184 than the above which is to be considered merely tentative.

ADIANTUM FRUCTUOSUM Pöppig

We have not seen herbarium material of this species, but judging from the excellent description there can be little doubt that under no. 66 we have the plant described by Pöppig in Sprengel, Syst. Veg. **4**: 113. 1827, and later by Kunze in Linnaea, **9**: 81. 1834.

ADIANTUM FRAGILE Sw.

The specimens of no. 421, although very uniform, are unusual in the shape of the segments which are narrowly cuneate and often somewhat bilobed. Otherwise they seem quite typical.

STRUTHIOPTERIS sp.

The material comprising number 146 consists of sterile leaves only. The species, which is probably undescribed is one of the several forms to which the name *Lomaria attenuata* Willd. is usually given.

Asplenium venustum sp. nov.

Plant 35–67 cm. high. Leaves closely tufted from a nearly naked stoutish suberect rootstock: stipe 15–37 cm., dull grayish-brown: lamina ovate-lanceolate, the apical portion long acuminate, once or twice cleft below, otherwise similar to the pinnae; pinnae 5–7 pairs, linear, subcoriaceous, subopposite below, alternate above, ordinarily diverging from the axis at an angle of about 30°, the 3 or 4 lowermost pairs 11–15 cm. long and 7–11 mm. broad (at the broadest point, which is about one third the distance from base toward apex); base of pinna narrowly and very obliquely cuneate (becoming stipitate), apparently never auricled, the superior portion only a trifle wider than the inferior; margin unequally biserrate (in large fronds occasionlly triserrate), the teeth rather slender, aute and outwardly curved; veins very oblique, forking usually once; sori 1–2.7 cm. long, borne on the anterior branch and nearly parallel to the midvein; indusium firm.

The above description is drawn from two sheets, nos. 403185 and 403298 in the U. S. National herbarium, representing no. 139 collected by Charles L. Pollard and Wm. Palmer on "slopes and summit of El Yunque, near Baracoa, Santiago province, Cuba. Alt. 1000–2000 feet, January 30–31, 1902. "The species seems to us very distinct; certainly it has nothing to do with *Asplenium erosum* L.,* with it has, in one instance, been confused, — we refer to the reference here of Wright's no. 1043 as "var. *pinnis angustissimis*." † Wright's no. 1043 as represented in the National herbarium (sheet no. 26435) is exactly our plant, though the fronds bear an additional pair or two of pinnae. Reference to Sloane's plate 33, fig. 2, cited by Linnaeus under *A. erosum*, is sufficient to disprove any supposed alliance with the plants there represented.

Asplenium venustum is easily distinguished by the extreme narrowness of the pinnae, their peculiar hacked appearance on account of the acute flaring teeth, and by their extremely oblique gradually narrowed bases. Sheet no. 403185 bears a typical plant 3.8 dm. high, comprising 10 overlapping fronds. Sheet no. 403298 contains a juvenile plant and a single detached frond 6.7 dm. high.

ASPLENIUM MONTEVERDENSE Hooker

This rare species was described in Species Filicum, 3: 195. 1860 and figured in Hooker's 2d Century of Ferns, *pl. 41*. 1861. It was founded on C. Wright's no. 1029 collected, in 1859, "under overhanging rocks near Monte Verde, on the eastern side

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* Sp. Pl. ed. 2, 2: 1539. 1764.

† Sauvalle, Fl. Cubana, 211. 1878.

of Cuba." The specimens of the present collection (no. 117) are much larger than the original, or indeed than the other specimens we have seen, which are: (1) Matanzas, Cuba, 1849, *Rugel, 9* (C); (2) Eastern Cuba, 1856–1857, *Wright, 856* (Y). Except in size the plants (117) agree well with the original description and plate.

Diplazium aemulum sp. nov.

Plant 40–60 cm. high. Leaves borne in a close crown on a rather slight erect rootstock: stipes 1–2 dm., sparingly paleaceous below with firm dark brownish linear or linear-lanceolate long attenuate scales: large mature lamina broadly lanceolate, broadest just below the middle, dark green, paler beneath, comprising 20 or less pairs of lanceolate pinnae, the lowermost of which diverge from the rachis at an angle of about 70°, the uppermost at from 45° to 60°: pinnae spreading, subopposite below, soon becoming alternate above, the largest 1 dm. long by 1.7 cm. wide, lanceolate, terminating rather abruptly in a serrulate attenuate somewhat falcate apex, the base cuneate (the lower edge much more obliquely so than the upper), the margin pinnatifid into shallow obtusish lobes (about 12), which are regularly serrate by the free repeatedly forking veinlets extending to the margin; sori linear, curved, averaging 5 mm., borne on the first anterior of each group of veinlets; indusia both single and double, the former perhaps predominating.

Type specimen, no. 403220 in the U. S. National herbarium collected on the "slopes and summit of El Yunque, near Baracoa, Santiago province, Cuba, January 30–31, 1902, by Charles L. Pollard and William Palmer; no. 179, altitude 1000–2000 feet." We would also refer here no. 159, same data.

The type sheet consists of a rather small plant about 4 dm. high and a single detached fully matured leaf measuring about 6 dm. The latter is larger than most of the specimens distributed, so that the measurements here given probably represent nearly the maximum for the species. The shallow lobation so characteristic of the larger pinnae is manifest in the smaller ones in less degree and commonly only as an irregular double serration.

DRYOPTERIS LONCHODES (D. C. Eaton) Kuntze

Aspidium lonchodes D. C. Eaton, Mem. Am. Acad. II. **8**: 210. 1863.

Dryopteris lonchodes Kuntze, Rev. Gen. Pl. 2 : 813. 1891.

This species was described from nos. 1007 and 1008 of Wright's Cuban plants. The specimens (no. 239) of the present collection agree closely with the type and represent a remarkably distinct species. We have seen no other specimens.

Polystichum aquifolium nom. nov.

Polystichum ilicifolium Feé, Gen. Fil. 279. 1850–52. Not *P. ilicifolium* Moore, Ind. Fil. 94. 1858, which is *Aspidium ilicifolium* Don, Prodr. Nep. 3. 1825.

We have little hesitation in pronouncing the *Polystichum ilicifolium* of Feé, described from specimens collected by Linden in Santiago province, Cuba, quite distinct from *P. triangulum* or any other species of this group. The name *ilicifolium* is quite untenable by reason of Don's species having been properly transferred to *Polystichum* by Moore. Feé's choice of a specific designation was, however, so much to the point that we can do no better than substitute *aquifolium*, the long-used generic name for the holly.

No. 420 comprises specimens collected near El Cobre, Santiago province, Cuba, by Messrs. Charles L. Pollard and William Palmer, February 21–24, 1902, which are identical with Feé's plants as represented by *pl. 6. f. 4* in his 6th Mémoir (1854).

DANAEA NODOSA (L.) J. Sm.?

A sterile leaf or two of a *Danaea*, collected as number 142, show certain differences from the true *Danaea nodosa*, notably in the extreme closeness of the venation which averages 18 veinlets per centimeter ; but neither stipe nor sporophyll being at hand it seems best not to separate as a distinct species.

Dates of the "Nova Genera" of Humboldt, Bonpland and Kunth

By John Hendley Barnhart

Every student of systematic botany is familiar with the abbreviation "H.B.K.," and this at once brings to his mind the great seven-volume work, "Nova genera et species plantarum," commonly credited to Humboldt, Bonpland and Kunth; although the editorial work upon it was wholly Kunth's, and Baron von Humboldt's only contribution appears to have been the introductory essay. This work was the most extensive of several which constituted the botany of Humboldt and Bonpland's "Voyage," and different from the rest in the language employed, this being written in Latin, the others exclusively in French.

Having occasion recently to determine the date of publication of a certain portion of this work, and knowing that as it appeared in parts the title-page dates could not be depended upon, I undertook to ascertain the pagination and dates of all the original fascicles. The only recent reference to this subject which could be found was in a paper published in the Journal of Botany for June, 1901.* The authors of this paper appear to have been investigating the facts surrounding the publication of the zoölogical portion of Humboldt and Bonpland's "Voyage," and to have accumulated incidentally considerable information relating to the botanical volumes; and a debt of gratitude is certainly due them for placing their results within the reach of all.

Messrs. Sherborn and Woodward seem to have given us an accurate and fairly complete account of the "Plantes équinoxiales," "Melastomes," "Rhexies," "Mimoses "and "Graminées" of the Voyage reports, but as much cannot be said of their attempt to elucidate the "Nova genera." On one page they give a summary of the seven volumes, showing that these consist of 55, 51, 57, 39, 54, 68 and 66 sheets or signatures respectively; on the following pages they list the fascicles as announced from time to time in the "Bibliographie de la France," from which it would

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*Sherborn, C. D., & Woodward, B. B. The Dates of Humboldt and Bonpland's "Voyage." Jour. Bot. 39: 202–205. Je. 1901.

appear that the volumes contained about 89, 98, 91, 63, 86, 106 and 119 signatures respectively; after which they merely remark, "[The sheeting of the French records is a mystery to both of us]."

It is well known, or ought to be, that the "Nova genera" appeared simultaneously in two editions, one of folio size, the other in quarto. It is not so well known, except to those who have tried to verify references in the wrong edition, that the two differ widely in pagination; the only printed mention of this fact which I have seen is a brief note by Dr. Otto Kuntze,* and he does not seem to have had access to a copy of the fourth volume of the folio edition. The matter in the two editions is the same; they were issued in the same number of fascicles (36), and at the same time; and the plates were alike in the two editions, except for the width of the margin; but, the quarto page being much smaller, the text extended over a greater number of pages, so that each quarto fascicle consisted of many more pages than the corresponding folio fascicle, and the quarto volumes are thicker than the folio ones. Messrs. Sherborn and Woodward described the quarto volumes; nearly all of their quotations from the "French records" refer to the folio edition; it was for this reason that they were mystified. The "Bibliographie de la France," upon which they were obliged to rely almost wholly for the list they give, repeatedly mentions the quarto edition, and in many cases specifies the "sheeting" of the quarto parts; it is difficult to see how they could overlook this fact, although it may well have added to their perplexity.

The folio edition seems to have been prepared so that subscribers to the entire series of "Voyage" reports might have them of uniform size; the quarto edition, that botanists might secure this particular work at a reduced price. The latter, probably because of its cheapness and consequent greater accessibility to the average student, is the one almost invariably cited by botanists; it is the one always referred to by Kunth himself, in his later works. While convenient, this practice is not strictly logical; for, as the fascicles were issued without breaking signatures, those numbered correspondingly never contained precisely

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* Kuntze, O. Rev. Gen. 3^2: 156. 28 S. 1898.

the same text in the folio and in the quarto form. In many instances, in order to determine with exactness the date of publication of a new genus or species, it would be necessary to find out whether it first appeared in a folio or a quarto fascicle. A table showing the genera and species concerned, with the original place and date of publication, might prove useful in determining some question of priority; but such a list would be of very doubtful value until we are more certain than we can be at present of the exact pagination of every fascicle. It is very important, as mentioned by Sherborn and Woodward, that any one possessing the original fascicles, or any of them, should submit them to some bibliographer who would publish a careful description of them; but it must not be forgotten that *contemporary evidence is the best*, for a fascicle may appear to be in its original form, when actually altered in important particulars.

Before proceeding to a consideration of the probable contents of each part, it may be well to take a general survey of the pagination, signatures, etc., of the completed volumes. In this connection it must be remembered that the quadruple title-page in each volume took an entire quarto signature or two folio ones, while these were counted in numbering neither the signatures nor the pages. In some cases the French journal seems to have counted the title-pages in giving the number of signatures in a part, in other cases, not; and the uncertainty in this respect, together with the fact that the title-pages were probably published with the first part of most of the volumes, but with the last part of one or two, causes most of the trouble in definitely assigning certain pages to each fascicle. It must also be borne in mind that a single sheet forms four folio pages, but eight of quarto size, so that while the quarto volumes and fascicles have more pages than the folio, they have fewer signatures. The plates and title-page dates are the same in both editions; it is only in the text that they differ.

VOL.	FOLIO TEXT.	QUARTO TEXT.	PLATES.	T. P. DATE.
I.	(8), xlvi, (2), 302 pp. (2), 87½ (=a–i, k–m, 1–76) sign.	(8), lviii, (2), 377 pp. (1), 54¾ (=a–h, 1–48) sign.	1–96.	1815
II.	(8), 324 pp. (2), 81 sign.	(8), 404 (2) pp. (1), 50¾ (=1–51) sign.	97–192.	1817

III.	(8), 356 pp.	(8), 456 pp.	193–300.	1818
	(2), 89 sign.	(1), 57 sign.		
IV.	(8), 247 pp.	(8), 312 pp.	301–412.	1820
	(2), 62 sign.	(1), 39 sign.		
V.	(8), 338 (2), pp.	(8), 432 pp.	413–512.	1821
	(2), 85 sign.	(1), 54 sign.		
VI.	(8), 420 (2) pp.	(8), 542 pp.	513–600.	1823
	(2), 105½ (= 1–106) sign.	(1), 67¾ (=1–68) sign.		
VII.	(8), 399 pp.	(8), 506 pp.	601–700.	1825
	(2), 100 sign.	(1), 65¼ (=1–66) sign.		

VOLUME I

This volume, in the folio form, presents little difficulty. It is true that fasc. 1 and 2 are noticed together in the B. F.* for 3 F. 1816, while it is quite likely that they were separately published, one or both of them before the end of the year 1815 (the title-page date). As we have absolutely no data indicating the pages at which they were separated, however; and as I have no strong evidence even in support of the supposition that they appeared separately, fasc. 1–2 will be treated here as a "double number." The fascicles forming Volume I folio were noticed as follows:

Fasc. 1–2.	44 sign, *44 pl.*	B. F. 3 F.	1816.
" 3.	20 " *25 pl.*	B. F. 11 My.	" †
" 4.	25½ " *27 pl.*	B. F. 31 Au.	"

In all, 89½ signatures and 96 plates, precisely as the folio volume is described above, and we need have no hesitation in assigning data as follows:

Fasc. 1–2.	T.-p., pp. i–xlviii, 1–120, *pl. 1–44.*	Ja. 1816 (or D. 1815?)
" 3.	Pp. 121–200, *pl. 45–69.*	My. "
" 4.	Pp. 201–302, *pl. 70–96.*	Au. "

The B. F. gives no descriptions of fasc. 1–4 in the quarto form, and the following division is simply a provisional one, based upon the supposition that the corresponding quarto and folio parts contained approximately the same matter: a supposition which is warranted by the known facts in the case of many of the later fascicles.

Fasc. 1–2.	T.-p., pp. i–lx, 1–152, *pl. 1–44.*	Ja. 1816 (or D. 1815?)
" 3.	Pp. 153–256, *pl. 45–69.*	My. "
" 4.	Pp. 257–377, *pl. 70–96.*	Au. "

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* In the following discussion the references to the "Bibliographie de la France" will be so frequent that its title will be abbreviated to "B. F."

† Not 2 My. as given by Sherborn and Woodward.

VOLUME II

This volume consisted of fasc. 5–8. Unfortunately fasc. 5 is badly mixed in the B. F. It is noticed 3 My. 1817, but is called the *fourth* fascicle (an error corrected 13 D. 1817, in noting the next fascicle *), and although the description, "13 feuilles et demie, plus 25 planches," is accompanied by the statement "in-folio," it is evident from the price named that it was the quarto edition which the bibliographer had in hand. There is little doubt, however, that fasc. 5 contained, in the folio form, pp. 1–80, and in the quarto, pp. 1–96, and the B. F. is no doubt correct in saying 25 plates, viz., *pl. 97–121.*

Fasc. 6, 7 and 8 are given by the B. F. as follows :

Fasc. 6.	Folio, 18 sign.	Quarto, 12 sign.	*25 pl.*	13 D. 1817.
" 7.	" 17 sign.	" 11 sign.	*22 pl.*	28 F. 1818.
" 8.	" 50 sign.	" 25 sign.	*34 pl.*	6 Je. 1818.

The record in the case of fasc. 8 is certainly very puzzling. Sherborn and Woodward suggest that the "34" plates may be a typographical error for "24," but there is no need to suppose such an error, for there is little doubt that ten plates (*193–202*) belonging to the following volume appeared with this fascicle. It is the record of the text which is surprising. These three fascicles alone (6, 7 and 8), according to the B. F., contained 85 signatures, folio, while the entire volume had only 83, *title-pages included!* We are left only two explanations : either the B. F. is in error, the folio fasc. 8 consisting of about 26 signatures, the quarto of about 16 ; or, as is liable to occur in any such work as this, fasc. 8 may have contained a second printing of some of the previously published text, which in its original form was not satisfactory to the authors.

The probable pagination and dates of fasc. 5–8 are as follows :

FOLIO

Fasc. 5.	T.-p. pp. 1–80 (with reprint of vol. I, pp. 301–302 ?), *pl. 97–121.*	Ap. 1817
" 6.	Pp. 81–152, *pl. 122–146.*	D. "
" 7.	Pp. 153–220, *pl. 147–168.*	F. 1818
" 8.	Pp. 221–324 (+ ?), *pl. 169–202.*	Je. "

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* "Cette sixième livraison est la deuxième du second volume ; c'est la cinquième (et non la quatrième), qui a paru en mai dernier."

QUARTO

Fasc. 5.	T.-p., pp. 1–96, *pl. 97–121.*	Ap. 1817
" 6.	Pp. 97–192, *pl. 122–146.*	D. "
" 7.	Pp. 193–280, *pl. 147–168.*	F. 1818
" 8.	Pp. 281–406 (+?), *pl. 169–202.*	Je. "

VOLUME III

The third volume consisted of five fascicles, nos. 9–13; although plates 193–202 had appeared with fasc. 8. The B. F. gives the data for these fascicles, in folio, as follows:

Fasc. 9.	20 signatures,	*25 plates.*	3 O. 1818.
" 10.	19 "	*15* "	13 F. 1819.
" 11.	19 "	*25* "	17 Jl. "
" 12.	18 "	*25* "	27 N. "
" 13.	15 "	*9* "	11 Mr. 1820.

The number of signatures agrees exactly with the description of the volume given above, so that we have no hesitation in deciding upon the pagination. We have here mention of only 99 plates, however, while the volume contained 108, one of which was issued twice, as will be mentioned further on; and this, with the distinct statement of the B. F. that fasc. 13 completed the third volume, is additional evidence that the B. F. was correct in assigning 34 plates to fasc. 8. If more evidence is desired, it is not lacking. The "Allgemeine Repertorium" of Leipzig, in its first mention of this work,* reviews the folio edition as far as Vol. III, page 148, *plate 242;* evidently to the end of fasc. 10 ("1818," by the way). Now if fasc. 10 ended with plate 242, and contained 15 plates, it must have begun with plate 228; if fasc. 9 ended with plate 227, and contained 25 plates, it must have begun with plate 203; but the volume began with plate 193; therefore, plates 193–202 must have appeared with fasc. 8, and the B. F. must be correct in assigning 34 plates to that fascicle — or, if it contained only 24, there must have been 25 plates in fasc. 10, instead of 15 as stated. At least, the B. F. is consistent with itself in this matter, and I prefer to accept its statements until they are proven incorrect.

Plate no. 216 was published in fasc. 9, the name upon it reading "*Aragoa juniperina.*" When this species was reached in the text, however, in fasc. 10 (page 121 of the folio, page 156 of the

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* Allg. Repert. 1819^3: 132–136.

quarto), it was called "*Aragoa cupressina*"; and later (not with fasc. 10, but probably with fasc. 13), a new plate numbered "216" appeared. The new plate bore the corrected name, and upon it the original detail figures were replaced by entirely new ones.

Fasc. 9 contained the descriptions of certain new species of *Nicotiana* and *Heliotropium*, which had been published by Lehmann, under the same or in some cases under different names, only a short time before. This greatly annoyed Kunth, who thought that Lehmann should have awaited the appearance of this portion of the "Nova genera" before issuing his work. A letter written by Kunth in this connection, with Lehmann's reply, may be found in the first volume of Flora.*

In noting fasc. 9–13, the B. F. mentions the quarto edition several times, but gives the number of signatures only in the case of fasc. 10, when there were twelve. There is little doubt of the pagination, however, and we may, sum up this volume thus :

FOLIO TEXT.	QUARTO TEXT.	PLATES.	DATE.
Fasc. 9. T.-p., pp. 1–72.	T.-p., pp. 1–96.	*203–227.*	S. 1818.
" 10. Pp. 73–148.	Pp. 97–192.	*228–242.*	F. 1819.
" 11. Pp. 149–224.	Pp. 193-288.	*243–267.*	Jl. "
" 12. Pp. 225–296.	Pp. 289–384.	*268–292.*	N. "
" 13. Pp. 297–356.	Pp. 385–456.	*293–300, 216 bis.*	Mr. 1820.

VOLUME IV

Volume IV comprised fasc. 14–18, the last of which was not given to the public until late in the year 1820; although, as we shall see, the entire text was in print, and to a limited extent accessible, two years earlier. According to Sherborn and Woodwood, fasc. 14 contained Vol. III, pp. 417–456, and Vol. IV, pp. 1–72. It is apparent that they were led to this conclusion by some evidence that this fascicle ended with page 72 (which is true of the quarto); but as 72 pp. in their quarto edition made only 9 signatures, and the B. F. stated that fasc. 14 consisted of 14 signatures, they decided that this fascicle must have contained the last five signatures (which would be pp. 417–456 of the quarto) of Vol. III — in other words, their confusion of the two editions in this case led them into grave error. The B. F. distinctly states that fasc. 13 completed the third volume, and there can be no doubt that this was the case.

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* Flora, 1 : 601–607. 20 D. 1818.

Sherborn and Woodward, in describing fascicle 15, say of the plates: "25 pls. 326–340." This is plainly either a clerical or a typographical error; the 25 plates were nos. 326–349, two plates bearing the number "332."

The B. F. gives us quite complete data for this volume:

Fasc. 14.	Folio, 14 sign.	Quarto, 9 sign.	*25 plates.*	15 Ap. 1820.
" 15.	" 16 sign.	" 10 sign.	*25* "	27 My. "
" 16.	" 12 sign.	" 9 sign.	*24* "	22 Jl. "
" 17.	" 12 sign.	" 8 sign.	*24* "	16 S. "
" 18.	" 9 sign.	" 4 sign.	*13* "	24 D. "

The "13" plates credited to fasc. 18 probably should be 15; and in counting the folio signatures the title-pages, which in this case seem to have come out with the last fascicle of the volume instead of the first, must have been reckoned as one instead of two. This gives the following summary.

	FOLIO TEXT.	QUARTO TEXT.	PLATES.	DATE.
Fasc. 14.	Pp. 1–56.	Pp. 1–72.	*301–325.*	Ap. 1820.
" 15.	Pp. 57–120.	Pp. 73–152.	*326–332 bis, 332–349.*	My. "
" 16.	Pp. 121–168.	Pp. 153–224.	*350–373.*	Jl. "
" 17.	Pp. 169–216.	Pp. 225–288.	*374–397.*	S. "
" 18.	Pp. 217–247, t.-p.	Pp. 289–312, t.-p.	*398–412.*	D. "

It will be noted that these five fascicles followed one another with unprecedented rapidity; and "thereby hangs a tale." On the 26th of October, 1818, in order to fix the date of publication of this volume, Kunth presented a complete copy of the text to the Academy of Sciences of Paris. It consisted of loose sheets of the folio edition, and had a manuscript title-page, on which was set forth the fact that the printing was begun in September, 1817, and completed in September, 1818. At this time the publication of Volume III had only just begun, and Kunth had no idea of offering Volume IV to the public until it was reached in its turn after the completion of Volume III; in fact, the plates of Volume IV had not been engraved. Yet Kunth hurried the text through the press, and took this method of securing its advance publication.

Henri Cassini, one of the members of the Academy, had devoted his leisure "for the past eight or nine years," as he tells us, to the study of the Compositae, and was at that time recognized as the foremost living authority upon that group of plants. Volume IV of the "Nova genera" comprised the Compositae, and the Compositae only; was it any wonder, then, that Cassini regarded the "extraordinary precipitancy" of Kunth, in presenting this copy to the Academy, as a decidedly personal affair? Cassini criticised Kunth for issuing the work in this way, in loose sheets, with a manuscript title, and without plates; in the folio form, too, "qui n'est probablement consacré qu'a un petit nombre d'exemplaires," while the quarto is the one more generally distributed and usually quoted. But especially did he protest against the recognition of this method of publication, as it contained no guarantee that the work as finally issued to the public would be identical with the copy presented to the Academy.

Kunth insisted that Volume IV was printed simply because the funds were available and the manuscript had been completed for several years; he pledged his honor that the work as finally issued to the public would be identical with the copy presented to the Academy, except for the alteration of one short and unimportant paragraph to which Cassini had objected; and he further mollified the latter by presenting him with a copy of the volume in dispute, on the first of December, 1818. On his part Cassini agreed to accept the latter date as the actual date of publication. A delicate question is here involved. We cannot insist that this volume was not published in 1818 because it was not offered for sale at that time, for some works whose due publication is never questioned (Linnaeus' "Hortus Cliffortianus" is a famous example) were never offered for sale until at length second-hand copies came into the market. It is universally agreed that as long as all copies of a printed work remain in the hands of the author, its status is the same as that of a manuscript, even if he permits it to be inspected by others. But does the distribution of one or two copies constitute publication? The question here is almost identical with that involving the date of publication of Fournier's "Mexicanas Plantas, Pars II. Gramineae." This bears the date 1886 upon the title-page, and was not accessible to the general public until that year; but Bentham had a copy of the text as early as 1881, and repeatedly cited it; nor is it certain that other complimentary copies were not issued in advance.

We come now to consider the single change in Volume IV after it was first printed. A note, near the bottom of page 243, in the " addenda et corrigenda," read originally as follows : " Pars hujus operis, quae de Compositarum familia tractat ; jam ante tres fere annos a me finita, illo tempore, a clarissimo Henrico Cassini, leviter quidem, ob magnam specierum et generum copiam inspecta est. Quo factum est, ut nomina et characteres generum nostrorum novorum non retinens, Ampherephis speciei tertiae, in herbario illustr. Jussieu asservatae, tanquam distincto generi, nomen Centhratheri imponeret." Immediately and indignantly did Cassini resent this implied reflection upon his honor, and brand it as a falsehood ; and although Kunth maintained that no offense had been intended by the original staement, the objectional paragraph was modified until, as finally presented to the subscribers to the " Nova genera," it took this harmless form : " Pars hujus operis quae de Compositarum familia agit, jam exeunte anno 1815 a me ad finem perducta, nonnisi mense septembre 1817 typis describi coepta est, absoluta eodem mense 1818, vulgata 1820. Interea celeberrimus Cassinius, observationum mearum inscius, Compositas summa diligentia raraque sagacitate scrutari continuavit sectionesque et genera proponere : quo factum est, ut eorum complura diversis nominibus a Cassinio et me nuncupata exstent ; quod semper usu veniet, quotiescunque duo in plantas examinandas aeque exercitati botanici eandem familiam investigant generaque in ea instituere necesse judicant et instituunt. Ampherephis species duas in herbario Humboldtiano observavi, tertiam in herbario Jussiaeano, cui nomen a me inventum tunc stylo cerussato adscribere haud neglexi, Celeberrimus Cassinius vero non animadvertens, opinor, id nomen ibi jam a me appositum esse, plantae Jussiaeanae nomen Centratheri imposuit."

Those wishing to learn further particulars of this controversy should consult the papers by Cassini and Kunth, published in volume 89 of the " Journal de physique, de chimie et d'histoire naturelle ; " * and those who do not acknowledge that the volume was published until issued in parts in 1820, should not overlook

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* Cassini, H. Analyse critique et raisonnée du quatrième volume de l'ouvrage de M. Kunth, intitulé, *Nova genera et species plantarum.* Jour. phys. 89: 5–33. Jl. 1819.

Kunth, C. S. A une article de M. Cassini, ayant pour titre : *Analyse critique et raisonnée du quatrième volume du* Nova genera et species plantarum aequinoctialium. Jour. phys. 89 : 278–284. O. 1819.

the fact that the new genera were all listed and criticised by Cassini in this "Journal de physique" during the preceding year.

VOLUME V

This volume consisted of fasc. 19–23, and the B. F. furnishes quite a complete account of them, except in the case of quarto fasc. 21, which probably was composed of 12 signatures.

Fasc.	19.	Folio, 16	sign.	Quarto, 9	sign.	*24*	*plates.*	26 My.	1821.
"	20.	" 14	"	" 8	"	*24*	"	29 S.	"
"	21.	" 16	"	" –	"	*20*	"	23 F.	1822.
"	22.	" 15	"	" 10	"	*20*	"	29 Je.	"
"	23.	" 25½	"	" 15⅓	"	*15*	"	22 Mr.	1823.

The pagination and plates were probably as follows:

FASC.	FOLIO TEXT.	QUARTO TEXT.	PLATES.
19.	T.-p., pp. 1–56.	T.-p., pp. 1–64.	*413–436.*
20.	Pp. 57–112.	Pp. 65–128.	*437–460.*
21.	Pp. 113–176.	Pp. 129–224.	*461–480.*
22.	Pp. 177–236.	Pp. 225–304.	*481a–b, 482, 483, 483a, 484–498.*
23.	Pp. 237–338.	Pp. 305–332.	*499a–b, 500–512.*

The two unnumbered pages of the folio edition following page 338, and the corresponding pages of the quarto edition, *may* have appeared at a later date.

VOLUME VI

Six fascicles constituted this volume, viz. nos. 24–29. Of these the B. F. gives data for quarto fasc. 24–26, and all the folio fascicles. There is evidently some error in the number of plates assigned to fasc. 24, unless many of the earlier plates were reissued at this time. This makes the numbers of the plates in each fascicle of this volume quite doubtful:

Fasc.	24.	Folio, 28 sign.	Quarto, 10 sign.	*37*	*plates.*	19 Ap.	1823.
"	25.	" 17 sign.	" 12 sign.	*15*	"	30 Au.	"
"	26.	" 15 sign.	" 9 sign.	*15*	"	24 Ja.	1824.
"	27.	" 16 sign.		*17*	"	24 Ap.	"
"	28.	" 15 sign.		*16*	"	21 Au.	"
"	29.	" 15 sign.		*15*	"	4 S.	"

In noting the folio, the title-page seems to have been counted as one signature; and the two unnumbered pages forming signature 106, at the end of the volume, do not seem to have been included, and may have appeared with a later fascicle. From the description in Férussac's Bulletin (cited by Sherborn and Woodward) we can fix the pagination of quarto fasc. 28, and indirectly that of the preceding and following fascicles. The following is a record of this volume as I understand it:

Fasc.	24.	Folio, T.-p.,	Pp. 1–108.	Quarto, T.-p.,	Pp. 1–72.	*Pl. 513–522?*
"	25.	"	Pp. 109–176.	"	Pp. 73–168.	*Pl. 523–537?*
"	26.	"	Pp. 177–236.	"	Pp. 169–240.	*Pl. 538–552?*
"	27.	"	Pp. 237–300.	"	Pp. 241–320.	*Pl. 553–569?*
"	28.	"	Pp. 301–360.	"	Pp. 321–392.	*Pl. 570–585?*
"	29.	"	Pp. 361–420 (2?).	"	Pp. 393–542.	*Pl. 586–600?*

In this volume, for the first time, the proportionate size of the corresponding folio and quarto parts is widely at variance.

VOLUME VII

The final volume was published in fasc. 30–36. As the B. F. says that fasc. 30 (folio) was composed of 13 signatures, while it quite certainly contained only pp. 1–48, the other signature very likely consisted of the "addenda et corrigenda" of Volumes V and VI. It may have represented the title-pages of Volume VII, but as these are dated 1825, they were probably issued with the last part (fasc. 36). Fasc. 36, too, is said to have been composed of 29 signatures; if so, some 18 of these must have been re-issues of earlier portions of the work. The B. F. mentions the quarto edition several times, but fails to give its sheeting. Its record of the folio is this:

Fasc.	30.	13 signatures.	*15 plates.*	13 N.	1824.
"	31.	16 "	*15* "	25 D.	"
"	32.	16 "	*15* "	19 F.	1825.
"	33.	15 "	*15* "	14 My.	"
"	34.	15 "	*15* "	18 Je.	"
"	35.	15 "	*18* "	30 Jl.	"
"	36.	29 "	*10* "	3 D.	"

The probable pagination is given herewith, but it must be confessed that in the case of the quarto this is largely guess work.

FASC.	FOLIO TEXT.	QUARTO TEXT.	PLATES.		
30.	Pp. 1–48.	Pp. 1–56.	*601–615.*	N.	1824.
31.	Pp. 49–112.	Pp. 57–144.	*616–630.*	D.	"
32.	Pp. 113–176.	Pp. 145–224.	*631–645.*	F.	1825.
33.	Pp. 177–236.	Pp. 225–296.	*646–659 659 bis.*	My.	"
34.	Pp. 237–296.	Pp. 297–376.	*660–661 bis, 662–673.*	Je.	"
35.	Pp. 297–356.	Pp. 377–448.	*674–688 bis, 689–690.*	Jl.	"
36.	Pp. 357–399(+?).	Pp. 449–506(+?).	*691–700.*	N.	"

RÉSUMÉ

The following résumé is intended merely as an aid to those who may wish to determine quickly the probable date of publication of a given page or plate. Consequently all details of title-pages, repeated plates, etc., are omitted. Data which seem to me certain beyond a reasonable doubt are indicated by an exclamation point (!), while a mark of interrogation (?) accompanies those which are simply guesses. The unmarked data are chiefly strong probabilities.

FASC.	VOL.	FOLIO TEXT, PP.	QUARTO TEXT, PP.	PLATES.	DATE.	
1–2	I.	i–xlviii, 1–120.	i–lx, 1–152?	*1– 44!*	Ja. 1816.	[B. F. 3 F.]
3		121–200.	153–256?	*45– 69!*	My. "	[B. F. 11 My.]
4		201–302.	257–377?	*70– 96!*	Au. "	[B. F. 31 Au.]
5	II.	1– 80!	1– 96.	*97–121!*	Ap. 1817.	[B. F. 3 My.]
6		81–152.	97–192!	*122–146!*	D. "	[B. F. 13 D.]
7		153–220.	193–280.	*147–168!*	F. 1818.	[B. F. 28 F.]
8		221–324.	281–406.	*169–202!*	Je. "	[B. F. 6 Je.]
9	III.	1– 72.	1– 96!	*203–227!*	S. "	[B. F. 3 O.]
10		73–148!	97–192.	*228–242*	F. 1819.	[B. F. 13 F.]
11		149–224.	193–288.	*243–267?*	Jl. "	[B. F. 17 Jl.]
12		225–296.	289–384.	*268–292?*	N. "	[B. F. 27 N.]
13		297–356.	385–456.	*293–300?*	Mr. 1820.	[B. F. 11 Mr.]
14	IV.	1– 56.	1– 72.	*301–325!*	Ap. "	[B. F. 15 Ap.]
15		57–120.	73–152.	*326–349!*	My. "	[B. F. 27 My.]
16		121–168.	153–224?	*350–373!*	Jl. "	[B. F. 22 Jl.]
17		169–216.	225–288?	*374–397!*	S. "	[B. F. 16 S.]
18		217–247.	289–312.	*398–412!*	D. "	[B. F. 24 D.]
		(Entire folio text of Volume IV. accessible at Paris from 26 O. 1818.				
19	V.	1– 56.	1– 64.	*413–436.*	My. 1821.	[B. F. 26 My.]
20		57–112.	65–128.	*437–460.*	S. "	[B. F. 29 S.]
21		113–176.	129–224.	*461–480.*	F. 1822.	[B. F. 23 F.]
22		177–236.	225–304.	*481a–498.*	Je. "	[B. F. 29 Je.]
23		237–338.	305–332. 432	*499a–512.*	Mr. 1823.	[B. F. 22 Mr.]
24	VI.	1–108.	1– 72.	*513–522?*	Ap. "	[B. F. 19 Ap.]
25		109–176.	73–168.	*523–537?*	Au. "	[B. F. 30 Au.]
26		177–236.	169–240.	*538–552?*	Jan. 1824.	[B. F. 24 Ja.]
27		237–300.	241–320.	*553–569?*	Ap. "	[B. F. 24 Ap.]
28		301–360.	321–392!	*570–585?*	Au. "	[B. F. 21 Au.]
29		361–420.	393–542.	*586–600?*	S. "	[B. F. 4 S.]
30	VII.	1– 48!	1– 56.	*601–615!*	N. "	[B. F. 13 N.]
31		49–112.	57–144.	*616–630!*	D. "	[B. F. 25 D.]
32		113–176.	145–224.	*631–645!*	F. 1825.	[B. F. 19 F.]
33		177–236.	225–296.	*646–659 bis!*	My. "	[B. F. 14 My.]
34		237–296.	297–376.	*660–673!*	Je. "	[B. F. 18 Je.]
35		397–356.	377–448.	*674–690!*	Jl. "	[B. F. 30 Jl.]
36		357–399.	449–506.	*691–700!*	N. "	[B. F. 3 D.]

There is little doubt that the first two fascicles were dated "1815," and that fascicle 10 was dated "1818"; and it is not certain that these fascicles were not actually issued before the close of those years. In fact, all of the dates under which notices appeared in the "Bibliographie de la France" may be as much as six or eight weeks later than the actual publication of the fascicles.

TARRYTOWN, N. Y.

The Polyporaceae of North America. I. The Genus Ganoderma*

By William Alphonso Murrill

It is evident, even to the beginner in mycology, that the present classification of the higher fungi is not satisfactory. This is particularly true of the group containing *Polyporus* and its allies, which is at present very imperfectly divided into genera, and contains many species which are confused and uncertain, because of the incompleteness of the original descriptions. Before the group can be reduced to order, full descriptions must be had of all its species, the type specimens in Sweden, England, Germany, and elsewhere must be examined, and sufficient knowledge gained of the life and habits of each plant to determine its natural position in the group. In this paper an attempt is made to present in order the members of the "*lucidus*" group of *Polyporus* occurring in North America. A large number of the specimens examined have been collected during several years past by Professor Lucien M. Underwood, and by various contributors to his private herbarium. The extensive literature and large collections of the New York Botanical Garden and Columbia University have also been most generously placed at the writer's disposal.

I desire also to express my appreciation of the many courtesies extended me by Professor Paul Magnus, Mr. P. Hennings, Professor Kjellman, Professor T. M. Fries, Professor H. Von Post, Mr. Lars Romell, Mr. W. B. Hemsley, Mr. George Massee and others, while studying forms of this group in Germany, Sweden, and England.

HISTORY OF THE GENUS

The species upon which this genus was founded was first described in its immature form as an agaric, but when perfect specimens were obtained it was placed in *Boletus*, a genus established by Dillenius in 1719 to include all pore-bearing fungi, and later adopted by Linnaeus, although Micheli had erected

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*Read by invitation before the Botanical Society of America, Pittsburg, June, 1902.

the genus *Polyporus* as early as 1729. *Polyporus* was used by Persoon in his Synopsis only as a subgenus under *Boletus*, from which position it was later raised by Fries to equal rank with *Boletus* and made to include the woody forms of pore-bearing fungi. In 1851, Fries tried the experiment of breaking *Polyporus* up into *Fomes*, *Polystictus*, and *Poria*, a division which, though discontinued in his later works was resurrected by Cooke in his *Praecursores* in 1885 and adopted by Saccardo and others since.

When a systematic arrangement of the Polyporaceae of Finland was undertaken by Karsten (Rev. Mycol. 1881), one of the new genera established was *Ganoderma*, which was based upon the laccate character of pileus and stipe and embraced *Polyporus lucidus* only. In Karsten's "Finlands Basidsvampar" published in 1889, *Ganoderma* is characterized as follows: "Basiderna 4-sporiga, n. klotrunda, cystiderna icke anmärknings värda. Sporerna äggrunda eller elliptiska, värtiga, gulbrunaktiga." Although no mention is here made of the laccate pileus and stipe, no other species are included with *G. lucidum* in the genus. As a synonym of *Ganoderma*, Karsten here mentions *Placodes Quél.*, which genus was erected in 1886 to include a variety of forms which were "covered with a hard crust, without zones or concentrically sulcate, persistent, woody." Along with *P. lucidus* in one of the subdivisions are placed also *P. dryadeus*, *P. resinosus*, *P. erubescens*, and *P. helveolus*.

The transfer of *G. lucidum* from *Ganoderma* Karst. to *Phaeoporus* Schroet. in Schroeter's flora of Silesia was a violation of modern principles and consequently could not meet with general favor. In 1887, Patouillard, following the lead of Quélet, extended the range of *Ganoderma* to include all forms of Polyporaceae with colored spores, adhering tubes and shining crusted pilei; and in 1889 he published a partial monograph of the genus as extended, listing forty-eight species, which were arranged in subgroups upon spore characters. As to the wisdom of so broad a treatment of the genus mycologists appear to be divided. The following synopsis includes only those species which, while essentially alike in internal structure, possess a shining varnished surface produced by the exudation and hardening of a reddish juice similar to that found in *G. pseudoboletus*.

Synopsis of the North American Species

1\. Context pallid to tawny. 2.
Context umbrinous-chestnut. 5.

2\. Spores over 6 μ long, verrucose, ferruginous. 3.
Spores less than 6 μ long, smooth, pale; pileus less than 3 cm. broad, margin entire; tubes not stratified. 4. *G. parvulum.*

3\. Context ochraceous to fulvous; plants stipitate or sessile, growing on deciduous trees. 4.
Context pallid; plants usually stipitate, annual, growing on hemlock. 1. *G. tsugae.*

4\. Plants stipitate, or rarely sessile, perennial; margin of pileus truncate at maturity. 2. *G. pseudoboletus.*
Plants sessile, annual; margin of pileus acute. 3. *G. sessile.*

5\. Spores smooth, pale yellowish-brown. 6.
Spores roughly echinulate, dark brown; pileus sessile, very thick, its diameter decreasing downward; context less than one third the length of the tubes. 5. *G. Oerstedii.*

6\. Pileus zonate, even; tubes not stratified. 6. *G. zonatum.*
Pileus sulcate, azonate; tubes stratified. 7. *G. sulcatum.*

1. **Ganoderma tsugae** sp. nov.

A conspicuous reddish-chestnut fungus growing on dead or dying hemlock. Pileus corky to woody, fan-shaped, convex above, concave below, 4–20 × 5–25 × 1–4 cm.;* surface glabrous, uneven, concentrically sulcate, laccate, lustrous, yellowish-red to mahogany-colored, at length black; margin light-yellow, acute, becoming concolorous, truncate, and marked with many shallow furrows, often undulate and at times more or less lobed: context soft-corky, radiate-fibrous, white or nearly so, 1–3 cm. thick; tubes annual, 0.5–0.75 cm. long, 6–4 to a mm., brown within, mouths circular or polygonal, white to light-cinnamon, edges obtuse, becoming acute: spores ovoid, obtuse at the summit, attenuate and truncate at the base, verrucose, yellowish-brown, 9–11 × 6–8 μ: stipe lateral, ascending, frequently forked, cylindrical, equal, 2–20 × 1–4 cm., resembling the pileus in color, surface and context.

This fungus occurs only on *Tsuga Canadensis*, upon the decaying trunks and roots of which it is very abundant. In West Virginia and New York it has been found full grown as early as June, but it may not reach maturity until autumn, when it speedily de-

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* These figures indicate length, breadth and thickness respectively. When the stipe is lateral the pileus is an outgrowth from it and length is measured in the direction of this growth. When the pileus is sessile, the tubercle marking the beginning of growth may be considered a lateral stipe much reduced. When the question of length is settled, breadth and thickness need no explanation.

cays or falls a prey to insects. So subject is it to insect attack that recognizable specimens are rare in the herbarium. As its ordinary host is confined to America, there is no reference to it in European literature, unless the plants found on *Picea excelsa* by Karsten in Sweden belong here rather than with *G. pseudoboletus.*

Extensive collections of various forms of this species were made by Professor Underwood at Syracuse, N. Y., in July 1884, and at West Goshen, Conn., August 1896. Miss A. M. Vail brought specimens from Tyringham, Mass., in August 1897.* Professor G. F. Atkinson has figured the species in plate 66 of his work on mushrooms. Wherever the hemlock grows it appears to be common. It is nearly related to *G. pseudoboletus*, but is annual, grows on coniferous trees, decays soon after maturity, and is usually much lighter in weight and paler in substance.

2. **Ganoderma pseudoboletus** (Jacq.)

Agaricus pseudoboletus Jacq. Flor. Austr. **1**: 26–27. *pl. 41.* 1773.

Boletus rugosus Jacq. Flor. Austr. **2**: 44. *pl. 169.* 1774.

Boletus lucidus Leyss. Flora Halensis, 300. 1783.

Boletus obliquatus Bull. Herb. de la France, *pl. 7.* 1780; *pl. 459.* 1790.

Polyporus lucidus Fries, Syst. Myc. **1**: 353. 1821.

Polyporus laccatus Pers. Myc. Eur. **2**: 54. 1825.

Polyporus Curtisii Berk. Kew Gard. Misc. **1**: 101. 1849.

A large fungus common on decaying trunks and stumps of deciduous trees conspicuous on occount of its brilliant varnished appearance. Pileus corky to woody, usually kidney-shaped, convex above, concave below, 2–20 × 2–25 × 1–5 cm., yellow to reddish-chestnut or black; surface glabrous, shining, laccate, broadly sulcate and usually marked with concentric lines or bands of a darker color; margin white or light yellow, sterile, thin, acute, becoming truncate, sulcate, and concolorous as new strata are added; context soft-corky or woody, radiate-fibrous, concentrically banded, ochraceous above, tawny next to the hymenium: tubes one- to many-layered, the strata varying in distinctness, 0.5–2 cm. long, 3–5 to a mm., brown within; mouths circular to

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* During the summer of 1902 fine specimens have been collected in the hemlock grove of the New York Botanical Garden by Messrs. Burnham and George, in Connecticut by Miss White, and in Ohio by Professor A. D. Selby.

hexagonal, white or yellow, at length brown, dissepiments entire, obtuse, becoming acute: spores ovoid, obtuse, at the summit, attenuate and truncate at the base, yellowish-brown, verrucose, 9–11 × 5–6 μ: stipe lateral, excentric, central, or wanting, erect to ascending, 0–30 × 0.5–4 cm., equal, irregular, or enlarging above, concolorous, glabrous, shining, laccate, the substance similar to the context and darker at the center.

On living or dead trunks, stumps, or roots of oak, alder, hazel, maple, willow, honey-locust, sweet-gum, and beech in Sweden, Germany, Bavaria, France, England, America and Australia. American material has been examined from New York, New Jersey, Delaware, Pennsylvania, Ohio, Indiana, Kentucky, Michigan, Virginia, North Carolina, South Carolinia, Georgia, Florida, Alabama, Mexico, and Nicaragua.

This fungus has been found fossil in the lake dwellings of Switzerland and has been known for a long time on account of its conspicuous coloring caused by a thick glutinous juice which exudes from its surface and dries upon it as a thin lustrous coating. Albino or semi-albino forms occur where the coating is lacking or incomplete. In age the varnish disappears and the pileus takes on a grayish weather-beaten appearance. As the young pileus begins to form at the end of the stipe it is white or yellow in color without varnish and somewhat resembles an unexpanded agaric. It is this stage that Jacquin figured and described in his Flora Austriaca as *Agaricus pseudoboletus.* Several immature plants were found by him in a grove growing about the base of a dead oak trunk. The description he gives is quite a good one and, taken with the fine colored plate, leaves no doubt as to the identity of the specimens. The succeeding year he collected several mature plants which he described as *Boletus rugosus* as follows :—

> "Fungus speciosus putridis arborum truncis innascitur, totus lignoso-coriaceus et persistens. Stipes durus, inaequalis, badius, vernice veluti obductus, calamum vel policem crassus ratione voluminis ipsius fungi, pileum gerit plerumque subdimidiatum, dum laterali ejusdem parti adnecitur. Hic superne planus est, rugosus primum, ex rubro badius et nitidissimus, tandem hepaticus minusque nitens. Corticis pauca substantia est interne coriacea, holoserisea, cinnamomea, tenax atque ad fomitem apta. Substantia tubulosa concolor, crassa, a corticosa separabilis, subtilissime porosa; subtus punctata, in principio pallens, sensim magis cinnamomea; ad cibum inepta. Fungi duo, ex eodem loco exorti, et majores, in tabula proponuntur, hinc atque illiuc spectati. Tum fungulus minor; et fungi pars, ut pateant interiora."

The specimen upon which Leysser's *Boletus lucidus* is founded was collected by Curtis on a decaying hazel stump near London in November, 1780, and figured in Flora Londinensis, **4**: *pl. 224*. Leysser's description is as follows:—

> "*Boletus lucidus stipitatus, pileo coriaceo castaneo lucido sulcis circularibus, poris minutissimis, albis, stipite laterali.*"

Specimens collected by Rev. M. A. Curtis in South Carolina seemed to Berkeley sufficiently distinct from Leysser's plant to constitute a new species, which he thus describes in Kew Garden Misc. **1**: 101. 1849:—

> "Pileus excentric, soft-corky, sulcate, zonate, ochroleucous, in places sanguine-lacquered; stipe elongated, rugose, sanguine-lacquered; hymenium from white to ochraceous, pores punctiform."

A special study of many specimens called *Polyporus Curtisii* Berk. shows them to be only variations of *G. pseudoboletus* due to age, rapidity of growth, and perhaps to differences in the host. The yellowish form so common in the southern part of the United States is figured by Bulliard and Gillet as also occurring in France, while farther north the color is usually darker and more lustrous, the texture firmer, and the hymenium less stratose. These differences are not sufficiently constant, however, to enable one to separate the forms geographically.

Another interesting variation observed by Langlois in Louisiana is so distinct from the ordinary form of the plant that it might easily deceive the skilled mycologist. Specimens in the Underwood herbarium have the stipe exactly central, the pileus very even and thin, at first deeply infundibuliform with white margin, at length becoming nearly plane, reddish-brown, and polished, with the margin concolorous.

3. **Ganoderma sessile** sp. nov.

A large sessile plant, with wrinkled varnished cap and acute margin, found on decaying deciduous trees. Pileus corky to woody, dimidiate, sessile, imbricate or connate at times, conchate, thickest behind, thin at the margin, 5–15 × 7–25 × 1–3 cm., yellow to reddish-chestnut, at length opaque dark brown; surface glabrous, laccate, shining, radiate-rugose, concentrically sulcate, usually marked near the margin with alternating bay and tawny zones; margin very thin and acute, usually curved downward, often undulate, not becoming truncate, white, at length concolorous: context soft-corky or woody, radiate-fibrous, concentrically banded, ochraceous-fulvous; tubes 0.5–2 cm. long, 5–3 to a mm., brown within, mouths circular or angular, white to grayish-brown, edges thin, entire: spores ovoid, obtuse at the summit, attenuate and truncate at the base, verrucose, yellowish-brown, 9–11 × 6–8 μ.

This species occurs on deciduous trees and has the general habit of *G. pseudoboletus*, from which it differs in being annual and sessile, with a very acute margin and a more rugose surface. So far as I have been able to determine, it does not occur in Europe, and has not yet been figured. Specimens have been collected by Professor L. M. Underwood on decaying oak at Greencastle, Ind., Oct. 1894, and at White Plains, N. Y., May 1897, and on dead sycamore at Fort Lee, N. J., May 1899, and March 1901. Plants collected by Morgan in the Miami Valley, Ohio, Dec. 1894, were placed under *G. pseudoboletus* and referred to in the following note: "As it grows in this region, the stipe is always more or less deformed and often wanting; the pilei, when sessile, are sometimes imbricated and connate." In Dec. 1896, it was found by C. F. Baker, at Auburn, Ala., and in Nov. 1897, Rev. A. B. Langlois collected it near St. Martinsville, La., on decaying logs in low woods and marked it "Perhaps a form of *F. lucidus?*" Miss Sadie F. Price has recently sent to the New York Botanical Garden from Bowling Green, Ky., two specimens of this plant collected on oak in Nov. 1901, and Feb. 1902. Specimens sent to Kew by American collectors are included there under *G. pseudoboletus*.

4. **Ganoderma parvulum** sp. nov.

A very small sessile fungus shining bay above and honey-yellow below. Pileus woody, nearly circular in outline, attached by a point, convex above, plane or convex below, thickest behind, 2 × 2.5 × 1 cm.; surface glabrous, laccate, azonate, slightly tubercular, very lightly marked with a few concentric furrows, margin acute: context soft-woody, pale ochraceous, 0.5 cm. thick, with dark horny radiations from the point of attachment: tubes not stratified, 3 mm. long, 5 to a mm., umbrinous within, mouths polygonal, honey-yellow, dissepiments entire, obtuse: spores subglobose, smooth, pale yellowish-brown, 4 × 5 μ.

Collected by C. L. Smith in Nicaragua during the winter of

1891–1892. This beautiful little plant is closely related in habit and general appearance to the American species of *Ganoderma* occurring farther north, but it is of much smaller size and its spores are quite distinct in form, size and color. It is possible that the specimens I have are not quite mature.

5. **Ganoderma Oerstedii** (Fries)

Polyporus Oerstedii Fries, Nov. Sym. 63. 1851.

Pileus reniform, ungulate-applanate, gibbous at the base, a foot in diameter; surface horny-incrusted, very glabrous, adorned with shallow furrows, which almost disappear with age, shining reddish chestnut becoming almost black; margin very obtusely truncate and marked with concentric furrows, the upper annual growths exceeding the lower; context partly hard and horny and partly floccose, umbrinous next to the tubes, more tawny beneath the cuticle, very thin in older specimens, the tubes forming the principal part of the pileus: tubes contiguous and hence indistinctly stratified, 3–5 cm. long, umbrinous within, mouths lighter in color, dissepiments entire, obtuse: spores broadly ellipsoid, truncate, very dark yellowish-brown, abundantly and roughly echinulate, 11 × 9 μ.

Two imperfect specimens of this plant are in the herbarium of the New York Botanical Garden, one collected by C. L. Smith in Nicaragua, and the other by C. T. Townsend on an orange tree in Jamaica. These specimens, while corresponding with the Friesian types at Upsala, hardly justify any considerable departure from the Friesian description.

6. **Ganoderma zonatum** sp. nov.

A soft laccate fungus of medium size marked with numerous tawny and chestnut-colored zones. Pileus very soft-corky, sessile, dimidiate, applanate or convex above, concave below, glabrous, zonate, not sulcate, 5 × 7 × 1.5 cm.; margin velvety, acute, becoming obtuse and concolorous: context very soft, floccose, radiate-fibrous, concentrically banded, 0.5 cm. thick, chocolate-brown: hymenium velvety, not stratose, tubes 1 cm. long, 3–4 to a mm., umbrinous within; mouths white to umbrinous, regular, polygonal, stuffed at first with whitish material, covered 0.5–2 cm. from the margin with yellowish or reddish varnish; dissepiments entire, obtuse to acute: spores elongated ellipsoid, smooth, pale yellowish-brown, 8–10 × 4–6 μ.

Collected by Professor Underwood in Florida. Closely related to *G. sulcatum*, but differing in general appearance, size of pores, and in the extent and arrangement of varnish upon the hymenium. A similar coating of varnish exists in *G. sulcatum* and *G. pseudoboletus* at times, but in neither of these has it been found as a broad distinct marginal band. This band is sometimes split by the growth of the margin and a zone of pores appears between the two laccate portions. Additional material may reveal the existence of intermediate forms connecting this species with *G. sulcatum.*

7. **Ganoderma sulcatum** sp. nov.

A large sessile plant without zones, but marked with a few conspicuous concentric furrows. Pileus corky, dimidiate, sessile or arising from a lateral tubercle, plane or convex above, thickest behind, 8 × 11 × 2 cm.; surface laccate, glabrous, azonate, fulvous to chestnut, deeply sulcate ; margin rounded, velvety, ochroleucous, at length concolorous : context very soft, floccose, radiate-fibrous, concentrically banded, 1 cm. thick, umbrinous-chestnut: tubes indistinctly stratified, 1.25 cm. long, 4–5 to a mm., umbrinous within, mouths whitish or yellowish, at length umbrinous, dissepiments entire, obtuse : spores ellipsoid, pale yellowish-brown, smooth, 8–10 × 4–6 μ.

This plant was collected on soft palmetto logs in Florida by Mr. C. G. Lloyd, January, 1897 ; type in New York Botanical Garden. It is very nearly related to *G. zonatum.*

SPECIES INQUIRENDAE

Fomes incrustatus Fries, collected in Costa Rica by Oersted. Pileus 5–7 cm. broad, sordid umbrinous, laccate : context scanty, pallid, tubes concolorous ; stipe central, torulose, unequal. This species was not transferred by Patouillard to the genus *Ganoderma.*

G. nutans (Fries) Pat., also collected by Oersted in Costa Rica. Pileus scarcely 2 cm. broad, orbicular, pallid to bay-black, laccate ; context scanty, pallid, pores pallid to brown ; stipe long, slender, twisted as though climbing, recurved at the apex, giving the pileus the appearance of nodding ; spores ovoid, brown, echinulate, 12–15 × 10 μ.

Specimens seen in foreign herbaria appear to be very distinct. Fries' description in Novae Symbolae 61–62 is quite full and cannot be improved upon at this time on account of lack of material for critical study.

G. nitens (Fries.) Pat. On trunks in tropical America. Pileus large, sessile, semiglobose, chestnut to black, shining, hanging by a process behind; context umbrinous, tubes very long and slender. It is quite possible that this is not a distinct species.

G. neglectum Pat. Pileus sessile, 8–10 cm. broad, reddish-black, shining; context brown, tubes white, very short; spores globose, yellow, roughly echinulate, 11 – 12 μ. On trunks in Nicaragua.

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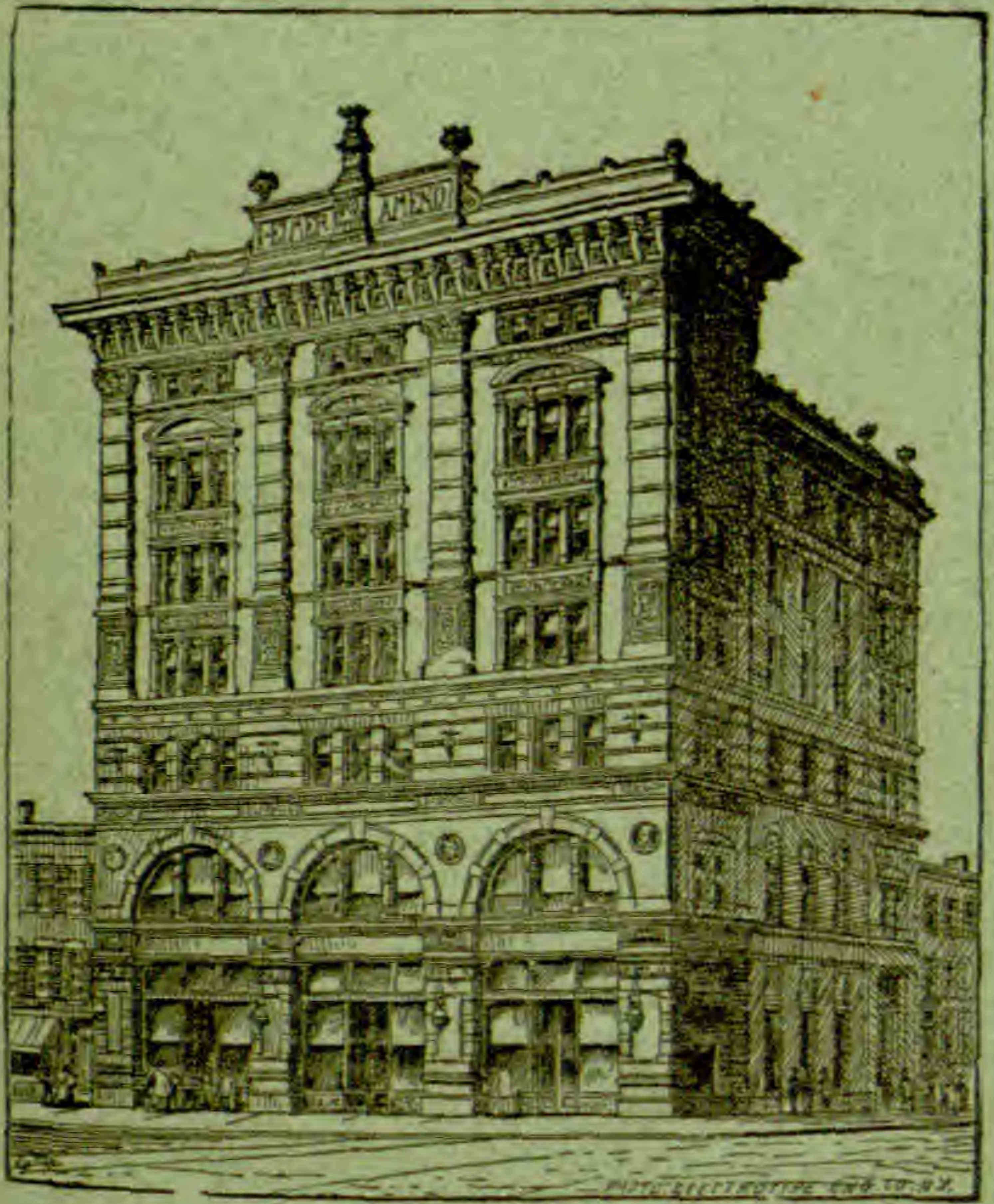

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BULLETIN

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NOVEMBER, 1902

American Ferns—IV. The Genus Gymnogramme of the Synopsis Filicum

BY LUCIEN MARCUS UNDERWOOD

For too long a period the study of systematic botany in America was in a more or less servile condition dominated by English ideas emanating mainly from Kew. A quarter of a century ago Asa Gray stood practically alone in the study of the higher flora of America. Bentham and Hooker's masterpiece, then about completed, was taken as authoritative, and the Kew rules dominated every action where personal preference did not supersede all rules. A little before this time had come the culmination of the work of a lifetime on the systematic study of ferns which was destined to exert a more wide-spread influence than Kew had exerted among the higher plants even. The *Species Filicum* of the elder Hooker which had followed the earlier publications of that distinguished man while he was associated with his still more acute compeer, Greville, had represented a lifetime of study on one of the largest collections of ferns that had ever been brought together, and was completed in 1864. The notes and corrections to this series added during the twenty years of publication had been incorporated in Hooker's own copy of the work, and he had commenced to bring out a revision in abridgement under the now familiar title of *Synopsis Filicum*, when his career was somewhat suddenly terminated by death. John Gilbert Baker, who afterwards became for many years the keeper of Kew herbarium, was entrusted to push this revision to a close, the first edition appearing in 1868, and the second with an extensive appendix in 1874. This work with its ample references to the more complete *Species Filicum* has had a remarkable and world-wide influence, and being the only general work containing a systematic treatment of the ferns of the entire world in a convenient form, has been adopted as a guide to practically all the great collections of ferns. On this account, but not without many silent and published protests, its conclusions regarding the limitations of both genera and species have been very widely adopted.

Protests against the irrational treatment of genera in this useful work are nothing new and did not originate far from the headquarters of the work itself, for no more vigorous restrictions have ever been drawn on its generic arrangement than those of John Smith, the distinguished gardener of Kew, where the present collection of living ferns notable among the great collections of the world, was largely brought together through the energy and influence of this careful worker and furnished the living material on which Smith based a generic system for ferns vastly more logical than anything that Kew has ever produced in the natural arrangement of this group. Smith's results do not differ very widely from those of Moore, another English protester against the Kew system; from those of Fée, the brilliant but somewhat isolated worker at Strasburg; and especially from those of the most liberal of all fern systematists, Carl B. Presl of Prag.

Were the specific limitations of the fern systematists at Kew to be characterized by a single word, it would be conglomeration — the essence of a practice somewhat vulgarly known as "lumping," — and one who desires to do honest and critical work to-day is forced to unravel the tangles into which specific limitation has been twisted, in connection with the ample materials that this noblest of all fern collections affords, by tracing the threads of the tangle back to their original type localities, and by introducing into their understanding the element of geographic distribution which has always cut too slight a figure in the determinations of the Kew pteridographers. We can best illustrate this condition by a specific case. Under the species *Lomaria attenuata*, *Synopsis Filicum* gives (p. 176) the following distribution:

> "America from the West Indies and Guatemala southward to Brazil and Juan Fernandez; Polynesian Islands, Norfolk Island, Mauritius, Bourbon, Fernando Po and Cape Colony."

When we come to examine the specimens of this seemingly widespread species, which from the above statement, apparently disregards all known laws of geographic distribution, we find as we might expect that the species as treated at Kew is a conglomerate of several not very closely related species that have been miscellaneously grouped together, and the whole covered by what Dr. Giesenhagen has recently and not inappropriately called a "Kautschukdiagnose." We find that the original species bearing this name came from Mauritius whence it was originally described by Swartz (not Willdenow as the misleading practice of citing only the galvanizer instead of the original author would lead us to suspect) and was appropriately named *attenuata* from the long attenuate tip of the leaf which does not appear in the more common species of the West Indies, which all the botanists who have studied it down to the acute and lamented Jenman, following the misleading of Kew have confused with this characteristic Mauritian species which appears to be endemic in that island.* In a similar way another West Indian member of the same genus has been confused with *Lomaria procera* originally described from New Zealand, but which this comprehensive but inaccurate guide reports from

> "Mexico and West Indies southward to Chili; Malayan and Polynesian Islands, N. Zealand, S. Australia, Van Dieman's Land and S. Africa."

These are by no means isolated cases for the whole work bristles with such distributional absurdities, some even more pronounced.

In *Synopsis Filicum* more than in *Species Filicum*, there are many species reduced to synonymy frequently when the specimens had never been seen by the author. Kunze's species have been slaughtered wholesale and many of them will have to be revived, and the same is true of many of the species of Fée. In the Kew copy of the works of the latter author many of the species are penciled as being equivalent of this and that species already described, leaving scarcely any of them to stand as "good species." In a number of instances Mr. Baker has redescribed some of Fée's

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*With such a wide range of possibilities involved in the elastic description of *L. attenuata*, it is not surprising that even Mr. Davenport was misled by it into calling Pringle's no. 4999 *L. attenuata*, for surely it is little more diverse in general habit than some other things that have been included in this species, although Pringle's plant is properly a member of a distinct genus, *Plagiogyria biserrata*. The same error was copied by C. L. Smith in his Plantae Mexicanae, 2063, which is also *P. biserrata*.

species as new. In the case of *Acrostichum mollissimum* the Kew copy of Fée's notable work on the ferns of Brazil is marked opposite this species "= *Aubertii*," a plant originally described from Mauritius and naturally having nothing to do with the American species, although some recent fern writers have continued to call this an American species. When the same plant came in from St. Vincent collected by Smith, it was described as *Acrostichum Smithii* Baker, but it exactly matches both Fée's figure and his type. Up to the time of Baron Eggers' visit to the West Indies only one species of *Lygodium* had been described from Santo Domingo. This was figured by Plumier on plate 92 of his Traité des Fougères, and from his description and plate was called *Hydroglossum oligostachum* by Willdenow. The constant habit of neglecting type localities for species led the next specimens from this island collected by Eggers to be described as a new species, *Lygodium gracile* Baker. In addition to Eggers' specimen the plant had been collected on Santo Domingo by the botanists of the U. S. Commission of Inquiry, sent out when annexation was being considered, and specimens collected then are represented both in the U. S. National herbarium and in that of Columbia University. All these specimens represent one species and correspond admirably with Plumier's plate on which Willdenow's species was based.* I refer to this incident in this connection to emphasize the importance of the problem of type localities so often utterly neglected in systematic work among ferns.

Naturally this undue conglomeration at Kew has led to a wide misconception of the extent and diversity of fern species. In the second edition of *Synopsis Filicum* we have approximately 2,700 species of ferns described as representing "all known ferns" up to the year 1874. To these must be added the 1,100 species included by Mr. Baker in his supplementary list of new species published in 1891, and the 565 species of other pteridophytes

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* The synonymy of this species will then be:

LYGODIUM OLIGOSTACHYUM (Willd.) Desv. Ann. Soc. Linn. de Paris, **6**: 205. 1827

Hydroglossum oligostachyum Willd. Sp. Pl. **5**: 81. 1810.

Lygodium gracile Baker, Jour. Bot. **26**: 35. 1888.

The further exploration of the island of Haiti will doubtless clear up many mysteries concerning ferns based on Plumier's plates.

from his Handbook of the Fern Allies (1887). This enumeration, however, is conservative and entirely inadequate. In the Schizaeaceae sixty species are included in *Synopsis Filicum ;* Prantl, who monographed this family in 1881, included eighty-nine species and that without having seen the Kew collection, which would have enabled him to add a number of species to his list. *Synopsis Filicum* gives twenty-two species of *Polypodium* § *Niphobolus.* In Giesenhagen's recent monograph of *Niphobolus* (1901) we have fifty species, and had he consulted the more ample range of materials in the Kew herbarium he would certainly have found additional species for his admirable monograph. In Kuhn's *Chaetopterides* nine species of *Jamesonia* are placed under the new genus *Psilogramme* where *Synopsis Filicum* had reduced them to one. From the collection of materials at Kew included there under the single cover marked *Aspidium juglandifolium* we have been forced to separate no less than eight well-marked species of *Phanerophlebia* and the tale is not all told yet. *Synopsis Filicum* reduced the world's species of *Botrychium* to six, and Mr. Baker reiterates this number in his summary of new ferns in 1891 ; Prantl enumerated fifteen species in his synopsis in 1884, and this number is still too small as we have now at least that number of well established species of the genus within the limits of the United States alone. A paper by Müller* describing six species in the small genus *Vittaria* has been entirely passed over in both *Species Filicum* and *Synopsis Filicum.* In *Die natürlichen Pflanzenfamilien* (1901) Hieronymus gives 559 species of *Selaginella* against the 335 species recorded by Baker in 1887. Such examples as these show the extreme conservatism and incompleteness of this work and it is more than likely that when the next enumeration of the pteridophytes is made the number of existing species will reach six thousand, and perhaps more, for the species published as new during the last decade form a surprising list.

But it is the treatment of genera in this work that we wish more especially to consider, for there could scarcely be a more unnatural or artificial system of genera than the *Synopsis Filicum* contains

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*Müller, K.: Einige Worte über die Bedeutung des Zellenbaues für die Klassifikation, nebst Beschreibung sechs neuer arten der Farnngattung *Vittaria.* Bot. Zeitung, 12: 537–548. 1854.

following almost exactly the lead of the earlier *Species Filicum.* It is not too much to say that for the pteridophytes it represents a system as antiquated and artificial as the so-called sexual system of Linnaeus for flowering plants.

As might be expected *Synopsis Filicum* is moulded on the old conceptual idea that a genus is a definition framed in set characters, instead of the modern evolutionary idea that a genus is a group of closely related species. This of necessity reduces the author's position to the inclusion of notorious absurdities. Having defined *Polypodium* as with "Sori on the back of the lobes, round or rarely oblong, not more than twice as long as broad," it becomes necessary to include in one genus such diverse plants as *Dipteris*, *Phegopteris Dryopteris*, *Arthropteris tenella*, *Cyclophorus acrostichoides*, and *Cheiropteris palmatopedata* in the same genus with *Polypodium vulgare* irrespective of any other character than the possession of round and naked sori!

Habit also plays little part in the arrangement of genera and subgenera in the Hookerian system. Note if you will a striking example presented in the section *Hemidictyum* of the immense and cumbrous genus *Asplenium.* This is characterized as having "Veins anastomosing towards the margin. Sori single" and among its four species two such absolutely diverse plants as *Ceterach** and *Hemidictyum marginatum* are included. If we should search the whole range of the Polypodiaceae we could scarcely find two species more remote in their natural affinities, and yet here they stand not only in the same genus but in the same subgenus placed almost side by side! There is nothing more astoundingly incongruous in the whole Linnaean system.

Among the many incongruities among genera, the genus *Gymnogramme* is one of the most irrational and unnatural conglomerations that appear in the *Synopsis Filicum.* It forms the largest genus of the tribe Grammitideae of the Hookerian arrangement

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* The near allies of *Ceterach* which forms a distinct genus whose name is dependent on the settlement of the question of generic types, are strangely scattered in *Synopsis Filicum.* In addition to the common European species they are *Asplenium alternans* which there appears under § *Euasplenium.* *A. aureum* which appears as a subspecies of *A. Ceterach;* and *Gymnogramme cordata* which appears in a distinct tribe as its indusium is wanting. Thus are natural relationships violated by the establishment of artificial lines and genera which are limited by definition only.

with *Notholaena, Monogramma, Antrophyum, Vittaria, Hemionitis,* and several smaller genera, associated in this tribe by the possession of sporangia arranged in lines not covered by an indusium. In this way the most variable and ephemeral of all the structures possessed by the ferns, namely the membranous indusium which as a peripheral structure, a mere flattened trichome, more subject to variation than any other single structure, is made the artificial character by which genera are united into tribes and by which the individual genera are characterized, to the exclusion of real characters based on more fundamental portions of the plant anatomy or on habit relations which so often are real guides to blood relationship. *Notholaena* is simply a non-indusiate complex of the *Pterideae*, in part related to *Cheilanthes* and in part related to *Pellaea;* *Vittaria* is properly the type of a tribe in which some of the smaller genera will associate themselves; while *Gymnogramme* as represented by the ninety-eight species described in *Synopsis Filicum* is the most unaccountable and unnatural collection of misfits that ever figured in the pages of a treatise on systematic botany. With the possible exception of *Hemionitis,* no part of *Gymnogramme* as here treated has any natural relation to the other genera with which it is associated, and the removal of its broken fragments almost bodily to the tribe Pterideae by Diels in his treatment of the family in *Die natürlichen Pflanzenfamilien* give them no more secure a resting-place, for the diverse sections of the genus are related some to one tribal alliance and some to another, while some may have to form a tribe by themselves with no very close relations to any other known forms.

The genus *Gymnogramma* was established by Desvaux * in 1811 based on thirteen species in the order named below:

Sec. 1. *Frondibus pinnatis.*
1. G. RUFA (*Pteris ruffa* L., *Acrostichum rufum* L.).
2. G. TOMENTOSA (*Asplenium tomentosum* Lam.).
3. G. ACROSTICHOIDES (*Hemienitis acrostichoides* Sw.).

Sec. 2. *Frondibus bipinnatifidis.*
4. G. FILIPENDULAEFOLIA (*Asplenium filipendulaefolium* Aubert).
5. G. TRIFOLIATA (*Acrostichum trifoliatum* L.).

Sec. 3. *Frondibus bipinnatis.*
6. G. JAPONICA (*Hemionitis Japonica* Thunb.).

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* **Desvaux,** Berl. Mag. **5**: 304. 1811. (Copy in the New York Public Library.)

7. G. LEPTOPHYLLA (*Polypodium leptophyllum* L.).
Sec. 4. *Frondibus tripinnatifidis.*
8. G. CHAEROPHYLLA Desv.
9. G. TARTAREA (*Acrostichum tartareum* Cav., *Hemionitis dealbata* Willd.).
10. G. SULPHUREA (*Acrostichum sulphureum* Sw.).
11. G. AUREA (*Hemionitis aurea* Willd.).
Sec. 5. *Frondibus decompositis.*
12. G. ROSEA (*Hemionitis argentea* Willd.).
13. G. FLEXUOSA Desv.

It thus contains representatives of six or more genera as now understood, and the species were arranged, as was common during the first quarter of the last century, in the inverse order of complexity of leaf division. The first species mentioned under *Gymnogramma* was *Pteris ruffa* L., which thirteen years earlier had stood as the sole type of the genus *Gymnopteris* established by Bernhardi.* The latter name must therefore stand for the group which contains its monotype in spite of the fact that various botanists, including Diels, who wrote the Polypodiaceae for *Die natürlichen Pflanzenfamilien*, have used *Gymnopteris* for an entirely different group of plants. Whether the name *Gymnogramma* must pass forever into synonymy or be applied to some of the other species it originally contained, will be dependent on the final settlement of the question of generic types. And not only this, but the settlement of this problem will also affect all the generic groups later established on any of the species involved in the original *Gymnogramma*. There can never be generic stability until this problem is eternally settled, and the only ground on which it ever can be

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* As Bernhardi's genus is cited as late as 1875 by no less an authority on ferns than John Smith himself (Historia Filicum, p. 138) as "founded by Bernhardi in 1800, on the *Acrostichum quercifolium* of Retzius" it is desirable to know exactly what Bernhardi did in Jour. für die Botanik, 1799 : 297. 1799 (not 1800 : 121, as cited by Pfeiffer!). His genus *Gymnopteris* is no. 3 and is placed under "*I. Sporangiis gyro instructis*" and under "*A. Nudis*," as follows:

"3. GYMNOPTERIS. *Sporangia* pedicellata lineatim aggregata. E. g., Acrostichium *rufum* L."

It was not till 1806 that Bernhardi (Neues Journal für die Botanik, 1^2 : 20) gave a new account of *Gymnopteris* under which he cites two species by name "Gymnopteris *discolor* (Osmunda Forst.)" and "* * * quercifolia (Acrostichum Retz.)" among numerous other groups which he denominates as "familiae" under the genus.

The only safety in accurate systematic work is to consult the original papers where genera and species are described. We cannot depend on many of the traditional ideas based on ancient and hurried examination of original descriptions without a new verification of their data.

settled is in our own country, and the only body that can ever settle it are the botanists of America. Should American botanists take a stand in this matter that can be agreed upon it matters not whether the slower conservatives of Europe follow or not.

Following the numbered species of *Gymnogramme* in *Synopsis Filicum* over twenty have stood as the types * of genera already established:

No. 2. LEPTOGRAMMA J. Sm., 1841. (Includes also nos. 1–11.)

No. 12. DIGRAMMARIA Presl, 1836.

No. 13. STEGNOGRAMMA Blume, 1828.

No. 14. PTEROZONIUM Fée, 1850–52; also the first species under *Trichiogramme* Kuhn, 1882. Represented also by *P. cyclophylla*, a second South American species.

No. 15. AUSTROGRAMME Fourn., 1873.

No. 16. HECISTOPTERIS J. Sm., 1842.

No. 19. GYMNOPTERIS Bernh., 1799; also the first species mentioned under *Gymnogramma* Desv., 1811, and *Neurogramma* Link, 1841. (Includes also nos. 17, 18, 23, 32.)

No. 21. PLEUROSORUS Fée, 1850–52.

No. 24. PSILOGRAMME Kuhn, 1882. (Includes also nos. 25–30, 36, 38–42, 48–49.)

No. 31. ASPLENIOPSIS Mett., 1882.

No. 35. CONIOGRAMME † Fée, 1850–52.

No. 37. ERIOSORUS Fée, 1850–52.

No 44. ANOGRAMMA Link, 1841. (Includes also nos. 45, 46.)

No. 51. TRISMERIA Fée, 1850–52.

No. 54. CEROPTERIS Link, 1841. (Includes also nos. 52–57.)

No. 62. SYNGRAMMA J. Sm., 1845. (Includes also nos. 58–65.)

No. 66. SYNAMMIA Presl, 1836.‡

No. 76. SELLIGUEA Bory, 1824. (Includes also nos. 68–82.)

No. 83. DICTYOGRAMME Fée, 1850–52.

No. 84 BOMMERIA Fourn, 1876. (Includes also no. 43.)

Besides this No. 20 is a species of *Ceterach*, No. 33 (*Gymnogramme Houghtoni* Hook.) may belong to the same genus, and two or three others are too little known to enable us to be certain of their relations.

These facts alone will show that there has been a decided op-

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* By type I mean here the first species described under the genus where no type is stated or implied.

† *Coniogramme* was founded on three species of which *C. Javanica* is first figured. Diels has united *Dictyogramme* with this and indicates only a single free-veined species while there are evidently several.

‡ Presl founded this on two species, *Grammitis elongata* Sw. and *Polypodium trilobum* Cav., figuring the latter. John Smith in reviewing Presl's work refers the first species perhaps probably to *Phymatodes* and limits Presl's genus to the second.

position in almost every quarter against the Kew conception of this genus and it is to be said that the genera named above represent in most cases valid genera. Of the series, *Digrammaria*, *Stegnogramma*, *Aspleniopsis*, *Coniogramme*, *Syngramma*, and presumably *Selliguea* and *Dictyogramme* represent exclusively Old World genera. *Leptogramma*, *Austrogramme*, *Pleurosorus*, *Gymnopteris*, *Anogramma*, and *Ceropteris* are found on both continents; while *Pterozonium*, *Hecistopteris*, *Psilogramme*, *Bommeria*, *Trismeria*, and *Synammia* are so far as known exclusively American. The genera and species represented in North America are as follows:

I. LEPTOGRAMMA J. Sm.; Hook. Jour. Bot. **4**: 51. 1841
(Based on *L. asplenoides* (Sw.) and six other species.)

1. LEPTOGRAMMA PILOSUM (Mart. & Gal.)

Gymnogramme pilosa Mart. & Gal. Mem. Acad. Sci. Bruxelles, **15**: — (27). *pl. 4. f. 1.* 1842. (Type from Orizaba, *Galeotti, 6267, 6268.*)

Hab. Mexico.

2. LEPTOGRAMMA LINKIANUM (Presl) J. Sm.; Hook. Jour. Bot. **4**: 52. 1841

Grammitis Linkiana Presl, Tent. Pterid. 209. 1836.
Gymnogramme Linkiana Kunze, Linnaea, **18**: 310. 1844.
Hab. Mexico.

Confused in *Synopsis Filicum* with *L. diplazioides* (Desv.) from Haiti, as is also *Leptogramma rupestre* Klotzsch, Linnaea, **20**: 415. 1847, from Colombia, likewise a distinct species.

3. LEPTOGRAMMA GRACILE (Heward) J. Sm.; Hook. Jour. Bot. **4**: 52. 1841

Gymnogramma gracile Heward, Mag. Nat. Hist. II. **2**: 457. 1838.

Hab. Jamaica.

4. **Leptogramma diplazioides** (Desv.)

Gymnogramma diplazioides Desv. Ann. Soc. Linn. de Paris, **6**: 214. 1827.

Hab. West Indies to South America.

It is probable that this list will be somewhat extended when Fée's collection becomes better known.

As stated in an earlier paper of this series this genus is closely related to *Phegopteris* and will form a member of the tribe *Aspidieae*. It has no near relation to any other group of this group.

II. HECISTOPTERIS J. Sm. Lond. Jour. Bot. **1**: 193. 1842
(Monotypic)

1. HECISTOPTERIS PUMILA (Spreng.) J. Sm. Lond. Jour. Bot. **1**: 193. 1842

Gymnogramma pumila Spreng. Tent. Supp. ad Syst. Veg. Linn. 31. 1828. (Type from Guiana.)

Hab. Trinidad and Guatemala to Guiana.

This genus has somewhat uncertain relations. Diels places it among the VITTARIEAE, with which it has doubtful affinity.

III. GYMNOPTERIS Bernh. Schrader's Jour. für die Botanik, 1799: 297. 1799
(Monotypic, based on *Pteris ruffa* L. = *Acrostichum rufum* L.*)

1. GYMNOPTERIS RUFA (L.) Bernh. Schrader's Jour. 1799: 297. 1799

Pteris ruffa L. Sp. Pl. 1074. 1753. (Based on Sloan, *pl. 45. f. 1*, from Jamaica.)

Acrostichum rufum L. Sp. Pl. ed. 2, 1525. 1763.

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* Besides the North American species the genus *Gymnopteris* contains the following:

Gymnopteris tomentosa (Lam.)

Asplenium tomentosum Lam. Encyc. Meth. Bot. **2**: 308. 1786. (*Type* from Brazil.)

Gymnopteris vestita (Wall.)

Grammitis vestita Wall. Cat. Pl. n. 12. 1828. (Type from India.)

Gymnogramme vestita Hook. Ic. Pl. **2**: *pl. 115*. 1837.

Gymnopteris Mülleri (Hook.)

Gymnogramme Mülleri Hook. Sp. Fil. **5**: 143. *pl. 295*. 1864. (Type from Australia. *F. Müller.*)

Gymnopteris Gardneri (Baker)

Gymnogramme Gardneri Baker, Syn. Fil., Ed. 2, 515. 1874. (Type from Brazil. *Gardner, 4077.*)

Gymnopteris Delavayi (Baker)

Gymnogramme Delavayi Baker, Annals Bot. **5**: 484. 1891. (Type from Yunnan, China, *Delavay.*)

Hab. West Indies from Cuba and Jamaica to Guatemala, Honduras, Nicaragua, and throughout South America to Paraguay.

2. **Gymnopteris subcordata** (D. C. Eaton & Dav.)

Gymnogramme subcordata D. C. Eaton & Dav. Contr. U. S. Nat. Herb. **5**: 138. *pl. 16.* 1897.

Hab. Mexico, Ymala and Lodiego, *Palmer.*

3. **Gypmnopteris ferruginea** (Kunze)

Gymnogramme ferruginea Kunze, Linnaea **9**: 34. 1835. (Type from Peru, *Poeppig.*)

Hab. Guatemala to Peru.

IV. PSILOGRAMME Kuhn, Chaetop. 12. 1882

(Based on *Gymnogramme elongata* Hook. & Grev. and twenty-two other species.*)

1. PSILOGRAMME WARSCEWICZII (Mett.) Kuhn, Chaetop. 17. 1882

Gymnogramme Warscewiczii Mett. Ann. sc. nat. V. **2**: 211. 1864. (Type from Colombia.)

Hab. Costa Rica to Colombia.

2. PSILOGRAMME FLEXUOSA (H.B.K.) Kuhn, Chaetop. 19. 1882

Grammitis flexuosa H.B.K. Pl. Aequin. **2**: 167. *pl. 138.* 1809. (Type from Caracas.)

Cryptogramma retrofracta Hook. & Grev. Bot. Misc. **3**: 385. *pl. 112.* 1833. (Type from Peru.)

Hab. Costa Rica to Bolivia.

3. **Psilogramme Domingensis** (Baker).

Gymnogramme Domingensis Baker, Annals Bot. **5**: 485. 1891. (Type from Causal, Santo Domingo.)

Hab. Santo Domingo.

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* In founding the genus *Psilogramme*, Kuhn commits the error of absorbing an earlier named genus, extending its characters, and placing the whole under a new name. He divides his genus into two sections: § 1, *Jamesonia*, which is a valid genus established by Hooker and Greville, and § 2, *Eupsilogramme*. By this saving word he indicated what species he regarded as typical of his new genus and we take up here his *Psilogramme* in a narrower sense than originally established by excluding the Andine *Jamesonia* which even at Kew has always been regarded a valid genus. As here taken up *Psilogramme* is nearly the equivalent of *Gymnogramme* § *Eugymnogramme* of *Die natürlichen Pflanzenfamilien*, although Kuhn (1882) had restricted the genus *Gymnogramme* to what Link in 1841 called *Anogramma*. In *Die natürlichen Pflanzenfamilien* and in this paper Link's genus is accepted as valid.

4. **Psilogramme schizophylla** (Baker)

Gymnogramme schizophylla Baker, Jour. Bot. **15**: 266. 1877. (Type from Jamaica, *Jenman, 16.*)

Hab. Jamaica.

The synonymy of the other species which are South American may be found in Kuhn, *loc. cit.*

V. ANOGRAMMA Link, Fil. Sp. in Hort. reg. bot. Berl. 137. 1841 (Based on *Gymnogramma leptophylla* and *G. chaerophylla.*)

1. ANOGRAMMA LEPTOPHYLLUM (L.) Link, *l. c.* 137

Polypodium leptophyllum L. Sp. Pl. 1092. 1753. (Type from southern France.)

Hab. West Indies, Mexico; Mediterranean region, Canaries, Madeira.

2. ANOGRAMMA CHAEROPHYLLUM (Desv.) Link, *l. c.* 138

Gymnogramma chaerophylla Desv. Berl. Mag. **5**: 305. 1811.

Hab. West Indies to Paraguay.

The Guatemalan specimens referred to this species in *Synopsis Filicum* are fragmentary, but indicate a possibly distinct species.

VI. TRISMERIA Fée, Genera Filicum, 164. 1850–52

(Based on three species of which *Acrostichum trifoliatum* Pohl is first as *T. argentea; Acrostichum trifoliatum* L. is second as *T. aurea;* and *T. microphylla* Fée, *l. c.* 165, from Peru is the third.)

1. TRISMERIA TRIFOLIATA (L.) Diels.* Die nat. Pflanzenf. **1**^{4}: 365. 1899

Acrostichum trifoliatum L. Sp. Pl. 1070. 1753.

Trismeria aurea Fée, Genera Filicum, 165. 1850–52.

Hab. West Indies to Brazil.

Species with silvery powder as indicated by Fée are unknown to me in collections. A second species, *Trismeria longipes* (Baker) Diels., occurs in Paraguay.

VII. CEROPTERIS Link, Fil. Sp. in Hort. reg. bot. Berol. cult. 141. 1841

(Based on five species of which *C. calomelaena* is first named.)

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* Diels, *loc. cit.*, credits this species to Fée, but Fée did not take up the Linnaean name.

Synopsis of the North American Species

- Leaves more or less pentagonal in outline.
  - Lower basal divisions of lowest pinnae deeply pinnatifid; powder yellow or rarely white; upper surface smooth, dark green. 1. *C. triangularis.*
  - Lower basal divisions of lowest pinnae only slightly sinuate-lobed; powder white; upper surface viscous. 2. *C. viscosa.*
- Leaves elongate-triangular or lanceolate-ovate in outline.
  - Venation distinctly pinnate.
    - Pinnules blunt, entire or with rounded lobes at the base; powder white.
      - Texture coriaceous or firm; pinnules broad, usually expanded. 3. *C. tartarea.*
      - Texture herbaceous; pinnules smaller and narrower with strongly revolute margins. 4. *C. Peruviana.*
    - Pinnules acute, entire or with one or more acute lobes at base.
      - Powder white. 5. *C. calomelanos.*
      - Powder golden yellow. 6. *C. chrysophylla.*
  - Venation flabellate or pseudo-flabellate.
    - Powder white. 7. *C. triangulata.*
    - Powder yellow. 8. *C. sulphurea.*

✓ 1. **Ceropteris triangularis** (Kaulf.)

Gymnogramma triangulare Kaulf. Enum. Fil. 73. 1824.

Stipes densely clustered from a very short rootstock, pale chestnut brown or sometimes blackish; lamina pentagonal, 4–10 cm. long, equally wide, with 6–7 pairs of opposite pinnae gradually ending in a short apex: lowest pinnae unequally triangular, the lowest outer divisions much produced, broad, pinnatifid, the segments on the lower side considerably larger, the upper divisions more or less pinnatifid, all with broad segments; second pair of pinnae lanceolate, pinnatifid with broad short segments, the lowest outer division scarcely produced; upper pinnae becoming merely sinuate or the extreme uppermost entire; upper surface smooth; lower surface covered with yellow or occasionally white powder: sporangia in lines following the forking veins, sometimes confluent when old.

Hab. California to Alaska (?); common. Commonly known as the "gold fern" or "golden back."

In the Kew herbarium there are three scrappy Nuttallian specimens each marked with an asterisk and a name in Nuttall's characteristic hand. Two of these are from Oregon and the third is from Santa Barbara, California. One of the Oregon specimens marked "**viscosa*" is apparently the same as *var. viscosa* of D. C. Eaton, which we can now with more ample materials separate as a distinct species. All of Nuttall's forms have white powder and that feature is not uncommon in *C. triangularis.* There are, however, indications in our collections of a third species with white powder from Lower California.

2. **Ceropteris viscosa** (D. C. Eaton)

Gymnogramme triangularis var. *viscosa* D. C. Eaton, Ferns of N. Am. **2**: 16. *pl. 48. f. 5.* 1880.

Stipes clustered from a very short rootstock, chestnut brown, shining, slender: lamina more or less pentagonal with 6–7 pairs of pinnae which disappear gradually in the more or less tapering apex; lowest pair of pinnae deeply pinnatifid, the lowest basal divisions elongate and slightly and irregularly sinuate or lobed, the remaining divisions almost entire; second pair of pinnae pinnatifid with the lowest outer division mostly narrow and elongate, upper pinnae becoming less and less pinnatifid, the uppermost almost entire; upper surface viscous; lower surface covered with white powder; sporangia on the veins, soon confluent.

Hab. California. The following collections have been examined: So. California, 1888, *J. G. Lemmon;* Temecula, 1 May, 1893, *W. G. Wright;* Santa Catalina Island, 1889, *Georgia M. Rose* (all in herb. Underwood); Avalon, Santa Catalina Island, March, 1901, *Blanche Trask* (herb. New York Botanical Garden). In the herbarium of Columbia University is a single leaf of this species collected at "San Diego, Dry Hills," by C. C. Parry, on the Mexican Boundary Survey.

3. CEROPTERIS TARTAREA (Cav.) Link, Fil. Sp. in Hort. reg. bot. Berol. cult. 141. 1841

Acrostichum tartareum Cav. Descr. de las Plantas, 242. 1801. (Type from Peru.)

Hab. West Indies and Mexico to Peru.

In a paper by B. Shimek * this species, wrongly attributed to Linnaeus, is reduced to a variety of *C. calomelanos* as had hitherto been advocated by Baker and others, but the two are abundantly distinct, as can be seen by the study of any large collection.

4. CEROPTERIS PERUVIANA (Desv.) Link, Fil. Sp. in Hort. reg. bot. Berol. cult. 142. 1841

Gymnogramma Peruviana Desv. Berl. Mag. **5**: 329. 1811. (Type from Peru.)

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* The Ferns of Nicaragua. Bull. Lab. Nat. Hist. State Univ. Iowa, **4**: 191. 1891.

Ceropteris plicata Fée, Mem. 8: 81. 1857.

Ceropteris Schaffneri Fée, Mem. 8: 80. 1857.

We have examined North American specimens as follows:

VERA CRUZ: Orizaba, *Müller, 1643;* Calcareous bluffs near Orizaba, 4000 ft., *Pringle, 6078.*

JALISCO: Gravelly bluffs near San Marcos, *Pringle, 4377.*

Both in the herbarium of Columbia University.

5. CEROPTERIS CALOMELANOS (L.) Link Fil. Sp. in Hort. reg. bot. Berol. cult. 141. 1841 (as *C. calomelaena*)

Acrostichum calomelanos L. Sp. Pl. 1072. 1753. (Type from West Indies based on Sloan, *pl. 30. f. 2* and Plumier, *pl. 40.*)

Hab. West Indies, general, and Mexico to Brazil.

6. CEROPTERIS CHRYSOPHYLLA (Sw.) Link, Fil. Sp. in Hort. reg. bot. Berol. cult. 143. 1841

Acrostichum chrysophyllum Sw. Fl. Ind. occ. 3: 1598. 1806. (Type from Martinique, based on Plumier, *pl. 44.*)

Hab. West Indies.

Although not covered beneath by a waxy powder but in the young state by fine rusty hairs, is it probable that *Gymnogramme. Hookeri* J. Sm. belongs to this genus as it agrees perfectly in habit and every other character save this. A single specimen occurs in the collection of the New York Botanical Garden. *Gymnogramme Bommeri* Christ from Costa Rica which we have not seen may also belong here. Other species of gold and silver ferns from South America occur in collections and there are indications of two or three additional species from Central America and the West Indies, but present material is too scanty for properly characterizing the latter.

7. **Ceropteris triangulata** (Jenm.)

Gymnogramme triangulata Jenm. Bull. Bot. Dep. Jamaica, 4: 206. 1897. (Type from Moody's Gap, Jamaica.)

Hab. Jamaica, Moody's Gap, 1900, *Clute, 162.* (Herb. Underwood.)

8. CEROPTERIS SULPHUREA (Sw.) Fée, Gen. Fil. 183. 1850–1852

Acrostichum sulphureum Sw. Nov. Gen. & Sp. Pl. 129. 1788. (Type from Jamaica.)

Hab. West Indies.

The last species with another from Africa is placed by Diels in a genus distinct from the other gold and silver ferns but the preceding species is quite intermediate between this and the other West Indian species in its venation.

VIII. BOMMERIA Fourn.; Baillon, Dict. de Bot. **1**: 448. 1876. Bull. Soc. Bot. de France, **27**: 327. 1880

(Based on *Gymnogramme Ehrenbergiana* Mett. and *G. pedata* Kaulf.)

1. BOMMERIA EHRENBERGIANA (Klotzsch) Fourn. Bull. Bot. Soc. de France, **27**: 328. 1880

Stenogramme Ehrenbergiana Klotzsch, Linnaea, **20**: 411. 1847. (Type from Mexico, *Ehrenberg, 662.*)

Gymnogramme podophylla Hook. Syn. Fil. **5**: 152. *pl. 296.* 1864. (Type from Orizaba, *Müller, 719.*)

Hab. Mexico. A single, sterile leaf occurs in the Meissner herbarium (Columbia University).

2. **Bommeria hispida** (Mett.)

Gymnogramme hispida Mett. Linnaea, **36**: 72. 1869. (Type from New Mexico, *Wright, 819.*)

Bommeria Schaffneri Fourn. Bull. Bot. Soc. de France, **27**: 327. 1880. (Type from Escabrillos prope San Luis Potosi, *Schaffner, 6.*

Hab. New Mexico and Arizona to Central Mexico.

3. BOMMERIA PEDATA (Sw.) Fourn. Bull. Bot. Soc. de France, **27**: 327. 1880

Hemionitis pedata Sw. Syn. Fil. 20. 209. *pl. 1. f. 3.* 1806. (Original country unknown to Swartz but the original specimen had been sent to him by Cavanilles.)

Hab. Mexico.

The first species has anastomosing veins while in the others the veins are free; until the type species of the genus is better known it will be somewhat uncertain whether all the species thus aggregated together by Fournier should thus remain. They are all characterized by a pedate habit.

The American species (*Gymnogramme elongata* (no. 66) and *G. Mexicana* (no. 67) which are referred in *Synopsis Filicum* to §

Selliguea have little in common with the old world representatives of that genus. While no. 66 was the type of *Synammia* Presl, it has been referred to *Phymatodes* by John Smith, and surely this treatment is quite satisfactory, as the plant differs from *Phymatodes* only in its slightly elongated sori. *G. Mexicana*, judging from Fée's figures, will follow *G. elongata*. *Gymnogramme heterophlebia* Gilbert, Bull. Torrey Club, **26**: 325. 1897, from Venezuela, is another species of *Phymatodes* described long ago from South America as *Polypodium persicariaefolium* Schrad., so that *Selliguea* based by Bory on *S. Feei* from Java is to be regarded as an exclusively old world genus.

SUMMARY

1. The genus *Gymnogramme* as treated at Kew, far from being a natural group of plants, contains among its species a number of generic groups, several of which bear no close phylogenetic relations to the others or to each other; some of these belong to different tribes even.

2. Certain of these genera are related to the *Polypodieae*, others to the *Aspidieae*, one possibly to the *Vittarieae*, but more are distinctly related to the *Asplenieae*, possessing every asplenioid character except the indusium.

3. The tribe Grammitideae as recognized in *Synopsis Filicum* has no good ground for recognition as a natural group of genera.

4. The members of *Gymnogramme* of the *Synopsis Filicum* have little relationship with the tribe Pterideae with which, for the most part, they are associated in *Die natürlichen Pflanzenfamilien*.

5. The name *Gymnogramma* being a typonym of the monotypic *Gymnopteris* established thirteen years earlier, disappears from botanical nomenclature.

6. While the genera are largely represented in the American tropics, some belong exclusively to the old world, and others have a wide distribution throughout tropical and warm temperate regions.

7. The two species hitherto referred to *Gymnogramme* occurring within the limits of the United States represent two distinct genera, *Ceropteris* and *Bommeria*. A third species (*Ceropteris viscosa*) is added from southern California.

Notes on the fossil Fruits and Lignites of Brandon, Vermont

By F. H. Knowlton

(With Plate 25)

It is now almost fifty years since Professor Edward Hitchcock published * the first account of the interesting lignitic deposit at Brandon, Vt. Many of the most characteristic species of fruits were figured and a general discussion given of the geological conditions under which they occur with an indication of the probable stratigraphic position. Later, in 1861, Professor Leo Lesquereux published an elaborate paper in which he gave careful descriptions of the species, with a discussion of the relationships of the flora with those of certain European deposits. These two articles were published without change, in 1862, in Hitchcock's *Geology of Vermont*, † and were further supplemented by a letter from Professor J. W. Bailey, ‡ to show specimens of the lignite and fruits which had been submitted for microscopical study. Professor C. H. Hitchcock described § a single species of *Carpolithes* in 1862, which completes the list of articles relating to the subject, with the exception of occasional mention in works on geology, etc.

Professor Hitchcock's account of the geology and mode of occurrence of this deposit is very complete, and I venture to give it in full:

"In the autumn of 1851 Professor Shedd, of Burlington, presented me with a few specimens of beautifully preserved fruits from Brandon, Vt. They were converted into brown coal, and retain exactly their original shape and markings. Early in the spring of 1852 I visited Brandon, and found that the fruits were obtained from a bed of brown coal connected with the white clays and brown hematite of that place. I perceived at once that an interesting field was open before me, and ever since I have been endeavoring to exploit it. * * * I shall first give a description of

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* Am. Journ. Sci. II. 15: 95–104. 1853.

† Pp. 226–234; 714–718.

‡ *Op. cit.*, 239, 240.

§ Portland Soc. Nat. Hist. 1: 95. *pl. 1. f. 5.* 1862.

the topography and geological associations of this carbonaceous deposit."

Geologists are aware that along the west base of the Green and Hoosac Mountains, from Canada to New York, occur numerous beds of brown compact and fibrous hematite iron ore. That in Brandon lies between two and three miles of the village; the surface rises slightly and exhibits clay, drift and limestone rock in place. According to my measurements with the anëroid barometer, Brandon village is 465 feet above the ocean, and the iron mine 520 feet above the same. A short distance east of the mine the Green Mountains rise rapidly.

At this spot we find the following varieties of substances in juxtaposition:

1. Beautiful kaolin and clays, colored yellow by ochre, rose-color by manganese (?), and dark by carbon.
2. Brown hematite and yellow ochre.
3. Ores of manganese.
4. Brown coal.
5. Beds of gravel connected with the clays.
6. Drift overlying the whole.
7. Yellowish limestone underlying the whole.

The position of the clays is difficult to determine exactly, as there seems to have been a good deal of disturbance of the strata, perhaps only the result of slides. The coal, in a few places, shows itself on the surface. In one spot a shaft has been carried through it only a few feet below the surface, and this has also been done to the same bed nearly 100 feet below the surface. In both places it was about 20 feet thick. I found it to be the conviction of the miners that the mass of coal formed a square column of that thickness descending almost perpendicularly into the earth, in the midst of the clay. My own impression was that it is a portion of an extensive bed, having a dip very largely towards the northwest; perhaps separated from other portions of the bed by some disturbance of strata.

From the above account it will be observed that this deposit has the appearance of almost complete isolation in the midst of much older and totally different strata, and it is not strange that it excited the attention and wonder of geologists, and the question of its age became at once the subject of speculation. From purely geological data Hitchcock concluded that it must be Pliocene, or possibly still newer Tertiary in age, while Lesquereux, from a consideration of the flora and its general resemblance to that of Oeningen, inclined to place it in the Miocene. Dana has suggested that it may possibly be as old as the Eocene, a conclusion which later investigation will probably not sustain.

LIGNITE

The mine mentioned by Professor Hitchcock has long since fallen into neglect, and is now almost entirely filled up. The mining of iron was stopped more than thirty years ago and the only industry remaining is the mining and manufacture of mineral paints. The only trace remaining of this extensive lignitic deposit is the mass of minute fragments scattered about the mouth of the shaft, and among which, by long and careful search, a few fruits are still to be found. For a description of the appearance of the lignite as it appeared when first taken from the mine, recourse must be had to Hitchcock's description, which is as follows:

"The greater part of the carbon of this deposit is in a condition between that of peat and bituminous coal. It is of a deep brown color, and nearly every trace of organic structure, save in the lignite and fruits, is obliterated. It burns with great facility with a moderate draught, and emits a bright yellow flame, but without bituminous odor.

"Interspersed through the mass of carbonaceous matter above described occurs numerous masses of lignite. In all cases which have fallen under my observation they are the broken portions of stems or branches of trees and shrubs, varying in size from that of a few lines to a foot and a half in diameter. They all appear to have been drift wood. This lignite, in all cases, retains and exhibits upon a first fracture its organic structure. Yet generally it is quite brittle, and when broken across the fibers, it has the aspect of very compact coal, which admits of a good polish."

The largest specimen obtained by Professor Hitchcock was four feet in length and sixteen inches in largest diameter. It is now in the museum of Amherst College. The largest specimen in my possession was given me by Dr. D. W. Prime, of Brandon.

It is almost twelve inches long and four inches broad. It breaks up very readily into small irregular fragments which appear destitute of structure on their transverse fracture, but when split along certain lines, notably in the direction of the medullary rays, very plain structure may be observed even with the naked eye. In general the only specimens that can be obtained for examination are small fragments hardly an inch in length. Most of the material upon which the following examination is based was kindly placed at my disposal by Professor H. M. Seely, of Middlebury College, and Professor George H. Perkins, of the University of Vermont.

Hitchcock was of the opinion that little if any of this lignite could be regarded as coniferous, while Bailey, in his letter before referred to, states positively that the woods "*are not coniferous.*" Contrary to these statements and my expectations, a large proportion of the lignite examined proved to be undoubtedly coniferous in character. These later results are perhaps due to improved methods of study, or possibly its character may differ in different parts of the area. This latter supposition seems hardly probable, however, as the area from which it was obtained has always been so limited.*

When specimens prepared as indicated above are placed under the microscope, a glance suffices to show that they have been much crushed and distorted by pressure. In transverse section the lumen of the cells is seen to be almost entirely obliterated, and they have been distorted in other ways. But by repeated selections of material and its careful study, points that have been especially favored during the processes of fossilization, are usually to be found, and from a study of these areas, in numerous examples, a pretty complete idea can be formed of its nature and appearance when living. The large specimen in my possession, mentioned above, was found to be undoubtedly coniferous. Selected sections from it show clearly the characteristic pits on the radial

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* To prepare this lignite for examination by transmitted light the directions given by Griffith and Henfrey in the *Micrographic Dictionary*, second edition, p. 178, are very satisfactory. The specimens are to be macerated in a strong solution of carbonate of potash for a few days, when they may be cut into thin sections with a razor. These thin pieces are boiled for a few moments in nitric acid, or until they become light brown in color. They are then washed out in pure water and mounted in glycerine.

walls (*f. 9*). The walls of the tracheïds were also found to be thickened spirally on their interior. In longitudinal tangential section the ends of the medullary rays show plainly (*f. 10*). They have been considerably distorted, yet their arrangement can be made out. They are usually simple; that is consist of a single layer of cells, yet scattered among these are a few compound rays with a single included resin-duct, a well-known character of the genus *Pinus*. Indeed, after a careful study I am scarcely able to distinguish the Brandon lignite from a species of *Pityoxylon* described by Schmalhausen* from the Eocene and Braunkohle of southwestern Russia. The material studied by Schmalhausen was better preserved and he was able to work out the details of structure in a more satisfactory manner than is the case with the Brandon material. Yet on the whole I am inclined to regard them as of only varietal difference. Schmalhausen has named the Russian species *Pityoxylon microporosum*. For the Brandon form I propose the name *Pityoxylon microporosum Brandonianum*.

The type is described as follows: Annual rings plainly marked, rather thick; medullary rays moderately numerous, the simple ones 1–7 cells high, the larger enclosing the resin duct about 18 cells high; wood-cells marked by numerous lines, the pores small and remote; pores on the medullary rays large, oval, 1–2 to the width of each wood-cell.

The Brandon form differs in the narrower annual rings and the smaller size of the cells in general. It is not well enough preserved to show markings on the medullary rays if these be present. The walls of the tracheïds are thickly covered with fine spiral lines and the bordered pits are also smaller than in the type. The contents of the resin-tubes can not be made out.*

While as already stated the bulk of the lignite examined proved to be coniferous, I fortunately secured one small but well

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* Beitr. z. Tertiär-Flora Süd-West-Russlands: Palaeont. Abhandl. von Dames u. Keyser, 1: 334. *pl. 41. f. 1–3.* 1884.

† At this point my study was interrupted and consists of a few scattered notes on a few species. It had been my intention to take up each form and subject in a careful microscopical study. As I can not hope to finish it along these lines for some time, if ever, I present the following fragments with due apologies for their disconnected nature, and in the hope that they may prove of some value should any one desire to take up the investigation.

preserved piece that was with equal certainty dicotyledonous. The accompanying figure (*f. 14*) shows it in longitudinal tangential section, and brings out the fact that it was provided with large dotted ducts and numerous medullary rays, the latter of about uniform size and two or rarely three layers of cells side. It suggests a wood allied to *Betula*, but of this I am uncertain.

One of the most abundant and conspicuous of the fruits was named *Carpolithes Brandonianus* by Lesquereux. As may be seen from the figures 1, 2, it is a large flat fruit with the opening a little below the apex. It has been suggested that its affinity is possibly with the living *Jeffersonia diphylla*, the well-known twin-leaf. Unfortunately most of the material at my disposal could not be used for sections, and I was obliged to confine my investigations to imperfect specimens. A section through the basal portion showed the thick fruit to be made up of very thick-walled tissue in which the lumen was reduced to a mere point (*f. 11, 12*). It had been so distorted that its true relationship could not be made out, more especially as the sections could not be made in the same plane through the whole fruit. Its appearance is shown in the two figures. I was not at the time able to secure working material o the capsule of *Jeffersonia*, so I am unable to speak of the relationship beyond the superficial resemblance, which is really striking.

Among the fruits sent me by Professor Seely and which were afterward sent to Lesquereux, was a single small nearly spherical fruit named *Carya globulosa* by Lesquereux himself. This was the first intimation of the existence of a species under this name, and for a time it proved a complete puzzle. Subsequently in looking over the collections belonging to the U. S. National Museum I found a small box containing fruit under this name, and in the catalogue the information that the species was unpublished.

This fruit may be described as follows (*f. 3–5*): Specimens almost completely spheroidal in shape, being only very slightly compressed at the apex. Some of the fruits have retained what seems to have been a thin outer covering or exocarp which entirely enveloped them. Through this thin exocarp the wrinkling or roughening of the true capsule is very plainly discernible, and in this condition they really very much resemble some living species of *Juglans* or *Hicoria*, which are provided with an indehiscent exocarp.

When this center covering is removed, several valves become apparent, and when the specimen has been macerated in the potash solution, may be very readily separated into six nearly equal valves. This shows that it can not possibly belong to either *Hicoria* or *Juglans*, for which, when still covered with the exocarp, it might be mistaken.

In its decorticated condition this capsule bears a very strong resemblance to species of *Cucumites* detected in the London clay by Bowerbank, particularly the six-valved form of his *C. variabilis*. It is also similar to what Lesquereux has called *Apeibopsis*, but all things considered it is probably best referred to the former genus. In view of the fact that the *Carya globulosa* was never actually published, it may be appropriate to name it in honor of Lesquereux who first detected it. It may be called *Cucumites Lesquereuxii*.

Explanation of Plate 25

FIG. 1. *Carpolithes Brandonianus* Lesq. Lateral view.
FIG. 2. *Carpolithes Brandonianus* Lesq. Front view.
FIG. 3. *Cucumites Lesquereuxii* sp. nov. Basal view.
FIG. 4. *Cucumites Lesquereuxii* sp. nov. Split along median line.
FIG. 5. *Cucumites Lesquereuxii* sp. nov. Transverse section.
FIG. 6. *Aristolochites* sp.
FIG. 7. *Tricarpellites fissilis* Lesq.
FIG. 8. *Tricarpellites fissilis* Lesq.
FIG. 9. *Pityoxylon microporosum Brandonianum* var. nov. Radial.
FIG. 10. *Pityoxylon microporosum Brandonianum*, tangential.
FIG. 11. *Carpolithes Brandonianus* Lesq. Section near base, × 310.
FIG. 12. *Carpolithes Brandonianus* Lesq. Section near base, × 90.
FIG. 13. *Aristolochites.* Section near middle, × 310.
FIG. 14. Dicotyledonous wood. Tangential section, × 310.

New and noteworthy Northwestern Plants—VII

By C. V. Piper

Lupinus brachypodus sp. nov.

Perennial, from a stout simple or branched caudex, 5–12 cm. high, loosely appressed-hirsute throughout, silvery: leaflets 5–7, unequal, lanceolate or somewhat oblanceolate, acute or acuminate, 8–18 mm. long, greener above; petioles 3–5 times as long as the leaflets; stipules subulate, small: flowering stems equalling or little exceeding the foliage, bearing one to two leaves: raceme dense, 2–4 cm. long; bracts subulate, 5–6 mm. long, nearly equalling the flowers, somewhat persistent; pedicels very short: calyx bracteolate, the bracts minute; upper lip two-cleft for half its length; lower lip minutely 2-toothed at the apex, one fourth longer than the upper: corolla 7–8 mm. long, blue, over twice as long as the calyx; standard broadly oval, glabrous on the back; wings oblong, slightly longer than the standard; keel coarsely ciliate, deep violet at the tip: young pods silky-villous: ovules about three.

Dry stony bottoms of a small stream, margin of Barren Valley, eastern Oregon, 12 June 1901, *Cusick, 2561.*

This plant is nearest related to *L. aridus* Douglas.

TRIFOLIUM ARCUATUM **Cusickii** var. nov.

Differing from the type essentially in its leaflets which are linear, 3–4 cm. long, 2–5 mm. wide.

Moist meadows of Camp Creek, Maurey's Mt., eastern Oregon, 2 July 1901, *Cusick, 2628.* Also Clover Creek, Blue Mts., Oregon, 1886, *Cusick.*

Arctostaphylos obtusifolia sp. nov.

Much branched shrub, about 1 m. high; bark dark red, smooth; young twigs glandular-pubescent: leaves bright green, ovate, obtuse, the bases usually truncate, sometimes cuneate, glabrous except the petioles and the bases of the midribs, these pubescent; blades 2–3 cm. long, about twice the petioles: panicle terminal, pendulous, 3–4 cm. long, its reddish branches glandular; bracts reddish, ovate-triangular, obtuse, glandular; pedicels glabrous, 4–6 mm. long, 3–4 times as long as the bracts: calyx lobes pink, ovate, obtuse, 1.5 mm. long: corolla pale pink, urceolate, 5–6 mm. long, sparsely hairy within: filaments hairy at the broadened bases : fruit globose, 8–9 mm. in diameter, the nutlets not united.

In great thickets about Black Butte, eastern Oregon, 30 July 1901, *Cusick, 2688a.*

Phlox lanata sp. nov.

Perennial from a stout woody caudex, densely tufted ; annual shoots about 2 cm. long, one-flowered : leaves subulate, sharply cuspidate, distinctly bisulcate, 6–7 mm. long, densely white woolly except near the tips : calyx woolly, the lobes subequal, cuspidate, 6–7 mm. long : corolla pubescent at base within, the tube 1 cm. long, the orbicular lobes half as long, purple : style one fourth the length of the corolla-tube.

Flat top of Stein's Mt., Oregon, 4,000 feet altitude, 10 June 1901, *Cusick, 2557.*

This is a very distinct species nearest related to *P. canescens* T. & G. It is much more woolly than any other North American species.

Allocarya jucunda sp. nov.

Low annual, branching from the base, prostrate or ascending, the branches, 5–10 cm. long, rather sparsely bristly throughout : leaves linear-oblong, obtuse, 1–2 cm. long, bristly-hirsute, excepting the glabrous upper face : racemes loose, the bracts gradually reduced : flowers white : calyx bristly, the acute lobes slightly broader at base : nutlets narrowly trigonous, 1.25 mm. long, rather light colored, somewhat vitreous-shining ; back very obscurely keeled, with about five low transverse rugae extending to the margin, not at all muriculate ; ventral surface keeled, with obscure oblique rugae extending to the margin ; scar basal, linear, the surrounding margin not sharply edged.

Margin of Christmas Lake, eastern Oregon, 5 August 1901, *Cusick, 2723, 2724.*

The species here proposed is very close to *A. Cusickii* Greene and to *A. hispidula*, but differs in the characters of its nutlets and leaves.

Mertensia Cusickii sp. nov.

Whole plant pale green throughout, with a fine closely appressed pubescence : stems erect, 30–45 cm. high, leafy to the top : radical leaves oblong-ovate or oblong, obtuse, veiny, the blade 48 cm. long, the petiole as long or longer : cauline sessile or nearly so, oblong or lance-oblong, mostly acute, 4–8 cm. long : panicle leafy, the peduncles exceeded by the leaves : pedicels and bracts hardly as long as the corollas: calyx pubescent, the lobes lance-ovate, acute, 4 mm. long: corolla blue, 10 mm. long, the ampliate limb as long as the tube: anthers as long as the filaments.

Dry soil, Stein's Mt., eastern Oregon, 7,000 feet altitude, 18 June 1901, *Cusick, 2532.*

The species here proposed is quite different from any of those recently published. The pubescence of the plant here described is very much more marked than on any similar plant known to the writer.

Lonicera sororia sp. nov.

Shrub 5–1 m. high: bark pale: young shoots sparsely glandular: flowering branches with three or four pairs of leaves: leaves thin, green and nearly glabrous, except the ciliate margins, all short-petioled, 2–4 cm. long, the lower one or two pairs elliptic-oblong, the obtuse apex mucronate; upper two pairs obovate, cuneate at base, acute or acuminate, especially the uppermost pair: bud-scales triangular-ovate, acute, persisting on the stem at least two years: fruiting peduncles about 2 cm. long, sparsely stipitate-glandular: fruit red, as large as a pea, formed of the two completely united ovaries: seeds 3 mm. long, finely reticulated: flowers not seen.

Wet forests, Cycan Mts., eastern Oregon, 14 August 1901, *Cusick, 2759.*

This is closely related to *L. conjugialis* Kellogg, from which its obovate leaves would seem to separate it.

ANTENNARIA PARVIFOLIA Nutt.

The type of this species is in the herbarium of the Philadelphia Academy of Sciences. It is by no means a satisfactory specimen to identify. Two opinions have been expressed in regard to it; the first by Dr. P. A. Rydberg (Flora Montana, 412), who regards it as identical with *A. rosea* Eaton; the other by Professor E. L. Greene (Pittonia, **3**: 280), who identifies it with *A. microphylla* Rydb. Mr. Elias Nelson, in his recent revision, Proc. U. S. Nat. Museum, **23**: 708, accepts Professor Greene's view, though he states in the introduction that he had not seen the type.

I am totally unable to agree with either of the above decisions, but would regard the plant as probably *A. aprica* Greene. Mr. M. L. Fernald has also examined the plant at my request and he too thinks it *A. aprica.*

A. microphylla Rydb. seems to me a valid species.

Aster Elmeri sp. nov.

Perennial, erect, about 1 m. high: stems rather stout, pubescent in a line except near the base: leaves rather distant, ample, 10–20 cm. long, 2–3 cm. broad, scarcely reduced up to the inflorescence, broadly lanceolate, acute, coarsely serrate, glabrous or glabrate except the scabrous margins, all narrowed at bases into broad petioles: inflorescence loose, with rather few heads, these 7–8 mm. high: peduncles 2–5 cm. long: involucre broadly turbinate, the bracts coriaceous, linear-oblong, acute, ciliate, green for the upper one half or one third, not at all squarrose, imbricated in about three ranks, the innermost and longest nearly equalling the disk-florets: rays pale violet, about 10 mm. long: pappus dirty-white.

In rich bottoms of Sinlahekin Basin, near Loomiston, Okanogan county, Wash., August 1897, *A. D. E. Elmer, 571.*

A well marked species of doubtful relationship.

Aster diabolicus sp. nov.

Perennial, erect, about 1 m. high, leafy to the top: stem sparsely pubescent: leaves thin, green, linear or linear oblanceolate, acute or obtuse, scabrous on the margins, entire or nearly so, the cauline 3–10 cm. long, sessile by broad bases, the basal 10–14 cm. long, narrowed with a broad sparsely ciliate petiole: inflorescence very loose, the heads mostly solitary, terminating long branches, 6–12 cm. long: heads 1 cm. high, rather large: involucral bracts wholly green, linear or linear-lanceolate, acute, ciliate, loosely appressed in about two series, shorter than the disk-florets: rays violet, 10–14 mm. long: pappus sordid.

Gravelly bars of Squaw Creek, Crook county, Oregon, 17 July 1901, *Cusick, 2670.*

A handsome species, closely related to *A. amplus* Lindley.

Aster Wattii sp. nov.

Perennial, branched from the middle, 40 cm. high, rough-pubescent throughout, leafy to the top: leaves all entire, thickish, oblanceolate, acute and bluntly cuspidate, all but the lowermost sessile by broad bases, 2–7 cm. long, 7–15 mm. broad: heads 1.5 cm. broad, terminating long leafy branches: involucral bracts all alike, green, linear-oblong, acute, pubescent, 5–7 mm. long, shorter than the disk-florets, the lower passing into the bracts of the stem: rays violet, 1 cm. long: akenes canescent.

A single specimen collected near North Yakima, Wash., Aug., 1895, by Professor G. H. Watt.

The species is allied to *A. foliaceus* Lindley. It is a very different plant from *A. foliaceus pubescens* Gray.

Aster (MACHAERANTHERA) **glossophyllus** sp. nov.

Biennial or perhaps perennial from a stout root: stems branching from the base, the whole plant finely puberulent; leaves scattered, oblong-spatulate, obtuse but mostly cuspidate, the basal attenuate into broad petioles, the others sessile, 1–3 cm. long, only the midrib evident: heads mostly terminating few-bracted branches, these with the involucre glandular, about 1 cm. broad, 6–8 mm. high: involucre hemispherical, the rigid bracts in 3–4 series, linear, acute or acuminate, ciliate at apex, only the tips green, these more or less squarrose: rays violet, few, 1 cm. long: pappus sordid: style-branches subulate: akenes pubescent.

Black Butte, eastern Oregon, 19 July 1901, *Cusick, 2680a.*

Most nearly related to *A. Pattersoni* Gray.

Aster vaccinus sp. nov.

Perennial, erect, .5–1 m. high: stems glabrous or sparsely pilose above: leaves distant, pale-green, glabrous, entire but scabrous-ciliate, the lower ones broadly lanceolate, acute, narrowed at base into broad petioles, 10–15 cm. long, 3 cm. broad: cauline lanceolate, acute, sessile by broad bases, 2–8 cm. long: inflorescence loose, its leaves much reduced: heads scattered, mostly solitary, terminating the branches: involucre hemispherical, the bracts numerous in about three ranks, the outer successively shorter, linear-lanceolate, acute, minutely ciliate, green for the terminal half, not equalling the disk-florets, the outermost passing into the narrow bracts of the branches: rays blue or pale violet, 8–12 mm. long: pappus sordid.

Stream banks, Cow Valley, Malheur county, Oregon, 4 Sept. 1901, *Cusick, 2782* (type); also no. 2785, head of Antone Creek, Blue Mts., Oregon, in moist soil, in black pine forests, 7,000 feet altitude, 26 Sept. 1901.

This species is quite closely allied to *A. adscendens* Lindley.

Supplementary Notes on the Erysiphaceae

BY E. S. SALMON, F.L.S.

ADDENDA

I have lately received from Professor Shotaro Hori a very interesting *Uncinula* from Japan (Tokio; coll. K. Yoshino, 6 Nov. 1901). The fungus presented these characters:

Perithecia truly amphigenous, mycelium subpersistent, very thin, effused; perithecia 85–120 μ in diam., cells of outer perithecial wall 10–14 μ wide; appendages 9–21, from slightly exceeding the diameter of the perithecium to 1.5 times its diameter, straight or slightly curved throughout their length, simple, colorless, aseptate, stout, about 7 μ wide in the lower half, not or only slightly enlarged upwards; apex closely coiled, not swollen, sometimes slightly helicoid, basal part of appendage becoming refractive and thick-walled; asci 4–6, broadly ovate, 45–50 × 28–30 μ, stalk very short; spores usually 4–6, rarely 3 or 7, very rarely 8, ellipsoid, rounded at the ends, 18–19 × 10 μ.

From typical *U. Sengokui* Salm., the above fungus differs only in the usually fewer appendages and in the fewer slightly smaller asci. The appendages also of the present form are, perhaps, more frequently straight, but otherwise, in shape, size, stoutness, etc., agree perfectly with those of typical *U. Sengokui*. When, as is often the case, the appendages are few and distant, the present form somewhat approaches *U. Delavayi* Pat., but that species differs in the larger cells of the outer wall of the perithecium, in the still fewer appendages which are distinctly swollen upwards, and in the larger asci and spores. When, however, the appendages are more numerous, the present form is seen clearly to be morphologically inseparable from *U. Sengokui*, of which it must, at any rate for the present, be considered a small form. *U. Sengokui* is only known on *Celastrus articulatus* (from Komaba, Tokyo), while the form described above was collected on *Fraxinus Bungeana* DC. var. *pubinervis* Wenz. This occurrence is especially interesting because hitherto the only *Uncinula* known to occur on *Fraxinus* was *U. fraxini* Miyabe (on *Fraxinus longicuspis*), a species quite distinct from *U. Sengokui* in the longer narrower appendages, and the regularly 8-spored asci, etc.

I have also received from Professor Shotaro Hori some beautiful specimens of *Uncinula verniciferae* P. Henn. with perfectly ripe perithecia. These specimens were collected, some on the leaves of *Rhus vernicifera* DC. (Prov. Hidachi, Japan; 10 Oct. 1901), and some on the fruit of *R. succedanea* L. (Prov. Idzumo, Japan, coll. F. Tanaka, 12 Oct. 1901; and Prov. Miye, coll. N. Miura, 17 Oct. 1901). An examination of this material shows *U. verniciferae* to possess these characters:

Amphigenous on leaves and fruit, mycelium subevanescent on the leaves, persistent on the fruit; perithecia gregarious or scattered, subglobose, black, very variable in size, 80–140 μ in diam., cells of outer perithecial wall about 15 μ wide; appendages variable in number, 15–35, or rarely as few as 6, equalling, to 1½ times exceeding, the diameter of the perithecium, simple, or very rarely forked towards the apex, colorless, aseptate, about 6 μ wide at the base, lower half becoming thick-walled, refractive, and often rough, narrowed into a closely coiled sometimes helicoid apex; asci 3–9, broadly ovoid, 45–60 × 35–45 μ, stalk short; spores 6–8, rarely 5, ellipsoid, 20 × 11–12 μ.

U. verniciferae is extremely variable in the size of the perithecium and in the number of its appendages, but may be readily recognized by the appendages being narrowed upwards to the closely coiled apex.

With regard to the reported occurrence of *Sphaerotheca mors-uvae* in Belgium (*ante*, p. 94), I am now able to state on the authority of Professor E. Marchal that this record was due to a mistake, and is to be expunged.

Quite recently, however, Hennings (1) has reported the occurrence of *S. mors-uvae* in Russia — "Government of Moskau, Gut Michailowskoje," where it was collected by Mr. N. A. Mossolow in July 1901. Hennings (*l. c.*) observes of the fungus: "Derselbe tritt anscheinend epidemisch auf kultivierten Stachelbeeren auf. Eine Einschleppung des Pilzes aus Nordamerika oder aus anderen Gebieten hat zweifellos nicht stattgefunden, sondern es ist dieser Pilz jedenfalls in Russland heimisch." Magnus (2), on the other hand, has expressed his opinion that neither in Ireland nor in Russia is *S. mors-uvae* to be considered indigenous, but that it has been introduced from North America. The reason that Magnus gives in support of his view is that if the fungus were indigenous to Ireland or Russia it would have certainly have been observed before, and would have spread to other countries.

With the object of obtaining further knowledge on the circumstances of the outbreak of the present fungus in Russia, I wrote to Mr. N. A. Mossolow and to Professor A. de Jaczewski, Vegetable Pathologist to the Minister of Agriculture, St. Petersburg. From the former I received the following information: "The infected gooseberry bushes were planted several years ago, and were bought in Petersburgh and in Riga. Various kinds of gooseberries were affected by the disease. The summer of 1901, when the disease appeared in Michailowskoje, was very hot and dry. We found the fungus in great abundance only on the fruit of the gooseberries and not on the branches. The fruit garden in which the gooseberries are growing is surrounded by the park and woods on one side; on the other side by a hedge of *Crataegus*. The fruit garden consists of apple trees, cherries, raspberries, strawberries, currants and a few hardy plants, *Rubus caesius*," etc. Professor A. de Jaczewski writes: "I do not know of the fungus having been found anywhere else in Russia than in the neighborhood of Moskau. I do not think, however, that there is any reason to believe that the parasite could have been introduced into Russia from America. We have a great many American fungi (on cultivated and wild plants) which could not have been introduced in any way (*Plasmopora Cubensis*, *Phytopthora phaseoli*, *Exobasidium platydiscus*). It is very probable that the *Sphaerotheca* is to be found in many localities here, but we have so few mycologists in Russia that there are scarcely any investigations on this subject, so that our knowledge on the geographical distribution of fungi in Russia is very defective."

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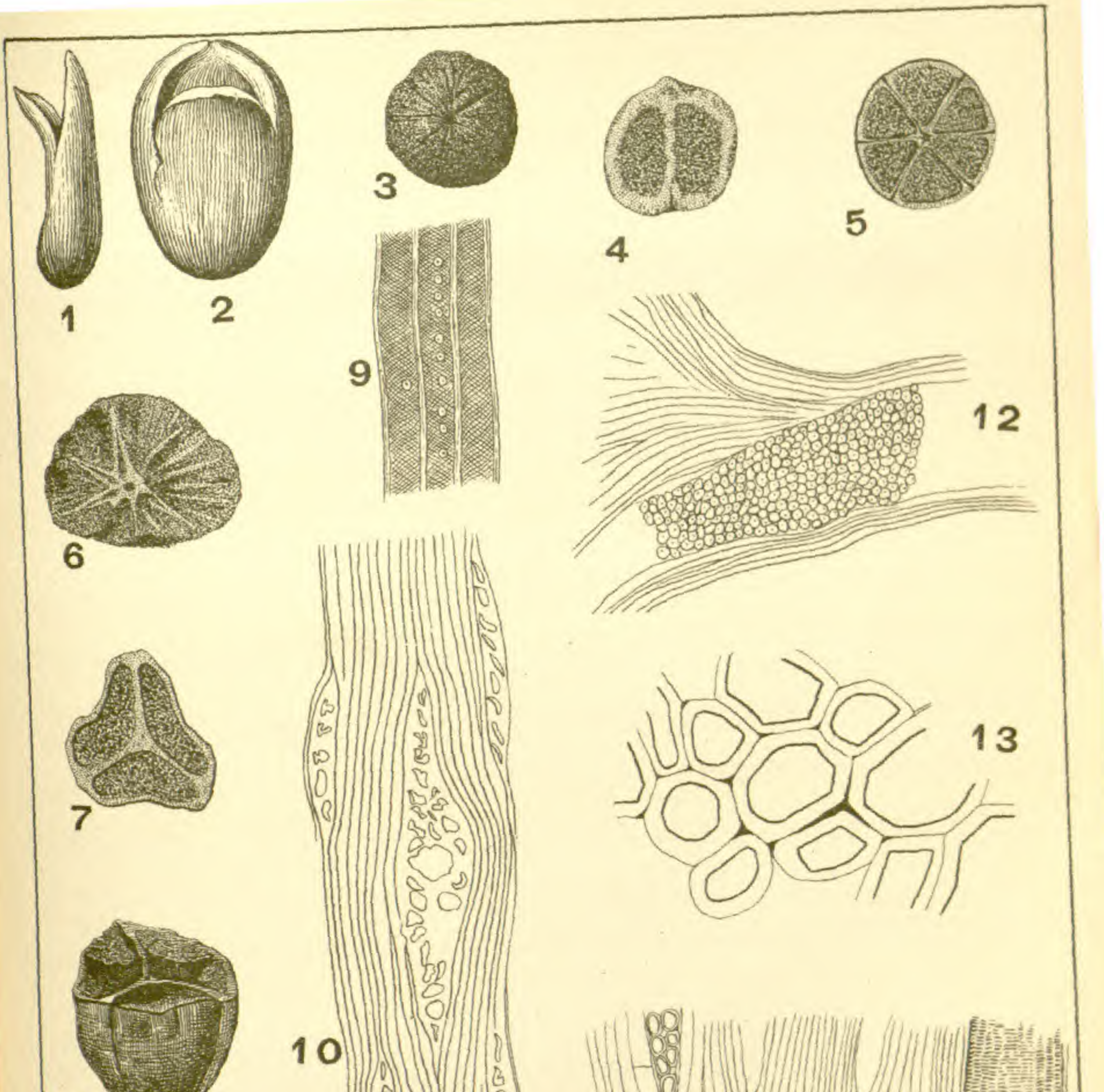

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Memoirs. (See last page of cover.)

VOL. 29 No. 12

BULLETIN

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TORREY BOTANICAL CLUB

DECEMBER, 1902

A cytological Basis for the Mendelian Laws

BY WILLIAM AUSTIN CANNON

In the decade following the year 1860, Gregor Mendel, an abbot of the Roman Church, experimented in the garden of his abbey in Brünn with plant hybrids. This experience led him to results and conclusions now believed by students of heredity to be of great importance. These were published in the *Verhandlung des Naturforschenden Vereins* of Brünn and were lost to the view of scientists until their rediscovery about two years ago by de Vries, Correns, and Tschermak. The plants experimented with by Mendel were mainly species of *Pisum*, *Phaseolus*, and *Hieracium*, and, although the results were in a measure contradictory, those founded upon his pea experiments were uniform, and constituted the basis for his conclusions, namely, those expressed by the "Mendelian Laws." The essential conception of Mendel may be briefly stated as follows:

When one pure form (*A*) is crossed with another pure form (*a*) the hybrid of the primary cross shows the *A* characters only. When, however, the hybrid plants of this generation are fertilized among themselves and produce offspring the *a* characters are first seen, and in a definite proportion to the form bearing the *A* characters. These constitute the hybrids of the second generation. If now the hybrids of the second generation are fertilized in such a manner that plants with *a* characters are crossed with those bearing the same characters, and likewise plants bearing the opposing characters with forms like themselves, the resulting hybrids will behave in a manner characteristic of the respective cross. That is (1) The plants with *a* characters will be found to transmit those characters only, *i. e.*, they are "fixed"; and (2) When the plants

[Issued 30 December]

with *A* characters are fertilized with other plants with the same characters, that is to say, if inbred, two sorts of hybrids will result: one portion will bear only the *A* characters, which may be demonstrated by inbreeding as before, and one portion, apparently also with *A* characters only, will be found to vary just as the hybrids of the primary cross varied, *i. e.*, this portion is really mixed or hybrid. The hybrids that bear the *a* characters are known as the "recessives"; they do not appear in the first generation, and those with the *A* characters are called the "dominants," and they mask in the first generation the recessives. This general scheme may be better understood if tabulated as follows:

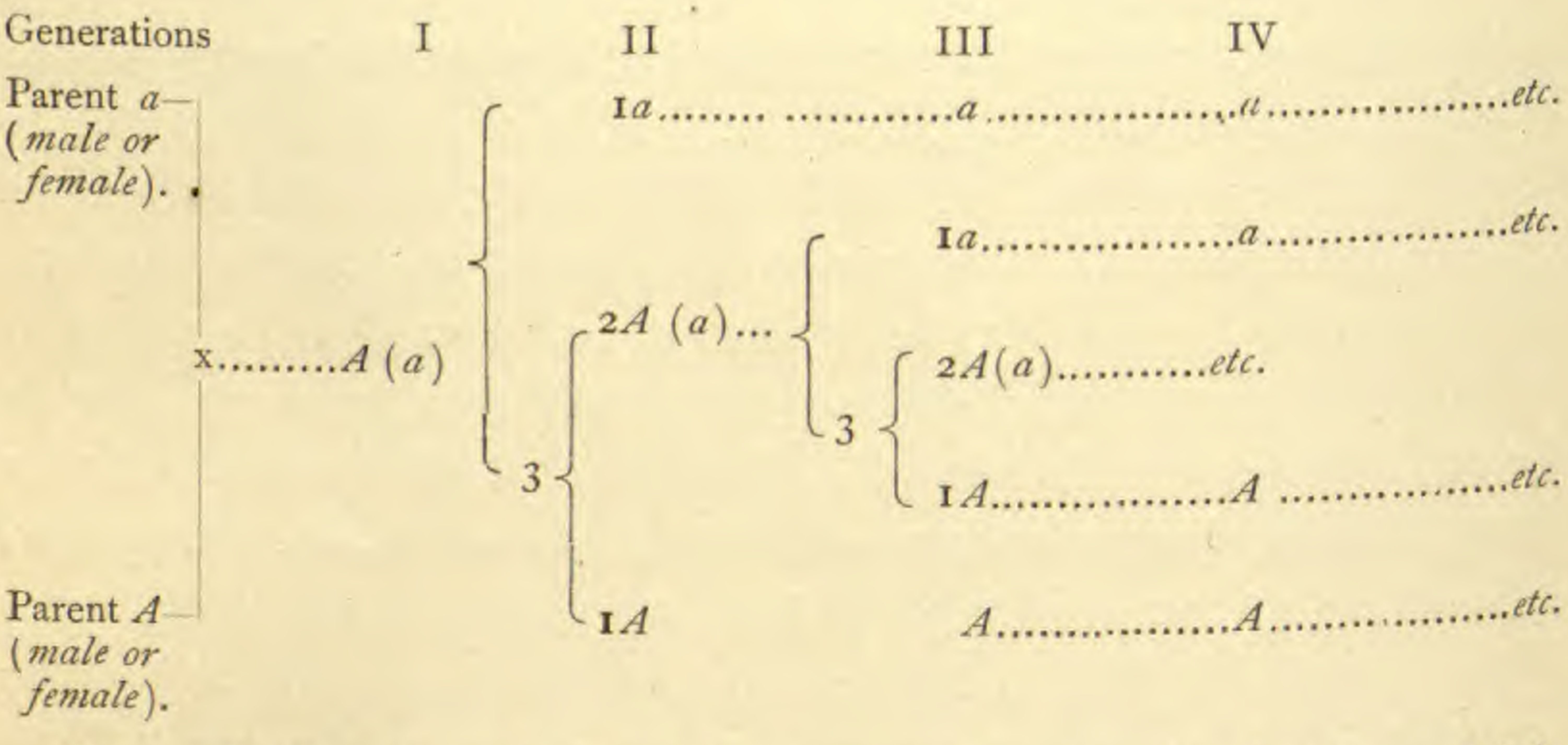

FIG 1. Explanation: *A*: dominant character; *a*: recessive character; *A* (*a*): a hybrid having both characters of which (*a*) is masked by *A*.

Not only do the hybrids vary thus in a regular manner but there is also a definite proportion of recessives (*a*), and dominants (*A*), as the table indicates. That is, referring to the table, in the second generation one fourth of the offspring is recessive (*a*), and three fourths apparently dominant (*A*) only, but really composed of the two sorts (*A*(*a*)) one third of these being dominant (pure), and two thirds mixed (*A*(*a*)). The latter continue in the succeeding generation to vary just as the hybrids of the primary cross varied, *i. e.*, one fourth of their offspring bearing recessive, one fourth bearing dominant characters, and one half being both dominant and recessive.

The regularity in the variation as just described in the second and later generations is accounted for by supposing that the hybrids of the first generation organize germ cells which are of pure descent, and that these unite in fertilization according to the laws of chance. Taking a specific case by way of illustration, we can imagine the following to take place when the sex cells $A(a)$ of say the second generation meet each other in fecundation.

The pollen, which is of pure descent, unites with the egg, which also is of pure descent, and the chances of union may be thus expressed: $A\ a$; $A\ A$; $a\ a$; $a\ A$. So that it happens, since the anther forms two sorts of germ cells and the ovary also two sorts, that in this way one half of the hybrids of say the third generation will be of mixed descent, and one half of pure, the latter being equally recessive and dominant. The results as calculated by the laws of chance, are thus seen to be precisely the same as what is found empirically to occur.

Such are the more essential facts and conclusions of the discovery by Mendel, and upon them are based the two so-called "laws" of Mendel, namely, the law of dominance and that of the splitting of the hybrid race. The latter alone concerns us at present.

We now arrive at the interesting question, Is there a cytological basis for Mendel's law of the splitting of the hybrid race?

Bateson has recently suggested the idea that the "*essential* part of the discovery (of Mendel—the italics are my own) is the evidence that *the germ cells or gametes produced by cross-bred organisms may in respect of given characters be of the pure parental types and consequently incapable of transmitting the opposite character.*" (The italics are in the original.) This notion has also been expressed by others, or may be implied from their conclusions. Assuming such to be the case, how may we account morphologically for the purity of the sex cells?

Do the sex cells, which are thus shown by experiment to be pure, arise by normal maturation mitoses, such as take place in pure races, or are the divisions irregular, abnormal, and peculiar to each hybrid organism? It has, I think, generally been felt by botanists that the variations in the hybrids were, in some manner, connected with that of the formation of the sex cells from which they arose, and this has apparently received cytological support. For instance, both Guyer, from his morphological studies of hybrid pigeons, and Juel, from studies of hybrid *Syringa*, arrive at the conclusion last given, although this must be implied from Juel's results, as for example, his account of how a *Syringa* hybrid pollen grain may become pure as respects the chromosomes of its nucleus. The pigeon hybrid was a fertile one and the *Syringa* infertile; the possibility thus comes up of the variation in the hybrid pigeons being caused and brought about by the normal, rather than the irregular maturation mitoses. I have for two years past been studying the spermatogenesis of a fertile cotton hybrid, and I have attained results similar to those of Guyer. In the case of the cotton, however, the abnormal divisions were so clearly such, that sex cells arising from them would, in all likelihood, not be capable of continuing the race. It, therefore, seemed to me that, at least in the cotton, variation in the hybrid offspring must come about either because the maturation mitoses were such as would induce them, or quite independently of these nuclear divisions, since, in fertile hybrids the mitoses are normal.

The nuclear divisions from which the pollen grains arise, as commonly understood by botanists to take place, would surely not induce the variation in the hybrids after the regular manner demanded by the law of Mendel, and, believing that this variation does not occur independently of these divisions, I venture to suggest a kind of maturation division which would, I believe, account for the variation as above given, and at the same time agree fully with the present day observations on the divisions if not with the conclusions derived therefrom.

This matter finds an apparently adequate explanation if we accept the results of Rückert and others (Wilson, The Cell, 257 and 273) based on the study of pure forms of both vertebrates and invertebrates. These results may be stated in brief as follows: The chromosomes derived from the father and the mother unite in synapsis and separate in the metaphase of one of the maturation divisions, and also a single longitudinal division occurs, so that the end is attained that the chromatin is distributed in such a way that two of the cells receive pure paternal, and two cells pure maternal chromosomes, and no cells receive chromosomes from both the father and the mother. In this manner *it has been demonstrated that pure races of animals may, and normally do, organize sex cells of pure descent.*

Now since such is shown to be the case in *pure* races of animals, I suggest that the sex cells of *fertile* animal hybrids *are formed in a similar way*, and thus we may have in animals a cytological basis for variation in accord with the Mendelian conception. And I further suggest that this is the case in plants as well. This notion is, I am well aware, squarely opposed to the present conception of the nature of the maturation mitoses in plants, but I submit (1) That the optical effect in the dividing sex nucle would be the same in either case, and (2) That closer study of the early stages in the spermatogenesis of plants would give a result entirely analogous to the results drawn from analogous morphological studies of animals.

NEW YORK BOTANICAL GARDEN.

Studies in the Asclepiadaceae—VI. Notes on the Genus Rouliniella

By Anna Murray Vail

A close examination of herbarium specimens variously labelled *Roulinia Jacquinii*, *R. unifaria* and *R. racemosa* show that there are several species which if not new are at least deserving of recognition; and this is an attempt to straighten out some of the species of a most interesting little genus.

About twenty-one or twenty-two species can be enumerated, ranging from Texas to Argentina; but as the genus is but poorly represented, even in foreign herbaria, it is difficult without careful dissection to determine whether all the species credited to *Roulinia* are correctly placed.

Rouliniella

Roulinia Decne.; D. C. Prod. 8: 516. 1844; Schumann, Die nat. Pflanzenfam. 4^2: 255. 1895. Not Brongniart, 1840.

The seven species enumerated here all bear small flowers and are closely related. The available material of the South American species is at present too scanty to study with any kind of satisfaction.*

Key to the Species

Crown-segments not exceeding the stigma. 1. *R. unifaria.*

Crown-segments barely exceeding the stigma, conspicuously 3-lobed. 2. *R. Columbiana.*

Crown-segments exceeding the stigma, long-ligulate.
  Flower-buds sub-globose.
    Central lobe of the crown-segments obscurely 3-toothed at the apex; flower-buds obtuse. 3. *R. Palmeri.*
    Central lobe of the crown-segments entire; flower-buds acutish. 4. *R. racemosa.*
  Flower-buds ovate, acute or sub-acuminate.
    Central lobe of the crown-segments truncate at the apex. 5. *R. lignosa.*
    Central lobe of the crown-segments acute at the apex. 6. *R. foetida.*
    Central lobe of the crown-segments very long and slender, undulate. 7. *R. Jaliscana.*

---

* The accompanying figures represent: *b*, the bud; *c*, the crown (diagrammatically enlarged); *f*, the expanded flower, and are all magnified four diameters; *p*, the pollinia, are magnified twenty diameters.

1. **Roulinielia unifaria** (Scheele)

Gonolobus unifarius Scheele, Linnaea, **21**: 760. 1848.
Roulinia unifaria Engelm. Mex. Bound. Surv. 160. 1850.

A slender climbing and twining vine. Stems pale gray-green when fresh, striate, glabrous or minutely pubescent in lines on the upper portion and somewhat sulcate: leaves opposite, on petioles 1–4 cm. long; blades 3–7 cm. long, ovate, somewhat hastately cordate, gradually acuminate, glabrous, thin, the auriculate basal lobes rounded, with a broad open sinus and a few glands at the base of the midvein above: peduncles longer than the petioles and as long as or exceeding the leaves: racemes as long or longer than the leaves, 7–12-flowered: rhachis minutely pubescent or puberulent in lines: flowers globose in bud: pedicels stout, 1 cm. long or less, pubescent: calyx-segments lanceolate-oblong, 4 mm. long, with a gland in each sinus: corolla 4–6 mm. long, white; segments 3 mm. long, linear-oblong, 2.5 mm. wide, broadly obtuse or nearly truncate, thin, 3-veined, the callous thickened margins revolute; crown attached to the base of the column, 5-parted to near the base; segments erect, not exceeding the anthers, minutely 3-lobed, the middle one slightly the longest, the lateral lobes with thin infolded margins at the base within: anther-wings small; anther-tips semi-orbicular, inflexed on the scarcely conic stigma: pollinia elliptical-ovoid; caudicles broad at the attachment, orange-red on the upper margin; corpuscle obtuse at the apex: follicles 6 cm. long, ovate, acuminate with an obtuse apex, coriaceous, glabrous: seeds 5 mm. long: coma 1 cm. long. (*Fig. 1.*)

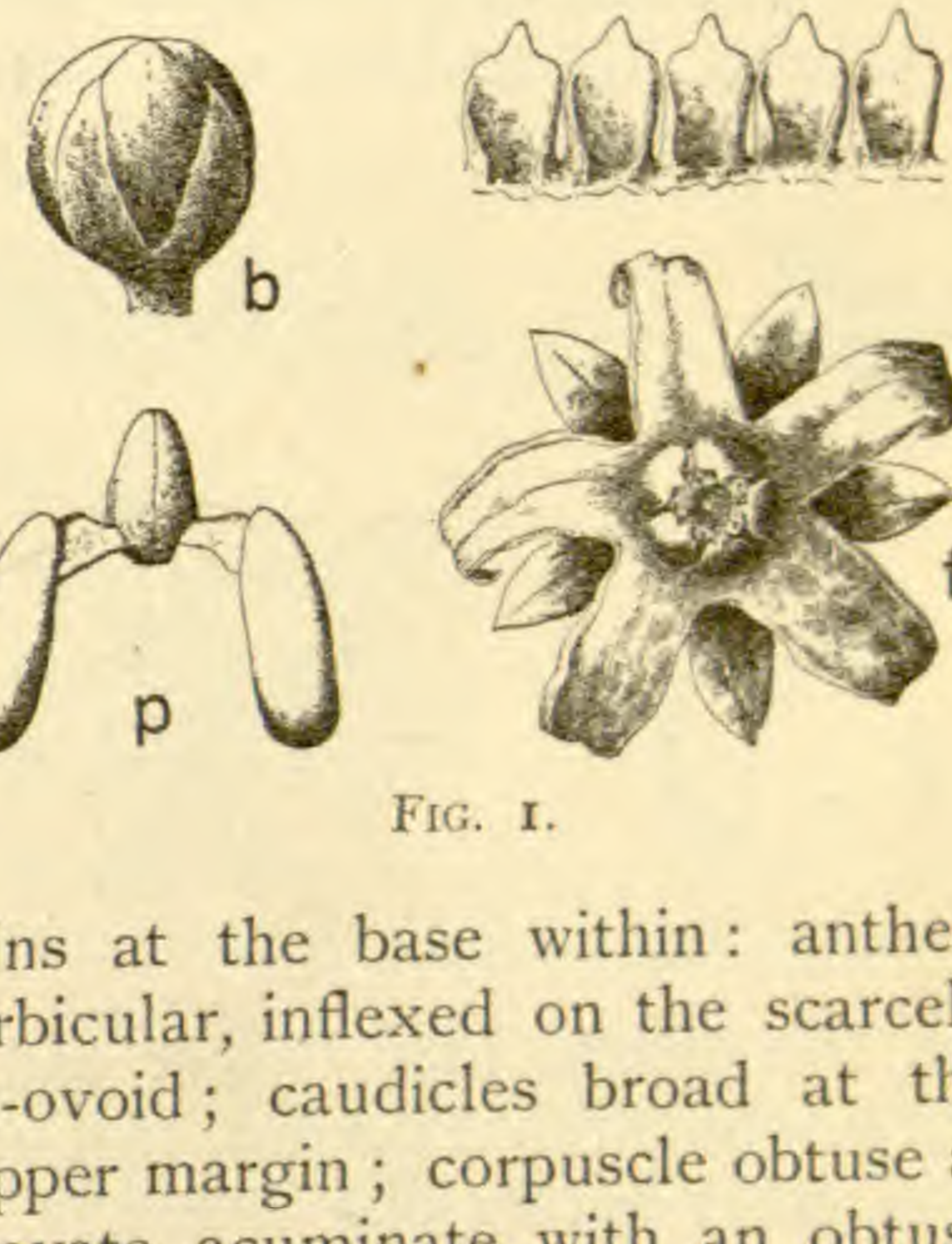

FIG. 1.

Type locality: On the Upper Guadeloupe River, near New Braunfels, Texas. Thickets, Kerr county, Texas, to "Mts. of Muerte," New Mexico. *Wright;* western Texas to El Paso, *Wright, 546;* near Kerrville, *Heller, 1899* (distributed as *Ampelanus ligulata*); Mexican Boundary Survey, *no. 1059.*

The specimens cited by Hemsley, for *Roulinia unifaria* from "North of Monclova, Coahuila," *Palmer, 829* are *Rouliniella Pal-*

meri. I have not seen any true *R. unifaria* as yet from Mexico. It closely resembles *R. racemosa* in general appearance, but in the latter species the leaves are commonly larger, the segments of the crown are 3-lobed, the central lobe long and acutely ligulate and the pollinia are oblanceolate in outline on very long slender caudicles. The crown-segments of *R. unifaria* are not long-ligulate and the pollinia are merely oblong in outline, the caudicles being very short and broad.

2. **Rouliniella Columbiana** sp. nov.

A twining vine up to 7 m. long. Stems puberulent or glabrate, slender: petioles channelled, 2–4 cm. long or somewhat shorter than the blades: leaves opposite; blades 3.5–8 cm. long, ovate-oblong, abruptly acuminate at the apex, the cordate basal lobes rounded, spreading, yellowish-green on both surfaces, sparingly pubescent with scattered hairs: racemes about the length of the petioles, 10–20-flowered: peduncles and pedicels puberulent, channelled: calyx-segments 2.5 mm. long, lanceolate, minutely puberulent: flowers sub-globose in bud, about 5 mm. in diameter when mature: corolla-segments 2 mm. long, apparently pale yellow, oblong, obtuse or acutish when dry, the margins revolute; crown 5-parted; segments white, 3-lobed, hood-like, the central lobe longer and incurved over the stigma, the lateral lobes with a narrow callous incurving ridge or crest on the inner side: anther-tips scarious, inflexed, conspicuous: pollinia oblong on broad caudicles. Follicles not seen. (*Fig. 2.*)

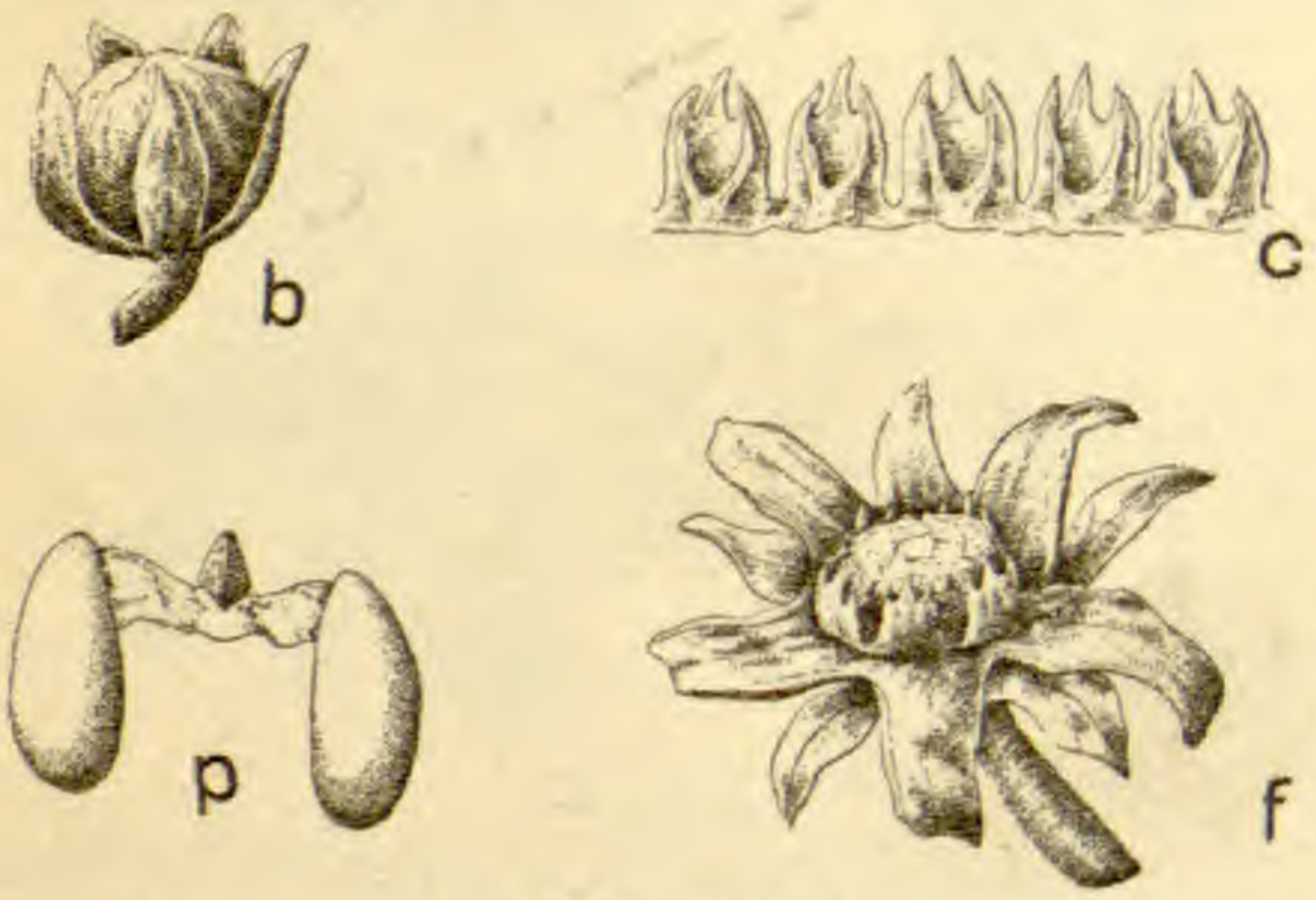

FIG. 2.

U. S. COLOMBIA: Bonda, thickets on the lowlands near the river, 1898–99, rare: *Herbert H. Smith, 1668.* Flowers Oct.–Nov. Type in the herb. of the New York Botanical Garden.

3. **Rouliniella Palmeri** (S. Wats.)

Roulinia Palmeri S. Wats. Proc. Am. Acad. **18**: 115. 1883.

A slender twining nearly glabrous vine. Stems with a narrow puberulent line: leaves on slender 3–4 cm. long petioles; blades cordate-hastate, with a wide open basal sinus, acuminate at the apex, 3–8 cm. long, grayish-green, thin : inflorescence sub-corymbose : peduncles 3–5 cm. long, 5–7-flowered : flowers sub-globose in bud : calyx-segments slender, linear-lanceolate, 4–5 mm. long, puberulent : corolla greenish-white, obtuse in the bud ; segments somewhat crisped and revolute on the margin, a little longer than the calyx : crown-segments united at the base, quadrate, 3-lobed at the apex ; middle lobe triangular, acutish or obtuse, obscurely 3-toothed at the apex, a little longer than the infolded lateral lobes : stigma nearly flat : pollinia oblong ; caudicles broad, with an orange-colored spot along the upper margin : follicles 10 cm. long, somewhat spongy when dry, wrinkled, glabrous : seeds 7 mm. long, glabrous, crenate along the apex : coma 2.5–3 cm. long. (*Fig. 3.*)

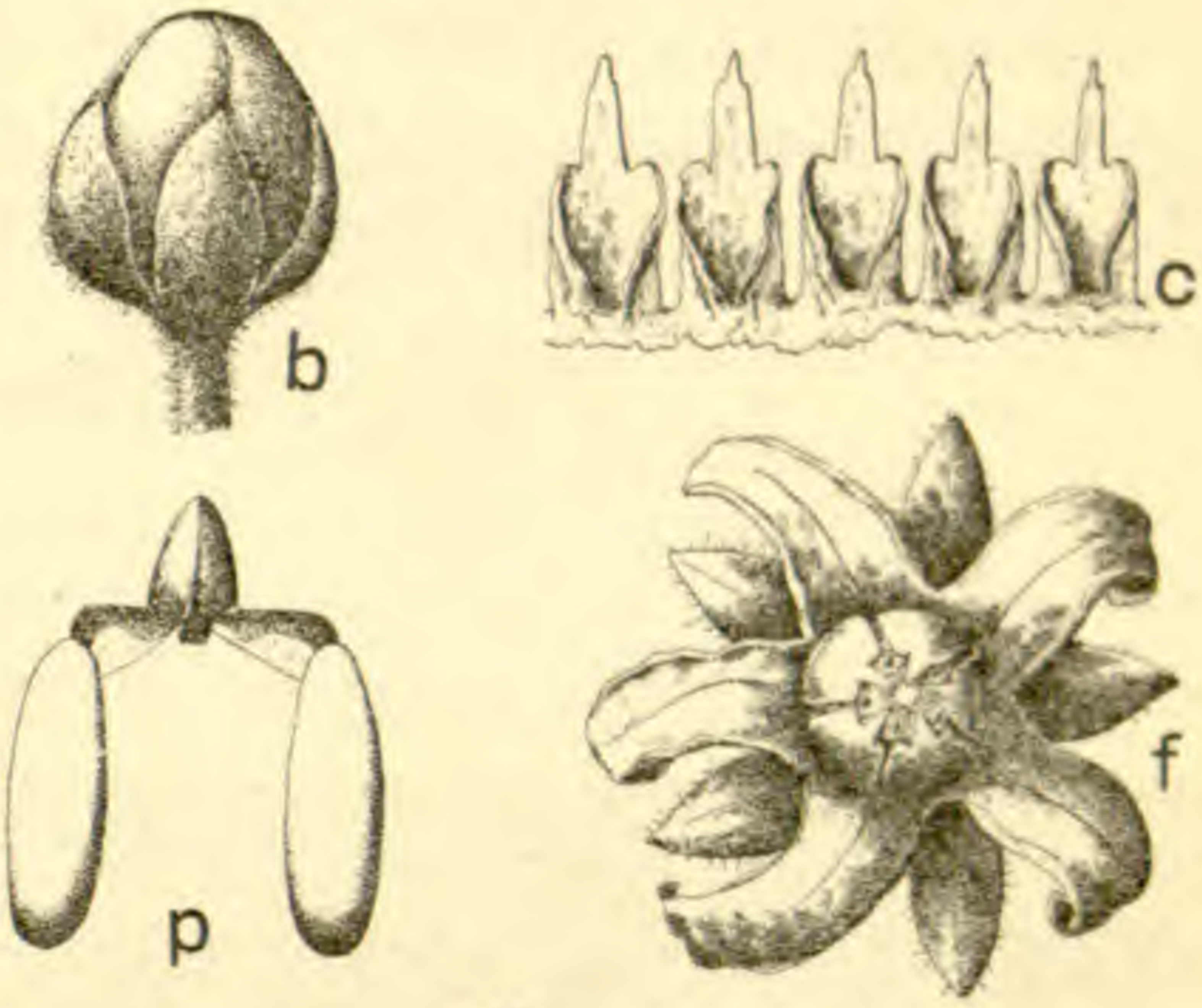

FIG. 3.

MEXICO : Mountains 24 miles northeast of Monclova, State of Coahuila, September 1880 ; *Palmer, 829.*

4. **Rouliniella racemosa** (Jacq.)

Cynanchum racemosum Jacq. Select. Am. 81. *pl. 54.* 1788.
Roulinia racemosa Kuntze, Rev. Gen. Pl. 422. 1891.

A much branched twining vine. Stems angled, slender, glabrous except for a narrow pubescent line : leaves on petioles 2–4 cm. long ; blades ovate-cordate, 6–9 cm. long, long-acuminate, with broadly rounded basal lobes and open sinus : inflorescence racemose, shorter than the leaves : peduncles 4–7 cm. long, 10–20-flowered : flowers 5 mm. in diameter, sub-globose in bud : calyx-segments lanceolate, acuminate, with a gland in each sinus : corolla greenish-white ; margins of the lobes crisped : crown-segments united at base, obtusely 3-lobed at the summit ; central lobe ligulate, twice or more longer than the

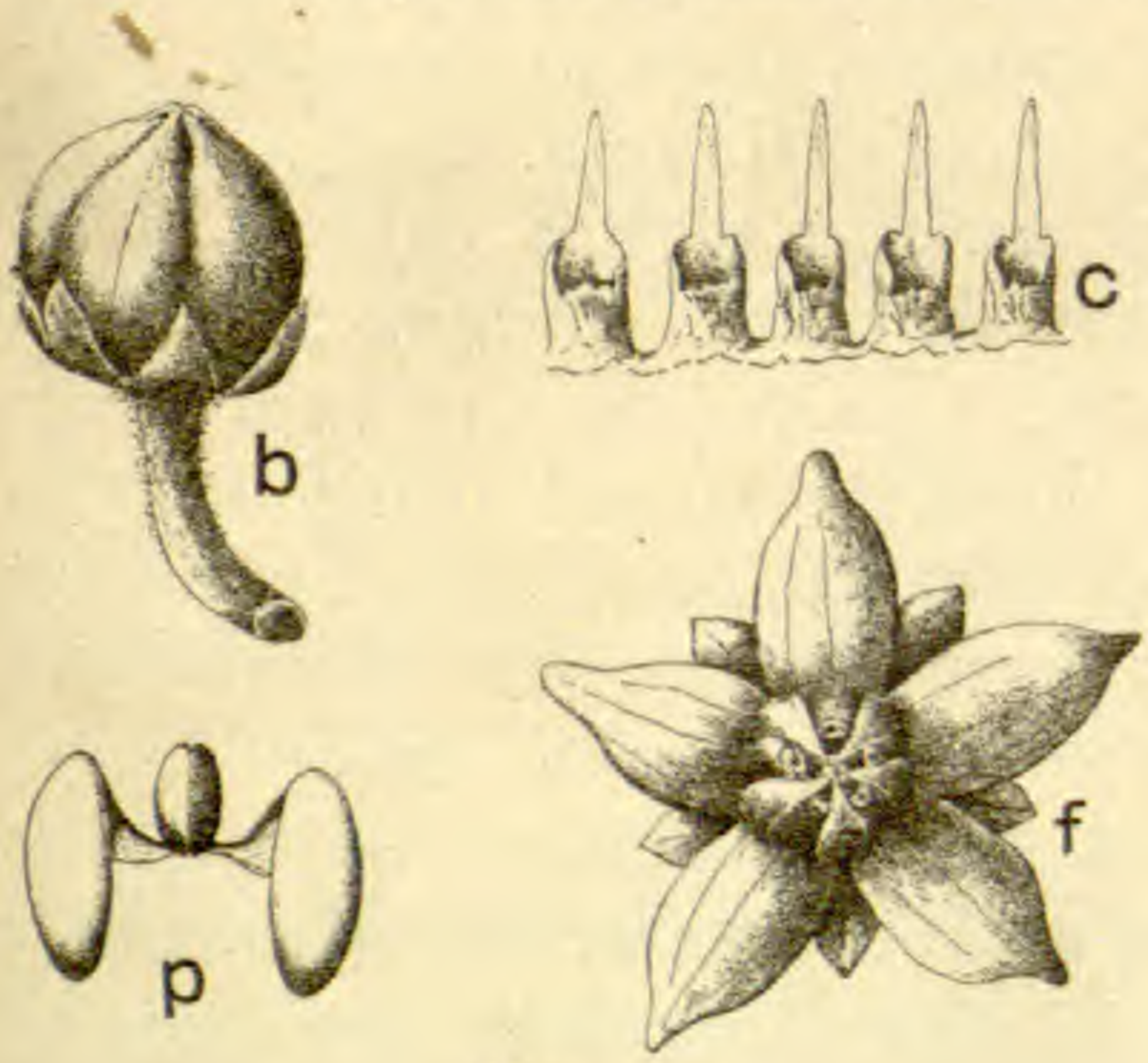

FIG. 4.

infolded lateral lobes : stigma rounded at the apex, scarcely conic : pollinia oblong ; caudicles broad and short, with a deep orange-yellow spot along the upper margin ; corpuscle large, bright red. Fruit not seen. (*Fig. 4.*)

Type locality, Cartagena, U. S. Colombia.

GUATEMALA : Patulúl, Depart. Sololá, alt. 3000 pp., *Heyde et Lux, 6349*, January, 1894.

VENEZUELA : near Tovar, *Fendler, 1055* (in herb. Gray).

5. **Rouliniella lignosa** sp. nov.

A woody vine. Stems pale grayish-brown, glabrous : branches 2–3 dm. long or more, somewhat angled, minutely tomentulose in lines, becoming glabrate : leaves opposite, on petioles 1.5–4 cm. long ; blades ovate or sub-lanceolate, cordately hastate, 3–6 cm. long, gradually acuminate, rather thick, yellowish-green, glabrous above, minutely pubescent on the veins beneath ; basal lobes rounded, short, with an open sinus, glandulose at the base of the midvein : peduncles longer than the petioles, pubescent : racemes slender, 5–7 cm. long, exceeding the leaves, 9–15-flowered : buds ovate : bractleoles very small, setaceous : pedicels 7–9 mm. long, slender, pubescent : calyx-segments ovate-lanceolate, 1 mm. long, puberulent with a minute gland in each sinus : corolla 5-parted to near the base, dull yellowish-purple, acute in the bud ; segments 6 mm. long, acute, minutely hispidulous on the inner surface, with a callous ridge within the membranous whitish revolute margins : crown attached to the base of the column, 5-parted to the base ; segments very thin, with somewhat involute lateral margins, prolonged into a long-ligulate obtuse or truncate apex, which is nearly as long as the corolla-segments : anther-wings very narrow and slender, not salient at the base : anther-tips ovate, inflexed over the barely conic, obscurely 5-rayed stigma : pollinia broadly oblong-ovoid ; caudicles broad ; corpuscle obtuse at the apex. Follicles not seen. (*Fig. 5.*)

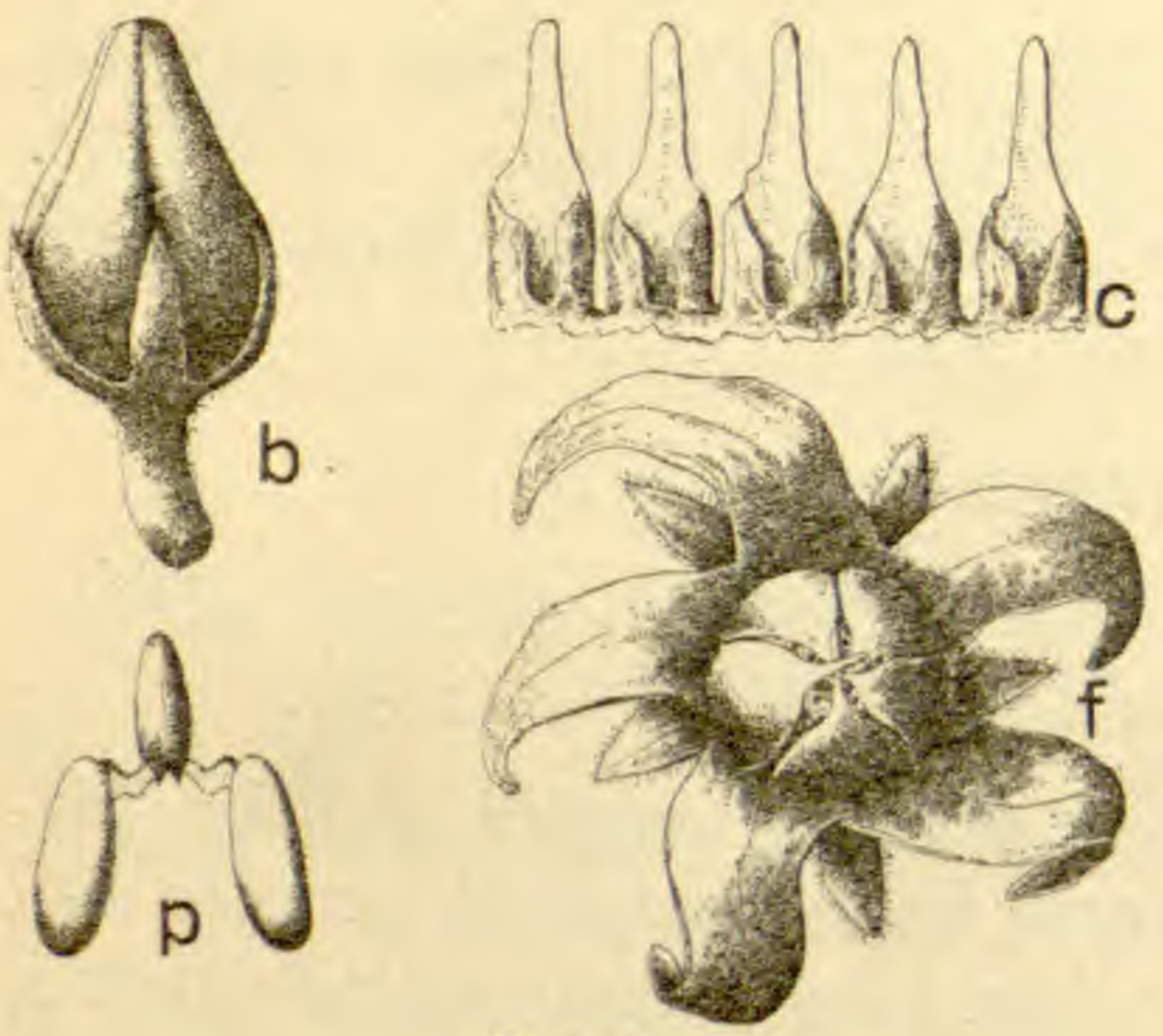

FIG. 5.

MEXICO : State of Jalisco, Rio Blanco, 1886, *Palmer, 314* ; (herb. Columbia University) : "*Cynanchum parviflorum*" Pavon, in herb. Kew: Oaxaca, *Ghiesbreght* (also in herb. Kew). The last two specimens are cited in Hemsley, Biol. Centr. Am. **2**: 329 under *Roulinia Jacquini.*

Differing from *R. unifaria* and *R. racemosa* in its more woody stem and lighter green thicker leaves. It has the crown-segments of *R. racemosa* but the pollinia of *R. unifaria.*

6. **Rouliniella foetida** (Cav.)

Asclepias foetida Cav. Ic. **2**: 45. *pl. 158.* 1793.
Cynanchum foetidum H.B.K. Nov. Gen. Sp. **3**: 202. 1818?
Roulinia Jacquinii DC. Prodr. **8**: 517. 1844. *Excl. syn.*

A slender twining vine. Stems glabrous or with a narrow puberulent line: petioles slender, 3–7 cm. long: leaves opposite; blades ovate or some of the smaller ones ovate-lanceolate, 5–11 cm. long, acuminate at the slender apex, cordate at the base with open sinus and rounded basal lobes, puberulent on the veins beneath: flowers 8–12 mm. in diameter in small sub-umbellate clusters; buds ovate: peduncles minutely puberulent, 2–3 cm. long, commonly shorter than the petioles: calyx 1.5 mm. long; segments linear-oblong, acutish at the apex, minutely ciliate, with a large gland in each sinus: corolla 6–7 mm. long, dull-greenish, fleshy, glabrous on the outer surface, whitish or cream color? with two raised puberulent callous ridges or crests along the upper portion within; crown-segments white, very thin, 5, the lateral margins infolded and adnate to the inner surface, the long ligulate apex very slender, as long as the corolla segments or nearly so: anther-wings long and narrow: pollinia oblong, on short broad pale yellow caudicles; corpuscle reddish, rounded at the apex, narrower at the bifid base: stigma barely conic, 5-rayed: follicles angled and winged. Mature follicles not seen. (*Fig. 6.*)

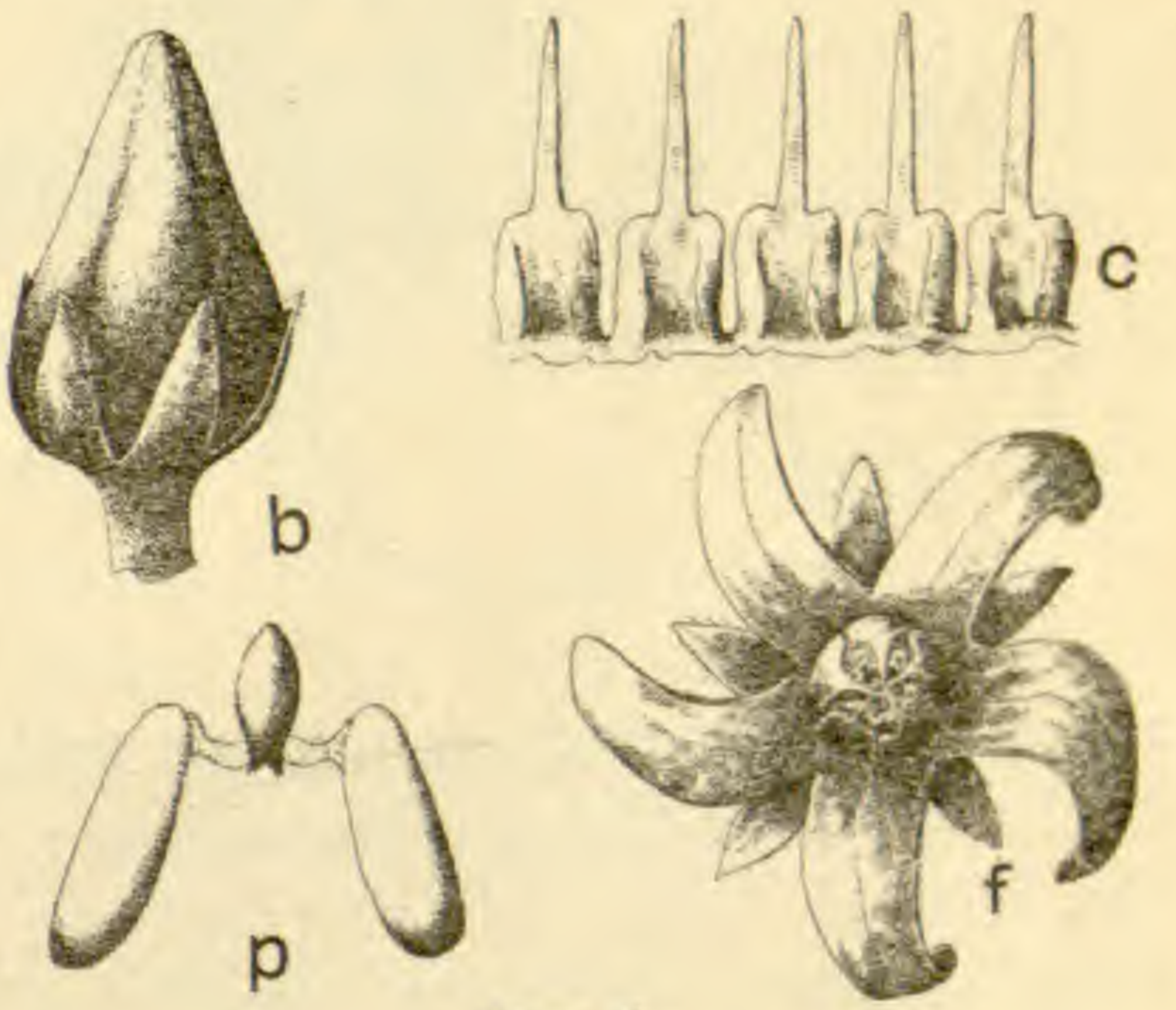

FIG. 6.

MEXICO: Oaxaca, *Galeotti, 1538* (in herb. Kew); near Oaxaca, alt. 1600 m., 1896, *C. Conzatti, 217;* Valley de Etla, Sept. 1895, *C. Alvarez, 768;* Huitzo, alt. 1700 m., 13 Aug. 1897, *C. Conzatti & V. Gonzales, 336* (in herb. Gray).

The plant from which the Cavanilles figure was drawn is said to have been grown at the Royal Botanic Garden, Madrid; and was native of Mexico. It agrees well with the specimens just cited, though in detail the central lobe of the crown-segments seem shorter.

7. **Rouliniella Jaliscana** sp. nov.

A twining vine. Stems glabrous, angled: branches glabrous or with a narrow puberulent line above: petioles channeled? 2–7 cm. long or more, glabrous or minutely puberulent: leaves opposite; blades 4–12 cm. long, ovate-oblong, abruptly acuminate at the apex, truncate at the base, dark green or glabrous above, paler, glabrous or minutely puberulent on the veins beneath: racemes shorter than the leaves, 8–12-flowered: buds ovate: peduncles minutely puberulent in lines, channeled: calyx-segments oblong, obtuse, 2 mm. long, minutely ciliate, oblong-linear: corolla-segments 4–5 mm. long, broadly obtuse or truncate at the obtuse somewhat ligulate revolute apex, with a narrow callus incurving ridge or crest on each side near the middle within: crown-segments white, 3-lobed, the lateral lobes infolded within; the central lobe long-ligulate, very slender, undulate, nearly as long as the corolla-segments: anther-wings very short, corneous: stigma 5-rayed, flattish: anther tips semi-orbicular, inflexed: pollinia oblong, pyriform on long slender caudicles: corpuscle lozenge-shaped. Follicles not seen. (*Fig. 7.*)

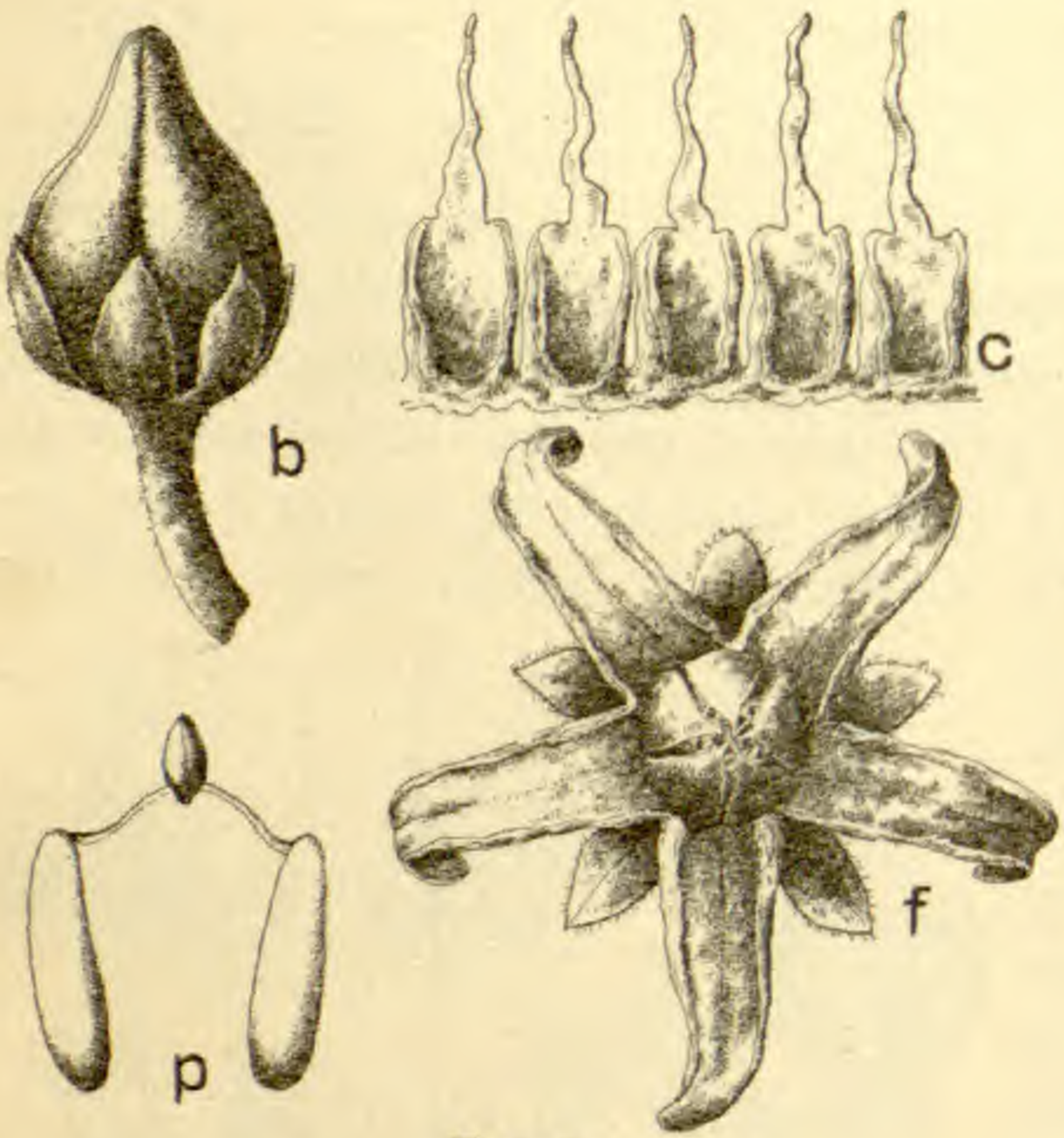

FIG. 7.

MEXICO: State of Jalisco, *Palmer, 384*; State of Jalisco, *Pringle, 4494*; Orizaba, *Botteri*. (Type in herb. of the New York Botanical Garden.)

NEW YORK BOTANICAL GARDEN.

American Ferns — V. A Review of the Genus Danaea

BY LUCIEN MARCUS UNDERWOOD

While the two genera *Marattia* and *Angiopteris* have received various attention at the hands of botanists, systematic and otherwise, the American genus *Danaea* has always been passed over and, except for the additions of species which have been made to it from time to time, has never received a special revision. There are numerous papers on the morphology, anatomy, and development of both *Marattia* and *Angiopteris*, but almost nothing has been done with any of the much more simple species of *Danaea*. De Vriese and Harting monographed the family Marattiaceae in 1853 * but did not include the genus *Danaea*.

In *Synopsis Filicum*, 1874, Baker recognized eight species of *Marattia*, one of *Angiopteris*, one of *Kaulfussia*, and thirteen of *Danaea*, although De Vriese and Harting had separated thirty species of *Marattia* (which they has distributed among five genera), four of *Kaulfussia*, and sixty of *Angiopteris*. In New Ferns, 1892, Baker adds two species of *Danaea*, bringing the number now recognized at that centre to fifteen. Besides the above genera, the family contains the old world genus *Archangiopteris* recently established with one Chinese species. We have two species of *Marattia* (*M. laxa* and *M. alata*) in tropical North America and a third species (*M. Douglasii*) in the Sandwich Islands.

The genus *Danaea* is strictly American, extending from Cuba and southern Mexico to Brazil, and is represented by ferns of a more or less coarse habit. The leaves are simply pinnate (or simple in one South American species) and dimorphous, the sporophylls being usually much smaller, with the under surfaces of the pinnae covered with the parallel linear synangia, each composed of rows of cells or cavities opening by a terminal pore. *Danaea* thus forms a group that is easily recognized when the sporophylls are present. Like its living and fossil congeners *Danaea* has free veins as would be expected in a simple and probably very old type of fern allies.

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* De Vriese & Harting, Monographie des Marattiacées. Folio, i–viii, 1–60. *pl. 1–9.* Leide et Dusseldorf. 1853.

A study of the material represented in the principal American herbaria together with that in the Berlin, Kew, and Cosson[*] herbaria in Europe has led me to recognize a larger number of species from north of the Isthmus of Panama than has been usual. A preliminary study is here presented in the hope that it will serve to bring out additional light regarding several of the species now imperfectly known.

Synopsis of the North American Species

- Pinnae of sterile leaves 2.5–8 cm. broad.
  - Stipes without nodes; sporophylls with 8–10 pairs of pinnae which are 12–18 cm. long and rounded at the base. 1. *D. nodosa.*
  - Stipes with 1–3 nodes.[†]
    - Leaves rounded and abruptly acuminate at the apex; lowest pinnae scarcely half as large as the upper. 2. *D. polymorpha.*
    - Leaves tapering to the apex. 3. *D. elliptica.*
- Pinnae of sterile leaves under 2.5 cm. wide.
  - Leaves with a single terminal pinna; stipes nodose.
    - Veins mostly simple, only rarely forking.
      - Veins 1 mm. or more apart.
        - Intercostal spaces about 6 to 1 cm. 4. *D. alata.*
        - Intercostal spaces 8–10 to 1 cm. 5. *D. Fendleri.*
      - Veins less than 1 mm. apart.
        - Intercostal spaces 12–13 to 1 cm. 6. *D. stenophylla.*
        - Intercostal spaces 18–19 to 1 cm. 7. *D. cuspidata.*
    - Veins mostly forked.
      - Margins eroded and curly throughout. 8. *D. crispa.*
      - Margins entire or serrate at the apex.
        - Pinnae of sterile leaves acuminate at apex; sporophylls with pinnae 5–7 cm. long. 9. *D. Jamaicensis.*
        - Pinnae of sterile leaves merely acute.
          - Sporophylls with pinnae only 3–4.5 cm. long. 10. *D. Wrightii.*
          - Sporophylls with pinnae 8–9.5 cm. long. 11. *D. Mazéana.*
  - Leaves with a pair of terminal pinnae; veins forked; intercostal spaces about 12 to 1 cm. 12. *D. Jenmani.*

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[*] The Cosson herbarium in Paris is one of the finest private herbaria in the world and is specially rich in materials from South America. It is particularly interesting to students of ferns because it has incorporated with it Fée's extensive collection rich in types from the West Indies, Mexico, Guiana, and Brazil. We have been greatly indebted to M. Barratte, the custodian, for his kindness in permitting us to examine this rich collection while in Paris in 1900.

[†] A species from Guadeloupe with nodose stipes resembles *D. nodosa* in the character of its foliage, but has sporophylls with only 5–6 pairs of pinnae. It doubtless represents a distinct species of which we have drawn up a MSS. description but this had perhaps best wait more complete information before publication.

1. DANAEA NODOSA (L.) Sm. Act. Taur. **5**: 420. *pl. 9. f. 11*

Acrostichum nodosum L. Sp. Pl. 1070. 1753. (Type from Martinique and Santo Domingo, Plumier, *pl. 108.*)

Danaea longifolia Desv. Berl. Mag. **5**: 307. 1811; Sturm, Fl. Bras. **2**^{1}: 157. *pl. 11.* 1859.

A stout coarse plant with long broad pinnae and no nodes to the stem. Stipes strong, 40–60 cm. long, erect, covered with fine furfuraceous scales; sterile leaves with 6 to 12 pairs of pinnae, which are 16–30 cm. or more long, 3–8 cm. wide, stalked and obtuse at the base, abruptly narrowed and acuminate at the apex; veins free or forked near the base, close, the intercostal spaces 13–15 to 1 cm.; sporophylls with 8–10 pairs of pinnae which are 14–18 cm. long, 1.5–2 cm. wide, obtuse at base, acuminate at apex.

Moist woods, West Indies generally and Mexico to Brazil. The rachis is darkened and nodular at the insertion of the pinnae but below the laminathe stem is free from nodes. A sub-species β *angustifolia*, Moore, Ind. Fil. 287. 1861 (*Danaea angustifolia* Presl, Suppl. Tent. Pterid. 35. 1845) will require more field study to distinguish more clearly.

North American specimens have been seen as follows:

CUBA: La Guinea, *Wright, 1815*, KECN;* Monte Verde, *Wright, 924*, CEKN.

PUERTO RICO: *Sintenis, 2596*, K; *ibid., 1757*, N.

SANTO DOMINGO: *Eggers, 2737*, K; [*Plumier*].

JAMAICA: 1844, *Purdie*, KE; 1884–5, *Balch*, C; *Jenman, 92*, K; *Clute, 270a*, U.

MARTINIQUE: *Husnot, 259*, K [*Plumier*].

GUADELOUPE: *L'Hermmier, 215*, KE; *Mazé, 64*, K.

DOMINICA: *Eggers, 963* K.

ST. VINCENT: *Guilding*, K; *Smith, 1129*, C.

GRENADA: *Sherring*, KC.

TRINIDAD: *Fendler*, 129, CKEUN.

PANAMA: *Cuming*, 1125, K.

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* As noted in a previous paper of this series these letters refer to the herbaria in which the specimens noted have been seen. B = Berlin; C = Columbia University and New York Botanical Garden herbarium, now incorporated together; Co = Cosson herbarium at Paris; E = D. C. Eaton's herbarium, New Haven, Conn.; G = Gray herbarium, Cambridge, Mass.; K = Kew herbarium; N = National herbarium, Washington, D. C., and U = the author's private herbarium.

2. DANAEA POLYMORPHA Leprieur; Baker, Annals Bot. **5**: 499. 1891; New Ferns, 116. 1892

Stipes of sterile leaves with one or two nodes, bearing 3–4 pairs of pinnae and an enlarged terminal one, the lowest pair scarcely half as large as the upper; terminal pinnae 15–20 cm. long, 5–6 cm. wide, abruptly acute at base, rounded at the apex and abruptly acuminate; upper pinnae 10–12 cm. long, 4 cm. or more wide, broadest above the middle, obovate, rounded and abruptly acuminate at the apex; lowest pinnae similar but smaller, 7–9 cm. long, 3 cm. or less wide; all the pinnae distinctly stalked; veins forked, about 1 mm. apart above the furcation; stipe of sporophylls up to 45 cm. long, with one or two nodes, and bearing 3–5 pairs of pinnae and a larger terminal one which is 12–13 cm. long and about 3 cm. wide; stalk of terminal pinna about 3.5 cm. long, of the lateral 5–8 mm.

GUADELOUPE: *Mazé, 483, 1028* (type), K.

Although Baker's description was based on Mazé's plants in the Kew herbarium there are plants in the Cosson herbarium collected and named by Leprieur himself from Guiana. These are mostly smaller and have fewer pinnae than the Kew material.

3. DANAEA ELLIPTICA Sm.; Rees' Cyclopedia, **11**: —(82). 1819. (Type from Jamaica, Sloane, *pl. 41. f. 1*)

A low coarse plant with 7–9 wide elliptic pinnae and nodose stems. Rootstock long, creeping; stipes 15–35 cm. long, more or less furfuraceous, usually with two distinct nodes; lamina of sterile leaf with 7–9 pinnae which are 12–15 cm. or more long, 3–4 cm. wide, acute at base and terminate in a slender acuminate apex; veins mostly forked near the base, the intercostal spaces about 10 to 1 cm.; laminae of sporophylls with 9–13 pinnae which are 6–8 cm. long, 2 cm. or less wide, acute at base and tapering at apex; synangia oblique.

Common from the West Indies to Brazil.

CUBA: Lomo del Gato, *Wright, 1816*, CKEN.

JAMAICA: *Jenman, 6*, K; *Purdie*, K.

ST. VINCENT: *Guilding*, K.

ST. LUCIA: *J. Gray*, K; *H. B. Murray*, K.

GUADELOUPE: *Mazé, 1067*, K.

DOMINICA: 1839, *Dr. Imray*, N.

GRENADA: *Sherring*, CK; *Murray & Elliott*, K.

TRINIDAD: *Fendler, 28*, CKUEN; 1897, *Hart*, CK; *Cruger*, K.

In the report on Fendler's Trinidad ferns Professor D. C. Eaton remarks: "The distinctions between this and *D. nodosa* are by no means clear. Mr. Charles Wright, who has had good opportunities for observing both in Cuba, considered them forms of but one species." With Eaton's herbarium before me there seems to be no reason for any such confusion. The Cuban specimens of this species are slightly smaller but the above characters hold quite constantly.

Jenman also calls attention to intergrading forms but says they can be distinguished readily by the nodose character of the stems of this species.

4. DANAEA ALATA Sw. Syn. Fil. 167. 1806. (Type from Martinique, Plumier, *pl. 109*)

A coarse plant with distant simple veins and broadly winged rachises. Rootstock unknown (except from Plumier's figure); stipes stout, more or less rusty scurfy, usually with one node; rachises broadly alate; pinnae 11–12 pairs, the lower 2–3 pairs smaller and widely separate, the upper gradually closer, rounded obtuse and unequal-sided at base, the apex more tapering, long-pointed and denticulate; sterile pinnae 12–16 cm. long, 2–2.2 cm. wide; veins mostly simple, the intercostal spaces about 6 to 1 cm.; sporophylls with 8–10 pinnae, which are linear, 8.5 cm. long, 7 mm. wide, abruptly acute at base, taper-pointed at apex, the upper gradually narrower, the terminal much like the rest.

ST. VINCENT: *Guilding*, K; 1834, *Macrea*, E; *Smith, 279*, K.

GRENADA: *Sherring*, C.

[MARTINIQUE: *Plumier*.]

Guilding's St. Vincent plant agrees perfectly with Plumier's *pl. 109* on which the species was founded, and I cannot comprehend how Jenman * could have been led to refer to this plate as representing *D. stenophylla*, which is a wholly distinct species, and which has been well figured by its author.

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5. **Danaea Fendleri** sp. nov.

A somewhat slender plant with small sporophylls and simple veins. Rootstock moderately slender, creeping or ascending; stipes of sterile leaves 12–15 cm. long, with 1–3 nodes; pinnae 6–9 pairs beside the terminal one, opposite, about 2 cm. apart except the lowest pair, short, cuneate at base with the upper side

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* Bull. Bot. Dept. Jamaica, 5: 189. Au. 1898.

slightly more produced, 6–9 cm. long, 1.5–2 cm. wide, abruptly short-pointed with the apex sharply denticulate: veins mostly simple, the intercostal spaces 8–9 to 1 cm.; stipes of sporophylls 14–24 cm. long with about 9–11 pairs of pinnae besides the terminal, unequally rounded at base, sharp-pointed, 6–9 cm. long, 2 cm. wide; rachis winged; terminal pinna about the length of those of the upper pairs.

Southern West Indies.

TRINIDAD: *Fendler, 147*, C (type) EKN.

GRENADA: *Sherring*, K.

DOMINICA: *Nicholls, 194*, K.

ST. LUCIA: *H. B. Murray*, K.

? MARTINIQUE: *Hahn, 59*, K. This plant approaches *D. Fendleri* very closely but has the pinnae slightly larger.

The species approaches *D. alata* closely but is smaller, has more closely placed veins, and a very different habit.

6. DANAEA STENOPHYLLA Kunze, Die Farrnkräuter, 1: 55. *pl. 28*. 1840

A small species with long-stalked sporophylls and closely placed simple veins. Rootstock unknown; rachises covered with a scurfy brown pubescence; sterile leaf with about 14 pairs of narrow pinnae and a similar terminal one, all short-stalked, about 1.7 cm. apart, rounded at base, tapering rather gradually to a sharply denticulate point, 11–14 cm. long, 1.5–1.8 cm. wide; veins mostly simple, the intercostal spaces about 12 to 1 cm.; stipe of sporophyll elongate, 65 cm. long, with 12–14 pairs of pinnae besides the terminal, 7–8.5 cm. long, 5–7 mm. wide, short-stalked, accurately rounded at base and rather abruptly acute at apex.

GUADELOUPE: *L'Herminier, 213*, K (ex. herb. Fée).

This species appears to be known only from this island, though Jenman confused another species with it and reported it as "plentiful" in Jamaica. Presl (Suppl. Tent. Pterid. 38. 1845) made this species the type of the genus *Heterodanaea*, but we see now no reason for separating it from the rest of the genus.

7. DANAEA CUSPIDATA Liebm. Mex. Bregner, 155. 1849

Stipe of sterile leaves with mostly two nodes, 25 or more cm. long; pinnae 14–19 pairs, 8.5–10 cm. long, about 1.5 cm. wide, rather blunt at base, tapering gradually into a long-acuminate point; veins mostly simple, occasionally forked close to the midrib, very close, the intercostal spaces 18–19 to 1 cm.; margins slightly undulate, serrate toward the apex; stipes of sporophylls up to 50 cm. long, usually with two nodes; pinnae about 15 pairs, narrow and elongate, 8–9 cm. long, about 7 mm. wide, rounded at base, tapering in upper third to a slender point; synangia growing smaller and more oblique towards the sterile serrulate apex.

MEXICO: Chinantla, *Liebmann*, B.

GUATEMALA: Pansamalá, *H. von Juerckheim* (J. D. S. 998), SK.

This species has been little known since its original collection by Liebmann. The fact that there was no specimen at Kew was sufficient reason for passing it over in *Synopsis Filicum* with Moore's doubtful reference of the plant to *D. stenophylla* which is possibly its nearest ally but from which it is clearly distinct. There is a single fragmentary specimen at Berlin and this compares very closely with the later Guatemalan collections, but both were erroneously placed under *D. stenophylla*. Its specific rank was maintained by Fournier; further field study will determine its position more closely.

8. DANAEA CRISPA Endres; Reich. f., Bot. Zeitung, **30**: 489. 1872. (Type from Costa Rica)

We have seen only scrappy specimens in the herbarium of J. Donnell Smith, and can add nothing to the original description.

12259 9. **Danaea Jamaicensis** sp. nov.

A low, coarse plant with acuminate sterile pinnae and narrow pointed pinnae on the sporophylls. Rootstock unknown; stipes pale, 18–24 cm. long, with 2–4 nodes; sterile leaves with a terminal and 11–12 pairs of pinnae, about 2 cm. apart except the lowest pair which is smaller, 10–14 cm. long, 1.7–1.9 cm. wide, tapering rather abruptly into a slender deeply serrate acuminate point; veins mostly forked, the intercostal spaces about 12–14 to 1 cm. (measured above the furcations); sporophylls with about 8–12 pairs of pinnae, about 2 cm. apart, short-stalked, 5–7 cm. long, 5–7 mm. wide, obtuse at base and tapering at apex; rachis somewhat alate above.

✓JAMAICA: *Clute, 105*, U (type) N; *Jenman, 83*, K; *Purdie*, K; *Harris, 7307*, K; *Hart*, C.

This appears to be the species confused by Jenman with *D. stenophylla* with which it has little in common, while both the Kew specimens enumerated above are placed under *D. Moritziana*. *D. Moritziana* is from Colombia and has the pinnae of the sterile leaf quite different in shape, tapering toward the cuneate base and much more gradually toward the apex; intercostal spaces 16–17 to 1 cm. According to Jenman it is "plentiful in moist stony forests 5,000 ft. altitude." It is not impossible that the true *D. Moritziana* will also be found in Jamaica but so far we have seen no specimens.

1977

10. **Danaea Wrightii** sp. nov.

A low-growing coarse plant with blunt sterile pinnae, small narrow pinnae on the sporophylls and forked veins. Rootstocks almost woody; stipes of sterile leaves 24–28 cm. long, usually with two nodes; pinnae 8–12 pairs, about 2 cm. apart, with a terminal pinna considerably longer than those of the upper pairs, all distinctly stalked, unequally rounded or blunt at the base, 6–7 cm. long, 2 cm. or less wide, the margin becoming serrulate toward the blunt apex; lower pairs of pinnae smaller and more distant (3–4 cm.); veins mostly once forked, the intercostal spaces 11–15 to 1 cm.; stipe of sporophylls stout, rusty-scurfy, with 8–12 pairs of pinnae, 3–4.5 cm. long, 6–8 mm. wide, distinctly stalked (5–8 mm.), the lower pair often distant and smaller, all blunt at both ends and mucronate at apex.

✓CUBA: La Guinea, "abundant on the steep northern declivity," *Wright, 1066*, E (type) KN.

PUERTO RICO: *Sintenis, 4681* C, (sterile specimens but apparently the same species).

This species is clearly distinct from any other of our series in the elongate terminal pinna and the long-stalked short blunt pinnae of the sporophylls.

1977

11. **Danaea Mazéana** sp. nov.

Rootstock unknown; stipes of sterile leaves stout, 30–35 cm. long, brownish, with 2–4 nodes; pinnae 11–14 pairs, about 2 cm. apart, with a terminal pinna slightly longer than those adjacent, 11–12 cm. long, about 2 cm. wide, acute and serrate at apex: veins mostly forked, the intercostal spaces (measured above furcations) 12–13 to 1 cm.; stipes of sporophylls 40–50 cm. long, with 2–3 nodes and 13–14 pairs of narrow pinnae, 1.7–2 cm. apart, 8–9.5 cm. long, 6–7 mm. wide, the lower pairs rather smaller and more distant, short-stalked, rounded at the base, and narrowed to a rounded point at the apex.

GUADELOUPE: *Mazé*, "*11, 143, 485*" (two sheets), K.* Although both are exactly alike, one of the Kew sheets is marked *D. stenophylla* by Baker, and the other occurs under cover with *D. alata* with neither of which it is closely related. The plant is known only from the type collection.

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12. **Danaea Jenmani** sp. nov.

Rootstock (as far as known) horizontal, rather stout; stipes brown scurfy, those of sterile leaf 10–11 cm. long, usually with one node; pinnae 7–9 pairs, opposite, 2–3 cm. apart, obtuse at base with a short pedicel, 4.5–6 cm. long by 1.8 cm. wide, abruptly short-pointed, the margin more or less serrulate at the apex; rachis scurfy, more or less alate; veins mostly forked, the intercostal spaces about 12 to 1 cm. above the furcations; basal and terminal pairs of pinnae shorter than the others; sporophylls with about 11 pairs of pinnae, 5–8 mm. apart, 3 cm. long, 5 mm. wide, mostly blunt and short-stalked.

JAMAICA: *Jenman, 66*, K (type); woods above Tweedside, between that property and New Castle, 1882, *Miss Taylor*, K.

This is the species called *D. alata* by Jenman, and although he calls it "frequent" in Jamaica it appears to be very rare in collections. It is clearly characterized as the only species with abruptly pinnate leaves and has little in common with *D. alata*.

SPECIES INQUIRENDAE

DANAEA ELATA Liebm. Mex. Bregner, 154. 1849. (Type from Hacienda de Jovo, Vera Cruz, Mexico.)

This is doubtless a well-founded species and is so accredited by Fournier, but we have seen no specimens.

DANAEA MEDIA Liebm. Mex. Bregner, 154. 1849. (Type from Hacienda de Jovo, Vera Cruz, Mexico.)

Reduced by Fournier to a synonym of *D. elliptica*, probably rightly, but as we have seen no specimens it is safer to leave the matter in doubt, especially as Moore refers it to *D. alata*.

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* The Kew herbarium is the most fortunate possessor of the finest collection of the ferns of the French West Indies anywhere to be found. The collections were made principally in Guadeloupe by Mazé and afford superior information concerning the flora of this island. Many of the specimens had been studied by the lamented Fournier, and there are numerous species noted as new by both Fournier and Mazé himself. Some of the sheets bear curious numbers, of which the present is an example, occurring on both sheets.

Danaea Wendlandi Reich. f., Bot. Zeitung, **30** : 490. 1872. (Type from Costa Rica, *Wendland.*)

We have seen no specimens of this species, which appears to be known only from its original collection.

Danaea sp. Pinnae about 30 pairs, 7.5 cm. long, 1.5 cm. wide, or the lower slightly smaller, truncate at base, abruptly long-acuminate at apex ; veins mainly free with occasional ones forked, the intercostal spaces about 11 to 1 cm.; rachis continuously winged throughout, the wing 1 mm. wide.

Nicaragua : Chontales, *Seemann, 218*, K ; a single sterile leaf but wholly different from any other species in that extensive collection. In Biologia Cent. Amer. **3** : 697 this plant is referred to *D. Moritziana* with which it has little in common.

Danaea sp. Pinnae 12–12 pairs ; veins simple, close, the intercostals about 17 to 1 cm.; rachis winged, the wings broadest just below each pair of pinnae and becoming narrower and almost wanting just above them.

Costa Rica : *J. J. Cooper*, K ; two sterile leaves only but with characters unlike any known species. Baker (Jour. Bot. **25** : 26. 1887) says of it : "*Danaea Moritziana var.* or perhaps a distinct species." It is surely not the former.

Danaea oligosora Fourn. said to have been collected in Guadeloupe but apparently never described. Said by Baker (Annals Bot. **5** : 499) not to differ materially from *D. polymorpha.*

The remaining described species of the genus are as follows :

Danaea Augustii Karst. ; Kunze, Linnaea, **20** : 2. 1847. (Type from Venezuela.)

Danaea dubia Presl, Suppl. Tent. Pterid. 36. 1845. (Type from Rio de Janeiro, Brazil.)

Danaea humilis Moore, Ind. Fil. 286. 1861. (Type from Peru, *Spruce, 4769.*) (Moore also gives Colombia and Ecuador in its distribution.)

Danaea Leprieurii Kunze, Die Farrnkräuter, **1** : 137. *pl. 60.* 1840. (Type from French Guiana.)

Danaea Moritziana Presl, Suppl. Tent. Pterid. 35. 1845. (Type from Venezuela, *Moritz 257.*) (*Synopsis Filicum* gives its distribution as "Columbia to Peru.")

DANAEA NIGRESCENS Jenm. Gard. Chron. III. **24**: 413. 1898. (Type from Guiana.)

? DANAEA PALEACEA Raddi, Fl. Bras. 76. *pl. 5. f. 2.* 1819. (Type from Brazil.) A doubtful species on which Presl founded the genus *Danaeopsis.*

DANAEA SELLOWIANA Presl, Suppl. Tent. Pterid. 37. 1845; Corda, Beitr. Fl. Vorw. *pl. 51. f. 18–23.* 1845. (Type from Brazil.)

DANAEA SERRULATA Baker, Jour. Bot. **19**: 208. 1881; Hook. Ic. Pl. *pl. 1699.* (Type from Colombia, *Kalbreyer, 1352.*)

DANAEA SIMPLICIFOLIA Rudge, Pl. Guian. **1**: 24. *pl. 36.* 1835. (Type from Guiana.)

DANAEA TRICHOMANOIDES Spruce; Moore, Ind. Fil. 288. 1861. (Type from Peru, *Spruce, 4710.*)

DANAEA TRIFOLIATA Reich.; Kunze, Anal. Pter. 4. *pl. 2.* 1837. (Type from Surinam.)

Studies on the Rocky Mountain Flora—IX

By P. A. Rydberg

THE NYCTAGINIACEAE OF THE ROCKY MOUNTAIN REGION

The family Nyctaginiaceae has been sorely neglected by the systematic botanists in this country. Until lately we have had not even an attempt at a monographic work since Dr. Gray's notes were published in the Botany of the United States and Mexican Boundary Survey in 1859. Gray's treatment there as a whole can scarcely be regarded as an improvement on that by Choisy, published ten years earlier in De Candolle's Prodromus, and of course, both are now out of date. Professor Heimerl's treatment in *Die natürlichen Pflanzenfamilien* is as good as could be expected from a European monographing an almost exclusively American family; but this gives little help beyond the genera. Recently there has appeared a revision of the family by Marcus E. Jones * as it is represented on the Great Plateau. As the territory covered by Jones practically includes that treated in this article, it would seem superfluous to duplicate the work; but I have had the advantages of a large library and the rich collections of Columbia University, the United States National herbarium, and the New York Botanical Garden. These advantages are, however, somewhat balanced by Mr. Jones' longer field experiences. Jones' paper is valuable because it gives fuller descriptions of many poorly known species, descriptions drawn by a botanist who knows the species in the field. It is deplorable, however, that this paper in many places shows a good deal of carelessness, especially in the matter of citing publications. Under *Allionia*, it has for instance:

"5. A. GLABER † (Wats.) Kuntze, Am. Nat. 76," and

"7. A. AGGREGATA (Vahl) Spreng. Ic. 5 437."

In the first case, one would suppose that Kuntze published the combination in the American Naturalist, while the fact is that Watson there published *Oxybaphus glaber*, on which *Allionia glabra* is based.

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* Contributions to Western Botany, 10: 34–54. June, 1902.

† This should have been *A. glabra*.

If interpreting the second case in a similar way, one would come to the conclusion that *Oxybaphus aggregatus* Vahl was published in Vahl's Icones, if not in Sprengel's Icones; but neither is the case, for no book with that title was ever published by either Vahl or Sprengel. From Mr. Jones' citation no one could imagine that Ic. 5 437, stands for Cavanilles' Icones, where *Mirabilis aggregata* appeared. This is not the earliest appearance of the name *aggregata*, however, for this was originally published by Ortega * as *Calyxhymenia aggregata*. As Cavanilles' plant is different from Ortega's, the former being *Allionia decumbens* (Nutt.) Spreng., the latter *A. agregata* (Ortega) Spreng. as shown below, Jones citation becomes not only unintelligible but also incorrect. It would have been much better to leave out the citation of publications altogether, which by the way is advisable for anyone who does not possess good library facilities.

Key to the Genera of the Rocky Mountain Region

Bracts distinct.
    Fruit crested or winged; bracts in a whorl at the base of the head-like cluster; perianth salverform. 1. *Abronia.*
    Fruit globular, neither crested nor winged; bracts attached each to a pedicel of the umbel-like or corymbose inflorescence; perianth funnelform. 2. *Hermidium.*
Bracts united.
    Fruit neither strongly tubercled nor winged.
        Fruit not ribbed; involucre herbaceous, little if any enlarging in fruit, not becoming membranous.
            Stamens usually 5; involucres campanulate, not enlarged in fruit. 3. *Quamoclidion.*
            Stamens 3; involucre rotate, somewhat enlarged in fruit in the manner of the next genus, but not membranous. 4. *Allioniella.*
        Fruit ribbed; involucre rotate, in fruit becoming much enlarged and membranous. 5. *Allionia.*
    Fruit with two rows of strong tubercles on the back and surrounded by two toothed inflexed wings. 6. *Wedelia.*

1. ABRONIA Juss. Gen. 448. 1789

Tricratus L'Her.; Willd. Sp. Pl. **1**: 807. 1799.

Cycloptera Nutt.; Gray, Am. Jour. Sc. II. **15**: 319. 1853.

In the original publication, no type species was mentioned. The genus was described from a plant collected on De la Peirouse's journey in California and cultivated by Mr. Colignon. Hooker in

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* Nov. aut Rar. Pl. **8**: *pl. 11*. 1798 (or 9?).

his Exotic Flora, *pl. 193 & 194*, identifies Colignon's plant as *Abronia umbellata*. The type of *Tricratus* is the same, and that of *Cycloptera* is *A. cycloptera*.

- Fruit narrowly winged or crested ; wings or crests not completely encircling the fruit.
  - Fruit biturbinate, *i. e.*, tapering at both ends, irregularly ridged or crested.
    - Flowers about 2 cm. long ; limb 5–10 mm. wide.
      - Bracts broadly obovate, over 1 cm. long. 1. *A. fragrans.*
      - Bracts ovate-lanceolate, less than 1 cm. long. 2. *A. nudata.*
    - Flowers about 1 cm. long ; limb 3–5 mm. wide ; bracts ovate to lanceolate-ovate, about 5 mm. long.
      - Petioles of the stem-leaves shorter than the very thick blades ; plant low, about 1 dm. high. 3. *A. pumila.*
      - Petioles of the stem-leaves much longer than the moderately thick blades ; plant slender, 2–4 dm. high. 4. *A. ammophila.*
  - Fruit turbinate or obpyramidal, *i. e.*, almost truncate above, distinctly winged ; the wings very broad above.
    - Plant almost acaulescent ; stem and leaves greatly surpassed by the long peduncles. 5. *A. nana.*
    - Plant with an elongated stem.
      - Bracts broadly ovate or obovate, acute or obtusish.
        - Stem distinctly viscid-pubescent ; leaves scabrous-puberulent ; bracts 1–1.5 cm. long.
          - Blades of the stem-leaves elliptic ; bracts broadly obovate, 12–15 mm. wide, obtusish. 6. *A. salsa.*
          - Blades of the stem-leaves lanceolate ; bracts oval, acute, about 6–7 mm. wide. 7. *A. fallax.*
        - Stem finely puberulent or glabrous ; leaves glabrous ; bracts 5–8 mm. long.
          - Stem puberulent. 8. *A. elliptica.*
          - Stem glabrous. 9. *A. glabra.*
      - Bracts oblong-lanceolate or lanceolate, attenuate or cuspidate.
        - Stem glabrous. 10. *A. lanceolata.*
        - Stem more or less pubescent.
          - Stem puberulent ; wings with double lamina, coriaceous. 11. *A. Carletoni.*
          - Stem villous ; wings with single lamina, membranous. 12. *A. villosa.*
- Fruit completely surrounded by the broad netted-veined membranous wings.
  - Flowers 3 cm. or more long ; limb about 1 cm. wide ; peduncles longer than the leaves. 13. *A. cycloptera.*
  - Flowers 1.5–2 cm. long ; limb about 5 mm. wide.
    - Stem glabrous or nearly so ; peduncles often nearly equalling the leaves. 14. *A. pedunculata.*
    - Stem densely pubescent ; peduncles at least in flower much shorter than the leaves. 15. *A. micrantha.*

1. ABRONIA FRAGRANS Nutt.; Hook. Kew Journ. 5 : 261. 1853

On the plains from South Dakota to Montana, Idaho, New Mexico and Kansas.

✓ 2. **Abronia nudata** sp. nov.

Perennial, stems very long and decumbent, sparingly hispidulous: leaves thick, glabrous; petioles 2–10 mm. long; blades broadly lanceolate, obtusish, 2–5 cm. long: peduncles 4–6 cm. long, almost glabrous: bracts ovate-lanceolate, less than 1 cm. long: flowers many, about 2 cm. long; limb 5–6 mm. wide: achenes very irregular, the inner ones of the head bipyramidal, thickest a little above the middle, crested, 8–10 mm. long, those of the margin very obliquely ovoid-fusiform, scarcely at all crested.

This species is nearest related to *A. fragrans* and *A. ammophila.* From the former it differs in the small bracts, smaller leaves and almost glabrous stem; and from the latter in the much longer flowers and the scanty or no pubescence.

MONTANA: Colgate, near Glendive, 1892, *Sandberg, MacDougal & Heller, 1016* (type in herb. N. Y. Bot. Garden).

3. **Abronia pumila** sp. nov.

Perennial, caespitose: stems ascending, about 1 dm. long, puberulent: leaves very thick, minutely puberulent; petioles 1–2 cm. long, those of the stem-leaves usually shorter than blades; these 1.5–3 cm. long, oval, elliptic or somewhat ovate: peduncles 2–3 cm. long, puberulent: bracts elliptic-ovate or lanceolate, 7–8 mm. long, short-acuminate: flowers about 12 mm. long; limb about 3 mm. wide: fruit bipyramidal, *i. e.*, tapering towards both ends but more so downwards, the greatest breadth being about one third from the apex, merely crested or the inner ones somewhat winged.

Dr. Heimerl referred this to *A. truncata* Torr., but the fruit is very unlike that of that species. *A. pumila* is nearest related to *A. ammophila*, from which it differs mainly in the thicker and short-petioled leaves and the dwarfed habit.

UTAH: Emery, 1894, *M. E. Jones, 5445q* (type in U. S. Nat. herb.); six miles up Salida Cañon, *5416a.*

4. ABRONIA AMMOPHILA Greene, Pittonia, **4**: 226. 1900

Abronia arenaria Rydb. Mem. N. Y. Bot. Garden, **1**: 137. 1900. Not Menz. 1827.

Yellowstone National Park.

5. ABRONIA NANA S. Wats. Proc. Am. Acad. **16**: 294. 1870

Southern Utah to Arizona and southern California.

6. **Abronia salsa** sp. nov.

Abronia fragrans S. Wats. King's Rep. **5**: 284. 1871. Not Nutt.

Perennial: stem ascending, 3–4 dm. high, densely viscid-pubescent especially above, stout: leaves very thick, puberulent; petioles 2–3 cm. long; blades oval or elliptic, obtuse, or the lowest rounded oval, 3–5 cm. long, 1–3 cm. wide: peduncles 5–7 cm. long, densely viscid-pubescent; bracts rounded obovate, about 15 mm. long and often as broad, pubescent: flowers many, about 2 cm. long with a limb about 4 mm. wide: fruit about 1 cm. long, similar to those of *A. lanceolata* and *A. fallax* but the wings are rather thicker.

The sheets in the National Herbarium bear the following labeling by Dr. Heimerl: "*Abronia fragrans* Nutt. (*ad formam* **ellipticam** (Nelson) *accidens!*);" but neither *A. salsa* nor *A. elliptica* A. Nelson have the fruit of *A. fragrans*, and therefore can not be regarded as forms of that species. *A. salsa* differs from *A. elliptica* in the stouter viscid-pubescent stem, the larger bracts and flowers. It grows in sandy saline soil at an altitude of 1000–1300 m.

UTAH: Salt Lake City, 1869, *S. Watson, 965* (type in herb. Columbia University); same locality, *Capt. Stansbury*, and 1871, *Hayden;* Silver Reef, 1894, *M. E. Jones;* Grand Junction, 1900, *S. G. Stokes.*

7. **Abronia fallax** Heimerl sp. nov.

Perennial; stem erect, almost shrubby below, branched, straw-color or white, viscid-pubescent above: leaves thick, puberulent, erect; petioles 1–2 cm. long; blades of the lower oval, of the upper long-lanceolate, 2–5 cm. long, 1–1.5 cm. wide, obtuse or the upper acute: peduncles 1–2 cm. long, densely viscid-pubescent; bracts 5–6, oval, about 1.5 cm. long, 6–7 mm. wide: flowers many, about 15 mm. long: fruit with the wings about 6 mm. wide and 8 mm. long, cuneate-obpyramidal.

The type in the U. S. Nat. herbarium bears the following remarks from the hand of Dr. Heimerl: "*Abronia fallax m.*—? *Hybrida ex A. fragrans et A. turbinata.*—*Ab A. fragrans anthocarpinis alis apice transverse dilatatis, ab A. turb. bracteis capitulorum magnis, scariosis diversa.*" * To me it seems that the plant has little to do with *A. fragrans* and is less related to *A. turbinata*

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* In a letter lately received from Dr. Heimerl, he has authorized me to use his name and notes.

than to *A. elliptica* A. Nelson. From this it differs in the upright stem, which is decidedly viscid-pubescent instead of merely puberulent.

UTAH: Salt Lake City, 1879, *M. E. Jones, 1337* (type in U. S. Nat. herb., also in herb. Columbia University).

8. ABRONIA ELLIPTICA A. Nelson, Bull. Torrey Club, **26**: 7. 1899

Wyoming and Colorado.

✓ 9. **Abronia glabra** sp. nov.

Perennial: stem ascending, about half a meter high, glabrous, straw-colored: leaves thick, glabrous; petioles 1–2 cm. long; blades oval to oblong, 1–4 cm. long, obtuse: peduncles oval, 2–4 cm. long, glabrous; bracts obovate or about 5 mm. long, acute: flowers 12–15 mm. long, numerous: fruit cuneate-obpyramidal, with the wings 4–5 mm. wide and 7–8 mm. long: wings very thick, of two lamina, semi-cordate at the apex: wingless tip of the fruit very short.

This species is intermediate between *A. elliptica* and the next species. From the former it differs in the glabrous stem and the stricter habit, from the latter in the broader and shorter bracts and the smaller flowers.

COLORADO: Grand Junction, 1883, *M. E. Jones* (type in U. S. Nat. herb.).

✓ 10. **Abronia lanceolata** sp. nov.

Perennial: stem glabrous, decumbent, several decimeters long: leaves rather thick, glabrous; petioles 2–3 cm. long; blades oblong-oval, 2–5 cm. long, 1–1.5 cm. wide: peduncles 5–15 cm. long; bracts 6–8, lanceolate, acute or acuminate, about 1 cm. long: flowers numerous, about 1.5 cm. long, with a limb 4–5 mm. wide: fruit with the thin wings about 8 mm. wide and about as long, cuneate-obpyramidal in outline, puberulent: wings strongly reticulate, semicordate at the apex, where the tip of the achene extends for about 2 mm.

The type was labeled *A. fragrans,* which species it resembles in general habit, but it is easily distinguished both by the narrow bracts and the strongly winged fruit. These characters place it nearer *A. Carletoni* Coult. & Fisher which is of a different habit and has a puberulent stem. *A. lanceolata* grows in drifting sand.

IDAHO: Idaho Falls, 1901, *Merrill & Wilcox, 870.* (Type in herb. N. Y. Botanical Garden.)

11. ABRONIA CARLETONI Coult. & Fisher, Bot. Gaz. **17**: 349. 1892

Colorado.

12. ABRONIA VILLOSA S. Wats. Am. Nat. **7**: 302. 1873

Southern Utah to Arizona and California.

13. ABRONIA CYCLOPTERA A. Gray, Am. Journ. Sci. II. **15**: 319. 1853

From Wyoming to Texas and Arizona.

14. **Abronia pedunculata** (M. E. Jones)

Abronia micrantha pedunculata M. E. Jones, Proc. Cal. Acad. II. **5**: 716. 1895.

In the Navajo Basin of eastern Utah.

15. ABRONIA MICRANTHA Torr. Frem. Rep. 96. 1845

From South Dakota to Montana and New Mexico.

2. HERMIDIUM S. Wats. King's Rep. **5**: 296. 1871

A monotypic genus.

1. HERMIDIUM ALIPES S. Wats. *l. c.*

Nevada and western Utah.

3. QUAMOCLIDION Choisy; DC. Prod. **13**^{2}: 429. 1849

This genus was based on two species, of which the second was referred doubtfully to the genus. The first had before been known as a species of *Mirabilis*, viz., *M. triflora* Benth. The type of the genus *Mirabilis* L. is *M. Jalapa* L. In the latter the filaments are united at the base, the fruit is not viscid and the corolla is salver-shaped with a long tube and broad limb. In *Quamoclidion* the filaments are distinct, the fruit viscid and the corolla from nearly cylindrical to bell-shaped but with a small limb. In *Mirabilis* the flowers are solitary and in the typical species of *Quamoclidion* 3–6 in the involucre; but as the number of flowers are not of value as a generic character I have here included a species with one-flowered involucres.

Involucre 5–6-flowered: perianth elongated funnelform.	1. *Q. multiflorum.*
Involucre 1-flowered: perianth open-campanulate.	2. *Q. laeve.*

1. QUAMOCLIDION MULTIFLORUM Torr.; Gray, Am. Journ. Sc. II. **15**: 321. 1853

Oxybaphus multiflorum Torr. Ann. Lyc. N. Y. **2**: 237. 1828.

Nyctaginia Torreyana Choisy; DC. Prod. **13**^{2}: 430. 1849.

Mirabilis multiflora A. Gray; Torr. Bot. Mex. Bound. 173. 1859.

Choisy, who had not seen any specimens of this species and who believed that it had distinct bracts, referred it to *Nyctaginia;* but it is evidently congeneric with and closely related to *Mirabilis triflora* Benth., the type of *Quamoclidion. Q. multiflorum* ranges from Colorado and New Mexico to Arizona and California.

2. **Quamoclidion laeve** (Benth.)

Oxybaphus laevis Benth. Bot. Sulph. 44. 1844.

O. glabrifolius var. *crassifolius* Choisy; DC. Prod. **13**^{2}: 431. 1849.

O. glabrifolius Torrey, Pac. R. R. Rep. **4**: 131. 1857. Not Vahl.

Mirabilis Californica A. Gray; Torr. Mex. Bound. Surv. 173. 1859.

O. Californicus Benth. & Hook. Gen. **3**: 4. 1880.

This species has quite often been included in *Oxybaphus, i. e., Allionia*, and often in *Mirabilis.* Professor Heimerl, in his treatment of the Nyctaginiaceae in *Die natürlichen Pflanzenfamilien,* merges *Oxybaphus* into *Mirabilis;* but associates this species with the one-flowered species of *Allionia.*

It is evident that if *Allionia* is to be treated as a distinct genus, *Q. laeve* can not be included in the latter genus for it lacks the essential characters, viz., the ribbed fruit and the enlarging and membranous involucre. It is evidently closer related to *Quamoclidion* than any other genus. The only important difference between it and the typical species is the open short perianth and the flowers solitary within each involucre. The species ranges from Utah to Arizona and California.

4. **Allioniella** gen. nov.

Bracts five, united into a gamophyllous viscid rotate involucre, which enlarges somewhat in fruit but does not become membranous : flowers in each involucre 3 : perianth open, short funnelform : stamens 3, distinct : fruit ellipsoid, neither angled nor ribbed, very indistinctly tubercled, glabrous.

Only one species.

✓ 1. **Allioniella oxybaphoides** (A. Gray)

Quamoclidion oxybaphoides A. Gray, Am. Journ. Sc. II. **15**: 320. 1853.

Mirabilis oxybaphoides A. Gray, Bot. Mex. Bound. Surv. 173. 1859.

Oxybaphus Wrightii Hemsl. Biol. Cent. Am. **3**: 3. 1882.

Allionia oxybaphoides Kuntze, Rev. Gen. 533. 1891.

From the many synonyms can be seen that this species has been moved from one genus to another. Most botanists have regarded it as an *Allionia* (*Oxybaphus*), which it resembles most in general habit, the perianth and the number of stamens; but it lacks the most essential characters of that genus, viz., the ribbed fruit and the membranous involucre. It is, therefore, more closely related to the *Mirabilis* series; and could be included in genus *Quamoclidion* had it not the open *Allionia*-like perianth, only three stamens and a flat rotate involucre. It is, therefore, better to regard it as the type of a new genus, intermediate between *Allionia* and *Quamoclidion*.

A. oxybaphoides grows from southern Colorado to western Texas and Arizona ; also in northern Mexico.

5. ALLIONIA Loefl. It. Hisp. 181. 1758

Vitmania Turra; Cav. Ic. **3**: 53. 1794. Not *Vitmannia* Vahl. 1794.

Oxybaphus L'Her.; Willd. Sp. Pl. **1** : 185. 1797.

Calyxhymenia Ortega, Nov. aut Rar. Pl. Hort. Matr. 5. 1797.

Calymenia Pers. Syn. **1** : 36. 1805.

The genus was based on a plant which a year later received the specific name *A. violacea* L. *Vitmania* and *Oxybaphus* were both based on *Mirabilis viscosa* Cav.; *Calyxhymenia* on *C. glabrifolia* and *Calymenia* on six species without the type being designated.

Key to the Species

- Leaves from cordate to broadly ovate-lanceolate: all distinctly petioled.
  - Leaves cordate. 1. *A. nyctaginea.*
  - Leaves ovate, rounded or cuneate at the base. 2. *A. floribunda.*
- Leaves ovate-lanceolate, oblong or linear, sessile or only the lower short-petioled.
  - Involucres in open terminal cymes.
    - Stem more or less hirsute as well as viscid.
      - Leaves ovate or broadly oblong, as well as the stem conspicuously hirsute. 3. *A. hirsuta.*
      - Leaves linear-lanceolate, almost glabrous; stem sparingly hirsute or glabrous except under the nodes. 4. *A. pilosa.*
    - Stem glabrous below, not hirsute, viscid-puberulent above.
      - Flowers solitary in the involucre on short slender pedicels; fruit nearly glabrous. 5. *A. glabra.*
      - Flowers 2–3 in the involucres, subsessile; fruit decidedly pubescent.
        - Leaves of the cymes much reduced and bract-like, upper portion of the stem densely and finely puberulent. 6. *A. bracteata.*
        - Leaves of the cymes neither much reduced nor bract-like.
          - Leaves erect or ascending; lobes of the involucre rounded or broadly triangular-ovate.
            - Plant prostrate or diffuse; involucres and branches of the inflorescence densely viscid hairy. 7. *A. diffusa.*
            - Plants more simple, erect or ascending; branches of the inflorescence usually merely viscid-puberulent.
              - Leaves from ovate or obovate to linear-lanceolate, usually over 5 mm. wide. 8. *A. lanceolata.*
              - Leaves narrowly linear, less than 5 mm. wide. 9. *A. linearis.*
          - Leaves divergent; lobes of the involucre elliptic or oval. 10. *A. divaricata.*
  - Involucres on solitary axillary peduncles, rarely also in small dense terminal clusters.
    - Leaves oblong, lanceolate or linear-lanceolate.
      - Stem hirsute. 11. *A. aggregata.*
      - Stem glabrous. 12. *A. decumbens.*
    - Leaves narrowly linear. 13. *A. Bodinii.*

1. ALLIONIA NYCTAGINEA Michx. Fl. Bor. Am. **1**: 100. 1803

Oxybaphus nyctagineus Sweet, Hort. Brit. **1**: 334. 1825.

A well-known and common plant growing in rich soil from Illinois and Saskatchewan to Wyoming, New Mexico and Louisiana.*

2. ALLIONIA FLORIBUNDA (Choisy) Kuntze, Rev. Gen. 533. 1891

A. ovata Pursh, Fl. Am. Sept. **1**: 97. 1814. Not *Oxybaphus ovatus* Vahl. 1806.

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* *Allionia Cervantesii* has been reported from Colorado, but the specimens on which this assertion has been made belong in all cases I know to *Allioniella oxybaphoides.*

O. floribundus Chois; DC. Prod. **13**^{2}: 433. 1849.

A. nyctaginea ovata Morong, Mem. Torrey Club, **5**: 146. 1894.

In dry soil from Missouri and South Dakota to Wyoming, New Mexico and Texas.

3. ALLIONIA HIRSUTA Pursh, Fl. Am. Sept. **2**: 728. 1814

Oxybaphus hirsutus Sweet, Hort. Brit. **1**: 334. 1825.

In sandy soil from Minnesota and South Dakota to Colorado.

4. **Allionia pilosa** (Nutt.)

Calymenia pilosa Nutt. Gen. **1**: 26. 1818.

Oxybaphus pilosus Sweet, Hort. Brit. **1**: 334. 1825.

This has been confused with the preceding, but I think it amply distinct. So it was regarded by Nuttall and by Sweet. It is perhaps nearer related to *A. floribunda* and Nuttall cites *A. ovata* Pursh as a synonym; but it is well to note that Nuttall describes the stem of his species as pubescent, which does not agree with Pursh's plant. *A. pilosa* grows in dry sandy soil from Wisconsin and North Dakota to Texas and Louisiana.

5. ALLIONIA GLABRA (S. Wats.) Kuntze, Rev. Gen. 533. 1891

Oxybaphus glaber S. Wats. Am. Nat. **7**: 301. 1873.

A rare plant from the arid districts of southern Utah, Arizona, and New Mexico.

6. **Allionia bracteata** sp. nov.

A branched, more or less viscid perennial: stem glabrous below, densely viscid-pubescent above, 4–12 dm. high, erect or ascending: leaves subsessile; blades oblong to linear-lanceolate or linear, 3–9 cm. long, thick, mostly ciliate, glabrate: leaves of the inflorescence elliptic or oblong, to lanceolate, reduced, less than 1 cm. long, more or less viscid-pubescent: involucres often numerous in terminal cymes, 10–14 mm. wide; lobes broadly ovate, obtuse: perianth white or pale, about 10 mm. broad: fruit oblong-obovate, 5–5.5 mm. long, prominently 8-ribbed, apiculate, constricted near the base.

This species has been mistaken for *A. linearis* and *A. albida*, but is easy distinguished by the reduced leaves of its inflorescence. It grows in dry rocky soil.

MISSOURI: Malden, 1894, *Bush, 459* (type in herb. Columbia University); Wayne, 1900, *825*; also Courtney, 1891; McDonald county, 1893, *310*.

SOUTH DAKOTA: Spring Basin, 1891, *T. A. Williams*.

ALABAMA: Selma, 1888, *McCarthy*.

7. ALLIONIA DIFFUSA Heller, Minn. Bot. Stud. 2: 33. 1898

On dry plains, from North Dakota and Wyoming, to Kansas, New Mexico and Arizona.

8. **Allionia lanceolata** sp. nov.

A. albida Rydb. Cont. U. S. Nat. Herb. 3: 520. 1896. Not Walt. 1788.

A branched perennial. Stems erect or ascending, glabrous below, viscid-pubescent with short hairs, 4–15 dm. high: lower leaves short-petioled, the upper sessile; blades lanceolate or ovate-lanceolate to almost linear, 3–10 cm. long, very thick, obtuse or blunt at the apex: involucres numerous, in terminal cymes, 1–1.5 cm. wide; lobes rounded ovate, sometimes acutish: perianth pink, about 10 mm. broad: fruit obovoid, 4.5–5 mm. long, with usually 4–5 broad ribs and finely tuberculate faces.

This has usually gone under the name of *Allionia albida* which it resembles in habit, but that species has white perianths and sharply acute or acuminate thin leaves. *A. albida* is confined to South Carolina and Georgia and is represented by *A. lanceolata* in the West. The latter grows in dry soil on the plains, from Minnesota and Wyoming to Tennessee and Texas.

COLORADO: Estes Park, Larimer county, *Osterhout, 1556* (type in herb. N. Y. Botanical Garden).

9. ALLIONIA LINEARIS Pursh, Fl. Am. Sept. 2: 728. 1814

Calymenia angustifolia Nutt. Gen. 1: 26. 1818.

Oxybaphus angustifolius Sweet, Hort. Brit. 1: 334. 1826.

In dry soil on the plains, from Minnesota to Montana, Arizona, Mexico and Louisiana.

10. **Allionia divaricata** sp. nov.

A slender perennial. Stems usually solitary, erect, 6–10 dm. high, glabrous and shining up to the viscid-puberulent inflorescence: leaves more or less distinctly petioled, usually spreading;

blades glabrous, thickish, linear to linear-lanceolate, acute, 5–10 cm. long: involucres numerous, in terminal cymes about 1.5 cm. wide, cleft below the middle into elliptical or oval obtuse lobes: perianth pink, about 8 mm. wide: fruit oblong-obovoid, slightly compressed, bluntly angled and not strongly tubercled, strigose.

Perhaps closest related to *A. linearis*, but distinguished by the thinner divergent leaves, the form of the involucre and the fruit.

COLORADO: Durango, 1898, *Baker, Earle & Tracy, 512* (type in herb. N. Y. Bot. Garden).

ARIZONA: Bakers Butte, Mogollon Mountains, 1887, *Mearns, 253.*

11. ALLIONIA AGGREGATA (Ortega) Spreng. Syst. **1**: 384. 1825

Calyxhymenia aggregata Ortega, Nov. aut Rar. Pl. **8**: *pl. 11.* 1798 (or 1799?).

Oxybaphus aggregatus Vahl, Enum. **2**: 41, in part. 1806.

This is not the plant named *O. aggregatus* by Torrey, Watson and others, from Arizona and northern Mexico, but one that is closely related to *A. hirsuta* and generally has been confused with it. It differs mainly in the axillary solitary peduncles and in this respect is analogous to *A. Bodinii*. Vahl evidently had two plants confused, citing as synonyms *Calyxhymenia aggregata* Ortega and *Mirabilis aggregata* Cavanilles, both illustrated and closely related species of *Allionia*. Ortega's plant, which was the first published,* is densely hirsute, while Cavanilles' plant is glabrous. Vahl, in his diagnosis, describes it as glabrous but remarks in parentheses "according to Ortega hirsute."

A. aggregata grows in dry soil from Wisconsin to Texas and New Mexico, also in northern Mexico.

12. ALLIONIA DECUMBENS (Nutt.) Spreng. Syst. **1**: 384. 1825

Mirabilis aggregata Cav. Ic. **5**: 22. *pl. 437.* 1799.
Oxybaphus aggregatus Vahl, *l. c.* in part.
Calymenia decumbens Nutt. Gen. **1**: 26. 1818.
Oxybaphus decumbens Sweet, Hort. Brit. **1**: 334. 1826.

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* I have not been able to find the exact date of Ortega's fascicle in which the description appears. The ten fascicles were published in 1797–1800; but Cavanilles cites Ortega, which indicates that the latter's description was published first.

This species stands in the same relation to *A. lanceolata* as the preceding does to *A. hirsuta* and the following to *A. linearis*, differing mostly in the mode of blooming. One of the reasons for holding them as distinct species and not as forms of the species mentioned is that their ranges are different, *A. aggregata* and *A. decumbens* extending further south into Mexico and the Gulf states, while their cymose analogues are northern, and the range of *A. Bodinii* is more limited than that of *A. linearis*. *A. decumbens* grows in dry soil on the plains, from Missouri and South Dakota to Wyoming, Mexico and Mississippi.

13. ALLIONIA BODINII (Holz.) Morong, Mem. Torrey Club, **5**: 354. 1894

Oxybaphus Bodinii Holz. Contr. U. S. Nat. Herb. **1**: 287. 1893.
In dry soil from western Kansas to Utah and western Texas.

6. WEDELIA Loeff. Iter. Hisp. 180. 1758

Allionia L. Syst., Ed. 10, 890, in part. 1759.

The genus was based on a plant which the following year received the specific name *Allionia incarnata* L.

1. WEDELIA INCARNATA (L.) Kuntze, Rev. Gen. Pl. 533. 1892

Allionia incarnata L. Syst., Ed. 10, 890. 1759.
From western Texas and southern Colorado to California.

An Enumeration of the Plants collected by Dr. H. H. Rusby in South America, 1885–1886, XXXII

By H. H. Rusby

(Continued from Bull. Torrey Club, 28 : 313. 21 My. 1901)

BURMANNIACEAE

Burmannia tenella Benth. Kew Journ. **7** : 10. 1855. Yungas, 6000 ft. (no. 858) and Mapiri, 2500 ft., May 1886 (no. 859). Growing in leaf mould, in deep forest shade.

SCITAMINEAE

Costus spicatus (Jacq.) Sw. Prod. Veg. Ind. Occ. **11.** Yungas, 6000 ft., 1885 (no. 1295). Growing in a ravine, in deep shade. (Same as Bang's nos. 912 and 1248.)

Costus Guanaiense sp. nov.

Leaf-sheaths densely and long appressed yellowish-hirsute: stems 6–8 dm. high, very stout, leafy at the top: leaf-blades 2.5–3 dm. long, 5 or 6 cm. broad, oblong, short-acuminate: floral bracts about 5 cm. long, 3 cm. broad, thick, rigid, brown, strongly nerved, the foliaceous tips about 1 cm. long, 6 or 7 mm. broad, obtusish, appressed or reflexed at the tip: fruit densely yellowish-sericeous, 1.5 cm. long, and more than half as broad, oval or slightly broader above, the fruiting calyx-segments 1.75 cm. long, about half as broad, oval, thick, rigid, about 15-ribbed, the ribs strong and sharp; seed black, 2.5 mm. long, broadly oval, coarsely and bluntly tuberculate.

Guanai, 2000 ft., May 1886 (no. 2225).

Costus phlociflorus sp. nov.

Minutely puberulent under the lens. Stems erect, slender for the genus, about 4 dm. high, leafy only at the summit, clothed with bladeless sheathes below: leaves 1–1.5 dm. long, 3–4 cm. broad, oblanceolate or obovate, rather abruptly acuminate and acute: floral bracts 2–2.5 cm. long, closely surrounding the perianth-tube, abruptly keeled near the summit with a broad yellowish keel about 5 mm. long, about 19-nerved, the nerves very fine: perianth bright crimson, drying deep-purple, the segments horizontally spreading, 1–2 cm. long and nearly as broad.

Falls of Madeira, Brazil, Oct. 1886 (no. 229).

The handsomest species known to me in this handsome genus. Near *C. lanceolatus* Peterson.

Ethanium racemosum (R. & P.) Kuntze, Rev. Gen. Pl. 689. Mapiri, 2500 ft., May 1886 (no. 2778 = Bang, no. 1237, printed "Etherium," Mem. Torrey Club, **6**: 123).

Ethanium sp. Mapiri, 5000 ft., May 1886 (no. 2784). Flower scape only preserved.

Ethanium sp. Sorata, 10,000 ft., Feb. 1886 (no. 2781), in same condition as last. No. 2231, from Mapiri, 2500 ft., May 1886, leaf specimens, is apparently of the same species.

Ischnosiphon gracilis (Rudge) Körn, Bull. Soc. Nat. Mosc. **35**: 94. 1862. (*Maranta gracilis* Rudge, Pl. Guian. Rar. **8**: *pl. 3.*) Junc. Rivers Beni and Madre de Dios, Aug. 1886 (no. 2228).

Stromanthe spectabilis Lem. Jard. Fleur. *pl. 401.* Yungas, 4000 ft., 1885 (no. 2224). The same as Burchell's no. 2040, and Bang's no. 513.

Calathea capitata (R. & P.) Lindl. Bot. Reg. *pl. 1210.* (*Maranta c.* R. & P. Fl. Per. **1**: 3. *pl. 5.*) Guanai, 2000 ft., May 1886 (no. 2227).

Calathea grandifolia (A. Dietr.) Lindl. Bot. Reg. *pl. 1210.* (*Maranta g.* A. Dietr. Sp. Pl. **1**: 26.) Falls of Madeira, Brazil, Oct. 1886 (no. 2226).

Calathea (Monosticha) divaricata sp. nov.

Minutely puberulent: stems very slender, about 5 dm. long in my specimen, sheathed only at the base, the sheaths acutish; petioles 4 or 5 cm. long: leaves .75–1.5 dm. long, 2–4 cm. broad, oblong, acute: peduncle 1 dm. long, very slender, spreading horizontally or slightly deflexed, strongly costate: heads subhemispherical, about 2 cm. broad, rather loosely flowered, bracts 1–1.5 cm. long, broadly ovate, obtuse, strongly nerved: anthers conspicuous, exceeding the bracts, nearly 4 mm. long, slender, acutish, tapering toward the base. (Dissection material wanting.)

Mapiri, 5000 ft., April 1886 (no. 2233).

Canna Brittoni sp. nov.

Strongly glaucous throughout: stems very stout: leaf-blade (but one seen) 4 dm. long, 3.75 dm. broad, rhomboidally ovate, very slightly cordate at the base, blunt at the apex, the principal nerves about 45 pairs, meeting the midrib at an angle of about 50°: bracts .8–1.5 dm. long, lance-oblong, obtuse, imbricated, the racemes about 1.5–2.5 dm. long, somewhat panicled or solitary: pedicels 3 cm. long, very stout, strongly flexed at the apex: perianth about 6 cm. long, the divisions of the calyx 7 cm. long, 1.5 cm. broad, lanceolate: petals adnate to the androecium about one third of their length: anther 2.5 cm. long, narrowly linear, divisions of the androecium only 3, as long as the petals, oblong, 1–1.5 cm. broad: style fleshy, dark, flattened, 5 mm. broad, obtuse: pod 5 or 6 cm. long, oval, rounded at both ends, tipped by the persistent sepals: seeds blackish, smooth, a little more than 1 cm. long and broad.

Yungas, 6000 ft., 1885 (no. 2857). The same as Bang's no. 2417, of which Mr. Bang says: "Plant about 10 ft. high, forming a bush, the flowers white; in wet forest soil at Sacramento, Aug. 1894. Local names "Chias," "Tacara." Seeds very hard, used in weighing "gold."

Heliconia cannoides A. Rich. Nov. Act. Nat. Cur. **15**: Suppl. 24. *pl. 9.* 1831. Yungas, 6000 ft., 1885 (no. 2221), and junc. of Rivers Beni and Madre de Dios, Aug. 1886 (no. 2223). The same as Bang's no. 4112 and the same collected by Holton.

Heliconia Bahai L. Mant. **2**: 211. Reis, 1500 ft., June 1886 (no. 2222).

Heliconia psittacorum L. f. Suppl. 158. Junc. of Rivers Beni and Madre de Dios, Aug. 1886 (no. 2230).

BROMELIACEAE

Ananas sativus Schult. *f.* Syst. 7: no. 1283. Mapiri, 2500 ft., May 1886 (no. 2851). The plant grows in a perfectly wild state, along forest-roads, distant from habitations.

Billbergia (Helicodea) Boliviensis Baker, sp. nov.

Acaulis, foliis lanceolatis tenuiter lepidotis aculeis marginalibus minuto, pedunculo elongato, bracteis superioribus magnis patulis rubellis, floribus in spicam simplicem subdensam dispositis, bracteis minutis, ovario oblongo subtiliter sulcato albo lepidoto, sepalis oblongis ovario duplo longioribus, petalis viridulis angustis longe unguiculatis, serratabilus petalis longioribus.

Leaves few in a rosette, 1.5–2 ft. long, about an inch broad at the middle: peduncles shorter than the leaves: lower bract-leaves appressed, those towards the base of the spike spreading, bright red, 4–5 in. long: spike 6 in. long: ovary .25 in. long: petals an inch longer than the calyx, with a narrow blade and long slender claw.

Allied to *B. decora* Pöpp. et Endl. Nov. Gen. 42. *pl. 157* (*B. Baraginniana* Lemaire), figured lately in the Botanical Magazine, *pl. 6937*.

Unduavi, 8000 ft., Oct. 1885 (no. 2853).

Pitcairnia consimilis Baker, Journ. Bot. **19**: 269. 1881. Yungas, 6000 ft., 1885 (no. 2847) and Vic. la Paz, 10,000 ft., Apr. 1885 (no. 2845). Growing upon shaded, rocky banks. The same as Mandon's no. 1173.

Pitcairnia pulverulenta R. & P. Fl. Per. **3**: 86. *pl. 259*. Yungas, 6000 ft., 1885 (no. 2844).

Puya Brittoniana Baker, sp. nov.

Foliis ensiformibus acuminatis subpedalibus facie glabris dorso tenuiter albo-lepidotis aculeis marginalibus magnis patulis castaneis, floribus in spicam simplicem cylindricam dense lanuginosam dispositis, bracteis magnis ovalis acuminatus, sepalis lanceolatis, petalis latis calyce duplo longioribus, genitalibus petalis brevioribus.

Leaves a foot long, moderately firm in texture, .60–.75 in. broad, low down, tapering gradually to a long spine: upper leaf-bracts of the peduncle large, and very acuminate: spike 2½–3 in. diam., densely coated with loose brown wooly pubescence: flower bracts 2 in. long: sepals .60–.75 in. long: petal-blade .25–.35 in. broad.

Near *P. pyramidata*, Schultes = *Puya pyramidata* Ruiz et Pavon. Fl. Peruv. III. 34. *pl. 257*.

Ingenio del Oro, 10,000 ft., Mar. 1886 (no. 2849).

Growing upon exposed, grassy and rocky hills.

Puya sp. Vic. la Paz, 10,000 ft., Apr. 1885 (no. 2846, and probably no. 2850, also. Differs from *P. coerulea* Lindl. in its longer pedicels, and is doubtless a distinct species, but represented only by portions of the inflorescence.

Cottendorfia Rusbyi Baker, sp. nov.

Acaulis, foliis lanceolatis subpedalibus membranallis tenuiter lepidotis, pedunculo foliis aequilongo bracteis parvis adpressis, floribus parvis in paniculam amplam laxam ramis elongatis multifloris secundis dispositis, bracteis minutis sepalis oblongis, petalis oblanceolatis, calyce duplo longioribus.

Leaves about a foot long, 1–1.25 in. broad at the middle, very thin in texture for a bromeliad, quite entire: peduncle about as long as the leaves: panicle a foot long; central branchlets rather compound, 4–5 in. long: flower-bracts very small: pedicels .08–.20 in. long, articulated at the apex: sepals .08 in. long: stamens shorter than the petals: capsule oblong, membranous, as long as the petals, dehiscing septicidally.

Only two very rare species of this genus are known previously. It is perfectly distinct from *Dyckia*, under which it is mentioned in the Genera Plantarum, both in structure and habit.

Yungas, 6000 ft., 1885 (no. 2541). Growing upon rocky, partly shaded banks.

Tillandsia floribunda H.B.K. Nov. Gen. et Sp. **1**: 292. Yungas, 6000 ft., 1885 (no. 2163).

Tillandsia recurvata L. Sp. Pl. 287. Ingenio del Oro, 10,000 ft., Mar. 1886 (no. 2165).

Tillandsia propinqua Gay, Fl. Chil. **6**: 15. Vic. la Paz, 10,000 ft., Apr. 1885 (no. 2164). Growing upon apple trees.

Tillandsia sphaerocephala Baker, Journ. Bot. **26**: 141. 1888. Vic. la Paz, 10,000 ft., Apr. 1885 (no. 2848). Terrestrial, upon sunny, gravelly and rocky banks. The same as Mandon's no. 1188.

Tillandsia complanata Benth. Bot. Sulph. 173. Vic. la Paz, 10,000 ft., Oct. 1885 (no. 2855).

Tillandsia (Allardtia) micrantha Baker, sp. nov.

Acaulis, foliis paucis loratis obtusis tenuiter lepidotis, pedunculo foliis aequilongo, bracteis parvis adpressis, spicis pluribus lanceolatis distichis in paniculam amplam dispositis, bracteis floribus oblongis obtusis, calyce bractea aequilongo sepalis obtusis.

Leaves above a foot long, .25 in. broad at the middle: panicle a foot long, consisting of 20–30 dense distichous spikes, 1.5–2 in. long, .25 in. broad, the upper sessile, the lower peduncled: branch-bracts at most an inch long: flower-bracts oblong-navicular, .15 in. long: petal-blade minute.

Allied to *T. spiculosa* Griseb., but panicle much more compound.

Yungas, 6000 ft., 1885 (no. 2852) (no. 2232 is the inflorescence only of a species of *Tillandsia*).

HAEMODORACEAE

Xiphidium floribundum Sw. Prod. Veg. Ind. Occ. **1**: 17. Mapiri, 5000 ft., Apr. 1886 (no. 2529).

IRIDACEAE

Orthrosanthus Chimboracensis (H.B.K.) Baker, Gard. Chron. **2**: 67. 1876. (*Moraea Chimboracensis* H.B.K. Nov. Gen. et Sp. **1**: 322. Sorata, 10,000 ft., Feb. 1886 (no. 700).

Sisyrinchium iridifolium H.B.K. Nov. Gen. et Sp. **1**: 324. Vic. La Paz, 10,000 ft., Apr. 1885 (no. 693) and Sorata, 8000 ft., Feb. 1886 (no. 694). The same as Mandon's no. 1211.

Sisyrinchium junceum E. Meyer in Presl. Rel. Haenk. **1**: 118. Unduavi, 8000 ft., Oct. 1885 (no. 699). The same as Mandon's no. 1222.

Sisyrinchium Mandoni Baker, Journ. Bot. **14**: 269. 1876. Sorata, 10,000 ft., Feb. 1886 (no. 696). The same as Mandon's no. 1217.

Sisyrinchium leucanthum Colla in Mem. Acc. Torin. **39**: 18. 1836. Unduavi, 8000 ft., Oct. 1885 (no. 695).

Sisyrinchium tinctorium H.B.K. Nov. Gen. et Sp. **1**: 324. Ingenio del Oro, 10,000 ft., Mar. 1886 (no. 697), and Mapiri, 5000 ft., Apr. 1886 (no. 698).

AMARYLLIDACEAE

Hippeastrum Mandoni Baker, Handb. Amaryll. **49**. Yungas, 6000 ft., 1885 (no. 2454).

Hippeastrum equestre Herb. App. 31. Yungas, 4000 ft., 1885 (no. 2453), *fide* Baker.

Hymenocallis Quitoensis Herb. App. 44. Yungas, 4000 ft., 1885 (no. 2452).

Alstroemeria Ligtu Linn. Diss. Alstroem. 10: Am. Acad. **6**: 254. Near Valparaiso, Chile, June 1885 (no. 554).

Bomarea brevis (Herb.) Baker in Journ. Bot. **20**: 202. 1882. (*Sphaerine brevis* Herb. Amaryll. 108. *pl. 18, f. 1.*) Unduavi, 10,000 ft., Oct. 1885 (no. 570).

Bomarea distichophylla (Herb.) Baker, *l. c.* Unduavi, 8000–9000 ft., Oct. 1885 (nos. 571 and 574).

Bomarea edulis (Tussac) Herb. Amaryll. 111. (*Alstroemeria edulis* Tussac, Fl. Antill. **1**: 109. *pl. 14.*) Yungas, 6000 ft., 1885 (nos. 568 and 1031), and Sorata, 8000 ft., Feb. 1886 (no. 565). Mr. Baker so refers these three, with the following three of Mr. Bang's collection. To me, however, they appear to represent three distinct species, as follows: First, no. 568 and Bang's no. 593*a*; second, nos. 565 and 1031 and Bang's no. 2915; third Bang's no. 2037.

Bomarea formossissima (R. & P.) Griseb. ex Baker, Handb. Amaryll. 153. Yungas, 6000 ft., 1885 (no. 566).

Bomarea glaucescens (H.B.K.) Baker, Journ. Bot. **20**: 201. 1882. (*Alstroemeria glaucescens* H.B.K. Nov. Gen. et Sp. **1**: 282.) Unduavi, 8000 ft., Oct. 1885 (no. 572).

Bomarea multiflora (L. f.) Mirbel, Hist. Nat. Pl. **9**: 72. 1804. Yungas, 6000 ft., 1885 (no. 564). The same as Bang's nos. 1936 and 2038.

Bomarea tomentosa (R. & P.) Herb. Amaryll. 117. (*Alstroemeria tomentosa* R. & P. Fl. Per. **3**: 62. *pl. 292, a*). Unduavi, 8000 ft., Oct. 1885 (no. 563).

Bomarea acutifolia Herb. Amaryll. 112? Yungas, 4000 ft., 1885 (no. 569) and Sorata, 13,000 ft., Feb. 1886 (no. 567).

Bomarea (Sphaerine) Boliviensis Baker sp. nov.

Caule suberecto subpedali, foliis lanceolatis membranaceis dorso hispidis, umbellis pauciradiates, bracteis paucis parvis foliaceis, pedicellis pubescentibus bracteolatis simplicibus vel furcatis, perianthii segmentis parvis aequilongis, staminibus perianthio brevioribus.

Stem leafy for less than a foot. Leaves 2–3 in. long, .35–.5 in. broad: rays of the umbel about an inch long: perianth segments .5 in. long.

Allied to *B. brevis* Baker (Mathews, 1660). Vic. La Paz, 10,000 ft., Apr. 1885 (no. 573).

DIOSCOREACEAE

Dioscorea cymosula Hemsl. Biol. Cent. Am. Bot. **3**: 355. Guanai, 2000 ft., May 1886 (no. 1449).

Dioscorea furcata Griseb. in Mart. Fl. Bras. **1**: 45. Guanai, 2000 ft., May 1886 (no. 532), and Mapiri, 5000 ft., Apr. 1886 (no. 1047). The same as Mandon's no. 1230, Tweedie's no. 1877 from Tucuman and Balansa's no. 626 from Paraguay.

Dioscorea multiflora Griseb. in Mart. Fl. Bras. **1**: 35. Guanai, 2000 ft., May 1886 (no. 556).

Dioscorea polygonoides H. B. ex Willd. Sp. Pl. **4**: 795. Mapiri, 5000 ft., Apr. 1886 (no. 557).

Dioscorea angustifolia sp. nov.

Sparsely short-pilose: stems stout, terete, purple: petiole (but one seen) 1 dm. long, very stout; blade 1.75 dm. long, 3 dm. broad, strongly cordate, 5-lobed, the sinuses narrow, rounded at the termination, extending three fourths of the way to the base, the lobes ovate or obovate, terminating in a very short broad obtuse point, the middle 5-ribbed, the others 2-ribbed, the ribs connected by straightish secondaries: leaf thin, deep-green, the venation sharply prominent and pubescent underneath: staminate panicle (but one seen) 2 dm. long, loosely much-branched, the branches elongated, slender or filiform, loosely flowered: bracts deciduous, ovate, attenuate, two thirds as long as the fully-grown bud: perigone thickened, divided nearly to the base, sparsely pilose without, the segments 3 mm. long, oblong or very little broader above the middle, obtuse, the midrib broad and stout, almost a keel: stamens two-thirds as long as the perigone segments, adnate one sixth of the length of the latter, the filaments stoutish, the anthers .5 mm. long, truncate.

Species near *D. trifida*, but that has not the loosely paniculate inflorescence of this.

Mapiri, 5000 ft., May 1886 (no. 534). Dr. Britton says the same as Burchell's no. 10,031.

Dioscorea Mandoni sp. nov.

Calyx-tube pubescent, the rachis slightly so: branchlets angled: petioles (but two seen) 6–8 cm. long, gradually dilated downward and broadly channelled, ribbed; blades 1.4 dm. long, exclusive of the basal lobes, and of about the same breadth, cordate, the basal lobes about 5 cm. long, rounded, nearly meeting, the sinus rounded at the petiole insertion, the summit of the leaf abruptly contracted into an acumination about a cm. long and broad; primary ribs 7, the latter bordering the lobes for a short distance, then throwing off one to three branches, yellowish, prominent underneath: one pistillate spike seen, 3.5 dm. long, including the peduncle which is 1 dm. long, very slender, drooping, very closely flowered; bracts about half the length of the ovary, narrowly lanceolate and alternate: perianth-tube of the freshly opened flower 5 mm. long, lance-oblong, grayish-pubescent, the lobes nearly 3 mm. long, oblanceolate, acutish: stigmas 1 mm. long, thick, strongly recurved, lobed or cut at the summit.

Guanai, 2000 ft., May 1886 (no. 533).

The same as Mandon's no. 1232, the fruit of which is 2.5–3 cm. long, half as broad, ellipsoidal, but slightly broader above, shining, the beak very short and broad, light-brown, the nerves barely perceptible.

LILIACEAE

Smilax floribunda Kunth Enum. Pl. **5**: 229. Mapiri, 5000 ft., Apr. 1886 (no. 558).

Smilax phylloloba Griseb. in Mart. Fl. Bras. **1**: 21? Guanai, 2000 ft., May 1886 (no. 560).

Smilax irrorata Griseb. in Mart. Fl. Bras. **1**: 10. Reis, 1500 ft., June 1886 (no. 561).

Excremis coarctata (R. & P.) Baker in Journ. Linn. Soc. **15**: 320. 1876. Yungas, 6000 ft., 1885 (no. 2504*a*) and Mapiri, 5000 ft., Apr. 1886 (no. 2856). The same as Bang's no. 2277.

Nothoscordum striatum (Jacq.) Kunth Enum. Pl. **4**: 459. (*Allium striatum* Jacq. Coll. Suppl. 51.) Near Valparaiso, Chile, June 1885 (no. 581).

Milla andicola (Kunth) Baker in Journ. Linn. Soc. **11** (1870): 381. (*Nothoscordum andicolum* Kunth l. c. 643.) Vic. La Paz 10,000 ft., Apr. 1885 (no. 579), and Yungas, 6000 ft., 1885 (no. 580). The same as Mandon's no. 1235. Also collected by Bang.

Miersia Rusbyi Britton, sp. nov.

Minutely puberulent under a lens: bulb ovoid or broadly pyriform: leaves few, narrowly linear or filiform: scapes 1.5–2.5 dm. long, very slender, slightly thickened upward, the several flowers loosely umbelled: bracts 1–2 cm. long, thin and delicate: pedicels 2–5 cm. long, filiform, striate: perianth-segments regularly acuminate from the base to the acute apex, the sepals nearly 1.5 cm., the petals a little more than 1 cm. long.

I find my specimens labelled "Yungas, Bolivia, 6000 ft., 1885," but it is my impression that they were collected near Llai-llai, Chile, under shrubbery on a shaded hillside (no. 2540).

PONTEDERIACEAE

Eichornia crassipes (Mart.) Schum. in DC. Monog. Pharm. **4**: 527. (*Pontederia crassipes* Mart. Nov. Gen. et Sp. **1**: 9.) Falls of Madeira, Brazil, Oct. 1886 (no. 509).

Eichornia pauciflora Seub. in Mart. Fl. Bras. **1**: 91. Reis, 1500 ft., June 1886 (no. 553).

COMMELINACEAE

(Determined by Mr. C. B. Clarke)

Commelina Quitensis Benth. Pl. Hartw. (no. 258). Sorata, 8000 ft., Feb. 1886 (no. 847). The same as Mandon's no. 1238.

Commelina elliptica H.B.K. Nov. Gen. et Sp. **1**: 259. Mapiri, 2500 ft., May 1886 (no. 848). A common weed in Cinchona and coffee plantations.

Dichorisandra hexandra (Aubl.) Kuntze, Rev. Gen. Pl. 721. (*Commelina hexandra* Aubl. Pl. Guian. **1**: 35. *Dichorisandra Aubletiana* Schult. f. Syst. **7**: 1181). Mapiri, 2500 ft., May 1886 (no. 1230).

Dichorisandra inaequalis Presl. Rel. Haenk. **1**: 140. Yungas, 6000 ft., 1885 (no. 1231).

Dichorisandra pubescens Mart.; Schult. f. Syst. **7**: 1186. Yungas, 4000 ft., 1885 (no. 1232).

Dichorisandra villosula Mart.; Schult. f. Syst. **7**: 1185. Mapiri, 5000 ft., Apr. 1880 (no. 1233).

Tradescantia multiflora Swz. Prod. Veg. Ind. Occ. 57. Mapiri, 5000 ft., Apr. 1886 (no. 1369).

Campelia Zanonia (L.) H.B.K. Nov. Gen. **1**: 264. Guanai, 2000 ft., May 1886 (no. 1228), and Yungas, 6000 ft., 1885 (no. 1229).

JUNCACEAE

Luzula gigantea Desv. Journ. Bot. **1**: 145. 1808. Unduavi, 10,000 ft., Oct. 1885 (no. 58).

Luzula racemosa Desv. *l. c.* 162. Vic. La Paz, 10,000 ft., Apr. 1885 (nos. 59 and 60), Sorata, 13,000 ft., Feb. 1886 (no. 182), and Unduavi, 8000 ft., Oct. 1885 (no. 57).

Juncus Chamissonis Kunth, Enum. **3**: 348. Sorata, 10,000 ft., Feb. 1886 (no. 181).

Juncus brunneus Buchenau in Brem. Abl. **6**: 405. 1879? Vic. La Paz, 10,000 ft., Apr. 1885 (no. 61), and Sorata, 13,000 ft., Feb. 1886 (no. 180). The same as Bang's no. 73 and 1076. Dr. Buchenau thinks it may be *J. brevifolius Quitensis* Buch.

PALMAE

Geonoma sp. Yungas, 4000 ft., 1885 (no. 2860).

Martinezia sp.? Guanai, 2000 ft., May, 1886 (no. 2862).

CYCLANTHACEAE

Carludovica sp. Mapiri, 2500 ft., May 1886 (no. 2431).

AROIDEAE

(Determined by Mr. N. E. Brown)

Spathantherum Orbignyanum Schott. Bonplandia, 165. 1859. Sorata, 8000 ft., Feb. 1886 (no. 2433). Also collected by Mandon and Bang.

Stenospermation Mathewsii Schott. Gen. Aroid. Pt. 70? Unduavi, 8000 ft., Oct. 1885 (no. 2432).

Anthurium violaceum (Sw.) Schott. Melet. **1**: 22. Yungas, 6000 ft., 1885 (no. 2427). The same as Bang's no. 2307 pp.

Anthurium indecorum Schott. Oestr. Bot. Zeitschr. 350. 1858. Yungas, 6000 ft., 1885 (no. 2428).

Anthurium gracile Lindl. Bot. Reg. *pl. 1635*. Yungas, 6000 ft., 1885 (nos. 2429 and 2430).

ALISMACEAE

Alisma tenellum Mart. in Schult. f. Syst. **7**: 1600. Reis, 1500 ft. June 1886 (no. 555).

Report on a small Collection of fossil Plants from the Vicinity of Porcupine Butte, Montana*

BY F. H. KNOWLTON

(WITH PLATE 26)

The following report is based on a small collection of fossil plants made by Mr. Walter Harvey Weed, of the U. S. Geological Survey, in July, 1892. They come from the sandstone series above the bend of the Sweet Grass, west of Porcupine Butte, Montana, and embrace about twenty pieces of matrix. Only the four following species of plants have been determined, although there are fragments of stems, apparently of grasses, and others of dicotyledonous leaves.

GLYPTOSTROBUS EUROPAEUS UNGERI Heer

Glyptostrobus Europaeus Ungeri Heer, Fl. Tert. Helv., **3**: 159. 1859; Lesquereux, Cret. & Tert. Fl., *222. pl. 46. f. 1–1^c*. 1883.

The collection contains a number of small fragments that with very little doubt belong to this form as described and figured by Lesquereux. It is probably the same as that identified by Newberry as *G. Europaeus* Unger, in his *Later extinct Floras of North America* (24. *pl. 26. f. 6–8*), but, as I have stated in another place (*Catalogue of the Cret. & Tert. Pl. of N. A.*, 113), much confusion still exists regarding the status of these forms, which can only be settled by an adequate series of well-preserved specimens.

ONOCLEA SENSIBILIS FOSSILIS Newb. (*Pl. 26*)

Onoclea sensibilis fossilis Newb., Ann. N. Y. Lyc. Nat. Hist., **9**: 39. Ap. 1868; Lesquereux, Ill. Cret. & Tert. Plants, *pl. 8. f. 1–9; f. 1–5*. 1878; Newberry, Later extinct Floras, 8. *pl. 23. f. 3; 24. f. 1–5*. 1898.

This form was first described by Newberry in 1868, from material obtained by Dr. F. V. Hayden, near the mouth of the Yellowstone River, in Montana, in what are now known as the Fort Union beds. It has since been collected in approximately the same locality, and also along the North Saskatchewan, in beds of

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the so-called Canadian upper Laramie, which is of the same age as the Fort Union.

Dr. Newberry based his determination entirely on the sterile fronds, and until the present time no fruit appears to have been found. This little collection made by Mr. Weed fortunately contains undoubted specimens of the fertile fronds, thus proving the correctness of Dr. Newberry's identification of the material with *Onoclea*.

At first thought it hardly seems probable that a form now living could have been in existence in early Tertiary times, and have been so little modified in coming down to us. This view appealed strongly to Dr. Newberry, and he sought diligently for characters by which to separate them. On this point he speaks as follows: "Varying as the living *Onoclea* does, in size, outline, and nervation of the sterile frond—from six inches to three feet in height, from a finely reticulated to an open dichotomous nervation, from a bipinnate frond, with remote obovate pinnules, to a pinnate form with wave-margined pinnae and broadly alate rachis—it plainly includes all the characters of the fossils before us, and I, therefore, find it impossible to separate them." As a matter of fact, about the only point of difference lies in the somewhat more robust habit of the fossil forms, and this obviously can have but little weight.

This close similarity is still further emphasized by the fertile fronds which are here figured for the first time. The best of the several fruiting fragments, shown in *Pl. 26, f. 1*, is quite well preserved, and does not exhibit any particular difference from the fruit of living examples. It has, as may be seen, a strong rachis and the numerous berry-like pinnules arranged along the slender branches, exactly as in the living fronds. For the present at least it seems impossible to do more than retain it under the above name.

ARALIA NOTATA ? Lesq.

Aralia notata Lesq., Tert. Fl., 237. *pl. 39. f. 2–4.* 1878.

The collection contains fragments of two large leaves that appear to belong to this species.

Tilia Weedii sp. nov.

Leaf large, of firm texture, broadly cordate-ovate or nearly orbicular in outline, rounded above (apex not preserved) and broadly rounded below to a cordate, very slightly unequal-sided base; margin not well preserved but apparently coarsely toothed; nervation palmate, strongly 5-ribbed from the base; central or midrib strong, somewhat flexuose, with about 4 pairs of alternate strong secondaries, which arise at an angle of about 45°, arch upward and produce a few branches on the lower side, all of which apparently end in the marginal teeth: upper pair of ribs nearly as strong as the midrib, curving by a broad bow and passing up nearly to the end of the blade, each with from 7–9 secondary branches on the outside which fork and probably end in the teeth; lowest pair of ribs slenderer than the others, arising nearly at a

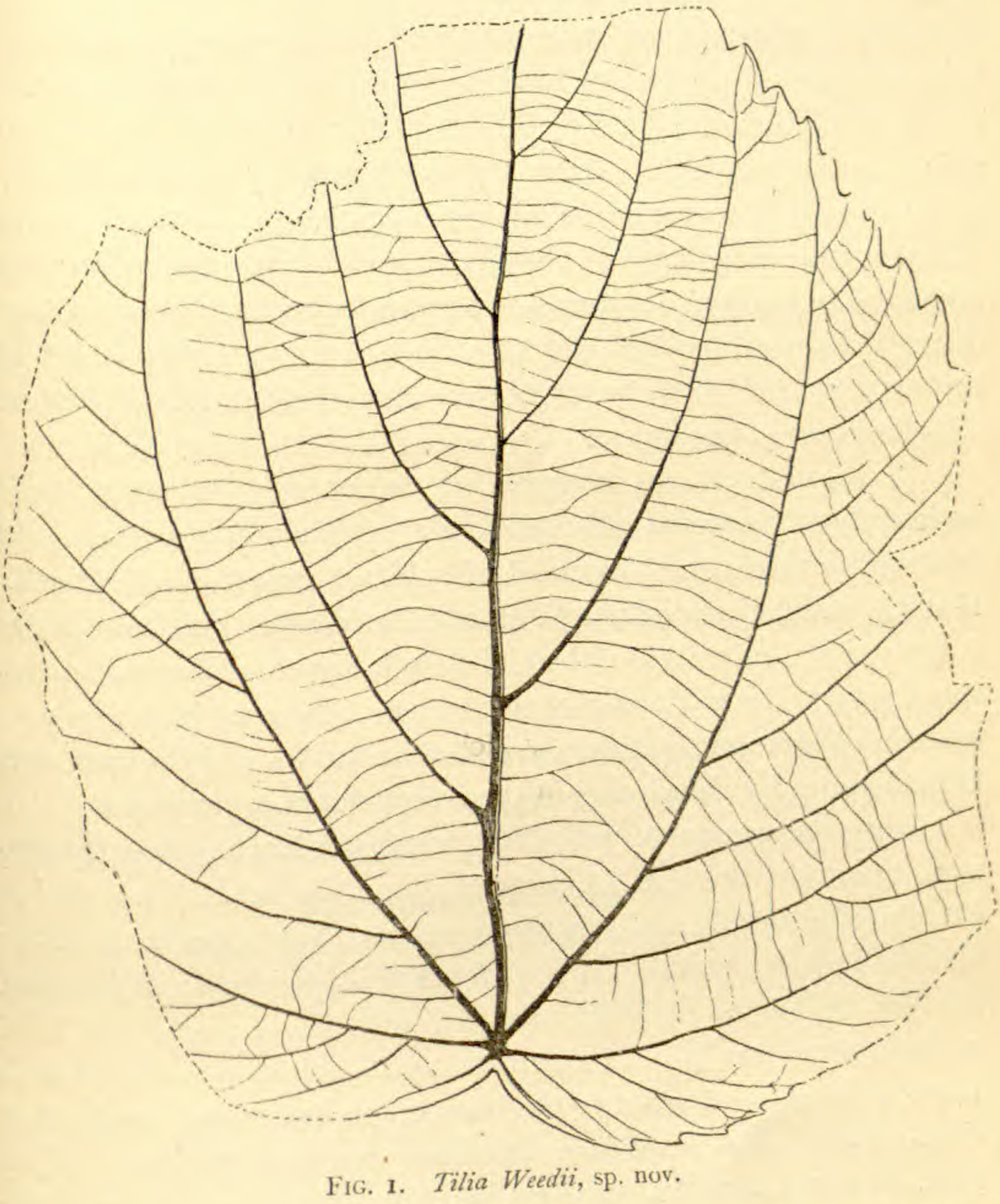

FIG. 1. *Tilia Weedii*, sp. nov.

right angle to the midrib, slightly arching upward and provided on the lower side with some 6 or 8 secondary branches, which also apparently fork and end in the teeth; nervilles numerous, strong, mostly percurrent and unbroken; finer nervation producing quadrangular areas.

The example figured was the only specimen contained in the collection; unfortunately it is not perfectly preserved, especially in its margin. It appears to have been very broadly cordate-ovate or almost orbicular. As now preserved it is 11 cm. in length and about 10 cm. in width. From the configuration it seems hardly probable that it was more than 1 or 2 cm. longer or 1 cm. wider when living. The base is distinctly cordate, with well-rounded lobes. The margin, as already stated, is not well preserved, but from the manner in which the veins fork it was probably toothed throughout, with the veins ending in these teeth. The nervation is well shown in the figure.

On account of lack of knowledge regarding the margin it is impossible to compare this leaf closely with other species. At first sight it seems to be identical with *Viburnum antiquum* (Newb.) Hollick,* which was called *V. tilioides* by Ward,† but this species is not strictly palmately ribbed, although approaching it in some specimens. The most important point of difference is in the secondaries, these being distinctly dichotomous in *V. antiquum*, and branching on the lower side in the leaf under consideration.

It may be compared with *Tilia populifolia* Lesq.,‡ from Florissant, Colorado, this species being of about the same size. It has the margins deeply and regularly serrate, but appears to differ essentially in nervation. It is 5-ribbed from the base, as in ours, but the midrib is perfectly straight, with more numerous thin, straight secondary branches, and the upper pair of ribs do not arch upward but pass straight to the margin on the same angle that they arise. The secondary branches are also thinner. They fork, however, sending branches into the teeth, as presumably the present one does.

Among living species this form seems to approach most closely to *T. Americana*, which agrees well in size and nervation. The

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* Later Extinct Floras, 128. *pl. 33. f. 1, 2.*

† Types of the Laramie Flora, 107. *pl. 50–52. f. 1, 2.*

‡ Cret. & Tert. Fl., 179. *pl. 34. f. 8.*

living species is usually more unequal-sided at base than the fossil, but there is variation in this respect, certain of the leaves being almost regular below. In the fossil leaf the midrib is proportionally thicker, more zigzag and the first pair of lateral ribs more curved upward. The nervilles and finer nervation are practically the same.

I have named this species in honor of the collector.

AGE OF THE BEDS AS INDICATED BY THE PLANTS

The number of species, although small, is sufficient to give a pretty clear idea of the age. Four species have been enumerated, three of which were previously known. Of these *Onoclea sensibilis fossilis* has only been found in the Fort Union beds, at the mouth of the Yellowstone and in the Canadian Upper Laramie. *Aralia notata* was described originally from the Fort Union and has only been found in beds of similar.age in the Yellowstone National Park. *Glyptostrobus Ungeri*, if this be the proper name by which to call it, is abundant in the Fort Union beds, and has also been found elsewhere. The new species (*Tilia Weedii*) is of uncertain affinity and is therefore of little value in this instance. The things it most resembles belong to the Fort Union.

Taking into account the locality whence these plants came the character of the material and the species as above enumerated, I do not hesitate to say that the beds in which they occur should be referred to the Fort Union.

Explanation of Plate 26

FIG. 1. Fruiting frond of *Onoclea sensibilis fossilis* Newb.

FIGS. 2–4. Sterile fronds of same.

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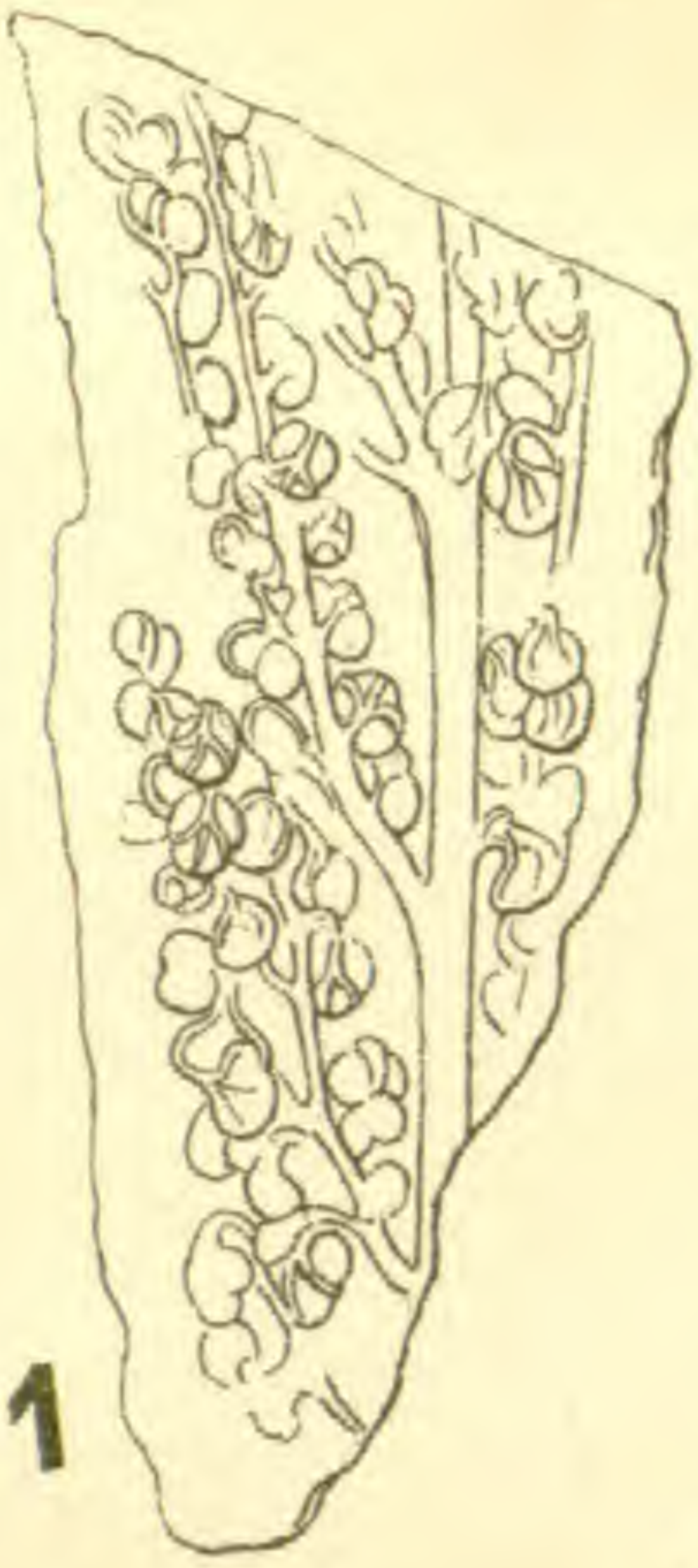

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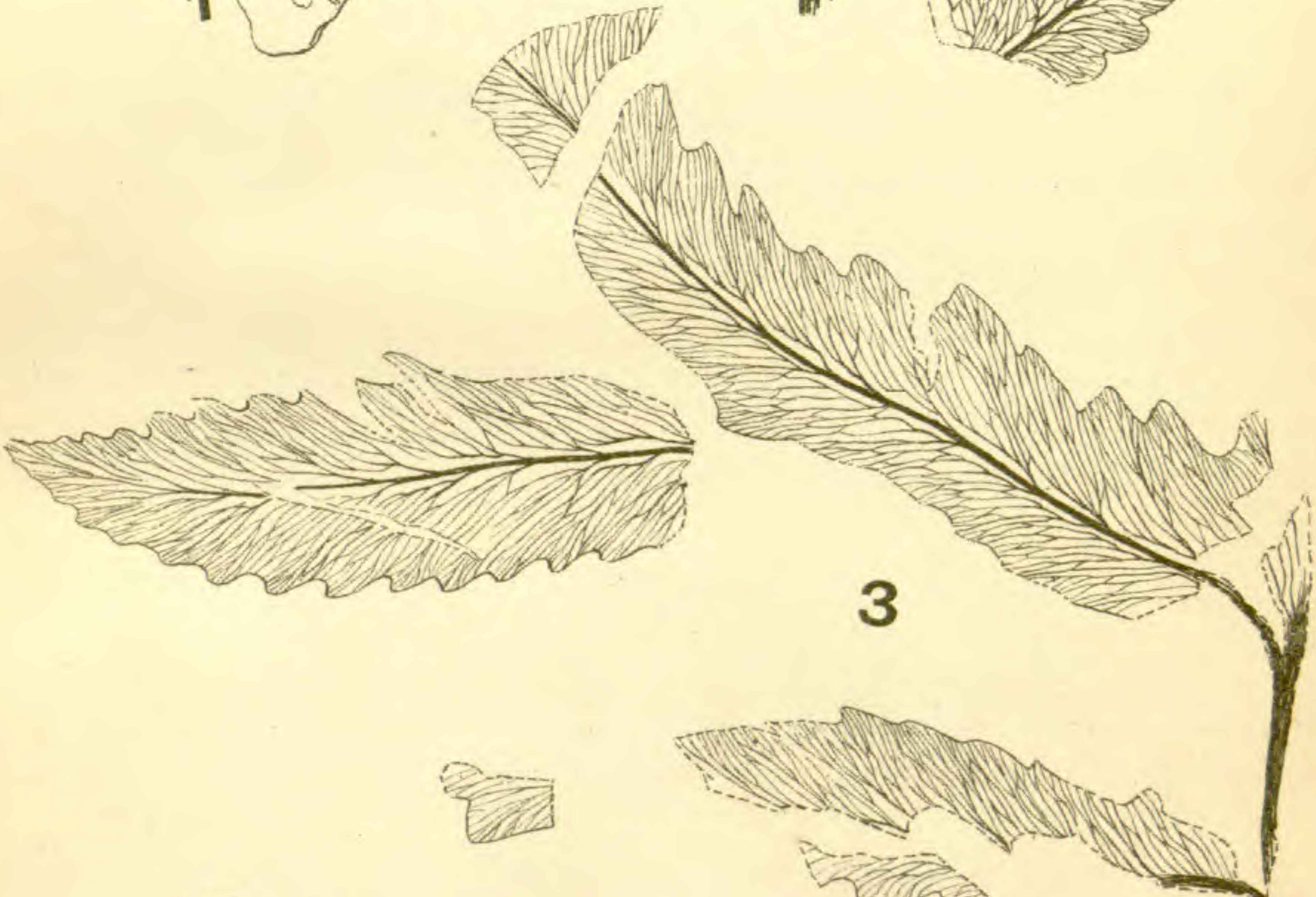

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