# BOTANICAL GAZETTE

THE

# BOTANICAL GAZETTE

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VOLUME XXII
JULY—DECEMBER, 1896



CHICAGO, ILLINOIS
PUBLISHED BY THE UNIVERSITY OF CHICAGO
1896

THE UNIVERSITY OF CHICAGO PRESS

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OPEN LETTERS—*Continued*



## DATES OF PUBLICATION.

No. **1**, July 31; No. **2**, August 31; No. **3**, September 23; No. **4**, October 20; No. **5**, November 23; No. **6**, December 24.

## ERRATA.

p. 10, line 18, for *nutkana*, read *Nutkana*.

p. 50. After line 7 insert the paragraph "Missouri: on sand rocks near Perryville, Perry co. (*Rev. C. H. Demetrio*, 1894)."

p. 51, line 19, for VENELLA, read TENELLA.

p. 52, line 20, instead of "form" read "forms."

p. 106, line 3, for $H_2Po_4^-$, read $H_2PO_4^-$.

p. 185, line 5, for ence, read hence.

p. 226, line 5 from below, for Glæo-, read Glœo-.

p. 246, line 7, for H., read R.

p. 247, line 7, for *viridiflore*, read *viridiflora*.

p. 250, line 10 from below, for *viridiflore*, read *viridiflora*.

p. 428, line 2 from below, for Linden, read Lindau.

Vol. XXII JULY 1896 No. 1

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ISSUED JULY 31

CHICAGO, ILLINOIS

Published by The University of Chicago

The University of Chicago Press

# Botanical Gazette

A Monthly Journal Embracing all Departments of Botanical Science

**Annual Subscription, $3.00** **Single Numbers, 30 Cents**

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**Money Orders** and drafts should be made payable to The University of Chicago.

[Entered at the Post-office at Chicago, Ill., as second-class postal matter.]

VOLUME XXII NUMBER 1

# BOTANICAL GAZETTE

*JULY 1896*

## ROSÆ AMERICANÆ. I.

### OBSERVATIONS UPON THE GENUS ROSA IN NORTH AMERICA.

FRANÇOIS CRÉPIN.

*To the Editors of the Botanical Gazette:*

The preface to the observations on American roses, which it is my intention to contribute from time to time, I shall put in the form of a letter, which will permit me to enter into the subject more easily. Recently I asked whether your excellent journal would grant me the courtesy of its pages to address American botanists upon the roses of their country, thinking that I would reach them better than if I should continue to publish my observations in European journals. You have kindly granted my request, and I hasten to take advantage of it.

In the first place, I would call the attention of your readers to the fact that twenty years ago (1876) I published a monograph of the American roses,[1] in which I gave a résumé of our knowledge at that time. Ten years afterwards the late Sereno Watson published a similar work,[2] but based upon more abundant material than had served for my monograph. This monograph, of incontestible merit and containing contributions to our knowledge, was after all simply a preparation for a complete presen-

[1] "Prodrome d'une monographie des roses américaines," in *Bull. Soc. bot. Belg.* **15**: —. 1876.

[2] "A history and revision of the roses of North America," in *Proc. Amer. Acad.* **20**: —. 1885.

tation of American roses. Watson did not always seize upon the natural affinities which hold together certain forms, being misled by appearances simply or by a misinterpretation of certain characters. Thus, he separated *R. acicularis* Lindl. into two species, one taking the name *R. Sayi* Schwein.; then later into a third species, *R. Engelmanni*.[3] These three species are actually but three varieties of the same specific type. Also he has recognized as a distinct species *R. Arkansana* Porter, which is perhaps but a variety of *R. blanda* Ait. He has preserved as a separate species *R. lucida* Ehrh., which is indeed but a variety of *R. humilis* Marsh. Finally, he has organized two specific groups under the names *R. Fendleri* Crépin and *R. Woodsii* Lindl., each of which seems to me to be composed of heterogeneous elements. As for his *R. Mexicana*, the few specimens which have been collected scarcely permit me to know whether he has well separated it as a distinct species. In any case it seems to belong to the section CAROLINÆ.

In the preface of his monograph Watson says that if the roses were reduced to their primary types North America would contain but nine species. This proposed condensation indicates that he had not acquired sufficient acquaintance with roses, and that he had formed false conceptions of certain forms. It was to call attention to the errors in Watson's work that I published in 1887 and in 1889 a series of remarks upon American roses.[4]

About the same time, another American student of roses, Mr. G. N. Best, took up the study of American roses, concerning which he has published a number of interesting notes,[5] which deserve to be consulted by all who study the genus.

Thanks to researches and multiplied observations which have been made, the acquaintance with a certain number of species is

[3] Garden and Forest, 1887.

[4] "Nouvelles remarques sur les roses américaines," *ibid.* **26**: —. 1887, and **28**: —. 1889.

[5] Remarks on the group CAROLINÆ of the genus *Rosa*, in *Bull Torr. Bot. Club*, 1887. Remarks on the group CINNAMOMEÆ of the North American Roses, *ibid.* 1890. North American roses; remarks on the characters with classification, in *Jour. Trenton Nat. Hist. Soc.* 1889.

sufficiently complete, and these species are scarcely able to cause confusion, at least to collectors and authors who will take the trouble to consult good descriptions. These species are: *R. setigera* Michx. (*R. rubifolia* R. Br.), *R. Carolina* L., *R. humilis* Marsh. (incl. *R. parviflora* Ehrh. and *R. lucida* Ehrh.), *R. nitida* Willd., *R. foliolosa* Nutt., *R. gymnocarpa* Nutt., and *R. minutifolia* Engelm.

But besides these species there are others less well known, which have frequently given rise to confusion. These latter will be considered especially in the notes sent to the BOTANICAL GAZETTE.

The genus *Rosa* has had the singular fortune of having been studied more than any other genus, and of having had its species become more obscure and less recognizable as the work upon them has multiplied, so that today the study of the genus is dreaded by the great majority of botanists. On account of the chaotic state to which the genus has been reduced by species makers, some students have concluded that there are no established boundaries between the species, and that it is useless to seek for constant characters with which to separate them. For some years I have not ceased to protest against this idea, which is radically false, and contradicts well-observed facts. I will continue to affirm that the true species of the genus *Rosa* are clearly characterized, and as distinct from each other as those of any other genus.

One can attribute the deplorable state of the genus for half a century to two principal causes, *viz.*, the condition of the collected material, and the desire of numerous amateurs and florists to discover a great number of new species in a small territory. In most genera the species are represented in herbaria by individuals more or less numerous all of which usually show the characters necessary for good specific determination, so that one may compare individuals with each other, may distinguish dwarf and giant variations, and may form some adequate conception of the possible modifications by organs due to lack or excess of vigor.

But in *Rosa* this is not the case. The species are represented in herbaria by fragments only, either in flower or in fruit, from which one cannot always obtain all the factors for a just conception. If it had been possible to represent the roses in collections, as has been the case with herbaceous plants, by entire individuals, that is to say by bushes, the recognition of the species would not be in so great uncertainty. To the difficulties resulting from insufficiency of material there are added those which the species makers have accumulated, the "counters of hairs," as they are sometimes called, who have multiplied specific types in a needless fashion.

It is to warn my American confrères against the breaking up of species, and to show them how careful one must be before proposing a new type, that I intend to submit to them some considerations based upon long experience, taking up especially species of the section CINNAMOMEÆ.

Each species may present itself in three conditions of vegetation: an habitual state, which may be called the medium, a dwarf state, and a giant state. It is from the medium state, that is, the most frequent one, that the description of the type is usually drawn. The distinctive characters furnished by this state are put in relief in the diagnoses. The dwarf and giant states, however, present certain characters which do not correspond to these diagnoses, and lead to an inference of the existence of specific forms distinct from those described. This has frequently occurred. The dwarfing or the enlargement in the genus *Rosa* affects the form of the prickles, the dimensions of the leaves, of the flowers, of the fruits, etc.; affecting not only the *ensemble* of a bush, but also different parts of the same bush. Thus a delicate or more or less exhausted axis may give rise to puny floriferous branches with small leaflets and single-flowered inflorescences; while a vigorous axis may give rise to floriferous branches with large leaflets and many-flowered inflorescences. These two kinds of branches, if they be isolated, appear very different from each other, and may give rise to the idea of two varieties or even of two species. It is the dwarfing or enlargement occurring upon a single bush, however, which deserves special study.

In the section CINNAMOMEÆ the armature of the axes shows three conditions: (1) all the axes may be covered with setaceous prickles, scattered and more or less abundant; (2) scattered prickles may occur only in the lower parts of the axes, being completely wanting in the upper parts, which thus become unarmed; (3) prickles may be borne, as before, upon the lower parts and disappear in the upper parts, where the armature is reduced to the regularly paired prickles upon each leaf. It may happen that in species normally provided with paired prickles, these may not be produced upon certain floriferous branches, as also at the extremity of the stems.

In the first case, in which the axes are completely setigerous, dwarfing has apparently no influence upon the armature; but enlarging produces a diminution in the number of prickles at the extremity of the axes. In the second case, dwarfing produces the appearance of numerous prickles distributed equally over all the axes; while enlarging increases the unarmed appearance. Lastly, in the third case, dwarfing produces the development of numerous prickles equally distributed upon those parts of the axes which are normally without them and introduces an obstacle to the regular arrangement of the paired prickles; while enlarging favors the occurrence of paired prickles upon the extremity of the axis.

These variations in the armature result in specimens of the same species differing much from one another, according as they have been taken from the dwarf or giant bushes, or from the lower or upper parts of the same bush.

Again, dwarfing may produce the curious result of transforming the main stem into flower-bearing branches. These stems, remaining dwarf, instead of terminating in a leaf bud which continues the axis, end in an inflorescence which is more or less many-flowered. These stems are thus transformed into floriferous branches, differing in appearance from the normal floriferous branches, and showing one or two more pairs of leaflets, with leaves and upper stipules more crowded. It is this exceptional state of growth which seems to me to have suggested the establishment of *R. Arkansana* Porter.

In Europe, the pubescence and glandulosity have played a preponderant and excessive part in the separation of species and have led to the establishment of a host of pretended species. These have encumbered the genus to such an extent, that it has become nearly impossible to study it. I do not intend to rule out entirely pubescence and glandulosity as means of distinguishing species, but it is necessary to abandon the idea of using them as distinguishing characters of the first order, and to limit their use to indicating differences of a very secondary value. Many species may be either glabrous or pubescent, glandular or non-glandular; but some are more frequently glabrous, others more frequently pubescent, or more habitually glandular, or more often non-glandular. Finally, there are some species which are glandular with great constancy.

What has just been said with reference to smoothness and pubescence, and a glandular and non-glandular condition, is applicable to the form of the leaf-teeth as well, which in the same species may be simple, double, or glandular-compound.

The form of the floriferous and fructiferous receptacles is also subject to frequent variation in the same species. Certain species, however, have the receptacles habitually rounded, while others have them more or less ovoid or elongated. In the section CINNAMOMEÆ the rounded form is the most common.

An attentive study of the numerous variant forms displayed by different species reveals parallel lines of variation, which are faithfully repeated in the different species. The existence of these parallel variations strengthens the evidence as to the folly of an excessive multiplication of species. I wish to say, in passing, that the fragmentation of species of *Rosa* has had in America an exponent in Rafinesque. This singular naturalist, whom one should never take seriously, has constructed some species which will remain enigmas forever.

In Europe the recognition of true species was retarded for a long time by the ignorance concerning the existence of hybrids, whose intermediate and vacillating characters often render obscure those of genuine types. At present, however, since the frequent occurrence of hybrids has been demonstrated and the bastard products partly classified, the distinction of species has become more precise and rigorous. It is probably true that American roses do not escape hybridization any more than the European and Asiatic species, and the American botanists must face the duty of discovering the hybrids of their country, for their first recognition ordinarily cannot be made with certainty except in the field. They will have to examine with much attention the more or less intermediate forms which occur where several species grow in company. Perhaps they will discover hybrids between *R. pisocarpa* and *R. Nutkana*, between *R. pisocarpa* and *R. gymnocarpa*, between *R. blanda* and *R. acicularis*, etc. M. Th. A. Brutsin has described a *R. neglecta*, which he considers *R. lucida* × *blanda*.[6] Up to the present, in such herbarium material as I have studied, I have recognized but one form which has seemed to me a hybrid, a form which seems to be *R. Carolina* × *humilis*.

I herewith close this preamble, which may appear long, but which I thought indispensable to enable my American confrères to understand thoroughly my way of looking upon species of the genus *Rosa*.

BRUSSELS, March 5, 1896.

## ROSA NUTKANA Presl.

I begin my remarks with this species because it has just been the object of a new specific creation under the name of *R. Macdougali* Holzinger.[7] The description of this supposed new species given by Mr. Holzinger is entirely insufficient, and does not permit even the section to be recognized. Two beautiful specimens that Mr. Coville has kindly sent me[8] have enabled

[6] Vergleichende Flora Wisconsin in *Verhand. d. K. K. Zool.-bot. Gesell. in Wien* **26**: 246. 1877.

[7] BOTANICAL GAZETTE **21**: 36. 1896.

[8] Mr. Coville has also sent to me specimens of *R. blanda*, *R. Fendleri*, *R. Cali-*

me to recognize the plant. It is a variety of *R. Nutkana*, with twigs and floriferous branchlets unarmed (in my two specimens), leaflets pubescent on the principal veins, simple teeth, one-flowered inflorescence, hispid-glandular pedicels, receptacles beset with numerous glandular hairs, and sepals glandular on the back. The author says that the single character of hispid-glandular receptacles permits his new species to be distinguished from all other American types. However, several other American species may have their receptacles as hispid as that of *R. Macdougali.* If Mr. Holzinger had consulted the BOTANICAL GAZETTE of 1894 he would have found that Mr. Merritt Lyndon Fernald had described (p. 335) a variety of *R. Nutkana*, under the name of *hispida*, whose receptacles are strongly hispid-glandular. This variety *hispida* was established upon specimens received by Watson from Rock Creek, Montana, and through C. V. Piper from Pullman, Washington. In 1885 Watson in his monograph alluded to the Rock Creek plant, and was inclined to consider it a variety of *R. Nutkana.* Does the variety *hispida* have leaflets glandular beneath and glandular-compound teeth? I have reason to suppose that it has. In 1890, Mr. Edward L. Greene sent me some undetermined specimens which had been collected at Lake Pend d'Oreille, which proved to be a variety of *R. Nutkana* probably identical with the var. *hispida.* The leaves have become almost glabrous, but are glandular beneath, with glandular-compound teeth, and the pedicels, receptacles and sepals are densely hispid-glandular. In my *Prodromus* of 1876 I have given a history of *R. Nutkana*, which at that time was poorly known. Afterwards, the rich material which I have brought together, and the study which I have made of the plant in cultivation, make me somewhat acquainted with the different variations of this type. They are numerous, and can be grouped in several series, which are parallel with the series of variations produced by other species of the same section. These series

*fornica*, and *R. gymnocarpa*, cited by Mr. Holzinger in his "Report on a collection of plants made by J. H. Sandberg and assistants in northern Idaho in the year 1892," in Contributions from the U. S. National Herbarium 3:223. 1895.

show us glabrous or pubescent leaves, simple or glandular-compound leaf-teeth, leaves glandular or non-glandular beneath, and the floral organs smooth or hispid-glandular.

Instead of describing at length all these variations, a work reserved perhaps for a monograph, in would seem best to present the characters proposed to distinguish *R. Nutkana* from the neighboring species.

I shall compare it first with *R. blanda*, which it resembles in certain features. The armature, when it is normally developed, is sufficient alone to distinguish the two types. Both, as is the case habitually among the CINNAMOMEÆ, bear numerous ordinarily setaceous[9] prickles below, but in *R. Nutkana* these prickles are accompanied by stouter prickles regularly paired on the leaves, prickles which are entirely lacking in *R. blanda*. The paired prickles of *R. Nutkana*, on the stems especially, are very peculiar and very different from the prickles of other American species of this section, often being thick, triangular in form, and more or less decurrent at base, normally straight and perpendicular to the axis from which they arise. On the branches these paired prickles become less robust, and likewise on the floriferous branches. Watson describes the prickles of *R. Nutkana* as being decurved, and Best says the same. I have examined sufficient material, both wild and cultivated, to be well assured that the prickles belong to the straight type, only exceptionally becoming decurved and hooked, as is the case in European and Asiatic species with prickles of the straight type. But the decurving is simply an accident, and it is this accident which Watson and Best saw. Prickles normally curved and hooked apparently occur in but one American species of the section CINNAMOMEÆ, namely, *R. Californica*.

The paired prickles also distinguish *R. Nutkana* from *R. blanda*, which is absolutely free from them. But if for some reason the paired prickles disappear from certain parts of the axes, it is then necessary to have recourse to other distinctions. Such are

[9] In the variety of *R. Nutkana* which I formerly called *R. Durandii* the setaceous spines are often replaced by pedicellate glands.

not wanting, but they are not as easy of application as those drawn from the prickles. The form of the leaflets, perhaps, may be usefully employed. In *R. Nutkana* the leaflets are oval, more or less rounded at base, with teeth rather open; while those of *R. blanda* are obovate, relatively narrower, more or less attenuate at base, with teeth turned towards the apex. It can be added that the former frequently has glandular-compound teeth, while the latter almost always has simple ones. To judge well the differences I have described it is necessary to compare quite an amount of material of the two species, for fear of being deceived by certain variations of form.

The inflorescence can also be used for a distinction, but should be used only with sufficient material for accurate judgment. The inflorescences of *R. Nutkana* are much more often one-flowered than are those of *R. blanda*. The statistics which I have obtained concerning the inflorescences give the following proportions between the one-flowered and many-flowered inflorescences: for *R. nutkana*, 1.8:1; for *R. blanda*, 1:1.4.[10]

The corolla is notably larger in *R. Nutkana*, and the fructiferous receptacles and akenes are a little larger. The tissue of the fructiferous receptacle at complete maturity is drier and less pulpy than in *R. blanda*. I wish to remark, in passing, that the size of the akenes, from which Mr. Best has obtained the means of distinguishing *R. Carolina* from *R. humilis*, deserves the attention of American botanists. In the section CINNAMOMEÆ it will be found probably that the size of the akenes may be usefully employed as a distinguishing character.

The upper stipules and bracts are habitually much more dilated in *R. Nutkana* than in *R. blanda*.

All of these last characters, resting simply upon a difference in size, certainly are of importance, but unfortunately they very often weary the perplexed observer who cannot compare a sufficient amount of well chosen material.

*R. pisocarpa* and *R. Californica* have paired prickles, as in *R. Nutkana*. In the former, these prickles, which are straight, are

[10] *Cf.* Remarques sur l'inflorescence des Rosa in *Bull. Soc. bot. Belg.* $34^2$: —. 1895.

slender and never take the form, at least on the stems and principal branches, of the stout prickles of *R. Nutkana.* In the latter, the paired prickles are more or less curved or hooked, and only exceptionally on the slender axes do they become more or less straight. I shall consider later other characters which separate *R. pisocarpa* and *R. Californica* from *R. Nutkana.*

Let us examine at present the geographical distinction of the latter. In his monograph, Watson says that it occurs along the Pacific coast from Alaska, in 62° lat., to Oregon, and extends eastward into the mountains of Idaho and northern Utah, where the Wahsatch marks its limit. Including the variety *hispida*, its eastern limit is extended into western Montana. From material which I have received, I have recognized the species beyond the limits of the United States in Vancouver island, in the lower valley of the Fraser, along the upper Columbia, also in Alberta. I have received specimens from the island of Sitka, which appear to me to belong to *R. Nutkana.* The material from the island Kodiak, which I have described under the name of *R. Aleutensis*, perhaps is, as Watson thought, a variety of the type of Presl, but before accepting this identification fresh investigation must be made.

Upon this side of the frontiers of the Dominion the species occurs in Washington and Oregon between the Pacific coast and the Rocky mountains. Does it reach California or Nevada? It occurs in the Siskiyou mountains, at the boundary of Oregon and California. Towards the east it extends to the mountains of Idaho and Montana. It is not very rare in Utah in the Great Salt Lake region, from which I have received specimens collected by Jones. In these localities it occurs at an altitude of 8,000 feet. Mr. Porter has sent me two floriferous branches collected by Mr. John Scott, in 1869, in the mountains of Colorado. These branches, reported as *R. Woodsii*, seem to me to belong to *R. Nutkana.* It is altogether likely that the species will be discovered in the mountains of Wyoming. According to the known facts, therefore, *R. Nutkana* has a boreo-occidental distribution.

## Rosa blanda Ait.

According to Watson, *R. blanda* extends from Newfoundland to Hudson's Bay, and southward to northern New York, whence it extends to the west as far as Minnesota, traversing Ontario, Michigan, Illinois, and Wisconsin, and appearing again to the north in Manitoba. We have in this a boreo-oriental distribution. In the consideration of *R. Arkansana* a little later we shall see whether this western limit of *R. blanda* should not be extended. Recently, Mr. Holzinger (*loc. cit.*) has pointed out *R. blanda* as occurring in Idaho (valley of Little Potlatch river, no. 381; Lake Cœur d'Alene, no. 581), but no. 581 of the Sandberg collection, of which I have received a beautiful specimen, appears to me to belong well to *R. Nutkana*. Its prickles are paired, its leaflets are pubescent and with simple teeth, its pedicels are ordinarily hispid-glandular, and its sepals are glandular without. As for no. 381 of the same collection, there is not the least doubt that it is *R. Nutkana*, with pubescent leaflets and simple teeth, and pedicels, receptacles and sepals smooth. The corolla is very large.

*R. blanda*, which often has pubescent leaves, sometimes displays leaves perfectly glabrous; the teeth are almost always simple, and very rarely do they become glandular-compound. Rarely, also, are the leaves a little glandular beneath, and the receptacles hispid-glandular. Different ages may give rise to various series of variations.

## Rosa Arkansana Porter.

In my *Nouvelles remarques sur les roses américaines* (1889) I have discussed at length the value of *R. Arkansana*, which I had concluded to consider only a variety of *R. blanda*.

According to the terms of the original description, the name *R. Arkansana* can strictly apply only to the form producing simple stems crowned with a terminal inflorescence. These simple stems, about a foot high, are more or less clothed with scattered, slender, straight and often setaceous prickles; the leaves, which are really cauline leaves, have four or five pairs of leaflets; and the exterior sepals sometimes bear lateral appendages. The authentic specimens whieh I have received from Mr. Porter have glabrous leaves.

Under the name *R. Arkansana*, Watson has not well included the preceding form, which alone constitutes *R. Arkansana* as it had been described by Mr. Porter, but applies it to tall forms, with stems attaining six feet in height and bearing floriferous branchlets which arise directly from the stem or are borne on the branches.

According to the abundant material which I have brought together in my herbarium under the name *R. Arkansana*, this species does not always have simple stems terminated by a many-flowered inflorescence and more or less setigerous. It may give rise to stems more or less tall and branching. In this case, the entire stem perhaps is clothed with numerous setaceous prickles which completely cover it or the greater part of the floriferous branchlets, which are then as setigerous as those of *R. acicularis*. It remains to be seen whether *R. Arkansana* in the dwarf state or in the tall bushy state may not be sometimes completely unarmed, with its floriferous branchlets entirely bare of prickles as are the upper branches. I have reason to think so. But in the last case what remains to distinguish *R. Arkansana* from *R. blanda?* Nothing seems to remain, for when the former produces floriferous branchlets upon the stem of the second year, or on the branches, these floriferous branchlets do not have four or five pairs of leaflets as in the false floriferous branchlets of *R. Arkansana* as constituted by Mr. Porter, but leaves of only five or seven leaflets, as those of *R. blanda ;* and, on the other hand, I do not see any difference between the normal branches of the two species. Perhaps it can be claimed that in *R. Arkansana* the exterior sepals are a little less rarely appendaged than in *R. blanda*.

It appears, then, that between these two roses there is a simple difference in the degree of abundance of prickles. The leaflets are the same, either glabrous or pubescent, and the floral organs appear to be identical.

Despite the extremely close affinity of these two forms, I think it prudent to obtain additional information before uniting them. Therefore in the dichotomous table at the end of this paper I have separated *R. Arkansana* as a distinct species, for the purpose of facilitating investigation. It is especially necessary to examine the mode of vegetation of *R. Arkansana*, and to discover the modifications involved in dwarf and giant forms. The cause of the dwarfing, which is quite frequent, should be investigated. Perhaps the frequent fires which ravage the prairie region where *R. Arkansana* appears to occur may have some connection with the dwarfing. It is important to know whether *R. blanda*, more or less typical, does not occur quite frequently associated with *R. Arkansana*, and whether the latter does not gradually pass into the former by a series of intermediate states.

I have specimens of typical *R. Arkansana* from Minnesota, Nebraska, Kansas, Colorado, and Manitoba, and from the Saskatchewan. I have described the plant from the last station under the name *R. blanda* var. *setigera*.

Finally, if *R. Arkansana* is found to be a variety of *R. blanda*, the area of distribution of the latter will be extended chiefly westward.

ROSA PISOCARPA A. Gray.

In 1876 (*Prodromus*) I expressed doubts as to the autonomy of *R. pisocarpa* A. Gray. These doubts have been removed by subsequent study of abundant material received from America, and from cultures which I have made. Before entering into the discussion, I wish to remark that Nuttall, who first had recognized the character of *R. gymnocarpa* and *R. foliolosa*, and likewise of *R. Nutkana*, which he had designated in his herbarium as *R. megacarpa*, had taken *R. pisocarpa* for a new species, to which he gave the name *R. arguta* MS. If Torrey and Gray had retained these two names proposed by Nuttall, there would have been two more species to his credit.

In its habitual form, such as Asa Gray described and figured in the *Botanical Magazine* (*pl. 6857*), *R. pisocarpa* cannot be confounded with any other species. Its prickles regularly paired, and its leaflets more or less conspicuously rounded at base, distinguish it from *R. blanda*. Its slender and straight prickles, and its inflorescence with small and usually numerous flowers, separate it from *R. Nutkana*. Lastly, the form of its prickles, which are straight and not curved or hooked at the tip, permits no confusion with *R. Californica*.

Despite these differences, there is more or less confusion. Thus, specimens of *R. pisocarpa* received from the Siskiyou mountains, Washington, from Mr. Pringle and Mr. Suksdorf, have been reported by Watson as *R. Californica*. This error came from the appearance of the specimens and a too narrow conception of *R. pisocarpa*. They do not always show the small rounded fructiferous receptacles as large as a pea, such as were described by Asa Gray. These receptacles can become notably larger, either strongly constricted at the neck, or ellipsoidal. On the other hand, the leaflets, which are glabrous or pubescent, sometimes show small glands upon the lower surface. In the last case, the teeth either remain simple or become glandular-compound. Among the rich material from Washington sent to me by Mr. Suksdorf, and which I have placed in my herbarium under *R. pisocarpa*, there are forms whose leaflets are more or less attenuate at base, as in *R. blanda*, instead of rounded as in the type. Will the contraction of the lower part of the leaflets necessitate the making of a species distinct from *R. pisocarpa?* This is impossible, for this difference is not to be regarded. Such contraction will always weaken the amount of distinctive characters which separate *R. pisocarpa* and *R. blanda*.

*R. pisocarpa* seems to be subject to the same variations as are *R. Nutkana* and *R. blanda* from dwarfing and enlarging, and to show very marked differences between specimens from dwarf bushes and those from more vigorous and taller bushes.

The geographical range given to *R. pisocarpa* by Watson seems to me to need extension, and that, too, probably at the expense of the two groups of forms which he has included under the names *R. Fendleri* and *R. Woodsii*. Towards the north Watson does not extend the limit beyond the southern part of British Columbia. Does the species occur farther north ? I am inclined to believe so. Mr. Greene has sent me a small flowering specimen collected by Mr. Bates, in 1882, near Fort Yukon, Alaska, which seems to me to belong to *R. pisocarpa*. However, I do not wish to announce this determination with certainty; but I am certain that it is not *R. acicularis*, which Watson cites from the same locality.

*R. pisocarpa* passes down the Columbia into Washington and Oregon, penetrates California in the Sacramento valley, and, I am well assured, reaches Nevada City.

It now remains to see whether it does not extend towards the east and south by the Rocky mountain range, as is the case with *R. Nutkana*. In Idaho Mr. Sandberg has collected, on the shores of Lake Pend d'Oreille (no. 871), a form reported by Mr. Holzinger as *R. Californica*, which appears to me to be a variety of *R. pisocarpa*, the same as two other forms obtained by the same collector in Montana (no. 973 and no. 1009) and reported by Mr. Holzinger as *R. Fendleri*. Mr. Greene, also, has obtained from Idaho, near Montpelier, a form which I think should be referred to *R. pisocarpa*. I have from Utah different forms collected by Mr. Jones, among which I think I recognize the type of Gray. Lastly, from Colorado I have received several roses whose specific identity, for want of sufficient material, is perplexing to me; nevertheless I have reason to suppose that *R. pisocarpa* is among them. These forms of Utah and of Colorado for the most part have been referred by Watson to *R. Fendleri* and *R. Woodsii*.

### ROSA FENDLERI Crépin.

I have given the name *R. Fendleri* to a rose obtained by Fendler in New Mexico. Watson has described under this name plants from a great number of localities, and upon considering the description given in his monograph and the extent of the geographical distribution, one is tempted to believe that he has characterized a good species; but despite long study I am unable to form a clear idea of that specific group. I am tempted to believe that *R. Fendleri* as constituted by Watson is probably an artificial group formed, in part, at the expense of *R. pisocarpa* and *R. blanda*, and perhaps partly of one or of several other species as yet incompletely known. As for my *R. Fendleri* of New Mexico I have examined too little material to be actually sure that it is an autonomous type.

For elucidating the problem of *R. Fendleri* a number of investigations need to be made. The botanists who explore the vast region of the Rocky mountains should make careful observations as to the appearance of the bushes. They should examine the variations which accompany the dwarf and giant states, and obtain abundant, well-selected material from which to form a trustworthy opinion of the armature of the different axes. In short, in my opinion, *R. Fendleri* remains as an obscure species, not capable of being clearly defined in the dichotomous table which I have added at the close of the paper.

## Rosa Woodsii Lindl.

*R. Woodsii* was established upon a plant cultivated in the Garden of the Horticultural Society of London. It was supposed to have come from the basin of the Missouri. I have authentic specimens in my herbarium, and have seen others in the Lindley herbarium. One perceives how much cultivation ordinarily modifies the appearance of a species, and how much a description drawn from a single cultivated plant can introduce uncertainty when there is an attempt to apply such a description to the wild plant. This is certainly the case with the description of *R. Woodsii*.

I here wish to digress a moment in reference to this. Watson established, within the Cinnamomeæ which he described, two principal divisions. The first is characterized by the prickles all scattered, and includes *R. acicularis*, *R. Sayi*, *R. blanda*, and *R. Arkansana*; the second is distinguished by the paired prickles, and includes *R. Nutkana*, *R. pisocarpa*, *R. Californica*, *R. Fendleri*, and *R. Woodsii*. This last division is subdivided into two groups, one of which has the sepals all entire, and the other with the outer sepals ordinarily having one or several lateral segments. The last includes only *R. Woodsii.* Certainly the form of the sepals is extremely important in distinguishing species and even sections, but it is necessary that that form be normal and constant. Now in the section CINNAMOMEÆ the sepals are normally entire, and it is only exceptionally that they produce toward the summit small entire and erect appendages. The difference is great between these sepals exceptionally appendaged and those normally producing lateral appendages from the base. It should be mentioned that the exceptional appearance of lateral appendages is not peculiar to *R. Woodsii*, but may occur in almost all of other American CINNAMOMEÆ.

It follows, therefore, that the most distinctive character used by Watson to sustain the autonomy of *R. Woodsii* has no value, or at least a very secondary value. What other characters, therefore, can separate this species from its neighbors? I have not been able to discover them. In 1876 I expressed the opinion that *R. Woodsii* was only a variety of *R. blanda.* Today I would not dare to be so positive, and would reserve my judgment concerning this form. New researches are necessary either to merge it with another species or to establish it as distinct.

The original description of *R. Woodsii* was corrected by Lindley himself in the *Botanical Register* **12**, which contains a beautiful figure of it (*pl. 976*). This figure, drawn from the cultivated plant, of which I have specimens, has glabrous leaflets oboval and attenuate at base as those of *R blanda*, and with simple teeth; perfectly entire sepals, although in my specimens the exterior ones are sometimes laterally appendaged; receptacles sensibly larger than in these same specimens; and lastly, prickles quite regularly paired as well upon the branches as upon the floriferous branchlets, while in my specimens they are generally scattered and paired only beneath a few leaves terminating the branches. Lindley, in his original description, says the prickles are scattered, but become paired toward the "extremities." By "extremities" he doubtless meant the summit of the main branches or leaf-bearing branches. In the corrected description of the *Botanical Register* he declares that they are scattered. It is important to know whether the prickles are normally scattered or paired, for, in the former case it would make *R. Woodsii* approach *R. blanda*, while in the latter case it would approach *R. pisocarpa.* This observation must be made in the Missouri region, which appears to be the natural habitat of *R. Woodsii.*

Watson identifies *R. Maximiliana* Nees as *R. Woodsii.* I have authentic specimens of that rose obtained by Prince Max. von Wied in the prairies on the banks of the Missouri. Apart from its pubescent leaflets that form shows very close affinity to *R. Woodsii*, with which it certainly seems to be identical. The armature of its axes very much resembles that of specimens of *R. Woodsii* to which I have alluded above, and leaves me without doubt as to the arrangement of the prickles.

In conclusion, *R. Woodsii* of Lindley remains doubtful to me. Perhaps it constitutes a distinct species; perhaps it is but a variety of *R. blanda* or of *R. pisocarpa.* In reference to *R. Woodsii* as constituted by Watson, I believe it is composed of heterogeneous specific elements.

### Rosa gratissima Greene.

Mr. Greene described his *R. gratissima* in 1891 in his *Flora Franciscana*, and remarks that it has the look of *R. Californica.* According to Mr. Greene the prickles, which are slender and straight, are paired only upon the vigorous growing shoots.

Upon comparing the descriptions of *R. gratissima* and *R. Californica* given by Mr. Greene, we find that the first is distinguished from the second (1) by its prickles straight and slender, not stout and habitually curved; (2) by its leaves thin and bright green, not firm and dark green, with teeth a little falciform and not open; (3) by the stipules of the cauline leaves strongly denticulate and not entire. From an examination of specimens sent to me by Mr. Greene, undetermined, but with no doubt as to their identity with *R. gratissima*, I would point out (1) that the prickles are slender and straight, abundant and all scattered on two long fragments of stems, less abundant on the portions of the stem bearing floriferous branchlets where they are also scattered or rarely irregularly paired, also irregularly paired but more often scattered on the floriferous branchlets; (2) that the leaves are thin and bright green, with teeth usually simple and directed somewhat towards the apex; (3) that the stipules of the cauline leaves are quite strongly denticulate, but so also are the upper stipules of the floriferous branchlets and the bracts. But Mr. Greene has not remarked the fact that the upper stipules and bracts are dilated, while those of *R. Californica* remain narrow. This dilatation of stipules and bracts, in my judgment, constitutes an important distinctive character.

I observe, moreover, that the inflorescences are all pluriflorous, with 2 to 5 flowers, that the pedicels are long and slender, quite often a little pubescent, that the pubescence may invade the receptacle, that the sepals may be silky on the back and the exterior ones sometimes furnished above with one or two small very narrow and entire lateral appendages, and, lastly, that the corolla is quite small. Mr. Greene seems to lay stress upon the fragrant glands of the leaves. I would remark, however, that the glandular character of certain varieties of *R. Californica* is more marked and persistent. In *R. gratissima*, as in the forms of *R. pisocarpa* with glandular leaves, the leaf glands are very small, sessile, very abundant on very young leaves and as abundant on the petioles as upon the lower surface of the leaflets; but these glands are fugacious and disappear with age, for the most part quite promptly. In *R. gratissima* these minute glands may also invade the upper surface of the leaflets.

The question suggests itself whether *R. gratissima* constitutes an autonomous specific type, or is an aberrant variety of *R. Californica*. The material which I have received, obtained perhaps from one bush, does not permit me to decide with certainty. Nevertheless, by reason of its dilated upper stipules and bracts, and its straight spines, I consider that *R. gratissima* is specifically distinct from *R. Californica*, and that other characters do not permit it to be a variety of *R. pisocarpa*.

It is important to know whether the character drawn from the denticulation of the stipules and bracts[11] remains constant on all the bushes or is exceptional. In the second place, an important point to elucidate is the normal disposition of the prickles. Are they normally scattered and only exceptionally paired, or are they regularly paired on bushes more or less vigorous?

If *R. gratissima* constitutes a distinct type, it can be expected to occur with glabrous leaves and glandular-compound leaflet-teeth, and also, perhaps, with pedicels and receptacles hispid-glandular.

### ROSA CALIFORNICA Cham. & Schlecht.

*R. Californica* is a species which occurs extensively throughout California. It seems to be somewhat common there and plays about the same rôle as does *R. canina* in Europe. It ought, therefore, to produce numerous varieties.

Watson groups *R. Californica* with *R. pisocarpa* and *R. Fendleri* in a subdivision characterized by its small flowers, ordinarily in pluriferous inflorescences, and its short and narrow stipules; while he forms with *R. Nutkana* another subdivision distinguished by its large flowers, ordinarily in one-flowered inflorescences, and its dilated stipules. *R. Nutkana* is well distinguished, indeed, by a large corolla, by inflorescences often one-flowered, and by the upper stipules remarkably dilated; but in *R. pisocarpa* the stipules cannot be said to be altogether narrow, and the upper ones, although smaller than those of *R. Nutkana*, are, nevertheless, more dilated than those of the lower and cauline leaves. The same thing is seen in the forms which Watson has described under *R. Fendleri*. In *R. Californica* all the stipules appear to remain narrow, the upper ones becoming no more dilated than the lower, as is the case in *R. spithamæa*. This would suggest an important distinction to be established between the species with upper stipules and bracts dilated, including *R. Nutkana*, *R. pisocarpa*, *R. gratissima*, *R. Fendleri*, *R. Woodsii*, *R. blanda*, and *R. acicularis*, and those with upper stipules and bracts remaining narrow, including *R. Californica* and *R. spithamæa*. I would call the

[11] An analogous denture is observed sometimes in *R. blanda* and *R. Arkansana*.

special attention of American botanists to these differences, and urge them to see whether they are constant.

The form of the prickles affords a second important distinctive character for *R. Californica*. In that species alone are the prickles curved at the tip or more or less hooked. Watson does well to assign straight or recurved prickles to *R. Nutkana*, *R. Fendleri*, and *R. Woodsii*, but in those species, in my opinion, prickles recurved at the tip are only exceptional.

It is well to consider the regions of the axes where the prickles habitually show their normal form. These regions are ordinarily situated in the middle part of the stems and branches. On the floriferous branchlets, prickles normally recurved or hooked, following the weakness of the axes, may become straight. These variations in the armature, both in the form of the prickles and their arrangement, explain the necessity of judging only from quite large specimens, and the extreme usefulness of being able to observe the whole bush.

The form of the leaflets seems to vary quite widely in *R. Californica*, as well as the teeth, which may be simple or glandular-compound. The base, however, appears to be almost always rounded, and not attenuate or cuneate. The leaflets are almost always pubescent, with the lower surface glandular or not. According to Watson, they very rarely are completely glabrous, and that author cites but a single case, that of specimens obtained by Palmer at San Bernardino. No. 454 of the Palmer collection, representing *R. Californica* of that locality, is made up of specimens taken from several bushes which do not all belong to the same variety or even to the same species. Some have completely glabrous leaves and straight prickles, while others have pubescent leaves and more or less hooked prickles. Engelmann had sent to me specimens of this last form, also from San Bernardino. If the pubescent specimens belong to *R. Californica*, those with glabrous leaves appear to belong to another species. In my *Prodromus*, I have described a variety *glabra* of *R. Californica*, established on a plant cultivated in the Jardin des Plantes, Paris, under the name *R. myriantha* Decaisne, but that plant can as well be a variety of *R. pisocarpa* with glabrous leaves, and appears to be identical with the *R. pisocarpa* of Nevada City, to which I have already alluded.

Watson attributes to *R. pisocarpa* and *R. Fendleri* globular fructiferous receptacles, and to *R. Californica* ovoid receptacles narrowed above. Even if in the last the receptacles are almost constantly of that form, they may be sometimes globular, as, on the other hand, those of *R. pisocarpa* and *R. Fendleri*, in their turn, may be ovoid and narrowed above. Despite these variations, perhaps we should retain for these species the characters drawn by Watson from the form of the receptacles.

In comparing the diverse varieties which I include under the name *R. Californica*, with prickles curved or more or less hooked, and upper stipules and bracts narrow, one wonders whether several distinct specific types are not included under it, whose characters are not yet well known. For want of sufficiently abundant material I am compelled to reserve my judgment upon this question. I hope that the botanists of California, understanding the interest that attaches to the elucidation of *R. Californica*, will be willing to send to me numerous specimens of that species, obtained from different parts of their country.

Let us examine now the geographical distribution of the species. Watson says that it is found throughout California, ascending the mountains as far as 6,000 feet altitude ; that it had been encountered in Oregon and Washington, and perhaps in British Columbia; and existed in western Nevada and extreme northern Lower California. This range traced by Watson seems to me to be incorrect at several points. The specimens which made him include Oregon and Washington in the range belong to *R. pisocarpa*. As for British Columbia, I believe that it is entirely foreign to *R. Californica*. I have received from Nevada a specimen obtained by Mr. Greene from Reno, in the Sierra Nevada, not far from the California boundary. San Diego is the southernmost point from which I have seen specimens. Perhaps towards the south it extends beyond California into Arizona. I have received from Mr. Greene some flowering specimens obtained by him on Mt. Bill Williams, which have some resemblance to *R. Californica*, but I do not venture to pronounce with certainty as to their specific identity. It is very likely, from the known facts, that *R. Californica* is a species entirely western, peculiar to California, and having the Sierra Nevada as its eastern limit.

If one should believe Mr. Holzinger (*loc. cit.*) the limit of this species should be extended to Idaho, but no. 173 of the Sandberg collections, reported by that author as *R. Californica*, is *R. Nutkana*, while no. 871 certainly does not belong to *R. Californica.* The specimen which I have received is a vigorous flowering branchlet, with inflorescence 22-flowered. Despite this many-flowered inflorescence and quite a small corolla I am inclined to believe that this specimen is a variety of *R. Nutkana.*

In his *Flora of California* Watson describes a variety of *R. Californica* under the name *ultramontana*. This is passed over in silence in the monograph of the same author, and I do not possess authentic specimens of it. Mr. Jones has distributed, under no. 2455, with the name *R. Californica* var. *ultramontana* Watson, specimens of a form obtained at Salt Lake City, which reasonably agrees with the description of the variety *ultramontana*, but which does not appear in any way to belong to *R. Californica.* It rather seems to be a variety of *R. pisocarpa.*

### ROSA SPITHAMÆA Watson.

*R. spithamæa* was established by Watson in 1880, in his *Flora of California.* Later, in his monograph, he did not maintain the species, but reduced it to a variety of *R. Californica.* Perhaps Watson was influenced by the opinion which I had expressed concerning its establishment as a species.[12] Since 1882 I have received some new specimens of that curious rose, and their examination has induced me to think that it can very well be specifically distinct from *R. Californica.* In the valley of the Trinity river, where Mr. Rattan first discovered it, it is ex-

[12] *Cf.* Note sur les recentes découvertes de roses en Amérique, in *Bull. Soc. bot. Belg.* 21²: 146. 1882.

tremely abundant. That botanist wrote to Dr. Engelmann that he had encountered there thousands of plants, that the shrub was habitually but three or four inches high, and that it was only in fertile and shady places that it attained as much as a foot in height. The species seems to preserve its dwarf habit in other localities from which I have specimens.

This extremely reduced stature does not appear to be due to accidental dwarfing, and is very constant, constituting very probably an essential difference from *R. Californica*, which is habitually quite tall. This difference is further emphasized by the fact that the prickles of the former are almost always slender and belong well to the straight type, that the corolla is smaller, and that the receptacles are prominently hispid-glandular, a thing said to be very rare in *R. Californica*, and which, for my part, I have never yet observed.

It appears to me that in *R. spithamæa* the upper stipules and bracts are narrow as in *R. Californica*. This point, nevertheless, must be verified by more abundant material than I have at my disposal.

In *R. pisocarpa*, *R. blanda*, and *R. acicularis*, the stock produces more or less elongated subterranean shoots, which multiply the plants, and quickly transform a single individual into a colony which increases year after year. This very general mode of vegetative propagation among the CINNAMOMEÆ appears in *R. spithamæa*. Does it occur in *R. Californica*? We should be made sure of it.

In his *Flora Franciscana* Mr. Greene describes *R. spithamæa* as a distinct type, and, by the side of it, he establishes a new type under the name *R. Sonomensis*, which seems to be a very nearly allied form. This new species is about a foot high, and is distinguished from *R. spithamæa* by its stipules with auricles truncate and not acuminate; its leaflets broadly oval or almost orbicular, truncate or slightly cordate at base, and not obovate or elliptical and attenuate at base ; its inflorescence usually with more numerous flowers; its floriferous receptacles rounded-pyriform, and not ovoid; and its larger sepals.

Not yet having received authentic specimens of *R. Sonomensis* I can only judge of its value by its description. From a careful examination of the specimens of *R. spithamœa* which have come to me, and among them those which have been obtained from Mr. Greene, I am inclined to think that *R. Sonomensis* is but a variety of Watson's species. The future will show whether my supposition is correct or not.

In my *Prodromus* I have spoken of a rose to which I had once given the name *R. Bridgesii*, and which I have merged with *R. Californica*. That rose which I described, and of which I have seen new specimens from the herbaria of Asa Gray, DeCandolle, and the Jardin des Plantes of Paris, may well be specifically identical with *R. spithamœa*. If its identity is recognized, the name *R. Bridgesii* will have to replace *R. spithamœa*.

*R. spithamœa* is noted by Watson in northern California, in Trinity county, and in the middle of the state at New Alameda and near San Luis Obispo. Mr. Greene notes it in Yuba county, and his *R. Sonomensis* in Sonoma county. To these localities should be added Fresno county, in the Sierra Nevada, where Engelmann obtained the species in a Sequoia forest. I have a specimen obtained by Cuming, but without indication of locality.

Some specimens from San Luis Obispo, which I have seen in the herbarium of Asa Gray, often show numerous glandular-tipped bristles in the intervals between the pairs of paired prickles. It should be remarked that these bristles also appear (but rarely) in *R. Californica*. There is reason to believe that *R. spithamœa* will be discovered in other localities. Perhaps the species is exclusively Californian.

### ROSA ACICULARIS Lindl.

The American *R. acicularis* has been long confused among the varieties of *R. blanda*. Borrer, in 1833, in the first volume of Hooker's *Flora Boreali-Americana*, had been on the point of separating it from *R. blanda*. According to Watson, Schweinitz had described this rose in 1825 under the name of *R. Sayi*. In 1876

(*Prodromus*) I described *R. acicularis* Lindl. under its variety *Bourgeauiana* (*R. Bourgeauiana* Crép. at first).

In his monograph, Watson described an arctic form under the name *R. acicularis* Lindl. taking up a second species under the name *R. Sayi*, to which he referred my variety *Bourgeauiana*. According to this author this second species extends less northward than the first. Under these two names are there really two distinct species? I do not think so. It appears to me almost incontestable that the differences used by Watson to separate his *R. acicularis* from *R. Sayi* are not constant, and hence without true value.

In describing his *R. acicularis* of the arctic zone, he seems to try to bring together as near as possible the American form with the form of the old world in attributing to it leaves of five leaflets, elongated receptacles, leaflets mostly with simple teeth and not glandular beneath, and entire sepals. I have not seen specimens from Alaska, but I have received some obtained from Fort Simpson, along the Pelly River, in 63° lat., and in the upper part of the Liard River, in 60° 30′ lat. These specimens show leaves of five to seven leaflets, leaflets glandular beneath and with glandular-compound teeth, sepals all entire or the exterior ones provided with one or two lateral appendages, and fructiferous receptacles globular or elongated-ovoid. I have reason to suppose that the Alaskan form is not different from those to which I have just alluded. As for *R. Sayi*, to which Watson attributes globular fructiferous receptacles and appendaged exterior sepals, it almost always occurs with entire sepals, and if the receptacles are often globular they are not very rarely oblong-ovoid. It is a variety of *R. Sayi* with elongated receptacles which has served Watson for the establishment of his *R. Engelmanni*.[13]

There is no doubt in my mind that under the names *R. acicularis* Lindl. sec. Wats., *R. Sayi* Schwein., and *R. Engelmanni* Wats. there exists only a single and unique type,

[13] *Cf.* Observations on *Rosa Engelmanni* Watson, in *Bull. Soc. bot. Belg.* $28^2$: 93-95.

to which I gave the name, as above, of the American *R. acicularis.*

It now remains to examine whether this ought to be merged specifically as a variety of *R. acicularis* of the Old World. As early as 1876 I expressed doubts as to the complete specific identity of these two roses. Today I am not disinclined to separate them from each other, and to consider them as two distinct species, although very closely related. The characters which separate them seem important and constant enough to justify their separation. Thus, the American *R. acicularis* has the average leaves of the floriferous branchlets normally of seven leaflets rather than five; its leaflets almost always, if not always, glandular beneath, with teeth glandular, apparently simple or glandular-compound; while in *R. acicularis* of the Old World the leaves have five leaflets, which are always eglandular beneath and with simple teeth. Besides, in the American rose the auricles of the upper stipules are not so long and of a little different form, the inflorescences are less rarely pluriflorous, and the receptacles are habitually less elongated. It is probable that a more searching study will reveal other distinctive characters.

Whether this is the case, is a problem which ought to exercise the sagacity of rhodologists. If the distinction proposed is confirmed, the name *R. acicularis* Lindl. should be retained for the Old World plant, and the American *R. acicularis* should take the name *R. Sayi*, provided the description of Schweinitz applies, as Watson thought, to the rose in question.

Another question to consider is the distinction between the American *R. acicularis* and *R. blanda* and *R. Arkansana.* There are certainly some essential differences between the first and the other two, but these differences sometimes are not such as to make confusion impossible, especially when *R. blanda* and *R. Arkansana* become very setigerous. In the American *R. acicularis* all the axes, from the stem to the floriferous branchlets, are covered with abundant setaceous prickles or bristles. In *R. blanda* it is habitually only the lower part of the stem which is setigerous, the branches and the floriferous branchlets being unarmed. In this case it is easy to distinguish the two species ; but if *R. blanda* increases its armature by extending it to the middle regions of the bush, and even to certain floriferous branchlets ; or one finds *R. Arkansana* with axes completely setigerous, then recourse must be had to other characters. Those taken from the leaves are most practical. The leaves of *R. acicularis* are oval, rounded at base, almost always glandular beneath, with open teeth, margins glandular-denticulate or provided with glands ; while those of *R. blanda* and *R. Arkansana* are oboval, relatively narrower, quite strongly attenuate or cuneate at base, very rarely glandular beneath, with teeth almost always perfectly simple and directed towards the apex. The form of the stipules is a little different in *R. acicularis*. The inflorescences are much more frequently one-flowered in *R. acicularis* than in *R. blanda* and *R. Arkansana*. The statistics that I have obtained show that the one-flowered inflorescences are to the many-flowered inflorescences as 3.4 to 1 in *R. acicularis;* while in *R. blanda* they are as 1 to 1.4, and in *R. Arkansana* as 1 to 1.6. Lastly, the fructiferous pedicels of *R. acicularis* are more slender, less rigid, and often have a tendency to become incurved, instead of remaining straight.

As to its geographical range the American *R. acicularis* occupies a very considerable area. In latitude it extends from the neighborhood of the polar circle to 38° in the Rocky mountains of Colorado. In longitude it embraces almost all of the continent within the Dominion. To the south it has been observed in Michigan, Wisconsin on the borders of Lake Michigan, and in Minnesota on the borders of Lake Superior. I have received specimens obtained by Messrs. Greene and Kelsey from Helena, Montana, and by Mr. Coulter from the Teton region in Idaho. It is likely that it exists here and there in the Rocky mountains from the borders of Canada to Colorado, where it does not appear to be very rare. As yet there is no indication of it in Oregon and Washington, or in Vancouver Island.

In the Old World *R. acicularis* extends perhaps farther north, but it extends less towards the south than in America.

ROSA GYMNOCARPA Nutt.

*R. gymnocarpa* Nutt. presents an appearance and distinctive characters which never permit it to be confused with any other American species. Its stem, branches, and floriferous branchlets are habitually clothed with scattered prickles which are very slender, setaceous and very numerous ; only in rare cases are the branches and branchlets entirely unarmed. In vigorous and slender bushes, at the extremity of the axes the prickles become more sparse and beneath some leaves appear more or less regularly paired ; but that is a simple accident which may happen in the other CINNAMOMEÆ with normally scattered prickles.

Its leaflets are remarkably thin, with teeth richly glandular-compound, the lower surface glabrous and the midrib with quite large glands, which very rarely extend to some of the lateral veins. As to their form and dimensions, the leaflets are very variable ; they are very small or quite large, elliptical, oval-elliptical, oval, or oval-suborbicular ; the base is often rounded, and quite rarely attenuate.

Watson has described, under the name of variety *pubescens*, some specimens obtained in the Sierra Nevada by Asa Gray, and in Silver mountains by Brewer. It is really that form with finely pubescent leaves. Does it appear specifically distinct from *R. gymnocarpa?* Not having seen it I am not able to express a competent opinion upon it, as upon another form observed by Watson in Montana with corolla two inches in diameter instead of very small.

In *R. gymnocarpa* the inflorescences are habitually one-flowered, rarely many-flowered. The corolla is remarkably small, its diameter not exceeding $20^{mm}$. The very slender pedicels are often glandular-hispid, more rarely smooth.

As yet I have always seen the receptacles smooth, but they may be expected to be sometimes glandular-hispid. The fructiferous ones are generally very small, habitually ovoid, rarely globular, and produce a very small number of akenes.

This species presents a character peculiar to it, at least in America. The receptacles, before complete maturity, are cut off by an articulation towards the summit, permitting the calyx to detach itself in one piece, leaving the receptacular cavity open. This singular articulation, which is constant, also occurs in two Asiatic species of the same section of CINNAMOMEÆ, *R. Beggeriana* Schrenk and *R. Alberti* Regel.

Watson includes in the geographical range of *R. gymnocarpa* British Columbia, Washington and Oregon, and all of California to the latitude of Monterey. He expresses doubt as to the existence of the species as far south as San Diego. Lastly, he also includes in the range northern Idaho and northwestern Montana. With the exception of Montana I have received numerous specimens representing the different regions cited by Watson. The northernmost station from which I have received specimens is situated in 55° lat. These were obtained by Mr. Meehan. I should add, in passing, that I can confirm the exactness of the mention by Mr. Holzinger (*loc. cit.*) concerning northern Idaho. According to the facts thus far recorded the distribution of *R. gymnocarpa* appears to be occidental, and does not extend very much towards the east.

As can be seen from the above remarks, there remain many researches to be made and points to be established before arriving at a complete acquaintance with the genus *Rosa* of western North America. When it is known how much research the roses of the Alps have demanded, it should be expected that the immense extent of the Sierras and Rocky mountains would in their turn demand an equal amount of investigation.

It is reasonable to suppose that these American regions have not yet disclosed all their rhodological riches ; and that there will be discovered there unpublished types. Perhaps many such are already in herbaria, but confused as varieties of species already known.

Among the readers of the above paper who desire to cooperate in the work to which I urge American botanists perhaps there may be found those who shrink from the task of extracting from my notes anything essential or practical for the distinction of species. For their benefit I have prepared an analytical key or dichotomous table. In it I will not include species of the section CAROLINÆ, or *R. setigera* Michx., which belongs to the section SYNSTYLÆ. I will confine myself to the CINNAMOMEÆ, including with them *R. minutifolia* Engelm., from Lower California, which constitutes by itself the monotypic section MINUTIFOLIÆ.

## ANALYTICAL KEY TO THE ROSES OF THE WESTERN STATES.

1 Inflorescences always one-flowered, without bracts; exterior sepals appendiculate from the base, with the appendages incised or denticulate; leaflets incised; receptacles with long silky pubescence - - - - - *R. minutifolia* Engelm

Inflorescences one or many-flowered; pedicels with one or more bracts; exterior sepals entire or with one or two small entire and erect appendages at the summit; leaflets toothed; receptacles smooth or clothed with pedicellate glands - - 2

2 Flowering branchlets more or less setigerous, with scattered setaceous prickles - - - - - - - - - - 3

Flowering branchlets unarmed - - - - - - 7

Flowering branchlets with regularly paired prickles under the leaves - - - - - - - - - - 11

3 Corolla very small (15 to 20$^{mm}$ in diameter); calyx detaching itself in a single piece during ripening, leaving the receptacles open at summit; akenes not very numerous; leaflets thin, glabrous, with glandular compound teeth - *R. gymnocarpa* Nutt.

Corolla usually much exceeding 20$^{mm}$ in diameter; sepals erect upon the fructiferous and persistent receptacles - - 4

4 Inflorescences ordinarily one-flowered; leaflets oval, broadly rounded at base, with glandular compound teeth

*R. acicularis* Lindl.

Inflorescences usually many-flowered; leaflets often more or less attenuate at base, with teeth usually simple - - - - 5

5 Corolla rather small (about 30$^{mm}$ in diameter); leaflets oval-elliptic; sepals silky outside; stipules and bracts strongly denticulate - - - - - - *R. gratissima* Greene

Corolla rather large; leaflets obovate, strongly narrowed or cuneate at base; bracts usually entire - - - - - - 6

6 Annual stems often transformed into false flower-bearing branchlets with leaves 9 to 11-foliate, or normal flowering branchlets densely setigerous - - - - *R. Arkansana* Porter

Annual stems not transformed into false flower-bearing branchlets; normal flowering branchlets with prickles more or less rare *R. blanda* Ait.

7 Corolla very small (15 to 20mm in diameter); calyx detaching itself in a single piece during ripening, leaving the receptacle open at summit - - - - *R. gymnocarpa* Nutt.

Corolla more than 20mm in diameter; sepals erect upon the fructiferous and persistent receptacles - - - 8

8 Upper stipules and bracts narrow; sepals usually silky outside, *R. Californica* Cham. & Schlecht.

Upper stipules and bracts more or less large; sepals not silky 9

9 Upper stipules and bracts much dilated; inflorescences often one-flowered; corolla usually large; fructiferous receptacles large, remaining quite dry at maturity, with large akenes; leaflets often glandular beneath and with glandular compound teeth *R. Nutkana* Presl

Upper stipules and bracts moderately dilated; inflorescences often many-flowered; corolla quite small or middle-sized; fructiferous receptacles small or middle-sized; leaflets usually without glands beneath, and with simple teeth - - - 10

10 Leaflets oval, more or less rounded at base, with open teeth; fructiferous receptacles often small; corolla quite small *R. pisocarpa* A. Gray

Leaflets obovate, narrowed or cuneate at base, with teeth, directed toward the apex; fructiferous receptacles large or middle-sized; corolla quite large - - - *R. blanda* Ait

11 Paired prickles with tips more or less curved or hooked; upper stipules and bracts narrow; receptacles nearly always smooth *R. Californica* Cham. & Schlecht.

Paired prickles straight; upper stipules and bracts more or less dilated, rarely narrow - - - - - 12

12 Bushes very small, a few inches in height and not surpassing a foot; upper stipules and bracts narrow; corolla very small, not exceeding 20mm in diameter; receptacles often glandular-hispid - - - - *R. spithamæa* Wats.

Bushes not very small; upper stipules and bracts more or less dilated; receptacles rarely glandular-hispid - - 13

13 Paired cauline prickles stout, more or less triangular, with straight tips; upper stipules and bracts much dilated; leaflets often with glandular compound teeth; inflorescences often one-flowered; corolla usually very large; fructiferous receptacles large and with large akenes, rarely glandular-hispid *R. Nutkana* Presl

Paired cauline prickles not stout, slender or quite slender; upper stipules and bracts moderately dilated; leaflets usually with simple teeth; inflorescences usually many-flowered; corolla middle-sized or small; fructiferous receptacles small or quite small - - - - - - - 14

14 Stipules and bracts quite deeply denticulate; foliar teeth directed towards apex; sepals more or less silky outside *R. gratissima* Greene

Stipules and bracts entire; foliar teeth quite open; sepals not silky - - - - - *R. pisocarpa* A. Gray

BRUSSELS, BELGIUM.

# THE DEVELOPMENT OF THE CYSTOCARP OF GRIFFITHSIA BORNETIANA.

ARMA ANNA SMITH.

(WITH PLATES I AND II)

THE fruiting portion of *Griffithsia* was described in 1861 by Nägeli,[1] who, however, excluded from the genus several of Agardh's species, among them *G. corallina*, which he included under the genus *Heterosphondylium*. The fruiting branch of this genus he described as consisting of a basal joint, bearing a whorl of enveloping branches, a short terminal cell, and one or two intermediate joints, bearing two, or rarely three, trichophores and the favellæ, besides "a characteristic rounded, flattened cell."

Bornet and Thuret[2] in 1867 confirmed Nägeli's observations in regard to the two trichophores borne by the intermediate cell in this species.

Janczewski[3] in 1877 published a detailed account of the development of the cystocarp in the same species, of which a brief summary is here given. The mother cell of the procarp divides by two horizontal walls into three cells, of which the upper undergoes no further development, while the intermediate cell cuts off an anterior cell, which is functionless, and afterwards produces two lateral cells, each of which divides at once into two cells, one small and appendicular (probably Nägeli's "characteristic" cell). The other, which is larger, divides into a "carpogenic cell," which touches the anterior cell, and a mother

[1] Beiträge zur Morphologie und Systematik der Ceramiaceæ; Sitz. d. königl. bayr. Akad. d. Wiss. 2: 391–397. 1861.

[2] Recherches sur la fécondation des Floridées; Ann. d. Sci. Nat. Bot. V. 7: 147. 1867.

[3] Notes sur le développement du cystocarpe dans les Floridées; Mem. de la Soc. nat. d. Sci. nat. de Cherbourg 20: 109. 1877.

cell of the trichophoric apparatus, which is turned towards the neighboring vegetative cell. The trichophoric apparatus consists of four cells with a trichogyne. After fertilization, all the cells of the procarp gradually die except the carpogenic cell, which increases in size and divides into two cells, of which the upper represents a placenta, giving rise to the lobes of the favella, each consisting of several spores. Only one trichogyne has been found fertilized in a single procarp.

Dr. Farlow,[4] in The Marine Algæ of New England, published in 1882, says of *G. Bornetiana* Farlow: "In the structure of the procarp this species differs considerably from *G. corallina* as described by Janczewski. There is only one trichogyne instead of two, as in the last named species. The procarp begins by the growth of a hemispherical cell at the upper part of an articulation. The cell is then divided into two parts by a partition parallel to the base. It is from the lower cell thus formed that the involucre is formed, and from the upper arise the carpogenic cells in the following way: By usually four oblique partitions there are formed four external hemispherical cells and a central pyramidal cell with a broad base. By subsequent division of one of the hemispherical cells, generally of the one lying nearest the axis of the plant, there is cut off a cell which divides into three smaller granular cells, the upper of which grows into a trichogyne. The spores are formed by the subsequent growth of the other three hemispherical cells."

As a more detailed account of the development of the cystocarp in this species seemed desirable, the present study was undertaken, the special aim being to learn the method by which the spores arise and the means of transmitting the fertilizing influence from the carpogonium to the cell or cells giving rise to the spores. In the course of the study several interesting resemblances between this species and *G. corallina* were observed, which have not been published.

The work was carried on under the supervision of Professor Geo. F. Atkinson, to whose assistance in tracing genetic con-

[4] Report U. S. Commission of Fish and Fisheries for 1879. Washington, 1882.

nections is largely due whatever of value the paper may contain.

The material used in these investigations had been fixed and preserved in a 2 per cent. solution of formalin in sea water. When needed for study, it was stained for an hour in a 1 per cent aqueous solution of acid fuchsin, then washed in fresh water, which was gradually replaced by glycerin, used as the mounting medium. In such preparations it was usually possible to detect the strand of protoplasm passing from a cell to its daughter cell, even though the two were somewhat separated. In some cases, when the connection had been completely broken by accident after mounting, the origin of a cell could be determined by the corresponding portions still projecting from it and from its mother cell. All the important conclusions given in this paper, however, are based upon connections still intact.

The thallus is normally branched dichotomously, and the fruiting branch forms one arm of a dichotomy, arising from the apex of a joint in the upper portion of the shoot. As the corresponding vegetative joint soon exceeds it in size and gives off at its apex, in turn, a fruiting and a vegetative branch, the latter often continuing the process, a series of apparently lateral cystocarps is thus formed. No uniformity in the relative positions of vegetative and fruiting branches was observed, the cystocarp being in some cases on opposite sides of the corresponding vegetative cell in succeeding joints, sometimes on the same side.

After one fruiting branch has arisen, one usually occurs at each succeeding joint, but two or three sterile joints were sometimes found intervening, without branching. No case was observed in which, after the production of a fruiting branch, further branching resulted in only vegetative joints.

Although the normal branching is dichotomous, cases of trichotomy were observed several times, either three sterile joints arising from the apex of one joint, or a fruiting branch accompanied by two sterile branches.

Judging from the preparations studied, the mother cell of the fruiting branch is cut off before the corresponding vegetative cell, but the latter appears before the first division in the former, a two-celled fruiting branch being accompanied by a corresponding vegetative one. When, in rare cases, an older fruiting branch was found alone and apparently terminal, as in *fig. 3*, it was not always possible to determine whether it was an abnormal state, or whether the sterile cell had been severed by accident.

The mother cell of the fruiting branch is hemispherical, and is richer in protoplasm than the joint from which it arises. It is soon divided by a wall parallel to its base into a flattened, more or less irregular, hemispherical upper cell and a lower irregularly oblong cell.

A cell is now cut off from the upper cell by a wall oblique to the axis of the branch, as is seen in *fig. 3*. When viewed in some positions this wall appears parallel to the first, as is shown in *fig. 4*. Careful focusing in this case, however, showed that the third cell lies partially under its mother cell and is separated from it by an oblique wall. This may be the terminal cell of Nägeli and Janczewski. It lies in this particular case, however, on the side of the branch towards the vegetative cell, while Janczewski, judging from his figures, though he does not explain his view point, terms cells in this position lateral, and these, according to him, arise after the terminal and the anterior cells in *G. corallina*.

Spalding[5] calls attention to the "irregularity in both the number and position of peripheral cells in *G. Bornetiana*." The present study has confirmed his conclusion, and hence has made the use of such terms as lateral and anterior appear of doubtful propriety in this species, at least.

*Fig. 5* represents the same stage as *fig. 4*, but with the vegetative cell at one side. Here the first two peripheral cells are plainly "lateral" according to Janczewski's use of the term, but this was not the case in all the preparations studied.

Before the appearance of a third peripheral cell, one of the two first cut off usually divides into two cells, of which the

[5] Development of the sporocarp of Griffithsia Bornetiana. Abstract; Proc. A. A. A. S. 39: 327. 1890.

upper is the smaller (*fig. 6*). A third peripheral cell is now cut off, after which a second peripheral cell frequently divides into two cells, making at this time two two-celled branches and one of one cell arising from the central cell. The term central cell in this paper, as in the one quoted,[6] refers to the second cell of the fruiting branch, from which the peripheral cells are cut off, not to the cell giving rise to the spores, to which the term has been applied by Schmitz[7] and Hauptfleisch,[8] but which is here designated as the placental cell, a name used in this sense by Janczewski. This seems to be the normal order, although cases were frequently observed in which only one of the branches consisted of two cells, while in some cases no "appendicular" cell was found in the entire branch. Dr. Farlow does not refer to this division of part of the peripheral cells, and whether it is not a constant feature in this species, as Janczewski holds it to be in *G. corallina*, or whether the appendicular cell, being specially liable to be severed in manipulation, is thus frequently lost sight of, is not easily determined.

The fourth peripheral cell, to which both Farlow and Janczewski refer, was in no case observed in the earlier stages, and its presence was not demonstrated in later ones. This coincides with Spalding's conclusion in regard to the variability in the number of these cells.

The peripheral cells usually present a flattened hemispherical form in optical section, with beak-like projections of protoplasm where they join the mother cell. When lying over the mother cell, the outline is broadly elliptical. They remain smaller than the central cell, which can readily be distinguished until nearly the last stages of the developmental process by its size and its tetrahedral form, produced by the oblique walls

[6] Farlow, l. c.

[7] Untersuchungen über die Befruchtung der Florideen; Sitzb. d. könig. pr. Akad. d. Wiss., Berlin,—: 215. 1883. English translation of same by W. S. Dallas; Ann. and Mag. Nat. Hist. 13:1. 1884.

[8] Die Fruchtentwickelung der Gattungen Chylocladia, Champia, und Lomentaria; *Flora* 75: 307. 1892.

meeting at the apex. The change in its contents by which it is also made conspicuous in the later stages will be described later.

One of the peripheral cells first produced, which has already cut off an upper sterile cell, now grows rich in protoplasm and becomes the supporting cell of the carpogenic branch, cutting off the basal cell at one side, but apparently not always on the same side, as may be seen by comparing *figs. 8* and *9*. In *fig. 8* two of the peripheral cells have cut off each a sterile cell. The third peripheral cell has been severed from its mother cell, but the point of former contact may still be distinguished on each cell. In *fig. 9* the mother cell of the carpogenic branch has divided into two cells, which are still in very close connection. Here the supporting cell of the carpogenic branch is the only one with an "appendicular" cell, and as neither of the others shows indications that one has been broken off, it is probable that no other has been produced.

In none of the mature carpogenic branches observed were fewer than four cells found. The branch is curved so as to form almost a right angle at the second cell (*figs. 10–13*). The terminal cell, the carpogonium, is smaller than the others, nearly triangular in outline, and prolonged into a trichogyne from the pointed apex.

The trichogyne is an elongated slender structure, as long as the remainder of the fruiting branch, and is straight or only slightly curved, lying in a direction parallel with the axis of the branch. Its diameter is slightly greater at the apex than in the portion adjoining the carpogonium. Its contents do not take the fuchsin stain, but a decidedly granular appearance is observable.

In *fig. 11* a peculiar development is shown, and a somewhat similar, though not quite identical, appearance was observed in another case. The supporting cell of the carpogenic branch has given rise, not to a single sterile cell, but to a branched cellular filament. The carpogonium is slightly larger than usual, and no trace of a trichogyne is seen. It seems probable that in default of fertilization the disappearance of the trichogyne has been followed by vegetative growth in the carpogenic branch and by the production of extra vegetative cells elsewhere. Here, too, there seem to be four peripheral cells, though the relations of the two cells lying below the central cell were not positively determined.

The process of fertilization and its immediate effects were not observed, lack of suitable material making a nuclear study impossible. In *fig. 12* a pollinoid is shown in contact with a trichogyne, which is enlarged at the point of attachment, but how far fusion takes place was not ascertained.

After fertilization, the trichogyne gradually withers and soon disappears, the basal portion remaining for a time attached to the carpogonium. The latter loses its contents, assumes an irregular form, and becomes disorganized. The adjacent cell at the same time apparently increases in size, but it also soon loses its contents, and in some cases appears to become disorganized, while the two lower cells take a deeper stain than before. Whether the intervening walls are absorbed or a transfer of protoplasm takes place through the enlarged pit connections was not determined, but it is evident that with the disorganization of the upper portion of the carpogenic branch, the supporting cell and the central cell grow rich in contents, the latter especially at this time taking a very deep stain with fuchsin. The carpogonium does not persist long after fertilization, either individually or as a part of a large fusion cell.

Schmitz (l. c.) includes *Griffithsia* among the genera in which conjugation probably takes place between the carpogonium and the supporting cell, which thus becomes the auxiliary cell. He does not state, however, that he has observed the process in any species of the genus. The two cells do not always lie sufficiently near together at the time of fertilization to allow direct conjugation, and no evidence was seen either of change of position or of the growth of ooblastema threads.

In no case was any indication of spore production seen until after a gradual loss of contents in the upper cells of the carpogenic branch, which seemed to be followed by changes in the appearance in the lower ones, both following upon fertilization.

At this stage the supporting cell, now rich in protoplasm, increases in size and cuts off a cell, which, in turn, becomes larger, though without taking a deeper stain, and becomes the placental cell. From all sides of this cell, cells arise which are distinguishable at once by their large nuclei, and it is by their subsequent division that the lobes of spores arise, each cell thus cut off from the placental cell developing into one lobe. Each cell cuts off small cells from the sides and end, and soon assumes a cuneate form, the individual segments having a similar or a clavate form. Each lobe consists for a time of a compact mass of cells, but as the cells separate and become rounded off as spores, it develops into a branched tuft made up of loosely connected chains of ovoid or elliptical spores, developed in basipetal succession, each with a large nucleus. The process, however, is apparently not strictly uniform in all cases, as may be seen by comparing *figs. 15–19*. The lobes arise successively, and thus different stages of spore formation may be seen in a single preparation (*figs. 15–19*). According to Harvey[9] each lobe constitutes a favella, and thus several favellæ are contained within a single involucre, while Farlow regards the lobe collectively as constituting one favella.

The favellæ, as well as the vegetative cells of the thallus, are surrounded by gelatinous membrane, which has been omitted in the figures for the sake of clearness. Around the vegetative cells it is so swollen by the glycerin as to be very evident, but it often remains in such close contact with the lobes of spores as to be detected with difficulty.

Directly after fertilization, as the central cell begins to take a deep stain, the growth of the involucral branches begins. The basal cell of the fruiting branch cuts off cells, which remain small and oblong, but from each of which another cell is cut off,

[9] Nereis Boreali-Americana 2: 227. 1853. Smithsonian Contributions to Knowledge No. 5.

which grows rapidly, assumes at first an obovate, later an elliptical form, slightly reniform, and a length greater than that of the cystocarp. The cells form thin, translucent, expanded plates, and although they completely envelop the favellæ, the cells within may be studied, the details, however, being greatly obscured by them. Seven of these involucral branches were counted in one case, but the number varies. Nägeli and Janczewski call attention to the bicellular character of these branches in *G. corallina*, which, the former states, had been overlooked by systematists, and to which the present writer has found no reference in published descriptions of *G. Bornetiana*.

Although the later stages in the development of the cystocarp are made out with difficulty, the placental cell can be seen to stretch out and become irregular in form, and it seems highly probable, though not quite certain, that fusion takes place between it, the supporting cell, and the central cell, forming one large placenta, the lobes arising from the portion corresponding to the original placental cell. *Fig. 19* is drawn to the same scale as the others, and thus shows not only the great irregularity in the form of this fusion cell, but also the great increase in size over any cell previously met with in the cystocarp. It is difficult to determine the exact nature of the large cells joined to it, but they seem to be sterile cells unconnected with the sporogenous cells, which for some reason have taken on this increase in size.

No evidence was found that the peripheral cells other than the supporting cell of the carpogenic branch have a part in spore production. They gradually become inconspicuous after fertilization, and finally disappear with the carpogenic branch and the sterile cell given off from the supporting cell, unless the branch referred to in the preceding paragraph and represented in *fig. 19* is made up of such cells which have taken on vegetative growth. It is easier to conceive the influence of fertilization as transmitted to the supporting cell through the cells of the carpogenic branch than to the other two or three peripheral cells, either through the central cell or by separate conjugation with the carpogonium.

The development of the cystocarp in this species thus resembles very closely that of *G. corallina* as described by Janczewski, with the single exception of the one carpogenic branch instead of two. He does not speak, either, of the fusion forming a large central cell, though one of his figures (7) suggests that it may take place.

The process has its more or less perfect analogy in related genera also. In *Ceramium decurrens*, according to Janczewski, the supporting cell, which, after cutting off a sterile cell, gives rise to two trichophores, becomes the "carpogenic cell," cutting off an upper placental cell after fertilization. Schmitz concludes that here conjugation probably takes place between the carpogonium and the supporting cell, but does not claim to have observed it. Janczewski represents the two cells as lying adjacent, and so this fusion would be more easily accomplished than in *Griffithsia Bornetiana*, where they are not always close together, though they are in some cases, as is seen in *fig. 10*.

Phillips[10] states of *Rhodomela subfusca*, *Polysiphonia nigrescens P. fastigiata*, and *P. violacea* that the second cell of a branch cuts off five pericentral cells, one of which, besides serving as supporting cell of the carpogenic branch, gives off two sterile branches, one of two cells and one of one cell, and then becomes the auxiliary cell, cutting off, after fertilization, an upper sporogenous cell. In these cases the carpogenic branch is so curved that the carpogonium lies close to the auxiliary cell, and both Schmitz and Phillips conclude that conjugation takes place between the two, though neither of them actually observed the process. According to Phillips, fusion takes place between the sporogenous cell, the auxiliary cell, and its sterile branches in *P. nigrescens* and *P. fastigiata*, while in *P. violacea*, as apparently in *Griffithsia Bornetiana*, the central cell is included in the fusion.

[10] On the development of the cystocarp in the Rhodomelaceæ, Ann. Bot. 9: 289. 1895.

In connection with this study the question naturally arises as to the proper limitations in the use of the term "auxiliary cell." Schmitz applies it to cells performing slightly different functions. 1. To a cell of the thallus or of the carpogenic branch which grows rich in protoplasm and then gives up its contents to an ooblastema thread, thus supplying it with the extra nutriment necessary for the production of spores, as in *Naccaria* and *Petrocelis*. 2. To a cell which enters into conjugation with the fertilized carpogonium or with a filament arising from it, and which after thus receiving the influence of fertilization, itself cuts off a cell from which the sporogenous filaments arise, as observed by him in *Glœosiphonia*. It is in this sense that he applies the term to the supporting cell in *Griffithsia*, assuming that conjugation takes place between it and the carpogonium, either directly or by means of a short conjugation process. Mr. Davis,[11] in his description of *Champia parvula*, applies the term to ordinary thallus cells, which, so far as he has observed, do not fuse with any of the cells directly concerned with the development of the cystocarp, but which give rise to the wall of the cystocarp, after a modification of their contents and union with one another and with the supporting cell by means of protoplasmic processes. It seems very doubtful if such a use of the term is in accordance with Schmitz's application of it. It would seem much less questionable to apply it in *Griffithsia* to the supporting cell, which gives rise to the placental cell, even though the influence of fertilization is transmitted through the cells of the carpogenic branch by a broadening of pit connections or the absorption of walls instead of by means of conjugation between the carpogonium and the supporting cell. Janczewski following Bornet and Thuret applies the term carpogenic cell to the cell which gives rise to the spores, whether it be the carpogonium, which these writers regard as a part of the "trichophoric apparatus," or some other cell which performs the function of spore production. Later writers limit the application of carpogenic cell to the cell directly beneath the trichogyne, whatever its fate after fertiliza-

[11] Development of the cystocarp of Champia parvula, BOT. GAZ. 21: 109. 1896.

tion, and there seems to be at present no general term agreed upon for the spore producing cell. The study of the exact process of fertilization and its effects in a greater number of species is necessary before the question of homologies, and hence of terminology, can be definitely settled.

Besides the greater complexity and the presence of the enveloping cells, which render it more difficult to trace the later stages of the development of the cystocarp in *Griffithsia Bornetiana*, the obscurity is increased by the presence in large numbers of dichotomously branched hairs, which sometimes nearly cover the cystocarp. Dr. Farlow calls attention to these hairs arising from the upper border of the thallus cells. In the present study they were never found elsewhere than at the upper portion of a joint, and, with one exception, never on other joints than those bearing cystocarps. In that case it seemed possible that a cystocarp had been broken off, though that could not be demonstrated. Although a cystocarp sometimes occurs without these hairs their presence was found to be so nearly constant as to suggest a possible connection between the two, either morphological or physiological.

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## EXPLANATION OF PLATES I AND II.

All the figures were drawn with the aid of the camera lucida from material stained with acid fuchsin and mounted in glycerine.

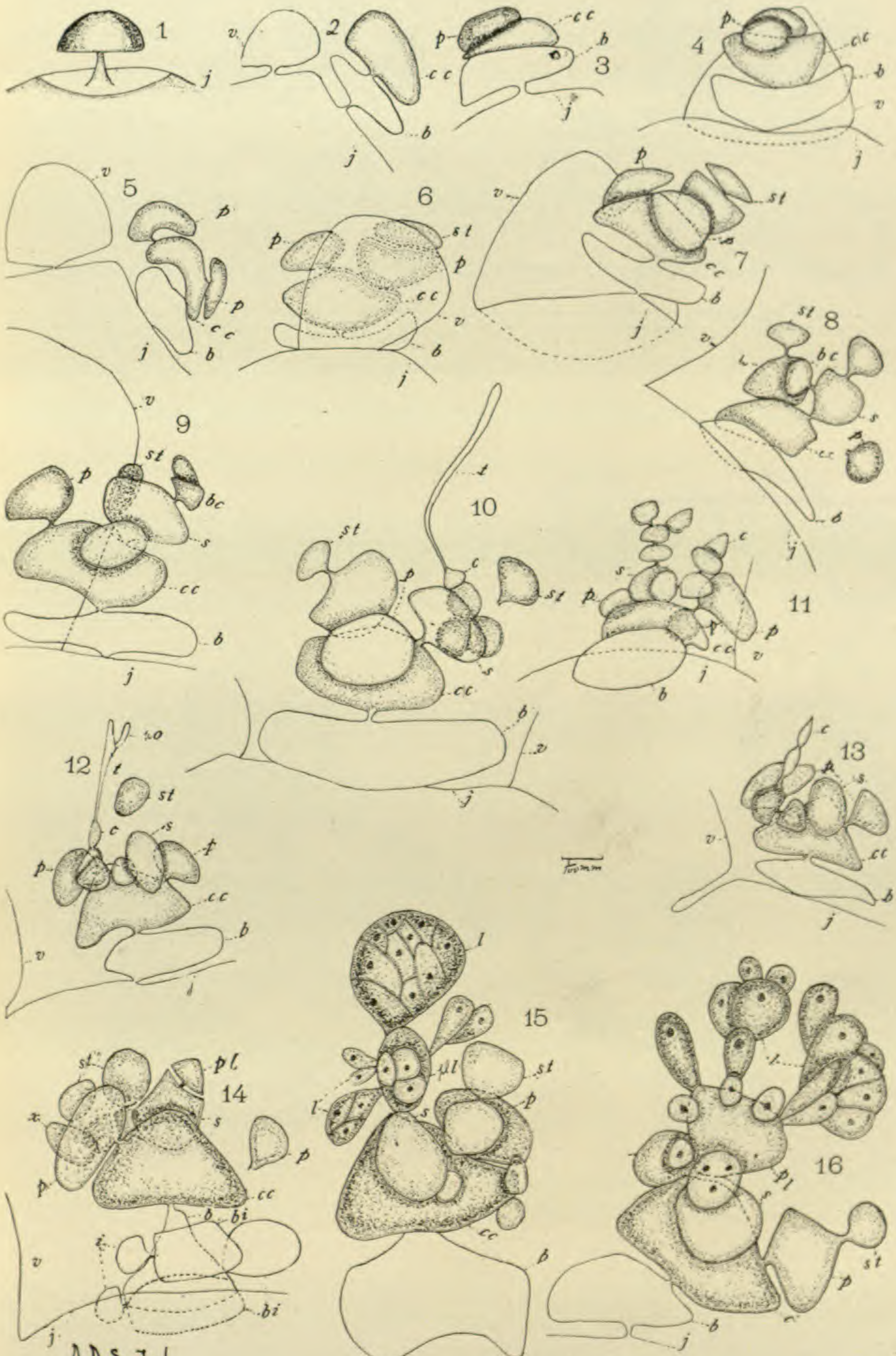
*j*. Joint from which the fertile branch has arisen. *b*. Basal cell of fruiting branch. *c. c*. Central cell. *p*. Peripheral cell. *st*. Sterile cell cut off from peripheral cell. *s*. Peripheral cell functioning as supporting cell of carpogenic branch. *c*. Carpogonium. *t*. Trichogyne. *pl*. Placental cell. *l*. Sporogenous lobe. *sp*. Spore. *b. i*. Basal cell of involucre filament. *i*. Terminal cell of involucre filament. *v*. Neighboring vegetative cell.

FIG. 1. One-celled fruiting branch, somewhat separated from main joint, but connécted by a stout strand of protoplasm.

FIG. 2. A two-celled branch.

FIG. 3. The first peripheral cell has been cut off from the central cell by an oblique wall. The vegetative cell has not developed or has been severed.

FIG. 4. The four-celled branch lies over the vegetative cell. One peripheral cell lies partially beneath, the other above the central cell.



SMITH on GRIFFITHSIA.


SMITH on GRIFFITHSIA.

FIG. 5. A different view of a stage similar to that represented in *fig. 4*.

FIG. 6. The branch lies under the vegetative cell. One of the peripheral cells has cut off a sterile cell.

FIG. 7. The third peripheral cell has been cut off from the central cell.

FIG. 8. Two peripheral cells have divided, and the supporting cell has produced the basal cell of the carpogenic branch (*b. c.*). One peripheral cell has been severed from its mother cell.

FIG. 9. The carpogenic branch now consists of two cells. The second peripheral cell has no appendicular cell.

FIG. 10. The entire fruiting branch lies above the corresponding vegetative cell. The carpogenic branch has reached maturity, and the carpogonium is prolonged into the trichogyne.

FIG. 11. An abnormal vegetative development from the supporting cell.

FIG. 12. A pollinoid (*p.*) is attached to the trichogyne. Penultimate cell of the carpogenic branch large and lying partially beneath the second cell.

FIG. 13. The trichogyne has disappeared, and the carpogonium and penultimate cell have lost their contents and shrunken. The second cell of the carpogenic branch, as well as the basal cell, is rich in protoplasm.

FIG. 14. The supporting cell and the central cell have abundant protoplasm. The former has cut off the placental cell. The meaning of *x* is uncertain, its connection with any other cell not being clearly made out. The involucral filaments have begun to develop.

FIG. 15. The entire branch has increased in size. The carpogenic branch has become disorganized, the basal cell remaining attached to the supporting cell. Several lobes are arising from the placental cell, and are seen in different stages. Involucral threads omitted to avoid confusion.

FIG. 16. A similar or slightly later stage than *fig.* 15. Involucral threads again omitted.

FIG. 17. The young cystocarp inclosed in the involucre. Three of the filaments are fully grown; one is still small.

FIG. 18. A slightly later stage with involucre omitted.

FIG. 19. A still later stage. Fusion has apparently taken place between the placental cell, supporting cell, and central cell, and lobes are arising from the large fusion cell (*f.*). Some of the spores are mature, and their connections have been broken. Most of the sterile cells have disappeared, while some seem to have developed abnormally.

# NEW MOSSES OF NORTH AMERICA. VI.

F. RENAULD AND J. CARDOT.

(WITH PLATES III–V)

GYMNOSTOMUM CALCAREUM N. et H. var. **Winonense** Holzinger in litt.—Differs from the var. *tenellum* Sch. by the leaves acute and the capsule not constricted at the mouth. Very small and loosely cespitose or gregarious.

Minnesota: Winona, amongst the stems of *Myurella Careyana* (*J. M. Holzinger*, 1893).

**Dicranum Demetrii.**—In very compact, yellowish-green tufts, brownish and a little tomentose below. Stems erect, simple or sparingly branching, three to four inches long. Leaves crowded, erecto-patent when moist, crispate when dry, from an oblong-obovate base rather suddenly constricted and linear-subulate, canaliculate, smooth, quite entire or subsinuate at apex, 3–6$^{mm}$ long, 0.30–0.60$^{mm}$ broad at base; costa narrow, percurrent or subexcurrent; cells smooth, small, quadrate or short rectangular and incrassate in the upper part, becoming narrowly linear and slightly porose toward the base near the costa, the alar looser, subrectangular. Perichætial leaves from an oblong sheathing base suddenly long cuspidate. Fruit unknown. Seems diœcious.

Labrador: Rattler's Bight (*Rev. A. C. Waghorne*, 1892; comm. Rev. C. H. Demetrio). Specimens bearing young fructifications and remains of old pedicels.

Seems to have some affinities with *D. elongatum* Schw., but is readily distinguished at first sight from this species by its leaves crisped in dry state, which gives it rather the appearance of *D. montanum* Hedw., and also by the very different areolation of the leaves.

**Dicranum trachyphyllum.**—Diœcious. Cespitose, green or olivaceous. Stems erect; 2–6$^{cm}$ long, simple or branching, sparingly tomentose in the lower part. Leaves falcate or flexuous-patent when moist, flexuous-crisped when dry, often tufted, linear-lanceolate, canaliculate above and rather thickly subulate, strongly serrate on the margins, spinulose-dentate at apex; costa stout, about one-fourth the width of leaf-base, generally very rough at back, percurrent or short-excurrent into a spinulose-dentate point; cells of the upper part quadrate or subrotundate, mostly papillose on the back, oblong or linear and smooth toward the base, the alar lax, inflated, brownish or hyaline. Perichætial leaves from an oblong sheathing base constricted into a long rough subula; costa narrower. Pedicel pale, at last twisted to the left above when dry. Capsule and peristome as in *D. fuscescens*.

Newfoundland: Leading Pickles and Hermitage Bay (*Rev. A. C. Waghorne*, 1893 and 1895).

Closely allied to *D. fuscescens* Turn., to which it might be subordinated as a subspecies, but nevertheless easily distinguished by the leaves more strongly serrate, very rough on the back, less narrowly subulate and the nerve thicker and broader.

DICRANUM FUSCESCENS Turn. var. EATONI Ren. et Card. in *Bull. de l'herb. Boissier* 4:15. (*Musci Am. Sept. Exsicc.* no. 206).—A striking form, approaching var. *flexicaule* BS., but forming dense deep tufts; stems erect, not flexuose, reaching $20^{cm}$ high; leaves shorter; lower cells less elongated and with thinner walls.

New Hampshire: Mt. Washington (*D. C. Eaton*, 1894). Sterile specimens only.

We received this very interesting variety from the lamented D. C. Eaton some weeks before his death.

**Dicranum subfulvum.**—Loosely cespitose, dark green, filled with earth below. Stems erect, $1–2^{cm}$ high, simple or sparingly branched, little radiculose. Leaves erecto-patent, flexuous, crisped when dry, narrowly lanceolate, acuminate-subulate, subula canaliculate, subentire or minutely denticulate at apex; costa strong, very broad, about half width of leaf base, smooth or nearly so at back; cells very small, opaque, quadrate, scarcely papillose, somewhat larger and quadrate or short-rectangular below, all very chlorophyllose, the alar lax, enlarged, quadrate or subhexagonal, pellucid, yellowish, brownish or subhyaline. Flowers and fruit unknown.

Distinguishable from *D. fulvum* Hook. by the stems not flexuose, the leaves not tufted, nearly entire, the costa broader, smooth or only very slightly papillose on the back and the supra-alar cells chlorophyllose, scarcely distinct from the others.

FISSIDENS DECIPIENS DeNot. var. **Winonensis.**—Differs from the type by its smaller size, the smaller and narrower leaves with the pellucid border most often indistinct and the less opaque areolation.

Minnesota: Winona (*J. M. Holzinger, Mosses of Minnesota,* no. 6).

**Trichostomum indigens.**—Very small, gregarious, dirty green; stems scarcely 1–2$^{mm}$ high. Leaves patent, subcirrate when dry, 1.25–1.75$^{mm}$ long, oblong-lingulate, obtuse, apiculate or subacute, margins revolute below, plane above, very minutely crenulate by the projection of the papillæ; costa stout, percurrent or vanishing just below the apex; cells minute, rotundate or subquadrate, densely papillose, becoming gradually larger, oblong, rectangular, pellucid and smooth toward the base. Perichætial leaves from an oblong and loosely reticulate base, linear-lingulate, obtuse or mucronate. Pedicel thin, reddish, paler above, 4–6$^{mm}$ long, slightly twisted to the left under the capsule when dry. Capsule small, erect, oblong-cylindrical, chestnut-colored, about 1$^{mm}$ long. Lid unknown. Annulus simple, teeth of the peristome purple, slightly twisting, on a narrow basilar membrane, segments filiform, minutely granulose, marked with a longitudinal line, articulate, slightly nodose and partly connected in the lower part. Probably diœcious (male flowers unseen).

Newfoundland (*Rev. A. C. Waghorne,* 1895).

Resembling the smallest forms of *Barbula unguiculata* Hedw., by the shape and the areolation of the leaves, but well distinct by the peristome much shorter and less twisted, the teeth describing scarcely half a spiral turn.

ULOTA CRISPULA Brid. var. **dolosa.**—Distinct from the genuine form by the dark green tint, the leaves less crispate and generally broader and the areolation less incrassate, the lower cells looser, shorter, hyaline or greenish, not yellow.

District of Columbia: Tenallytown, mixed with *Orthotrichum Ohioense* and *O. Braunii* (*J. M. Holzinger*, 1892).

This variety differs considerably from the type by its much looser basilar areolation, and would be easily taken for a well distinct species; but we have specimens, gathered at Atco, New Jersey, by Mr. H. A. Green, which are intermediate between this variety and the typical form.

AMBLYODON DEALBATUS Pal. Beauv. var. AMERICANUS Ren. et Card. in *Bull. de l'herb. Boissier* 4: 13. (*Musci Am. Sept. Exsicc.* no. 180).—Differs from the European type by the segments of the endostome more subulate, nodulose and strongly granulose, and by the leaves more distinctly serrate above.

Minnesota: Osceola, St. Croix river (*J. M. Holzinger*, 1890).

PHILONOTIS VENELLA C. Muell. var. **Coloradensis.**—Areolation more chlorophyllose; marginal cells narrower, teeth of the leaves more patulous. Sterile.—Perhaps a small, depauperate form of *Ph. Muehlenbergii* Brid.?

Colorado: Springdale, Boulder co. (*Marie Holzinger*, 1892; comm. J. M. Holzinger).

ANOMOBRYUM FILIFORME Husn. var. **Americanum.**—Differs from the var. *concinnatum* (*Bryum concinnatum* Spr.) by the more slender and shorter stems, the smaller leaves and the shorter cells. Costa percurrent or vanishing just below the point. Sterile.

Wisconsin: Trempealeau Mt. (*J. M. Holzinger*, 1893).

With Rev. Boulay, we consider *Anomobryum filiforme* (Dicks.) Husn., *A. juliforme* Solms, *A. sericeum* De Lacroix and *A. concinnatum* (Spr.) Husn. as belonging to the same specific type, which is widely distributed under numerous local or regional forms, throughout Europe, Africa, North, Central, and South America.

HYPNUM CHRYSOPHYLLUM Brid. var. BREVIFOLIUM Ren. et Card. in *Bull. de l'herb. Boissier* 4: 19 (*Musci Am. Sept. Exsicc.* no. 248). —Leaves shorter and areolation somewhat looser than in the typical form.

District of Columbia: Rock creek (*J. M. Holzinger*, 1891). Sterile specimens.

**Hypnum implexum.**—Tufts depressed, light green. Stems intricate, pinnately ramulose, branchlets hooked, fastigiate above. Leaves falcate-secund, from a broadly ovate-deltoid base rather suddenly constricted into a narrow subulate acumen, plane on the margins, quite entire or subdenticulate at the base of the acumen; costa double, short; cells narrowly linear, those of the angles few but distinct, small, quadrate, greenish or pellucid. Flowers and fruit unknown.

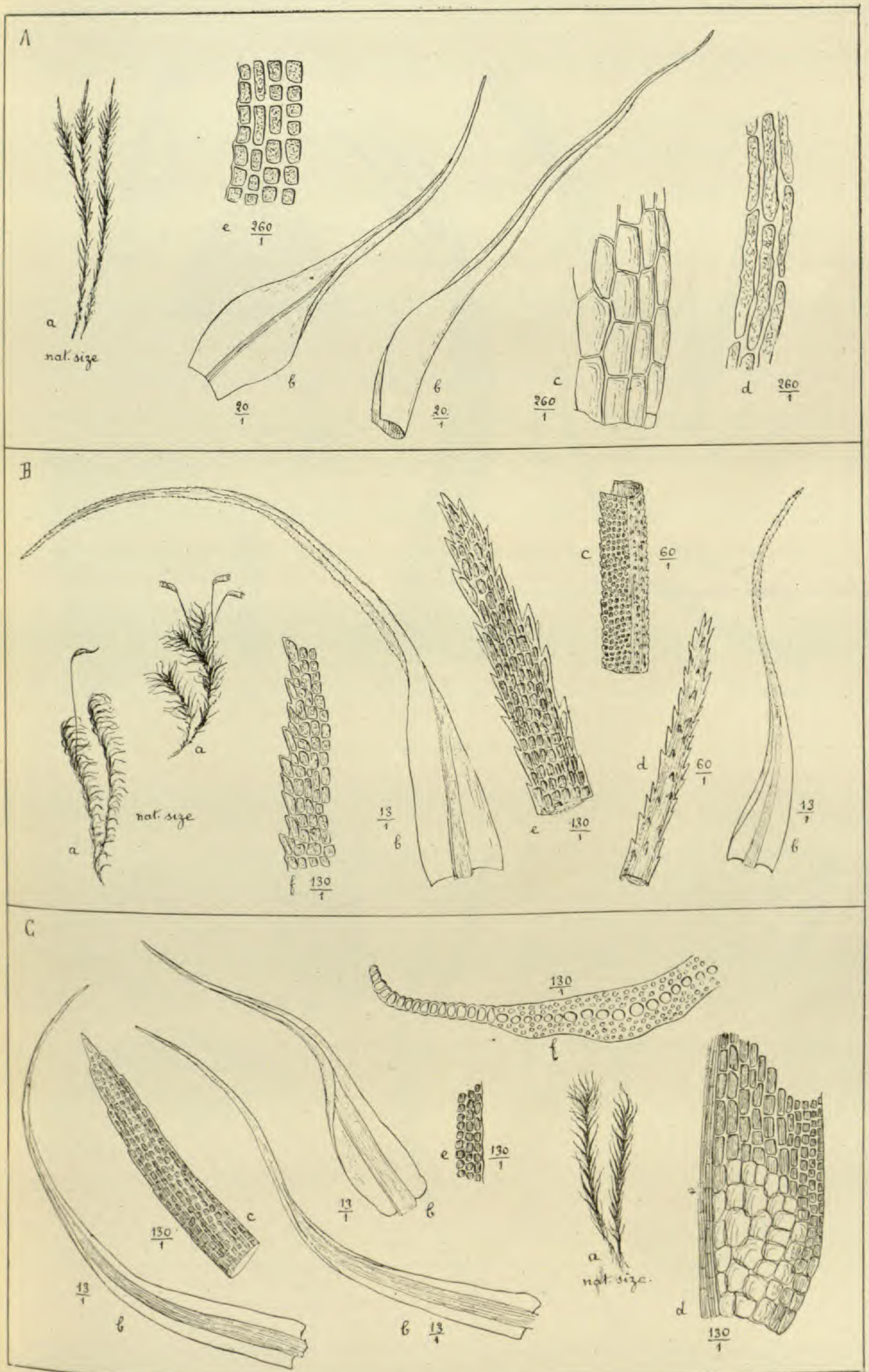
Labrador: Seal Island (*Rev. Arthur C. Waghorne*, 1893).

Allied to *H. hamulosum* Sch., but more robust, and distinct by the light green tint; the leaves broader at base and more suddenly constricted into a subulate acumen, and the alar cells more numerous and more conspicuous. Much resembling the small green form of *H. cupressiforme* L., but in this the leaves are narrower and the alar cells still much more numerous and conspicuous.

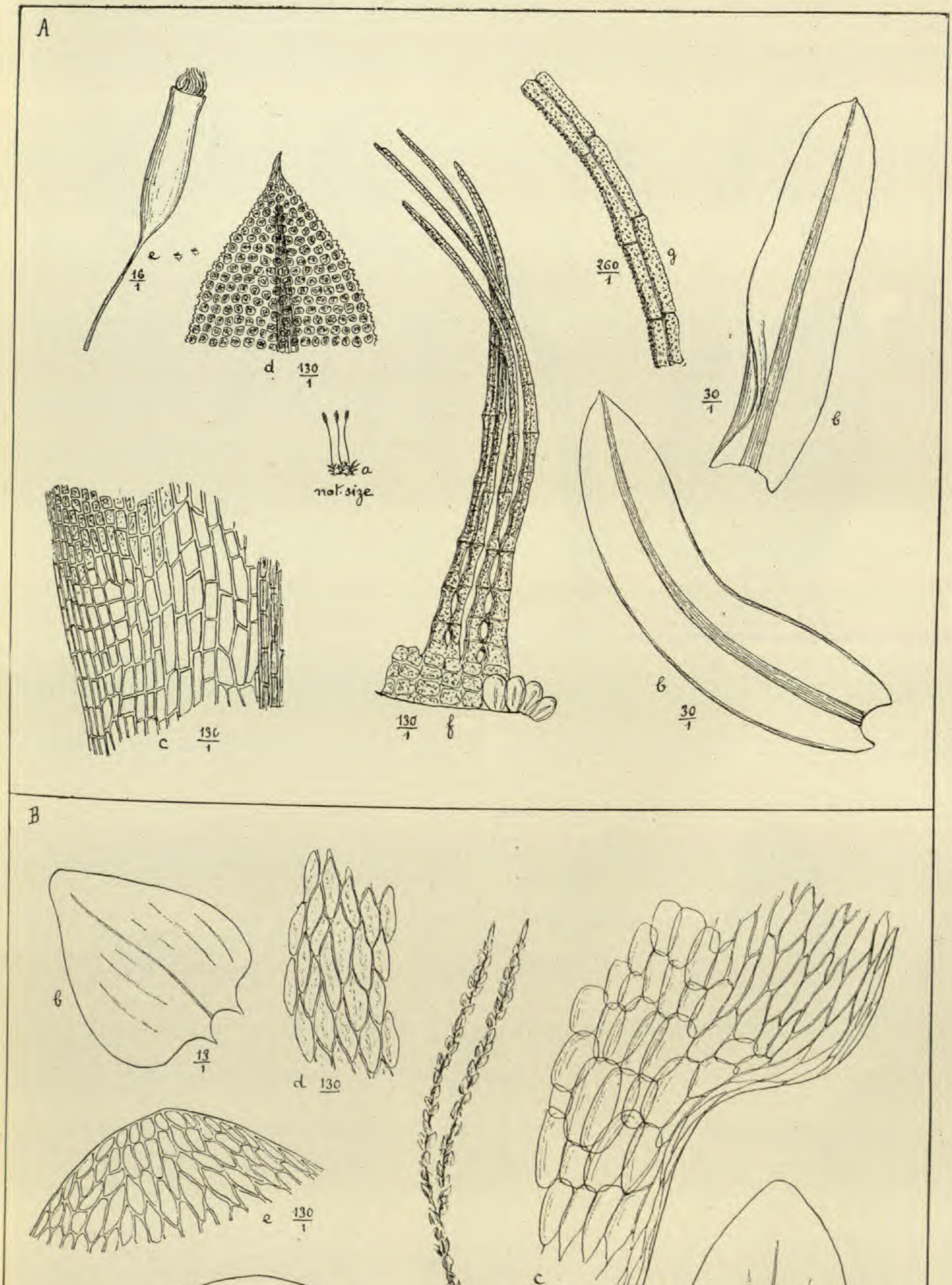
**Hypnum subeugyrium.**—Monœcious, resembling *H. eugyrium* Sch. var. *Mackayi* Sch., from which it differs by the alar cells of the leaves small, quadrate, not forming excavate auricles and the capsule exannulate. From the forms of *H. palustre* L. having the leaves subimbricate, it is distinguishable by the minutely denticulate apex of the leaves and by the costa always double and shorter.

Newfoundland: Exploits (*Rev. A. C. Waghorne*, 1893).

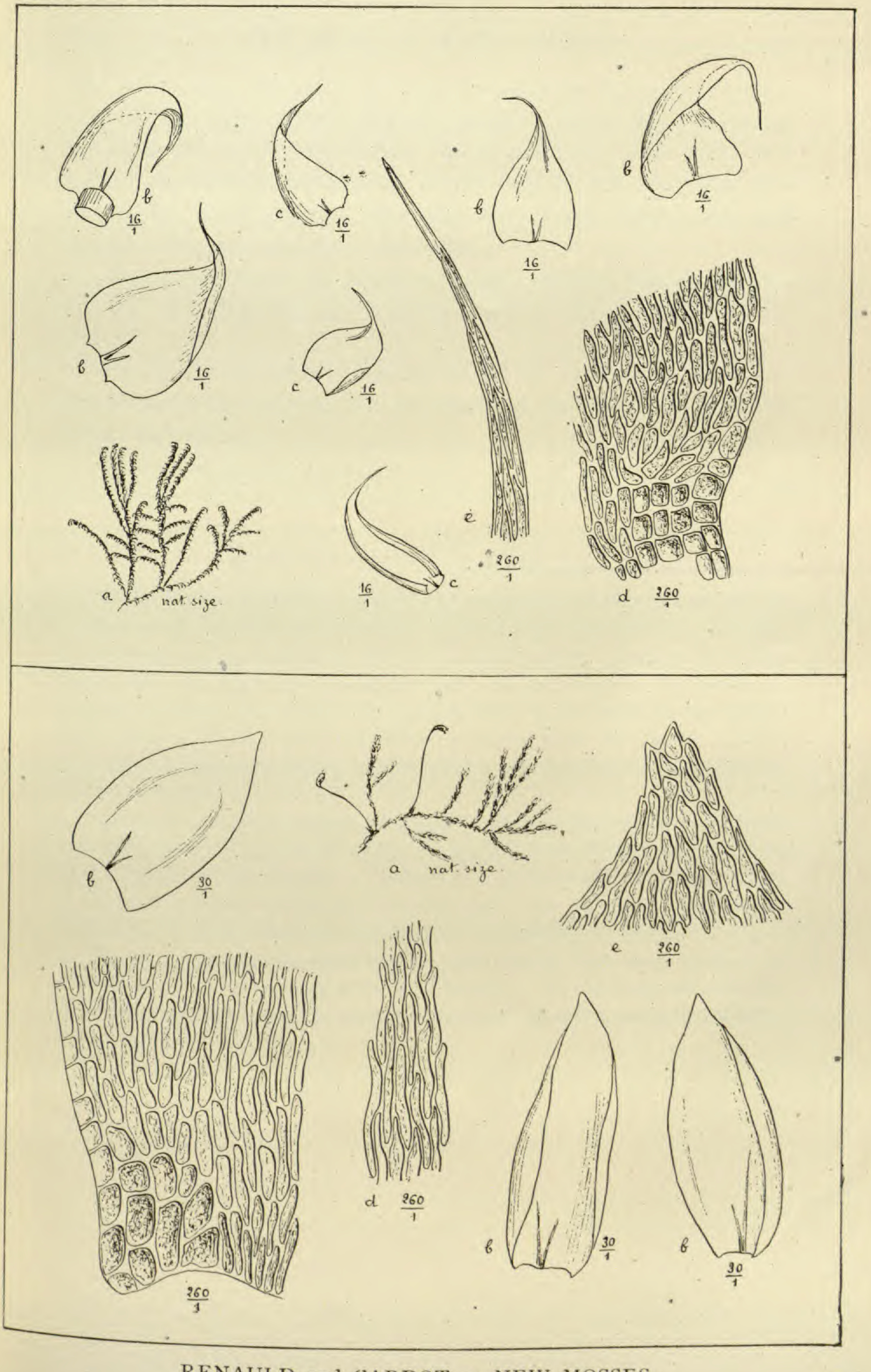
HYPNUM ORBICULARICORDATUM Ren. et. Card. in *Bull. de l'herb. Boissier* 4: 19 (*Musci Am. Sept. Exsicc.* no. 249). Tufts very soft, pale lurid-green above, decolored whitish-yellow and brownish-variegated below. Stems slender, erect, 4–9$^{cm}$ high, simple or sparingly branching, not radiculose, cuspidate at apex. Leaves soft, erecto-patent or very loosely imbricate, subundu-




RENAULD and CARDOT on NEW MOSSES.




RENAULD and CARDOT on NEW MOSSES.




RENAULD and CARDOT on NEW MOSSES.

late when dry, decurrent at base, broadly cordate-suborbicular, very obtuse, quite entire, slightly sulcate; costa thin, vanishing far from the apex; areolation loose, pellucid; cells soft, thin walled, rhomboidal-hexagonal in the middle, the marginal narrower, the upper shorter, the alar very loose, large, soft and empty. Flowers and fruit unknown.

Northwest shore of Hudson's Bay: Depot Island, N. lat. 63° 79′, W. long. 90° 20′ (*George Comer*, 1893; comm. D. C. Eaton).

Easily distinguished from the allied *H. cordifolium* Hedw. by the stems nearly simple, the leaves very soft, broader, and the looser areolation.

VESOUL AND STENAY, FRANCE.

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## EXPLANATION OF PLATES III–V.

All the figures magnified are drawn by means of Nachet's camera lucida.

PLATE III. A. *Dicranum Demetrii.* *a*, entire plant; *bb*, leaves; *c*, alar cells; *d*, areolation in the middle of the base, near the costa; *e*, areolation of the upper part. B. *Dicranum trachyphyllum.* *aa*, entire plant; *bb*, leaves; *c*, portion of a leaf in the middle; *de*, point of same; *f*, areolation of the borders in the middle. C. *Dicranum subfulvum.* *a*, entire plant; *bbb*, leaves; *c*, point of a leaf; *d*, basal areolation; *e*, areolation of the upper part; *f*, transverse section of a leaf.

PLATE IV. A. *Trichostomum indigens.* *a*, entire plant; *bb*, leaves; *c*, basal areolation of a leaf; *d*, point of a leaf; *e*, capsule; *f*, two teeth of the peristome with a portion of the annulus; *g*, portion of a segment of a peristomial tooth. B. *Hypnum orbicularicordatum.* *a*, entire plant; *bbb*, leaves; *c*, basal areolation of a leaf; *d*, areolation in the middle; *e*, areolation of apex.

PLATE V. A. *Hypnum implexum.* *a*, entire plant; *bbbb*, stem leaves; *ccc*, branch leaves; *d*, angular areolation; *e*, acumen. B. *Hypnum subeugyrium.* *a*, entire plant; *bbb*, leaves; *c*, angular areolation; *d*, areolation in the middle; *e*, areolation of the point.

# BRIEFER ARTICLES.

**Bark within a tree trunk.**—The accompanying photograph is from a section of an elm tree about eighty years old, grown at Oberlin, Ohio. Some forty years ago, by an accident of some kind, the trunk

was split down the entire side and the inner parts rotted away. The split was gradually closed by growth and the two opposite sides folded inwards, each side covered with bark, until the result was reached as seen in the photograph. The two sides produced such a pressure as to obliterate the bark at the line of contact, and a few years more would doubtless have closed the wound with a continuous cambium.

When cut down the bark seemed as vigorous and nearly as thick within the trunk, where it must have been quite dark, as on the outside of the tree.

The section is preserved in Oberlin College museum.—F. D. KELSEY, *Oberlin, Ohio.*

**A horizontal microscope** (with plate VI).—The laboratory for plant physiology can hardly be considered adequately equipped which does not possess a microscope adapted to measuring directly the vertical growth of plants. The auxanometer, in simple or complex form, is scarcely more indispensable. If no specially constructed instrument is available some makeshift must be devised to enable direct observation of growth. After utilizing common microscopes in various degrees of disorganization, but with unvarying dissatisfaction, the instrument illustrated by *plate VI* was devised by the writer, in consultation with Dr. Rodney H. True, to facilitate whose researches it was immediately needed.

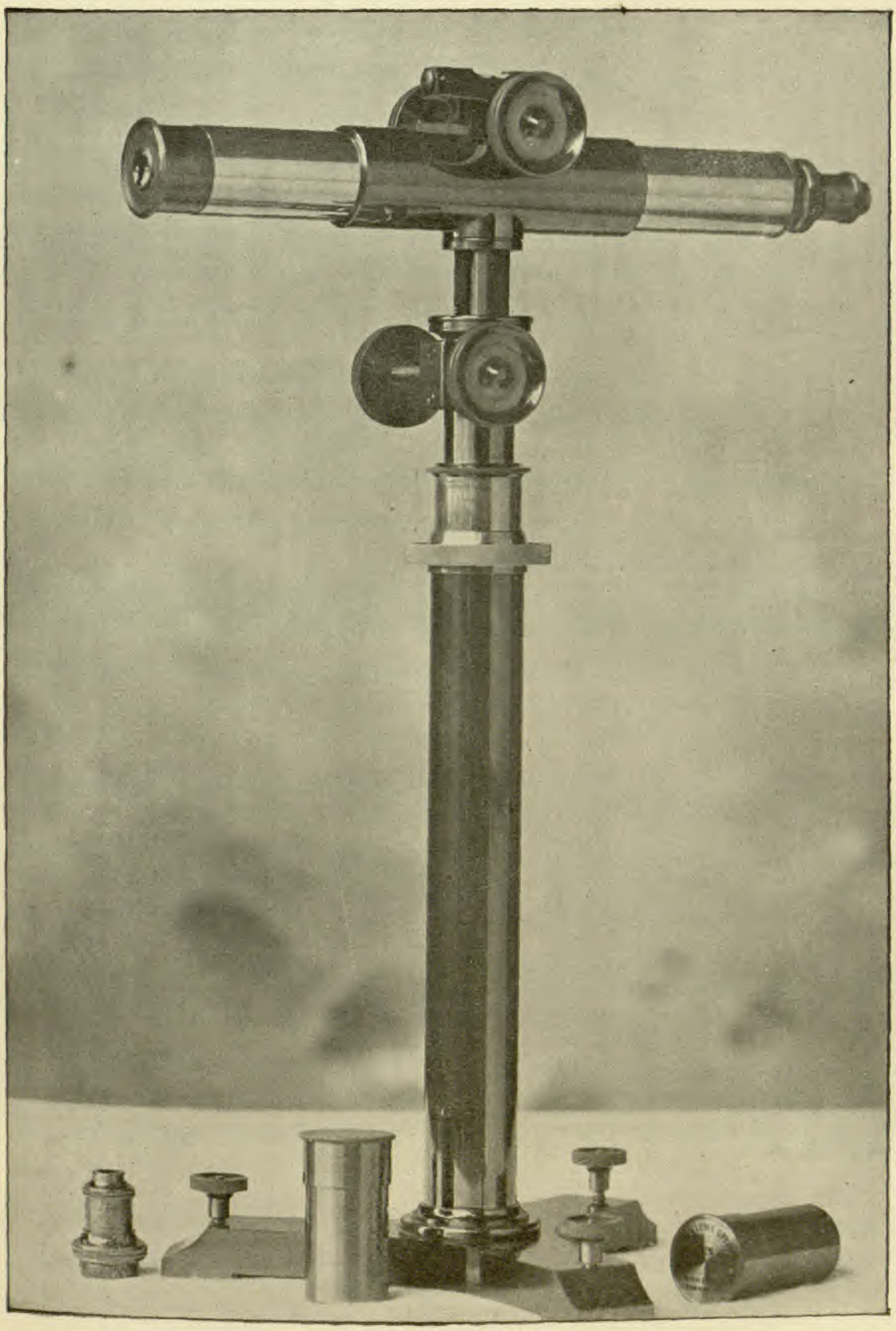
It will be observed at a glance that the general idea of the instrument is that illustrated in Pfeffer's *Physiologie* 2:85, *fig. 8*, which is essentially the form still used in the Leipzig laboratory. Upon comparison, however, it will be readily seen that the instrument here described has a number of points of superiority in the accuracy, readiness, and range of adjustment. It was constructed from my drawings by the Bausch & Lomb Optical Co., of Rochester, N. Y., to whose courtesy I owe the illustration.

The base is the large lead-filled brass tripod of their "Investigator" stand, with leveling screws. This base is the only part which I now think could be improved. It would be better were it somewhat larger and heavier. Its radial spread is now $10^{cm}$; it might well be $12^{cm}$ with correspondingly increased weight. From the base rises a tube $3^{cm}$ in external diameter, sawed at the top, where it is pinched by a screw collar. Within the outer tube slides a nickel draw-tube, $22^{cm}$ long, which can be set at any height, up to its maximum, by means of the screw collar. The upper end of the draw-tube carries a pinion, with double milled heads, engaging a rack on a triangular slide. By means of this rack and pinion the body, which has been roughly brought to the required height by means of the draw-tube, can be accurately set. A finer adjustment has not been found necessary, since a $1^{in}$ objective has given the highest power required, and with this the micrometer lines can be made to coincide accurately with the tip of the object under observation.

At right angles to the triangular slide is fixed a tube in which moves the nickeled body, actuated by a pinion which engages a rack on the body. This adjustment serves to focus the instrument. Above the pinion, between its milled heads, is fastened a spirit-level, accurately parallel with the body, so that by means of the leveling screws it can be made horizontal.

The optical parts consist of a $2^{in}$ eyepiece, $1^{in}$ and $3^{in}$ objectives. Fixed in the focus of the eye lens of the ocular is a micrometer divided into tenths of a millimeter.

The method of using the instrument is so obvious that it needs no special explanation.— CHARLES R. BARNES, *University of Wisconsin, Madison.*



BARNES on HORIZONTAL MICROSCOPE.

# EDITORIAL.

The establishment of a biological survey by the Department of Agriculture, under a recent act of Congress, should mark the beginning of a new era in the botanical field-work of the United States. Some work of this kind has been done by the general government, and by different institutions, but it has been desultory and without any general plan. At the head of the new survey no more competent man could have been placed than Dr. Merriam, for his whole work has tended in this direction and his publications have shown a wide grasp of the problems. To be made most effective, large cooperation must be obtained from local organizations, which will work along definite lines in a general plan. The natural allies of the Department will be the Experiment Stations already established in every state, but even these should not be regarded as adequate. Where state biological surveys are organized, these should be associated with the government survey and work under its general direction; and where they are not, such organizations should be formed, or the biologists of the state should individually associate themselves with the general survey. There can be no doubt that abundant and important service can be suggested to every worker by Dr. Merriam. The new survey should prove a great stimulus to the coming generation of botanists, and to the strong movement in botany which is impelling them to emerge from herbaria and laboratories and to come in contact with the larger problems of plant-life. The gradual shifting of the botanical standpoint is becoming daily more evident, and the period of morphology is merging into one to be dominated by physiology, not merely the chemistry and physics of physiology, but the larger field of ecology.

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The movement for the appointment of a scientific chief of the department of agriculture seems to have received a check, whether through its friends or enemies we are not informed. But as it has received already the cordial endorsement of a considerable number of the foremost scientific men and societies, it is be to hoped that it will yet be carried to success. What may be the condition in other lines of scientific work we do not know, but we do know that under the present division of labor in botany there is a dissipation of energy and a duplication of work that might be largely avoided under a more logical and consistent organization, such as could probably be secured by a wise and broad-minded scientific executive. Now that the head of the department holds a cabinet portfolio, it is out of the question to expect other than a political adviser of the President to be appointed. If under him there were a permanent chief, empowered to organize and harmonize all the scientific divisions as the president of a university directs its policy in consultation with heads of departments, we should find increased economy and efficiency of every division. Under the present conditions there is a division of botany, a division of agrostology, a division of forestry, and a division of vegetable physiology and pathology. It is needless to point out the absurdity of the naming of these divisions, which have been split off one by one from the original division of botany. Each now is wholly independent of the others in control, appropriations, quarters and equipment. There is a force of live young men in these divisions and a very great amount of work is done, on whose high quality we have had occasion frequently to comment. There should be a chief of the division of botany, with general direction of all botanical work; the present "division of botany" should be rechristened, while it and the other botanical divisions should be made sections, each in charge of an assistant chief. This would make it possible to concentrate the office and routine work so that each chief would be left freer to push the work of his section. There can be no doubt that under some such plan we should see even more important advances in pure and applied botany than have been possible under the present system.

# CURRENT LITERATURE.

## BOOK REVIEWS.

### Missouri Botanical Garden.[1]

THE ANNUAL REPORTS from this garden have come to be regarded as among the most important contributions to American botany, and the one before us is worthy of its predecessors. The three scientific papers are as follows:

1. *Juglandaceæ of the United States*, by WILLIAM TRELEASE. Since 1893 Dr. Trelease has been preparing a synoptical revision of this group, its publication being delayed from time to time on account of the necessity of additional material. Now that the family has appeared in Sargent's "Silva," Dr. Trelease has thought best not to publish the entire manuscript, and has presented in the paper before us "merely such a tabulation of the fruit, twig, bark and bud characters as it is thought will be helpful in field studies." It is certain that these so-called "winter characters" will be extremely useful, but we wish that Dr. Trelease had given us the benefit of his complete revision. It seems that most of the species are more readily recognized in their winter condition than during the period of flowering or the early summer season. The revision contains our ten hickories and four walnuts, with notes on certain hybrid forms, which are very helpful in explaining certain puzzling forms, which have long troubled botanists. The twenty-five excellent plates, many of them from remarkably clear photographs, thoroughly illustrate habit, bark, buds, etc., and there would seem to be little excuse left for not recognizing our species.

2. *A Study of the Agaves of the United States*, by A. ISABEL MULFORD. The exceptional facilities at the Missouri Botanical Garden for the study of this interesting and difficult genus are well known, and Miss Mulford seems to have availed herself of them fully. The paper is a clear and full presentation of her results, which the thirty-eight plates make still more valuable. A general account of the genus and of its economic uses, which are numerous, prefaces the synoptical presentation of the species. The subgeneric divisions based upon differences in the inflorescence, recognized by Dr. Engelmann, are followed, but Baker's substantive names, *Manfreda*, *Littæa* and *Euagave*, are applied to them. The specific limitations are not distinct, as is to be expected in such a group, and absolute precision in definition is not to be looked for. About twenty species and varieties are presented, three of which are proposed as new.

[1]Missouri Botanical Garden. Seventh annual report. 8vo. pp. 210, pl. 67. St. Louis, Mo. 1896.

3. *The ligulate Wolffias of the United States*, by CHARLES HENRY THOMPSON. Under this title reference is made to the subgenus *Wolffiella*, which the author is inclined to believe is a distinct genus intermediate between *Wolffia* proper and *Lemna*, but unfortunately it has never been known to produce flowers. Only one form has been credited to the United States, and that a variety of the Mexican *W. gladiata*, known only from the subtropical region of Florida. Mr. Thompson found it among the collections of Bush, made in the swampy region of southeastern Missouri, and has also discovered the Mexican *W. lingulata* in California, growing in an irrigation canal near Bakersfield. A careful account of these two forms is given, illustrated by three plates.—J. M. C.

**A popular work on ecology.**

UNDER the somewhat uncertain name of *The Great World's Farm*, a valuable and delightful work has been written by Selina Gaye.[2] The title was suggested by a passage in Professor Drummond's account of untrodden Africa, and refers to the way in which plants establish themselves and flourish unattended by man.

The subjects treated are the natural methods of soil formation, water and food elements in soil and air, the action of leaves and roots, flowers and their pollination, the distribution of seeds, friends and foes, the chances of life, changes due to man, and similar matters.

This enumeration of subjects does not, however, give any suggestion of the great diversity of topics and the extraordinary array of facts which have been brought together. The work is written from the most modern point of view, and although dealing with scientific matters, technical terms have been so skilfully avoided, that any well informed person may read the book with enjoyment, without possessing previous knowledge of the subject, or of its terminology. The volume also contains much about worms, insects, birds and other animals in connection with the account of vegetation. There are so few lapses from full scientific accuracy that they may be ignored by both reviewer and reader. Some of the historical statements may be taken with a grain of incredulity, such as the story of the Persians keeping pollen of the date for nineteen years during a civil war in order to secure a crop of fruit at its close, yet they are currently accepted and serve to accentuate general truths.

The book is well printed and the illustrations, mostly full page plates, are especially commendable. Altogether the work forms a compact volume of entertaining and instructive information, and can be heartily recommended to the lover of nature whether dilettante or earnest student.—J. C. A.

[2] GAYE, SELINA.—The great world's farm; some account of nature's crops and how they are grown. With a preface by G. S. Boulger. 8vo. pp. x + 365. Illustrated. London: Seeley & Co. 1893. Chicago: The Macmillan Co. $1.50.

**The spraying of plants.**

NOTHING more remarkable has taken place in the history of botany than the development of methods for the protection of cultivated plants against the attacks of fungi and insects, especially by spraying, and the consequent encouragement given to the study of the life history of fungi. It is scarcely more than a decade since the first impetus was felt, its inception being traceable to the discovery of the value of Bordeaux mixture as a fungicide and Paris green as an insecticide. The former was first used in France and the latter in central United States. The importance of these discoveries cannot be overestimated, and the extent and variety of the practical and scientific results which have followed can only be fully appreciated by one studying the subject. It is therefore a valuable service which Mr. E. G. Lodeman[3] has rendered to practical and scientific men alike by the publication of a work on the general subject of spraying.

In four hundred closely printed pages he has recorded a great number of facts and opinions, and given a clear survey of the growth of the subject and its present status. Beginning with the history and principles of spraying in general, he traces its rise and adoption in foreign countries and in America, together with improvements in machinery for its application; then discusses the action of fungicides and insecticides upon the parasite, the host, and the soil, and devotes the last third of the work to descriptions of fungous diseases and insect enemies of many kinds of plants, with directions for treatment.

There are several aspects in which the work is a specially valuable contribution to scientific literature. The chronological study of the subject in its different lines of development and from various geographical centers, with the abundant reference citations, presents a record of lasting importance, although necessarily limited by the size of the volume.

The fact that America leads in the study of plant diseases, in devising new remedies, perfecting those already known, and in the readiness with which the cultivator accepts and applies the suggestions of the investigator is cause for congratulation, as it augurs well for the continued growth of pathology and incidentally of other branches of botany in this country.

The number of diseases brought to light and the number of remedies suggested have been so perplexingly numerous that the cultivator and the investigator alike will welcome the part of the work dealing with specific diseases and their treatment. Although necessarily brief, it is sufficient for the guidance of the cultivator, and affords the student a needed survey of the field. It is fortunate that insects and fungi are examined with equal

[3] LODEMAN, E. G.—The spraying of plants: a succinct account of the history, principles and practice of the application of liquids and powders to plants for the purpose of destroying insects and fungi. With a preface by B. T. Galloway. 12mo. pp. xvii + 399. Illust. New York and London: The Macmillan Co. 1896. $1.00.

thoroughness in this work, as it gives an opportunity to compare the results of the labors of entomologists and mycologists.

As a piece of book making, the work leaves nothing to be desired. It forms the second volume of the Rural Science Series, edited by Professor L. H. Bailey of Cornell University.—J. C. A.

### A new "Vegetation der Erde."

THE CLASSICAL *Vegetation der Erde* of Grisebach will always be looked upon as one of the great books upon the distribution of plants. But recent progress has brought to knowledge much of detail which now needs to be incarnated in general principles. In brief, such is the plan of Professors Engler and Drude. They propose to edit a collection of monographs upon the various phases of plant geography under the general title *Vegetation der Erde*, thinking that the time is ripe for at least beginning a publication which shall, on the one hand, bring to light the lifelong work of some of the older savants, and, on the other, enable younger investigators to know what needs to be done and to plan their studies accordingly.

No definite order for the monographs can be announced, and almost entire freedom will be allowed individual contributors in the arrangement of their material. Naturally the countries of central and western Europe will be the first to be treated, on account of the more thorough study to which they have been already subjected. Each monograph will constitute an independent volume, to be published in the German language, by translation, if need be, from the native tongue of the author. The editors themselves promise some of the general work upon plant geography and plant history, together with the special treatment of certain regions.

This is a courageous plan, demanding even more optimism and energy than the inception of the great *Pflanzenfamilien* which is now nearing completion. We trust that the senior proposer, Professor Engler, of Berlin, will be enabled to see this materialize, as he has seen his monumental *Pflanzenfamilien*. Certainly he will have an able coadjutor in Professor Drude of Dresden. No one who inspects the tentative outline of the work can fail to be impressed with its comprehensiveness. Three sections are suggested The first, treating of climatology in its influence upon the distribution of plants, the developmental history of floras, and phylogenetic investigations upon geologic and biological principles, will naturally be the last to begin. The second will treat the plant formations, especially those of Europe and neighboring regions, while the third will discuss the principles of plant distribution as illustrated by natural floral regions.

An editorial in this journal recently[4] urged students, instead of compiling state floras after the usual pattern, to work out carefully the distribution

[4] BOTANICAL GAZETTE 21: 303. May 1896.

of plants in relation to others and to geographic and climatological features. If any one desires to see what this suggestion means in detail he would do well to examine the first volume of this projected *Vegetation der Erde*, namely, Willkomm's *Grundzüge der Pflanzenverbreitung auf der iberischen Halbinsel*.[5]

The Iberian peninsula is particularly well suited for a special study of this kind, cut off as it is from the rest of Europe by the Pyrenees. While its limit is thereby defined its interior presents exceedingly diversified conditions, the rainfall alone varying from less than 300$^{mm}$ in small regions about Salamanca and Lérida, to over 1600$^{mm}$ about Santiago and Roncesvalles, while a large part of the table-land of Old Castile, New Castile, and Aragon receive less than 400$^{mm}$. With six mountain systems, in five of which peaks and chains reach the alpine region, and in one the snow-line with peaks of 11,000 feet; with a coast line of 2250 miles, sometimes abrupt, sometimes sand dunes backed by marshes, as diversified a surface as can well be imagined is presented.

After giving an account of the history and literature of botanical exploration in the peninsula and its physical features, Willkomm discusses the peculiarities of the combination of the Iberian flora and its biological statistics; the distribution of the plant formations; the limits of various species whose polar or equatorial limit is therein reached; and the relation of the Spanish-Portuguese flora to that of neighboring countries and islands.

The second part, which constitutes the larger part of the book, depicts the formations and the collective vegetation in each of the five districts into which he divides the region, viz., the Pyrenaic, North Atlantic, central Mediterranean, south Atlantic, and west Atlantic. An appendix treats of the changes in the vegetation through cultivated and adventive plants.

It is impossible for any foreigner to criticise such a work, whose details must be tested by local botanists; but it cannot fail to leave an impression of great thoroughness. To it the venerable author had devoted a good share of his life. It was fortunate indeed for us that he was able to complete the manuscript and to see more than half of it through the press before his death a few months ago. A more auspicious beginning of Engler and Drude's great work could scarcely have been made.

From the publisher's point of view the book is faultless. The two maps, one showing isohyetes and the other the steppes and the vegetation limits, are exquisite specimens of modern cartography.—C. R. B.

## MINOR NOTICES.

DR. T. F. ALLEN has published another fascicle of his *Characeæ of America*, being part II, fascicle 3. Ten species of *Nitella* are described, and

[5] WILLKOMM, MORITZ. Grundzüge der Pflanzenverbreitung auf der iberischen Halbinsel. 8vo, pp. xvi + 395, *f. 21, pl. 2, maps 2*. Leipzig: Wilhelm Engelmann. 1896. M. 12 unbound; M. 13.50 bound.

illustrated by nine handsome plates. *N. Leibergi* is a new species from Oregon; *N. transilis* is a new species of the north Atlantic states; and *N. Asagræana* Schaffner, in Herb. Farlow, is Mexican. The other species are *N. mucronata* A. Br., *N. capitellata* A. Br., *N. gracilis* (Smith) Ag., *N. tenuissima* (Desv.) Coss. et Germ., *N. pygmæa* A. Br., *N. minuta* Allen, and *N. intermedia* Nordst.—J. M. C.

THE METROPOLITAN PARK COMMISSION of Massachusetts has issued a catalogue of the flora of the Blue Hills, Middlesex Fells, Stony Brook, and Beaver Brook Reservations, compiled and edited by Mr. Walter Deane. The work could not have been put into more competent hands, as Mr. Deane's acquaintance with the flora of the whole region is most intimate and accurate; and although he insists that the list is but a preliminary one we question whether it is not more complete than most catalogues. The 7508 acres of very diversified territory have furnished a large list of plants, many of which, it is to be hoped, will be carefully guarded. In addition to the vascular plants, the numerous mosses are presented by Edward L. Rand, the Characeæ by J. W. Blankinship, the algæ by F. S. Collins, the lichens by Clara E. Cummings, and the fungi by A. B. Seymour and Flora W. Patterson. The pteridophytes are furnished by G. E. Davenport.—J. M. C.

IN THE SERIES of bulletins issued by the laboratories of Natural History of the State University of Iowa the current number bears the date of February, 1896. Mr. R. I. Cratty makes some useful notes on the aquatic "phenogams" of the state; Mr. Paul Bartsch deals with the Cretaceous flora of western Iowa; Messrs. Ellis and Macbride publish a list of Nicaraguan Hymenomycetes, collected by the university expedition to that country; Mr. B. Shimek notes over fifty species of plants not heretofore recorded as growing in the state, and also new stations for very many of those already recorded, making the very sensible remark, "The object of this list is to add, if possible, to the knowledge of the plants of the state, not to the volume of the nomenclature literature. Therefore, without regard to the present controversy, the nomenclature of the latest edition of Gray's Manual is followed, as the plants will be readily recognized by the names therein given;" and Professor Macbride describes an interesting Nicaraguan puff-ball, *Bovista lateritia* Berk.—J. M. C.

A CONSPICUOUS example of the bookmaker's art is *The White Pine*, by Pinchot and Graves,[6] and this in more senses than one. For the book is scarcely more than a magazine article as to length, by the printer's skill put together most admirably to form a dainty volume. As to contents, its facts and conclusions are confessedly "based . . . on a short period of observation and a comparatively restricted number of measurements." It may be added

[6] PINCHOT, GIFFORD, and GRAVES, HENRY S.—The white pine—a study. With tables of volume and yield. 12mo. pp. xii + 102. New York: The Century Co. 1896.

that these were made in a still more restricted region, viz., the pine forests of Pennsylvania. It is hardly conceivable that tables based on data from 160 trees of which only 100 were over 100 years old, in one of the most unimportant pineries of the country, can be sufficiently well founded to command confidence.

Whatever of good is accomplished by the book will be in showing what forest study aims to do, and how it can be made in this country, as in Europe, of direct commercial value.—C. R. B.

## NOTES FOR STUDENTS.

CZAPEK has examined the acid root secretions[7] and found that the commonest source of the acid reaction is primary potassic phosphate, primary potassic oxalate occurring in only a few cases. No free acids, with the exception of carbonic acid, were found.

MM. BERTRAND AND MALÈVRE, whose work upon pectase, a new diastatic enzyme, has already been noticed in this journal, find that it is very widely distributed among plants; so widely that they feel justified in saying that it may be regarded as universally diffused in green plants.[8] It is especially abundant in the leaves and probably spreads to the other organs. It may be prepared from alfalfa or clover by braying in an iron mortar full-grown plants, whose juices are then expressed. This fluid is saturated with chloroform to prevent alteration by micro-organisms and set aside for 12–24 hours in an open flask protected from light. It then undergoes a special coagulation, which renders it easy to filter. To the clear liquid twice its volume of 90 per cent. alcohol is added, which throws down a white precipitate which is collected and dissolved in a little water. After twelve hours it is filtered and the almost colorless liquid which runs through is received in four to five volumes of alcohol. The pectase separates anew and is collected and dried in a vacuum. In this way a liter of juice yields 5–8$^{gm}$ of a white, non-hygroscopic substance, very soluble in water, which produces a vigorous pectic fermentation. A 1 per cent. solution of pectin will be coagulated in forty-eight hours by the addition of $\frac{1}{1000}$ of its weight of the pectase from alfalfa, or $\frac{1}{1800}$ of the pectase from clover.—C. R. B.

MOLISCH describes[9] a new microchemical reaction for chlorophyll, which depends upon a special relation to potassic hydroxide. If a bit of tissue containing chlorophyll, which should not be wet with water, be transferred to a *saturated* watery solution of KOH, the chlorophyll bodies become almost instantly yellow-brown, changing again in 15–30 minutes almost to green. The

[7] Berichte d. deutsch. bot. Gesells. 14:29. 1896.

[8] Jour. de Bot. —: —. 1896.

[9] Ibid. p. 16.

change of the yellow-brown (which the author compares to the color of living diatoms) to green follows immediately upon heating to the boiling point or by the addition of water, and somewhat less quickly upon the addition of alcohol, ether, or glycerin.

Chlorophyll bodies killed by boiling water, by drying, or by any medium which does not destroy the coloring matter, show this reaction likewise. Solid chlorophyll prepared from an alcoholic extract also shows it. Alkali-chlorophyll does not; which confirms the contention of Tschirch, Schunck, and Marchlewski, as against A. Hansen, that dilute alkalies do alter chlorophyll.

Diatoms and brown algæ, after being killed by boiling water, upon which they become green, show the reaction, but in Florideæ and Cyanophyceæ its value is impaired by the accompanying reactions of phycoerythrin and phycocyanin.

No other bodies have been found by Molisch to respond to the chlorophyll test.—C. R. B.

MOLISCH also gives an account[10] of the crystallization of xanthophyll and his method of recognizing this yellow coloring matter which always accompanies chlorophyll. Inasmuch as the two are separable in solution, it seemed possible to devise a mode of removing the chlorophyll and leaving the xanthophyll *in the leaf*. The process is as follows: Fresh green leaves or small pieces of them are brought into 40 per cent. (by volume) alcohol which contains 20 per cent (by weight) of KOH. In this they remain several days protected from light, until all the chlorophyll is extracted. To prevent absorption of $CO_2$ this should be done in glass preparation jars with close-fitting glass stoppers. The potash solution is then washed out for several hours with distilled water and permanent preparations made by mounting bits of the leaves in pure glycerin. The xanthophyll is found crystallized in almost every previously chlorophyllous cell.

This process has yielded the described result in about 100 genera of seed plants at different times of year. Only rarely does the xanthophyll remain as yellow drops or diffused in the cell sap.

After giving an account of the physical and chemical peculiarities of the crystals Molisch points out the close similarity of the yellow coloring matters, xanthophyll, chrysophyll, etiolin, phycoxanthin, etc., and their relation to carotin. He proposes the use of the word carotin in the broad sense, already given to it by Zimmerman,[11] to designate all the yellow and orange-red crystals of the leaf obtained by the method described. It would therefore designate not a chemical individual but a group of nearly allied substances, just as "sugar" and "albumen" do.—C. R. B.

[10] Berichte d. deutsch. bot. Gesells. 14:18. 1896.

[11] Bot. Mikrotechnik 99.

IN A SECOND CONTRIBUTION on "The influence of light upon the form of Cacti and other plants,"[12] Goebel discusses the dependence of the form of the leaves of *Campanula rotundifolia* upon the intensity of light and introduces some remarks upon the dependence of the heterophylly of a few other plants upon external factors.

The usual form of *Campanula rotundifolia* is well known in the northern states. The early round leaves, from which it takes its specific name, form a radical rosette, but often perish early, so that the name seems very inappropriate when only the linear-lanceolate upper leaves are seen. The erect flowering branches arise in the axils of the lower leaves of the rosette and normally produce elongated leaves. Goebel was able, by diminishing the light, to cause shoots to produce round leaves exclusively until more strongly illuminated, when they formed long leaves. Others in weak light produced shoots in the upper axils bearing round leaves. But the most instructive case was that in which a shoot, after producing normal leaves, gradually returned to the development of round leaves, those at the tip of a $20^{cm}$ shoot being of typical orbicular-cordate outline. To determine whether the formation of the round[13] leaves could be suppressed by strong illumination from the beginning, or whether the process of development is so ordered that under all conditions round leaves appear first, plants were subjected to artificial illumination, finally with two arc lamps of 2000 c. p. each. But in no case was the formation of round leaves hindered. Goebel argues, therefore, that *Campanula rotundifolia* has not inherited the *Anlage* of two (or if one considers intermediate forms, many) leaf forms whose appearing is determined by the different degrees of intensity of light as a releasing factor, but only the *Anlage* of the round form, which under the normal condition of sufficient light is transformed into the long type, not suddenly but gradually, so that various intermediate forms appear. In the course of the ontogeny of an individual leaf these intermediate forms do not appear because the transforming factor very early directs the development of the leaf *Anlage* into another course. But if this factor be removed the inherited form reappears, as in the cultures in weak light.—C. R. B.

DR. J. WIESNER, who has contributed so much to the general subject of physiology, gathers up[14] in a rapid review the suggestions he has made in regard to the phenomena and terminology of the inequilateral growth of plant members. Having summarized the various forms of heterotrophy of tissues and members—evidently in many cases a complex phenomenon, which is conditioned on the one hand upon innate peculiarities and on the other upon

[12] Flora **82**: 1–13. 1896.

[13] Goebel says, apparently by a slip of the pen, "Langblattform," instead of "Rundblattform."

[14] Berichte der deutschen botanischen Gesellschaft **13**: 481–495. 1896.

external influences — he proposes to cover all cases by the simple special term *trophy*, which he defines as follows : " By *trophies* I understand all one-sided accelerations of growth in tissues or organs which depend upon the position of the organs concerned ; position being taken in its widest sense as indicating the spatial relation of the heterotrophic organ to the horizontal . . . . and to its mother shoot." [15]

As to position with reference to the horizontal, there are to be distinguished epitrophy and hypotrophy ; as to position with reference to the mother axis, exotrophy and endotrophy. The two latter are fixed by heredity. Influences effective by reason of position with reference to the horizontal, such as light, gravitation, and unequal wetting by precipitation, lead to paratonic trophies, which may be more exactly designated as phototrophy, geotrophy and hydrotrophy.

Wiesner then sums up the final results of his researches on anisophylly, which he holds to be evidently the result of combined trophies, in these words:

"1. Anisophylly, *i. e.*, the inequality of the leaves of the shoot in consequence of position (in the above exactly defined sense) serves, as a rule, to make possible to those plants with more abundant foliage a suitable fixed light position of the leaves themselves without the twisting of the internodes.

"2. For attaining this object plants utilize various trophies, either spontaneous (commonly exotrophy), or paratonic (phototrophy, hydrotrophy, probably also geotrophy), or both, which is the common method."—C. R. B.

IGNAZ FAMILLER has a paper in the current number of *Flora* (April) entitled "Biogenetic researches upon reduced or metamorphosed sexual organs." A brief extract of some of the important points will be useful, but the full paper should be read to appreciate the investigations upon which the conclusions are based. Cases in which plant organs have been reduced or transformed to meet changed conditions are by no means rare, and in the floral parts these phenomena are quite extensive. The author disregards all isolated observations of reduction and transformation, because only chance observations are accessible ; and also excludes all diclinous plants, as they would need an entire paper for adequate consideration. His application of sexual terms to stamens and carpels is certainly reprehensible, but using his own phraseology, the main points are as follows:

*Male Organs.* — Viewed from the standpoint of the typical structure of the normal anther, the rudimentary organ remains permanently in some stage of development through which the normal organ passes. The degree of devel-

[15] "Ich verstehe unter Trophieen alle an Geweben oder Organen vorkommenden einseitigen Wachsthumsförderungen, welche von der Lage des betreffenden Organs abhängen, wobei aber Lage in weiterem Sinne genommen wird, nämlich als die räumliche Beziehung des heterotrophen Organs zum Horizont . . . . und als die räumliche Beziehung des heterotrophen Organs zu seinem Muttersspross."

opment may vary considerably, sometimes the reduced organs being almost imperceptible and sometimes almost normally developed. Goebel remarks "That 'normally' reduced organs occasionally develop is common enough." The ray flowers of Compositæ, the fifth stamen of *Acanthus mollis* and the outer flower of *Viburnum Opulus* show the stamen in the form of a roundish elevation hardly perceptible to the naked eye. In a further step this first development is visible but no archesporium is formed. In many cases the rudiments are raised upon filaments as in *Catalpa*, or the entire organ may have a leaf-like aspect as in staminodia of *Linum*.

Another step shows that a cell-division which would otherwise lead to normal anther development sets in, but the staminodium remains in an interrupted stage. Here great variations are possible. Only the archesporium mother-cell may differentiate. Usually, however, more divisions occur and one can find the development arrested at all stages. In *Boronia* the staminodia in outward form closely resemble stamens. In *Boronia megastigma*, in earlier stages of development, stamens and staminodia show the same cell divisions, but in the staminodia the archesporium is smaller and so changes itself by repeated division that in the mature staminodium the cell divisions bear no resemblance to those of stamens. A nearly normal development is seen when the anthers form regularly but remain smaller than the perfect anthers, as in *Cassia*. When staminodia are to serve as organs of secretion, cell divisions resembling archesporium formation set in, but the epidermal cells frequently take part and so furnish an outlet for the secretion. The case in which staminodia become petaloid with no trace of anther formation must be considered the most extreme transformation.

As to the function of staminodia, two observers disagree. H. Müller[16] and Heinricher[17] regard them as useless organs, while Kerner v. Merilaun doubts whether any plant produces anything which is not of advantage and which is not necessary. Even those organs which people so freely call "rudimentary" are not without meaning for the life of the plant. Our author believes that the transformed stamens play a useful rôle in the economy of the plant. They may serve for attraction, they may be a protection to the young stigma, they may furnish a resting place for the insect visitor, they may secrete honey, they may direct the insect to the honey or prevent the honey from running out.

In flowers with many stamens and staminodia the transition from one to the other is gradual. A reduction of the anther-cells in size and number, a one-sided development of the same, a crowding from the normal position and also changes in the vascular bundle, filament and connective are shown by transitional forms.

[16] Schenk, Handbuch der Bot. 1.

[17] Oesterreich. Bot. Zeitschrift 44:—. 1894. [no. 2.]

Various examples from *Acanthaceæ*, *Bignoniaceæ*, *Commelinaceæ*, *Gesneriaceæ*, *Labiatæ* and *Scrophulariaceæ* are considered in detail.

*Gynæcium.*—Reductions in the gynæcium are not uncommon. Sometimes there is only a slight trace of it, or the carpels may appear as little elevations, the ovary may form and show the beginning of a placenta, the ovule may appear but with the embryo-sac-mother-cell and the integument formation checked, or the embryo-sac may form but with the integuments suppressed, or, finally, the ovule may form normally and may seem capable of fertilization, but on account of position or general weakness of development may become stunted.

Several members of the *Caprifoliaceæ*, *Valerianaceæ* and *Umbelliferæ* are considered in detail. *Quercus* and *Tilia* proved very difficult, and decisive results were not obtained.

*Entire Flowers.*—The most easily explained case of reduction of the entire flower is that in which the upper flowers of a rich inflorescence fail to develop because the nutritive materials are taken by the earlier, lower flowers.

Flowers may become sterile on account of abnormal enlargement of the floral axis as in the garden form of *Celosia cristata*, or through the enlargement of the floral envelopes as in *Viburnum* and *Hydrangea*. This completes the transformations which are caused by an effort on the part of the flower to serve other than reproductive purposes, like the attractive apparatus of the transformed flowers of *Muscari comosum*, the reduced flowers of *Rhus Cotinus*, whose pedicels serve as wings for the seed, or, finally, the transformation for glands in *Sesamum*.

*Arum maculatum*, *Brassica oleracea*, *Celosia cristata*, *Hydrangea serrata*, *Muscari comosum*, *Oncidium heteranthum*, *Rhus Cotinus*, *Sesamum orientale*, and *Viburnum Opulus* were the forms studied.

The author's résumé of his entire work is about as follows:

1. The reduction or transformation of arrested organs is a standstill (stehen bleibe) at different stages of normal development.

2. In arrested male organs the commonest cases are the following: (*a*) A standstill at a primitive stage with a feeble development of a perianth, or (*b*) a part of the cell-divisions appears which in the normal organ leads to the formation of the anther wall, but the usual archesporium does not proceed further or divide.

In female organs, generally, but not always, the embryo-sac is formed but integument formation is reduced. If the reduced ovules develop like the normal in their entire structure, they are at least smaller.

3. In flowers with many stamens and staminodia the transition from one to the other is gradual.

4. If the reduced male organs form pollen, the pollen grains, though fewer in number, are still like those of the entirely normal organ, an observation which agrees with the results of E. Amelung in his work "Ueber mittlere

Zellengrössen," where he says different sized organs of the same sort in a plant individual consist of cells of the same or nearly the same size (*Flora* —: 207. 1893).

5. Filamentous staminodia as they appear, *e.g.*, in species of *Pentstemon* correspond not to the filament alone, but they show in young stages a remnant of anther formation in their cell structure even if this is not outwardly apparent.

6. The transformed male organs, like normally transformed and sterile entire flowers, serve for the enlargement of the attractive apparatus, for mechanical devices for the direction of insects or for secretion.

7. There is a genuine transformation of the organ. Staminodia begin like normal stamens and partly complete the further development, but toward the end they form organs of secretion.

Finally, it must be noted that mechanical causes cannot explain the reduction or transformation of these organs, because often from the first, without an external cause, a different formation is recognizable. It may be necessary to take into consideration an inner power resting in the plasma, so that sometimes, as Eichler remarks, the later development of the flower even at its earliest inception may exercise a noteworthy influence, and sometimes, by the entrance of internal disturbances, changes in the typical, external form may take place without necessitating the question of atavism.—CHAS. CHAMBERLAIN.

# OPEN LETTERS.

*To the Editors of the Botanical Gazette:*—Will you kindly allow the following few words of explanation in reference to certain statements made in a book review in the April number of your magazine? The writer first begs leave to thank the reviewer for the occasion thus given to make at the same time an explanation, or perhaps an extension, of the preface of the little book on plant anatomy. It is quite evident that it was the first effort of its kind ever undertaken by the author, and it is a somewhat consoling reflection that probably had a clearer and more definite statement been made of the purpose for which the book was written, it would have prevented, in some degree at least, certain unfavorable criticisms.

It was taken for granted that the title, *Elements of Plant Anatomy*, would of itself suggest the fact that the plan pursued by the author in teaching these "dry bones" of the science was an exact parallel to the modern one adopted by biological teachers in the different departments of descriptive work, or that known as the type system. According to this, a bird's-eye view of the field is first taken and a foundation laid upon which the superstructure is to be raised, either by lectures or text books of an advanced character or both. But nowhere in the book is it stated that it was designed *not* for teachers but for students, and to be used by them as a framework merely, upon which each individual teacher could build by filling out the outlines in his own way. It is in no way fitted for a reference book except for the learner.

It was therefore by design and not through accident or ignorance that the recent theories, such as those relating to nuclear division and the nature of the starch grain, were omitted and the simple elementary facts upon which the later investigations are based were alone considered. That a serious and disappointing error has been made in the determination of what is really elementary in character is certainly a matter to be regretted. At the same time, as the reviewer kindly suggests, it is a mistake which may easily be corrected in a future edition.

It is, however, quite otherwise with certain statements made in the review which must have resulted from a hasty or careless perusal of the text and it is to these especially that the author begs to call attention. That a misstatement or a misrepresentation of the facts of the development of the tissues of plants has been made, is a charge so serious that simple justice must allow the author a chance to plead not guilty.

In answer to several of these charges, it is only necessary to refer to numerous German, French and English text-books whose authority rests upon original monographs. For example, the definition of bark, which is criticised, differs in no essential point from that given by De Bary in his text-book on anatomy and repeated by Vines in his text-book of botany, published in 1895. In fact, the same definition was given in an article on "Cork Wings," which was printed in the BOTANICAL GAZETTE in 1888. The expression objected to in regard to the formation of the cambium ring is a very common one in numerous German books, and its truthfulness has never before been called in question, at least to the author's knowledge. This is also true of the statement made concerning monocotyledonous stems, namely, that they may change from the mono- to the dicotyledonous type. It is not quite so evident perhaps that the tracheids and accompanying cells may be called the assistants of the ducts and sieve-tubes. Even here the author can lay no claim to originality. Almost all modern text-books of plant physiology contain a similar statement or intimate that such is the fact. The phloem carries the prepared food about the plant, the sieve-tubes the insoluble, the accompanying cells the soluble portions; while whatever may be the function of the ducts it is admitted by all authoritative writers that the tracheids aid them in this function, or, in certain cases, supply the place of the ducts which are wanting. With reference to the "confusion regarding the elements of secondary bast," etc., it is, perhaps, only necessary to say that the statements made on this subject were the result of the comparative study of all the leading text-books as well as numerous original articles, and, we may add, a modest amount of original work on the part of the author. The language was made as simple as possible, and it may be that the entire omission of the customary technical phraseology caused the reviewer to suppose something must be wanting.

For one familiar with the facts of plant anatomy by years of study, not only of text-books but also of the plants themselves, it is hard to conceive how a candid critic could take exception to these statements. Indeed, if the author may not be considered "authority" on these subjects she has erred in company with the illustrious scientists of the present and past, with such men as Naegeli, Cramer, De Bary, Sanio, Vines, Reinke and Schwendener.

The author heartily agrees with the reviewer in wishing the book were better and also in the hope that a revision, in the near future, may be made which will render it more useful. EMILY L. GREGORY, *New York City.*

[The reviewer must call attention to the fact that as regards the "bark" he merely raised the question whether it was the *Borke* of the Germans which is "commonly called bark." He is aware that in English translations of German works this word has been translated *bark,* but he is unwilling to accept "authority" on this question, with which he may deal elsewhere shortly.

As to the cambium ring: since the completion of the ring by the formation of interfascicular cambium *precedes* the formation of secondary bundles, the reviewer cannot understand how the ring "may be said to be formed *either* by the intercalation of new bundles *or* by the formation of interfascicular cambium." And that "numerous German books" say it in no wise enlightens the obtuse critic.

Dr. Gregory misses the point of the criticism regarding the so-called change in structure of a stem as it grows older from the mono- to the dicotyledonous type. The fact was not questioned. But does it not strike her as a poor sort of classification (albeit widely used) which makes no better provision for such a fact? Is it possible to maintain as types of structure those which are subject to so many exceptions as these?

The statement that "there is certainly confusion regarding the secondary bast fibers and the similar tissues arising from the pericycle" is based not upon simplicity of language but upon the author's inclusion of all thick-walled fibers and stone cells in the "elements of the secondary phloem" (p. 129). If they are not included by her in that category, then there is the entire omission of any statement that such tissues often belong to the pericycle instead of to the secondary phloem; in which case the confusion would be transferred from the author to the students using the book.—ED.]

# NEWS.

DR. WILLIAM TRELEASE is now in Europe. He will return about August first.

HARVARD UNIVERSITY at its recent commencement conferred upon Professor W. G. Farlow the degree LL.D., an honor most worthily bestowed.

THE LAST ISSUES of Lloyd's *Photogravures of American Fungi* (nos. 9 and 10) illustrate *Polyporus Berkeleyi*, and maintain the high character of the previous issues.

PROFESSOR D. T. MACDOUGAL has an untechnical article on the colors of plants, especially the non-green colors, in the May number of the *Popular Science Monthly*.

PROFESSOR THOS. A. WILLIAMS, professor of botany in the Agricultural College of South Dakota, has been appointed an assistant in the Division of Agrostology in the Department of Agriculture.

DR. J. W. HARSHBERGER, in pursuing his ethno-botanical studies, has reached the conclusion that the pumpkin is indigenous in America, a view which he elaborates to some extent in *Science* (June 19th).

MR. A. A. HELLER has been appointed instructor in botany and curator of the herbarium in the University of Minnesota *vice* E. P. Sheldon, who resigns to find a more congenial field in the real-estate business.

MR. JAMES BRITTEN has published an account (*Jour. Bot.*, June) of Arruda's Brazilian plants, the occasion of it being the doubtful or inaccurate citation of them in what he is pleased to call "Jackson's *Index*."

A NEW CASE of apparent symbiosis, between *Tetraplodon* and *Peziza*, n which the rhizoids of the moss were associated with the fungus hyphæ, has been found by Professor F. E. Weiss. (*Rep. Brit. Ass.* 1895: 855).

IN THE *Bull. Torr. Bot. Club* (May), W. W. Rowlee and K. M. Wiegand describe some very interesting hybrids of *Salix candida*, found near Ithaca, N. Y.; and S. M. Tracy and F. S. Earle describe numerous new fungi from Mississispi.

A LIST OF forty-seven freshwater algæ new to Great Britain is given by W. and G. S. West in *Jour. Roy. Mic. Soc.*, April, 1896. Fourteen new species are described with two new genera. Two plates of very crowded illustrations accompany the list.—S.

DR. V. F. BROTHERUS, of Helsingfors, left about the middle of April upon a botanical journey into central Asia. He will explore the high mountain flora of Issikul, giving particular attention to the mosses. He expects to return about the first of September.

PROFESSOR C. S. SARGENT, of Boston, and M. H. de Vilmorin, of Paris, are the best known of the four recipients of the Veitch medals, awarded by the Royal Horticultural Society to gardeners promoting the advance of horticulture. (*Gard. Chron.*, May 16).—S.

PROFESSOR GANONG, of Smith College, has distributed, as a separate from the elective pamphlet, an outline of the courses in botany offered for 1896–7. It would be useful to botanists if the practice were general, so that each might know what is offered to students in the way of advanced work.

A WELL-EXECUTED colored plate of *Erythronium mesochoreum* Knerr is published in the commencement number of *The Midland*, the college magazine of Midland College, Atchison, Kansas. A short general account of the plant by Professor E. B. Knerr is also illustrated by text figures of sterile and fertile plants of *E. albidum* and *E. mesochoreum*.

A CONTINUATION of Briquet's *Labiatæ* forms part 134 of *Die Natürlichen Pflanzenfamilien.* We note in it the splitting up of *Cedronella*, retaining the old name for the single species of the Canary islands, and recognizing two American genera, *Meehania* Britton, and *Brittonastrum* Briquet. Part 135 contains the conclusion of Engler's *Burseraceæ*, and *Meliaceæ* by H. Harms.

MR. F. S. EARLE, formerly connected with the Gulf Station of the Mississippi Agricultural Experiment Station and with the Agricultural Department of the United States, was appointed adjunct professor of horticulture at the Alabama Polytechnic Institute in January last. Upon Professor Underwood's appointment to Columbia University he was recently promoted to the professorship of biology.

FOLLOWING the appearance of our violets in the *Synoptical Flora*, Professor E. L. Greene (*Pittonia*, May 16), and Mr. C. L. Pollard (*Proc. Biol. Soc.*, Wash., May 26) have added to the literature of the genus. The work of the former was mentioned in this journal for June. Mr. Pollard deals with the purple-flowered acaulescent forms of the Atlantic coast, presenting ten forms, of widely different limitation and nomenclature from the presentation of the same forms in the *Synoptical Flora*.

RECENT NUMBERS of the *Gardeners' Chronicle* (Apr. 4, 18, and May 2) give considerable space to a discussion of the larch disease, or blister, caused by the fungus, *Peziza Willkommi*, with several illustrations. The disease originates probably in early spring when the hydrostatic pressure is considerable. Though essentially a bark disease, it frequently causes malformations of the trunk and even the death of the tree. Cold and damp are thought to be the prime causes. — S.

IN A PAPER read before the London Pathological Society, Mr. S. G. Shattuck gives the results of some investigations in regard to the healing of incisions in vegetable tissues. When both surfaces were freely exposed to the air, on each surface a layer of cork was formed, which gave place to the underlying parenchyma when the two corky layers met. The other common method of healing was by cell-division on either face of the injury and was usual when the surfaces were not sufficiently separated to admit the air. (*Gard. Chron.*, May 23). — S.

AT THE CALL of a committee of representative persons interested in Maine botany, a convention was held at Portland, July 12–15, 1895. The different sessions were attended by about one hundred persons, many of whom expressed a desire to become members of a permanent organization, and as an outgrowth from this convention the Josselyn Botanical Society of Maine was formed. The second annual meeting was held in the State Normal School, Farmington, July 7–10, 1896. The general plan for the meetings is to devote the first two days to papers and discussions, and the last two to field expeditions into the surrounding country.

THE FIRST BULLETIN of the New York Botanical Garden, recently issued, contains a full statement of the status of this important enterprise. Of special interest to botanists is the agreement with Columbia University, whereby the large herbarium and library of the college is to be deposited with the Garden. This will make the latter at once a great botanical center, situated in surroundings which will give ample room for expansion, and for the proper development of every phase of botany. In the interest of botanical science in America it is to be hoped that Dr. Britton will find generous support for the development of his far-reaching plans. Such opportunities should develop more than a great taxonomic center, but to accomplish it New York must continue to be very generous.

OTTO KAISER has reinvestigated the nuclear division in various cells of Characeæ. He finds that mitosis alone occurs in all apical, segment, nodal and peripheral cells, in the nodal cells of the cortical lobes, the cells of the antheridia and of young oogonia. In the segment cells, especially in those of the so-called leaves, the aster, metakinesis and diaster stages are somewhat different from the ordinary form, being of the barrel type. Centrosomes were present with the resting nuclei as well as with all stages of their division. Fragmentation occurs only in the cortical cells of older oogonia, and in the internodal cells of the stem, of the "leaves," and of the older cortical lobes. Only in these is more than one nucleus found. Kaiser's best results were obtained with material fixed in corrosive sublimate solution, or Hermann's or Flemming's fluids. Staining with Heidenhain's hæmatoxylin produced sharply outlined mitotic figures.

THE CORNER STONES of the Hull Biological Laboratory of The University of Chicago were laid July 3d, with appropriate ceremonies. An address was delivered by Dr. George L. Goodale, of Harvard University, upon "Some of

BOTANICAL HALL.

the relations of the new natural history to modern thought and modern life," in which the speaker made a strong statement concerning the claims of biology to a place in educational schemes and also upon the community. Head Professor John M. Coulter officiated at the laying of the corner stone of the Botanical Hall and made a brief statement concerning the purposes of the building. In the evening the visiting biologists were entertained by The University at the Quadrangle Club House, where informal responses were called for by President Harper. Among the visiting botanists present were: Dr. Geo. L. Goodale, Harvard University; Dr. T. J. Burrill, University of Illinois; Dr. T. H. MacBride, University of Iowa; Dr. Charles R. Barnes, University of Wisconsin; Dr. G. F. Pierce, University of Indiana; Dr. C. F. Millspaugh, Field Columbian

Museum. The accompanying cut will give some idea of the external appearance of the building, which will be ready for use in the spring of 1897.

THE RECENT TORNADO at St. Louis was so destructive that much anxiety was felt by botanists as to the fate of the Missouri Botanical Garden. In the absence of Dr. Trelease, Mr. C. H. Thompson, Acting Director, has furnished the following statement for the readers of the GAZETTE:

"The Garden was in the direct path of the storm, at the very beginning of the territory destroyed, and received less injuries than the region east of us. However, the damage done in the Garden is very considerable, the most of it being in the arboretum, where something like 160 trees were either uprooted or broken off near the ground, so that they had to be taken out. These, of course, were total losses. Something over 250 were very badly damaged. In many cases the tops of the trees were almost entirely carried away. Many of these, by judicious pruning, will in a few years grow to be beautiful trees again, while many are so badly broken that it is probable that they will die. The shrubbery was badly whipped and broken, but fared better than the trees. The bed plants were almost totally destroyed in the exposed parts of the grounds. However, these are now replaced. The wreckage from the trees is rapidly being gathered up, and the Garden promises by another month to be as beautiful as ever, with only the vacant places here and there to remind us of the ravages of the storm.

Buildings suffered somewhat. The Linnean house, which shelters the palms in the winter season, had the glass portion of the roof entirely demolished. The office building had the tin roof torn from the south wing, and other buildings escaped with slight damages. At the office building, where the library and herbarium are kept, no damage whatever was done to the contents of the building. No permanent damage was done to the Garden, and most of it can be repaired in a short time."

PROFESSOR E. L. GREENE, in the continuation of his "studies in Compositæ" (*Pittonia* 3: 43), presents further conclusions in regard to the "asteraceous" forms. Generic lines in this vicinity either were or are in a chaotic state, and possibly ever will be. Apparently species may belong to any one of several genera dependent upon the standpoint of the observer. In the present paper the genera *Oonopsis* (a new genus), *Xylorrhiza, Heleastrum, Dœllingeria, Eucephalus,* and *Machæranthera* are presented synoptically, *Aster* and *Applopapus* being the most frequent synonyms.

DR. JOHN K. SMALL, in *Bull. Torr. Bot. Club* (May), has taken Raimann's work on *Œnothera*, as presented in Engler and Prantl's *Natürlichen. Pflanzenfamilien*, and applied it to a study of North American materials. The composite character of this Linnæan genus was notably pointed out by Spach in 1835, but his numerous genera, for some reason, were not largely accepted. Raimann adopted Spach's idea, but seems to have presented his conclusions in a more satisfactory way. Dr. Small presents fifteen genera as represented in North America under the single generic name *Œnothera*, the old name retaining but five species, such as *Œ. humifusa*, *Œ. laciniata*, *Œ. rhombipetala*, etc. Those having somewhat acquainted themselves with the genus will be lost for a time in the maze of revived generic names. A new genus, *Gaurella*, is described, founded upon *Œ. canescens* Torr. & Frem., a number of new species are described, and abundant opportunity is given for new combinations. It is to be hoped that such extensive fragmentation may not be found necessary in many of our large genera, or there will be a call for an international congress to define a genus.

WE HAVE RECEIVED a bulletin from the Alabama Experiment Station which should occasion some remark. It is Bulletin 70, and is entitled "The Flora of Alabama, Part V," by P. H. Mell, botanist to the station. The four preceding parts have never come to our notice, but the present one deals with the *Leguminosæ* and *Rosaceæ*. We suspect, however, that this is the first part to appear, as certain prefatory matters would indicate. The author seems to be aware that botanists have been doing something in the last "ten or twelve" years, for he says so; but just what, he is evidently uncertain about, as the list testifies. We would suggest that if an "up-to-date" flavor be desired for the catalogue, the conspectus of orders had better be changed in several particulars, at least by removing the gymnosperms from their unnatural position between dicotyledons and monocotyledons; some dubious species had better be investigated, and all of them should be substantiated by herbarium specimens; and more than all, Dr. Chas. Mohr's relation to this work should be clearly stated. Botanists outside of Alabama have known for years that Dr. Mohr has been working upon a flora of his state, and we have expected a model state flora, because Dr. Mohr's zeal and patient accuracy are well known. In the list before us certainly one-half of the *Leguminosæ* and one-third of the *Rosaceæ* are credited to Dr. Mohr alone; and we cannot believe that this extensive information was obtained from our good friend with the expressed intention of anticipating his own flora. In other words, Dr. Mohr must have granted a favor that has been abused.

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# THE BOTANICAL GAZETTE

EDITORS



ISSUED AUGUST 31

CHICAGO, ILLINOIS
Published by The University of Chicago

The University of Chicago Press

# Botanical Gazette

A Monthly Journal Embracing all Departments of Botanical Science

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VOLUME XXII NUMBER 2

# BOTANICAL GAZETTE

*AUGUST 1896*

## ON THE TOXIC ACTION OF DISSOLVED SALTS AND THEIR ELECTROLYTIC DISSOCIATION.[1]

LOUIS KAHLENBERG and RODNEY H. TRUE.

### THE THEORY OF ELECTROLYTIC DISSOCIATION.

During the last decade work in physical chemistry has been characterized by a thorough and systematic study of solutions from both theoretical and experimental points of view. As a result of the activity along this line our knowledge of the nature of substances dissolved in various solvents has been greatly extended. In 1887 van't Hoff,[2] basing his argument upon the osmotic experiments performed by Pfeffer[3] ten years earlier, was enabled to show almost a complete analogy between the behavior of solutions and gases. This analogy grows out of the fact that when the volume of a solution and its osmotic pressure are taken into consideration the same laws hold as in the case of gases when the volume of the gas and its pressure are considered. So close is the analogy that, considering the temperature constant, the osmotic pressure exerted by a substance dissolved in a certain amount of solvent is the same as the pressure exerted by the gas if the same amount of substance is conceived of as being

[1] Abridged by the authors from a paper soon to appear as a Bulletin of the University of Wisconsin (Science Series).

[2] Zeitschr. f. physik. Chem. 1: 481.

[3] Osmotische Untersuchungen, Leipzig, 1877.

volatilized and as occupying the same volume as that possessed by the solution. Thus van't Hoff showed how the laws of Boyle and Gay-Lussac can be applied to dilute solutions. He was also enabled to make the following important extension of Avogadro's hypothesis: Equal volumes of all solutions having the same temperature and the same osmotic pressure contain an equal number of molecules, which number is identical with that contained in a gas having the same volume, temperature and pressure.

When Avogadro put forth his hypothesis that equal volumes of all gases under the same conditions of temperature and pressure contain an equal number of molecules, facts were found that apparently spoke strongly against this view. Thus it was observed that the vapor density of the chloride of ammonium was only a little more than half as great as was required by the principle of Avogadro, or, in other words, the molecular weight of the chloride of ammonium as calculated from the vapor density was found to be only a little more than one-half of that expressed by the formula $NH_4Cl$. This fact at first caused much opposition to Avogadro's views, which was finally cleared away, however, when it was shown that in the vapor of the chloride of ammonium there are not simply molecules of that salt, but also hydrochloric acid and ammonia molecules, the products into which ammonium chloride in the vapor state is largely dissociated.

The theory of van't Hoff had to contend with a similar difficulty. While the behavior of many solutions was such as to strongly support the theory, a large number of solutions (particularly aqueous solutions of acids, bases and salts) showed considerable deviation in their behavior from what the theory required, inasmuch as their osmotic pressures were greater than they ought to be according to the theory. The empirical results of Raoult,[4] which led to the methods for determining molecular weights of dissolved substances from the diminution of the vapor tension (or the elevation of the boiling point) of the

[4] Compare Ostwald, Lehrbuch der allgemeinen Chemie 1:715, 748.

solution or the lowering of the freezing point of the same, were explained from theoretical standpoints by the above mentioned work of van't Hoff, and so these methods were placed upon a thoroughly scientific basis. Solutions that showed too great an osmotic pressure also showed too great a diminution of the vapor tension or too great a lowering of the freezing point, and consequently too small a molecular weight.

In his mathematical formulæ van't Hoff for the time being arbitrarily introduced a factor *i* to account for the deviations that such solutions showed from what the theory required. Soon, however, Arrhenius,[5] from the relation between the lowering of the freezing point of solutions and their electrical conductivity, came to the conclusion that in aqueous solutions of salts, acids and bases, in short, in solutions that are conductors of electricity, the dissolved substances showing too small molecular weights (as did the chloride of ammonium in the vapor state) are to be regarded as being dissociated[6] into part-molecules or ions.[7] These ions are charged with electricity, each gram-equivalent bearing 96,540 coulombs. This latter figure has been determined by experiments on electrolysis and has well been termed the constant of Faraday's law. There are in a solution of an electrolyte as many ions charged with positive electricity as with negative electricity and thus the electrical neutrality of the solution is preserved.

Viewing things, then, in the light of the theory of Arrhenius, we have, for example, in a solution of sodium chloride sodium ions and chlorine ions, besides a certain number of undissociated sodium chloride molecules. Experiments on the electrical conductivity show that in this case dissociation is practically complete when one gram-molecule (*i. e.*, $23+35.5=58.5$ grams) of the salt is dissolved in 1000 liters of water. There are at this dilution then in solution not NaCl molecules, but Na ions and Cl ions. These are usually written $Na^-$ and $Cl^+$.

[5] Zeitschr. f. physik. Chem. 1:631. 1887.

[6] Because this dissociation takes place only in case of electrolysis it is termed electrolytic dissociation.

[7] A term that dates back to Faraday.

It has often been asked in what way Na ions and Cl ions differ from ordinary sodium in the metallic state and ordinary chlorine gas respectively. The difference lies in the energy possessed by the substances in the ordinary state and in the ionic state. Ten grams of chlorine ions, for example, contain less energy than do ten grams of chlorine. Supply the energy to the ions, as is done in the case of electrolysis, and the ions are changed to ordinary chlorine gas. The lack of understanding of this point at first caused much reluctance to accept the theory of electrolytic dissociation (or the theory of free ions as it is also called), notably on the part of English chemists.

Since Arrhenius published his theory of electrolytic dissociation, all investigations made on salt solutions have confirmed it. In addition to the lowering of the freezing point and the electrical conductivity, the elevation of the boiling point, the specific volume, and the optical and thermal properties of solutions of electrolytes, all strongly support the views of Arrhenius. This theory in the hands of Nernst[8] has yielded a clearer understanding of the processes that take place in voltaic combinations and has made it possible to calculate with accuracy in advance what the electro-motive force of a galvanic chain will be. It has enabled Ostwald[9] to place analytical chemistry upon a firmer scientific basis. In short, all the physical and chemical properties of aqueous solutions of electrolytes are well explained by the assumption that in these solutions the dissolved substances are split up into part-molecules or ions, and that the various properties that the solutions possess are due to the properties of the ions.

The more dilute the solution of an electrolyte is, the greater is the percentage of the dissolved substance that is dissociated, and only at infinite dilution is this dissociation complete. In the case of many substances, however, namely strong acids and bases as well as salts of these, dissociation goes on very rapidly

[8] See Nernst, Theoretische Chemie 563–569, where other references will also be found.

[9] Die wissenschaftlichen Grundlagen der analytischen Chemie, Leipzig, 1894.

as dilution increases, so that, as was pointed out above in the case of sodium chloride, dissociation is practically complete when an equivalent in grams is dissolved in 1000 liters of water.

Hydrochloric acid dissociates into H ions and Cl ions. A dilute solution of sodium chloride and one of hydrochloric acid both contain Cl ions. Their difference, then, is due to the fact that the former solution contains H ions, whereas the latter contains Na ions. To this difference are to be ascribed all the differences of properties that the two solutions possess. Solutions of all acids contain H ions, solutions of all chlorides contain Cl ions, those of sulphates $SO_4$ ions, those of nitrates $NO_3$ ions. Salts of copper in solution yield Cu ions, those of lead Pb ions, etc. In general, if BA represent the formula of a salt, B representing the basic radical and A the acid radical, then in dilute aqueous solutions this compound is to a greater or less extent dissociated into the ions $B^+$ and $A^-$, and, as stated, all the physical and chemical properties that such a solution possesses are due to the properties of the ions together with the properties of the undissociated molecules present.

THE PHYSIOLOGICAL ACTION OF DILUTE SOLUTIONS.

It has always been taken as axiomatic that the physiological action of any substance is due to its chemical character. *Now if, in the case of the solutions in question, all the chemical and physical properties are due to the properties of the ions plus those of the undissociated molecules it contains, it seems very probable that the physiological effect produced by such solutions is also due to these.* This thought, simple as it is, has to our knowledge never before been expressed.

Many investigations on the physiological action of aqueous solutions of salts on bacteria and higher forms of plant life as well as on animals have been made. The strengths of the solutions with which these experiments were performed have always been expressed in per cent. by weight; thus chemically equivalent quantities (*i. e.* molecular quantities) of the different substances were not compared, and it is probably for this reason that general considerations have entirely escaped observation.

If a very dilute solution of sodium chloride differs from a dilute solution of hydrochloric acid only in that the former contains Na ions and the latter H ions, then the poisonous action of the latter is plainly due to the H ions present. In like manner comparing a very dilute solution of sodium nitrate with a similar solution of nitric acid, the poisonous nature of the latter would be due to the H ions present. In general, if the solution is sufficiently dilute so that the acid is completely dissociated and the acid radical is of such a nature that at this concentration its ions have practically no poisonous action, the toxic value of the acid solution is due only to the H ions present. Now strong acids are highly dissociated in aqueous solutions, thus rendering these relatively rich in H ions. Weaker acids are not as strongly dissociated, their solutions contain less H ions, and are consequently less active. It must be borne in mind that the salt remaining undissociated is present in the solution as well as the ions. That these undissociated remainders and the anions of the acid radical also exert an effect is not to be denied, but in many cases, such as that of the Cl ions in hydrochloric acid solutions, the action is practically *nil* at the strength at which hydrochloric acid is still effective, since a solution of common salt containing as many Cl ions as the hydrochloric acid solution in question is ineffective. The same reasoning may be applied to nitrate of sodium and nitric acid, also to sodium hydroxide and common salt. In the latter case the solutions differ from each other in that the former contains OH ions, whereas the latter contains Cl ions. All solutions of bases (lyes) contain OH ions and their toxic action is due to these alone, provided that the metal or radical forming the cathion is itself harmless at the concentration used. Thus it is evident that H ions and OH ions have toxic properties. That it is the ionic condition which brings this about is shown by the fact that in the case of water where we have these constituents in practically an undissociated state, there is no toxic action.

The poisonous property of a very dilute solution is then due to the ions it contains, and if at the particular concentration in hand only one physiologically active ion is present the effectiveness of the solution is to be attributed to that one ion. Solutions of hydrochloric, nitric and sulphuric acids are nearly completely dissociated when an equivalent in grams is dissolved in 1000 liters of water. Hence such or more dilute solutions of these acids, when chemically equivalent quantities are dissolved, ought to have the same toxic effect, the Cl, $NO_3$ and $SO_4$ ions at such dilution being harmless. That these radicals are harmless is shown by the fact that like concentrations of the sodium salts of these acids are harmless.

## EXPERIMENTAL METHODS.

We have tested this point experimentally for the higher plants by ascertaining the strength of solution in which roots of the ordinary field lupine will just live. We have found that the limit for these acids is reached in case of a solution containing one equivalent in grams in 6400 liters of water. We may say, then, that one gram of hydrogen ions distributed through 6400 liters of water will give a solution in which roots of the lupine will just survive. It is entirely immaterial at this dilution whether we take hydrochloric, nitric or sulphuric acids; the toxic action of the solutions is the same, provided they contain the same amount of hydrogen ions. The molecular weight in grams, or simply one gram-molecule of acid sulphate of potassium in 6400 liters, would contain as much ionic hydrogen as a gram-molecule of hydrochloric acid, and should therefore have the same toxic effect. This has been confirmed by experiment.

It seemed best to confine our first investigations to one order of plants, and, by reason of the nature of the question under consideration, to operate with objects which by previous physiological study have become in a degree well known to botanists. It is for this reason that the seedlings of *Lupinus albus* L. were selected. This seedling is remarkable for its straight, clean radicle, the ease with which uniform specimens can be obtained, and for its great sensitiveness to solutions.[10] The seeds were germinated in the usual manner. After being swelled in water they were placed in moist, loose cotton batting and set in the dark until the radicles had reached a length of from $2^{cm}$ to $4^{cm}$, when they were ready for use.

Experiments were made with solutions contained in glass beakers of convenient size that were, of course, cleaned with the utmost care each time they were used. To support the seedling in proper position the following arrangement was used. Through a large cork fitting loosely over the beaker was thrust a glass rod which played rather tightly through it. Another and smaller piece of cork (small enough to allow ample room about it in the beaker) was likewise tightly pushed on the rod. To the circumference of this inner cork the seedlings were secured by means of glass pins, and by sliding the cork support up or down on the rod they were set into the solution at the desired depth. The large cork, by closing loosely the mouth of the beaker, allowed sufficient change of air within, at the same time preventing undue evaporation from the solution.

Since in the experiments the prime thing sought was the degree of concentration at which each solution just allowed the radicles to live, it became important to avail ourselves of all the means which would aid in deciding whether a radicle was living or dead. As Askenasy[11] has pointed out, almost the only reliable indication concerning the condition of a plant is its growth rate. Accordingly access was had to the well known method of Sachs.[12] A fine mark of India ink was made $15^{mm}$ from the tip of the root, a distance safely including the entire growing zone of the radicle. Thus marked, the roots were placed in the solutions, set in the dark, and again observed after a period of from fifteen to twenty-four hours. In order to deter-

[10] True, On the influence of sudden changes of turgor and of temperature on growth. Ann. of Bot. 9:372. 1895.

[11] Askenasy, Ueber einige Beziehungen zwischen Wachsthum und Temperatur. Ber. d. deutsch. bot. Gesellsch. 8:75. 1890.

[12] Sachs, Ueber das Wachsthum der Haupt- und Nebenwurzeln. Arb. d. bot. Institut Würzburg 1 : —. 1873, and Gesammelte Abhandlungen über Pflanzen-physiologie. 2:778. 1893.

mine the condition of the roots, the general appearance and the growth made after the beginning of the experiment were taken into account. If a much too concentrated solution was used a plainly abnormal aspect was usually found. In the acid solutions the satiny luster of the normal surface was lost and a dead-white color was observed, suggesting a condition perhaps best described by the word *coagulated*. Although difficult to describe, this condition is quickly detected by the observer, and is undubitable evidence of death. An instructive discussion of this and other *post mortem* symptoms has recently been presented by Paul Klemm.[13] The radicles killed in colored solutions, as salts of copper, iron, cobalt, etc., took on more or less decidedly the color of the medium. Some radicles after death assumed an unusual transparent appearance. This was the case with those in potassium hydroxide, and in mercuric cyanide, potassium ferro and ferricyanide, hydrocyanic acid and potassium cyanide.

Another evidence that death has taken place is seen in the flabby condition following the loss of turgor pressure. This, in the extremely dilute solutions here used, could in no case be due to the osmotic properties of the solutions, and it would be still more improbable that, after fifteen to twenty-four hours in the medium, the flabby appearance could be due to this cause. Turgor accommodation in a normal root, when placed in a solution osmotically equivalent to those here used, would take place very soon,[14] and living roots would be turgid.

Another indication of the condition of the radicles was sought in the changes in length occurring after the beginning of the experiment. In strongly toxic concentrations where death occurred very quickly, the accompanying loss of turgor left the roots shorter than at the beginning of the experiment. As the solutions were increasingly dilute but still, within the time limit of our experiments, fatal, various amounts of growth were found

[13] Paul Klemm, Desorganizationserscheinungen der Zelle. Jahrb. f. wiss. Bot. **28**: 30. 1896.

[14] True, *ibid.* 382.

to have taken place before death, sometimes nearly equaling the normal under the prevailing conditions of temperature, etc. It was thus possible from the *ante mortem* growth in a series of solutions to locate roughly the concentration limit sought.

When neither aspect nor growth rate gave plain evidence, the radicles were measured and returned to the solutions to be again observed. If between the last observation and the first, no elongation had occurred, it was inferred that the roots were dead at the time of the former inspection.

Since, as the concentration decreases, an increasingly long exposure is necessary to work fatally, it was decided to choose a period of exposure to the solutions within which the action of the same should be judged. This period was from fifteen to twenty-four hours following the introduction of the roots into the solution. Although the time limit may seem rather broad, it must be borne in mind that solutions were always diluted by one-half, and therefore with a strong time limit, we should still be far from any absolute concentration limit.[15] Individual differences in the seedlings frequently show themselves, one radicle at times being killed, another beside it surviving. In such cases, the first surviving individual indicated the concentration sought.

Usually two seedlings were placed in each concentration tested, but sometimes only one was used. When grounds for doubting the accuracy of results were present, experiments in question were repeated.

It is not to be inferred that the limits here obtained represent the greatest strength of the given substances that these radicles can endure, since a gradual increase of concentration allows a very considerable accommodation on the part of the plant to be made, and the consequent toleration of solutions that would upon immediate use have proved fatal. This was shown in several experiments in which dead roots were left for a time in the solutions. Laterals pushed out above the dead region and grew in the solutions without serious harm.

[15] P. Klemm, *ibid.*, 33 (for acids).

TABULATED DATA.

The detailed results of the most essential experiments are presented in the appended tables. At the top of each table is given its number, the substance used, and, in the second line, the date at which the radicles were set into the solutions, and the date at which the results were observed. The distance at which the mark previously mentioned was placed from the root tip was always $15^{mm}$. In the first column appear the concentrations used expressed in gram-molecules or gram-equivalents per liter of the solution. The column headed "length" shows the distance between the line and the root tip, giving, therefore, after subtracting $15^{mm}$, the growth made during the period indicated. If further observations and measurements were made, the dates and lengths are placed in adjacent columns. Under "remarks" are verbal indications on the condition of the radicles. Death or survival indicates the condition at the time given in column two. The number of horizontal readings under each concentration shows the number of roots employed and their individual records. For a large majority of the substances, there appears in the table the record of the last plainly fatal dilution and of all weaker solutions as far as tested. Thus the concentration limit in most cases is the second concentration in the table.

It will be noted in the concentrations not fatal, that, in general, the amount of growth increases as the concentration decreases. Since, in these experiments, external conditions were not particularly controlled, the value of the growth rates must not be overestimated and are significant only in features recurring with regularity.

Tables 1 to 5 show that the seedlings just survive in a solution that contains $\frac{1}{6400}$ gram of hydrogen ions per liter. It is evident from what has been stated before that the anions have no toxic action at this dilution, and that the poisonous action of the solutions is solely due to the hydrogen ions present, inasmuch as these various acids affect the seedlings alike.

## 1. Hydrochloric acid ($HCl$).

(Begun January 9, 8 P.M.; closed January 10, 3 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | $17.8^{mm}$ | flabby, dead |
| . . . | 19.0 " | " " |
| $\frac{1}{6400}$ | 29.0 " | appearance normal |
| . . . | 18.5 " | tip dead |

## 2. Hydrobromic acid ($HBr$).

(Begun January 11, 6 P.M.; closed January 12, 10 A.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | $18.5^{mm}$ | flabby, dead |
| . . . | 18.0 " | " " |
| $\frac{1}{6400}$ | 27.5 " | apparently normal |
| . . . | 23.5 " | flabby, dead |
| $\frac{1}{12800}$ | 28.5 " | apparently normal |
| . . . . | 31.5 " | " " |

## 3. Nitric acid ($HNO_3$).

(Begun January 11, 5 P.M.; closed January 12, 10 A.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | $17.5^{mm}$ | flabby, dead |
| . . . | 17.0 " | " " |
| $\frac{1}{6400}$ | 28.0 " | apparently normal |
| . . . | 25.0 " | " " |
| $\frac{1}{12800}$ | 30.5 " | " " |
| . . . . | 34.0 " | " " |

## 4. Sulfuric acid ($H_2SO_4$).

(Begun January 9, 9 P.M.; closed January 10, 4 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | $19.0^{mm}$ | flabby, dead |
| . . . | 17.5 " | " " |
| $\frac{1}{6400}$ | 23.0 " | " " |
| . . . | 27.5 " | apparently normal |
| $\frac{1}{12800}$ | 28.0 " | " " |
| . . . . | 27.0 " | " " |

### 5. Acid-potassium sulfate ($KHSO_4$).

(Begun January 10, 6 P.M.; closed January 11, 1 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 15.5mm | flabby, dead |
| $\frac{1}{6400}$ | 30.5 " | apparently normal |
| . . . | 32.0 " | " " |
| $\frac{1}{12800}$ | 24.0 " | " " |

### 6. Hydrochloric acid. March 7, 10 A.M.

(Concentration : $\frac{1}{3200}$ gm. mol. per liter.)

| No. | March 7, 2 P.M. 20° C. | | March 7, 8 P.M. 19° C. | |
|---|---|---|---|---|
| 1 | 18.0mm | 3.0mm | 17.6mm | flabby |
| 2 | 18.5 " | 3.5 " | 19.0 " | " |
| 3 | 18.5 " | 3.5 " | 18.5 " | " |
| 4 | 19.5 " | 4.5 " | 19.5 " | " |
| | Av. growth per hr. 0.91mm | | All dead. | |

### 7. Hydrochloric acid. March 7, 10 A.M.

(Concentration : $\frac{1}{6400}$ gm. mol. per liter.)

| No. | March 7, 2 P.M. 20° C. | | March 7, 8 P.M. 19° C. | | March 8, 11.30 A.M. 25° C. | |
|---|---|---|---|---|---|---|
| 1 | 19.5mm | 4.5mm | 23.0mm | 3.5mm | 34.0mm | 11.0mm |
| 2 | 18.5 " | 3.5 " | 20.5 " | 2.0 " | 22.5 " | 2.5 " |
| 3 | 19.5 " | 4.5 " | 22.0 " | 2.5 " | 28.0 " | 6.0 " |
| 4 | 19.0 " | 4.0 " | 22.5 " | 3.5 " | 34.0 " | 11.5 " |
| | Av. growth per hr. 1.03mm | | Av. growth per hr. 0.5mm | | Av. growth per hr. 0.2mm | |

It will be noticed, on inspecting tables 1 to 5, that in the lowest fatal dilution, a growth prior to death of from 5mm to 10mm usually occurred. This raised the question whether, in case of the acids the hydrogen ions might not act catalytically and hasten the chemical processes of the cells and possibly also the growth of the radicle. Experiments with hydrochloric acid have thus far yielded entirely negative results. Tables 6 to 11 give the record of these experiments, but more work along this line is needed. The first column simply numbers the experiment; the remainder give the results at the times and temperatures named.

### 8. Distilled water (Control). March 7, 10 A.M.

| March 7, 2 P.M. 20° C. | | March 7, 8 P.M. 19° C. | | March 8, 11:30 P.M. 25° C. | |
|---|---|---|---|---|---|
| 19.0mm | 4.0mm | 23.0mm | 4.0mm | 31.0mm | 8.0mm |
| 21.5 " | 6.5 " | 26.5 " | 5.0 " | 36.5 " | 10.0 " |
| 21.0 " | 6.0 " | 28.5 " | 7.5 " | 43.0 " | 14.5 " |
| 21.0 " | 6.0 " | 26.0 " | 5.0 " | 36.0 " | 10.0 " |
| Av. growth per hr. 1.5mm | | Av. growth per hr. 0.87mm | | Av. growth per hr. 0.69mm | |

### 9. Distilled water (Control). March 14, 11 A.M.

| March 14, 3 P.M. 20° C. | | March 15, 10 A.M. 22° C. | | March 16, 9:30 A.M. 25° C. | | March 17, 11 A.M. 23° C. | | March 19, 3 P.M. 20° C. | |
|---|---|---|---|---|---|---|---|---|---|
| 18.5mm | 3.5mm | 34.5mm | 16.0mm | 52.0mm | 17.5mm | 66.0mm | 14.0mm | 86.5mm | 20.5mm |
| 17.5 " | 2.5 " | 34.0 " | 16.5 " | 54.5 " | 20.5 " | 71.0 " | 16.5 " | 96.0 " | 25.0 " |
| 18.5 " | 3.5 " | 36.0 " | 17.5 " | 56.0 " | 20.0 " | 76.5 " | 20.5 " | 104.0 " | 27.5 " |
| 18.5 " | 3.5 " | 28.0 " | 9.5 " | 45.0 " | 17.0 " | 59.0 " | 14.0 " | 87.0 " | 28.0 " |
| Av. growth per hr. 0.81mm | | Av. growth per hr. 0.8mm | | Av. growth per hr. 0.83mm | | Av. growth per hr. 0.63mm | | Av. growth per hr. 0.57mm | |

### 10. Hydrochloric acid. March 14, 11 A.M.

(Concentration: $\frac{1}{12800}$ gm. mol. per liter.)

| March 14, 3 P.M. 20° C. | | March 15, 10 A.M. 22° C. | | March 16, 9:30 A.M. 25° C. | | March 17, 11 A.M. 23° C. | | March 19, 3 P.M. 20° C. | |
|---|---|---|---|---|---|---|---|---|---|
| 17.0mm | 2.0mm | 26.0mm | 9.0mm | 43.5mm | 17.5mm | 65.0mm | 21.5mm | 87.5mm | 22.5mm |
| 18.0 " | 3.0 " | 30.0 " | 12.0 " | 45.0 " | 15.0 " | 60.0 " | 15.0 " | 77.5 " | 17.5 " |
| 18.5 " | 3.5 " | 30.0 " | 11.5 " | 39.5 " | 9.5 " | 52.0 " | 12.5 " | 71.0 " | 19.0 " |
| 19.0 " | 4.0 " | 33.0 " | 14.0 " | 49.0 " | 16.0 " | 69.0 " | 20.0 " | 90.0 " | 21.0 " |
| Av. growth per hr. 0.78mm | | Av. growth per hr. 0.61mm | | Av. growth per hr. 0.64mm | | Av. growth per hr. 0.68mm | | Av. growth per hr. 0.39mm | |

## 11. Hydrochloric acid. March 14, 11 A.M.

(Concentration : $\frac{1}{25600}$ gm. mol. per liter.)

| March 14, 3 P.M. 20° C. | | March 15, 10 A.M. 22° C. | | March 16. 9:30 A.M. 25° C. | | March 17, 11 A.M. 23° C. | | March 19, 3 P.M. 20° C. | |
|---|---|---|---|---|---|---|---|---|---|
| 17.0mm | 2.0mm | 29.0mm | 12.0mm | 41.0mm | 12.0mm | 51.5mm | 10.5mm | 72.0mm | 20.5mm |
| 18.5 " | 3.5 " | 32.0 " | 13.5 " | 50.0 " | 18.0 " | 66.0 " | 16.0 " | 94.5 " | 28.5 " |
| 18.5 " | 3.5 " | 29.0 " | 10.5 " | 39.0 " | 10.0 " | 50.0 " | 11.0 " | 72.0 " | 22.0 " |
| 17.5 " | 2.5 " | 24.0 " | 6.5 " | 31.5 " | 7.5 " | 41.0 " | 9.5 " | 57.0 " | 16.0 " |
| Av. growth per hr. 0.72mm | | Av. growth per hr. 0.56mm | | Av. growth per hr. 0.50mm | | Av. growth per hr. 0.52mm | | Av. growth per hr. 0.35mm | |

## 12. Potassium hydroxide (KOH).

(Begun January 9, 9 P.M., closed January 10, 4 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{200}$ | 16.5mm | rather transparent—alive(?) |
| . . . | 17.5 " | " " " (?) |
| $\frac{1}{400}$ | 27.0 " | apparently normal—alive |
| . . . | 28.0 " | " " " |
| $\frac{1}{800}$ | 36.0 " | " " " |
| $\frac{1}{1600}$ | 32.0 " | " " " |
| $\frac{1}{3200}$ | 42.0 " | " " " |
| $\frac{1}{6400}$ | 37.5 " | " " " |

The above table for potassium hydroxide shows that the seedlings plainly live when the solution contains $\frac{1}{400}$ gm. mol. per liter. The potassium hydroxide used was free from carbon-dioxide at the beginning of the experiment, but of course the solution absorbed the carbon-dioxide given off by the plant as well as some from the air during the progress of the experiment, so that the hydroxyl ion is to be regarded as somewhat more poisonous than the above figures would indicate.

Tables 13 to 15 show that in case of the three copper salts investigated, the strength of the solution in which the seedlings will just survive is $\frac{1}{51200}$ gm. mol. per liter. As these salts can be regarded as practically completely dissociated[16] at this great dilution, and as they act alike, it is evident that this figure gives

[16] Compare the tables of the electrical conductivity of copper salts collected by Ostwald in his Lehrbuch d. allgem. Chem., 2 : 770 [ed. 2]. The electrical conductivity of

the concentration at which the copper ions in the solution are insufficient to kill the beans.

13. COPPER SULFATE ($CuSO_4$).

(Begun February 26, 4 P.M.; closed February 27, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{25600}$ | 16.0$^{mm}$ | discolored, dead |
| . . . . | 16.5 " | " " |
| $\frac{1}{51200}$ | 21.0 " | alive |
| . . . . | 22.0 " | alive (?), tip slightly discolored |
| $\frac{1}{102400}$ | 32.0 " | alive |
| $\frac{1}{204800}$ | 28.0 " | " |

14. COPPER CHLORIDE ($CuCl_2$).

(Begun February 26, 4 P.M.; closed February 27, 1 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{25600}$ | 16.2$^{mm}$ | dead |
| . . . . | 17.0 " | " |
| $\frac{1}{51200}$ | 19.0 " | alive (?), tip slightly darkened |
| . . . . | 18.0 " | alive |
| $\frac{1}{102400}$ | 21.0 " | " |
| $\frac{1}{204800}$ | 26.5 " | " |

15. COPPER ACETATE. $-Cu(C_2H_3O_2)_2$.

(Begun February 26, 5 P.M.; closed February 27, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{25600}$ | 16.0$^{mm}$ | dead |
| . . . . | 16.0 " | " |
| $\frac{1}{51200}$ | 23.0 " | alive |
| . . . . | 22.0 " | " |
| $\frac{1}{102400}$ | 21.0 " | " |
| . . . . | 21.0 " | " |
| $\frac{1}{204800}$ | 28.0 " | " |
| . . . . | 26.0 " | " |

solutions of the compounds used in the above tables 1 to 6, as well as of most of the inorganic substances mentioned in this paper, are also to be found in Ostwald's Lehrbuch, 2:722–772.

### 16. $1CuSO_4 + 1C_{12}H_{22}O_{11} + 3KOH$.

200 cc. $CuSO_4$, $\frac{1}{200}$ gm. mol. per liter; 200 cc. sugar, $\frac{1}{100}$ gm. mol. per liter; 3 cc. normal KOH.

(Begun December 5, 8 P.M.)

| Concentration gm. mol. per liter | Length Dec. 6, 9 A.M. | Length Dec. 9, 9 A.M. | Remarks |
|---|---|---|---|
| $\frac{1}{400}$ | 18.0$^{mm}$ | 22.0$^{mm}$ | living |
| ... | 19.0 " | 21.0 " | " |

(Slight precipitate, probably due to contact with air and $CO_2$ excreted from roots. Concentration given based on $CuSO_4$ content.)

### 17. $1CuSO_4 + 1C_{12}H_{22}O_{11} + Ca(OH)_2$.

200 cc. $CuSO_4$, $\frac{1}{200}$ gm. mol. per liter; 400 cc. sugar, $\frac{1}{100}$ gm. mol. per liter; 106.4 cc. $Ca(OH)_2$ (saturated solution).

(Begun December 5, 8 P.M.)

| Concentration gm. mol. per liter. | Length Dec. 6, 9 A.M. | Length Dec. 9, 9 A.M. | Remarks |
|---|---|---|---|
| 0.00142 | 19.5$^{mm}$ | 46.0$^{mm}$ | alive |
| | 19.5 " | 48.5 " | " |
| | 18.5 " | 46.5 " | " |

(Solution deep blue. A slight precipitate formed on standing. Concentration given based on $CuSO_4$ content.)

It has been shown[17] recently that in Fehling's solution and allied solutions containing copper the copper does not exist as an ion by itself, but as a part of a complex ion formed with the organic substance present. Such complex ions, according to our theory, we should naturally expect to have a quite different toxic action from that shown by copper ions. Experiment has verified this. In tables 16 and 17 are given the results obtained with solutions of the character just mentioned. The composition of the solution is indicated in each table. Cane sugar was used instead of Rochelle salts in order to avoid getting too many salts into the solution. An excess of caustic alkali was also avoided for it would have introduced hydroxyl ions into the solution which are of themselves poisonous. The beans grow in this

[17] Kahlenberg, Zeitschr. f. physik. Chem. **8**: 587, 608–613.

case in solutions that are perfectly blue in color and contain $\frac{1}{400}$ gram atom copper per liter. The enormous contrast that this result presents with that obtained in the experiments in which the copper exists in the solution as ion (tables 14 and 15) is apparent and shows that the copper ion is far more poisonous than the complex ion which contains copper.

### 18. Ferric chloride ($FeCl_3$).

(Begun December 5, 9 P.M.)

| Concentration gm. per liter | Length Dec. 6, 9 A.M. | Length Dec. 9, 9 A.M. | Remarks |
|---|---|---|---|
| Fe, 0.0477; Cl, 0.0906 ........ | 15.0mm | | dead, mahogany red |
| | 15.7 " | | " " " |
| Fe, 0.00500; Cl, 0.00930 ....... | 19.7 " | | turgor gone, dead |
| | 20.5 " | | " " " |
| Fe, 0.00250; Cl, 0.00477 ....... | 21.5 " | 21.0mm | dead |
| | 21.5 " | 21.5 " | " |

(Concentration allowing growth not reached. Probably found at next dilution with half the Fe and Cl content of the last in the table.)

### 19. Dialyzed iron ($FeCl_3$).

(Begun November 21, 5 P.M.)

| Concentration | Length Nov. 22, 9 A.M. | Length Dec. 2, 9 A.M. | Remarks |
|---|---|---|---|
| Fe, 0.009555%; Cl, 0.0093 ..... | 18.5mm | | dead, laterals form in solution |
| | 17.5 " | | " " " " " |
| Fe, 0.00477%; Cl, 0.00047 ...... | 23.5 " | 51.5mm | living, surface reddish |
| | 24.0 " | 62.0 " | " " " |
| | 26.0 " | 51.5 " | " " " |

From table 18, giving the results obtained with ferric chloride, it is evident that ferric ions have a quite strong toxic action. It is known that ferric chloride splits up hydrolytically in dilute solutions, which makes this case somewhat complicated. The main object, however, was to compare the action of the ferric chloride solution with that of a solution of dialyzed iron,[18] which contains no ferric ions inasmuch as potassium ferrocyanide (which is a test for ferric ions) produces no precipitate in the solution. The absence of chlorine ions in the solution is shown by the fact that silver nitrate produces no turbidity in such a solution. The tables show conclusively that ferric ions are much more poisonous than are the complex ions containing ferric iron in the dialyzed iron solution.

### 20. Ferrous sulfate ($FeSO_4$).

(Begun March 7, 12 M.; closed March 8, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{12800}$ | 18.0mm | dead, purplish spotted |
| ..... | 19.0 " | " " " |
| $\frac{1}{25600}$ | 24.0 " | alive, tip somewhat discolored |
| ..... | 22.0 " | dead, discolored |
| $\frac{1}{51200}$ | 34.0 " | alive, root-tip dead |
| ..... | 29.0 " | " " " |

Table 20 shows that for ferrous ions the concentration limit at which the seedlings will just survive is $\frac{1}{51200}$ gram ion per liter. The same limit obtains in case of the nickel and cobalt ions (tables 21 to 24). Two nickel salts and also two cobalt salts were tested in order to show again that it is immaterial at this dilution whether the nitrates or the sulphates are used; in other words, that the toxic action of the solutions is solely due to the ions of the metals present.

### 21. Nickel sulfate ($NiSO_4$).

(Begun March 7, 11 A.M.; closed March 8, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{2560}$ | 19.0mm | dead |
| ... | 22.0 " | " |
| $\frac{1}{51200}$ | 33.5 " | alive |
| ..... | 31.0 " | " |

[18] The solution of dialyzed iron used in the experiments of table 19 was prepared according to the directions given in the British pharmacopœia.

## 22. Nickelous nitrate ($Ni(NO_3)_2$).

(Begun March 20, 4 P.M.)

| Concentration gm. mol. per liter | Length March 21, 10 A.M. | Length March 23, 3 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{25600}$ | 26.0mm | 26.5mm | dead |
| . . . . | 20.0 " | 20.0 " | " |
| $\frac{1}{51200}$ | 28.0 " | 28.0 " | " |
| . . . . | 37.0 " | 45.0 " | " liv. Mar. 21 |

## 23. Cobaltous sulfate ($CoSO_4$).

(Begun March 20, 3 P.M.)

| Concentration gm. mol. per liter | Length March 21, 10 A.M. | Length March 23, 3 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{12800}$ | 20.0mm | 19.0mm | dead |
| . . . . | 22.0 " | 22.0 " | " |
| $\frac{1}{25600}$ | 23.0 " | 27.5 " | " liv. Mar. 21 |
| . . . . | 27.0 " | 33.0 " | " " " " |
| $\frac{1}{51200}$ | 35.0 " | 61.5 " | alive |
| . . . . | 35.0 " | 46.0 " | dead, liv. Mar. 21 |

## 24. Cobaltous nitrate ($Co(NO_3)_2$).

(Begun November 23, 5 P.M.; closed March 24, 3 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{25600}$ | 38.0mm | alive |
| . . . . | 15.5 " | dead |
| $\frac{1}{51200}$ | 40.0 " | alive |
| . . . . | 28.0 " | " |

That cobalt, nickel and iron in the ionic condition thus have the same toxic effect would tend to arouse in the mind of the chemist the question whether this is not connected with the fact that these metals have nearly the same atomic weight. Whether there is a definite relation between the toxic effects of the ions of the metals and the atomic weights of the latter, in other words whether the periodic law finds application here, is a question that can be answered only after more experimental data have been gathered.

## 25. Cadmium nitrate ($Cd(NO_3)_2$).

(Begun March 23, 5 P.M.)

| Concentration gm. mol. per liter | Length March 24, 3 P.M. | Length March 25, 3 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{102400}$ | 20.0$^{mm}$ | 19.5$^{mm}$ | dead |
| . . . . . | 21.0 " | 20.5 " | " |
| $\frac{1}{204800}$ | 29.0 " | | alive |
| . . . . . | 24.0 " | | " |

This table shows that cadmium ions are exceedingly poisonous in character.

## 26. Potassium cyanide ($KCN$).

(Begun February 3, 4 P.M.; closed February 4, 4 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{6400}$ | 17.5$^{mm}$ | alive, near boundary |
| . . . | 18.0 " | " " " |
| $\frac{1}{12800}$ | 20.5 " | " |
| . . . . | 21.0 " | " |
| $\frac{1}{25600}$ | 25.0 " | " |
| . . . . | 18.0 " | " |
| $\frac{1}{51200}$ | 30.0 " | " |
| $\frac{1}{102400}$ | 26.5 " | " |
| $\frac{1}{204800}$ | 33.5 " | " |

## 27. Potassium ferrocyanide ($K_4FeCn_6$).

(Begun December 15, 7 P.M.)

| Concentration gm. mol. per liter | Length Dec. 14, 12 M. | Length Dec. 17, 9 A.M. | Remarks |
|---|---|---|---|
| $\frac{1}{100}$ | 17.0$^{mm}$ | | dead, transp'rent |
| $\frac{1}{200}$ | 17.0 " | 21.5$^{mm}$ | living, appearance normal |
| . . . | 16.0 " | 17.5 " | " " " |
| $\frac{1}{400}$ | 19.5 " | 19.0 " | dead |
| . . . | 17.5 " | 18.0 " | living, ap. nor. |
| $\frac{1}{800}$ | 20.0 " | 21.5 " | " " " |
| . . . | 20.5 " | 23.5 " | " " " |
| $\frac{1}{1600}$ | 24.5 " | 30.0 " | " " " |
| . . . . | 24.5 " | 33.5 " | " " " |

28. POTASSIUM FERRICYANIDE ($K_3FeCn_6$).

(Begun December 13, 8 P.M.)

| Concentration gm. mol. per liter | Length Dec. 14, 1 P.M. | Length Dec. 17, 10 A.M. | Remarks |
|---|---|---|---|
| $\frac{1}{200}$ | 18.5mm | 18.5mm | alive, boundary |
| . . . | 19.0 " | 19.0 " | " " |
| $\frac{1}{400}$ | 20.5 " | 26.0 " | " " |
| . . . | 20.0 " | 20.0 " | " " |
| $\frac{1}{800}$ | 27.5 " | 41.0 " | " " |
| . . . | 25.0 " | 37.0 " | " " |
| $\frac{1}{1600}$ | 27.5 " | 52.0 " | " " |
| . . . . | 25.5 " | 45.0 " | " " |

Table 26 gives the concentration of cyanogen ions that the lupines can bear; it is about the same as that for hydrogen ions. In potassium ferrocyanide and potassium ferricyanide the iron and the cyanogen radical form complex ions[19] which, as tables 27 and 28 show, have the same toxic effect. This is much less, however, than in the case where iron exists in the solution as an ion by itself or where cyanogen ions as such are present in the solution.

Experiments were also performed with a solution of mercuric chloride. The detailed results of these have unfortunately been mislaid, but the concentration of this solution that the lupines can bear was found to be $\frac{1}{12800}$ gm. equivalent per liter. Mercuric chloride is a compound that is but slightly dissociated at concentrations at which it is ordinarily used in laboratories; at the above mentioned concentration, however, the dissociation must have advanced to a considerable degree.

From a solution of mercuric chloride mercuric oxide can be precipitated by means of potassium hydroxide. If, however, a considerable amount of dextrine be first added to the mercuric chloride solution caustic alkali no longer precipitates mercuric oxide. The solution remains clear, which shows that mercuric ions no longer are present and that the mercury has united with the dextrine to form a complex ion. The latter ions are not as poisonous as mercuric ions, as is apparent from table 29.

[19] These ions are $Fe''\,CN_6$ and $Fe'''\,CN_6$ respectively.

### 29. MERCURIC CHLORIDE + DEXTRINE + CAUSTIC POTASH.

The detailed record having been mislaid, the end results are here given.
(Concentrations calculated on the mercuric chloride.)

| Concentration gm. mol. per liter | Result |
|---|---|
| $\frac{1}{200}$ | died |
| $\frac{1}{400}$ | " |
| $\frac{1}{800}$ | " |
| $\frac{1}{1600}$ | " |
| $\frac{1}{3200}$ | " |
| $\frac{1}{6400}$ | lived |
| $\frac{1}{12800}$ | " |

### 30. MERCURIC CYANIDE ($HgCN_2$).

(Begun February 25, 5 P.M.; closed February 26, 3 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{25600}$ | 24.0mm | transparent in growing parts, dead |
| . . . . . | 28.5 " | " " " " |
| $\frac{1}{51200}$ | 28.5 " | dead |
| . . . . . | 30.0 " | " |
| $\frac{1}{102400}$ | 45.0 " | alive |
| $\frac{1}{104800}$ | 44.0 " | " |
| $\frac{1}{409600}$ | 45.0 " | " |
| $\frac{1}{819200}$ | 44.0 " | " |
| . . . . . . | 46.0 " | " |

Mercuric cyanide solutions possess no measurable electrical conductivity. This compound is then practically not dissociated in its solutions. Its toxic effect is consequently due to the undissociated salt ($HgCN_2$) in the solution. The fact that the roots can bear only $\frac{1}{102400}$ gm. mol. per liter of this substance speaks for its pronounced poisonous character.

In tables 31 and 32 are the results obtained with solutions of silver nitrate and silver sulfate respectively. That these solutions behave alike toward the lupines is again evidence that it is only the silver ions they contain that are active. Their extremely poisonous character will be noted. They are the most poisonous ions that we have investigated.

## 31. Silver nitrate ($AgNO_3$).

(Begun February 3, 6 P.M.; closed February 4, 10 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{204800}$ | 17.5mm | dead |
| $\frac{1}{409600}$ | 20.0 " | alive (?) |
| $\frac{1}{819200}$ | 22.0 " | alive |
| . . . . | 17.0 " | " |
| $\frac{1}{1638400}$ | 22.0 " | " |

## 32. Silver sulfate ($Ag_2SO_4$).

(Begun March 23, 5 P.M.)

| Concentration gm.equiv.per liter | Length March 24, 3 P.M. | Length March 25, 3 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{204800}$ | 21.0mm | | discolored, dead |
| . . . . | 16.0 " | | " " |
| $\frac{1}{409600}$ | 23.0 " | 22.0mm | dead |
| . . . . | 25.0 " | 26.0 " | " (?) |
| $\frac{1}{819200}$ | 25.0 " | | alive, distorted |
| . . . . | 29.0 " | | " " |

## 33. Silver nitrate ($AgNO_3$) $\frac{1}{10}$ gm. mol. per liter, 10cc.
## Potassium cyanide ($KCN$) $\frac{1}{10}$ " " " " 30cc.

(Concentrations estimated on basis of Ag present.)

(Begun April 14, 4 P.M.)

| Concentration gm. mol. per liter | Length April 15, 4 P.M. | Length April 17, 4 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{6400}$ | 22.0mm | 22.0mm | dead, discolored |
| . . . . | 21.0 " | 22.0 " | " " |
| $\frac{1}{12800}$ | 22.0 " | 23.0 " | " " |
| . . . . | 21.0 " | 22.0 " | " " |
| $\frac{1}{25600}$ | 20.0 " | 20.0 " | " " |
| . . . . | 24.0 " | 26.5 " | alive April 15 |
| $\frac{1}{51200}$ | 25.0 " | 27.0 " | " " |
| . . . . | 26.0 " | 31.0 " | " " |
| $\frac{1}{102400}$ | 26.5 " | 33.5 " | living |
| . . . . | 29.5 " | 39.0 " | " |
| $\frac{1}{204800}$ | 32.0 " | 41.5 " | " |
| . . . . | 31.0 " | 51.5 " | " |
| $\frac{1}{409600}$ | 35.0 " | 61.0 " | " |

34. SILVER NITRATE ($AgNO_3$) $\frac{1}{10}$ gm. mol. per liter, 10cc.
POTASSIUM CYANIDE ($KCN$) $\frac{1}{10}$ " " " " 27.5cc.

(Concentrations based on Ag present.)

(Begun April 14, 5 P.M.)

| Concentration gm. mol. per liter | Length April 15, 4 P.M. | Length April 17, 4 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{12800}$ | 21.0$^{mm}$ | 21.0$^{mm}$ | dead |
| .... | 20.0 " | 20.0 " | " |
| $\frac{1}{25600}$ | 20.0 " | 21.5 " | " alive Apr. 15 |
| .... | 24.0 " | 26.0 " | " " " |
| $\frac{1}{51200}$ | 22.5 " | 25.0 " | living |
| .... | 24.5 " | 26.0 " | " |
| $\frac{1}{102400}$ | 24.0 " | 36.5 " | " |
| .... | 23.5 " | 27.0 " | " |
| $\frac{1}{204800}$ | 31.0 " | 46.0 " | " |
| .... | 31.0 " | 30.0 " | dead |
| $\frac{1}{409600}$ | 31.0 " | 55.0 " | living |

When silver nitrate in solution is treated with potassium cyanide solution, a precipitate of silver cyanide is formed, which upon further addition of potassium cyanide redissolves. The solution of silver cyanide in cyanide of potassium is due to the formation of potassium silver cyanide, $KAgCN_2$, which in aqueous solutions dissociates into the ions $K^+$ and $AgCN_2^-$. The latter are very stable, and we should naturally expect from the theory that they have a different toxic action from the Ag ions. This is confirmed by experiment. The results are given in tables 33 and 34 which show that the ions $AgCN_2^-$ are far less poisonous than silver ions.[20]

A few other inorganic acids will now be considered, the action of which is not quite as readily explained as that of the acids mentioned in tables 1 to 4. Hydrocyanic acid is practically not dissociated in aqueous solutions, for its electrical conductivity is almost *nil*. The toxic action of this acid must be due, then, to the undissociated HCN present in the solution. Table 35 shows that the lupines will bear $\frac{1}{12800}$ gm. mol. per liter of this acid.

[20] Compare iron and the potassium ferro- and ferricyanides as given above.

Although phosphoric acid is a tribasic acid, the electrical conductivity of its solution shows that it splits up chiefly into the ions $H^+$ and $H_2Po_4^-$,[21] and consequently we should expect a solution containing phosphoric acid (made up molecularly) to show the same concentration at which the plants will grow in it as a solution of hydrochloric acid for instance, for the content of hydrogen ions is the same in both cases. Experiment verifies this as table 35 shows.

[21] See Ostwald's Lehrbuch, *loc. cit.*

### 35. Hydrocyanic acid (HCN).

(Begun March 2, 4 P.M.)

| Concentration gm. mol. per liter | Length March 3, 5 P.M. | Length March 4, 3 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{6400}$ | 17.0mm | | dead |
| .... | 16.5 " | | " |
| $\frac{1}{12800}$ | 17.0 " | 17.0mm | " |
| .... | 21.5 " | 25.5 " | alive |
| $\frac{1}{25600}$ | 21.5 " | | " |
| .... | 21.0 " | | " |
| $\frac{1}{51200}$ | 23.5 " | | " |
| .... | 39.5 " | | " |

### 36. Phosphoric acid ($H_3PO_4$).

(Begun January 31, 4 P.M.; closed February 1, 1 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 17.0mm | flabby, dead |
| .... | 19.5 " | " " |
| $\frac{1}{6400}$ | 33.5 " | apparently normal |
| ... | 28.5 " | " " |
| $\frac{1}{12800}$ | 27.0 " | " " |
| .... | 21.0 " | " " |

Table 36 shows the toxic effect of a solution of chromic acid. This is a weak acid and is probably not completely dissociated at the concentration at which the roots survive in it. Whether the ion $^-Cr_2O_7^-$ is harmless at this concentration can of course only be settled by testing a solution of potassium bichromate or sodium bichromate, in which cases the salts are to a high degree dissociated. The cathions are harmless, and consequently the concentration limit for the ion $Cr_2O_7$ can be found.

### 37. Chromic acid ($H_2Cr_2O_7$).[22]

(Begun February 1, 5 P.M.)

| Concentration gm. mol. per liter | Length February 2, 3 P.M. | Length February 3, 11 A.M. | Remarks |
|---|---|---|---|
| $\frac{1}{3200}$ | 17.0mm | | dead |
| .... | 17.5 " | | " |
| $\frac{1}{6400}$ | 22.0 " | 27.0mm | alive |
| .... | 28.0 " | 34.5 " | " |
| $\frac{1}{12800}$ | 25.0 " | | " |
| .... | 18.0 " | | " |

### 38. Boric acid.

(Begun February 3, 1 P.M.; closed February 4, 10 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{2}{25}$ | 18.0mm | dead |
| .. | 16.0 " | " |
| $\frac{1}{25}$ | 16.5 " | " |
| .. | 18.0 " | alive (?) |
| $\frac{1}{50}$ | 17.5 " | living (?) |
| .. | 21.5 " | " |
| $\frac{1}{100}$ | 28.5 " | apparently normal |
| ... | 28.0 " | " " |
| $\frac{1}{200}$ | 39.0 " | " " |
| ... | 35.0 " | " " |
| $\frac{1}{400}$ | 32.0 " | " " |
| $\frac{1}{800}$ | 29.5 " | " " |
| ... | 41.5 " | " " |
| $\frac{1}{1600}$ | 29.5 " | " " |
| .... | 22.5 " | " " |
| $\frac{1}{3200}$ | 28.0 " | " " |
| .... | 35.0 " | " " |
| $\frac{1}{6400}$ | 30.5 " | " " |
| .... | 39.5 " | " " |

Boric acid solutions are poor conductors of electricity. The acid is then but very slightly dissociated. Experiments on this acid seemed desirable since it is used so much as an antiseptic.

[22] See Ostwald, Zeitschr. f. physik. Chem. **2**: 78.

## 39. MANNITE.

(Begun February 3, 1 P.M.; closed February 4, 10 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{2}{25}$ | 26.5mm | alive |
| .. | 34.5 " | " |
| $\frac{1}{25}$ | 32.5 " | " |
| .. | 31.5 " | " |
| $\frac{1}{50}$ | 27.0 " | " |
| $\frac{1}{100}$ | 26.0 " | " |
| $\frac{1}{200}$ | 44.0 " | " |
| $\frac{1}{400}$ | 37.0 " | " |

## 40. BORO-MANNITIC ACID.

(Begun February 3, 1 P.M.; closed February 4, 10 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{25}$ | 15.5mm | dead |
| .. | 16.5 " | " |
| $\frac{1}{50}$ | 18.5 " | " (?) |
| .. | 18.0 " | " (?) |
| $\frac{1}{100}$ | 22.0 " | alive |
| $\frac{1}{200}$ | 32.0 " | " |
| $\frac{1}{400}$ | 34.0 " | " |
| $\frac{1}{800}$ | 35.0 " | " |
| $\frac{1}{1600}$ | 34.0 " | " |

## 41. BORIC ACID AND CANE SUGAR.

(Begun February 3, 5 P.M.; closed February 4, 10 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{25}$ | 16.5mm | alive ? |
| .. | 17.0 " | " ! |
| $\frac{1}{50}$ | 19.0 " | " ! |
| .. | 19.0 " | " ! |
| $\frac{1}{100}$ | 22.5 " | " |
| ... | 20.0 " | " |

Table 38 shows the results that were obtained. From these the weak action of the acid is apparent. Mannite has no toxic action on the seedlings, as is shown by table 39; however, it is well known that when boric acid and mannite solutions are mixed the resulting solution has an acid reaction caused by the presence of hydrogen ions that have resulted from the electrolytic dissociation of a complex boro-mannitic acid that has been formed in the solution. We should, therefore, expect such a solution of boric acid mannite, containing more hydrogen ions than a solution which contains the same amount of boric acid but without the mannite, to have a greater toxic effect than the latter. Table 40 shows results that confirm this. Cane sugar and boric acid do not form a complex acid with each other, consequently no increase of concentration of hydrogen ions is caused by mixing them, and of course we should expect the mixture to have the same toxic action as an equivalent solution of boric acid without addition of cane sugar. A comparison of tables 38 and 41 shows that this is in accord with experimental facts.

In his extensive work on the affinity of constants of organic acids, Ostwald[23] determined the electrical conductivity of a large number of acids, thus giving us a knowledge of the degree to which these acids are dissociated in their solutions. The most dilute solutions with which he worked contained 1 gm equivalent in 1024 liters. Only a relatively small number of the acids he investigated are highly dissociated at this concentration. In investigating the toxic effect of organic acids upon the lupines, it was found that the concentrations in which the plants would just survive are less than 1 gm. equivalent in 1024 liters, so that it is impossible from Ostwald's determinations to tell to what degree the acids are dissociated at these higher dilutions. In only a few of the cases investigated can the acid be considered as practically completely dissociated, as was done in case of the strong mineral acids, so that the effect of the undissociated acid present cannot be left out of account. This anion, too, in many cases no doubt exerts a distinct poisonous action of its own.

Typical acids from the fatty series and from the aromatic series were investigated. The results are given in the tables that follow.

[23] Zeitschr. f. physik. Chem. 3:170, 241, 369.

## 42. Formic acid.

(Begun January 11, 8 P.M.; closed January 12, 11 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | $21.5^{mm}$ | flabby, dead |
| . . . | 19.0 " | " " |
| $\frac{1}{6400}$ | 28.0 " | apparently normal |
| . . . . | 27.5 " | " " |
| $\frac{1}{12800}$ | 34.0 " | " " |
| . . . . . | 26.0 " | " " |

## 43. Acetic acid.*

(Begun January 11, 9 P.M.; closed January 12, 11 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | $18.5^{mm}$ | dead |
| . . . | 18.6 " | " |
| $\frac{1}{1600}$ | 25.0 " | alive |
| $\frac{1}{3200}$ | 31.5 " | " |
| $\frac{1}{6400}$ | 30.5 " | " |
| $\frac{1}{12800}$ | 30.0 " | " |

## 44. Propionic acid.†

(Begun January 11, 10 P.M.; closed January 12, 11 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | $18.5^{mm}$ | dead |
| $\frac{1}{3200}$ | 28.5 " | alive |
| $\frac{1}{6400}$ | 28.0 " | " |
| $\frac{1}{12800}$ | 34.0 " | " |

## 45. Butyric acid.

(Begun January 14, 10 P.M.)

| Concentration gm. mol. per liter | Length Jan'y 15, 10 A.M. | Length Jan'y 15, 6 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{800}$ | $18.0^{mm}$ | $18.0^{mm}$ | dead |
| . . . | 18.0 " | | |
| $\frac{1}{1600}$ | 18.5 " | 18.5 " | dead |
| . . . | 18.5 " | 18.5 " | " |
| $\frac{1}{3200}$ | 20.0 " | 23.0 " | alive |

* Repeated with same boundary.

† Repeated with same result.

### 46. Valerianic acid.

(Begun January 15, 4 P.M.; closed January 16, 3 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | 19.0mm | dead |
| . . . | 16.0 " | " |
| $\frac{1}{3200}$ | 28.0 " | alive |
| . . . | 28.5 " | " |

From table 42 it appears that the lupines survive in a solution of formic acid containing $\frac{1}{6400}$ gm. mol. per liter, the same concentration as in the case of the strong mineral acids. According to Ostwald's determination, formic acid is dissociated to the extent of 35.85 per cent. when one gm. mol. is present in 1024 liters. At 6400 it would be much more highly dissociated. From the result it would appear that dissociation is nearly complete at this high dilution, for the critical concentration is that obtained in case of the strong mineral acids. Whether this is true or not can be better decided after the effect of sodium formate on the seedlings has been studied. Table 43 shows that the radicles can bear much more acetic acid than formic. Acetic acid is not as strongly dissociated. Propionic, butyric and valerianic acids (tables 44 to 46) show the same critical concentration, $\frac{1}{3200}$ gm. mol. per liter. Ostwald's measurements show that these acids at 1024 are dissociated to approximately the same degree; and, as they are closely allied chemically, one would expect them to have the same effect on the roots. The content of hydrogen ions of the solutions is nearly the same, and the undissociated parts together with the anions would have about the same effect. Acetic acid is a little more strongly dissociated than the last named acids; the fact that nevertheless the seedlings will bear a greater concentration shows that it is not merely the contact of hydrogen ions that comes into consideration here, but that the action of the undissociated acid and the anions makes itself felt.

Glycollic acid is somewhat more strongly dissociated than lactic acid, so a greater toxic effect would be expected from the former than from the latter considering only the concentration of the hydrogen ions. A comparison of tables 47 and 48 shows that glycollic acid does have a greater poisonous action.

### 47. GLYCOLLIC ACID.

(Begun January 28, 5 P.M.; closed January 29, 9 A.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 19.0mm | dead |
| . . . | 19.5 " | " |
| $\frac{1}{6400}$ | 22.0 " | alive |
| . . . | 27.5 " | " |

### 48. LACTIC ACID.

(Begun January 28, 6 P.M.)

| Concentration gm. mol. per liter | Length Jan'y 29, 9 A.M. | Length Jan'y 31, 4 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{1600}$ | 18.0mm | | flabby, dead |
| . . . | 17.0 " | | " " |
| $\frac{1}{3200}$ | 21.0 " | | " " |
| . . . | 22.5 " | 35.0mm | alive |
| $\frac{1}{6400}$ | 26.5 " | | " |
| . . . | 22.5 " | | " |
| $\frac{1}{12800}$ | 29.0 " | | " |

The results obtained from the three chlor-acetic acids are given in tables 49 to 51. At the concentration in which the lupines survive these acids are all practically completely dissociated. The mono- and di-chlor-acetic acids yield the critical concentration for hydrogen ions, namely, $\frac{1}{6400}$ gm. mol. per liter. Tri-chlor-acetic acid as well as mono-brom-acetic acid still kill the seedlings at this concentration. This fact shows that at least in the latter cases the anions have a distinct toxic effect of their own, which can of course be determined by investigation of the sodium salts of the acids in question. That amido-propionic acid (table 53) has no poisonous action at the concentration tested is easily explained by the fact that the acid forms an inner salt and so does not yield hydrogen ions when dissolved in water.

### 49. Mono-chlor-acetic acid.

(Begun January 20, 8 P.M.; closed January 21, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 17.0$^{mm}$ | flabby, dead |
| . . . | 18.0 " | " " |
| $\frac{1}{6400}$ | 25.5 " | apparently normal |
| . . . | 26.0 " | " " |
| $\frac{1}{12800}$ | 22.0 " | " " |
| . . . . | 24.5 " | " " |

### 50. Di-chlor-acetic acid.

(Begun January 20, 9 P.M.; closed January 21, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 17.0$^{mm}$ | flabby, dead |
| . . . . | 16.0 " | " " |
| $\frac{1}{6400}$ | 22.0 " | dead (?) |
| . . . . | 22.0 " | alive ! |
| $\frac{1}{12800}$ | 24.0 " | apparently normal |
| . . . . . | 25.0 " | " " |

### 51. Tri-chlor-acetic acid.

(Begun January 20, 9 P.M.; closed January 21, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{6400}$ | 18.5$^{mm}$ | turgor gone, dead |
| . . . . | 19.0 " | " " " |
| $\frac{1}{12800}$ | 23.5 " | apparently normal |
| . . . . . | 27.5 " | " " |

### 52. Mono-brom-acetic acid.

(Begun January 20, 10 P.M.; closed January 21, 12:30 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{6400}$ | 20.5$^{mm}$ | turgor gone, dead |
| . . . . | 24.5 " | " " " |
| $\frac{1}{12800}$ | 28.5 " | turgid, living |
| . . . . . | 24.0 " | " " |

### 53. Amido-propionic acid.

(Begun January 24, 8 P.M.; closed January 25, 3 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{400}$ | 30.0mm | alive |
| $\frac{1}{800}$ | 36.0 " | " |
| $\frac{1}{1600}$ | 33.0 " | " |
| .... | 25.0 " | " |

Eight dibasic acids of the fatty series were investigated. The results are given in tables 54 to 62. In the case of oxalic acid it will be noted that the concentration in which the seedlings survive is $\frac{1}{6400}$ gram equivalent per liter, the same, then, as in case of the strong mineral acids. Oxalic acid at this concentration is practically completely dissociated. Its toxic effect in this weak solution is due only to the hydrogen ions that the solution contains, for a gram-molecule of acid potassium oxalate has the same poisonous effect as half a gram-molecule of the acid (compare table 55).

### 54. Oxalic acid.

(Begun January 14, 10 P.M.)

| Concentration gm. equiv. per liter | Length Jan. 15, 10 A.M. | Length Jan. 15, 6 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{3200}$ | 19.0mm | 19.0mm | dead |
| $\frac{1}{6400}$ | 24.0 " | 27.0 " | alive |
| $\frac{1}{12800}$ | 25.5 " | 30.0 " | " |

### 55. Acid potassium oxalate.

(Begun January 16, 5 P.M.; closed January 16, 6 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | 17.0mm | flabby, dead |
| ... | 18.0 " | " " |
| $\frac{1}{3200}$ | 21.0 " | apparently alive (?) |
| ... | 21.0 " | dead |
| $\frac{1}{6400}$ | 33.5 " | apparently normal |
| ... | 26.5 " | " " |

## 56. Malonic acid.

(Begun January 15, 6 : 30 P.M.; closed January 16, 3 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | 18.0$^{mm}$ | flabby, dead |
| $\frac{1}{3200}$ | 32.0 " | apparently normal |
| $\frac{1}{6400}$ | 29.0 " | " " |

## 57. Succinnic acid.

(Begun January 15, 4 P.M.; closed January 16, 3 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{800}$ | 17.5$^{mm}$ | flabby, dead |
| . . . | 16.0 " | " " |
| $\frac{1}{1600}$ | 25.0 " | alive |
| . . . | 16.5 " | flabby, dead |
| $\frac{1}{3200}$ | 27.0 " | alive |
| . . . | 33.5 " | " |

## 58. Fumaric acid.

(Begun January 15, 5 P.M.; closed January 16, 3 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 20.5$^{mm}$ | dead |
| $\frac{1}{6400}$ | 19.5 " | apparently living |
| . . . | 28.0 " | apparently normal |

## 59. Maleic acid.

(Begun January 15, 6 P.M.; closed January 16, 3 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | 18.0$^{mm}$ | dead |
| . . . | 20.5 " | " |
| $\frac{1}{3200}$ | 29.0 " | living |
| . . . | 23.5 " | " |
| $\frac{1}{6400}$ | 29.0 " | apparently normal |
| . . . | line gone | " " |

Malonic acid (table 56) is dissociated to the extent of 82.3 per cent. when one gram equivalent is dissolved in 1024 liters, so that at the concentration one gram equivalent in 3200 (the concentration in which the lupines live) the acid is highly dissociated though probably not completely.

Succinnic acid is a much weaker acid. It is dissociated only 30.82 per cent. when one gram equivalent is contained in 1024 liters (Ostwald). Table 56 shows that some of the seedlings survive when one gram equivalent of the acid is contained in 1600 liters.

Fumaric acid (table 58) allows the beans to survive when one gram equivalent is contained in 6400 liters, whereas maleic acid (table 59) permits them to live when one gram equivalent is present in 3200 liters. As maleic acid at the dilution 1024 is dissociated[24] 98.2 per cent. and fumaric only 78.5 per cent., we should expect the latter to be less poisonous than the former, if the toxic action be due to the hydrogen ions alone. That the opposite apparently takes place seems to show that the anions of fumaric acid exert a toxic action at this high state of dilution. Whether this is true or not can only be definitely settled by investigating the action of a salt of the acid the cathion of which has no toxic effect. We do not place much reliance on the results obtained from these two acids as it is questionable whether the substances were perfectly pure.

### 60. MALIC ACID.

(Begun January 28, 6 P.M.; closed January 29, 9 A.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | 18.5mm | flabby, dead |
| .... | 17.5 " | " " |
| $\frac{1}{3200}$ | 27.5 " | alive |
| .... | 20.5 " | " |
| $\frac{1}{6400}$ | 25.0 " | " |

In a solution of malic acid (table 60) the seedlings survive when one gram equivalent is present in 3200 liters. This is about

[24] See Ostwald, Zeitschr. f. physik. Chem., 3: 380.

what one would expect considering the degree of the dissociation of this acid and the fact that at this concentration the hydrogen ions alone are active.

### 61. Aspartic acid.

(Begun January 24, 9 P.M.; closed January 25, 4 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | $18.5^{mm}$ | dead |
| .... | 16.5 " | " |
| $\frac{1}{6400}$ | 28.0 " | alive |
| .... | 31.0 " | " |
| $\frac{1}{12800}$ | 20.0 " | " |
| .... | 26.0 " | " |

Aspartic acid (table 61) has a strong toxic action, the seedlings only surviving when the solution contains $\frac{1}{6400}$ gram-molecule per liter. The electrical conductivity of this acid is not given in Ostwald's tables. It is not probable that the acid is completely dissociated at this concentration, however. Whether the anion is active toxically can be determined by investigating the action of the sodium salt of the acid.

### 62. Tartaric acid.

(Begun January 15, 5 P.M.; closed January 16, 3 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | $19.0^{mm}$ | dead |
| .... | 20.0 " | " |
| $\frac{1}{6400}$ | 29.0 " | alive |
| .... | 21.0 " | " |

Tartaric acid (table 62) gives the limit $\frac{1}{6400}$ gram equivalent per liter. This acid is a relatively strong acid and is practically completely dissociated at this high dilution. We get only the effect of the hydrogen ions here, for a solution of sodium tartrate of like strength would not kill the seedlings.

Citric acid (table 63) was investigated in this connection. The critical limit, $\frac{1}{3200}$ gram equivalent per liter, found for this acid is what one would have expected it to be from the concentration of the hydrogen ions in this solution.

### 63. Citric acid.

(Begun January 24, 9 P.M.; closed January 25, 4 P.M.)

| Concentration gm. equiv. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | 17.0mm | dead |
| .... | 17.0 " | " |
| $\frac{1}{3200}$ | 20.0 " | living |
| .... | 20.0 " | " |
| $\frac{1}{6400}$ | 27.5 " | " |
| .... | 26.0 " | " |
| $\frac{1}{12800}$ | 28.5 " | " |
| .... | 26.0 " | " |

The poisonous action of eleven acids of the aromatic series has been determined. The acids of this series are of special interest, for the undissociated molecules as well as the anions in nearly all cases possess a distinct toxic action of their own, even at great dilutions.

### 64. Benzoic acid.

(Begun January 14, 8 P.M.)

| Concentration gm. mol. per liter | Length January 15, 9 A.M. | Length January 15, 6 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{3200}$ | 20.0mm | | dead |
| .... | 18.0 " | | " |
| $\frac{1}{6400}$ | 22.5 " | 24.0mm | living |
| .... | 24.0 " | 27.0 " | " |
| $\frac{1}{12800}$ | 26.5 " | 29.0 " | " |
| .... | 23.0 " | 25.0 " | " |

### 65. Hippuric acid.

(Begun January 23, 9 P.M.; closed January 24, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 20.5mm | dead |
| .... | 20.0 " | " |
| $\frac{1}{6400}$ | 26.5 " | alive |
| .... | 24.5 " | " |
| $\frac{1}{12800}$ | 28.5 " | " |

Benzoic and hippuric acids (tables 64 and 65) are both relatively weakly dissociated, the former 21.61 per cent. and the latter 37.51 per cent. at the dilution 1024, according to Ostwald. Both of these acids kill the lupines until the concentration $\frac{1}{6400}$ gm. mol. per liter is reached. It is not probable that these weak acids are completely dissociated even at this great dilution. The result shows that here the toxic effect is due in a high degree to the undissociated molecules and the anions present. Whether the undissociated acid is more poisonous than the anions can be determined by testing the action of the sodium salts.

**66.** CINNAMIC ACID.

(Begun January 23, 9 P.M.; closed January 24, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{800}$ | 15.5^mm | turgor lost, dead |
| . . . | 15.5 " | " " " |
| $\frac{1}{1600}$ | 16.0 " | " " " |
| . . . | 16.5 " | " " " |
| $\frac{1}{3200}$ | 18.0 " | " " " |
| . . . | 17.5 " | " " " |
| $\frac{1}{6400}$ | 23.5 " | " " " |
| . . . | 20.5 " | " " " |
| $\frac{1}{12800}$ | 29.5 " | turgid, apparently normal |
| . . . | 17.5 " | " " " |

Cinnamic acid (table 65) is only dissociated to the extent of 17.34 per cent. at 1024, and yet in a solution of it the lupines will not survive until the acid is diluted so that it contains only $\frac{1}{12800}$ gm. mol. per liter. At this dilution we know that hydrogen ions are no longer harmful to the plants, hence the strong toxic action of this acid is due to the anions and the undissociated molecules present in the solution.

Another interesting group is that of the oxy-benzoic acids. The results obtained from the three monoxy-benzoic acids are given in tables 67 to 69. It will be seen that salicylic acid has the greatest poisonous action, the seedling surviving in a solution that contains 1 gm. mol. in 6400 liters; then follows meta-oxy-benzoic acid, which is only fatal after the concentration 1 gm. mol. in 3200 liters is overstepped; and finally para-oxy-benzoic acid of which the radicles will bear 1 gm. mol. in 1600 liters.

### 67. SALICYLIC ACID.

(Begun January 14, 9 P.M.)

| Concentration gm. mol. per liter | Length Jan. 15, 9 A.M. | Length Jan. 15, 6 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{3200}$ | 16.0mm | | dead |
| .... | 18.5 " | | " |
| $\frac{1}{6400}$ | 24.5 " | 26.0mm | alive |
| .... | 18.5 " | | dead |
| $\frac{1}{12800}$ | 26.0 " | 29.0 " | alive |

### 68. META-OXY-BENZOIC ACID.

(Begun January 23, 8 P.M.)

| Concentration gm. mol. per liter | Length Jan. 24, 12 M. | Length Jan. 25, 3 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{1600}$ | 19.5mm | | flabby, dead |
| .... | 18.0 " | | " " |
| $\frac{1}{3200}$ | 23.5 " | 28.0mm | living |
| .... | 23.5 " | 28.5 " | " |
| $\frac{1}{6400}$ | 29.0 " | | apparently n'r'ml |
| .... | 28.0 " | | " " |
| $\frac{1}{12800}$ | 20.5 " | | " " |
| ..... | 24.5 " | | " " |

### 69. PARA-OXY-BENZOIC ACID.

(Begun January 23, 8 P.M.)

| Concentration gm. mol. per liter | Length Jan. 24, 12 M. | Length Jan. 24, 7 P.M. | Remarks |
|---|---|---|---|
| $\frac{1}{1600}$ | 19.0mm | | flabby, dead |
| .... | 25.0 " | 26.0mm | living |
| $\frac{1}{3200}$ | 24.5 " | 26.0 " | " |
| .... | 27.5 " | 29.5 " | " |
| $\frac{1}{6400}$ | 32.5 " | | apparently n'r'ml |
| .... | 32.0 " | | " " |
| $\frac{1}{12800}$ | 25.5 " | | " " |
| ..... | 33.5 " | | " " |

The order of the poisonous action of these acids is, then, ortho, meta and para. This is also the order of their electrolytic dissociation, the degrees of dissociation of the three acids at the dilution 1024 being 62.80 per cent., 25.70 per cent. and 15.68 per cent. respectively, according to Ostwald. Whether the toxic action of these acids at the concentration at which they are fatal to the lupines is due in part to the anions here also calls for an investigation of the sodium salts.

As typical examples of other oxy-benzoic acids protocatechuic and gallic acids were chosen (see tables 70 and 71). The concentration of the former in which the beans survive is $\frac{1}{3200}$ gm. mol. per liter. The degree of dissociation of this acid at 1024 is 16.68 per cent., somewhat higher, then, than para-oxy-benzoic acid. Considering the action of the hydrogen ions alone, we should expect protocatechuic acid to be somewhat more poisonous than para-oxy-benzoic acid. It seems probable, however, that the action of the undissociated molecules and the anions can not be considered *nil* at the concentration 3200.

In the case of gallic acid, which is dissociated 18.72 per cent. at 1024, the seedlings survive only at the concentration 6400 as table 71 shows. Here clearly the anions and the undissociated molecules must have a toxic action of their own even at this high dilution, for the acid can clearly not be considered as completely dissociated.

**70.** PROTOCATECHUIC ACID.

(Begun January 24, 8 P.M.; closed January 25, 3 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | 17.0$^{mm}$ | flabby, dead |
| .... | 17.8 " | " " |
| $\frac{1}{3200}$ | 24.5 " | alive |
| .... | 18.5 " | dead |
| $\frac{1}{6400}$ | 27.0 " | alive |
| .... | 29.0 " | " |
| $\frac{1}{12800}$ | 29.0 " | " |
| ..... | 28.0 " | " |

### 71. GALLIC ACID.

(Begun January 23, 10 P.M.; closed January 24, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{1600}$ | 18.5mm | dead |
| $\frac{1}{3200}$ | 24.0 " | " |
| $\frac{1}{6400}$ | 23.5 " | alive |
| $\frac{1}{12800}$ | 28.0 " | " |

Finally the action of the three mono-nitro-benzoic acids was investigated. Tables 72 to 74 show that the ortho compound is least poisonous, seedlings surviving in the concentration 6400, whereas in both the meta and para compounds the solutions proved fatal until the concentration 12,800 was reached. The degrees of dissociation of these acids at 1024 are 87.9 per cent., 44.4 per cent. and 46.4 per cent. respectively. It is clear that in case of the meta and para acids, the toxic effect at 12,800 can no longer be due to hydrogen ions, and consequently must be ascribed to the undissociated molecules and the anions; as the concentration of the former is not great at this high dilution, it seems probable that the toxic action is mainly due to the anions. An investigation of the sodium salts will, of course, be necessary to decide this point definitely. Ortho-nitro-benzoic acid is practically completely dissociated at 6400. The anions of this acid are therefore less poisonous than hydrogen ions. The action of a solution of the sodium salt will very likely confirm this.

### 72. ORTHO-NITRO-BENZOIC ACID.

(Begun January 16, 5 P.M.; closed January 17, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 19.0mm | flabby, dead |
| .... | 18.5 " | " " |
| $\frac{1}{6400}$ | 36.0 " | apparently normal, living |
| .... | 29.0 " | " " " |

73. META-NITRO-BENZOIC ACID.

(Begun January 16, 3 P.M.; closed January 17, 1 P.M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{6400}$ | 20.5mm | dead |
| .... | 16.0 " | " |
| $\frac{1}{12800}$ | 36.0 " | apparently normal |
| .... | 36.0 " | " " |

74. PARA-NITRO-BENZOIC ACID.

(Begun January 16, 6 P.M.; closed January 17, 12 M.)

| Concentration gm. mol. per liter | Length | Remarks |
|---|---|---|
| $\frac{1}{3200}$ | 17.0mm | flabby, dead |
| .... | 17.0 " | " " |
| $\frac{1}{6400}$ | 21.0 " | dead |
| .... | 19.0 " | " |
| $\frac{1}{12800}$ | 33.0 " | apparently normal |
| .... | 33.0 " | " " |

That the modern theory of solutions would throw light on their physiological action was to be expected. From the foregoing detailed results it is evident that in the case of plants the toxic action of solutions of electrolytes, when dissociation is practically complete, is due to the action of the ions present. When dissociation is not complete, the undissociated part of the electrolytes may also exert a toxic effect, as has been pointed out in several instances. We have here then, as it were, a recognition of the theory of electrolytic dissociation by the organic world.

Mr. F. D. Heald, Fellow in Botany at the University of Wisconsin, has investigated the action on other plants of a considerable number of the solutions which we have tested. The results that he obtained are presented in an accompanying paper. They are perfectly analogous to those that we have found, and hence strongly confirm our conclusions.

It is clear that a knowledge of the mere presence of a metal or other element in a solution does not allow one to draw a conclusion as to its physiological action; it must also be known as to whether that element exists as an ion by itself or is combined with other elements to form a complex ion. If the addition of certain substances to a solution containing a physiologically active ion forms a complex ion of much less powerful action, it follows that these additional ingredients afford a means of reducing, so to speak, the physiological action of the simple ion.

Although this work has thus far been carried out only with higher plants, investigations on bacteria that are being carried on in this connection at the Bacteriological Laboratory of the University of Wisconsin have already yielded results supporting the theory. Anyone inspecting Miquel's table of the efficiency of antiseptics in Sternberg's "Manual of Bacteriology," and at the same time bearing in mind the theory of Arrhenius, although the concentrations are given in per cent. instead of chemical equivalents, will be able to see in it, only in rough outline to be sure, the corroboration of the views here advanced. Experiments on animals are contemplated.

It will be seen that a wide field for research along physiological lines opens up by applying to the field of biology the dissociation theory that has proved so fertile in chemistry and physics. Further work in this direction, using the latest and best that the new physical chemistry has to offer, it is to be hoped will place our knowledge of the physiological action of solutions of electrolytes on a better basis than the purely empirical one on which it has thus far rested. It does not seem too much to expect that the effects of such study will soon be felt in agriculture and therapeutics, while bacteriological study pursued from the standpoint of the new theory will yield important additions to our knowledge of antiseptics.

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# ON THE TOXIC EFFECT OF DILUTE SOLUTIONS OF ACIDS AND SALTS UPON PLANTS.

F. D. HEALD.

(WITH PLATE VII)

## I. INTRODUCTION.

The desire for a deeper and clearer insight into the subject of nutrition of plants has led many botanical investigators to endeavor to determine the poisonous or nutritive qualities of a large number of compounds. Within the last decade a considerable number of papers have appeared dealing with the toxic effect of compounds which are generally classed as non-nutritive. The majority of these older experiments have been along the same line, and so far as known the compounds have been prepared by making solutions of a certain per cent. by weight. During the last year Kahlenberg and True[1] have carried out numerous experiments with very many inorganic and organic acids and various salts in which a different method was employed. In these experiments the solutions were prepared according to gram equivalents, and the results obtained are extremely interesting both from the chemical and the biological point of view. All of the experiments alluded to were carried out with a single plant, *Lupinus albus*.

It is important to know whether these results can be confirmed by the use of other plants, which might be expected to differ in their reactions; and to this end, at the suggestion of Dr. Kahlenberg, the present investigation has been made.

Before taking up the results in detail it may be well to present a few general considerations in regard to plant, or rather protoplasmic, poisons. Compounds which have a toxic effect upon animals are generally poisonous to plants, although we find different degrees of sensibility to the same compound in

[1] BOT. GAZ. 22 : 81. 1896.

both plants and animals. The toxic effect of a substance is evidently due to one of two things. In plant tissue the effect upon the *turgescence* of the cell must play an important part,[2] since when the turgor-pressure is suddenly and decidedly decreased, the growth is either retarded or inhibited. An inhibition or a retardation of growth must then be regarded as a symptom of poisoning. In comparison with turgescence the *direct effect* upon the protoplasm is by far the more important, since in simple turgor experiments the retardation of growth is due to the irritation of the protoplasm as well as to the turgor-change. Now, since the irritability of the protoplasm of different plants differs widely, we may reasonably expect quite a wide range in the amount of different compounds which various plants will withstand.

Why and how certain substances have a toxic effect, and certain others a nutritive value, is not known. For example, it is at present impossible to say why it is that potassium sulfate has a nutritive value while copper sulfate produces a toxic effect. Those substances which are poisonous to plants are generally such substances as are not accessible to plants in their normal habitats, at least to any extent, while those substances which are generally present in the soil have no injurious effect, or at least not in the same degree of concentration at which we find them in the soil. If the poisonous action of various substances is a mere matter of adaptation and adjustment, as seems to me highly probable, then we might expect that by adding gradually more and more copper sulfate to the soil in which a plant is growing it would come in the course of time to adapt itself to quite a large amount of this salt, which is normally extremely poisonous to the majority of plants. So far as known no experiments of exactly this nature have been carried out, and an experimental test of this would be highly interesting.

## 2. Method.

In the experiments performed, three different plants were used: *Pisum sativum*, *Zea Mais*, and *Cucurbita Pepo*. I describe

[2] Annals of Botany 9: 385. 1895.

first the method of germination. The peas were placed in a beaker, covered with distilled water and allowed to soak for twenty-four hours; they were then placed in a Petri-dish between moistened sheets of filter paper and allowed to remain until the radicles just burst through the seed coats. In all the experiments it was important that the seedlings should have straight roots, since it was necessary to measure the roots at intervals to determine the growth. If the peas were allowed to remain between sheets of moistened filter paper the roots grew crooked and twisted and could not be used, so it became necessary to resort to other methods of growing them.

Two different methods were used, both of which were quite satisfactory.

1. A thin sheet of cork was perforated by means of a cork-borer with a series of holes as shown in the diagram (*fig. 1*), the large opening being just small enough to keep the pea from slipping through. This cork was then floated in a deep Petri-dish of distilled water, and as soon as the radicle had burst through the seed coats the peas were transferred to the cork. The peas were so placed that the radicle was directed toward the small opening of the cork, and the whole was covered with a sheet of filter paper which hung down into the water and thus kept the peas moist (*fig. 2*). The peas were then allowed to grow until they were of sufficient size for use in the experiments. In cases where germination was slow it was found necessary to change the distilled water several times before the seedlings were of sufficient size for use. In the majority of seedlings the roots grew quite straight.

2. Another method, quite similar to the above, was also used. Two sheets of cork were taken; one was provided with openings somewhat larger than the pea; the other sheet of cork was provided with smaller openings which would register as shown in diagram when the two corks were placed one above the other (*fig. 3*). The two sheets of cork were then wired together and the small openings were provided with glass tubes about $5^{cm}$ long. The whole was placed in a deep dish and the peas were

placed in the openings in such a manner that the roots grew down the glass tubes (*fig. 4*). By this method it was impossible for the roots to grow crooked.

The seedlings of *Zea Mais* and *Cucurbita Pepo* were grown in a different way since germination took place more readily, and there was not so great a tendency to grow crooked roots. The seeds were soaked in distilled water for twenty-four hours, and then placed carefully between sheets of moistened filter paper. Care was taken to place the seeds in a flat position and in most cases the roots were straight, so that the extra work of a transfer was avoided. In all cases the seedlings were allowed to grow until the roots had attained a length of about twenty millimeters. For the acids, *normal* stock solutions[3] were used, that is, solutions of the mono-basic acids like HCl would contain one gram-molecule of HCl per liter, while the di-basic acid like $H_2SO_4$ would contain one-half gram-molecule of $H_2SO_4$ per liter, so that in each case the normal solution would contain one gram of H per liter. For the stock solutions of the various salts, either solutions containing a gram-molecule per liter were used or solutions containing a certain fraction of a gram-molecule. For the seedlings of *Pisum sativum* the experiments were carried out in the following manner: The solutions in which the seedlings were to be grown were placed in small beakers of about 300$^{cc}$ capacity. A cork of sufficient size to close the opening of the beaker was provided with a glass rod which extended down into the solution. On the end of the glass rod was a smaller cork, and the seedlings were supported on this cork by means of glass pins. The cork was then set at such a level that the cotyledons of the seedlings were just above the surface of the solution. This will also be made plain by the appended diagram (*fig. 5*).

For the seedlings of *Zea Mais* and *Cucurbita Pepo* a more convenient method was found. A small piece of sheet cork of sufficient size to float in the beaker was provided with two openings and the seedlings were placed in these so that the roots

[3] Special thanks are due to Dr. Kahlenberg for the majority of the stock-solutions, and also to Mr. Schlundt for several salt-solutions.

were immersed in the solution, and the beaker covered by a cork to prevent evaporation (*fig. 6*).

In all of the experiments performed two seedlings were used. Before placing them in the solutions they were allowed to grow until the roots had reached a length of about $20^{mm}$, and then a distance of $15^{mm}$ was marked off from the tip of each root by means of a fine brush and India ink. The time was then recorded, and at twenty-four hours from that time, the seedlings were removed from the solutions and measured again and the growth recorded. The roots were also carefully examined for any other symptoms of poisoning besides the retardation or inhibition of growth. They were then replaced in the solutions and allowed to stand for another twenty-four hours when measurements were again made. In all cases the seedlings were grown in a dark chamber with nearly a uniform temperature (21°–23° C.) The lengths given in the tables are the average growth per twenty-four hours.

The mixture of the solutions for the growth of seedlings was made as follows:

$$10^{cc} \text{ of nor. sol. to } 1000^{cc} = \tfrac{N}{100}$$
$$25^{cc} \text{ of } \tfrac{N}{100} \text{ to } 200^{cc} = \tfrac{N}{800}$$
$$100^{cc} \text{ of } \tfrac{N}{800} \text{ to } 200^{cc} = \tfrac{N}{1600}$$
$$100^{cc} \text{ of } \tfrac{N}{1600} \text{ to } 200^{cc} = \tfrac{N}{3200} \text{ etc.}$$

### 3. H-ACIDS.

Two seedlings of *Pisum sativum* were placed in each of the solutions of the strengths shown in the table and the growth recorded for forty-eight hours.

| Acids. | | $\frac{N}{1600}$ | $\frac{N}{3200}$ | $\frac{N}{6400}$ | $\frac{N}{12800}$ |
|---|---|---|---|---|---|
| HCl | 1st 24 hours... | ...... | ...... | $3.25^{mm}$ | $4.75^{mm}$ |
| | 2d 24 hours... | ...... | ...... | ...... | 7.5 " |
| $H_2SO_4$ | 1st 24 hours... | ...... | ...... | 3.5 " | 12.5 " |
| | 2d 24 hours... | ...... | ...... | ...... | 5.25 " |
| $HNO_3$ | 1st 24 hours... | ...... | ...... | ...... | 6.5 " |
| | 2d 24 hours... | ...... | ...... | ...... | 7. " |
| HBr | 1st 24 hours... | ...... | ...... | ...... | 5.5 " |
| | 2d 24 hours... | ...... | ...... | ...... | 6.25 " |

In the $\frac{N}{1600}$ and $\frac{N}{3200}$ solutions no growth whatever occurred, and at the end of the first twenty-four hours the tips of the roots were very soft and flabby and were considered as dead. In the $\frac{N}{6400}$ solution a growth occurred in the HCl and $H_2SO_4$ solutions for the first twenty-four hours, but the second twenty-four hours showed no additional growth, while the roots were very soft and flabby. In the $HNO_3$ and HBr no growth whatever took place in the $\frac{N}{6400}$ solution. In the $\frac{N}{12800}$ solution the seedlings grew for the entire forty-eight hours and at the end of that time the roots were very rigid and did not show any symptoms of poisoning.

It is worthy of note here that in case of the seedlings in the $\frac{N}{6400}$ solution a large number of lateral roots were formed before the root was killed. The delicate cells of the root tip were the first to be affected by the poison, and thus having its main growing point destroyed the plant was stimulated to the production of lateral roots in its struggle to withstand the effects of the poison. Another point which cannot be overlooked is the fact that in the $\frac{N}{1600}$ solution of HCl the roots of the seedlings were covered with a dense growth of fungus at the end of the experiment. The species of the fungus was not determined. So far as known from experiments it is true that fungi generally are able to withstand stronger solutions of poison than green plants. *Penicillium*, for example, will grow in a comparatively strong solution of $CuSO_4$. A solution of $\frac{N}{100}$ acetic acid, after standing for some time in the laboratory, was found to be filled with a dense growth of fungus, the species of which was not determined.

Two seedlings of *Zea Mais* were placed in each of the solutions recorded in the following table, and the growth recorded at periods of twenty-four hours.

From the degree of concentration at which the seedlings of *Pisum sativum* were killed it was thought that the solutions $\frac{N}{3200}$, $\frac{N}{6400}$, and $\frac{N}{12800}$ ought to show the strength of solution which these seedlings would withstand, and so at first only solutions of that strength were used. In all of these, however, the growth was considerable for the first twenty-four hours, with generally an increase in the amount of growth for the next twenty-four hours. A glance at the following table will also show that the growth in the $\frac{N}{3200}$ and $\frac{N}{6400}$ solutions was somewhat less than in the $\frac{N}{12800}$ solution, so that even if the growth was not inhibited in the former a very perceptible retardation of the growth occurred. Since growth was not entirely inhibited in the solutions from $\frac{N}{3200}$ upward, seedlings were placed in two stronger solutions, $\frac{N}{800}$ and $\frac{N}{1600}$. In the $\frac{N}{800}$ solution no growth whatever occurred, and at the end of the first twenty-four hours the roots were very soft and flabby near the tip. In the $\frac{N}{1600}$ solution, however, the roots showed quite an increase in length for the first twenty-four hours but for the second twenty-four hours showed no increase, so that the $\frac{N}{1600}$ solution is the strength at which the roots were killed.

ZEA MAIS.

| Acids. | | $\frac{N}{800}$ | $\frac{N}{1600}$ | $\frac{N}{3200}$ | $\frac{N}{6400}$ | $\frac{N}{12800}$ |
|---|---|---|---|---|---|---|
| HCl | 1st 24 hours | .. | 3.5 mm | 8.25mm | 11.5 mm | 11.25mm |
| | 2d 24 hours | .. | ..... | 18.25 " | 16 " | 15.25 " |
| $H_2SO_4$ | 1st 24 hours | .. | 2.75 " | 12.5 " | 11.5 " | 17.5 " |
| | 2d 24 hours | .. | ..... | 27.5 " | 14 " | 33 " |
| $HNO_3$ | 1st 24 hours | .. | 4.5 " | 7 " | 14 " | 16.5 " |
| | 2d 24 hours | .. | .5 " | 9 " | 11.5 " | 29 " |
| HBr | 1st 24 hours | .. | 3 " | 7.5 " | 12 " | 15 " |
| | 2d 24 hours | .. | ..... | 8.25 " | 13.75 " | 30.5 " |

A glance at the table for *Pisum sativum* shows a very considerable difference in the amount of the acids which the seedlings could withstand. In the case of *Pisum sativum* the $\frac{N}{6400}$ solution was of sufficient strength to inhibit the growth, while in the case of the *Zea Mais* seedlings it required a $\frac{N}{1600}$ solution, or a solution four times as concentrated. This very great difference in the degree of irritability is the more worthy of note, since the one, *Pisum*, has its reserve food supply stored in the form of carbohydrates, while corn contains quite a large amount of fatty material.

Two seedlings of *Cucurbita Pepo* were placed in each of the solutions of the strength shown in the following table:

CUCURBITA PEPO.

| Acids. | | $\frac{N}{1600}$ | $\frac{N}{3200}$ | $\frac{N}{6400}$ | $\frac{N}{12800}$ |
|---|---|---|---|---|---|
| H Cl | 1st 24 hours... | ...... | ...... | 2.5 mm | 3.75 mm |
| | 2d 24 hours... | ...... | ...... | 3.25 " | 9.25 " |
| $H_2SO_4$ | 1st 24 hours... | ...... | ...... | 9. " | 6. " |
| | 2d 24 hours... | ...... | ...... | 4.75 " | 6.5 " |
| $H NO_3$ | 1st 24 hours... | ...... | ...... | 5.25 " | 3.5 " |
| | 2d 24 hours... | ...... | ...... | 8. " | 4. " |
| H Br | 1st 24 hours... | ...... | ...... | 4.5 " | 5.75 " |
| | 2d 24 hours... | ...... | ...... | 2. " | 1.75 " |

Seedlings were set first in the $\frac{N}{1600}$ and $\frac{N}{3200}$ solutions and after the first twenty-four hours no growth had taken place and the root tips were soft and flabby; they were, however, replaced in the solutions and allowed to stand for another twenty-four hours. At the end of the forty-eight hours no additional growth had occurred. In the $\frac{N}{6400}$ and $\frac{N}{12800}$ solutions the growth was considerable for both the first and second twenty-four hours. Then the strength of solution necessary to inhibit the growth is —$\frac{N}{3200}$, which is less than in the case of *Pisum sativum* seedlings, but more than in the case of *Zea Mais* seedlings.

The relative sensibility to the acid poisons then is as follows:

1. Pisum sativum, seedlings killed by $\frac{N}{6400}$ solution.
2. Zea Mais, seedlings killed by $\frac{N}{1600}$ solution.
3. Cucurbita Pepo, seedlings killed by $\frac{N}{3200}$ solution.

Before discussing the results of the experiments with the acids, a short statement in regard to the so-called theory of *electrolytic dissociation* will be necessary. The theory was published by Arrhenius[4] in 1887 and amounts practically to this: Aqueous solutions of acids, bases, or salts are, to a greater or less extent, broken up or dissociated into part-molecules, the so-called *ions*. It is not necessary to mention here the facts which confirm this theory, but it suffices to say that it now stands on a

[4] Zeitschrift für Physikalische Chemie 1: 631.

comparatively firm experimental basis. The amount of dissociation depends upon the strength of the solution. The more dilute the solution, the more complete is the dissociation, until at infinite dilution the dissociation is complete. When a certain acid, for example HCl, dissociates, the result is H-ions and Cl-ions; the H-ions are charged positively with electricity, while the Cl-ions are charged negatively, there being an equal number of positive and negative ions in order to preserve equilibrium. The manner of dissociation may be expressed by $H^+$ and $Cl^-$. In the case of a salt, as $CuSO_4$, for example, the dissociation will take place as $^+Cu^+$ ions and $^-SO_4^-$ ions, and in a similar manner for other salts, the radicle always being the electro-negative *ion* and the basic element or radicle the electro-positive ion.

A comparison of the results obtained with the acids, with some investigations on the plant cell, is interesting as affording some light upon the nature of the effect produced by the acids. Klemm[5] states that ½ to 1 pro mille $HNO_3$ causes the streaming motion of the protoplasm in the hairs of *Trianea* to cease and also produces a granulation and aggregation of the protoplasm. A 1 promille solution of $HNO_3$ would contain 1 gram of $HNO_3$ to 1000$^{cc}$ of water. The strength of solution which killed the roots of *Pisum sativum* was $\frac{N}{6400}$, which is equivalent to 1 gram of $HNO_3$ to 101,587$^{cc}$ of water. For *Zea Mais* roots the killing point was the $\frac{N}{1600}$ solution, which is equivalent to 1 gram of $HNO_3$ to 25,396$^{cc}$ of water. For the *Cucurbita Pepo* seedlings the roots were killed by the $\frac{N}{3200}$ solution, which is equivalent to 1 gram of $HNO_3$ to 50,793$^{cc}$ of water. From these figures it will be seen that the strength which was required to produce a disorganization of the protoplasm in the *Trianea* hairs was so much greater than that required to kill the roots of the seedlings, that the toxic effect can hardly be due to a visible disorganization of the protoplasm. Klemm also states that the same thing takes place with equally dilute solutions of $H_2SO_4$ and HCl.

[5] Desorganisationserscheinungen der Zelle; Jahrbücher f. wiss. Botanik **28**: 658–964. 1895.

In regard to the relation of these results to the theory of dissociation, Kahlenberg and True[6] have demonstrated quite clearly in their work that it is the $H^+$ ion which produces the toxic effect. HCl will form $H^+$ ions and $Cl^-$ ions; $H_2SO_4$ will dissociate first into $H^+$ and $HSO_4^-$, but the final product will be two $H^+$ ions and $^-SO_4^-$ ions; $HNO_3$ splits to form $H^+$ ions and $NO_3^-$ ions; HBr will dissociate to form $H^+$ ions and $Br^+$ ions. As has been before stated, the more dilute the solution, the more complete the dissociation, but with the dilutions used for the acids, dissociation would be practically complete, so that we need not take into consideration anything but the $H^+$ ions and the electro-negative ions. Take for example NaCl, which will dissociate as $Na^+$ and $Cl^-$ ions. Now NaCl at the dilution at which the HCl was effective is practically without effect; the $Cl^-$ ions must then be considered as non-poisonous in the HCl, since both HCl and NaCl contain $Cl^-$ ions. Now if the $Cl^-$ ions are without any toxic effect at this dilution it is plain that the poisonous effect must be due to the $H^+$ ions.

The $H_2SO_4$ may be considered in the same way. If a plant be subjected to an equally concentrated solution of $K_2SO_4$, which is one of the compounds from which plants quite commonly obtain their potassium, it would be entirely unharmed at that dilution. The $K_2SO_4$ would dissociate to form $K^+$ ions and $SO_4^-$ ions, and since $K_2SO_4$ and $H_2SO_4$ solutions have $SO_4^-$ ions in common it is evident that the $SO_4^-$ ions of the $H_2SO_4$ are non-poisonous. This then leaves only the $H^+$ ions to produce the toxic effect. The non-poisonous character of the $SO_4^-$ ions can be shown by the action of other sulfates, such as $CaSO_4$, $MgSO_4$ and $Na_2SO_4$. Again: sulfur is a constant constituent of proteid substances, and is absorbed by all plants in the form of sulfates, so that plants are constantly subjected to the action of $SO_4^-$ ions. The solutions were so mixed that the $H_2SO_4$ solutions contained the same amount of ionic H as the other acids, that is, a normal solution of $H_2SO_4$ contained only ½

[6] BOT. GAZ. **22**:81. 1896.

gram molecule to the liter. Now the $H_2SO_4$ solution which contains the same amount of ionic H as the other acids kills at the same point of dilution, so that this again points to the toxic effect of the $H^+$ ions.

The action of $HNO_3$ may be discussed in a similar manner. $Ca(NO_3)_2$ is one of the common compounds by which a plant receives calcium and nitrogen and at a dilution relatively the same as that at which the acid killed the seedlings, it is without any harmful effect. It is presented to the plant in the form of $^+Ca^+$ ions and $NO_3^-$ ions. The $HNO_3$ and $Ca(NO_3)_2$ contain $NO_3$ in common and since the $NO^-{}_3$ ions are non-poisonous it leaves the $H^+$ ions again as the agent which produces the toxic effect. A large part of the nitrogen contained in a plant is supplied to it in the form of nitrates, so that here again the plant is constantly subjected to the action of $NO^-{}_3$ ions. The non-poisonous character of the $NO^-{}_3$ ions may be shown by other nitrates as well.

It may seem doubtful at first whether HBr can be considered in the same way as the other acids, but Dirck[7] has found that KBr in dilute solution produces no harmful effect. Now since this would dissociate as $K^+$ ions and $Br^-$ ions, it follows that in dilute solution Br-ions are non-poisonous, and hence play no part in the toxic effect of the HBr, at least not at the dilution at which the HBr killed the roots of seedlings. It will also be seen from the tables that the HBr kills the seedlings at the same degree of concentration as the other acids; now since it has been shown that the toxic effect of HCl, $H_2SO_4$ and $HNO_3$ is due to the $H^-$ ions, we should expect HBr to kill at a different degree of concentration if the Br was poisonous also, for then we should have the sum of the effect of $H^+$ ions and $Br^-$ ions. Here again the entire toxic action is produced by the $H^+$ ions.

It has been clearly shown by the above experiments that in the case of poisoning by acids, the harmful effect is produced entirely by the $H^+$ ions. By putting the results of the experiments in a different form we can get a better idea of the

[7] Bericht d. Verhdlg. d. sächs. Ges. d. Wiss. zu Leipzig **21**: 20. 1869.

extremely small amount of ionic H necessary to kill the roots of seedlings. In the case of the *Pisum sativum* seedlings one part of ionic $H^-$ to 6,400,000 of water was sufficient to kill the roots. The roots of *Cucurbita Pepo* were killed by 1 part of ionic $H^-$ to 3,200,000 parts of water, while the roots of *Zea Mais* were the most resistant, requiring one part of ionic H to 1,600,000 parts of water.

When expressed in the form of per cent. the extremely small amount of acid necessary to kill the *Pisum sativum* seedlings is even more apparent, and may be expressed as follows: HCl, 0.00056%; $H_2SO_4$, 0.00076%; $HNO_3$, 0.00098%; HBr, 0.00126%.

From this it will be seen that the per cent. according to weight gives a different result, showing apparently a difference in the toxic power of the acids, which would be obtained if the theory of dissociation was overlooked.

Before leaving the subject of acids and their toxic effect a few points in connection with the relation of the plant to $CO_2$ are worthy of note. All $CO_2$ which reaches the plant, whether it be the root or the green aerial parts must be brought into solution before it can be absorbed. As soon as $CO_2$ and water come together we no longer have simple $CO_2$ and water but $H_2CO_3$, carbonic acid. Now this carbonic acid in aqueous solution will dissociate to form two $H^+$ ions and $^-CO_2^-$ ions. $CO_2$ has been found to be poisonous to the green parts of plants, and the question which naturally suggests itself is, does the toxic effect depend simply upon the $CO_2$, as has always been stated, or does the ionic H of the carbonic acid bring about the poisoning? In the case of the green parts of a plant the amount of $CO_2$ necessary to produce a toxic effect is quite large, and this may be urged as an objection to the ionic explanation. This can however be easily explained. The $CO_2$ absorbed by a leaf is taken up with some difficulty, the resistance depending upon the structural porosity of the leaf and upon the permeability of the cell walls, so that it takes a very considerable external pressure or a large per cent. of $CO_2$ in the surrounding air to cause the accumulation of $CO_2$ to any amount in the tissue of the plant since it is constantly being removed from the scenes of activity in the photosyntactic processes.

That the ionic explanation is the true one is also strengthened by the experiments of Gigliole,[8] who found that various seeds when subjected to the action of $CO_2$ in their dry condition, retained their vitality as well as in ordinary air, but when the seeds were soaked in water they were killed. This effect seems to me to be due to the H-ions present.

The experiments in regard to the poisonous action of $CO_2$ are somewhat conflicting since Jentys[9] concluded from a series of experiments that beans, lupines, rye, and wheat were not harmed by $CO_2$. These experiments, however, are not conclusive, since the plants were grown in earth in glass pots. The $CO_2$ was introduced by a tube in the floor of the pot, and since the air which was passed in contained only about $\frac{4}{12}$ per cent. $CO_2$ the roots were probably subjected to only a small per cent. of $CO_2$ in the form of carbonic acid. In the experiments which I have performed with the acids the whole plant was not killed but simply the main root, so that if the plants had been growing in the soil they would not have been killed. Fungi are also able to withstand more $CO_2$ than green plants, which has been shown to be the case with other acids. More experiments are necessary to prove conclusively the fact that $CO_2$ poisoning is due to the effect of the ionic $H^-$, and as soon as possible experiments with that view will be carried out.

ACETIC ACID.

| $CH_3$ COOH | | $\frac{N}{400}$ | $\frac{N}{800}$ | $\frac{N}{1600}$ | $\frac{N}{3200}$ | $\frac{N}{6400}$ |
|---|---|---|---|---|---|---|
| P. sativum | 1st 24 hrs | .... | ....... | ..... | $4.75^{mm}$ | $1.25^{mm}$ |
| | 2d 24 hrs | .... | ....... | ..... | 5.25 " | 14.5 " |
| Zea Mais | 1st 24 hrs | .... | $10.25^{mm}$ | $15.5^{mm}$ | 11 " | ...... |
| | 2d 24 hrs | .... | 6.75 " | 10.5 " | 27 " | ....... |

[8] Gazetta chimica italiana 9: 477–478. 1879.

[9] Extrait du Bulletin de l'Académie des Sciences de Cracovie, July 1892.

Some experiments with acetic acid also were performed. In these, only seedlings of *Pisum sativum* and *Zea Mais* were used, and the results at the different dilutions are shown in the preceding table.

From the above table it will be seen that $\frac{N}{1600}$, $\frac{N}{3200}$ and $\frac{N}{6400}$ solutions were used for the seedlings of *P. sativum*. In the $\frac{N}{1600}$ solution no growth whatever occurred and at the end of the first twenty-four hours the root tips were very soft and flabby. In the two remaining solutions considerable growth resulted, but it will be seen from the amount of growth that the $\frac{N}{3200}$ solution produced a marked retardation.

For the *Zea Mais* seedlings much greater concentrations were used to start with, since it had been found in the experiments with other acids that these seedlings were much more resistant. In the $\frac{N}{400}$ solution no growth whatever occurred while in the other dilutions the growth was considerable. The figures here also show that growth was to some extent retarded in the dilutions which were not sufficient to kill the roots.

The dissociation of acetic acid is into $H^+$ ions and $C_2H_3O_2^-$ ions, so that here again we have to deal with $H^+$ ions. In this acid, however, the degree of dissociation is not complete at the dilutions which were used in the experiments. The amount of dissociation in a $\frac{N}{1024}$ solution is only 12.66 per cent. according to Ostwald,[10] and in a $\frac{N}{512}$ solution 9.14 per cent. Then here we have to deal with a certain amount of dissociated acetic acid and a certain amount which remains unchanged, the effect of which cannot be overlooked. Sodium acetate in equally strong solution is non-poisonous and since both sodium acetate and acetic acid contain $C_2H_3O_2^-$ ions in common it follows that the $C_2H_3O_2^-$ ion is non-poisonous, so that the $H^+$ ions and the undissociated acid are left to produce the toxic effect. The part which is played by these two will depend upon the degree of concentration of the solution.

It will be noted that in the case of both seedlings the per cent. necessary to kill the roots is much greater than in the

[10] Zeitschrift für Physikalische Chemie 3 : 174.

experiments upon other acids. This fact is to be explained by the partial dissociation of the acetic acid.

It is also interesting to note that after the killing point has been found for the *Pisum sativum* roots it can be worked out by proportion for the *Zea Mais*. $\frac{N}{6400}$, the killing point in other acids for *Pisum*, is to $\frac{N}{1600}$, the killing point for *Zea Mais* with other acids, as $\frac{N}{1600}$, the killing point of acetic acid for *Pisum sativum*, is to $\frac{N}{x}$, the killing point for *Zea Mais*, that is,

$$6400:1600::1600:x;$$

whence $x = 400$, and a glance at the table will show that the $\frac{N}{400}$ solution was sufficient to kill the roots of *Zea Mais* seedlings.

Klemm[11] has shown that more concentrated solutions of the organic acids are necessary to produce disorganization than of the inorganic acids. This fact then falls in line with the result here obtained for the acetic acid.

### 4. Copper Salts.

For the copper salts stock solutions which contained $\frac{1}{160}$ gram-molecule to the liter were used. Three different copper-salts were used, copper sulfate, copper chloride, and copper acetate, and the dilutions were made as follows:

$10^{cc}$ of $\frac{1}{160}$ to $200^{cc} = \frac{1}{3200}$ mol.
$100^{cc}$ of $\frac{1}{3200}$ to $200^{cc} = \frac{1}{6400}$ mol.
$100^{cc}$ of $\frac{1}{6400}$ to $200^{cc} = \frac{1}{12800}$ mol. *etc.*

PISUM SATIVUM.

| Copper salts. | | $\frac{1}{6400}$ mol. | $\frac{1}{12800}$ mol. | $\frac{1}{25600}$ mol. | $\frac{1}{51200}$ mol. | $\frac{1}{102400}$ mol. |
|---|---|---|---|---|---|---|
| $CuSO_4$ | 1st 24 hours | .... | .... | $0.75^{mm}$ | $2.5^{mm}$ | $14^{mm}$ |
| | 2d 24 hours | .... | .... | ..... | .... . | 13.75 " |
| $CuCl_2$ | 1st 24 hours | .... | .... | 0.75 " | 3.25 " | 15 " |
| | 2d 24 hours | .... | .... | ..... | 3 " | 8.25 " |
| $Cu(C_2H_3O_2)_2$ | 1, 24 h | .... | .... | 0.75 " | 3.5 " | 12.75 " |
| | 2, 24 h | .... | .... | ..... | 3.5 " | 9 " |

Experiments were carried out first with the seedlings of *Pisum sativum*, two seedlings being placed in each of the solu-

11 Jahrbücher f. wiss. Botanik **28**: 658–664.

tions indicated in the preceding table. The amount of growth for periods of twenty-four hours was noted.

In the solutions which contained $\frac{1}{6400}$ and $\frac{1}{12800}$ molecule per liter no growth whatever was observed, and at the end of the experiment the root tips were generally quite soft and flexible and in most cases showed a faint greenish coloration. In the next dilution, $\frac{1}{25600}$ molecule, a very slight growth was observed for the first twenty-four hours but for the second twenty-four hours no growth whatever, and at the end of the experiment these roots were also soft and flexible and colored greenish. In the two next dilutions $\frac{1}{51200}$ molecule and $\frac{1}{102400}$ molecule, the growth was considerable, but it was much greater in the later solution showing that the growth was retarded to a considerable extent by the $\frac{1}{51200}$ molecule solution. In the $\frac{1}{51200}$ molecule, $CuSO_4$ solution no growth resulted for the second twenty-four hours, but this is not strange since in the others the growth was retarded to a considerable extent. Then the $\frac{1}{51200}$ molecule solution may be considered as the strength of the copper salts which will barely permit the roots to live.

A series of experiments similar to the above were also performed with seedlings of *Zea Mais* with the following results:

ZEA MAIS.

| Copper salts. | | $\frac{1}{6400}$ mol. | $\frac{1}{12800}$ mol. | $\frac{1}{25600}$ mol. | $\frac{1}{51200}$ mol. | $\frac{1}{102400}$ mol. |
|---|---|---|---|---|---|---|
| $CuSO_4$ | 1st 24 hours | .... | .... | $1^{mm}$ | $2.5^{mm}$ | $16.5^{mm}$ |
| | 2d 24 hours | .... | .... | ..... | ...... | 7 " |
| $CuCl_2$ | 1st 24 hours | .... | .... | 1 " | 1.25 " | 11.5 " |
| | 2d 25 hours | .... | .... | ..... | ...... | 7.5 " |
| $Cu(C_2H_3O_2)_2$ | 1, 24 h | .... | .... | ..... | 2 " | 14 " |
| | 2, 24 h | .... | .... | ..... | ...... | 13.5 " |

Now since the experiments with the acids showed that the seedlings of *Zea Mais* were able to withstand a greater amount it was thought that they would likewise withstand a greater amount of copper. For this reason only the first three dilutions shown in the above table were used, but it was found that in all except the last no growth resulted, and in the $\frac{1}{25600}$ molecule solution only a very small increase in length was noted in the $CuSO_4$ and $CuCl_2$ and none in the $Cu(C_2H_3O_2)_2$. The roots at the end of the experiment were soft and flexible and showed a greenish color similar to the roots of *Pisum sativum* in the copper solutions. Two higher dilutions were then used; $\frac{1}{51200}$ gram-molecule, and $\frac{1}{102400}$ gram-molecule. In the first of these very slight growth occurred during the first twenty-four hours but no further growth afterwards, while in the $\frac{1}{102400}$ solution the growth was considerable during the entire period of the experiment. The $\frac{1}{102400}$ gram-molecule solution is to be considered as the one which will first allow the seedlings to grow. That the seedlings of *Zea Mais* should be less sensitive to acids and more sensitive to copper salts seems a little strange, but the experiments plainly show that this fact is true.

When $CuSO_4$ exists in dilute solution, it will dissociate to form $^+Cu^+$ ions and $^-SO_4^-$ ions, and at the degree of concentration of the solutions used the dissociation would be practically complete. Hence only copper-ions and $^-SO_4^-$ ions need be taken into consideration. Now it has already been shown in the case of $H_2SO_4$ that the $SO_4^-$ ion is non-poisonous, at least in dilute solutions, so the Cu-ion is left to bring about the toxic action. $CuCl_2$, the second salt used, will dissociate to form $^+Cu^+$ ions and two $Cl^-$ ions, and here also the dissociation will be practically complete in the solutions used, so that in this case we have to deal simply with $^+Cu^+$ ions and $Cl^-$ ions. In the experiments with HCl it has been shown that the Cl ions are without effect, so that here also the toxic action must be due to the Cu ions. The next salt, $Cu(C_2H_3O_2)_2$ will dissociate to form $^+Cu^+$ ions and two $C_2H_3O_2^-$ ions, and here also the dissociation will be practically complete in the solutions used. Here then we have to deal simply with $^+Cu^+$ ions and $C_2H_3O_2$ ions. That the toxic action of this salt is due entirely to the Cu-ions can be clearly shown from the results obtained for the other copper salts. In the $CuSO_4$ and in the $CuCl_2$ the toxic action was due to the Cu alone, the $^-SO_4^-$ ions and the $Cl^-$ ions being without effect. Now in the case of the copper acetate if the $C_2H_3O_2^-$ was poisonous we should expect that the solution would kill the seedlings at a greater dilution, since it would have the combined action of $H^+$ ions and $C_2H_3O_2^-$ ions, but the experiments show the killing point for the acetate to be the same as for the other salts. Hence we must conclude that the $C_2H_3O_2$ ion is without any poisonous effect at this dilution.

Nageli[12] has shown that copper by its mere presence in the water in which plants were growing was able to produce toxic effects, and Löw[13] has also shown that water which was distilled from a copper retort resulted injuriously to plants. True also found that it was impossible to use brass pins to fasten seedlings to a cork while growing in various solutions. That the poisonous effect was due to the Cu and Zn of the pins is shown by the fact that as soon as glass pins were substituted the plants grew without any difficulty. We commonly think of copper as being insoluble but in the cases mentioned above it is very certain that enough Cu-ions were formed in the solutions to produce the toxic action.

A better idea of the extremely small amount of copper necessary to kill the seedlings can be obtained by putting the results in a different form. The seedlings of *Pisum sativum* were killed by the $\frac{1}{25600}$ gram-molecule solution which is the same as one part of copper to 404,423 parts of water. The seedlings of *Zea Mais* were killed by the $\frac{1}{51200}$ gram-molecule solution, which is equivalent to one part of copper to 808,846 parts of water.

Before leaving the copper salts one other fact should be mentioned. At the end of the experiments some of the seedlings were transferred to distilled water to see if the roots would revive, but in no case would the main root grow. The seedling as a whole was not dead, but would continue to grow and produce secondary roots above the part of the root which had been killed,

[12] Denkschr. d. schweizerischen naturf. Ges. **33**: 1. 1893.

[13] Landw. Jahrb. **20**: 235. 1891.

so that when it has been stated that the seedling was killed only the root has been referred to.

## 5. Nickel and Cobalt.

A series of experiments were carried out with two nickel salts, $NiSO_4$ and $Ni(NO_3)_2$ and two cobalt salts, $CoSO_4$ and $Co(NO_3)_2$. The same two seedlings, *Pisum sativum* and *Zea Mais* were used. First as to the results obtained with the seedlings of *Pisum sativum*. Seedlings were placed in the dilutions shown in the following table and the growth recorded for periods of twenty-four hours.

PISUM SATIVUM.

| Nickel and Cobalt. | | $\frac{1}{6400}$ mol. | $\frac{1}{12800}$ mol. | $\frac{1}{25600}$ mol. | $\frac{1}{51200}$ mol. | $\frac{1}{102400}$ mol. |
|---|---|---|---|---|---|---|
| $NiSO_4$ | 1st 24 hours | 1.25mm | 1.5 mm | 1.75mm | 10 mm | 13 mm |
| | 2d 24 hours | . . | . . | . . | 6.5 " | 5 " |
| $Ni(NO_3)_2$ | 1st 24 hours | 1 " | .75 " | 2.25 " | 7 " | 13.25 " |
| | 2d 24 hours | . . | . . | . . | . . | 11.75 " |
| $CoSO_4$ | 1st 24 hours | 1 " | 4 " | 7.5 " | 6.25 " | . . |
| | 2d 24 hours | . . | . . | 3.5 " | 5.75 " | . . |
| $Co(NO_3)_2$ | 1st 24 hours | 1 " | 3 " | 4.25 " | 7.5 " | . . |
| | 2d 24 hours | . . | . . | 1 " | 4.75 " | . . |

First as to the nickel salts. In the $\frac{1}{6400}$, $\frac{1}{12800}$ and $\frac{1}{25600}$ gram-molecule solutions a small amount of growth was observed for the first twenty-four hours but no further growth resulted. In the $\frac{1}{51200}$ and $\frac{1}{102400}$ gram-molecule solutions considerable growth occurred for the entire period, except in the $\frac{1}{51200}$ nickel nitrate, in which solution the normal conditions were not fulfilled, since the plants suffered from a copious growth of bacteria. At the end of the experiment the roots which were killed were not soft and flabby as in the acid or copper poisoning, but were extremely rigid. The roots were so rigid and brittle that if the seedlings were dropped on the table they would snap in pieces almost like so much glass. For the cobalt salts growth was observed in the $\frac{1}{6400}$ and $\frac{1}{12800}$ gram-molecule solutions for the first twenty-four hours, but no growth afterwards, while in the two next weaker solutions growth continued for the entire period. The roots which were killed by the cobalt solutions were also very brittle and rigid, the same as in the nickel solutions.

The results obtained for the seedlings of Zea Mais in the different solutions are given in the following table:

ZEA MAIS.

| Nickel and Cobalt. | $\frac{1}{1600}$ mol. | $\frac{1}{3200}$ mol. | $\frac{1}{6400}$ mol. | $\frac{1}{12800}$ mol. | $\frac{1}{25600}$ mol. | $\frac{1}{51200}$ mol. |
|---|---|---|---|---|---|---|
| $NiSO_4$ 1st 24 hours | .. | .. | 2 mm | 3 mm | 2.5 mm | 11 mm |
| $NiSO_4$ 2d 24 hours | .. | .. | .. | .. | .. | 8 " |
| $Ni(NO_3)_2$ 1st 24 h'rs | .. | .. | .. | 5.5 " | 4 " | 17.5" |
| $Ni(NO_3)_2$ 2d 24 h'rs | .. | .. | .. | .. | .. | 16.5" |
| $CoSO_4$ 1st 24 hours | 2.5 mm | 1 mm | 20.5 " | 27 " | .. | .. |
| $CoSO_4$ 2d 24 hours | .. | .. | 15 " | 18 " | .. | .. |
| $Co(NO_3)_2$ 1st 24 h'rs | 2 " | 3.25" | 22.5 " | 19 " | .. | .. |
| $Co(NO_3)_2$ 2d 24 h'rs | .. | .. | 19 " | 34 " | .. | .. |

The seedlings were set first in $\frac{1}{6400}$, $\frac{1}{12800}$, $\frac{1}{25600}$ and the $\frac{1}{51200}$ gram-molecule solution of $NiSO_4$. The first three showed growth for the first twenty-four hours but none afterwards, while those in the last solution grew for the entire period of the experiment. For the $Ni(NO_3)_2$ only the three solutions shown in the first table were used; in the first two growth occurred during the twenty-four hours, but none afterwards, so that the killing point for the nickel salts may be considered the $\frac{1}{25600}$ gram-molecule solution.

Reasoning from the results found for the *Pisum sativum* seedlings it was thought that the killing point for the cobalt salts might be found by the $\frac{1}{6400}$ and $\frac{1}{12800}$ gram-molecule solutions, but both of these dilutions gave a considerable growth for the entire forty-eight hours. Seedlings were then set in two stronger solutions, $\frac{1}{1600}$ and $\frac{1}{3200}$ gram-molecules. In these the roots grew for the first twenty-four hours, but no further growth had resulted at the second measurement. The killing point for the cobalt salts is thus placed at the $\frac{1}{3200}$ gram-molecule solution.

One point which must be noted in connection with all of the experiments with the nickel and cobalt salts is that in nearly every case a certain amount of growth resulted during the first twenty-four hours of the experiments in which the roots were killed. The nickel and cobalt are quite poisonous, but the toxic effect is not felt by the plant as soon as in the case of acid or copper poisoning. The toxic action of nickel is seen to be greater than cobalt, by the results on both *Pisum sativum* and *Zea Mais*.

In the case of the $NiSO_4$ the dissociation will be into $^+Ni^+$ ions and $^-SO_4^-$ ions. The $CoSO_4$ will form $^+Co^+$ ions and $^-SO_4^-$ ions. At the dilution used for both of these salts the dissociation will be practically complete. It has already been shown that the $SO_4^-$ ion is non-poisonous, so the $^+Ni^+$ ions and the $^+Co^+$ ions are left to bring about the toxic action.

The $Ni(NO_3)_2$ will form in dilute solution $^+Ni^+$ ions and two $NO_3^-$ ions. The $Co(NO_3)_2$ will dissociate to form $^+Co^+$ ions and two $NO_3^-$ ions. Here also the dissociation will be practically complete at the dilutions used, so that we have to deal simply with the resulting ions. The $NO_3^-$ ion has been shown to be non-poisonous, so that in this case also the toxic action must be due to the $^+NO^+$ ions and to the $^+Co^+$ ions.

The small amount of ionic Ni and Co necessary to kill the roots is shown below:

PISUM SATIVUM.

Nickel—$\frac{1}{25600}$ mol. = 1 part Ni to 435,374 $H_2O$.
Cobalt—$\frac{1}{12800}$ mol. = 1 part Co to 217,687 $H_2O$.

ZEA MAIS.

Nickel—$\frac{1}{25600}$ mol. = 1 part Ni to 435,374 $H_2O$.
Cobalt—$\frac{1}{3200}$ mol. = 1 part Co to 54,421 $H_2O$.

Even in the case of the cobalt and *Zea Mais*, which shows the greatest concentration for poisoning, the amount of ionic Co is very small when compared with the amount of $H_2O$.

### 6. Silver Salts.

In testing the toxic action of silver two salts were used, silver sulfate and silver nitrate. For these experiments the same two seedlings were used. The results obtained for the seedlings of *Pisum sativum* are given in the following table:

PISUM SATIVUM.

| Silver Salts. | | $\frac{1}{51200}$ equiv. | $\frac{1}{102400}$ equiv. | $\frac{1}{204800}$ equiv. | $\frac{1}{409600}$ equiv. | $\frac{1}{819200}$ equiv. |
|---|---|---|---|---|---|---|
| $Ag_2SO_4$ | 1st 24 hours | .. | .. | $8.25^{mm}$ | $12.25^{mm}$ | $11.25^{mm}$ |
| | 2d 24 hours | .. | .. | 11.75 " | 8.5 " | 14.25 " |
| $AgNO_3$ | 1st 24 hours | .. | .. | 5.5 " | 7.0 " | 9.5 " |
| | 2d 24 hours | .. | .. | 4.5 " | 7.5 " | 10.5 " |

The solutions here are expressed in equivalents of the toxic ion, since in the $Ag_2SO_4$ if we had the same fraction of a gram-molecule as in $AgNO_3$, the solution would contain twice as many silver ions. The dilutions were made as follows for $Ag_2SO_4$:

$25^{cc}$ of $\frac{1}{100}$ mol. to $400^{cc} = \frac{1}{1600}$ mol.
$25^{cc}$ of $\frac{1}{1600}$ mol. to $400^{cc} = \frac{1}{25600}$ mol. $= \frac{1}{128000}$ equiv.
$100^{cc}$ of $\frac{1}{25600}$ mol. to $400^{cc} = \frac{1}{102400}$ mol. $= \frac{1}{51200}$ equiv.
$100^{cc}$ of $\frac{1}{102400}$ mol. to $200^{cc} = \frac{1}{204800}$ mol. $= \frac{1}{102800}$ equiv., etc.

The dilutions for $AgNO_3$ were made as follows:

$10^{cc}$ of $\frac{1}{2}$ mol. to $1000^{cc} = \frac{1}{200}$ mol.
$25^{cc}$ of $\frac{1}{200}$ mol. to $200^{cc} = \frac{1}{1600}$ mol.
$25^{cc}$ of $\frac{1}{1600}$ mol. to $400^{cc} = \frac{1}{25600}$ mol.
$100^{cc}$ of $\frac{1}{25600}$ mol. to $200^{cc} = \frac{1}{51200}$ mol., etc.

In the first two dilutions no growth whatever occurred for the entire period and at the end of the experiment the roots were quite rigid, but not more so than in the ordinary seedlings grown under normal conditions. In the last three dilutions considerable growth was observed, so that the killing point for the silver salts is placed at $\frac{1}{102400}$ equivalents.

ZEA MAIS.

| Silver Salts. | | $\frac{1}{51200}$ equiv. | $\frac{1}{102400}$ equiv. | $\frac{1}{204800}$ equiv. |
|---|---|---|---|---|
| $Ag_2SO_4$ | 1st 24 hours.. | $1^{mm}$ | $5^{mm}$ | $17^{mm}$ |
| | 2d 24 hours.. | ..... | ... | 12 |
| $AgNO_3$ | 1st 24 hours.. | $1.5^{mm}$ | $4^{mm}$ | 11.25 " |
| | 2d 24 hours.. | ..... | ... | 9.25 " |

The results of the experiments for the seedlings of *Zea Mais* are given in the preceding table.

For the seedlings of *Zea Mais* it was only necessary to use three dilutions. In the first two of these the roots showed a slight growth during the first twenty-four hours, but no further growth was shown by the second measurement. In the $\frac{1}{204800}$ equiv. solution the growth continued for the entire period, so that here, as in the case of *Pisum sativum* experiments, the killing point is shown to be the $\frac{1}{102400}$ equiv. solution. Here also the roots which were killed remained quite rigid.

In $Ag_2SO_4$ the dissociation will be into two $Ag^+$ ions and $^-SO_4^-$ ions. The $AgNO_3$ will dissociate to form $Ag^+$ ions and $^-NO_3^-$ ions. It has already been shown in several cases that the $^-SO_4^-$ ions and $NO_3^-$ ions are without any toxic action. Now since dissociation is practically complete in the dilutions used, only the ions are to be considered, and the non-poisonous character of the electro-negative ions leaves the $Ag^+$ ions to produce the toxic effect.

The extremely small amount of ionic silver necessary to kill the root may be expressed as follows:

Both seedlings killed by $\frac{1}{102400}$ eq.$=$1 part Ag to 948,148 $H_2O$. According to the above the silver ion is somewhat more poisonous than the copper ion.

### 9. Mercury.

Experiments were performed with the seedlings of *Pisum sativum* and *Zea Mais* and a single mercury salt, $HgCl_2$. The results of these experiments are given in the following table:

CORROSIVE SUBLIMATE.

| $HgCl_2$ | | $\frac{1}{12800}$ mol. | $\frac{1}{25600}$ mol. | $\frac{1}{51200}$ mol. | $\frac{1}{102400}$ mol. | $\frac{1}{204800}$ mol. | $\frac{1}{409600}$ mol. |
|---|---|---|---|---|---|---|---|
| Pisum sativum | 1st 24 hrs | ... | $2^{mm}$ | $2.25^{mm}$ | $3.75^{mm}$ | $5.75^{mm}$ | $4.5^{mm}$ |
| | 2d 24 hrs | ... | .... | ..... | ..... | 7.25 " | 4 " |
| Zea Mais | 1st 24 hrs | $2^{mm}$ | $7.5^{mm}$ | $19^{mm}$ | $14.5^{mm}$ | ..... | .... |
| | 2d 24 hrs | ... | 10 | 28 | 10.5 " | ..... | .... |

The dilutions were made from the $\frac{1}{100}$ molecule solution the same as for the $Ag_2SO_4$. In the first three dilutions used for the seedlings of *Pisum sativum* a growth of a few millimeters occurred during the first twenty-four hours, but the second measurement showed no further growth. Those roots which were killed remained rigid, but were somewhat discolored at the end of the experiment. In the last two dilutions growth continued throughout the experiment, so that the killing point for the seedlings of *Pisum sativum* is shown to be the $\frac{1}{102400}$ gram-molecule solution. For the seedlings of *Zea Mais* the $\frac{1}{51200}$ and $\frac{1}{102400}$ gram-molecule was first used, but in both of these growth resulted, so two more concentrated solutions were used, which showed the killing point to be the $\frac{1}{12800}$ gram-molecule solution. This, then, shows that the seedlings of *Zea Mais* are able to withstand a much greater amount of mercury than the *Pisum* seedlings.

The $HgCl_2$ will dissociate to form $^+Hg^+$ ions and two $Cl^-$ ions, and at the degree of concentration used the dissociation will be practically complete, so we have to deal simply with $^+Hg^+$ ions and $Cl^-$ ions. The $Cl^-$ ions have been shown to be non-poisonous, so the toxic effect must be due to the ionic mercury. The amount of ionic mercury necessary to kill the plants may be expressed as follows:

*Pisum sativum*: seedlings killed by $\frac{1}{102400}$ mol. = 1 part Hg to 510,978 $H_2O$.

*Zea Mais*: seedlings killed by $\frac{1}{12800}$ mol. = 1 part Hg to 63,872 $H_2O$.

## 8. Potassium Cyanide.

The effect of CN on the roots of *Pisum sativum* and *Zea Mais* seedlings was tested by solutions of KCN. The results obtained with different solutions are shown in the table on next page.

For the *P. sativum* seedlings no growth whatever occurred in the $\frac{1}{1600}$ and $\frac{1}{3200}$ gram-molecule solutions, while in the $\frac{1}{6400}$ gram-molecule solution growth was noted during the first twenty-four hours but no further growth for the second measurement.

In all of the solutions by which growth was inhibited the roots were quite rigid at the end of the experiment. In the last two dilutions growth was noted for the entire period, so the killing point is shown to be the $\frac{1}{6400}$ gram-molecule solution. The seedlings of *Zea Mais* were started in the $\frac{1}{3200}$ gram-molecule solution which completely inhibited the growth, while the two next dilutions allowed growth to continue, so that here the killing point is shown to be the $\frac{1}{3200}$ gram-molecule solution showing the *Zea Mais* to be somewhat more resistant than the *P. sativum*.

POTASSIUM CYANIDE.

| KCN | | $\frac{1}{1600}$ mol. | $\frac{1}{3200}$ mol. | $\frac{1}{6400}$ mol. | $\frac{1}{12800}$ mol. | $\frac{1}{25600}$ mol. |
|---|---|---|---|---|---|---|
| P. sativum | 1st 24 hours | .... | .... | $1.25^{mm}$ | $3^{mm}$ | $2.5^{mm}$ |
| | 2d 24 hours | .... | .... | .... | 2 " | 3 " |
| Z. Mais.. | 1st 24 hours | | .... | 2.5 " | 3 " | |
| | 2d 24 hours | | .... | 7.5 " | 6 " | |

The KCN will dissociate to form $K^+$ ions and $CN^-$ ions, and the dissociation is nearly complete. Since we are dealing here with a potassium salt of HCN and quite dilute solutions, the amount of undissociated KCN will not be very great. At the dilutions used the $K^+$ ion would not produce any toxic action, so the poisonous quality of the KCN solutions must be due principally to the $CN^-$ ion and to a slight extent to the undissociated KCN, the effect of which will decrease as the dilutions become greater.

9. POTASSIUM FERRO- AND FERRI-CYANIDES.

Experiments were performed with the seedlings of *P. sativum* and *Zea Mais* and potassium ferro- and potassium ferri-cyanide.

In the $\frac{1}{25}$ and $\frac{1}{50}$ gram-molecule solutions of $K_4Fe(CN)_6$ the roots were killed, no growth whatever resulting. In $\frac{1}{100}$ molecule solution growth was observed during the first twenty-four hours, but none afterward. In the $\frac{1}{200}$ and $\frac{1}{400}$ gram-molecule solution growth continued for the entire period. In the $K_3Fe(CN)_6$, the seedlings were set first in the $\frac{1}{100}$ molecule solution in which no growth occurred. The two next weaker solutions allowed the seedlings to grow. The killing point may be placed, then, at $\frac{1}{100}$ gram-molecule. Those roots which were killed remained rigid, but were somewhat discolored. In the weaker solutions which did not entirely inhibit the growth a retardation of the growth is apparent.

The results of the experiments with *P. sativum* are given in the following table:

PISUM SATIVUM.

| Cyanides. | | $\frac{1}{25}$ mol. | $\frac{1}{50}$ mol. | $\frac{1}{100}$ mol. | $\frac{1}{200}$ mol. | $\frac{1}{400}$ mol. |
|---|---|---|---|---|---|---|
| $K_4Fe(CN)_6$ | 1st 24 hours | .... | .... | $1^{mm}$ | $2.25^{mm}$ | $7.5^{mm}$ |
| | 2d 24 hours | .... | .... | .... | .75 " | 5 " |
| $K_3Fe(CN)_6$ | 1st 24 hours | | | .... | 5 " | 7 " |
| | 2d 24 hours | | | .... | 3 " | 4 " |

The results of the experiments with *Zea Mais* are given in the following table:

ZEA MAIS.

| Cyanides. | | $\frac{1}{25}$ mol. | $\frac{1}{50}$ mol. | $\frac{1}{100}$ mol. | $\frac{1}{200}$ mol. |
|---|---|---|---|---|---|
| $K_4Fe(CN)_6$ | 1st 24 hours | .... | $1.5^{mm}$ | $2.5^{mm}$ | $6.75^{mm}$ |
| | 2d 24 hours | .... | .... | .... | 7.25 " |
| $K_3Fe(CN)_6$ | 1st 24 hours | .... | 1.5 " | 8.25 " | 15.25 " |
| | 2d 24 hours | .... | .... | .... | 3.75 " |

In both of the salts no growth occurred in the $\frac{1}{25}$ molecule solution. In the $\frac{1}{50}$ mol. and $\frac{1}{100}$ mol. solutions growth was noted for the first twenty-four hours but none afterwards. The $\frac{1}{200}$ mol. solution showed growth for the entire period, so that here as in the case of the *P. sativum* seedlings the killing point is the $\frac{1}{100}$ gram-molecule solution.

In the case of both salts the dissociation will be in the form of $K^+$ ions and $Fe(CN)^-$ ions, the only difference being the fact that whereas $K_4Fe(CN)_6$ solutions contain four K ions the $K_3Fe(CN)_6$ solutions contain three K ions. For the dilutions used the dissociation is not complete.

For the $K_4Fe(CN)_6$ at 18° C. and of $\frac{1}{32}$ gram-molecule strength about $\frac{15}{26}$ of the molecules will be broken up, and for a $\frac{1}{512}$ gram-molecule solution about $\frac{23}{26}$ of the entire number of molecules will be split up. For the $K_3Fe(CN)_6$ at 18° C. and of $\frac{1}{96}$ gram-molecule strength, about $\frac{18}{23}$ of the total number of molecules will be dissociated.[14] The solutions used will then contain a certain number of undissociated molecules besides the $K^+$ ions and the $Fe(CN)_6^-$ ions. The $K^+$ ions have already been mentioned as non-poisonous at these dilutions, so the toxic action must be referred to the $Fe(CN)_6^-$ ions and to some extent to the undissociated molecules.

The much greater strength of solutions which the seedlings are able to withstand in the above experiments over that for the KCN, show that the CN has lost its toxic action to a great extent by combining with the Fe to form the $Fe(CN)_6$ ion.

The roots of *P. sativum* were killed by the $\frac{1}{6400}$ KCN, while it took $\frac{1}{100}$ potassium ferro- or ferri-cyanide. The molecule of the potassium ferro- or ferri-cyanides contained six times as much cyanogen, hence it required 384 times as much cyanogen in the form of the $Fe(CN)_6$ ion to produce the same effect. The roots of *Zea Mais* were killed by the $\frac{1}{3200}$ KCN, while it took $\frac{1}{100}$ gram-molecule of $K_4Fe(CN)_6$ or $K_3Fe(CN)_6$ to produce the same effect, or 192 times as much CN in the form of the $Fe(CN)_6^-$ ion.

## 10. Silver Nitrate + 3KCN.

Some experiments were also performed to test the action of $AgNO_3$ + KCN upon the growth of the same seedlings as had been used before. The results are given below:

| | | $\frac{1}{12800}$ mol. | $\frac{1}{25600}$ mol. | $\frac{1}{51200}$ mol. | $\frac{1}{102400}$ mol. | $\frac{1}{204800}$ mol. |
|---|---|---|---|---|---|---|
| P. sativum | 1st 24 hrs... | 2.5mm | 3mm | 3mm | 6mm | 2.5mm |
| | 2d 24 hrs... | .... | ..... | 3.5 | 2.5 | 4 |
| Z. Mais | 1st 24 hrs... | 1.5 | 3.25 | 6 | 8.25 | .... |
| | 2d 24 hrs... | .... | 3.25 | 2 | 5.25 | .... |

[14] Ostwald, Chemische Energie 739.

For the *P. sativum* seedlings growth occurred in the first two dilutions for the first twenty-four hours only. In the next dilutions growth continued for the entire period. For *Zea Mais* growth was noted in the first dilution for the first twenty-four hours, but not afterwards, while in the following dilutions growth continued for the entire period. Those roots which were killed remained rigid.

The solutions were mixed upon Ag as a base, and the following action will show what the solutions contain:

$$AgNO_3 + 3KCN = KNO_3 + K(AgCN_2) + KCN.$$

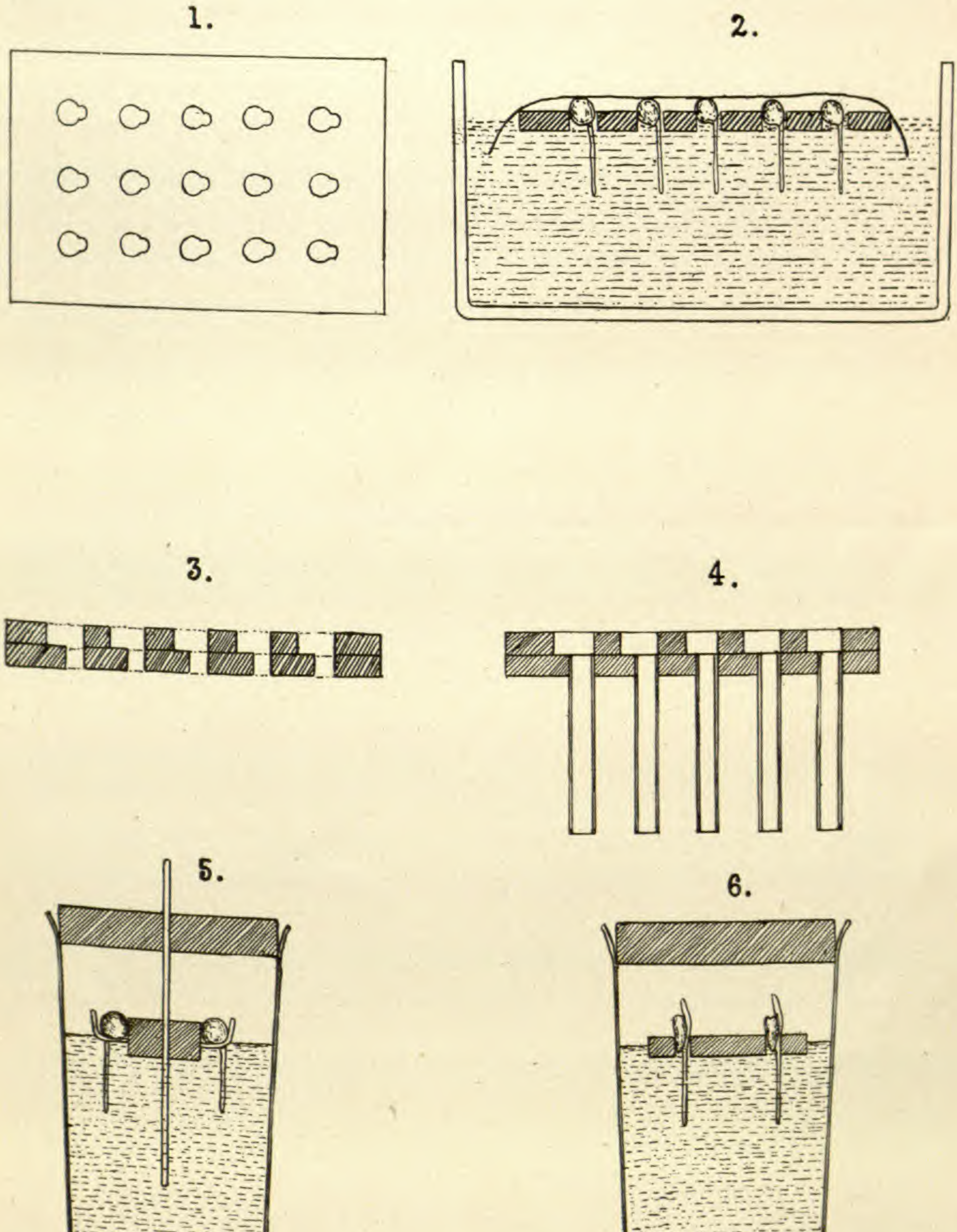
At the dilutions used the $KNO_3$ is without effect. The $K(AgCN_2)$ will dissociate to form $K^+$ ions and $AgCN_2^-$ ions; the KCN to $K^+$ ions and $CN^-$ ions.

The above experiments show that more silver is required to produce poisoning when present in the form of $AgCN_2^-$ ions, than when present as the simple Ag ion: four times as much for the *P. sativum* seedlings and eight times as much for *Zea Mais* seedlings.

A comparison of the results obtained by myself with those of True and Kahlenberg[15] is given in the following table. The dilutions given just allowed growth.

| Name of Compound | P. sativum | | Z. Mais | | L. albus | |
|---|---|---|---|---|---|---|
| HCl | $\frac{1}{12800}$ | eq. | $\frac{1}{3200}$ | eq. | $\frac{1}{6400}$ | eq. |
| $H_2SO_4$ | " | " | " | " | " | " |
| $HNO_3$ | " | " | " | " | " | " |
| HBr | " | " | " | " | " | " |
| $C_2H_4O_2$ | $\frac{1}{3200}$ | " | $\frac{1}{400}$ | " | $\frac{1}{1600}$ | " |
| $CuCl_2$ | $\frac{1}{51200}$ | " | $\frac{1}{102400}$ | " | $\frac{1}{25600}$ | " |
| $CuSO_4$ | " | " | " | " | " | " |
| $Cu(C_2H_3O_2)_2$ | " | " | " | " | " | " |
| $NiSO_4$ | $\frac{1}{51200}$ | " | $\frac{1}{51200}$ | " | $\frac{1}{25600}$ | " |
| $Ni(NO_3)_2$ | " | " | " | " | ........ | " |
| $CoSO_4$ | $\frac{1}{25600}$ | " | $\frac{1}{6400}$ | " | $\frac{1}{12800}$ | " |
| $Co(NO_3)_2$ | " | " | " | " | " | " |
| $AgNO_3$ | $\frac{1}{204800}$ | " | $\frac{1}{204800}$ | " | $\frac{1}{204800}$ | " |
| $Ag_2SO_4$ | $\frac{1}{204800}$ | " | " | " | " | " |
| $HgCl_2$ | $\frac{1}{204800}$ | " | $\frac{1}{51200}$ | " | $\frac{1}{12800}$ | " |
| KCN | $\frac{1}{12800}$ | " | $\frac{1}{6400}$ | " | $\frac{1}{6400}$ | " |
| $K_4Fe(CN)_6$ | $\frac{1}{200}$ | " | $\frac{1}{200}$ | " | $\frac{1}{200}$ | " |
| $K_3Fe(CN)_6$ | " | " | " | " | " | |

[15] BOT. GAZ. **22**: 81. 1896.




HEALD on EFFECT of DILUTE SOLUTIONS.

## 11. Conclusion.

1. In nearly all of the seedlings used quite a wide range in the sensibility to the same substance is to be noted. This is especially noticeable in the results obtained for the acids. In some of the salts, as silver salts and $K_4Fe(CN)_6$ and $K_3Fe(CN)_6$, all three of the plants were killed by the same solution.

2. Throughout the whole series of acids and salts used I have shown that the toxic action was due to the ions into which the substances split up in great dilutions. In some cases dissociation was not complete and the effect of the undissociated substance had to be taken into consideration.

3. In all cases, except KCN, $K_4Fe(CN)_6$ and $K_3Fe(CN)_6$, it was the electro-positive or cathion which produced the toxic action. In the three substances mentioned above it was the electro-negative or anions which produced the toxic action.

4. In the cases investigated, compound ions, which contain elements that have a very high toxic action, lose their toxic action to some extent by being combined. This may take place where a comparatively harmless ion unites with one of high toxic value to form a compound ion, or where two ions of high toxic value are associated in a compound ion.

The theory of dissociation in dilute solutions has thus thrown light upon the physiological action of different substances, and the theory has itself been strengthened by these experiments upon living subjects. The results obtained by Kahlenberg and True have been confirmed throughout all of my experiments.

I wish here to thank Dr. Kahlenberg for aid and many valuable suggestions, and for the kindly interest which he has taken in my work.

University of Wisconsin, Madison.

# FLOWERS AND INSECTS. XVII.

CHARLES ROBERTSON.

For a more extended title of this series I have adopted that of "Contributions to an account of the ecological relations of the entomophilous flora and the anthophilous insect fauna of the neighborhood of Carlinville, Illinois." The following papers should be regarded as parts of the same series: Flowers and Insects: Umbelliferæ. *Trans. St. Louis Acad. Science* **5**: 449–460. 1890; Asclepiadaceæ to Scrophulariaceæ, *ibid.* **5**: 569–598. 1891; Labiatæ. *ibid.* **6**: 101–131. 1892. (no. 4); Rosaceæ and Compositæ, *ibid.* **6**: 435–480. 1894. (no. 14); Flowers and Insects, *ibid.* **7**: 151–179. 1896. (no. 6); The Philosophy of Flower Seasons, American Naturalist **29**: 97–117. 1895. The cases of some plants, such as those observed in Florida, which properly do not come under the title, are distinctly specified.

The present paper discusses a number of plants, which, although not akin, should be compared because of the influence which their greenish yellow colors have been considered to have in determining the character of the insect visits.

CAULOPHYLLUM THALICTROIDES (L.) Michx. is a perennial plant, rather frequent in rich woods, and blooming a short time, April 23d to May 7th. The stems grow several decimeters high and bear single small loose panicles of yellowish green flowers. The flowers expand horizontally about $10^{mm}$, and, I think, remain open at night. Each of the six sepals has, lying upon its base, a short petal which is somewhat kidney-shaped, being expanded into a nectar gland as wide as the sepal. The style is very short and is tipped by a small stigma, which is receptive before the anthers dehisce. From the shortness of the stamens, as well as their later dehiscence, I think that spontaneous self-pollination does not occur. According to the views usually held with regard to flowers of like color and nectar exposure, we might expect a strong predominance of flies. My observations do not show this.

With the exception of no. 18, taken April 23d, the following list was observed on May 1st:

HYMENOPTERA—*Andrenidæ*: (1) Halictus confusus Sm. ♀, s. & c. p.; (2) H. 4-maculatus Rob. ♀, s.; (3) Augochlora viridula Sm. ♀, s.; *Braconidæ*: (4) Bracon trifolii Ashm.; (5) B. veronniæ Ashm.; (6) Microgaster gelechiæ Riley, ab.; (7) Opius ruficeps Prov.; (8) Dacnusa flavicincta Ashm.; *Chalcididæ*: (9) Prosacantha illinoensis Ashm. (MS)—all s.

DIPTERA—*Mycetophilidæ*: (10) Dynatosoma thoracica Coq. (MS); *Empidæ*: (11) Rhamphomyia piligeronis Coq. (MS); *Syrphidæ*: (12) Chilosia capillata Lw.; (13) Melanostoma obscurum Say; (14) Rhingia nasica Say; *Anthomyidæ*: (15) Hylemyia plumosa Coq. (MS); (16) Mydæa flavipes Coq. (MS); *Oscinidæ*: (17) Chlorops trivialis Lw.—all s.

COLEOPTERA—*Mordellidæ*: (18) Mordellistena biplagiata Hel.; *Curculionidæ*: (19) Idiostethus subcalvus Casey, both s.

PTELEA TRIFOLIATA L.—According to Hildebrand (1) and Kerner (3), the flowers are staminate and perfect. Urban (2) indicates that *Ptelea* is diœcious, and that self-pollination is impossible. As far as I have observed, it has appeared that this species is diœcious. I could find no perfect flowers.

The greenish white blossoms expand from 10 to 15$^{mm}$ and are crowded in compound cymes, which are nearly level topped and form convenient resting places for insects. In both forms nectar is secreted by the gynophore and is slightly concealed by the hairy bases of the filaments.

The following table shows the kinds of insects taken on *Xanthoxylum Americanum* and *Ptelea trifoliata*, the former blooming from April 12th to 28th and the latter from May 8th to June 12th:

| | Other Hymenoptera | Apidæ | Andrenidæ | Diptera | Lepidoptera |
|---|---|---|---|---|---|
| Xanthoxylum Americanum (39) | 0 | 6 | 19 | 13 | 1 |
| Ptelea trifoliata (51) | 12 | 1 | 22 | 14 | 2 |

The difference in Apidæ may be partly on account of the former having the nectar more concealed, but is mainly, I think, on account of the blooming time. At any rate, three of the Apidæ taken on *Xanthoxylum* have finished their flight before

*Ptelea* goes out of bloom. Of the twelve species of lower Hymenoptera taken on *Ptelea*, not one is flying during the period of *Xanthoxylum*. The inflorescence of *Ptelea* is more favorable for their visits.

The principal pollinators are Andrenidæ. May 28th, 30th and June 1st, 4th and 8th the following list was observed:

HYMENOPTERA—*Apidæ*: (1) Apis mellifica L. ☿, s., freq.; *Andrenidæ*: (2) Halictus coriaceus Sm. ♀, s.; (3) H. ligatus Say ♀, s.; (4) H. lerouxii Lep. ♀, s.; (5) H. cressonii Rob. ♀, s. & c. p.; (6) H. pilosus Sm. ♀, s.; (7) H. confusus Sm. ♀, s. & c. p.; (8) H. stultus Cr. ♀, s. & c. p.; (9) H. tegularis Rob. ♀, s. & c. p.; (10) Agapostemon radiatus Say, ♀, s.; (11) Augochlora pura Say, ♀ s.; (12) Andrena roberteonii D. T., ♀, s. & c. p., freq.; (13) A. platyparia Rob. ♂♀, s. & c. p.; (14) A. cressonii Rob. ♀, s.; (15) A. bipunctata Cr. ♀, s. & c. p., freq.; (16) A. nuda Rob. ♀, s. & c. p.; (17) A. rugosa Rob. ♀, s.; (18) A. spiræana Rob. ♂♀, s.; (19) A. hippotes Rob. ♀, s. & c. p., ab.; (20) A. claytoniæ Rob. ♀, s., freq.; (21) A. cratægi Rob. ♀, s. & c. p.; (22) Sphecodes confertus Say ♀, s., freq.; (23) Prosopis modesta Say, ♂, s.; *Eumenidæ*: (24) Eumenes fraternus Say, s.; (25–27) Odynerus spp., s.; (28) O. unifasciatus Sauss., s.; (29) O. tigris Sauss., s.; (30) O. foraminatus Sauss., s.; *Crabronidæ*: (31) Oxybelus illinoensis Rob. (MS), s.; *Philanthidæ*: (32) Cerceris compar Cr., s.; *Sphecidæ*: (33) Ammophila vulgaris Cr., s.; *Scoliidæ*: (34) Elis confluenta Say, s.; *Chalcididæ*: (35) Leucospis affinis Say, s.

DIPTERA—*Stratiomyidæ*: (36) Stratiomyia meigenii Wd.; *Conopidæ*: (37) Conops brachyrhynchus Mcq., s.; (38) Myopa vesiculosa Say, s.; *Syrphidæ*: (39) Sphærophoria cylindrica Say, s.; (40) Myolepta nigra Will., s.; (41) Volucella vesiculosa F., s.; (42) Mallota cimbiciformis Fil. f. bautias Wlk., s.; (43) Syritta pipiens L., s.; *Tachinidæ*: (44) Trichopoda sp., s.; (45) Jurinia smaragdina Mcq., s.; (46) J. apicifera Wlk., s.; (47) Micropalpus fulgens Mg., s.; *Muscidæ*: (48) Lucilia cornicina F., s.; *Anthomyidæ*: (49) Phorbia fusciceps Zett.

LEPIDOPTERA—*Rhopalocera*: (50) Neonympyha eurytris F., s.; *Heterocera*: (51) Alypia octomaculata Hbn.

Trelease (MS notes) captured the following insects on the flowers:

HYMENOPTERA—*Apidæ*: (1) Psithyrus (Apathus) laboriosus F., ♀; (2) Nomada sp.; *Andrenidæ*: (3) Halictus pilosus Sm., ♀; (4) Andrena pruni Rob., ♀; (5) A. illinoensis Rob., ♀; (6) A. cratægi Rob., ♀; (7) Agapostemon viridulus F., ♀; (8) Sphecodes confertus Say, ♀; (9) Prosopis modesta Say, ♀; *Vespidæ*: (10) Vespa germanica F.; (11) Polistes metricus Say; *Eumen-*

*idæ*: (12) Odynerus albophaleratus Sauss.; *Crabronidæ*: (13) Oxybelus 4-notatus Say; *Philanthidæ*: (14) Cerceris pedalis Cr.

COLEOPTERA—*Coccinellidæ*: (15) Analia bipunctata L.; *Dermestidæ*: (16) Anthrenus scrophulariæ L.; *Lampyridæ*: (17) Chauliognathus pennsylvanicus De G.; and other insects which I have not seen, probably flies.

On the literature of *Ptelea* see:

(1) Hildebrand, Geschlechtsvertheilung bei den Pflanzen, **11**:26. 1867.—(2) Urban, Zur Biologie und Morphologie der Rutaceen, Jahrb. bot. Gartens Berlin **2**:397–8. 1883. (Just **11**[1]:497.)—(3) Kerner, Pflanzenleben **2**:295. 1891. (Just **18**[1]:486.)

RHAMNUS L.—The species which have been studied are diœcious—*R. cathartica* (Darwin 7), *saxatilis* and *tinctoria* (Kerner 19)—or with flowers perfect, as in *R. Frangula* and *pumila* (Müller 3, 11), the former being proterandrous and the latter homogamous. *R. cathartica* has four sub-forms (Darwin 7), and *Frangula* shows a tendency to produce a long and short-styled form, as in our *R. lanceolata* (Schulz 17).

The flowers are small, greenish, with easily accessible nectar and have been considered to be adapted to flies (Delpino 5, Müller 12, 13), but this does not seem to be supported by sufficient data. Still more extreme is the limitation of the proper visitors to flesh-flies (Kerner 19). My list of visitors of *R. lanceolata* resembles those of white or yellow flowers with similarly placed nectar and blooming about the same time. The results of the observation of different species in separate regions is given in the following table:

| | Apidæ | Andrenidæ | Other Hymenop | Diptera | Coleoptera | Total |
|---|---|---|---|---|---|---|
| Rhamnus lanceolata, Illinois | 4 | 23 | 3 | 22 | | 52 |
| R. Frangula, Low Germany, Müller (3, 10) | 2 | 1 | 2 | 1 | | 6 |
| R. Frangula, Flanders, MacLeod (20) | 2 | | | 1 | 1 | 4 |
| R. pumila, Alps, Müller (11) | | | 4 | 8 | 5 | 17 |

RHAMNUS LANCEOLATA Pursh.—According to Darwin (7), this species is dimorphous, but not properly heterostyled. The small trees grow as high as three or four meters and bear numerous greenish flowers which appear with the leaves. The stamens are exserted so that the pollen may be eaten by Syrphidæ or collected by Andrenidæ, but the style is short and included. The calyx tube is about 2$^{mm}$ deep and 1$^{mm}$ wide. Consequently the nectar, which is secreted by a disk lining the tube, is readily accessible to small, short-tongued insects. From their structure and blooming time, April 23d to May 10th, the flowers seem to be specially adapted to Andrenidæ, but they are also visited less abundantly and less efficiently by flies. On the 1st and 2d of May I captured the following visitors:

HYMENOPTERA—*Apidæ:* (1) Apis mellifica L. ☿, s., one; (2) Bombus americanorum F. ♀, s.; (3) Ceratina dupla Say ♂, s.; (4) Nomada maculata Cr. ♀, s.; *Andrenidæ:* (5) Halictus foxii Rob. ♀, s. and c. p., freq.; (6) H. arcuatus Rob. ♀, s. and c. p.; (7) H. forbesii Rob. ♀, s. and c. p.; (8) H. lerouxii Lep. ♀, s. and c. p.; (9) H. fasciatus Nyl. ♀, s. and c. p., ab.; (10) H. pilosus Sm. ♀, s. and c. p., freq.; (11) H. confusus Sm., ♀, s. and c. p., freq.; (12) H. pruinosus Rob. ♀, s.; (13) H. illinoensis Rob. ♀, s.; (14) H. zephyrus Sm. ♀, s. and c p.; (15) H. stultus Cr. ♀; (16) Agapostemon radiatus Say ♀, s., freq.; (17) Augochlora viridula Sm. ♀, s.; (18) A. pura Say ♀, s. and c. p., freq.; (19) A. labrosa Say ♀, s. and c, p.; (20) Andrena erythrogastra Ashm. ♂, s.; (21) A. mandibularis Rob. ♀, s.; (22) A. nasonii Rob. ♀, s. and c. p.; (23) A. cressonii Rob. ♂♀, s. and c. p., ab.; (24) A. bipunctata Cr ♂, s.; (25) A. ziziæ Rob. ♂♀, s. and c, p., freq.; (26) A. cratægi Rob. ♂, s.; (27) Sphecodes mandibularis Cr. ♀, s.; *Eumenidæ:* (28) Eumenes fraternus Say, s.; (29) Odynerus tigris Sauss., s.; *Tenthredinidæ:* (30) Dolerus arvensis Say, s.

DIPTERA—*Empidæ:* (31) Rhamphomyia priapulus Lw.; *Syrphidæ:* (32) Pipiza femoralis Lw.; (33) Chrysogaster nitida Wd.; (34) Syrphus ribesii L.; (35) S. americanus Wd.; (36) Xanthogramma felix O. S.; (37) Allograpta obliqua Say, freq.; (38) Mesograpta geminata Say, ab.; (39) M. marginata Say; (40) Sphærophoria cylindrica Say, freq.; (41) Helophilus similis Mcq.; (42) Syritta pipiens L.; *Tachinidæ:* (43) Cyphocera fuesta V. d. W.; *Sarcophagidæ:* (44) Cynomyia mortuorum L.; (45) Sarcophaga ægra Wlk.; (46) S. cimbicis Twns.; *Muscidæ:* (47–48) Lucilia spp.; (49) L. latifrons. Schin.; *Cordyluridæ:* (50) Scatophaga squalida Mg.; *Anthomyidæ:* (51) Phorbia acra Wlk.; (52) P. fusciceps Zett.—all s. or f. p.

On the literature of *Rhamnus* see:

(1) Darwin, on the two forms, or dimorphic condition, in the species of *Primula*, and on their remarkable sexual relations; Journ. Linn. Soc. Bot. 6:95. 1862—*R. lanceolata*. (2) Hildebrand, Geschlechtsvertheilung bei den Pflanzen 9:40. 1867—*R. cathartica, lanceolata*. (3) Müller, Befruchtung

der Blumen 152. 1873—*R. Frangula.* (4) Kerner, Die Schutzmittel des Pollens 56. 1873. (5) Delpino, Ulteriori osservazioni, pt. II, fasc. 2:20, 214, 300, 316, Att. Soc. Ital. Sci. Nat., Milano **16**:168. 1873; **17**:——. 1874 —*R. cathartica, Frangula, alterna* (Just **2**:895). (6) Lubbock, British wild flowers in relation to insects 79. 1875—*R. cathartica, Frangula, lanceolata.* (7) Darwin, Forms of flowers, 273–7. 1877—*R. cathartica, lanceolata, Frangula.* (8) Bonnier, Les Nectaires, Ann. Sci. Nat. Bot. **8**:39. 1878. *R. Frangula, alpina*, inconspicuous flowers abundantly visited. (9) Dodel-Port, Die Liebe der Blumen **4–5**:185–240. 1880—*R. cathartica* (Just **8**[1]:183). (10) Müller, Weitere Beobachtungen, II, Verh. naturhist. Ver. preuss. Rheinl. u. Westf. 212. 1879—*R. Frangula.* (11) Müller, Alpenblumen 169–71. 1881—*R. pumila.* (12) Müller, Geschichte der Erklärungsversuche in Bezug auf die biologische Bedeutung der Blumenfarben, Kosmos **12**:125, N., 1882 (Just **9**[1]:506). (13) Müller, Die biologische Bedeutung der Blumenfarben, Biol. Centralblatt **3**:99, Ap. 1883. (14) Müller, Die Stellung der Honigbiene in der Blumenwelt, III, Deutsche Bienenzeit. **39**:157–61. 1883—*R. pumila*, Apis wanting. (15) Müller, Fertilization of flowers, 163–4. 1883—*R. Frangula, cathartica, lanceolata, pumila.* (16) Kirchner, Flora von Stuttgart und Umgebung, 363–4. 1888—*R. Frangula, cathartica.* (17) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen, **1**:31. 1888; **2**:61, 185. 1890. Bibliotheca Botanica, 10 und 17—*R. Frangula, cathartica, pumila.* (18) Trelease, North American Rhamnaceæ, Trans., St. Louis Acad. Sci. **5**:359. (19) Kerner, Pflanzenleben, **2**:169, etc. 1891—*R. cathartica, saxatilis, tinctoria.* (20) MacLeod, Over de bevruchting der bloemen in het kempisch gedeelte van Vlaandern, Bot. Jaarbock. **6**:247–9, 438, 1894—*R. Frangula, cathartica.* (21) Loew, Blütenbiologische Floristik **36**:215. 1894—*R. pumila, Frangula, cathartica, saxatilis.*

RHUS L.—The species are said to be polygamous or polygamo-diœcious. It might be better to call them diœcious, though of a recent form, for the staminate and pistillate flowers have large rudiments of pistils and stamens, and there is a tendency for them to revert to the perfect condition. Müller (4, 14) and Kerner (16) mention *R. Cotinus* as polygamous; but in Halle and in South Tyrol Schulz (15) found it to be diœcious, though it appears (Loew[1] 20) that in the former locality he afterwards found polygamous examples. In the manual *R. typhina* is called polygamous, while Müller calls it diœcious.

[1] In the Floristik, unfortunately, Loew mentions an author without citing any of the separate papers listed under that author's name.

Meehan (6, 18) referring to the fact that *R. copallina, venenata* and *Toxicodendron* are variously classed as diœcious, polygamo-diœcious, or polygamous, insists that they and *R. cotinoides* are all truly diœcious. I regard *R. glabra* and *Canadensis* as diœcious.

In regard to the staminate, perfect, and pistillate flowers of *R. Cotinus*, Müller observes that they decrease in size in the order mentioned, and that, consequently, most insects visit them in the most advantageous order. Schulz failed to confirm the latter observation. In *R. glabra* and *Canadensis*, I think insects prefer the staminate flowers, partly because they are more conspicuous and because they contain pollen as well as nectar, and that the order of their visits is advantageous. However, I do not believe that natural selection has operated in producing the difference, and so hold that it would be erroneous to say that the difference exists to secure the advantage. As a rule stamens are more conspicuous than pistils, and it is quite obvious that a small flower containing five stamens will be more evident than one containing a single pistil. The larger perianth may be explained as existing to support, and at first to protect, this exterior set of organs.

Two effects upon the insect visitors have been attributed to the dull yellow colors of *Rhus*. Müller says that *R. Cotinus*, like all other flowers of a dull yellow color, is almost completely avoided by Coleoptera. The general proposition is denied by Bonnier (9), and Schultz says that it is not true for *R. Cotinus* in the Tyrol, where he found many beetles among the visitors. *Pastinaca*, on which I have taken forty species of beetles, is mentioned by Müller as an example of the same kind.

The idea that the flowers of *Rhus* were specially attractive to flies (macromyiophilous) seems to have originated with Delpino (5). The "Tipo ramnaceo," which he regards as macromyiophilous, includes the greenish yellow species of *Rhus*, *Rhamnus*, *Euonymus*, *Euphorbia*, etc. In a special paper on the biological significance of flower-colors Müller (12) says that greenish yellow colors are frequent in flowers among whose visitors the larger Diptera predominate. Both authors distinguish these cases from the dark colored flowers, like *Stapelia*, *Asimina*, etc., which they consider to be adapted to flesh flies. The view in regard to the greenish yellow flowers does not seem to have been supported, if not entirely refuted, by subsequent investigations. Kerner's view (16) that these colors are specially attractive to flesh flies was never held either by Delpino or Müller, and so may be considered to be supported neither by authority nor recorded observations. Of the greenish yellow flowers which bloom in my neighborhood I have found a preponderance of general Diptera on none except *Sassafras*. Indeed I expect *Smilax herbacea* and *S. ecirrhata* to show a preponderance of flesh flies, but they differ from the others, and from all of the cases cited by Kerner, in having a scent of carrion.

The following table gives results of observations of insect visitors of *Rhus* in cases in which the species have been identified. The Andrenidae and lower Hymenoptera preponderate over the Diptera. In the Tyrol Schulz saw *R. Cotinus* very abundantly visited by a set of insects which in a general way must resemble my list for *R. glabra* (19).

| | Apidæ | Andrenidæ | Other Hymenop | Dipteria | Other insects | Total |
|---|---|---|---|---|---|---|
| Rhus Cotinus — Low Germany — Müller (4,14) | 1 | 3 | 6 | 6 | 1 | 17 |
| Rhus typhina — Low Germany — Müller (4,14) | 1 | 1 | .. | .. | 1 | 3 |
| Rhus glabra—Illinois (19) | 3 | 16 | 13 | 25 | 1 | 58 |
| Rhus Canadensis — Illinois (19) | 2 | 21 | 1 | 9 | .. | 33 |

RHUS CANADENSIS Marsh. *R. aromatica* Ait. This is a slender shrub growing on high creek banks, the stems rising from 1 to $2^m$ high. The branchlets are terminated by clusters of about three small, head-like racemes, which measure $8–10^{mm}$ in length, and appear before the leaves. The flower buds escape from hibernacula whose scales still clasp the bases of the stalks.

The flowers are small, greenish yellow, with short petals. They are quite shallow, the nectar being almost freely exposed. Nectar is secreted by five orange colored glands situated between the bases of the filaments. The staminate flowers have the petals a little longer and more often expanded, so that this form is the more conspicuous. The nectar glands are larger, more triangular and united at base. The pistil is so strongly developed that the flower appears to be perfect. In the pistillate flower the nectar glands are more bilobed. The stamens are of normal form, but greatly reduced in size, and are without pollen. Both forms are abundantly visited by insects.

In the case of *Xanthoxylum Americanum*, which blooms from April 12th to 28th, and *Ptelea trifoliata*, blooming from May 8th to June 12th, we have observed that the lists differ in the absence of the lower Aculeata from *Xanthoxylum*. This was explained as a result of the difference in their blooming time. If we compare *R. Canadensis*—April 4th to 27th—with *R. glabra*—June 8th to 24th—we find the same result. In the former case not one of the lower Aculeata occurring on *Ptelea* flies while *Xanthoxylum* is in bloom. Here we have a similar condition, for *Polistes metricus* is the only one taken on *R. glabra* which is flying during the flower season of *R. Canadensis*. The large inflorescences of *Ptelea* and *R. glabra* form more convenient resting places for these often large straddling insects. The differences in the inflorescences may be accounted for partly by the difference in the composition of the late insect fauna; but the early months, when there is apt to be frost, are not favorable for the development of large flower clusters. Then, too, before the leaves appear, the smaller clusters are sufficiently conspicuous. Other differences in the lists are connected with the blooming time, viz., the advent of *Prosopis*, substitution of two late *Colletes* for the early *C. inaequalis*, and an increase of *Halictus* associated with the decline of the vernal species of *Andrena*.

The following visitors of *R. Canadensis* were taken on April 4th, 10th, 12th and 19th:

HYMENOPTERA—*Apidæ*: (1) Ceratina tejonensis Cr., ♂; (2) Nomada maculata Cr., ♂♀, freq.; *Andrenidæ*: (3) Halictus sp. ♀; (4) H. foxii Rob., ♀, freq.; (5) H. forbesii Rob., ♀, freq.; (6) H. ligatus Say, ♀; (7) H. cressonii Rob., ♀; (8) H. zephyrus Sm., ♀, freq.; (9) H. stultus Cr., ♀; (10) Agapostemon texanus Cr., ♀; (11) Augochlora pura Say, ♀; (12) Andrena sp. ♂♀, freq.; (13) A. vicina Sm., ♂♀, freq.; (14) A. erythrogastra Ashm., ♀; (15) A. mandibularis Rob., ♂♀, freq.; (16) A. illinoensis Rob., ♀; (17) A. cressonii Rob., ♂; (18) A. bipunctata Cr., ♂♀, freq.; (19) A. rugosa Rob., ♂♀, ab.; (20) A. mariæ Rob., ♂, freq.; (21) A. claytoniæ Rob., ♂♀, ab.; (22) A. forbesii Rob., ♀; (23) Colletes inæqualis Say, ♂, freq.; *Ichneumonidæ*: (24) Lampronota coxalis Ashm. (MS.), ♀, type.

DIPTERA — *Empidæ*: (25) Rhamphomyia priapulus Lw.; *Syrphidæ*: (26) Syrphus americanus Wd., freq.; (27) S. ribesii L.; (28) Eristalis dimidiatus Wd.; *Tachinidæ*: (29) Gonia frontosa Say, freq.; *Sarphagidæ*: (30) Cynomyia mortuorum L.; *Muscidæ*: (31) Lucilia cornicina F., freq.; *Sciamyzidæ*: (32) Tetanocera pictipes Lw.; *Lonchæidæ*: (33) Lonchæa polita Say — all sucking.

On the literature of *Rhus* see:

(1) Hildebrand, Geschlechtsvertheilung bei den Pflanzen 10. 1867 — *R. Toxicodendron.* (2) Axell, Om anordningarna für de fanerogama växternas befruktning 47. 1869 — *R. Toxicodendron.* (3) Delpino, Altri apparecchi dicogamici recentemente osservati, Nuovo Giorn. Bot. Ital. 2:52. 1870. (4) Müller, Befruchtung der Blumen 157–8. 1873. (5) Delpino, Ulteriori osservazioni, Part II, fasc. 2:20, 214, 300. 1875, Atti. Soc. Ital. Sci., Milano 16:168. 1873; 17. 1874 (Just. 2:882, 895). (6) Meehan, On hermaphroditism in *Rhur cotinus* and in *Rhus glabra*, Proc. A. A. A. S., 1873; B. 73–5. (7) Meehan, On self-fertilization and cross-fertilization in flowers, The Penn Monthly, N.1876 (Just. 4:939). (8) Müller, Das Variiren der Grösse gefärbter Blüthenhüllen und sein Einfluss anf die Naturzüchtung der Blumen, Kosmos 2:132–3. 1887 — *R. Cotinus, typhina* (Just. 5:740–1). (9) Bonnier, Les Nectaires, Ann. Sci. Nat. Bot. VI, 8:71. 1878 — *R. Cotinus.* (10) Patton, Observations on the genus Macropis, Am. Journ. Sci. and Arts III, 18:211, 212. 1879 — *R. glabra typhinæ* (Just $7^1$:145). (11) Bontroux, Sur l'habitat et la conservation des lévures spontanées, Bull. Soc. Linn. Normandie, III, 6. 1881 — *R. Cotinus* (Just $13^1$:745). (12) Müller, Die biologische Bedeutung der Blumenfarben, Biol. Cent. 3:99. 1883 (Just $9^1$:506). (13) Müller, Die Stellung der Honigbiene in der Blumenwelt, III, Bienenzeit, Jahrg. 39:157–161. 1883 — *R. typhina* (Just $11^1$:476). (14) Müller, Fertilization of Flowers, 166–7. 1883. (15) Schulz, Beiträge Zur Kenntniss der Bestäubungseinrichtungen and Geschlechtsvertheilung bei den Pflanzen 2:62–4, 186. 1890, Bibliotheca Botanica 17 (Just $18^1$:517). (16) Kerner, Pflanzenleben 2:192, 297. 1891; Kerner & Oliver 2:173, 197, 297. 1895 (Just $17^1$:531, 2; $18^1$: 486). (17) Engler, Anacardiaceæ, Engler u. Prantl, Die nat. Pflanzenfamilien, 73:142. 1892 [Th. III, Abth. S] — *R. Cotinus* (Just $20^1$:481). (18)

Meehan, Contributions to the life histories of plants, VIII, Proc. Acad. Nat. Sci., Phila., 1892, 369–71 (Just **20**[1]: 494). (19) Robertson, Flowers and insects, XII, Bot. Gaz. **19**: 111, 112. 1894. (20) Loew, Blütenbiologische Floristik, 215 — *R. Cotinus*.

SASSAFRAS OFFICINALE Nees. *S. Sassafras* (L.) Karst. Hildebrand (1) observes that the pistillate and staminate flowers each have rudiments of the other set of organs, being what Kerner (2) calls pseudo-hermaphrodite. According to Bentham and Hooker's Genera Plantarum, and Gray's Manual this species is dioecious; and that is what I have always regarded it, though I paid attention to little except the insect visitors. Chapman, in the Flora of the Southern States, calls it diœciously polygamous, while Kerner calls it polygamous. My observations were made upon trees which I supposed bore only staminate flowers.

The flowers are greenish yellow, expand about 8 or 9$^{mm}$, and are arranged in corymbose clusters, which appear with the leaves. There are nine stamens. The three inner ones have at base of each a pair of stalked glands which secrete nectar. The nectar is therefore fully exposed on a convex surface.

There are a number of early flowers with convenient nectar, some of which on account of their greenish yellow color have been supposed to be principally visited by flies. In all except *Caulophyllum* and *Sassafras* the less specialized bees, Andrenidæ, outnumber the flies. *Sassafras* is the only one on which the flies clearly preponderate. In most of the species the nectar tends to collect in shallow cups, which make it very convenient for the Andrenidae, while in *Caulophyllum* and *Sassafras* it is secreted on convex surfaces, which make it more convenient for flies and less convenient for the little bees. However, the exposure of the nectar does not explain why *Sassafras* shows a preponderance of Diptera, but only why it shows more flies than the other greenish yellow flowers blooming about the same time. During the blooming season, April 19th–May 7th, the flowers are exposed to none of the lower aculeate Hymenoptera, except eight species of *Vespa* and *Polistes* and *Priocnemis conicus*. The last is the only one of these taken on the flowers. It happens to be the only one of the *Pompilidæ* flying during the blooming season. Suppose that *Sassafras* bloomed in the last of July, what would there be to keep it from being visited by several of the nineteen species of *Pompilidæ* flying at that time, or by many other short-tongued Aculeata which are then very abundant? In the south the lower Aculeata begin to fly earlier, and I should expect *Sassafras*, and many other early flowers with exposed or slightly concealed nectar, to show an increase in the proportion of these insects as we move in that direction.

The following insects were taken on the flowers on April 27th and 29th:

HYMENOPTERA—*Andrenidæ*: (1) Halictus cressonii Rob., ♀; (2) H. confusus Sm., ♀, s. & c. p.; (3) H. stultus Cr., ♀; (4) Andrena sp. ♀; (5) A. illinoensis Rob., ♂; (6) A. hippotes Rob., ♂; *Pompilidæ*; (7) Priocnemis conicus Say; *Chalcididæ*: (8) Eurytoma sp.; *Ichneumonidæ*: (9) Pimpla annulipes Br.; (10) Idiolespa anilis Grav.; (11) Ophion bifoveolatum Br.; *Tenthredinidæ*: (12) Hylotoma mcleayi Leach; (13) Monophadnus medius Norton.

DIPTERA—*Simulidæ*: (14) Simulium pecuarum Riley; *Bibionidæ*: (15) Bibio pallipes Say, freq.; (16) B. femorata Wd.; *Stratiomyidæ*: (17) Sargus iridis Say; *Empidæ*: (18) Empis compta Coq. (MS); (19) Rhamphomyia ravida Coq. (MS); (20) R. piligeronis Coq. (MS.); (21) R. priapulus Lw., freq.; (22) R. mutapilis Lw., freq.; (23) R. exigua Lw.; *Syrphidæ*: (24) Chilosia versipellis Will., freq.; (25) Chrysogaster nitida Wd.; (26) Platycheirus hyperboreus Staeg.; (27) Syrphus americanus Wd.; *Tachinidæ*: (28) Nemoræa aldrichii Twns.; (29) Gonia frontosa Say; (30) Micropalpus fulgens Mg.; (31) Phorocera edwardsii Will.; *Sarcophagidæ*: (32) Cynomyia mortuorum L., freq.; (33) Sarcophaga sp.; (34) S. cimbicis Twns.; *Muscidæ*: (35) Lucilia sp.; (36) L. cæsar L.; (37) L. cornicina F.; (38) Morellia micans Mcq., freq.; *Anthomyidæ*: (39) Homalomyia prostrata Rossi; (40) Caricea antica Wlk.; (41) Phorbia acris Wlk., ab.; (42) P. fusciceps Zett., ab.; *Cordyluridæ*: (43) Scatophaga squalida Mg.; *Oscinidæ*: (44) Chlorops trivialis Lw.; *Agromyzidæ*: (45) Agromyza latipes Mg.; (46) A. æneiventris Fll.

COLEOPTERA—*Lampyridæ*: (47) Telephorus bilineatus Say, freq.; *Œdemeridæ*: (48) Asclera puncticollis Say.

HEMIPTERA—*Corimelænidæ*: (49) Corimelæna pulicaria Ger.—all only sucking, except No. 2.

On the literature of *Sassafras* see:

(1) Hildebrand, Geschlechtsverteilung bei den Pflanzen 9. 1867. *Laurus Sassafras*: (2) Kerner, Pflanzenleben 2:297. 1891. Oliver, translation, 288 1895—*L. Sassafras*.

CARLINVILLE, ILLINOIS.

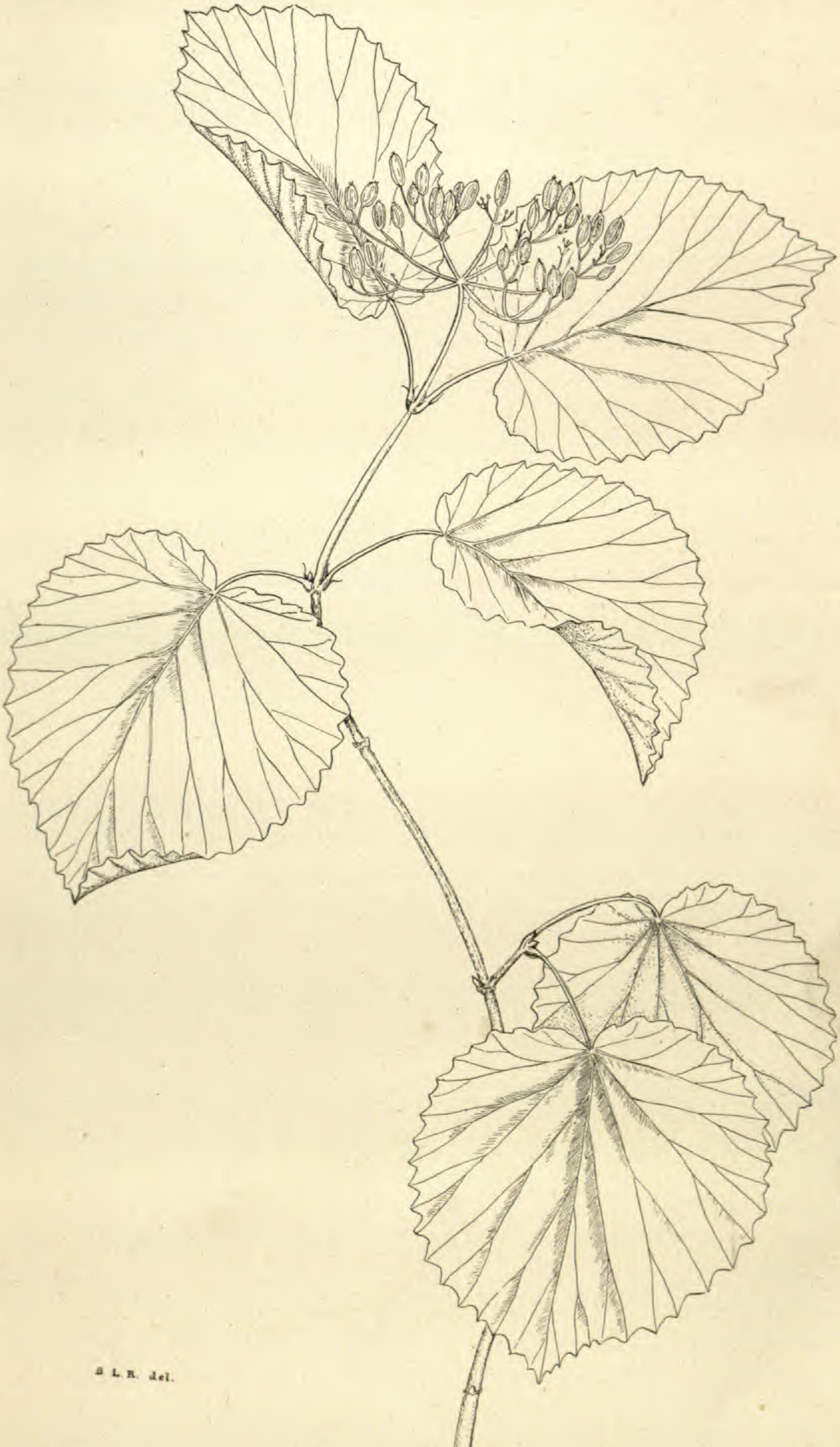
# BRIEFER ARTICLES.

## A NEW VIBURNUM FROM MISSOURI.

(WITH PLATE VIII.)

Among some herbarium exchanges sent last autumn by Mr. C. H. Demetrio, of Emma, Saline Co., Missouri, to Mr. Deane, was a noteworthy Viburnum, not satisfactorily referable to any described species. The plant had been discovered by Mr. Demetrio near Cole Camp, Benton Co., Missouri, in July, 1894, and appeared most closely related on the one hand to *V. dentatum* L., and on the other to *V. pubescens* Pursh. However, the single fruiting specimen, first received, scarcely warranted description, and Mr. Demetrio very kindly undertook, in May of this year, to secure further material, making for this purpose a considerable and somewhat arduous journey. On arriving at the locality above mentioned, he again found the desired species. Yet, although it was then more than a month earlier than when the plant was first observed, the flowers had already fallen and the fruit set. However, the more copious material now secured, corresponding in all points with the original specimen, leaves no doubt in the minds of the writers that this is a distinct species. It is distinguished from *V. dentatum* L. (which it most resembles in foliage) and from *V. molle* Michx., by its longer and much more compressed fruit and seed. The fruit is, in fact, very like that of *V. pubescens* Pursh. From the last named species, however, the present plant differs very decidedly in foliage, having, as may be seen from the accompanying plate, much more orbicular, deeply cordate, and much longer-petioled leaves, which are also of larger size than in any of the related species. The toothing of the leaves is somewhat different also from any of the species mentioned, the teeth here spreading in an even more radial manner than in *V. dentatum*.

Few states have received more botanical attention of late than Missouri, many portions of it having been carefully explored by Messrs. Bush, Eggert, Letterman, Blankinship, and others. This naturally argues that the present plant, which has not, to our knowledge, been



B. L. R. del.

DEANE and ROBINSON on a new VIBURNUM.

secured before, must be a very rare and local shrub. Certainly the exact limits of its distribution will be a matter for interesting investigation. The species, so far as now known from fruiting specimens, may be characterized as follows:

**Viburnum Demetrionis,** n. sp.—A bushy shrub, about 12 feet high: stems 5 to 20, erect, terete, glabrous, becoming ½ to 1½ inches in diameter, at first bright green, soon ashy gray, and at length brownish or grayish black, and in age much roughened with lenticels; bark, on stems two years old, exfoliating in brownish sheets: bud-scales ovate, acutish, ciliolate, sub-carinate: leaves suborbicular, or broadly ovate, cordate with narrow sinus and broad rounded basal lobes, short acuminate, radially and sub-acutely dentate, bright green quite glabrous and sulcate-nerved above, somewhat paler green and soft-pubescent beneath; the larger ones 3½ to 5½ inches long, 3 to 3¾ inches broad: petioles furrowed above, glabrate, ¾ to 1½ inches long: stipules filiform, 2 to 3 lines in length: umbelliform corymbs terminal on the branches, pedunculate, 2 to 3½ inches in diameter, glandular-puberulent; the primary rays mostly about 7, rarely as few as 4: calyx (persisting on young fruit) with 5 lance-oblong obtusish hispid-ciliate teeth: fruit not very fleshy, oblong in outline, rounded at both ends, 5 lines long, half as broad, much compressed, and in dried state concavo-convex, the convex surface having deep intramarginal grooves: putamen of essentially the same shape.—Collected July, 1894, and May 29, 1896, by C. H. Demetrio, near "Big Cave," bluffs of Cole Camp creek, Benton county, Mo.

Mr. Demetrio reports that on his second visit to the above locality he found no less than 20 shrubs of this species growing within a radius of a quarter of a mile. He also found, a little to the north of the "Big Cave," a second species of Viburnum, which was growing so near the edge of the creek that some of the branches were immersed. This species proved to be *V. pubescens* Pursh in all essential regards, but it differs from any specimens, accessible to the writers, in having petioles 4 to 6 or in some cases even 10 lines long, approaching in this respect *V. Demetrionis*. It is, however, very different from that species in the size, contour, and dentation of the leaves, and its unusually long petioles may well have been due to its exceptional habitat.

Types of *V. Demetrionis* will be deposited in the Gray Herbarium, and the herbaria of the Kew Gardens, Arnold Arboretum and Missouri Botanical Garden, as well as the private collection of Mr. Deane.—W. DEANE and B. L. ROBINSON, *Cambridge, Mass.*

## A NEW GENUS OF STERCULIACEÆ, AND SOME OTHER NOTEWORTHY PLANTS.

**Nephropetalum**, n. gen. of *Sterculiaceæ*.— Calyx deeply 5-parted; segments ovate. Petals 5, unguiculate, slightly adnate at base to the stamineal cup, free at the apex; blade small, reniform with a deep sinus at the attachment of the claw, concave, neither appendaged nor glandular. Stamens 5, united into a short cup; anthers 3-locular, sessile or nearly so, extrorse; cells parallel and longitudinally dehiscent. Staminodes 5, alternate with the stamens and opposite the sepals, rounded and cucullate at the summit. Ovary sessile, globose, 5-celled; cells 2-ovuled; ovules superposed on axial placentæ; style short, terete; stigma capitate. Young fruit globose, covered with very numerous pubescent processes; seeds by abortion solitary in the cells. —Stellate-tomentulose unarmed shrub with simple alternate ovate dentate petiolate leaves and small flowers in short axillary cymes. Most nearly related to *Ayenia* and *Buettneria*, and differing from the former in its free reniform petals and sessile ovary; from the latter in the entire absence of the appendage of the petals as well as in a very different habit. The origin and application of the generic name is apparent from the description.

**N. Pringlei**, n. sp.— Stem terete and nearly glabrate: leaves ovate, cordate with a narrow sinus, acuminate to an obtusish apex, crenate-dentate, palmately 7-nerved from the base, finely stellate-pubescent above, paler and tomentulose beneath, 3½ to 5 inches in length, 1½ to 3 inches broad: petioles canescent-tomentulose, 1½ inches long: stipules setaceous, deciduous, nearly 2 lines long: axillary umbelliform cymes 2 or 3-flowered, about an inch in length; the peduncles about equaling the pedicels: greenish flowers only a line in diameter.—Collected by C. G. Pringle, at Hidalgo, Texas, August 6, 1888 (no. 2272).

CORDYLANTHUS PILOSUS Gray, var. **trifidus**, n. var.— Pubescence duplex, consisting of a short close glandular puberulence and a loose spreading villosity: leaves broader than in the type, oblong rather than linear, distinctly 3-nerved, mostly 3-cleft below the middle: bracts also trifid; segments linear, entire, obtuse, somewhat dilated at the ends; the lateral spreading.—Collected by J. W. Congdon, on Chowchilla creek, Mariposa county, California, August 9, 1895 (no. 81).

AN INTRODUCED OROBANCHE, NEW TO AMERICA.— In July, 1895, Mr. J. A. Morton of Wingham, Ontario, collected on a lawn at that place an orobanchaceous parasite, not referable to any species characterized in American floras. He accordingly forwarded specimens of the plant to the Gray Herbarium for identification, and it has proved to be *Orobanche purpurea* Jacq. Enum. Stirp. Vindob. 108 : 252 (*O. cærulea* Vill. Hist. Pl. Dauph. 2 : 406 ; *Phelipæa cærulea* C. A. Mey. Enum. Cauc. 104), a species of wide distribution in Europe and Asia. There is no doubt that it was introduced in its Canadian occurrence, and probably with grass seed. Mr. Morton notes the fact that it was found growing "among *Achillea Millefolium*." This fact, of course, adds further proof of the identity of the American and European plants, since also in the Old World this species is regularly parasitic upon *Achillea Millefolium*.

A hasty search through recent American botanical literature has failed to show any reference to the presence of *Orobanche purpurea* Jacq. Reports of other localities may be awaited with interest. A very curious parasite, which attacks chiefly, if not exclusively, a common and noxious weed, is far from being the most undesirable sort of immigrant. The genus *Orobanche* is, of course, most nearly related to our American genus *Aphyllon*, so closely in fact that the two are united by some European authorities. The former, however, is in general readily distinguished by its 4-lobed calyx, the calyx of *Aphyllon* being 5-cleft. *Orobanche purpurea* Jacq. has the habit of *Aphyllon Ludovicianum* Gray. The only other Orobanche that has been introduced into the American flora is *O. minor* L., a variable species, which, however, has flowers ebracteolate, while in *O. purpurea* the flowers are subtended not only by conspicuous single bracts but also in each case by a pair of lance-linear attenuate bractlets. The whole plant is very glandular pubescent. Although a number of individuals were found, Mr. Morton regards the species as of very recent introduction in his locality.

ELYTRARIA VIRGATA Michx., var. **angustifolia** Fernald, n. var.— Leaves linear or narrowly oblanceolate, 3 to 4 inches long, barely ⅓ inch wide: scape more slender and bracts of the scape shorter and more appressed than in the type, from which it does not otherwise differ.—An extreme form, hardly worthy of specific rank, collected in thin calcareous soil near Biscayne Bay, Fla., by A. H. Curtiss, July 23, 1895 (no. 5494).

**Hemizonia Congdonii**, n. sp.—Low annual or perhaps biennial, much branched from the base, covered especially below with a copious loose lanate pubescence : root slender-fusiform, somewhat branched :

woolly stems white striate-angulate, lucid, leafy: lower leaves pinniatfid, 2 inches or more in length, not rigid nor pungent tipped, 1-nerved, with about 6 pairs of unequal dentate segments, these obtusish or acute, diminishing in size toward the winged clasping petiole; middle and upper leaves inch or less in length, rigidulous, pinnately 3 to 7-toothed with spinulose-tipped pungent teeth, soft-pubescent on both sides and somewhat revolute on the margins: heads terminal or sub-terminal on the branches, only moderately aggregated, including the spreading bracts 6 to 8 lines long; the bracts green except at the pungent tip, entire or rarely 3-toothed, with midrib prominent beneath and considerably thickened toward the base: ray-flowers including the achenes only 2½ lines long, ligules 15 to 18, yellow, 3-toothed at the apex; the tube very glandular-pubescent; the pappus of the disk-flowers 3 erect narrow awns, nearly equaling the yellow corolla: chaff 2 lines long, scarious-margined and with thickened somewhat recurved tips.—Collected by Mr. J. W. Congdon, at Salinos, Monterey county, California, May 26, 1886 (no. 151). Most nearly related to *H. Parryi* Greene, but of lower stature, and with very different woolly pubescence, more divided foliage, and shorter ray-flowers.—B. L. ROBINSON and J. M. GREENMAN, *Harvard University.*

# EDITORIAL.

DURING THE PRESENT MONTH there are meeting in Buffalo three botanical organizations of national scope: the Botanical Club of the A. A. A. S., the Botanical Section of the A. A. A. S., and the Botanical Society of America. Each organization has its own peculiar field, and has been a natural outgrowth from the remarkable botanical activity of the last few years. The question has been raised frequently whether this may not be an unnecessary multiplication of botanical organizations, and whether they may not overlap and interfere with each other. An examination of the original purpose of each makes it evident that no interference is contemplated.

THE BOTANICAL CLUB of the A. A. A. S. was organized when the botany of the Association was but a part of the Biological Section, and its double purpose was to bring the botanists together in a meeting of their own, and to provide a means for the informal presentation of botanical matters of interest and importance, but not adapted to formal presentation. There was no qualification excepting membership in the American Association, even those merely interested in botany being invited to enroll as members. It thus became and continues to be a very general botanical conference, with just organization enough to keep it in existence, and no publication. It is the best organization for the cultivation of a general botanical acquaintance, and the only botanical organization not strictly professional. It was not intended as an overflow from the Biological Section of the Association, except so far as the section was burdened by botanical material not properly belonging to it.

THE BOTANICAL SECTION of the A. A. A. S. was next established, when the botanical papers of the Biological Section justified a separate section. The papers of this organization are intended to be formal and professional, and are published by abstract in the widely circulated Proceedings of the Association, but the only limit to membership is the fee of the general Association. That botanists have repeatedly mistaken the purpose of this organization and have presented loose and rambling talks rather than formal and compact papers is not due to any fault in the design of the organization. However, while the papers are intended to be professional, the audience is miscellaneous, and the subjects selected or their treatment takes cognizance of this fact. It is the place where investigators seek to present their results to the general scientific public, and a semi-popular style is demanded.

THE BOTANICAL SOCIETY OF AMERICA, the most recent of these organizations, is purely professional, both as to membership and audience, and the papers which naturally belong to it are not adapted to either of the other organizations, for they are technical in subject matter and style, and are all prepared for publication in full.

IT WOULD SEEM, from the above presentation, that there is abundant reason for the continued existence of all these organizations, and that they furnish the natural channels of communication for every grade of botanical work, from the briefly stated observations of the amateur to the most elaborate researches of the professional. The first organization has in view the gathering up of miscellaneous observations; the second regards the interest of the public in the results of investigations; the third is concerned solely with the progress of botanical science.

WE HAVE ALREADY alluded to the neglect of foreign literature by some German botanists, as illustrated by the paper of Dr. Correns on the physiology of tendrils.[1] Professor MacDougal called attention to Correns' culpable oversight in a recent note in the *Botanisches Centralblatt*.[2] Correns' reply in the same journal[3] makes the rather curious plea in extenuation, "dass die BOTANICAL GAZETTE in der jene Angaben publicirt wurden, in Tübingen nicht existirt." What would be thought of an American student who excused himself for not knowing of Correns' work by saying that the *Botanische Zeitung* was not to be found in his college library? While the two cases are not precisely parallel they are sufficiently so to show the invalidity of Dr. Correns' plea. And what bearing has Correns' assertion that the first experiment by which he recognized the heat reaction was performed a year before the publication of MacDougal's paper? It would have been much better for Dr. Correns not to plead "extenuating circumstances," but to content himself with a frank acknowledgment of his oversight. We hope the incident will awaken our German friends to the need of consulting at least the index to American botanical literature.

[1] BOT. GAZ. **21**: 248, 398, 304. 1896.

[2] **66**: 145. 1896.

[3] **66**: 290. 1896.

# CURRENT LITERATURE.

## BOOK REVIEWS.

### Warming's plant geography.

THE GEOGRAPHICAL DISTRIBUTION of plants has received much attention for many years, but the earlier observers could do little more than accumulate facts and outline general zones. With the development of plant physiology it became possible to organize these facts upon a scientific basis, and this organization introduces us into the great modern field of ecology, of which geographical distribution is a conspicuous part. Many recent contributions to this region of ecology are scattered through botanical literature, and the time has come for the summing up of results in some general work. Such a work has been prepared by Dr. Warming, and the German translation by Dr. Knoblauch[1] is now before us. It is impossible to give a compact review of such a work, as it is a compendium of important information; and little more can be attempted than to present a brief outline. It is to be hoped that the promised English translation will put the book promptly into the hands of English students. In the introduction the prominent terms are defined. Floristic plant-geography deals with lists, districts, limits, and causes; ecologic plant-geography, the subject of the book, considers adaptations, sociology, and physiognomy. "Life-forms" (epharmony) and "plant-societies" (Pflanzenvereine) are defined, the latter referring to those plant associations which take possession of certain conditions.

The second section discusses the ecological factors and their effects under the following titles: atmosphere, light, heat, atmospheric moisture and precipitation (water obtained from air and soil is emphasized as being the chief ecological factor), atmospheric movements, nature of the nutrient soil, the structure of the soil, the air in the soil, the water in the soil, the heat of the soil, the depth of the soil, the nutriment in the soil, the kinds of soils, chemical *vs.* physical properties of the soil (the author regards the physical properties as most important, as they control the water supply, which is the most important factor), effects of inanimate coverings on vegetation (snow and

[1] WARMING, DR. EUGEN.—Lehrbuch der ökologischen Pflanzengeographie; eine Einführing in die Kenntniss der Pflanzenvereine. Deutsche vom Verfasser genehmigte, durchgesehene und vermehrte Ausgabe von Dr. Emil Knoblauch. 8vo. Berlin: Gebrüder Borntraeger. 1896. *M.* 7.

1896]

fallen leaves), effects of living plant coverings on the soil, activity of animals and plants in the soil, orographic factors (height, steepness, etc.).

The third section considers life-relations and plant-societies under the following subjects: life-relationship of living beings, encroachment of man, life-relationship with animals, life-relationship of plants with each other (parasitism, helotism, mutualism, epiphytes, saprophytes, and lianas), commensalism (plant-societies), classes of societies (amplified in the succeeding chapters).

In section four the hydrophyte societies are considered, the ecological factor being air, light, heat, food-stuffs, specific weight, color, and movements; the structural adaptations noted being in roots, water-conducting vessels, mechanical tissues, air-cavities, epidermis, slime, etc. The different classes of hydrophilous societies are grouped as follows: free-floating or swimming; fixed to the soil, with submerged or floating leaves; and swamp forms. Under the first heading there are four categories, the plankton, glacial plant-unions (ice and snow), saprophilous flagellate unions, and hydrocharite unions (littoral fresh-water free plants). Under the second heading (fixed to soil, with submerged or floating leaves) are plants fixed to stones (nereid-unions), and those fixed to loose soil (sea-grass vegetation, fresh-water vegetation, and schizophyte unions. Under the third heading (swamp plant-societies) the subdivision is into salt water (mangrove vegetation) and fresh water (reed-swamps, swampy moors, sphagnum moors, sphagnum tundras, swampy thickets and woods). Each of these fourteen categories is fully discussed, all the known factors in each situation being considered.

Section five is devoted to xerophyte societies, which involves a full discussion of the adaptations for regulating transpiration and for collecting and preserving water. Under the regulation of transpiration the titles are periodic surface reduction, movements for regulating light, constant profile position (compass plants, etc.), leaves and shoots with reduced surface, covering organs, anatomical structures reducing transpiration, etc. The classification of xerophilous societies is as follows: rock vegetation (subglacial and temperate regions, tropical and dry rock vegetation), subglacial vegetation on loose soil (rocky fields, moss heaths, lichen heaths), dwarf shrub heaths (chiefly ericaceous), sand vegetation (beaches, dunes, sandy fields, etc.), tropical deserts, xerophilous grass vegetation (steppes and prairies, savannas), rocky heaths, xerophilous thickets (in cold and temperate regions, alpine thickets, tropical thorn, palm, fern, bamboo thickets), and xerophilous woods (evergreen conifers, deciduous conifers, xerophilous foliage woods, leafless woods).

Section six considers halophyte societies, the structural adaptations being very marked and often readily modified by removal from halophytic conditions. Naturally halophytes include both xerophytes and hydrophytes, and are grouped as follows: tropical swampy beach vegetation, salt marshes with herbaceous plants (mostly Scirpus-like), rock societies, herb and shrub vegetation in salty sand and gravel, tropical sand-beach woods, leafless halophyte woods in sand, herb and shrub vegetation in clay soil (lagoon thickets, salt steppes), salt deserts, and beach meadows.

The mesophyte societies form the subject of section seven. The general condition is freedom from extremes. The vegetation is rich and dense, and there is great richness in leaf forms. This is the common vegetation of temperate regions and includes the numberless new societies of weeds and culture plants introduced by man. The grouping of mesophyte societies is into grass and herb societies and societies of woody plants. Under the former are included arctic or alpine grass or herb carpets, meadows, pastures on cultivated lands; under the latter, thickets, deciduous woods in temperate zones, and evergreen foliage woods (subtropical, antarctic, tropical rain woods, palm woods, bamboo woods, fern woods).

The last section discusses the struggle between plant societies. After general introductory remarks concerning the nature of the struggle, the facts of overproduction, the easy derangement of the organic equilibrium, etc., the main topics discussed are the production of new soils and their occupation, changes in vegetation induced by slow changes in soil, changes in vegetation without changes in climate or soil, the weapons for the struggle, rare species, the origin of species. We have space for fuller statement of but two of these topics. The general characteristics of vegetation occupying new soil are given as follows: The first vegetation is sparse and open; the number of species is small at first, then larger when the physiognomy is diverse, then comes an equilibrium and fewer species; annuals and biennals are common at first, but afterwards subordinated to perennials; the first species are those whose seeds are carried by winds and birds; light-trees appear before shade-trees; there is a gradual transition to former conditions, and thus there may be primal, transitional and final plant societies. In reference to the origin of species, the author believes that plants possess an innate power of adapting themselves directly to new conditions, a view which he supports by numerous illustrations of direct response of plants to changed conditions. This he regards as one of the greatest factors in the evolution of plants. Others are acquired variability, depending upon descent and not environment; natural selection; crossing of species; and correlation between the parts of a plant, a change in one part affecting the others.

The book certainly meets the demands of a "Lehrbuch" admirably, being comprehensive and yet full enough of details. Its arrangement is to be highly commended, as the numerous subdivisions enable one to find any special topic at a moment's notice. Very few references are made to American plant-societies, chiefly because they have not been investigated sufficiently.—J. M. C.

## Text-book of general botany.

ANOTHER work on general botany, of moderate size, and of a grade for use in colleges, has been provided for English students by the translation of Westermaier's recent volume. The translation has been made by Dr. Albert Schneider,[2] and with the exception of occasional aberrations in the use of *shall* and *will*, and some remnants of Teutonic phrases, it is acceptably done.

There are two reasons why this work is likely to meet with favor from a number of teachers. In the first place it intimately combines physiology with morphology and at every step inquires what use the particular cell, tissue, or organ serves. And then it comes from a new source, being dominated by the views of Schwendener and Nägeli, while our text-books heretofore for the most part have represented the views of Sachs and his followers.

The work is of a suitable size for text-book use, but is not to be put into the hands of novices in botany. For students who have passed the rudiments of the science, and who know something of chemistry and physics, and of the current theories of descent, it will prove serviceable, and, moreover, will be more than ordinarily suggestive and inspiring.

The work is not large, but inclines to be compendious, and this has necessarily led to condensing weighty matters into such brief compass that many statements will prove barely intelligible to the ordinary student unless expounded by a teacher.

While the work has many good qualities, there are some features of it that will surely meet with disapproval from well-informed instructors. The author has failed many times to present the latest and most approved views upon disputed or recently settled topics, especially when such views are in opposition to those of the school to which the author belongs. An instance of this is the presentation of Nägeli's theory of the growth of starch grains and cell wall by intussusception to the extent of several pages, while there is barely mention of the fact that there are later and more acceptable theories, and no attempt to outline them or name the investigators. We can, of course, afford to be a little charitable when the author insists upon his own imperfect views regarding the rise of sap in plants, and we have a curiosity to know just to whom or what he refers when he says that "in regard to this question many authors hold erroneous opinions;" but he does not enlighten us.

The trouble which the author takes to show his opposition to the prevailing views in evolution seem strange in such a work, and does not heighten our appreciation of it. There are many out of date points of view and a corre-

[2] WESTERMAIER, MAX.—A compendium of general botany. Translated by Albert Schneider. 8vo. pp. 299. figs. 171. New York: John Wiley and Sons. 1896. $2.00.

spondingly antiquated terminology maintained in the work, *e. g.*, as to the process of photosyntax in the chlorophyll grain, which is called assimilation, although genuine assimilation is also mentioned. Thus we get this highly ambiguous sentence: "The cotyledons begin the function of assimilation as soon as the reserve food is assimilated." Another instance of a similar nature is in regard to reproduction. Although the author states that "the entire phanerogamic plant with its flowers represents the asexual generation," he constantly speaks of male and female flowers, and of the gynœcium and andrœcium as male and female organs.

There are good things in the book, and we are grateful to the translator for making available for class use a work in which the theories of Schwendener, Nägeli, Haberlandt and their followers are prominent; but it will not do to accept it unthinkingly, even with the translator's footnote corrections. The order of the subjects is as follows: the cell, tissues and simple organs; organs and systems of organs, reproduction, general chemistry and physics of plant life, taxonomy.—J. C. A.

### The hardy bamboos.

MR. A. B. MITFORD, author of "Tales of Old Japan," has just given another result of his former residence in Japan in a book entitled "The Bamboo Garden."[3] The book does not profess to be technically scientific, but it is none the less interesting to botanists, containing much information concerning a large and important group of plants. It deals with the hardy bamboos in cultivation in England, thirty-eight of them being from China and Japan, one (*Arundinaria macrosperma*) from the United States, five from the Himalayas, and three whose nativity is uncertain. The Himalaya region is looked upon as likely to be the most productive of new forms, those of China and Japan having been long known and cultivated. The interesting facts concerning their inflorescence are pointed out, especially the fact that it occurs at long intervals of time, and then in a wonderfully simultaneous way over large areas, and results in the death of the plants. The older travelers, observing this phenomenon, have put upon record the often quoted statement that the plants after inflorescence die throughout, and that new growths come from the seed. They speak of great forests of bamboos disappearing in a single season, a serious calamity to communities so very dependent upon it as are the orientals of Eastern Asia. While this wholesale destruction at long intervals does actually occur, new growths spring very rapidly from the wide-spreading rootstocks. The interval between times of inflorescence was formerly stated definitely as thirty years; but, though infrequent, it varies widely,

[3] FREEMAN-MITFORD, A.B.—The bamboo garden. 8vo. pp. xii + 224, illustrated by Alfred Parsons. London and New York: The Macmillan Co., 1896. $3.00.

dependent upon climatic causes. What has been called the "suicidal mystery of the flower" is graphically stated as follows: "When the given moment has come round, every plant of the same species, whether old or young, over a vast region will put forth its flowers at one and the same moment, and, having seeded, for a time the plant disappears." A curious instance is given of this phenomenon observed under cultivation. In 1867 or 1868 *Arundinaria Japonica* began to bloom in Paris; "at the same moment" blossoms were noted on the plants at Marseilles; and even those in the government gardens at Algiers "flowered in concert with their European brethren; and not only did the whole of the canes, old as well as young, bear flowers together, but the very shoots (three to four inches high) as they showed above the soil, were transformed into flowering stems." In this case, however, the plants were not killed, but very much weakened; for a long time "remaining paralyzed." Mr. Mitford has observed that only those species are hardy in England whose leaves show "tessellated" venation, that is, "in chequers, crossing one another like the threads of a spider's web or the meshes of a net." The tender species observed all have leaves with the ordinary "striated" venation. Mr. Mitford has also observed this same tessellation in the leaves of the only hardy palm of England (*Chamærops excelsa*), and its absence in the tender palms. Mr. Thiselton-Dyer is quoted as remarking that "there must be something important behind a character like this."

The book is handsomely gotten up in white buckram and gilt, on thick paper with deckel edges. The full-page illustrations by Alfred Parsons are charming.—J. M. C.

### The Bonn text-book.

WHEN four of the botanical staff of the University of Bonn combined to write the text-book which, fifteen months after the first, appeared in a second edition,[4] they owed it to their readers to choose a more distinctive title than *Lehrbuch der Botanik*. One cannot cite it now in any decently brief way, but must perforce reel off the list of author's names like a catalogue! For this is a book that one needs to name to students, and that often. No text-book at all comparable with it has been produced in recent years, and unless we much mistake, it is destined to be of somewhat the same value to the present generation as Sachs' classical *Lehrbuch* was to the last. Its excellence carried it through four German and two English editions, besides others in other languages, while it directly inspired and formed the model for various texts by different authors. Much of the excellence of the Bonn

[4]STRASBURGER, NOLL, SCHENCK, and SCHIMPER:—Lehrbuch der Botanik für Hochschullen. Zweite umgearbeitete Auflage. 8vo. pp. vi+556. figs. 594, in part colored. Jena: Gustav Fischer. 1895. *M.* 7.50 unbound; *M.* 8.50 bound.

text-book is due to the division of labor made possible by having four collaborators, each a specialist in the section he treats.

Was it pure accident that exactly one-fourth of the pages are by Strasburger, on morphology, one-fourth by Noll, on physiology, while in the remaining half, the cryptogams, by Schenck, yield a little to the phanerogams, by Schimper? There seems something too much of exactness here for pure accident, particularly as one would hardly expect such a division of space from the nature of the subjects.

It is difficult, where all is so good, to point out the best; yet every reader will concede the palm to the first half of the book. External morphology is cut rather short by Professor Strasburger, and we are so charmed by his treatment of the internal morphology that we are less ready to forgive him the abbreviation. The presentation of the physiology is particularly clear and effective. But the enumeration of the characters of each order, and even of each family among the phanerogams, seems to us barren and unfruitful. Why can we not have a treatment of special morphology which shall be more thoroughly comparative? There is need to organize the facts known so that they shall form for the student a body of symmetric truth, rather than remain disconnected members, related indeed, but scattered as it were in a valley of dry bones. Some attempt at this indeed is made by both Schenck and Schimper, and with much greater success by the former. Schimper seems less able to free himself from the overpowering precedents in the treatment of phanerogams, so that one finds less that is fresh or suggestive here than in any other part of the book.

Yet it is all good after its kind; well put, well printed, excellently illustrated. The colored figures are rather for show than of value, though they are quite truthful in color. We hope soon to welcome an English translation of this excellent book.—C. R. B.

## MINOR NOTICES.

MR. B. T. GALLOWAY has prepared a brief paper upon "Frosts and freezes as affecting cultivated plants," in which he has brought together some of the more important facts relating to frosts and freezes as affecting the farmer, gardener, and fruit grower. The paper appears in the Yearbook of the Department of Agriculture for 1895, or may be obtained as a separate. —J. M. C.

MR. A. S. HITCHCOCK, in the last bulletin (no. 57) from the Kansas Experiment Station, which is the third contribution upon the subject of Kansas weeds, introduces some useful features in presentation. Instead of the customary bare list, with perhaps a few notes, the list is a descriptive one, with easy artificial keys; numerous plates give typical leaves, to aid in identification; and the distribution by counties of almost all the species is shown upon 172 reduced maps.—J. M. C.

THE FIRST REPORT on the flora of Wyoming by the botanist of the Experiment station, Mr. Aven Nelson, has just appeared (May) as Bulletin no. 28. The list of species, with full notes, contains 1118 spermatophytes, all of which are represented in the herbarium of the station. A very convenient feature of the report is that it also contains lists of plants reported for the state but not represented in the herbarium. Fourteen new forms are described, eleven of them as varieties, and three as species (*Aquilegia Laramiensis*, *Potentilla pinnatisecta*, and *Hymenopappus ligulæflorus*).—J. M. C.

ACCORDING TO Mr. Herbert J. Webber, who has studied the pineapple industry in the United States, this tropical fruit, indigenous to South America, is being so extensively cultivated in southern Florida as to be worthy of consideration. The sources of large supply for the United States have been and still are the West Indies and Bahamas, but with about 2500 acres already in cultivation in Florida and the possibility of large extension, increased demand for the fruit may be met by home supply. Mr. Webber presents a full report of his studies in the Yearbook of the Department of Agriculture for 1895.—J. M. C.

THE TUMBLING MUSTARD (*Sisymbrium altissimum*) has begun to attract the attention of those interested in agriculture. Apparently a native of the Mediterranean region, it has spread throughout Europe, northern Africa, and western Asia, as a troublesome weed in cultivated fields and meadows. During the past five years it has made extensive inroads in the Canadian northwest provinces, and now it is reported from nine different localities in the United States, ranging across the continent, and as far south as Missouri. Its method of seed dispersion is indicated by its popular name. The Department of Agriculture has sounded a note of warning, and has given all necessary information, in Circular no. 7, issued from the Division of Botany, and prepared by Mr. Lyster H. Dewey.—J. M. C.

IT MUST BE that such books have a distinct place to fill, or they could not run to third editions as has Mathews' *Familiar Flowers*.[5] This one has its striking merit in its illustrations, most of which are accurate and altogether admirable, though the author, who is likewise the artist, sometimes fails to catch the texture of his leaves. But the illustrations allow ready identification of the commoner attractive plants of the northeastern states. The chatty

[5] MATHEWS, F. SCHUYLER :—Familiar flowers of field and garden, described and and illustrated, with over 200 drawings by the author, and a systematical index and floral calendar. Third edition, 12 mo. pp. viii + 308. New York: D. Appleton & Co. 1896.

notes which accompany each figure are interesting, but unfortunately sometimes "popularize" facts at the expense of accuracy. It needs to be insisted upon that simplicity of statement need not involve any inaccuracy. Why, for example, should the author mislead his readers by comparing the chicory head with a single flower in this wise: "Not only these straps, but the center of the flower (the stamens and styles) looks very much like the dandelion." And of the everlasting (*Gnaphalium*) he writes: " . . . the little white flowers are so much like miniature pond lilies under the microscope that the resemblance is amusing," For the readers, however, these slips will not be disquieting, and are only worth mention because they mar an otherwise good book.—C. R. B.

ONE OF THE most interesting contributions from the National Herbarium is that by Mr. P. A. Rydberg upon the flora of the Black Hills of South Dakota.[6] The region is often called an intermediate one, because the floras both east and west of it have received more attention. The report, therefore, deals with one of the regions most in need of investigation. In his prefatory discussion Mr. Rydberg deals with such topics as geography, geology, altitudes, precipitation and temperature, and floral districts. Under the last topic he considers five districts differing in topographical and climatic conditions, and hence in vegetation. They are the foothills, Minnekahta plains, Harney mountain range, limestone district, and northern hills. It is interesting to note that the characteristic plants of the foothill region are grouped as follows: very hairy plants; plants with a glaucous foliage having a hard epidermis; plants with white, often shreddy, stems; plants in which the surface is reduced to a minimum; and plants with a deep-seated, enlarged root. The catalogue of species, which is full of valuable notes as to range and habit, contains about 700 spermatophytes and pteridophytes. One of the most interesting discoveries was that of true *Aquilegia brevistyla* in the United States, the plant from the Rocky mountains heretofore bearing that name having been proved to be quite a distinct species, which Mr. Rydberg has called *A. saximontana*. The plates consist of a good map of the region the two Aquilegias referred to, and *Poa pseudopratensis*, a new grass.—J. M. C.

## NOTES FOR STUDENTS.

ROSENBERG has found[7] that in herbaceous perennials differences in the starch content exist in the course of the winter similar to those well known in trees through the very exhaustive researches of Fischer.—C. R. B.

[6] RYDBERG, P. A.—Flora of the Black Hills of South Dakota. Contributions from the U. S. National Herbarium 3: 463–536. 1896. [No. 8.]

[7] Bot. Centralb. 66: 337. 1896.

DANGEARD has described the life-history of a parasite of the nucleus of *Amœba*, and named it *Nucleophaga Amœbæ*. It is probably one of the lowest Chytridiaceæ, related to *Sphærita*, which is a recently discovered parasite on *Euglena*.[8]—C. R. B.

IN REVIEWING the species of *Asimina*, Mr. Geo. F. Nash recognizes (*Bull. Torr. Bot. Club* 23 : 234. 1896) seven species, one of which (*A. speciosa*) is described for the first time, having been confused heretofore with *A. grandiflora* Dunal, which becomes *A. obovata* (Willd.)—J. M. C.

DR. F. W. KLATT has just described (*Bull. Herb. Boiss.* 4 : 456–475 and 479, 480. 1896) the following new genera of Compositæ, all African except the last, which is Cuban: *Symphipappus* (Inuloideæ), *Distegia* (Helianthoideæ), *Dolosanthus* (Mutisiaceæ), *Monactinocephalus* (Mutisiaceæ), and *Lepidesmia* (Eupatoriaceæ ?). Each genus is illustrated with a plate.—J. M. C.

WINOGRADSKY has communicated to the Paris Academy of Sciences[9] the results of M. V. Fribes' researches in his laboratory at St. Petersburgh upon the maceration of flax for the isolation of the fibers. The rotting is due to an obligate anaerobic bacillus, which acts not as a cellulose ferment but as a pectin ferment. It dissolves the middle lamella of the cortical parenchyma which consists of calcium pectinate, and thus isolates the fibers.—C. R. B.

MR. P. A. RYDBERG has begun a series of notes on *Potentilla* (*Bull. Torr. Bot. Club* 23 : 244. 1896), in which his views as to the limitation of species differ widely from those of Dr. Watson (*Proc. Amer. Acad.* 8 : 549–573), and agree closely with those of Dr. Christian Lehmann, of Hamburg, whose "Revisio Potentillarum" (1856) serves as a basis for the present work. As the genus is one of the most perplexing of our flora it is to be hoped that Mr. Rydberg will be successful in this attempt to disentangle the species.—J. M. C.

M. J. BRIQUET announces (*Bull. Herb. Boiss.* 4 : 354. 1896) the discovery of a hybrid between *Bupleurum ranunculoides* and *B. longifolium*, two species very distinct morphologically and topographically. The discovery is interesting, not merely on account of the distinctness of the parent species, but also because of the extreme rarity of reported hybrids among the Umbelliferæ. The hybrid, named *B. Guineti*, seems well established, is distinctly intermediate in its characters, and exhibits a wide range of variation.—J. M. C.

AMONG THE NEW Verbenaceæ recently described by J. Briquet (*Bull. Herb. Boiss.* 4 : 336. 1896), *Xeroplana* is a new genus from South Africa; *Lippia Pringlei* is a new species from Guadalajura, Mexico (*Pringle* 1733, dis-

[8] *Cf.* Bot. Centralb. 66 : 256. 1896.

[9] Compt. Rend. 121 : 742. 18 N 1895.

trib. of 1888); *Callicarpa Pringlei* is a new species from San Luis Potosi (*Pringle* 3094); *Vitex Hemsleyi* is a new species from near Oaxaca (*Jurgensen* 68), referred to by Hemsley in Biol. Centr.-Am. Bot. **2** : 540; *Citharexylum Jurgenseni* is a new species from near Oaxaca (*Jurgensen* 259); and the remaining nine species are mostly from northwestern South America.—J. M. C.

ABOUT A YEAR and a half ago Askenasy suggested that the vexed question of the ascent of water in plants was explicable by the force of imbibition of the cell-walls of the leaves and the cohesion of the water columns in the ducts.[10] He has devised an ingenious apparatus to illustrate the physical principles involved, which imitates fairly well the conditions in the plant. The fault common to the apparatus used by Jamin, Naegeli, and Strasburger is that the conducting portion consisted of porous material and was not essentially different from the evaporating and lifting portion. Askenasy's apparatus consists of a glass tube $90^{cm}$ long and $2.2$–$3.5^{cm}$ in diameter, ending in a small funnel which is plugged with gypsum or even has the gypsum spread over its whole inner surface. The gypsum corresponds to the membranes of the leaf, the tube to the wood vessels in which the water ascends. With certain precautions the tube is filled with water, its open end immersed in mercury, and fastened upright. In one experiment in 33 hours the mercury rose to $82^{cm}$, and in another in 26 hours to $89^{cm}$, *i. e.*, into contact with the gypsum. In the first its complete ascent was hindered by the formation of an air bubble. (*Cf.* Bot. Centralb. **66** : 379. 1896)—C. R. B.

DR. MAXWELL T. MASTERS has published from time to time the results of his researches among the Coniferæ. His most recent contribution deals with the genus *Cupressus*,[11] which he has reexamined with fuller material and assistance. The genus he regards as well-defined among its allies by the peltate expansion at the free end of the cone-scales, but the species are very difficult of limitation on account of the great inconstancy of the characters used, as well as the long cultivation of many of them. They are remarkably polymorphic, a certain well-known "stage of growth" in some species having given rise to the old genus *Retinospora*. The author regards *Chamæcyparis* as unworthy of generic rank, and is inclined to believe that the closely allied *Thuya* and *Libocedrus* might well be merged under *Cupressus*. His presentation of the alliances represents two divergent lines from *Cupressus*; one leading to *Juniperus*; the other, through the *Chamæcyparis* forms, leading to *Thuya*, *Libocedrus*, and *Fitzroya*. The varieties of foliage are discussed, but no physiological or phylogenetic significance suggested as explanatory of their

[10] Verh. nat. hist.-med. Ver. zu Heidelberg N. S. **5** : (1–23). 1895. *Cf.* Bot. Cent. **60** : 237. 1895.

[11] MASTERS, MAXWELL T.—A general view of the genus Cupressus. Jour. Linn. Soc. Bot. **31** : 312–363. 1895.

extreme anatomical diversity. The cone-scale, that fruitful organ for morphological discussion, shows distinctly its double nature in containing two distinct vascular systems, which are given off separately from the axis, the system of the seminiferous-scale portion having an inverse orientation of its elements. Fourteen species are recognized, five of which belong to the subgenus *Chamæcyparis*. The North American species are as follows: *C. Benthami*, of Central America, Mexico, and adjacent United States, and under which Greene's *C. Arizonica* appears as a variety; *C. macrocarpa*, of California, under which Watson's *C. Guadalupensis* appears as a variety; *C. Goveniana*, of California; *C. Macnabiana*, of California; *C. thurifera*, of Mexico; *C. thyoides* (*Chamæcyparis sphæroidea, Thuya sphæroidea*), of the Atlantic coast; *C. Nootkatensis* (*Cham. Nutkænsis, Thuya excelsa*), of the Pacific region from Oregon to Alaska; and *C. Lawsoniana* (*Cham. Lawsoniana*), of California and Oregon.—J. M. C.

MR. F. W. KEEBLE, during a brief stay in Ceylon in 1894, made a very considerable number of interesting observations, some of which he presents in a paper published in the Transactions of the Linnean Society of London, and more of which he promises to give in subsequent papers. In the present paper he sets down some of his observations on the Loranthaceæ native in Ceylon.[12] These green, semi-parasitic phanerogams have been attracting more than usual attention of late, as is shown by Van Tieghem's numerous publications concerning them, as well as others by less well known authors. Mr. Keeble's paper concerns itself first with the pollination of the flowers, which are large and conspicuous in many species, and deviate more or less from the regular type. To the observations of Wallace and others, that the tubular loranths are bird-pollinated, Keeble adds his own, giving greater precision to what was already known and contributing some new facts. Those flowers which depart from the type by developing a slit in the tubular corolla, and by placing the opened anthers in a row behind the style instead of in a ring around it, apparently derive a double advantage. The birds which frequent these flowers, being larger and less accurate in their movements than pollinating insects, are likely to rupture the delicate parts more or less, and do this even when the corolla is already split and the stamens are arranged in a row, though of course to a smaller and less damaging extent in such cases. Furthermore, their beaks, when these come into contact with the anthers on pushing into the flower, become dusted with pollen only upon the upper half, and deposit some of their pollen upon the protruding style of the next flower visited before pushing against its anthers. In those species whose otherwise tubular corolla is cleft, the stealing of nectar by birds which bite into the corolla-tube without cross-pollinating is materially less than in other species. A very considerable number of species have flowers which open only when

[12] Transactions Linnean Society of London, 2d Series, Botany 5: [May]. 1896.

struck. The blows which are needed to open such mature flowers are ordinarily given by the birds which frequent them. Mr. Keeble suggests that this is an adaptation which is mutually advantageous: "The bird knows it is worth its while to 'tap a new barrel' as it were," for obviously there will be most nectar in such still unopened, and ence unvisited, flowers; and the pollen is protected from rain. This, since the majority of the species with exploding flowers either blossom during the rainy season or else grow where there is almost daily rain the year through, is a matter of considerable importance. Blossoming during the rains, even when not a matter of necessity, may be an advantage, since the seeds germinate most successfully, if not exclusively, in moist air.

As to the dissemination of seeds, Mr. Keeble disagrees somewhat with the generalizations of some authors on the subject,[13] to the effect that the seeds pass through the alimentary canal of birds and are dropped in their excrement unharmed upon the branches of trees. He finds that, of the large seeds at least, such few as are swallowed are decomposed, if not profitably digested, but that most of them are carefully expelled from the fleshy pulp before it is eaten, and if they adhere to the bird's beak are rubbed off upon any convenient object, a branch or even a telegraph wire. "On the single telegraph wire," at the Hill-Garden of Hakgala, "there are every year hundreds of seedlings of *Loranthus loniceroides*, all in early stages of germination." Furthermore, the large amount of tannin found in the coats of the seeds would make them unpalatable, and prove a useful protection against the seeds being swallowed.

In the tropical species of the Loranthaceæ, germination begins as soon as the ripe seeds have fallen where there is sufficient moisture, if not in the substratum, at least in the air. In *Loranthus loniceroides* the large seed sticks in a vertical position upon a branch or similar object, usually with the plumule pointing downwards because of the very adhesive *viscin* which is most abundant at this end. From the upper end the chlorophyll containing hypocotyl grows out, its enlarged apex or head pointing vertically upwards and carrying a drop of resin. During its subsequent growth, the hypocotyl curves over and finally, if it has attained sufficient length so to do, applies its head, now enlarged somewhat into a disc-shaped "sucker," vertically upon the support. The cells in the center of the sucker become papillate and penetrate the superficial cells of the host, while meantime the peripheral cells of the sucker have multiplied and grown, and thus furnish a broader and stronger attachment to the host. After such an attachment has been effected, the hypocotyl straightens, thus detaching the seed from the branch and carrying it up into the air. Much of the food has been transferred from the endosperm to the hypocotyl and may perhaps be temporarily stored, for the nourishment of

[13] "The Natural History of Plants," Kerner, trans. Oliver, 2: 205.

the haustorium, in the enlarged sucker. Then the cotyledons and the remainder of the endosperm are cast off and the plumule appears. This small structure develops minute leaves in pairs upon successive nodes separated by very short internodes, the leaves falling soon after formation. Only after the haustorium has penetrated the host does any development of branches take place; then, however, growth becomes very rapid and large leaves form. Mr. Keeble interprets the growth of a lateral aerial root from the sucker, a phenomenon which not infrequently occurs before the penetration of the haustorium into the host, especially on small or poorly nourished branches, as throwing light on the manner in which these plants became parasitic. "The seeds, originally sticky, often lodged on trees, and, as in many species of Ficus, these seeds, germinating, threw out roots which rapidly reached the ground, or the earth which collects in the forks of trees. To enable the plant to exist in this early non-parasitic stage, the base (free end) of the sucker came to function as a reserve food store. From this stage the natural semi-parasitism was reached by the ability of certain cells of the distal end of the hypocotyl to penetrate the host."

The curvature of the hypocotyl, above referred to, has long been known to be independent of gravitation (it is ageotropic) and has been attributed solely to the influence of light (it is negatively heliotropic, and hence bends toward the central shaded portion of the tree to reach the branch upon which the seed has fallen and stuck); but Keeble demonstrates, by germinating the seeds in the dark, that the hypocotyls of some species imitate tendrils, and hence may, often do, succeed in applying their enlarged heads to the surface of branches in this way. Owing to the resinous matter which covers them, the heads stick. In these species, the nutation may cause the head or sucker end of the hypocotyl to point temporarily directly towards the light, but it obviously supplements the negatively heliotropic curvature at other times and hence is advantageous to the seedling. Though the general surface of the hypocotyl is not sensitive to the contact of solid bodies, the growth of the head or sucker, and its close application and subsequent attachment to the branch, are to be attributed in part to irritation by such contact. Contact with lifeless or otherwise innutritious objects does not, however, induce such active and prolonged growth as is produced by contact with a suitable host. On the other hand, the growth of the haustorium from the head and toward the solid object seems to be induced by contact with any solid body. Keeble describes an experiment in which he applied a small cover-glass to the head of the hypocotyl of *L. loniceroides*, with the result that there was only slight enlargement of the head, which had not developed an effective sucker, though it remained fast by reason of the adhesive resin, whereas the haustorium had grown out to a distance of $2^{mm}$ beyond the margin of the disc, being deflected from its course by impenetrable glass. The cells which form the central part of the surface of a sucker which is in contact with a host become papillate, and, by pressure and solvent action combined, penetrate the superficial cells of the host. When these have succeeded in penetrating, the sucker enlarges still more, and thus furnishes a strong brace for the haustorium, which must necessarily develop considerable pressure to penetrate into the deeper tissues of the host, although at the same time it may perhaps supplement this mechanical penetration by the softening or solvent action of any enzymes which it may be able to secrete. In these ways the behavior of the haustorium and the sucking-disc of the Loranthaceæ is not unlike that of the completely parasitic phanerogams. In an appendix, Mr. Keeble describes the forms of the fruits and seeds of some of the Cingalese Loranthaceæ. This interesting and suggestive paper is illustrated by several woodcuts and two large well-executed lithographic plates.—GEORGE J. PEIRCE.

# OPEN LETTERS.

## CAN RESEARCH WORK BE ACCOMPLISHED IN AMERICAN LABORATORIES?

*To the Editors of the Botanical Gazette:* — It has long been the custom of American botanists to make comparisons of the facilities for research afforded by our own laboratories and those of Europe, to the great disparagement of the former. In view of our rapid development in methods of elementary teaching, and the yearly establishment of a number of new chairs of botany, it may be well to inquire at this time into the particulars upon which our alleged inferiority is based, that we may remove the chief faults if inherent in our system of organization, or grow out of them as rapidly as possible.

The essential factors for original work are a group of living or prepared plants, a laboratory, the literature of the subject to which attention is directed, and a moderate amount of cerebral matter in possession of an enthusiastic determined person with thorough training and persistent botanical tendencies.

So far as plants are concerned, the American botanist has at his very door hundreds and thousands of species which furnish ample material for the solution of some of the more important problems, particularly those to be solved experimentally, a fact needing no discussion.

The chief dissatisfaction with our laboratory facilities arises from a narrow view of the fields open to research. No laboratory in the world is fitted for research in even a majority of the phases of the subject, and it is quite as easy to fix upon some problem which may not be worked out in a given laboratory, as it is to select those for which it is especially effective. This is especially true so far as apparatus is concerned.

It has come to be recognized in the laboratories in which research is most actively prosecuted, that costly and complicated pieces of fixed apparatus are by no means a requisite for the performance of valuable work, but that the proper appliances in each instance should be extemporized from a common stock of glass, wood, and hardware. In order to place a definite statement on record, the writer insists that even the laboratory with a yearly expense account of "thirty seven dollars" is not entirely debarred from research.

Perhaps the greatest difficulty which confronts the American worker is the lack of reference literature. There are, however, several extensive libraries in the country which are readily accessible, and with the exercise of some patience the investigator may possess himself of the information concerning work previously accomplished upon his subject, in ample time for the publication of his results. In many instances he may own the literature at a very slight cost.

Most serious of all, however, are the subjective difficulties of the director of the laboratory, who to the above category, adds that of lack of time, etc., and constantly calls attention to the fact that our European colleagues do so little actual teaching and executive work that they are able to accomplish a large amount of investigation ; a statement by no means confirmed by the personal experience of the writer in the more important laboratories of Germany and England. A dozen pages of this journal might be filled with titles of work accomplished with as limited facilities and under as great a stress of other duties as those which confront the American worker, and the writer confidently asserts that any American botanist may accomplish a certain amount of research if he is fully determined upon it, and that, too, without recourse to the "holidays and Sundays" in which a German zoologist completed a recently published work. It appears, therefore, that the greatest hindrances to research work lie, not in our material facilities or organization, but rather in the mental attitude of our would-be (?) investigators. In order to dispel any doubts remaining it might be well for the GAZETTE to publish a second laboratory number, which would also show our progress in that particular during the last decade.

In conclusion it is proper to state that by original work is not meant the collection of a number of random observations, but the acquisition of new facts, which added to those already known will suffice for the formulation of new laws, or the extension, or critical delimitation of existing generalizations

D. T. MACDOUGAL, *University of Minnesota.*

# NEWS.

MR. J. C. WILLIS has been appointed director of the Royal Botanic Gardens of Ceylon.

AT THE MEETING of the Linnean Society of London on May 7th, Profes- D. H. Campbell was elected a foreign member.

PROFESSOR D. T. MACDOUGAL returned from Europe August 15, after a short period of study in Professor Vöchting's laboratory at Tübingen.

DR. J. C. ARTHUR left Bonn about August 15th, intending to spend a few days in England, and to reach his work at Purdue University, September 1st.

MR. W. L. BRAY, who has recently had charge of the botanical work at Lake Forest in the absence of Dr. Harper, has gone to Germany to spend a year in study.

THE OBSERVER (Portland, Conn.) has been greatly enlarged and improved. It is now one of the best periodicals for amateur naturalists which comes to our table.

PROFESSOR R. A. HARPER, of Lake Forest University, returned from Europe a short time since. He was the recipient of the doctorate from the University of Bonn during the last semester.

MR. W. J. V. OSTERHOUT has accepted the position of instructor in botany in the University of California. He recently returned from a year's study in Professor Strasburger's laboratory at Bonn.

DURING A RECENT visit of the king of Siam to the Botanic Garden at Buitenzorg the dignity of Commander of the Order of the White Elephant was conferred upon Dr. M. Treub, director of the gardens.

DURING THE SEMESTER just closed the workers in Professor Strasburger's research laboratory at the Botanic Institute, Bonn, included five Americans, two Germans, one Swede, one Pole, one Russian and one Englishman.

Mr. D. G. FAIRCHILD, after more than two years' study in European laboratories, has gone to Buitenzorg, Java, to carry on further researches. He has severed his connection with the United States Department of Agriculture.

Dr. H. Schenck of Bonn, who was recently made professor extraordinary, has accepted the position of professor ordinary at the Polytechnicum at Darmstadt and director of the botanic garden, to succeed Professor Dippel, who retires from active work.

Coulter's *Flora of Western Texas*, published among the contributions from the United States National Herbarium, and issued in three parts, has been republished and bound into a single volume. The original edition of the first part had been entirely exhausted.

Dr. E. Koehne, of Friedenau bei Berlin, the well-known dendrologist and editor of the *Botanisches Jahresbericht*, has begun the issue of a "herbarium dendrologicum adumbrationibus illustratum," by the distribution of the first century. The generally poor representation of woody plants in herbaria ought to make this set of exsiccatæ particularly acceptable.

Professor Dr. Comes, who has been for some years engaged in a study of tobacco, offers seeds of a very large number of garden varieties, forms and their hybrids in exchange. He especially requests those who have any uncertain species or varieties of *Nicotiana* in their herbarium to send him specimens for examination, which he will promptly return. He recognizes, in a tentative classification, six varieties of *Nicotiana Tabacum* and seven of *N. rustica*.

Professor C. R. Barnes and Mr. F. D. Heald have recently sent to press a second and very greatly enlarged edition of Barnes' *Keys to the Mosses of North America*, which is to be published about Oct. 1st, as a *Bulletin* in the Science Series of the University of Wisconsin. It will make a work of from 175–200 pages, including not only a key to the published species, so far as possible, but also collected descriptions of species not described by Lesquereux and James in the Manual.

One of the features of the Innsbruck botanical garden is the planting together of plants illustrating certain ecological relations. Professor Dr. Heinricher has arranged thirteen groups among which may be noted compass-plants, climbers, humus plants, parasites, plants with weapons, etc. A list of the best representatives of each group, together with some culture notes, is given in the *Botanisches Centralblatt* **66**: 273. 1896. Other gardens with such grouping are Berlin, Munich, and Zürich.

Mr. George W. Vanderbilt has imported from Europe what is considered to be the most valuable library on forestry in the world, for his Biltmore estate. Mr. Vanderbilt has started forest culture on a large scale at Biltmore, under the management of Mr. Gifford Pinchot, and has built a number of cottages on his estate for the special use of students of forestry.

As these will have access to the library mentioned, it will be, for all practical purposes, a free library.—*Book Reviews,* August.

AT THE LAST meeting of the Linnean Society, just before the summer vacation, a paper was presented by Professor D. T. MacDougal on the relation of the growth of foliage leaves to the chlorophyll function, and also one by Mr. Alfred Russell Wallace on the value of specific characters. The occasion was especially notable as being the fortieth annual meeting since the joint presentation before the society of the subject of the origin of species by Charles Darwin and Alfred Russell Wallace. The gathering in consequence took on something of the character of an ovation to Mr. Wallace.

THE DEATH of William Hamilton Gibson in the latter part of July removes an acute observer and an artist of great excellence as an illustrator. His first work was done for the *American Agriculturist,* while his later work in *Harper's Magazine* and in popular books is familiar to all. His recent studies were chiefly upon the relations of flowers and insects, upon which he had prepared a series of lectures, illustrated by most ingenious mechanical charts, showing the insects and flower parts in action. He had already done much to popularize (in its best sense) the study of plants in the field, a greatly needed work cut short by his untimely death in middle life.

THE BOTANIC GARDEN at Oxford is said to be the oldest in Great Britain. It was presented to the University in 1632 by Henry L. Danvers, earl of Danby, who spent a large sum in filling in the ground to raise it above overflow from the river that runs along one side. He also built the high stone wall about it, as it now stands. at an expense of 5000 pounds sterling. Part of the elaborate gateway designed by Inigo Jones, including the statues of Charles I and Charles II, was added later. It is a curious feature that the ground on which Lord Danvers spent such a large amount of money was not bought, although it must have been a cheap piece of land, but was leased from Magdalen College at an annual rental of thirty pounds sterling. The lease is still in force without alteration, the last renewal in December 1880, being for sixty years. There is no danger, as reported in American journals, that the lease will ever be closed or changed, unless it is the desire of the University.

*BOTANICAL GAZETTE*

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Vol. XXII SEPTEMBER 1896 No. 3

THE

# BOTANICAL GAZETTE



ISSUED SEPTEMBER 23



CHICAGO, ILLINOIS

Published by The University of Chicago

The University of Chicago Press

# Botanical Gazette

A Monthly Journal Embracing all Departments of Botanical Science

**Subscription for 1896, $3.00** **Single Numbers, 30 Cents**

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[Entered at the Post Office at Chicago, Ill., as second-class postal matter.]

VOLUME XXII NUMBER 3

# BOTANICAL GAZETTE

*SEPTEMBER 1896*

## BOTANICAL OPPORTUNITY.[1]

WILLIAM TRELEASE.

IN selecting a subject for the first presidential address before the Botanical Society of America, which you have done me the honor of requiring of me, I have deviated somewhat from the customary lines of such addresses, inasmuch as I have not attempted to present an abstract of recent general progress in botany, nor any results of my own investigation. Such topics, indeed, are more likely than the one I have chosen to interest an assemblage of specialists like this society ; but as the society is supposed to have as a principal object the promotion of research, the present has seemed a fitting occasion to address, through the society, the large and growing number of young botanists who may be expected to look to this society for a certain amount of help and inspiration in the upbuilding of their own scientific careers : hence it comes that I have selected as my subject "Opportunity."

Let us for a moment compare the conditions under which scientific work is done today with those prevalent in the past. From a purely utilitarian, and, for a time, perhaps almost instinctive knowledge of plants and their properties, beginning, it may be, before our race can be said to have had a history, through

[1] Address of the retiring president, delivered before the Botanical Society of America, at Buffalo, N. Y., Aug. 21, 1896.

the pedantry of the Middle Ages with their ponderous tomes, botany, almost within our own memory, stands as the scientific diversion or pastime of men whose serious business in life was of a very different nature. Such training as the earlier botanists had was obtained as being primarily useful in other pursuits than pure research, though there is abundant evidence that the master often enjoined upon the pupil the possibilities of botanical study, and no doubt he stretched the limits of botanical instruction deemed necessary, just as is done today in technical schools, in the hope that the surplus might be so used as to increase the general store of knowledge ; but, at best, training was limited, and research was recreation and relaxation.

But our predecessors, even the generation immediately before us, lived under conditions which made it possible for a man to hold high place in the business or professional world, to accumulate wealth in commerce, and at the same time to devote much time to the study of nature. Today the man who is not entirely a business man is better out of business, and, with a few exceptions, the man who is not entirely a student is little better than a dilettante in science. Concentration is the order of the day, and specialization is the lot of most men. But specialization, the keynote of progressive evolution, is always intimately associated with a division of labor. Fortunately, the men who enter and win in the great game of commerce and manufacture see in a more or less clear way that nearly every great manufacturing or commercial advance has grown out of a succession of obscure discoveries made by the devotee to pure science, often considered by him, indeed, only as so many more words deciphered in the great and mysterious unread book of nature, but sooner or later adapted and applied for the benefit of all men by the shrewd mind of a master in the art of money-making. To these men, successful in business, we owe it that today not only are some men able to devote their entire time to scientific research and the propagation of knowledge, but that their work is done under favorable conditions, and with a wealth of aids and adjuncts that would hardly have been thought of a generation ago.

Instead of a smattering of systematic botany and organography, given as an adjunct in chemistry, medicine, or engineering, the student who wishes may today equip himself for a life of research in botany, by a considerable amount of preparatory work in the lower schools, beginning, perhaps, even in the kindergarten, and by devoting the larger part of his undergraduate time in college to the elements of the subject in the broadest and, if he wish, technical scope, having the benefit of marvelously detailed appliances and a broad knowledge of general facts. If he can and will work for a higher university degree, thus equipped, he may delve into the depths of the most limited specialty, guided for a time by those who have already broken soil there, and left at last with a rich and unexplored vein for his own elaboration. With this training, if he be fortunate in securing a position offering opportunity for research, or if he enjoy independent means, he may hope for a lifetime of more or less uninterrupted opportunity for unearthing the wealth of discovery that lies just within his reach.

Considering the prevalent conditions, my subject naturally divides itself into two quite distinct parts : the opportunity of institutions and of individuals. We stand today, apparently, at a transition point. Most of the active workers of the present time are college professors who have done the research work that has made their names known, during the leisure that could be found in the year's routine of instruction or during their long vacations, and with facilities nominally secured for class use, or, in many instances, like those of a generation ago, the private property of the investigator. Even when appreciated at something like its true value, their original work, for the most part, has been closely watched to prevent it from encroaching upon the first duty, class work ; and in most cases the facilities that they have been able to bring together are in direct proportion to the number of students attracted to their departments, and therefore in inverse ratio to their own leisure for research. But, as I have already stated, the feeling is growing among men able to foster such enterprises, that research is a thing worthy of being promoted, and we have before our eyes the spectacle of a gradually unfolding class of institutions in which investigation is not only tolerated but expected, either as an adjunct to instruction, as in the greater number of colleges, as a concomitant of educational displays, as in botanical museums and gardens, or, at least nominally, as a basis for technical or economic research, as in several of the larger drug houses, and, notably, in various agricultural experiment stations and the national Department of Agriculture. Perhaps the time has not yet come when laboratories of botanical research can stand out quite alone and justify their existence without reference to other ends, the utility of which is more generally understood and conceded, but it seems safe to predict that the next decade will see their complete evolution.

Opportunity for institutions lies primarily in equipment, and secondarily in its use. The problem of equipment for research is a complicated and difficult one. So long as there were no laboratories especially designed for this purpose, it was natural that the instructional laboratory should be furnished with appliances for demonstration, and that these should be amplified as far as possible, for the repetition of experiments, in the first place, and afterwards for their extension ; and it is no doubt true that a number of the smaller educational laboratories are today over-equipped when account is taken of the possible use to which they can be put. With a specialization such as we now see in progress, it may be questioned whether the ordinary collegiate equipment cannot be reduced in scope in many instances, with benefit to the institution, by releasing money often badly needed in other directions, either in the same or different departments. On the other hand, it is certain that the equipment of the broader research laboratories, whether connected with universities or independent, must be made much more comprehensive than any which today exists in this country.

Under the stimulus of the last two decades, botany has come to the front in most colleges as a study well calculated to develop the powers of observation and the reasoning faculties. Where it still occupies the place of a fixed study of a few terms' duration in a prescribed undergraduate course, it is evident that the necessary equipment of a department is expressible in the simplest terms: for each course, that which is needed to exemplify by the most direct object lessons the subject selected, and enough general and collateral material and literature to complement the work. But the case is somewhat different when, as is now frequent, a considerable option is allowed the student in the courses taken for the baccalaureate degree. Here the temptation exists to secure equipment for the broadest possible series of electives, and it is too often yielded to for the best interests of the institution. However liberal one may be in the matter of electives, it is evident, in most instances, that the student cannot afford to devote more than about one-half of his undergraduate time to a single study like botany, and in this time he can cover only a definite amount of ground. While there is a certain seductiveness in the perusal of long lists of electives in a college catalogue, the serious contemplation of them shows that few, if any, students can hope to take all of the courses of such a list, and as, for the most part, they are garnished out in an attractive form, there is likely to be embarrassment in the wealth of subjects, so that, if left to himself, the student is very likely to select a series of disconnected but pleasing fragments, rather than the proper links in an educational chain. Experience shows the wisdom of limiting the list of electives to those that there is reasonable probability that the student can take, and of making the list a consistent whole, fairly opening up the entire field of botany in such manner as to pave the way for a piece of advanced thesis work at the end, and for specialization after graduation. So far as undergraduate instruction is concerned, where, as is usually the case, funds are limited, it is here desirable, as in the other instance, to limit the scope of the departmental equipment quite closely to the requirements of the courses offered. As the senior thesis work is almost certain to be a further study of some one of the subjects already elected, the provision for it, in nearly every instance, is easily and quickly effected by a comparatively inexpensive addition, in each case, to the standard library and laboratory equipment. Such research work as the head of the department and his assistants find time for, as well as such post-graduate work as may be undertaken, can then be provided for in the same manner, piece by piece, with the exception of the final touches, demanding the use of the largest reference libraries or collections, the provision for which is not likely to be far to seek in the stronger research centers within a very few years.

Great herbaria, broad reference libraries, and large stores of apparatus and living or preserved material are possible only to few universities and to the still fewer institutions specially endowed for research, to which alone, indeed, they seem strictly appropriate. For the latter every shade of breadth of foundation is possible, from the laboratory and library limited to the narrowest specialty, to the institution founded and equipped for research in any branch of pure or applied botany. Fairly perfect equipment of the former class it is possible to find here and there, today, but though the seed is sown in several places, the broadest institutions, in their entirety, are still to be developed.

No doubt the first requisite in any such institution is a library of scope comparable with its own. Whatever may be said against the prevalent nomenclature discussions, it must be admitted that they are having the effect of bringing to the front the half-forgotten work of many of our predecessors, some of which, at least, is well worthy of resurrection, and incidentally this is stocking our larger libraries with a class of books which have confessedly been too much neglected of late. Without for a moment losing sight of the fact that botany is a study of one branch of nature, an object-study, we must recognize that its prosecution beyond the merest elements is not only greatly promoted by but almost dependent upon a knowledge of what has already been done.

Where an institution is located in a literary or scientific center, closely associated with large general libraries, learned bodies, and the like, it is usually relieved of the necessity for purchasing and keeping up the long files of such serial publications as the journals, proceedings of societies, etc., of mixed contents, which prove expensive alike in cost, binding, and space, which for a given subject are used but seldom, and which, nevertheless, are the most valuable part of a large reference library, since they are the hardest to duplicate. But where a botanical institution stands in absolute or comparative isolation, it must carry this burden in addition to that of maintaining a library of treatises on botany alone. And, moreover, no sooner is research begun in any direction, than the necessity of following up divergent threads running in many directions becomes evident; for so close and complex are the interrelations between things in organic nature, that no single subject can be pursued far without drawing in others at first sight having no possible bearing on it. After the serials, which from their expensiveness can be possessed by only the larger libraries, stand undoubtedly the general classics in the several subdivisions of botany, followed by the more restricted memoirs, and among these, for convenience of use, should be found, whenever possible, separates and reprints from the journals and series of proceedings, even when the latter are complete on the shelves.

Next to books, material preserving records, or available for study, forms the great foundation in any research institution. A generation ago, or even less, this expression would have been taken as synonymous with an herbarium, perhaps associated with a garden of greater or less extent; but today the most comprehensive of museum possibilities must be added, so greatly has the subject broadened and increased the needs. For a broadly planned institution, with ample means, no doubt the scope of the herbarium should be as great as that of the library, comprising every group of plants, representing a wide range of geographical distribution, the effects of cultivation, etc., and, however limited they may be at first, such museum accessories as alcoholic material, large wood and fruit specimens, and sections for microscopic study are sure to accumulate quite as rapidly as they can be cared for suitably, and to prove in time a very important part of the equipment. Though some of the best botanical work has been performed entirely in the herbarium, there has long been a growing conviction that for certain groups of plants, even for purposes of description and classification, field observation is absolutely necessary, while it is self-evident that for all studies of biology living material is essential. Side by side with the herbarium, then, and virtually as a part of the same general collection, stands the experimental garden, with the greenhouses and other appliances.

While many of the most useful studies are made with but few aids beyond the library and collections referred to, there is a large class of subjects now being closely followed by some of the keenest investigators which demand a special instrumental equipment. However it may be with library and collections, there seems little doubt that as a rule apparatus should be obtained only as it is needed for direct use. Except for the rotting of the bindings observed in the libraries of manufacturing cities, and where illuminating gas is used, books, when once classified and indexed, are easily and cheaply kept in a usable condition. If a few simple rules are followed, herbarium material is also preserved safely for generations at a very small cost; and even sections and specimens in fluid, if properly preserved in the first place, may be kept for many years without great deterioration. Instruments designed for research, as a general thing, represent a considerable sum of money, since, excepting microscopes, microtomes, and balances, they are rarely made in numbers allowing a great economy in the labor of manufacture. Each of them is also, unfortunately, with few exceptions, calculated for a restricted class of experiments and likely soon to be greatly modified. Apparatus, moreover, is usually of a delicacy of adjustment calling for the greatest care in handling it and the most perfect protection possible against rusting, etc., so that as a general thing a case of instruments ten years old is merely a historical curiosity, in part entirely out of date and for the rest so badly out of order as to be nearly or quite useless.

Except for a few standard instruments, I think it is not generally recognized that this part of the facilities, however costly it may be, should be regarded as transient, perishable material, rather than a permanent equipment. The history of the most successful physiological laboratories in which delicate apparatus is chiefly used furthermore shows that the most important results, as a rule, are not obtained by the use of commercial instruments, but by simple apparatus designed by the investigator to meet the precise needs of the problem with which he is busied, and usually constructed by him or his laboratory mechanic at very little cost.

Although it seems comparatively easy to decide on the proper limits of library, herbarium, and instrumental equipment for a given institution, knowing its scope, situation, and resources, it is very difficult to arrive at as satisfactory a conclusion concerning the extent of the research garden. As a general thing such gardens are also intended to be useful in college work, or to afford pleasure and instruction to the public, so that they are likely to be heterogeneous almost of necessity, and usually they are made far too comprehensive. More than any other class of facilities, garden plants require constant and expensive attention if they are to be kept in useful condition; and with all of the care that can be given them they are forever performing the most inexplicable and unexpected gyrations with their labels, so that the collections grown in botanical gardens (because of their variety) are notoriously ill-named, though it would naturally be supposed that they, of all collections, would be above suspicion in that respect.

My object being to speak of facilities for research rather than education or entertainment, I ought to pass by this part of the subject with a mere mention, but I can hardly dismiss it without comment. Where the only object is to supplement the facilities for undergraduate work, the scope of a garden can be very small or moderately large, according to the courses it is to help elucidate. It may be confined to what may be called a propagating bed for plants needed in quantity, either in season or out of season, for class use, to an exemplification of the natural affinities of plants, or to various other instructive synopses representing medicinal plants, fiber plants, forage plants, fruits, vegetables, timber trees, nut trees, shade trees, carnivorous plants, climbing plants, the sleep of plants, pollination, dissemination, etc., or it may be devoted to several of these combined. If it is to be a pleasure-ground as well, not only should the art of the landscape architect be invoked in the arrangement of the plants, but it is necessary to add collections of decorative shrubbery and a large variety of purely ornamental florists' forms of herbaceous plants. If research is added to its aims the collection must be further augmented by specially selected groups cultivated from time to time as needed for study.

Unfortunately, few if any gardens are so richly endowed that they can cover, in a satisfactory manner, the entire field indicated, or even any large part of it. From what has been said of the peculiar difficulties pertaining to the maintenance of botanical gardens, it is evident that in no other line of facilities, whether for pure research or not, is a wise restriction so necessary as here. Once properly prepared, a species is represented in the herbarium on one or more sheets of paper safely and economically stowed away in a pigeon-hole; but in the garden it is a constant source of care and expense as long as it lasts. Hence it is possible for one of the larger herbaria to contain representatives of more than half of the 200,000 species, more or less, of phanerogams, and a considerable, if smaller, proportion of cryptogams, while it is absolutely impossible for anything like this number to be represented in a living state in the best garden. No doubt the local requirements of every institution will do more to influence the exact scope of its living collections than any theoretical considerations, but it is certain that in most cases the greatest usefulness combined with the minimum expenditure will be reached by adapting the synopses chosen to the chief aims of the institution, as closely as possible, and very rigidly restricting the species cultivated to the smallest number capable of adequately expressing the facts to be shown. Perhaps it is safe to say that an institution able to maintain an herbarium of half a million specimens, representing one-fifth as many species, is doing exceedingly well if it has in cultivation at any one time 10,000 species of the higher plants, and there are very few gardens which actually grow half of this number, while no inconsiderable percentage of the plants cultivated are so deformed, distorted, dwarfed, and imperfect, as a general thing, that they can scarcely be said to represent the species whose name they bear, either in appearance or technical characters.

This leads to the conclusion that not only class gardens but research gardens should be kept within reasonably narrow bounds, so far as permanent planting is concerned, while allowing sufficient elasticity for rapid and ample temporary expansion in certain directions along which work is planned. This does not necessarily mean that any considerable amount of land not used in the permanent plantation need be reserved for special expansion. As a rule the more important gardens are situated in or near large cities, and the high price of land alone would prevent such reservation in most instances; but the impure atmosphere of many of the larger cities is a further and even stronger reason for selecting for any large experimental undertakings a suitably located and oriented tract of farming land easily rented for one or several years at a relatively low figure.

Granting the wisdom of such temporary adjuncts to a research garden, a step further leads to a recognition of the possibility of securing the most varied climatic conditions by establishing branch gardens located where particular kinds of study can best be carried on. In no other way can gardens be made to contribute to the fullest extent to the study of marine or seaside plants, alpines, or the great class of succulents etc., characteristic of the arid regions of our southwestern states and territories, and in no other way, except in the field, can these groups be studied satisfactorily, even from the standpoint of the classificatory botanist.

Undoubtedly, too, the research institution of the future will count as a part of its legitimate equipment the provision, as needed, of very liberal opportunities for the staff to visit even distant regions for the study in their native homes of plants which cannot be cultivated even in special gardens in such a manner as to be fully representative.

If the entire equipment here sketched in outline is not only appropriate, but essential, to the great centers of botanical investigation that are making their appearance as results of the specialization and division of labor that are now manifesting themselves in the endowment of research, it by no means follows that every institution, even of this class, should try to develop from the start on all of the lines which, intertwined, compose the complex tissue of botany. With ample means, the ideal development is that which, from the beginning, recognizes all branches as of value, and classifies and develops them alike in proportion to their relative importance. But to secure the greatest return for the money expended, it is desirable to equip fairly well before increasing the force of salaried men much beyond what is needed for the care and arrangement of the material accumulating. This principle, if followed out, almost forces an over-development in the branches of special interest to the earlier employés—a departure from the ideal symmetry, which is sure to be justified by the performance of more work in these hypertrophied specialties, with reference to the sum invested, than in other directions. From this may also be drawn the seemingly just inference that where the means are limited, it is far better to concentrate the entire equipment on the specialties of the persons who can use it, than to allow them to work at a disadvantage through an effort, however commendable it may at first appear, to secure a symmetrical equipment.

With the evolution of centers of pure research will appear new problems. Just as the attendance of a large number of students in the botanical department of a college has heretofore been found to justify the acquisition of facilities beyond the power of their immediate use, it will be found that where research institutions exist in close connection with a university of recognized standing, their equipment will be utilized more or less fully in postgraduate work done toward the acquisition of the doctor's degree, so that, like the undergraduate equipment, it will be more or less satisfactorily accounted for by the number of candidates for such degree; but with broadly grounded and well endowed research institutions not so situated, it is inevitable that as they take permanent form on the lines caculated to make them available for advanced research in any line of botany, they will sooner or later come to represent a very large sum of invested money, of which only a part is usefully employed at any given time, the remainder being held as a necessary but temporarily unproductive reserve. The same thing is seen, to a certain extent, in all large libraries and museums; but, unlike the general library, of interest to the entire reading public, or the collection of historical or political works, referred to by many people of ordinary intellectual attainments, the advanced equipment in botany, for the most part, is useful and interesting only to botanists, so that, while it may possess a passing interest for the general student, its serious use is limited to a very restricted class. How to increase this use to the maximum may well demand our best thought.

No doubt, just as many colleges now offer scholarships, making their advantages available to men who otherwise could not enjoy them, and some of our universities offer fellowships, opening their own postgraduate courses or those of foreign universities to deserving students, the evolution of research institutions will witness some such provision for enabling students who have partially completed pieces of research work to visit and utilize these centers without encroaching too far on the limited savings from the small salaries which, as a rule, are drawn by the botanists of the country. After all, however, the great opportunity of attainment, for such institutions, whether or not connected with colleges or universities, lies in the performance of research work by their own employés; and while, except in the few instances already referred to, and notably in the national Department of Agriculture, today there is some hesitancy in recognizing the employment of a staff of investigators as a legitimate part of the maintenance expense of an establishment which does not use a large part of their time in instruction or necessary curator's routine, it is quite certain that within a very few years opinion will have so changed that a considerable number of salaried positions for research work or applied botany will exist; and as these positions will compete with the professorships in the best universities, it seems probable that the salaries pertaining to them will be approximately those paid at the larger colleges.

In addition to bringing together facilities for research and rendering them easily accessible to competent investigators, and maintaining their own corps of workers, engaged in such studies, institutions of research have no small field of usefulness opened up as publishers of the results of the work they have promoted. I shall have occasion later to speak of the means of publication from the standpoint of the student who is seeking to bring out his work in the best form; but it also demands consideration from the point of view of the institution. Much difficulty is experienced in looking up the literature of a subject because of the large number of journals, etc., in which references must be sought, and it is probable that at some time or other most workers have impatiently wished that publication could be confined to one or a few channels. Simple as this would render the bibliography of botany, it is obviously impossible; and the amount of work deserving or demanding publication is so great, and so rapidly increasing, as to leave no doubt that means of effecting the latter must be considerably augmented. To publish the results of good work well is no less commendable or helpful than to facilitate or perform such work. Nor is it less appropriate to an institution such as I have in mind. The object of publication being the adequate preservation and diffusion of a record of the results of research, however, it is easily seen that harm may be done by injudicious or ill-considered publication. While a volume of homogeneous contents may be so published almost anywhere as to accomplish its purpose, a serial publication ought to be started only when there is reasonable probability that it will persist for a considerable length of time. Granting this probability, a research institution with adequate funds forms one of the most satisfactory and effective agencies of publication, since it can place its proceedings or reports in all of the principal libraries of the world, a thing which the journals do not always accomplish; and not only can it thus amplify its field legitimately, but almost of necessity it must assume the duty of publication if it is to accomplish the greatest results possible from its direct investigation.

One has only to pass a short time in the library of one of the larger scientific institutions to be convinced that a great deal of activity is manifested in the botanical world. Each month and each week bring many additions to the literature of the science, and so numerous, varied, and widely scattered are these contributions, that one feels the greatest hesitancy in publishing on even the most restricted subject, lest others should have antedated his discoveries. Yet notwithstanding the variety and number of botanical publications, and the great progress which is undeniably made every year, it is a matter of frequent comment that the progress made is by no means so much greater than that of our predecessors as might be expected, considering the greater advantages under which work is prosecuted today. While it must be borne in mind that the seizing of the general features of a landscape is far easier than the working out of its detailed topography, that the outlining of the field of botany or of its principal divisions could not fail to proceed more rapidly, even under unfavorable conditions, than the elaboration of the details of the many specialties into which it is now broken up, so that less prompt and voluminous results are naturally to be expected now than a generation ago, there is reason to question whether the present returns cannot be increased. How to secure the greatest possible results from the large number of trained men holding or soon to hold salaried positions, and from the large equipment in laboratories, libraries, herbaria and gardens, is a subject deserving of the most careful study, whether viewed from the standpoint of the endower or administrator of an institution of education or research, or from that of the botanist whose reputation is built up in the performance of the duties assigned to him in such an institution.

While there is every reason to expect large returns from the endowment of such independent departments of research, freedom from the duties of the class room, while leaving more time available for investigation, will not prove an unmixed blessing. I believe it to be the experience of the best investigators in this country that research is promoted by the necessity of imparting some or all of its results in the class room. In no other way, after specializing in the small field to which it seems necessary for most of us to confine ourselves, can one make sure of preserving the breadth of view needed for the investigation of even a limited specialty in the most successful manner. It must be admitted further that the power of application and concentration varies with different men, so that up to a certain point the interruptions introduced by limited teaching or looking after collections in many cases may give fresh zest to the pursuit of knowledge in the time remaining for research. And it may be that at this very point lies the greatest difficulty to be met and surmounted in the development and management of research institutions.

While there is no doubt that some supervision and pressure are conducive to the performance of the greatest possible amount of investigation, as of other work, since they insure consistent planning and close application, it cannot be overlooked that this is the extent to which scientific work can profitably be crowded. To require more of an investigator than that he shall be reasonably busy with thoughtfully planned study is and has always been antagonistic to the performance of his best work; and the requirement of some institutions that a bulletin shall emanate from each department at stated intervals, while it insures quantity in publication, generally does so at the expense of quality of attainment. As a rule, genius, which, left to itself, now and then leaps to the most unexpected accomplishments, is most effectively repressed by close supervision. It is tolerant of guidance but not of the goad; and yet, on the whole, perhaps, both guided and driven, if this is done wisely, it accomplishes most, for in harness it becomes plodding research, which is dull, to be sure, but, if persevering, productive of cumulative results which become of incalculable importance. In fact, whether fortunately or unfortunately I shall not attempt to say, the world has come to recognize the slow but sure progress of research as in the main more desirable than the irregular and intermittent leaps of genius, though the two are closely akin, patient labor over endless facts, on the one hand, and broad observation and untrammeled thought, on the other.

If, everything considered, it is slow and persistent investigation, rather than sudden inspiration, to which we must look for the accomplishment of the greatest collective results in botany, it is equally true that the individual student is more likely to build his reputation on the summation of the small accomplishments of many days of close application than to arrive at some great discovery by a leap; and this quite aside from the fact that the latter result is entirely impossible to many a man who in the other way may still hope to be of great usefulness. It has been said that there is a tide in the affairs of men, which, taken at the flood, leads on to fortune, and no doubt what is true in the military, literary, and commercial world is equally true in the smaller realm of science. In fact, I fancy that each member of my audience has in mind some one preeminent occasion which may have looked small or large at the moment, but the seizing or neglect of which he now sees marked a turning in his scientific career. But, it will be seen, it is not of the one great opportunity that I would now speak. Improving it always has marked and always will mark the turning point of life, but unfortunately the bridge cannot be crossed before it is reached, and great as the value of a true and wise friend's counsel then is, it cannot be replaced by any generalities in advance; therefore it is to the countless lesser opportunities, repeated with almost every day that dawns for us, that I turn, in the hope that something helpful may be said of them, and in the firm belief that in them lies the making of any intelligent and indefatigable young man.

To the investigator breadth of foundation is even more necessary than to the institution founded for his use, for while the latter should endure for centuries, and may be remodeled and improved at any time, he is limited to a single lifetime and can rarely in mid life or later repair the deficiencies of ill advised or defective training. Not only should his powers of observation be well developed, but he should be given more discipline in reasoning than is now customary, though the botanists of a generation ago counted among their number several men who are even more widely known as philosophers.

Equipped for the work, and enabled to use the material facilities that have been brought together against the day of his need, much depends on the early and wise formulation of the investigator's plans. Except for the tasks set by a teacher and really long contemplated by him and carried out by his intelligence if through the eyes and hands of pupils, few pieces of valuable research are taken up on the spur of the moment, without previous thought on the part of the investigator. They are usually the outgrowth of another, and turning and returning until it ultimately shapes into a definite plan. Simple as it may be in theory, few things are more difficult in practice than the formation and inception in early life, inexperienced, and often without certainty of the power of continuance for any great length of time, of a plan for a single piece of research work worthy of the devotion of a lifetime; and few and fortunate are the men, even among those who have outlined and entered upon such a task, who are not forced from the path by side issues, or whose lives are not unduly short. More commonly one must be content to choose several smaller subjects, for their own sakes somewhat closely related to one another, if possible, and to follow these up in succession. It is surprising how blind even the sharpest eyed among us are to all that does not directly interest us, and it is an equal surprise to see how quickly one's eyes open to things which he has once begun to think of and look for. If for no other reason than this, I would again urge breadth of early training, as giving the first impulse to many a series of special observations to be followed up in later life.

Once a subject is chosen, observations accumulate with surprising rapidity, and next to the selection of a subject nothing is so important as system in pursuing it. If we do not see it in ourselves, each one of us can see in others, a great waste of energy, resulting from shiftless and ill-considered methods of procedure, by which the mind is so distracted and the memory so overloaded with unessentials and dissociated fragments that those which belong together are not matched, nor the missing bits, in plain view, gathered. How often do we have to return time after time and review partial work that we have had to dismiss temporarily from the mind, in which, meantime, has been lost the connection between the completed portion and the continuation awaiting our leisure. A phenomenal memory may enable one to work in this disjointed fashion without the production of scrappy results or the review of all that has been done each time that the task is resumed; but for those not so gifted, order and method are absolutely necessary, and next to the clear idea of the end aimed at I should place the immediate making of full and exact notes as their most essential part. Some years since I was privileged to assist Dr. Gray in collecting and republishing the botanical writings of Dr. Engelmann, and it was a matter of surprise to us both, as it has been to others, to see how voluminous these were. Had Dr. Engelmann devoted his entire life to botany they would have been as creditable in quantity as in quality, but for the leisure hour productions of a busy professional man they were truly marvelous. Some years later, when, his herbarium and library having found a resting-place at the botanical garden in the development of which he had felt an interest for many years, it fell to my lot to arrange in form for permanent preservation Dr. Engelmann's manuscript notes, sketches, etc., I was far more surprised at the extent of these than I had been on collecting his printed works, for when mounted and bound they form sixty large volumes. In addition to their intrinsic value, these are of more than usual interest as showing the methodical manner in which Dr. Engelmann worked. On his table seems to have been always a bundle of plants awaiting study. As each specimen was examined its salient features were noted and sketched on the back of the ever ready prescription blank. When interrupted, he laid his unfinished sketch away with the specimen, to resume his observation and complete his study at the first opportunity, without any doubt as to what had been seen in the first instance. And so from individual to variety, from variety to species, from species to genus, and from genus to family, his observations were preserved in memoranda that facilitated the resumption of interrupted work at any time and after any lapse of time. In no other way could the odd moments between the daily calls and occupations of a busy physician have contributed so much to botanical knowledge; in no other way could his seemingly small opportunity for investigation have been converted into a great one.

Almost as important as the early selection of a worthy subject for study and the adoption of a method insuring the preservation and use of even the most trivial information bearing on it is the adoption of suitable library methods. The student whose specialty is small and little explored has mainly the task of observing and reasoning from the facts before him; but in the departments that have long been the subject of study, while a part of the work is already done to his hand, and the prospect is that he can go much further than on entirely new ground, the task of ascertaining and profiting by what his predecessors have done is often a difficult one. Not infrequently the literature of a subject is so scattered as to make it next to impossible to pass it all in review, and at best the task of finding the fragments is one calling for a special faculty. One or more attempts have been made to form general bureaus of scientific information to which one need only turn if he would be possessed of references to the principal literature of any subject in which he chanced to be interested. Perhaps as library facilities accumulate at the great centers of research, some method may be found of supplementing them with the skill of expert librarians who shall be able and willing to carry the contents of the library, at least in skeleton form, to those who cannot come to it ; but the time has hardly yet come when any American library is complete enough in all branches to offer this aid with a reasonable chance of doing what it promises, or so manned as to make such assistance possible except at the sacrifice of more valuable direct research.

For the present, then, the investigator must be content to do his own delving into the literature of his predecessors. Fortunately, much of the earlier literature has been sought out by some of the writers on any branch that has been the subject of earlier study, so that, starting with a memoir of recent date, one is guided to others, each of which may bring further references, until, if he have access to the works, almost the entire earlier literature is unearthed. On the other hand, the most recent literature of a subject is always the most difficult to find and use. After a study has been gotten well under way, so that the student is keenly alert to every observation or published item in any way bearing on it, if he have access to a library receiving the principal current journals he is not likely to overlook any important publication on his specialty which then appears. As a rule, all of the larger papers, at least, are noticed in Just's *Jahresbericht*, generally not more than a year later than that for which the volume purports to be compiled ; but as the *Jahresbericht* is always some three years in arrears it is difficult to prevent notes extending over a period of this duration from being defective, at least for the earlier part of the time, and there is at present no means of removing this difficulty, though the plan proposed to zoologists a year ago, and, I suppose, tested during the present season, if successful would be equally applicable to botany.

So far as the final result is concerned, perhaps the manner in which one's work is published is almost as important as the subject selected or the method adopted for its investigation. Alphonse de Candolle, in one of the most helpful treatises ever published in the hope of rendering botanical work methodical and productive,[2] lays a great deal of stress on the early selection of a form of publication for the results of each important study. This done, the work continually shapes itself to this end. Frequently there is much difficulty in securing the publication of a monograph or memoir in precisely the form and place desired by the author, but there is seldom an insuperable obstacle in the way of publishing any really meritorious work in about the manner wished, provided it is suitably prepared.

In general, it is desirable that works of a given class should be so published that in seeking one a reader is likely to learn of another. This appears less important for books than for shorter papers, since the arrangement of independently issued volumes in a library, and the fact that they are catalogued by authors, render it relatively easy to learn of and have access to them; but even here one finds no little convenience in the recognition that a book by a given author on a given subject is quite likely to be listed in the catalogue of a certain publishing house. Smaller papers, which are usually published in the proceedings of some society, or in a scientific journal, may almost be said to be made or ruined by the place selected for their publication. Probably as library facilities increase and are more thoroughly classified and subject-indexed, this will become less true than it now is, though the underlying reason for it will remain. Usually a reader turns to the popular journals only when looking for popularized science, and is not likely to seek the original results of research there, so that such papers are nearly or quite lost for a long time if published in these journals. Except where they are chiefly devoted to digests and abstracts, few nominally general journals now exist which do not lean so strongly toward a specialty that one unconsciously classes them with it, notwith-

[2] La Phytographie, ou l'art décrire les végétaux considérés sous différents points de vue. Paris, 1880.

standing the extraneous matter that they contain. While nothing once published is ever absolutely lost, all of this extraneous matter is likely to be overlooked by the persons most interested in the subjects considered. No small part of the present confusion and strife in botanical nomenclature arises from the comparatively recent unearthing of descriptions and names of plants published in such improbable or inaccessible places as to have escaped the attention of those whom they might have helped most, to be brought to light at a later date as great mischief makers. From now on, then, it may be concluded that a decreasing number of special papers are likely to be published in general journals, which will become more and more popular or bibliographic in their nature, with the exception that the necessarily slow differentiation of learned societies into special sections will for a long time cause the proceedings of many of the older to continue of the most miscellaneous character. Where papers are lengthy, though not adapted to publication in book form, such proceedings virtually offer the only means of printing them, and, except by the comparatively few botanists who enjoy the privilege of membership in purely botanical societies with publishing facilities, they must be accepted for the present, notwithstanding the attendant disadvantages. Shorter papers, however, can usually find room in the journals, and except in cases where they possess a temporary and exceptional value for the columns of a popular or general journal, or one devoted to another subject to which in some manner they are relevant, they are best published in a periodical exclusively devoted to botany, and, in most cases, in one devoted as closely as may be to their particular branch of botany, provided it have a fair general circulation and, especially, provided it reach the principal botanical libraries.

Especially in the earlier years of their work, writers are sometimes given to distributing their papers among a number of journals. Except for the purpose of specialization just referred to, this is usually a mistake. Knowledge that a certain student has published on a given subject is often first obtained through incidental reference, lacking every element of precision. The probability that all of his writings are to be found in one or a few journals, or series of proceedings, greatly simplifies the completion and use of such references, since the Royal Society's Catalogue, though perhaps more complete as to titles, is necessarily even farther behind than the *Jahresbericht*. Where the subject of an earlier paper is again passed in review by the author, only the gravest necessity should lead to the selection of a new medium for the publication of the later paper.

Whether the medium of publication selected or accepted be a journal or the proceedings of a society, the possibility of having separates struck off for the mere cost of press work, paper, and stitching, makes it possible for almost any paper to appear as an independent pamphlet, accredited, to be sure, to the journal from which it is an excerpt, but a book, necessitating author's citation in catalogues, and admitting of more ready arrangement in its proper place where the works of a library are disposed on the shelves according to subject. The time was when a pamphlet was considered of little value and quite certain not to be preserved, but one of the characteristics of the modern librarian is a great and growing appreciation of the value of this class of works, leading to their careful preservation.

No small part of the volume of M. de Candolle, already referred to, is devoted to very explicit and well considered directions for preparing the record of one's observations for the press; and the general conclusion is reached, after a careful analysis of the subject, that the maximum value of any manuscript exists at the exact moment of its completion, indicating this as the most suitable time for its publication. Though it is probable that the publishing of any important work should not be unnecessarily delayed after it has been pushed to what the author considers completion, at least so far as he can carry it, there may be reasons in some cases for publishing a preliminary statement considerably in advance of the completion of the work. Neglecting the publication of an early abstract of unfinished work as a means of securing priority, too often a purely personal matter, I may say that such abstracts, coupled with a request for material or data, not infrequently bring to the advanced student the means of greatly increasing the completeness and value of his work.

Time does not permit me to go into a detailed analysis of the many ways in which an investigator may use his time so as to make it productive of important results for himself and others. Having passed in somewhat comprehensive though hasty review the main factors in the question, I desire in closing to repeat that for most of us opportunity of life does not lie in a great and abrupt change of condition, but that it is composed of countless minor chances which are great only when viewed collectively. To see and use them calls for alert senses, a knowledge and use of the means of ascertaining what has already been done, and, by exclusion, something of what remains to be done, facilities adequate to the task in each case, and indomitable perseverance and ceaseless activity. Great as the value of facilities is, they are merely means to an end. They accomplish nothing themselves. Hence though it is certain that the most voluminous and, perhaps, the most comprehensive results, and those resulting from the performance of coherent experiments extending through a long series of years, will come from the great centers of research, there is no reason why qualitative results equal to the best may not continue to come, as they have in the past, from isolated workers, to the rounding out and completion of whose studies the facilities of the larger institutions will be more and more applicable as the problems of equipment are worked out.

MISSOURI BOTANICAL GARDEN.

# BOTANICAL PAPERS AT BUFFALO.[1]

## BOTANICAL SOCIETY OF AMERICA.

CONWAY MACMILLAN: *On the distribution of plants in a fresh-water insular region.*— The locality studied was Lake of the Woods, with its thousands of islands, varying in size from mere rocks to areas hundreds of square miles in extent. A general survey of the geological conditions shows that drift is sparingly distributed. According to vegetation the following types of islands were noted: (1) floating bog islands, (2) Scirpus and Phragmites islands, (3) sand dune islands, (4) irregular creviced-rock islands, (5) dome-shaped rock islands, with or without drift sheets.

The strand flora was discussed as (1) beach formation and (2) shore formation. In the beach three areas or zones of distribution were defined: (*a*) front strand, (*b*) mid strand, (*c*) back strand. Strand pools with concentric zones of vegetation were described as a feature of mid strand. Three types of strand vegetation in general were defined: (*a*) Cornus strand, (*b*) Salix strand, (*c*) Prunus strand. A discussion of the conditions under which beach formations arose was given, with reference to drift distribution and wave action.

The shore formations were discussed briefly, attention being given to surf plants, such as Scirpus, Phragmites, and Spiræa salicifolia. Gullies crossing a strand or shore, and the change in the distribution of shore plants consequent upon their existence, were described in outline.

It was shown that the islands with rock cones could be classified either as irregular or as dome shaped. The latter showed a remarkable zonal distribution of plants due to gradual soil-formation and the silting off of the soil in a regular way towards

[1] In almost every case the abstracts given have been prepared by the authors.

the periphery of the islands. The following zones were described from periphery to center: (1) shore zone, (2) outer shrub, (3) tree zone, (4) inner shrub, (5) central meadow or central shrub In islands in which the soil formation was recent the zonal distribution was shown to be distinct, but in older soiled islands, where the soil had become thick, it was shown that the central meadow at first becomes a central shrub and, finally, with the addition of further soil layers, a central tree formation is developed. Zonal distribution is still evident in islands with thick soil sheets, for the peripheral tree formation is made up of older individuals than occur at the center of the island. If, however, the rock surface is very irregular, this zonal distribution cannot appear, and the island in such a case is commonly clothed with a pretty uniform coniferous formation.

It was shown that after burning off an island zonal distribution will reappear in the new plants established only when the soil is thin; when it is thick the whole island is uniformly tenanted by light seeded species such as willows, poplars, and epilobiums.

The two basal forms of islands, the irregular and the dome-shaped, may be considered as combining and forming the variously shaped larger islands of the region. All islands can be explained in terms of these. Slope, contour, strike, and bedding of country rock, disposition of talus masses, direction and width of crevices, and formation of gullies, were discussed as influencing the general distribution of the plants, and attention was directed to the influence upon vegetation by proximate islands which modulated the wave action upon a given shore.

Zonal distribution on land is quite as evident in these areas as is the zonal distribution in lakes described by Mangin and others.

The paper was illustrated by numerous lantern slides.

N. L. BRITTON: *An Eleocharis new to North America.*—In the Alaskan collections of Thomas Howell an Eleocharis was found which proves to be a species hitherto known from Japan. It is remarkable for its very large tubercle, which exceeds the achene itself in length and breadth. In this regard it resembles the one or two large tubercled North American species already known, but it belongs to a different section of the genus, and its other American associates show no such character. It was suggested that the function of such tubercles (enlarged style bases) may be to give buoyancy to the achene in water.

GEORGE F. ATKINSON: *Some problems in sporophyll transformation among dimorphic ferns.*—In *Onoclea sensibilis*, the sensitive fern, abnormal spore-bearing leaves are sometimes found. This form is intermediate in character between the fertile and sterile leaves of the normal form of the species, and has been regarded at different periods as a distinct species, a variety, or an abnormal state caused by the contraction of the vegetative leaf. Experimental evidence shows that the form is produced by an unfolding and extension of the young sporophyll before its characters as such are fully determined, and is caused by a complete or partial loss of the vegetative leaves through injury. Cutting off the vegetative leaves in May and again in June resulted in a large number of these abnormal forms, together with examples of apospory. These results were briefly reported at the Brooklyn meeting of the A. A. A. S. in 1894.

The experiments were continued in 1895 on another species of the genus, *Onoclea Struthiopteris*, with identical results in the transformation of the sporophyll, though no cases of apospory were observed. During the same year experiments were begun on *Osmunda cinnamomea*, but as the fertile leaf has the sporangia formed in the autumn, and since they appear along with the sterile leaves in early spring, no results were obtained that season. During 1896 there were a few cases of partial sporophyll transformation, but the results were not marked since the injury to the vegetative leaves was introduced while they were very young and long before the incipient development of the sporophyll of the succeeding year. In 1896 the vegetative leaves were cut in July and again in August, and marked results will be looked for the coming year.

A peculiar transformation sometimes occurs in this same species, which gives rise to the form *Osmunda cinnamomea frondosa.* My attention was first called to this by Mr. C. D. McLouth of Muskegon, Mich., who has furnished me with considerable material. The transformation is peculiar, in that it appears to be an increase in the leaf surface along the mid-vein of the sporophyll, and also along the mid-vein of the pinnæ, so that the sporangia are borne on wing-like expansions. The locality where these forms were collected gave evidence of a fire, either in the late autumn or early spring, and the forms were very marked and abundant near dead stumps where the fire was the hottest. Since at this season of the year the sporangia are nearly all formed, the nature of the transformation would be different from what it would be if the vegetative leaves were destroyed during midsummer, when the sporophyll was in the incipient stages of development. It is also possible that the heat penetrated far into the stem of the plant and may have introduced disturbing factors of quite a different nature from that of the loss of the carbon assimilating members, which results when the leaves only are cut away.

Experiments at different seasons will be conducted in the hope of arriving at the fundamental laws operating in these cases. A large number of lantern slides made from photographs illustrated the paper.

L. H. Bailey: *The philosophy of species making.*—This paper will be published in full in an early number of the Botanical Gazette.

## SECTION G OF THE A. A. A. S.

D. T. MacDougal: *The relation of the growth of leaves to the* $CO_2$ *of the air.*—The leaves of seedlings accomplish a large proportion of their development but not always their entire development at the expense of food derived from the seed. Rapidly developing but small leaves furnished with large stores of reserve food are able to carry out a complete development, but are unable to endure continued existence in an atmosphere free from $CO_2$. The slowly developing leaves of many woody perennials develop normally and endure long continued existence under the above circumstances. This varying reaction of leaves is dependent upon a series of conditions which may be included under the title of "availability of the food supply." The death of a leaf in an atmosphere free from $CO_2$ is due to insufficient nutrition, and not to the pathological effects of disintegrated chlorophyll.

R. N. DAY: *The forces determining the positions oj leaves.*—Epinasty and hyponasty are inherent properties of leaves, whose reactions may be suppressed but not altered by external conditions. Dorsiventral leaves are diaheliotropic, diageotropic, or apogeotropic, epinastic or hyponastic. The predominating force in every instance is the heliotropic tendency, which suppressed other reactions. The position of the leaf is a physiological, not a mechanical, resultant, and cannot be expressed by the parallelogram of forces as proposed by Krabbe in 1889.

N. L. BRITTON: *On Cratægus coccinea and its segregates.*—The necessity of observing living forms in various stages of growth was pointed out. Typical *C. coccinea* is known by its cordate leaves, moderately glandular inflorescence, etc. Occurring with it, and lost sight of, has been *C. rotundifolia*, with smaller oval or oblong leaves narrowed at base, larger flowers, a densely glandular inflorescence, and a different time of blooming. Other segregates are *C. flabellata*, a northeastern species, with leaves narrowed at base and more incised; *C. macracantha*, the species with smallest fruit; and *C. mollis*.

L. M. UNDERWOOD and F. S. EARLE: *The distribution of the species of Gymnosporangium in the south.*—This paper appears in full in this number of the BOTANICAL GAZETTE.

L. H. BAILEY: *Morphology of the Canna flower.*—The author called attention to the prevailing asymmetry in the Scitamineæ, and remarked that groups of plants which show marked irregularities in form are nearly always fertile subjects for plant-breeding. The most nearly symmetrical flowers of this order are found in the banana tribe, in which five stamens are present and the sixth is represented by a sterile filament. He exhibited a banana fruit to show its five-angled form, and remarked that it is probable that somewhere in its phylogeny this fruit had lost its symmetry. He also called attention to the three seedless loculi of the fruit, and remarked that although the plant is seedless, it still varies or it is the subject of evolution, thus discrediting Weismann's hypothesis that all progressive or permanent variation arises through sexual union.

In the ginger tribe the stamen is reduced to one normal member. In the canna tribe the stamen is represented by what is apparently but a single loculus of the anther, the other loculus being apparently developed into a foliaceous organ. The remaining stamens are represented by petal-like staminodia and these members make up the showy part of the flower. The speaker exhibited specimens of canna flowers, and also charts, to show the very marked evolution in the form and size of the flower, and more especially of the staminodia, and the gradual increase in the size of the petal-like appendage of the one fertile stamen. There seems to be a considerable decrease in seed production in the modern cannas as compared with the types of a generation and more ago, and this decrease is probably associated with less pollen, or less efficient pollen, in the modern flowers. This tendency toward seedlessness is seen in many cultivated plants, of which the potato is a good example. Since new varieties come mostly from seeds, many persons have supposed that plant-breeding must eventually cease in these plants; but the speaker pointed out that the constant choice of seeds for sowing is itself a powerful agent in conserving the seed-producing power of the plant. So long as we select seeds, so long may we expect the effects of this selection to give seeds in at least a part of the individuals of every generation.

E. L. Mosely: *A comparison of the flora of Erie county, Ohio, with that of Erie county, N. Y.*—Both districts are adjacent to Lake Erie, but the Ohio district (including Erie county and the peninsula and islands of Ottawa county) contains 265 native species of phanerogams not known to occur within fifty miles of Buffalo. The cause is mainly climatic. The average date of the last killing frost in spring at Sandusky is April 30, at Buffalo it is May 20; the first killing frost in autumn at Buffalo is September 15; at Sandusky it is October 24; and the summer is decidedly cooler at Buffalo. Reasons for the difference in climate were given, including the blowing of the ice to the east end of the lake in spring and other considerations.

Charles E. Bessey: *The significance of the compound ovary.*—In the study of the gynœcium of angiosperms we are forced to conclude that its primitive condition was apocarpous; in other words, that whether monocarpic or polycarpic there was at least no union of ovary with ovary. The original ovary was doubtless simple. By a comparative study of the ovaries of existing plants we are led to the conclusion that the syncarpous gynœcium was derived from the apocarpous gynœcium. This is so plain that it is needless to dwell upon it. Both phylogenesis and ontogenesis furnish us with numerous illustrations of the truth of this statement.

It is to be observed that the compound ovary is a comparatively stable structure, and that it changes slowly within any natural group, or in passing from group to group. No part of the plant is more stable, yet with all its stability it undergoes changes in certain directions. It is a common occurrence to find a pentacarpellary ovary reduced to four, three, or two carpels, and this may proceed until, as in some of the Caryophyllaceæ, we seem to have but one carpel remaining. In rare cases there appears to be a reversion from syncarpy towards apocarpy, as in the Apocynaceæ and Asclepiadaceæ, but as a rule it may be said that syncarpy once attained by a group is persistently maintained, however much of simplification it may otherwise have undergone.

The ultimate development of the compound ovary is in the direction of a simplification of structure. Thus the many carpels of most Thalamifloræ and Heteromeræ are gradually reduced to the two carpels of the Bicarpellatæ. In the Calycifloræ the Rosales and Myrtales have generally several to many carpels, while in the Umbellales there are but two. Likewise in Inferæ the ovary in the lower group, Rubiales, has more carpels than we find in the highest group, Asterales. A similar simplification occurs in the monocotyledons, as we pass from the Coronarieæ to the sedges and grasses. This simplification of structure results in increased paternal care of the offspring. Thus while many embryos are to be nourished in the earlier cases, there are but one or two in the later. The biological significance of this result is so well known as to need no discussion here.

When we come to an application of what we know of the compound ovary to systematic botany, it appears to me that the following conclusions are warranted: (*a*) the apocarpous plants are to be regarded as lower than those which are syncarpous, and in a natural arrangement the former must precede the latter; (*b*) we must carefully distinguish between ovaries which are primitively simple, and those which have become simplified from a more complex structure, in which cases the first indicate a lower, and the second a higher position in the natural system; (*c*) grasses, sedges, etc., in which the ovaries are simplified from the compound type, are not the lowest of the monocotyledons; (*d*) willows, oaks, walnuts, etc., with their apparently simple flower structure, are not to be regarded as among the lowest of the dicotyledons.

H. L. Russell: *On the bacterial flora of cheddar cheese.*—The paper presented a quantitative delimitation of the bacteria in cheddar cheese from the time it is first made until it has been thoroughly broken down. The botanical changes are divided into three stages, as follows: (1) period of initial bacterial decline, (2) period of bacterial increase, (3) period of final decline. As to changes in different species it is found that the lactic acid bacteria develop to an overwhelming degree while the gas bacteria and the peptonizing germs are gradually destroyed.

CHARLES R. BARNES: *Terminology of reproduction and reproductive organs.*—Two points were discussed, which are not directly related:

(1) The distinction between vegetative and non-sexual reproduction. The reproduction of the earliest plants was undoubtedly vegetative reproduction. Non-sexual reproduction is not fairly differentiated from it until the Bryophyta are reached, and with them a clear alternation of generations. In Bryophyta, Pteridophyta, and Spermatophyta, the forms of vegetative reproduction, viz., by brood buds or gemmæ, by detached shoots, and by proliferation (with detachment late when it occurs at all) are clearly distinguishable from the non-sexual form, viz., by spores produced in a compound sporangium. The fundamental distinction lies in this, that vegetative reproduction *repeats the same phase*, while non-sexual reproduction *gives rise to the alternate phase*.

(2) The classification of sporangia and gametangia into *simple* and *compound* was suggested. The simple gametangium or sporangium is one consisting of a single cell whose contents become respectively the gametes or the spores. The compound gametangium or sporangium is an aggregate of several or many (rarely reduced to one) simple gametangia or sporangia surrounded by one or more layers of sterile protective cells. Oogonia and carpogonia are simple gametangia, archegonia are compound gametangia. Simple sporangia occur below Bryophyta; compound in Bryophyta and above.

BERTHA STONEMAN: *A comparative study of the development of some anthracnoses in artificial cultures.*—Different species of Glæosporium and Colletotrichum, and the allied genera Vermicularia and Volutella, present in artificial cultures distinct characters varying to a certain extent with varying conditions of light, temperature, and nutrient media. Under uniform conditions of growth the characters have been found sufficiently constant to be of value in distinguishing or uniting species whose similarity in morphological structure or variations resulting from the character of the host would render their systematic position uncertain. Of about thirty species studied, five Colletotrichums and two Glœosporiums have been definitely connected with an ascigerous form, the transition from one stage to the other occurring without the intervention of a pycnidial stage. The ascigerous stages of each, two of which have been found as saprophytes in nature, bear a close resemblance to each other and would fall in a genus near Gnomoniella.

W. W. ROWLEE: *The development of the vascular elements in the primary root of Indian corn.*—In many text-books the large cells in the central portion of the root-tip are described as the rows of cells from which the vessels are developed.

Investigations prove that these larger cells pass over into parenchyma and that the protoxylem is differentiated from cells radially opposite and nearer the surface than these.

JOHN M. COULTER: *Some remarks on chalazogamy.*—The use of chalazogamy as a basis of classification was first discussed, reasons against such use being the unnatural associations and separations, the use of a single character for important groupings, the fact that chalazogamy has to do not with a differentiated organ but with a process. The use of chalazogamy as an indication of phylogeny, as suggested by Nawaschin, was also discussed, the view that it is an intermediate stage in the adaptation of a gymnosperm-trained pollen-tube to the traversing of angiosperm cavities being objected to. It was shown that the necessity of "adaptation to cavities" was by no means so great as generally supposed, and that chalazogamy is more suggestive of being an occasional modification of porogamy than an antecedent condition. In regard to the significance of chalazogamy the speaker claimed that it is purely physiological, and does not involve any such change in structure as will define a natural group or indicate a line of descent. The route of the pollen-tube is dependent upon mechanical obstruction, nutritive material, possibly chemiotaxis, and this route may or may not include the micropyle, quite independent of plant affinities. Illustrations were given showing that chalazogamy is favored by a closed micropyle region, and by unfavorable position of the micropyle associated with favorable structure of the ovule, such as well-developed sterile macrospores.

L. M. UNDERWOOD: *The habitats of the rarer ferns of Alabama.*—The state of Alabama is especially interesting to the students of the pteridophytes (1) from the fact that it represents the southern limit of a number of species of the Appalachian district which follow the spurs of the mountains well into the interior of the state, and on the other hand the northern limit of several of our subtropical species; (2) because of the remarkable *Trichomanes Petersii* found only within its borders; and (3) because it contains the only station where the rare *Asplenium ebenoides* has been found in any quantity. The state has a comparatively large pteridophyte flora, including some forty species of ferns besides at least five species of Ophioglossaceæ, having been well explored by Judge Peters, Professor E. A. Smith, and Dr. Charles Mohr. We have been able to add one species (*Dryopteris Floridana*) to the list, and to rehabilitate one of the early species of Botrychium, *B. bipinnata* (Lam.), which is clearly distinct from *B. ternatum*, with which it has been confused for many years, largely because of the deficiency of collectors through the southern country.

A visit to the original station of *Trichomanes Petersii* has given some new points in regard to its habit and habitat. Likewise a visit to the out-of-the-way ravine in Hale county has enabled us to show the absurdity of regarding the rare *Asplenium ebenoides* as a hybrid. This species, far from possessing the habit of either of its supposed parents, is entirely distinct, and is more closely allied in its habit to its congeners, *A. pinnatifidum* and *A. montanum*. It is evidently a very old species, of which the present station doubtless contains the largest remnant of its former wide distribution.

FRANCIS RAMALEY: *On the stem anatomy of certain Onagraceæ.*— Seven genera of the disintegrated genus Œnothera, represented by thirteen species, were examined, with the following conclusions. There seem to be no marked anatomical characters of the stem which can be set down as belonging to one species and to no other. Plants of the same species growing under different conditions may present as great differences as are to be noted between species of comparatively remote genera. Slight differences in the thickness of the various zones of tissue are evident, as are also variations in the size of the constituent elements in some of the tissues. The following generalizations may be drawn: (1) there is a striking similarity in stem structures throughout all the genera examined, and stem anatomy will not serve to distinguish one genus from another; (2) the cortex is absent from old stems, being replaced by cork of characteristic structure; (3) the normal phloem is in all cases poorly developed; (4) bicollateral vascular bundles occur in all the species examined; (5) intra-xylar phloem islands are found in the stems of all the robust species; (6) raphides of calcium oxalate are present in all cases, generally occurring in both cortex and pith, often in the pericycle and phloem.

CHARLES E. BESSEY: *The point of divergence of monocotyledons and dicotyledons.*— In discussing this question I assume that it is unnecessary to bring forward proofs as to the common origin of the two subclasses, Monocotyledonæ and Dicotyledonæ. It is possible, but in my opinion improbable, that some plants are now included in them which have had an independent origin, but all will agree that after making the most liberal subtractions possible the two subclasses must still remain as two very closely related groups, with essentially the characters now assigned to them. We must bear in mind the well-known biological law that, in general, the relationship of allied groups is most marked between their lower members, that is, between those members which represent the primitive types, and that it is less marked between the higher members of the groups. In other words, we recognize the fact that groups diverge as they are evolved. If we represent the phylogenesis of plants by lines, we are compelled to arrange these lines so that they show repeated series of divergencies.

Another law which must be kept in mind, also, is that evolution for the most part has proceeded from the simple to the complex. The simpler plants of today represent to a large extent the types of the primitive plants of former periods, from which the complex plants of today were derived. In this connection, however, we must not overlook the fact, as pointed out elsewhere,[2] that in the evolution of the successive members of groups of plants there has often been a simplification of structure. Thus we often find apetalous derivatives from polypetalous types; bicarpellary ovaries from polycarpellary types; one-celled, one-seeded compound ovaries from several-celled, many-seeded ovaries. But there is a great difference between these simplified structures which have been derived from more complex structures, and those which are primitively simple. The former are nearer the end of a lengthened genetic line, the latter are nearer its beginning.

When we apply these principles to the system of Bentham and Hooker we find no contact points whatever between monocotyledons and dicotyledons. The lower monocotyledons are very unlike any of the Apetalæ. What similarity, for example, is there between the grasses and sedges, on the one hand, and the oaks, walnuts, and plane trees, on the other. It is only when we pass up to the Apocarpæ in the monocotyledons and to the Micrembryeæ, and possibly Piperaceæ of the latter, that there are many similarities of structure. To this I must refer later, and need only say here that evidently the authors made no attempt to indicate by their arrangement of families any contact point between the monocotyledons and dicotyledons.

[2] Evolution and Classification. Proc. A. A. A. S. **42**: 237. 1894, and The significance of the compound ovary, presented at this meeting.

In the system of Engler and Prantl one might look for such a disposition of the families of the two subclasses as to indicate a common point of origin, but in this we are disappointed When we compare the structure of the families placed at the beginning of the monocotyledons, Typhaceæ, Pandanaceæ, Sparganiaceæ, Potamogetonaceæ, Naiadaceæ, Aponogetonaceæ, Alismaceæ, etc., with those occupying a similar place in the dicotyledons, Saururaceæ, Piperaceæ, Chloranthaceæ, Lacistemaceæ, Juglandaceæ, Myricaceæ, Leitneriaceæ, Salicaceæ, etc., it is at once evident that here there is a great gulf between the two subclasses. It is becoming more and more evident that this system which promised so much is little better as an expression of genetic relationship than the system of Bentham and Hooker, which it is now displacing. Its so-called lower families are for the most part composed of plants not with a simple, that is, a primitive structure, but a simplified structure. As a rational system, designed to express our ideas of genetic relationship, it is sadly disappointing.

It is evident that we must cease to confuse the simplified with the primitively simple structures, and that in the latter alone can we find the point of divergence of the plants of the two subclasses under consideration. It is only when we do this that we are able to construct a system which shall suggest to us the solution of the problem. Our system must begin with simple pistils, not compound pistils; with really simple and not simplified pistils. It matters little whether the flowers are perfect or not; whether they have many or few flower-leaves or even none at all. We have learned that these are minor matters and that they change very readily even within narrow limits.

In accordance with these principles we may readily fix upon the apocarpous monocotyledons (Bentham and Hooker's Apocarpæ) as the representatives of the primitive members of this subclass. This structure will readily suggest the Ranales among the thalamifloral dicotyledons, and a closer examination shows a remarkable similarity of structure, in not only the reproductive but also in the vegetative organs of the plants of these two groups. After some years of study given to a comparison of these groups I am more firmly convinced than ever of their genetic relationship. They show their relationship in their gross anatomy, the histology of their tissues, and their embryology.

Allied to the Ranales are the Rosales, beginning with the Ranunculus-like Potentilleæ, and passing by easy steps to the simpler Leguminosæ (Cæsalpiniaceæ and Mimosaceæ), on the one hand, and the Saxifragaceæ on the other, and through the latter to Celastrales and Myrtales. Here, then, in my opinion, is the point of divergence of the monocotyledons and dicotyledons, represented by the Apocarpæ of the former, and the Ranales and Rosales of the latter. The similarities in structure between some Microspermæ and the Naiadaceæ in Bentham and Hooker's system, noticed above, as between some of the families (Naiadaceæ, Alismaceæ, Chloranthaceæ, etc.) placed by Engler and Prantl at the beginning of the two subclasses, are hints as to a natural arrangement which it is strange that these eminent systematists overlooked.

L. M. UNDERWOOD and F. S. EARLE: *Notes on the pine inhabiting species of Peridermium.*—The paper gave an enumeration of the species known to inhabit the various species of Pinus in the United States, with their distribution by hosts, and their geographical distribution. All the species are foliicolous except *P. cerebrum* Pk., which forms large distortions on the stems, trunks, and branches of its hosts. Remarks were made in reference to the various forms of these distortions, especially those produced in the south on *Pinus Tæda* and *P. echinata.* The species being perennial, the necessity of an alternate stage for the parasite is obviated.

D. T. MACDOUGAL: *Reaction of leaves to continuous rainfall.*—The first recognition of the influence of rainfall upon leaf forms was that given by Ridley in his *Flora of Pajang,* and an extensive exploitation of the subject was made by Stahl in 1893. Since the publication of Stahl's work, Jungner has carried on a great amount of observational work of doubtful value, and has made some attempts to produce rainfall characters in leaves experimentally. The hitherto recognized rainfall characters are as follows: attenuated apices, entire margins, a glossy appearance of the upper surface, ready adhesion of water to the upper surface, deepened furrows above the ribs, pendent positions of the laminæ, and enlargement of the pulvini. It is to be noted, of course, that in no one species do all of the above characters appear, and Jungner has been able to induce only the glossy appearance, adhesion of the upper surface to water, and the pendent position of the laminæ in a few of the many species tested.

During the past year I have carried out such a series of experiments with *Arisæma triphyllum*, *Trillium erectum*, and *T. recurvatum*. In the trilliums the pendent positions of the laminæ, the glossy appearance of the upper surface, and a reduction of the marginal teeth were obtained. In Arisæma, the glossy appearance, adhesion to water of the upper surface, a marked reduction of the truncate marginal teeth, and a deepening of the furrows above the ribs were obtained, and, in addition, the laminæ of this species assumed an upwardly convex form after exposure to rainfall continuously for twelve days. This must be considered as a new rainfall character, and is not to be identified with the rolling and twisting of leaves grown in a spray of cold water. In an attempt to distinguish the characters to which the glossy surface was due, it was found that in the normal leaf the external ends presented an outwardly papillose extension, giving a velvety appearance. In the rainfall leaves the outer wall of each cell was distinctly flattened. The smoothness of the upper surface is doubtless the principal factor in its adhesion to water, though it is entirely possible that chemical alterations in the outer wall have ensued. The results may be summarized as follows: (1) the determination of a new rainfall character, the upward convexity of the laminæ; (2) alterations in leaf margins; (3) inferentially, that the rainfall characters which may be induced experimentally are not identical, but rest upon the individuality of the species.

MARY A. NICHOLS: *Studies in the development of the ascospores in certain Pyrenomycetes.*—The paper contained an account of the early stages in the development of the ascigerous fruit in certain spheriaceous Pyrenomycetes. The observations relate specially to the question of sexuality, and point to the conclusion that a sexual process may be present in some member of the family and absent or very degenerate in others. Thus, in *Ceratostoma brevirostre* the origin of the ascospore is distinctly traceable to a fusion of differentiated gametes, while in Teichospora only possible rudiments of antheridia are present. The successive stages from the formation of the oosphere to the maturation of the ascospore reveal a process of development somewhat different from any heretofore suggested, but analogous to the development in Sphærotheca, as observed by Harper, and also somewhat similar to that in the Florideæ.

W. W. ROWLEE: *The stigma and pollen of Arisæma.*—The paper described the andrœcium and gynœcium of *Arisæma triphyllum* and *A. Dracontium.* The peculiarities noted were the consolidation of the stamens, the open style with the stigmatic papillæ not only on the surface of the stigma but also on the inner surface of the tube and forming a stigma-like tuft on the inner surface of the ovary. The pollen in one case was found to have already germinated within the anthers, and the tubes had folded back and forth upon themselves. Other cases examined did not show the same growth.

N. L. BRITTON: *Notes on the genus Amelanchier.*—Among the eastern forms, *A. Canadensis* can be distinguished easily from the rest, and is Appalachian and Canadian in distribution; *A. Canadensis obovalis* belongs to the coast and Great Lakes; *A. spicata* is a very low mountain species; and *A. rotundifolia* extends from Maine to the Saskatchewan. Among the western forms, *A. alnifolia* is reported from northern Michigan, but its occurrence so far east is doubtful, its eastern limit being rather from Nebraska to Manitoba; *A. Utahensis* ranges from Utah to

Arizona; *A. florida* occurs in Oregon and Washington; and *A. Pringlei* in Mexico.

ALEX. P. ANDERSON: *On the formation and distribution of abnormal resin ducts in conifers.*—By some extended work on the occurrence of normal and abnormal resin ducts in conifers the author found: (1) annual rings of *Pinus silvestris* and *Picea excelsa* containing frost rings have in cross sections fewer vertical resin ducts per square millimeter than the normal rings; (2) regulatory tissue in hyponastic branches of *Pinus silvestris* has in cross sections fewer resin ducts per square millimeter than the opposite side of the branch; (3) in *Abies pectinata* affected with *Æcidium elatinum*, (*a*) the resin ducts in the diseased bud-scales are more irregular in their form and contain fewer epithelium cells than the normal, (*b*) the fungus mycelium is never found in the resin duct canals, nor in the epithelium layer of cells surrounding the canals, (*c*) abnormal resin ducts are always found in the wood of the thickened portion of the diseased branch; (4) in *Pinus Strobus* diseased at the roots with *Agaricus melleus* Vahl, an increase in the number of resin ducts of the wood takes place in the whole plant above the diseased part; (5) in the wood of branches of *Abies pectinata* diseased with *Phoma abietina* Hartig abnormal resin ducts are found only above the constricted portion of the branch; (6) the same phenomenon as just mentioned occurs when young seedlings of *Abies pectinata* are diseased with *Pestalozzia Hartigii* Tub.

ARMA A. SMITH: *The development of the cystocarp of Griffithsia Bornetiana.* — Published in full in the July number of the BOTANICAL GAZETTE.

L. M. UNDERWOOD: *Notes on the allies of the sessile Trillium.*—Several species of Trillium have been confused apparently under this name. Even Linnæus included under this name at least two species which had been well figured before his day, the one by Plukenet and the other by Mark Catesby. One of these species, which is very distinct from the ordinary *T. sessile* in the states bordering the Ohio river, has been collected and studied in central Alabama during the past spring. It is a robust species with highly variegated leaves of at least three striking and distinct shades, and is well worthy of cultivation for its rich, velvety foliage, to say nothing of its large and rather handsome red flower. The species seems to have remained since Catesby's time without a name other than the polynomial he gave it. Other southern and southwestern species, as well as an equally remarkable series of species from the Pacific coast, have been unceremoniously and unnaturally combined under this name by American botanists, or barely separated as varieties or "forms." A revision of the group is badly needed. Attention was also called to a series of forms representing the earlier stages of the plant, and the study of post-embryonic stages was urged as a means of determining relationships.

C. L. POLLARD: *On an apparently undescribed Cassia from Mississippi.* — A remarkable Cassia, allied to *C. Chamæcrista*, but distinguishable by its virgate habit and strict pods, collected in northern Mississippi by Professor S. M. Tracy, proved, upon cultivation, to warrant its separation as a distinct species, to which the author proposes to give the name of the discoverer.

B. M. DUGGAR: *A bacterial disease of the squash-bug* (*Anasa tristis*). — Some squash-bugs kept for experimental purposes were found to be dying in considerable numbers, in an apparently healthful environment. The disease was readily passed on to other bugs. The distressed insects became sluggish, and very weak, and finally died, the body becoming a mass of gruel-like fluid. Cultures were made from dead insects upon various nutrient media, agar-agar, bouillon, gelatin, milk, etc., giving colonies of a bacillus. Inoculation of this bacillus produced the disease in healthy bugs. Infusions of different cultures were found to have characteristic toxic properties. Bugs placed in these infusions died with every symptom of distress. Preparations of the blood of diseased insects showed a short bacillus, single or in pairs. The tissues of the insects break down under the growth of these organisms, which probably enter insects through the spiracles.

C. R. BARNES : *What is bark?*— The varying use of this term suggests a consideration of how it should be used by American botanists. *Borke* and *Rinde* have been used by German botanists to denote respectively the external tissues of the root or stem which dry up, and the entire mass of tissues outside the cambium. In this usage, which has been tolerably consistent, they have been followed by the English. American popular usage, and scientific usage except as modified by foreign influence, assigns the name *bark* to the *Rinde* of the Germans. But *Borke* has been translated *bark*, while *Rinde* is translated *cortex* in the English editions of various German text-books. The author advocates the use of *bark* to designate the whole mass of tissue outside the cambium, while *cortex*, with suitable qualification, is used to designate certain parts of the bark. In this usage Americans are sustained by French botanists.

JOHN M. COULTER : *Structures of the embryo-sac.* — Attention was called to recent observations which showed a certain amount of variability in these apparently constant structures. These observations were supplemented by studies in Salix and the Compositæ. The results were summed up in the form of definitions of the three embryo-sac regions as follows : (1) *the egg-apparatus* consists of two or three usually naked cells, the oosphere and one or two synergids together representing a single archegonium, of which the synergids may represent canal cells ; (2) *the primary endosperm cell* is formed by the fusion of two vegetative cells (the polar cells), which process holds no relation to a sexual fusion and is stimulated normally by the act of fertilization to continue the vegetative development of the gametophyte, just as the adjacent sporophyte structures are stimulated to develop seed and fruit ; (3) *the antipodal cells* are variable in number (two to seventeen observed), evanescent or persistent, representing the vegetative region of the gametophyte not dependent upon fertilization for its development.

Embryos have been observed to develop both from synergids and in the antipodal region, and such may be regarded as arising through apogamy.

N. L. BRITTON: *Some Cyperaceæ new to North America, with remarks on other species.*—*Cyperus cylindrostachyus*, of the Old World tropics, has been introduced into the southern states, and is *C. cylindraceus* Chapman; *C. thyrsiflorus*, a Mexican type, extends into southern California; the Asiatic *C. pumilus* has been found introduced into Florida and Alabama. As waifs may be mentioned the Asiatic *C. congestus*, found at Painesville, Ohio; *C. glaber*, of southern Europe, found in Massachusetts; and *C. comosus*, of Greece and the Levant, found on ore heaps at South Bethlehem, Penn. The Cuban *Scirpus camptotrichus* has been found by Dr. Mohr as a native plant near Mobile. The author has also satisfied himself that the African *C. aristatus* is not the American plant so often bearing that name, and that the latter should retain its old name *C. inflexus*.

L. H. PAMMEL: *Grasses of Iowa.*—The paper contained a description of the topography of the state, and presented a list of the grasses. The grass flora is not diversified, containing fewer species than are to be found in any adjacent state. Among the species are noted twenty-nine species as from the north, forty-six from the south, eleven from the west, thirteen extra-continental, and fifty-five introduced.

W. A. KELLERMAN: *Ceres-pulver: Jensen's new fungicide for the treatment of smut.*—In 1890 Kellerman and Swingle published an account of successful experiments with potassium sulfid (liver of sulfur) as a preventive of smut of wheat and oats. This, according to J. L. Jensen, was the starting-point (*Ausgangspunkt*) for his *Ceres-pulver*. The exact composition of the fungicide is not given but it consists mainly of potassium sulfid. Other important ingredients are, according to Jensen, also added. He manufactures the ingredients and they are doubtless of purity superior to those usually kept in drug stores, and probably not too expensive, considering the quality.

The method of application is wholly different from that employed by myself and Mr. Swingle. I can, after trial, highly recommend it. A solution is made by dissolving 2 ℔s. in 125 liters of water. This is intended for 1000 ℔s. of seed. It is poured on the seed grain by means of an ordinary watering can, the mass at the same time being shoveled over and over on a tight floor, so that the solution may come in contact with every grain. The stirring of the heap of grain is repeated twice daily, the sowing to be done four or five days after the treatment. The heating will not be detrimental if the mass of grain is not more than six or eight inches deep. The initial stages of germination, which will be entered upon, are claimed to be of decided advantage.

My own experiments with this fungicide, though not yet completed, show that it is remarkably efficient and that it justifies the claims made for it by the originator.

N. L. BRITTON: *On the cardamines of the C. hirsuta group.*—*C. hirsuta* was distinguished from related species and regarded as probably a native of eastern North America, and not necessarily a marsh plant. *C. Pennsylvanica* Muhl., the most common form, is a tall leafy species, with elongated leaf segments, pods narrower than in the type, and is a bog and marsh plant. *C. parviflora* L. is a rock species of the mountains, and extending west to Lake Superior. It is a slender form with narrow leaf segments, and zigzag stem. *C. flexuosa*, a mountain species, is broadly leafy, with wide leaf segments, and pedicels shorter than in *C. Pennsylvanica* and pods two to three times as broad. *C. arenicola* is a species of the sand plains, from southern New England to New Jersey, Ohio, and from the Gulf states to Texas. It is rigidly erect, with narrow leaf segments and strictly erect pods.

JOHN K. SMALL: *The relation between the genera Thysanella and Polygonella as shown by a hitherto unobserved character.*—*Thysanella fimbriata*, the only representative of the genus, has persistently and apparently without reason been referred to the genus Polygonum. Its habit and morphology does not suggest Polygonum at all but strongly resembles that of Polygonella. The floral structure in Thysanella approaches more closely the conditions we find in Polygonella than anything known to exist in the genus Polygonum.

Another character possessed by both the genera in question, and one never mentioned in this connection, is the internodal branching. In all other members of Polygonaceæ the branches arise from the nodes; in Thysanella and Polygonella the branch or branchlet, as the case may be, is united to its primary axis often to beyond the middle of the internode.

JOHN K SMALL: *An apparently undescribed species of Prunus from Connecticut.*—This species is related to *Prunus maritima* and occurs in the immediate neighborhood and under precisely the same conditions. It is lower than the beach plum, more slender and delicate in habit, maturing its fruit earlier and losing its leaves earlier in the fall. The following differences from *P. maritima* may be noted: (1) the leaf is orbicular instead of elliptic or oblong; (2) the flowers are smaller with shorter and broader calyx-segments; (3) the drupe is smaller, always globose, and short pediceled; (4) the stone is smaller and more turgid (nearly as thick as broad) and pointed only at the base, while that of the common beach plum is flattened, more elongated, and pointed at both ends.

JOHN K. SMALL: *The flora of the summits of King's mountain and Crowder's mountain, N. C.*—The following phenomena may be noted: (1) the rare fern *Asplenium Bradleyi* is very common on the slopes and extends to the higher points; (2) normally large forest trees appear as small shrubs although the altitude is not great, and in this extremely stunted state produce abundant fruit; (3) the vegetation is shrubby with the exception of two perennial herbs, a fern and a sedge; (4) the occurrence of *Quercus nana* in the summits extends the geographic range of that species several hundred miles in an unexpected direction; (5) almost one-half of the shrubby plants on King's mountain are ericaceous, and the range of one, *Rhododendron Catawbiense*, is extended far to the east and in addition the station is at a much lower altitude than any at which the species has hitherto been known to occur; (6) although the summit of King's mountain is much smaller and some feet higher than that of Crowder's mountain it harbors six more species, chiefly shrubby.

DAVID F. DAY: *Parthenogenesis in Thalictrum Fendleri.*—In 1883 a seedling of *T. Fendleri* was sent home from Colorado for cultivation. In late May it flowered and proved to be pistillate. About the last of August it presented abundant and good seed, although no staminate plants of any species of Thalictrum were in the neighborhood. The seeds were planted and yielded abundantly staminate and pistillate plants. Staminate plants have been artificially prevented from maturing flowers almost every year since. At least eight times in the thirteen years the pistillate plants have produced good seed in abundance. Plants were sent to Meehan, Missouri Botanical Garden, and Orpet of S. Lancaster, Mass., and all report in 1896 perfect seed from pistillate plants. This seems to be a clear case of parthenogenesis. *T. dioicum* does not show a similar habit.

ELIAS J. DURAND: *A discussion of the order Pezizineæ of Schröter.*—A brief historical sketch giving the views of the principal systematists in regard to the classification of these plants, especially that of Schröter in his *Kryptogamen Flora von Schlesien.* The remainder of the paper deals with the most recent views and with a summary of investigations on the subject by the writer.

S. M. TRACY: *What should constitute a type specimen?*—The speaker called attention to the confusion existing in the use of such terms as "duplicate of type," "co-type," "type locality," etc., and suggested that some action be taken looking towards an agreement as to what should constitute a type specimen.

F. C. NEWCOMBE: *Rheotropism and the relation of response to stimulus.*— It has been shown by Strasburger and Stahl that plasmodia of Myxomycetes grow against a gentle stream of water. Jonsson found three fungi and the roots of three phanerogams that also grew either against or with a stream of water. For this phenomenon Jonsson proposed the term *rheotropism.* As the work was left by Jonsson there was no indication of the extent of rheotropism among phanerogams, nor was it determined whether there were any negatively rheotropic, nor whether there were any indifferent roots, since the three species cited by this author were positively rheotropic.

The work which is reported in this paper has shown that among seventeen species of monocotyledons and dicotyledons studied eight are positively rheotropic and nine are indifferent or neutral. None have been found to be negatively rheotropic. Only seedlings were used.

The phenomena of rheotropism in roots are these. When seedlings are suspended with their roots dipping into water flowing with a favorable velocity, the roots, if positively rheotropic, will bend their tips, in the course of a few to several hours, directly or obliquely against the stream. Since the roots grow against the mechanical pressure of the stream and display a latent period and an after-effect, rheotropism is assumed to be a response to irritability. The stimulus for this response we can do no better at present than to call the flowing water. There may be some unwillingness to regard this as the real stimulus, seeing that the response to such a stimulus is difficult to interpret as being to the advantage of the plant. This brings up the general question of the relation of response to stimulus.

It is quite certain that there is a chain of causal mechanism between stimulus and the response which the stimulus sets in motion. This mechanism has been developed by the reaction of the plant organ toward its environment. But it is almost certain that the mechanism may be started by other stimuli than those to which it has developed a special correspondence. If this be true we may look for responses in plants and animals that are not to their particular advantage. However this may be, the investigator is interested in all irritable responses, useful to the plant or not useful, for it is only by studying all phenomena that we may go a step farther toward solving the intricate problems of irritability.

HERMANN VON SCHRENK: *Some adaptations of shore plants to respiration.*—The paper treats about equally the following topics: (*a*) the different shore plants, classified according to proximity to water (aquatic plants are not considered); (*b*) the necessity of modified structure to meet new conditions; (*c*) the modifications thus caused in the form of water lenticels and the peculiar tissue, aerenchyma; (*d*) inconstant occurrences of the latter on many plants and reasons therefor; (*e*) discussions as to what the meaning of this power of adaptation in certain plants may be.

D. T. MACDOUGAL: *The mechanism of curvature in tendrils.*—The curvatures of tendrils in response to contact stimuli are due to contractions of the concave side. The coiling of free portions of tendrils is due to excessive growth of the convex side The two processes are entirely independent, and the second may be influenced to a minor extent only by the first.

EDWIN B. COPELAND: *A contribution to our knowledge of the relation between growth and turgor.*—The paper gives an account of the state of turgor of seedlings of *Vicia Faba*, grown at various temperatures, presented by means of a table. High turgor is present when growth is slow and *vice versa*. The turgor of *Lupinus albus*, normal, etiolated, and deprived of $CO_2$, is discussed. Prevention of growth is accompanied in this plant also by high turgor and *vice versa*. The conclusion drawn is that the rapidity of growth regulated the amount of turgor, instead of growth being regulated by amount of turgor.

BOTANICAL CLUB.[3]

W. A. KELLERMAN: *Distribution of certain Ohio plants.*—With the aid of a map, attention was called to the distribution of *Phoradendron flavescens* through the southern counties, the northern limit broadly coinciding with the southern limit of the drift; of *Bignonia crucigera*, occurring only in Lawrence county, the southernmost county of the state; and of *Polypodium polypodioides*, occurring in two Ohio river counties, Adams and Hamilton.

L. R. JONES: *A method of distributing fungi in pure cultures.*—When leaves contain numerous fungi the distribution of dried material frequently leads to confusion. Cultures of the desired fungus are made in agar and sent in blocks with the dried material.

MRS. E. G. BRITTON: *An interesting moss from the White mountains.*—In a recent collection of mosses made by Mr. Faxon in the White mountains there occurred specimens of *Tetraplodon mnioides*. The moss is known in small tufts on other mountains, but occurs abundantly in the new station. Its abundance seems to be explained by the presence of the mountain stables, from which the dripping urine of the horses has furnished peculiarly favorable nutrition.

DAVID F. DAY: *The branching rhizomes of Iris.*—Numerous native species of Iris in cultivation had been observed, and in every case the rhizomes branched terminally into three divisions, the central one alone giving rise to the flowering stem. This habit is believed to be true of all American species of Iris, and of all species excepting the so-called bulbous forms.

[3] No formal papers are read before the Club, but the topics reported are presented informally and discussed.

C. E. Bessey: *Distribution of Arctostaphylos Uva-ursi in Nebraska.*—The state was described as an almost treeless sloping plain, rising from the Missouri river at an elevation of 1000 feet to 5000 feet at the western boundary. Near the center of the state the bearberry was found a few years ago in a small cañon, and recently at a second station in a gorge of the bluffs of the Republican river at the southern boundary of the state These two isolated patches are widely separated from the present mass distribution of the species to the north and west. They are also noteworthy from the fact that ericaceous plants are notoriously absent from the whole region.

F. C. Newcombe: *An improvement in a paraffin bath.*—Shrinkage of protoplasm when imbedding plant tissues often occurs when they are transferred from the cold saturated paraffin solution to pure warm paraffin. To enable one to make this increase in temperature gradual some device must be adopted to allow the imbedding dish to be lowered gradually into the bath. A brass spring bearing against the side of the pocket which receives the dish was suggested.

W. W. Rowlee: *Notes on oaks.*—Specimens of oaks growing in the vicinity of Ithaca, N. Y., were displayed, showing (1) the habit of branching at the end of each annual growth, giving the characteristic appearance of rigidity; (2) a case of second shoot development during the present season, the winter bud having formed in June, and subsequently having developed its shoot; and (3) a remarkable case of leaf variation upon a single branch, giving the tree the appearance of bearing a branch of some other species.

C. E. Bessey: *Distribution of Pinus ponderosa in Nebraska.*—The distribution of this pine in Nebraska has been given usually as occurring in two regions: along the northern border of the state down the Niobrara and up its cañons; and at the southwestern corner of the state along the Platte. It is now found that the pine occurs in patches in cañons of the Loup in the center of the state, and also elsewhere, representing remnants of forests. A former extension eastward along the valleys was inferred, and their present bare condition was attributed to the destructive presence of man during the years of migration " across the plains."

L. H. JONES: *Notes on potato-leaf fungi.*—Cultures of *Macrosporium Solani* and inoculations with it indicate that it is not the cause of "early blight" or "leaf-spot disease," but is a true parasite. The cultures also proved it to be an *Alternaria*, and hence should be called *A. Solani*. What is known as "tip burn" was found to be associated with a fungus which proved not to be *M. Solani*, although usually confused with it. It produces alternaria chains, but the spores are smaller and more numerous in the chains than *M. Solani*. It is a saprophyte common to many plants and seems to be identical with *M. Tomato* Cke., which is certainly an Alternaria.

H. L. RUSSELL: *A method of hindering condensation of water in culture plates.*—Water is apt to condense upon the under surface of covers of culture plates, and dropping upon the surface of the culture plate causes more or less trouble. This can be remedied by placing the culture plate with its cover within a bowl covered by another bowl a little smaller.

C. E. BESSEY: *Notes on the flora of Colorado Springs.*—Attention was called to five distinct plant societies which occur in the region of Colorado Springs, and which abut closely upon each other with sudden transitions. The habitats of these societies are: (1) the plains; (2) open dry mountain ridges and summits; (3) deep cañons, in the lower stretches of the mountain elevation; (4) mountain meadows, at a greater elevation than the cañons; and (5) mountain swamps, usually lying between the meadows above and the cañons below. Rapid changes are taking place in the flora of the region, in explanation of which three causes were suggested as follows: (1) removal of forests by fires, etc., thus denuding the slopes; (2) the consequent opening of cañons to light, changing dark and damp conditions to those which are open and dry; and (3) vandalism of tourists, in the cañons especially, which have been ravaged, notably of ferns.

E. J. DURAND: *On a species of Epipactis.*—Upon a lawn in the village of Canandaigua, N. Y., *Epipactis viridiflore* suddenly made its appearance, although careful search of the whole region has failed as yet to discover it as a plant of the local flora. In the same connection Mrs. E. G. Britton called attention to a similar sudden appearance of *Arisæma Dracontium* in a garden upon Staten island, although not known to occur wild anywhere upon the island.

C. L. POLLARD: *Report of the National Herbarium.*—The new organization of the herbarium consequent upon its removal to the National Museum was explained. The customary appropriation of $25,000 to the Division of Botany had been reduced by the last legislature to $15,000. The necessary relief was then obtained by an additional appropriation of $10,000 upon the condition that the herbarium be placed in the care of the Smithsonian Institution. Mr. Coville is appointed honorary curator, while the staff directly connected with the work at the National Museum consists of J. N. Rose, in charge of the determination of the higher plants and the work upon the Mexican flora; O. F. Cook, in charge of the cryptogamic work; and C. L. Pollard, in charge of the mounting and distribution of material.

E. G. BRITTON: *Note on Schizæa pusilla.*—In 1879 Mrs. Britton made the first announcement of the discovery of this rare fern in Nova Scotia. During the present season she has received additional specimens of it from Mr. Waghorne.

K. M. WIEGAND: *Notes on Boschniakia.*—Studies of Tacoma material of *B. strobilacea* revealed characters not provided for in the generic description as it appears in the Synoptical Flora. The linear subulate bracts, and the two lateral calyx teeth are the notable discrepancies. Examination of *B. glabra*, the original species, showed that the generic description was constructed for it, and had not been modified so as to include *B. strobilacea*. Discrepancies were also pointed out in the section characters of the genus.

C. R. BARNES: *Photosyntax* vs. *photosynthesis*.— It was stated that the word photosyntax, proposed in 1893 by the speaker, but objected to by Professor MacMillan as etymologically bad, had been resubmitted to three competent Greek scholars and pronounced by all to be linguistically unobjectionable and accurately expressive of the process of carbohydrate formation as now understood.

J. F. COWELL: *Notes on some hybridized sunflowers*.— Ordinary flowers of *H. petiolaris* had been pollinated from some "doubled" *H. decapetalus*. Seedlings were shown which presented complete intermediate characters.

E. G. BRITTON: *Mnium Roellii* Broth.—The synonyms of *Bryum lucidum* E. G. Britton were explained, of which the last is *B. Sandbergii* Holzinger.

C. E. BESSEY: *The cañon flora of the plains of Nebraska*.— The cañons occurring in the general plain surface were described. Up to the very brink of these cañons sand-loving plants are found, but within the cañons they are suddenly replaced by moisture-loving plants, representing a totally different flora. The strong invasion of plants from the Rocky mountain region has, therefore, resulted in two types of incursion, that across the sandy plains, and that within the cañons. The invasion of eastern plants is observed to have a similar twofold expression. The cañon plants are not necessarily cañon plants at the west or east, but are simply moisture-loving.

E. B. COPELAND: *Turgor variation in mosses.*—The turgor variation in relation to temperature was specially noted, being in general greater in mosses than in other groups. Plasmolysis was used as the test of turgor. It was shown that in *Mnium cuspidatum* the accommodation to changed temperature was dependent upon the products of assimilation; while in *Funaria hygrometrica* it was proved that this was not the case.

A. P. ANDERSON: *A simple piece of apparatus for infecting and spraying plants.*—A syringe of peculiar structure, such as artists use in "finishing off" paintings, was suggested, as being a better distributor than the ordinary apparatus.

E. J. DURAND: *Structure of pseudo-parenchyma.*—The method of the transformation of ordinary hyphæ into pseudo-parenchyma is easily observed in its simplest form in Tubercularia. In Peziza it is not so evident, but gradual transition can be traced clearly. In general there is a rounding off of the cells of much septate hyphæ, and sometimes a coalescence of the cells of contiguous hyphæ.

HERMANN VON SCHRENK: *Notes on the hosts of Comandra umbellata.*—This plant is by no means always a parasite, but when it is such it is assumed to be an ericaceous parasite. While most commonly attached to species of Viburnum, the speaker had found it upon *Potentilla Norvegica, Solidago Canadensis*, and *Phleum pratense*. Attention was called to the fact that attachment does not always mean absorption, and this is notably true in the case of a grass host.

CONWAY MACMILLAN: *Function of the submerged leaves of Salvinia.*— The hairs upon the submerged leaves have been considered usually as not organs of absorption. The speaker had observed that when exposed in water containing small crustacea, etc., the sharp-pointed hairs, standing out in every direction, are avoided. It was suggested that the hairs, therefore, may be largely protective organs against predatory insects. They may serve also as a sort of counterpoise in high winds, offering resistance.

CONWAY MACMILLAN: *Nuclear budding in Cypripedium.*—The speaker had noted a peculiar fragmentation in the nuclei of the basal cells of the hairs. The process can be indicated best by the term "budding," as it seems to be a gradual outgrowth from the surface of the nucleus with final separation.

CONWAY MACMILLAN: *Adaptation of Coniferæ to wind-swept stations.*—In his studies of the flora of the Lake of the Woods the attention of the speaker had been called to a group of white pines which were not growing in the usual manner in rock crevices. In addition to the high branches a circle of branches flat upon the rocks had been developed, forming a dense circular mass, after the manner of a juniper. This was interpreted as an adaptation to a high wind-swept position, and shows that a forest plant may assume the juniper habit.

FLORENCE BECKWITH: *Plants new to the flora of Monroe county, N. Y.*—Since the recent publication of the Catalogue of the Rochester Academy of Science several plants new to the flora have been discovered.

EDNA M. PORTER: *Note on the pollination of Epipactis viridiflore.*—It was shown that the plant is pollinated by the wasp *Vespa diabolica.* In Europe, according to Darwin, *V. silvestris* is the pollinator. Plants covered with a netting set no seed. The observations were illustrated by an ingenious mechanical chart, *à la* Gibson.

E. B. COPELAND: *Turgor and unused residues.*—In all normal roots, stems and leaves there is a large residue of osmotically active matter which the plant cannot use to postpone starvation. In these organs the nutrient matter is relatively unimportant. In the storing places of dissolved food, however, this element in the turgor sometimes dominates; but here, too, a considerable unused residue is usually encountered.

A. P. ANDERSON: *Supposed pathological condition of a pine board.*—The speaker displayed a board whose appearance was supposed to indicate a fungus attack, but explained that the appearance was due to the remains of the "short shoots."

EMILY GREGORY: *An interview with Schwendener.*—The speaker described an interview with Schwendener concerning the views of Reinke upon the nature of lichens, in which Schwendener is reported as saying that Reinke's views differ in no essential respect from his own.

JOHN M. COULTER: *Cross-fertilization and heterospory.*—Attention was called to the danger of confusion in applying the terms close-fertilization and cross-fertilization to heterosporous plants. Close-fertilization, strictly defined as the fusion of gametes produced upon the same individual, cannot occur in heterosporous plants. Heterospory necessitates cross-fertilization, and the closest possible affinity is that of two gametophytes borne upon the same sporophyte. In seed-plants, therefore, we find close-pollination and cross-pollination, but only cross-fertilization. The significance of the flower, therefore, is not to bring about cross-fertilization, but to render more distant the relationship between the two gametophytes concerned.

E. G. BRITTON: *The mosses of R. S. Williams.*—The speaker announced that collections of the mosses of the Columbia region of northern Montana were being made by R. S. Williams, and commended his work to the favorable attention of botanists Sets for sale will be ready soon.

W. A. KELLERMAN: *An index card for local herbaria.*—A card was exhibited upon which was printed an outline map of Ohio, which could be variously marked to indicate the range.

# BRIEFER ARTICLES.

## NOTES ON TWO SPECIES OF BRASSICA.

BRASSICA SINAPISTRUM Boiss. In the *Synoptical Flora*, i. pt. 1, 134, it was stated that only the smooth-fruited form of this species had been introduced into North America, such being the inference derived from the specimens examined in the preparation of that work. During the present summer, however, the writer has found a number of specimens of this species, growing on railway ballast near West Cambridge, Mass., which have hispid fruit. This form occurred in company with the more typical plant, and appeared on close comparison to differ from it in no regard other than the one mentioned. Furthermore, the pubescence of the fruit, although more or less striking when well developed, passed in other specimens into minute sparse hairs, so that transitions to the smooth-fruited forms were by no means lacking. Indeed, in some cases, the pubescence of the different siliques on the same individual differed considerably, being somewhat more conspicuous upon the lower, earlier-formed fruit. In both the smooth-fruited and hispid-fruited forms the pedicels are often hirsutulous. Both forms of fruit have long been recognized in the Old World, but the differences have been rightly regarded as formal rather than varietal.

B. JUNCEA Coss.—In May 1895, Professor Britton (*Bull. Torr. Bot. Club* **22**: 225) called attention to the frequent occurrence of this Asiatic species in waste places of southern New York, Pennsylvania to Michigan and Virginia. It had previously been found in several parts of New England, and has since proved locally abundant in eastern Massachusetts and in New Hampshire. After giving a good description of *B. juncea*, in the place cited, Professor Britton states that it is "readily distinguished from *B. Sinapistrum* Boiss. by the total absence of the hispid pubescence of that species and by its erect longer subulate-beaked pods." Having had this summer excellent opportunities of comparing many dozen specimens of each of these species growing side by side, the writer would suggest that the distinctive characters here brought forward are by no means the most reliable. For the hispid pubescence is not always absent upon *B. juncea*, although always much less conspicuous than in *B. Sinapistrum;* the trichomes, when present, being confined to the lower leaves and lower part of the stem. Furthermore, the siliques of *B. Sinapistrum* vary greatly in position, being sometimes subappressed and sometimes widely spreading, so that they are accordingly either erect or very oblique. As to the length of the fruit there is no great difference between the two species, but if a distinction can be made on this feature it would seem that the fruit of *B. Sinapistrum* rather than of *B. juncea* was in general the longer.

On the other hand, several characters furnish very definite and constant differences. In the first place, *B. juncea* is a taller and much paler plant, having a distinctly glaucous stem and more or less glaucescent leaves, while *B. Sinapistrum*, at least as it occurs about Boston, is never glaucous at all. Then in *B. Sinapistrum* the upper leaves are broadest near the rather abruptly contracted base, while in *B. juncea* they are gradually cuneate at the base. But perhaps the most striking difference is in the fruiting pedicels, which in *B. Sinapistrum* are short and thick, being only about 4 or rarely $6^{mm}$ long, while in *B. juncea* they are much more slender and 6 to $10^{mm}$ in length. The beak of the fruit in *B. juncea* is slender, subulate, and apparently always empty. In *B. Sinapistrum*, on the other hand, it is rather stout, decidedly ancipital, and commonly contains one seed.

By these characters the plants in question can be readily distinguished, and when once recognized are not likely again to be confused. *B. juncea* seems already to be the commoner species of the two about Boston. Its rapid distribution and establishment in the United States recalls that of *Lactuca Scariola*, or the more recently disseminated *Sisymbrium altissimum*. The best illustration of *B. juncea* is that of Duthie and Fuller in their *Field and Garden Crops of the Northwestern Provinces and Oudh* (plate 41).—B. L. ROBINSON, *Harvard University*.

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## A NEW MAMILLARIA.

**Mamillaria Brownii**,[1] n. sp. Glaucous, globose, 5 to $8^{cm}$ high, simple: tubercles 20 to $28^{mm}$ long, at first terete but later becoming more or less quadrangular at base, very broad and large, the

[1] This plant will be *Cactus Brownii* to those who prefer the generic name *Cactus*

groove absent in young plants, but extending to the axil of the floriferous tubercle: radial spines 8 to 11, teretish, bulbous at base, spreading, 15 to $20^{mm}$ long, white or more or less tinted with purple, straight or slightly curved, lower spine and 1 to 3 slender upper ones a little farther back on tubercle than the remaining 7, which are very robust and form an almost perfect circle around the

stout central; central somewhat longer than radials and sometimes slightly flattened on upper side, always solitary and curved or hooked downward; all with horny tips: flowers 5 to $6^{cm}$ long and spreading to nearly same diameter, opening in bright sunshine and enduring for only a few hours, salmon-yellow: ovary tubular, 20 to $25^{mm}$ long, with from 4 to 7 minute, caducous scales; fruit and seeds unknown.—Type growing in cactus garden, University of Arizona.

Description drawn from plant collected three years ago by Herbert Brown, in the Baboquabari Mountains, in Southern Arizona, and which now flowers for the first time.

I have named this species for Mr. Herbert Brown, from whom the specimen was obtained. There has been some hesitation as to placing this plant in the genus Mamillaria or Echinocactus. Together with *Mamillaria macromeris* and *Echinocactus Simpsoni* this plant almost, if not completely, breaks down all generic differences between these two genera. The prominent tubercles in no definite arrangement and the deep groove extending almost if not quite to the axil would denote it to be a Mamillaria; on the other hand, the exceedingly robust spines and the scales on the ovary are characteristic of the genus Echinocactus. It seems, however, to agree more closely with the genus Mamillaria as at present understood.—J. W. TOUMEY, *University of Arizona.*

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## THE DISTRIBUTION OF THE SPECIES OF GYMNOSPORANGIUM IN THE SOUTH.

IT is a somewhat remarkable fact that no less than six very distinct species of Gymnosporangium are parasitic on *Juniperus Virginiana*. These species are all found in the states bordering on the Gulf of Mexico, and so far as present data indicate, two of them are peculiar to this region. The other species are of much wider distribution, but we still lack reliable information regarding the extent of range of any of the species of the genus. The species may be arranged in groups as follows:

Producing somewhat globose galls.
- Perennial species.
  - *Gymnosporangium globosum* Farlow.
  - *Gymnosporangium Bermudianum* (Farlow) Earle.
- Annual species.
  - *Gymnosporangium macropus* Link.
  - *Gymnosporangium* sp.[1]

Producing slight enlargement of stems or fasciation of branchlets.
- Perennial species.
  - *Gymnosporangium clavipes* Cooke & Peck.
  - *Gymnosporangium nidus-avis* Thaxter.

Of the above species *Gymnosporangium macropus* is the most conspicuous and widely distributed, its rœstelia occurring on the wild crab and the cultivated apple. We have also found it during the past year in Alabama growing on *Cratægus spathulata*. Its general distribution is doubtless coextensive with the wide distribution of its host, since its most common alternate host is as widely cultivated. In the

[1] The assignment of a name and description to this species has been left to Dr. Thaxter, to whom the writers are indebted for numerous comparisons of material and verifications of species during the past year.

south it is usually very common. It is found in South Carolina (*Ravenel*, Fungi Carol. no. 85), Georgia, Alabama, Mississippi, and is also reported from Florida (*Webber*) and Texas (*Jennings*). An interesting feature of its development occurred during the present season in Alabama, showing the effect of the season on habit of growth. An early rain caused the germination of some of the teleutospores, so that there was an early crop of rœstelias produced on the apples. At the time of the next rain, and after an interval of about six weeks, the remainder of the teleutospores were brought to germination, and at the same time the effects of the earlier sowing had already produced the characteristic spots and yellow thickenings of the rœstelias and the spermagonial stage was reached. Toward the end of July the new galls for the next season had already developed and had attained considerable size. With all our knowledge of this common species, we are still uncertain as to what may be the ordinary time and method of the formation of this gall on Juniperus.

*Gymnosporangium clavipes*, next to *G. macropus*, is the most common species in central Alabama. Since it produces no enlarged gall, its presence is often overlooked until after the germination of its teleutospores, when its semi-dried gelatinous spore masses render it quite conspicuous. Its Rœstelia is found on the cultivated quince and on various species of Cratægus. Its range appears to be confined to the Appalachian region. In the south it occurs in South Carolina (*Ravenel*, Fungi Amer. nos. 272, 502), Georgia, Alabama, and Mississippi.

An undescribed species of Gymnosporangium is the next most common in Alabama, and appears also to be frequent in Mississippi at Starkville (*Tracy*) and Ocean Springs (*Earle*). It is apparently an annual species producing galls similar to those of *G. macropus*, but of a peculiar red brown color and luster, reminding one of *G. Bermudianum*. In shape they approximate those of *G. globosum*, and are often very small, with single spore masses, but frequently have a peculiar ray like arrangement of four or five spore masses arranged at right angles to the (short) axis of the gall; occasionally they are larger, even reaching two or three centimeters in diameter. They are entirely devoid of the characteristic bark colored flakes of *G. globosum*. The spore masses are darker, shorter, broader and more conical than those of *G. macropus*, and are wholly unlike the dark wedge shaped masses of *G. globosum*. The spore characters are also different from either of the two allied species. The rœstelia of this interesting species is suspected to be a peculiar undescribed form first discovered by Professor G. F. Atkinson in Alabama, and since by one of the writers on *Cratægus spathulata*. Cultures of the Rœstelia were attempted in the greenhouse on young plants of Cratægus transplanted from the woods (which afterwards proved to be *C. parvifolia*), but with negative results. Preparations are in progress to make more extended cultures another year on *C. spathulata*, which is one of the common species of haw in the vicinity of Auburn.

*Gymnosporangium globosum* is rare at Auburn, Alabama, occasional at Starkville, Mississippi (*Tracy*), and found once at Ocean Springs, Mississippi (*Earle*). A second form of this species, whose characters have not yet been fully studied, also occurs in Mississippi.

*Gymnosporangium nidus-avis* appears to be quite rare in central Alabama, only three specimens having been found the present season, all of them the branch form, and none of them producing the peculiar fasciation of the branchlets so common in eastern Massachusetts. They appear very early in the south, the teleutospores germinating during the rains of the latter half of February. A marked feature of the branch form of this species, readily distinguishing it from *G. clavipes*, is the peculiar orange colored stain left on the somewhat hardened inner bark of the host; this is perceptible even in specimens long collected. The species seems to have a wide distribution, in the south commencing with South Carolina (*Ravenel*, Fungi Car. no. 87, distributed as *G. Juniperi*), and extending through Georgia (*Ravenel*, Fungi Amer. no. 791, distributed as *G. conicum*), Alabama, and Mississippi. A peculiar form appears in the collection of the Division of Vegetable Pathology and Physiology, which Professor Galloway has kindly permitted us to examine, under the name of *G. juniperinum*, collected at Fredericksburg, Texas, by F. Grasso in 1893 and again in 1895. It resembles closely certain foliicolous forms of *G. clavipes*, but the spore masses are larger and more prominent and the pedicels are not enlarged. It is desirable that we have as wide a series of specimens as possible from the entire Gulf region in order to determine more fully the limits of these species as well as their geographic distribution.

The last species of the list, *Gymnosporangium Bermudianum*, has the most limited distribution in the Gulf region, and is as remarkable in its life history as in its distribution. It is known from the Bermuda Islands, where it was first collected by Professor Farlow and described by him as Æcidium,[2] and from Ocean Springs, Mississippi, where one of the present writers discovered its true gymnosporangial character, and also its peculiar rœstelia, in 1892. The Mississippi material was first collected in January 1887 and sent to Professor Farlow, so that Mississippi is one of the type localities of the original description. Later in the spring of 1892 the teleutospores were discovered, and in October of the same year the rœstelia with its distinct, long exserted, lacerate peridia was found on the same galls, the old broken bases of which must have formed the peridia of the supposed Æcidium as originally described. The species, therefore, unlike all its congeners, produces its æcidial and teleutosporic stages on the same host, from the same gall, and in all probability from the same mycelium. The species can scarcely be said to be common, though when found it usually infests considerable portions of the tree in which it occurs. Several stations are now known for the parasite at distances of a few miles from the original tree where it was found in 1887.

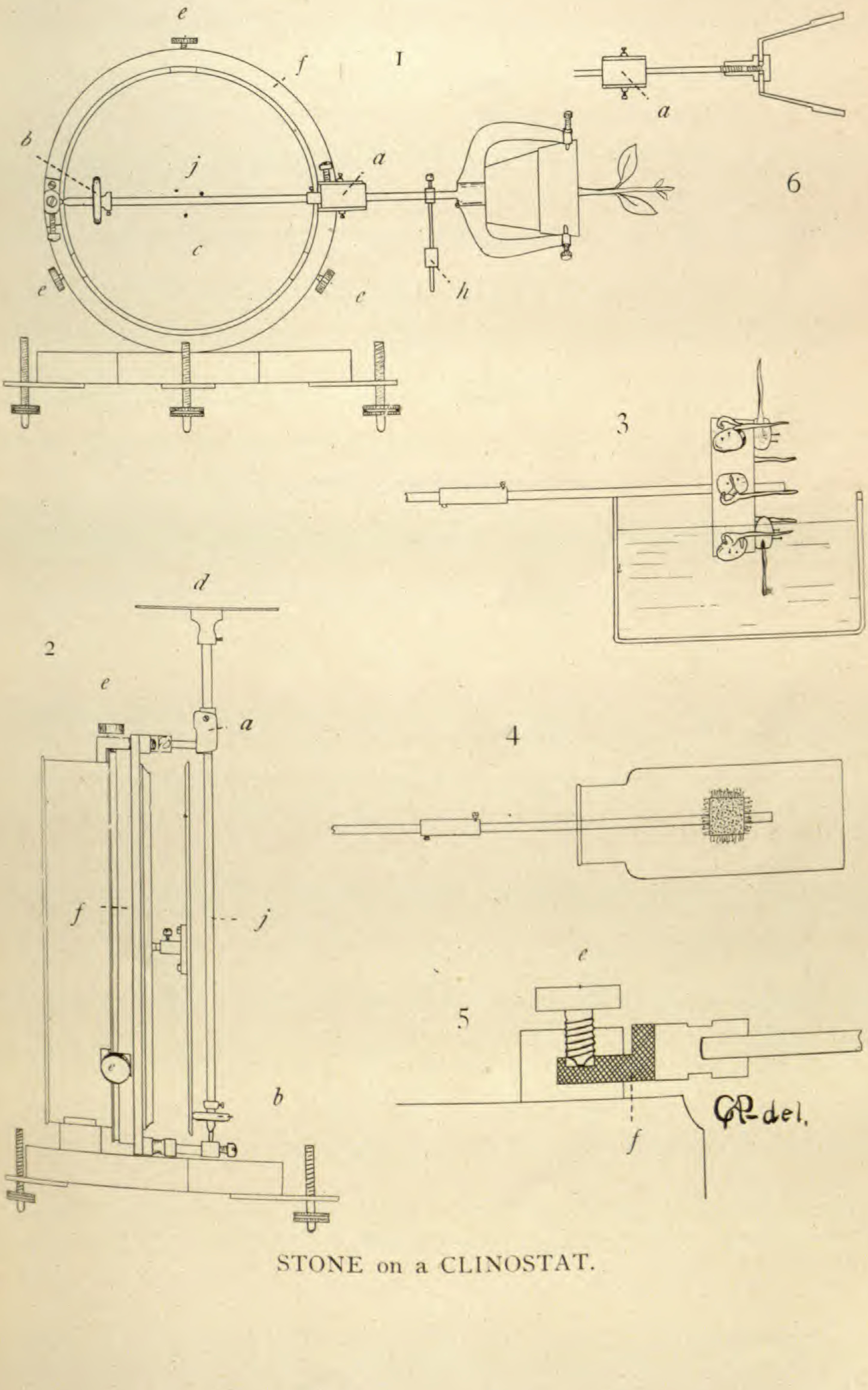
The conditions of growth manifested by the last species introduce a new and interesting problem into the question of the evolution of the various species of the genus. At one extreme of the series we have *G. macropus* and its new ally, annual species, producing their rœstelias on various Pomaceæ and consequently dependent for their perpetuity upon the success of their annual sowing and interchange of host. Then we have the various species that are perennial and thus capable of continuing from year to year without the intervention of the rœstelia stage, but with which they continue to propagate themselves more widely. Then, finally, we have *G. Bermudianum* producing both stages on the same host and therefore independent of the Pomaceæ for its continuance. The details of this evolution will constitute a further problem.— LUCIEN M. UNDERWOOD and F. S. EARLE, *Auburn, Alabama.*

## BOTANICAL APPLIANCES.

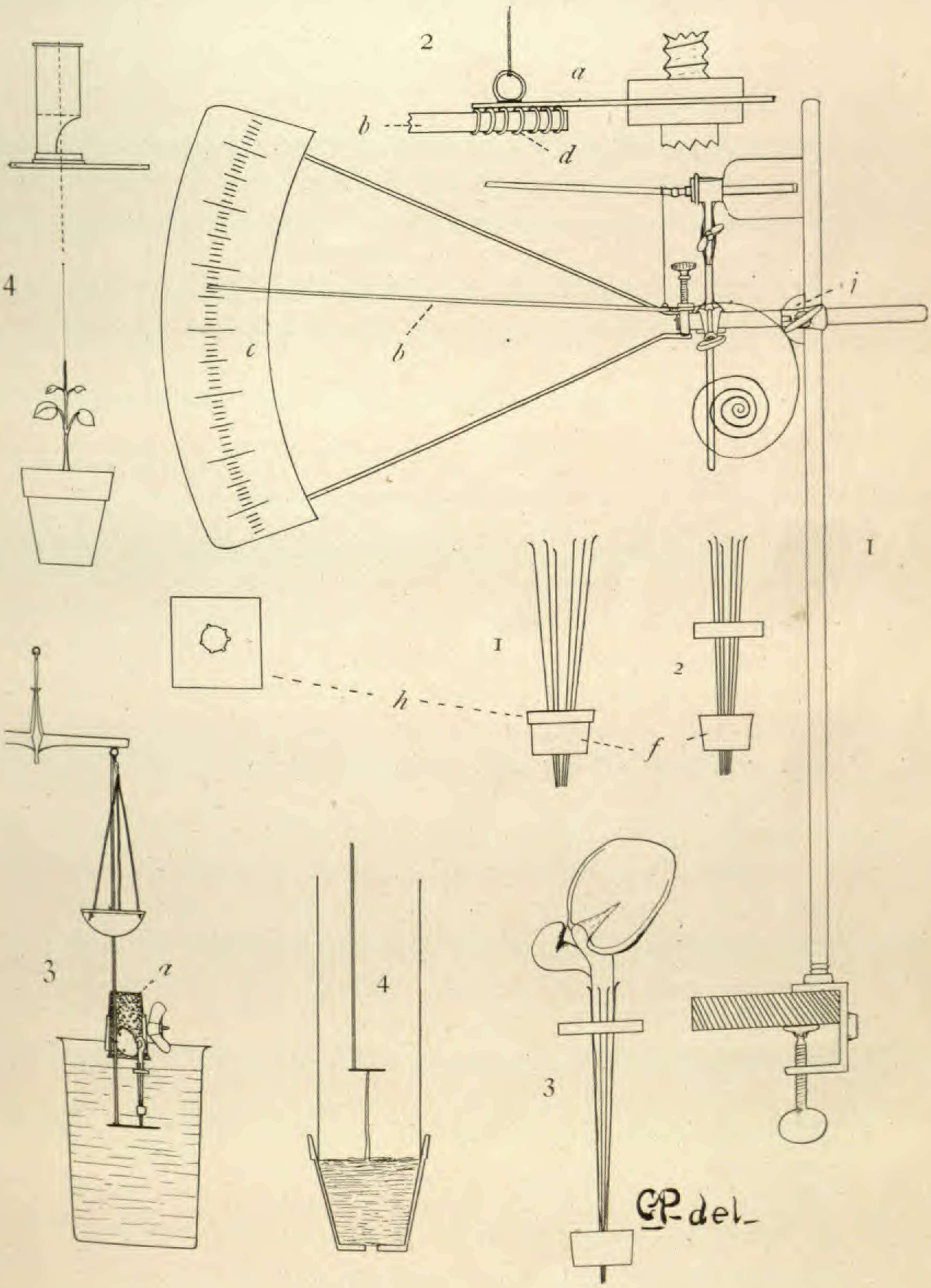
(WITH PLATES IX AND X.)

BOTANICAL appliances serve for investigation and demonstration, and while some of the following appliances were devised for special work they have also been used in demonstration in a practical course of vegetable physiology in our laboratory.

[2] *Æcidium Bermudianum* Farlow, BOT. GAZ. **12**: 206. 1887.




STONE on a CLINOSTAT.




STONE on BOTANICAL APPLIANCES.

**Clinostat** (*pl. IX*).—The phenomena of heliotropism and geotropism are of such fundamental importance that I believe it would not be out of place to offer demonstrations of them in secondary schools, especially since our elementary text-books lay some stress on plant physiology. It was partially with this idea that this instrument was devised, and in its construction we have endeavored to obtain a cheap and compact piece of apparatus, and one at the same time which will illustrate all of the principles. Undoubtedly the best clinostat which has been devised for general purposes is that of Pfeffer, made by Albrecht of Tübingen at a cost of $80. It can be adjusted to different rates of speed and is furnished with a powerful spring which enables it to run twenty-four hours without rewinding. An excellent clinostat is that of Wortmann, made at Strassburg, and costing about $60. So far as compactness is concerned this is the best, but a great drawback is that it has to be wound every twelve hours. Every laboratory where plant physiology is taught should endeavor to have one of the above, but when it is necessary to have more than one, or in case an instrument for illustrative purposes only is needed, a simpler and cheaper one will frequently answer as well. Such an instrument I have used in modified forms for three years. Briefly stated, it consists of an eight-day spring Waterbury clock (*figs. 1* and *2*) with a disk attached to the hour hand spindle which moves a shaft provided with a small friction wheel to which the plants are attached. The disk (*c*) is of aluminum $2^{mm}$ thick and $47^{mm}$ in diameter, fastened to the hour hand spindle by means of a set screw. The hour hand spindle is lengthened to extend beyond the face of the clock, and is larger and provided with a better bearing than is ordinarily supplied with the clock by dealers. This gives to the movement greater stability, although I have used the ordinary spindle with success. Shortening the hair spring of the balance wheel of the clock causes the hour hand spindle, and consequently the aluminum disk, to make a revolution every half hour.

In front of the disk there is a steel rod shaft (*j*) which runs on a point at the base and in an elongated bearing at the top and is provided with a swivel joint to prevent lateral friction. On this steel rod and at right angles to the disk there is a small brass wheel (*b*) $23^{mm}$ in diameter covered with a solid rubber ring, a tire, which is in direct contact with the disk. This wheel constitutes a friction wheel and revolves when in contact with the aluminum disk. It can be moved by means of a set screw to any position on the rod required, thus enabling one to modify the speed.

If, for example, the friction wheel be placed upon the shaft near the center of the disk, the speed is retarded; if, on the contrary, it is placed near the circumference, then the speed is accelerated. When the friction wheel is $23^{mm}$ from the center of the disk, the small shaft revolves once every half hour, at a distance of $46^{mm}$ from the center it revolves every fifteen minutes, and when at $69^{mm}$ it revolves in seven and one-half minutes. In fact any degree of speed can be obtained between seven and one-half and thirty minutes. Should it be necessary to obtain a higher speed a smaller friction wheel can be used, or the hair spring can be shortened still further. *Fig. 2* shows a side view of the clinostat when set up for the purpose of eliminating the effects of light, the plants being placed upon the horizontal disk (*d*). In *figs. 1, 3, 4,* and *5* the instrument is shown when in use for gravity experiments. In the latter instance the steel rod is placed horizontally. The apparatus is so arranged that any angle can be obtained. This is accomplished by means of three set screws (*e*) which are attached to the clock and fit into depressions in the metal rim (*f*) which is movable. This mechanism is shown more in detail in the enlarged cross-section of *fig. 5*, the metal rim being represented by the shaded portion. By loosening the three set screws (*e*) the rim can be revolved, and as the shaft attachments are connected with the rim they move with it. In *fig. 1* a holder is attached to the end of the shaft for the purpose of carrying the plant. The pot used is $2^{in}$ in diameter, and is centered and held in place by means of three screws. A simpler method of holding the plant is shown in *fig. 6*, where the end of the shaft is made to pass through a hole in the bottom of the pot, the pot being securely held in place by means of a double flange. The shaft is also provided with a balance wheel (*h*). In order that the plant may be balanced it is only necessary to remove the friction wheel from the disk, which allows the shaft to revolve freely, then adjust the compensating weight (*h*), bringing the center of gravity of the pot within that of the shaft. Instead of using a growing plant in the pot, grass nodes, or flower stalks, can be readily substituted. For eliminating the effect of gravity in roots the apparatus is set up as shown in *fig. 2*, in which case the roots are kept from drying up by revolving in a dish of water.

For Phycomyces or Mucor it can be conveniently arranged as in *fig. 4*, in which case the shaft is elongated. The clinostat is mounted on a wooden base provided with three leveling screws and will run four days without winding. It is made especially for light objects although I have carried fourteen pounds on it in a horizontal position for a number of hours. The apparatus could be constructed, I suppose, for about $15.

**Spring dynamometer** (*pl. X, figs. 1* and *2*).—This apparatus was devised for the purpose of measuring the power of growth induced by geotropism in grass nodes. It consists of a watch spring (*a*) having attached to its end a straw (*b*) which amplifies the movement on the graduated scale of the arc (*c*). The straw is held securely by means of a spiral wire (*d*) soldered to the underside of the spring, allowing the straw to be removed at leisure. Directly above this straw is a wire loop for attaching a thread, the other end of which is fastened to the grass culm at a distance from the node of ½$^{in}$. The grass culm has its lower end inserted in a bottle containing water provided with a perforated cork through which is placed a glass tube tightly fitting the culm, thus holding it securely. The bottle is supported by an Arthur clamp and is mounted on a vertical rod which can be adjusted to any desired angle by a unique joint (*j*) made by the O. C. White Company, Worcester, Mass. By lengthening or shortening the spring the tension can be readily varied. In the illustration the whole watch spring is shown, but of course only a short piece is necessary.

**Apparatus for measuring and recording root-growth** (*pl. X, fig. 3*).—Having had occasion in my experiments to record the hourly increments of growth in the length of a large number of roots I was obliged to devise a self-regulating apparatus for this purpose. So far as I am aware no self-registering appliance has been employed in the growth of roots. The method in general use consists in direct readings with a horizontal microscope. Any one who has employed this method must be aware that it is exceedingly tedious, and, moreover, that it is not accurate on account of the nutation of the root, which under high magnification is liable to give rise to serious errors in the readings. The root constitutes one of the most delicate organs of a plant, and it is clear therefore that whatever apparatus we use must be of the most sensitive kind. It must be able to keep the root straight, yet allowing a certain amount of play; it must be constructed out of material which will not injure the root; and the apparatus which multiplies the growth must possess the least resistance possible.

In describing this apparatus it will not be necessary to go into the details of the experiments which I have made with various contrivances. It is sufficient to say that I have never detected the slightest influence of any description detrimental to the normal growth of the root on account of its use. The apparatus consists of a simple hand balance with a light straw attached to one arm and a metal rod to the other.[1] The lower end of this rod has a metal disk attached to it and is suspended in a beaker of water. The root is fastened securely by pinning the seed to a cork (*a*) held by a clamp. Surrounding the lower end of the root is a harness which eliminates all curvatures and keeps the root straight. The lower end of the harness is in direct contact with the disk, and every increment of growth of the root in length causes a corresponding depression of the balance arm, which movement is multiplied and registered by means of the straw on a recording cylinder. The details of the harness are shown in cuts *1*, *2*, and *3*. It consists of six long nickel plated wires, such as are used for insect pins. These are passed at equal distances from each other through a piece of cork (*f*) $5^{mm}$ in diameter. They are not passed vertically through the cork, but spread at the top as shown in *1*. Another smaller piece (*h*) has a circular hole provided with grooves for the pins, and enables them to be adjusted to the root. By sliding the cork up the wires are brought into close contact with the root and by sliding it down the root is released. It is necessary that the harness should not clasp the root too tightly, but just fit easily. The harness figured is made for *Vicia Faba*, and it would not be advisable to use it for other species. A delicate mechanism, however, could be constructed entirely out of metal which could be adjusted to any root. With the hand balance as a multiplying agent I have never used a weight for the root to overcome which exceeded $50^{mg}$. As the straw does not pass through a vertical line in its movements, there is a slight error in registering, but it is so minute that it need not be considered, as for every millimeter's growth of the root in length the error in our apparatus would equal but $\frac{1}{400}^{mm}$. The same multiplying apparatus can be used also for measuring the growth of the cotyledons in grasses, in which instance a paper cylinder is placed around the cotyledon to eliminate the effects of light. By applying the harness to the cotyledon, the power of growth can also be obtained.

**Nutating apparatus** (*pl. X, fig. 4*).—This instrument is similar to that recommended by Wiesner, who has justly criticised the method

[1] *Cf.* BOT. GAZ. 17:105. 1892.

used by Darwin. It consists of a diopter made out of a short metal tube 2.5$^{in}$ high and 1$^{in}$ in diameter, having a section cut out of its lower half for the purpose of inserting a pen. In the inside of the tube is a coverslip (represented by the horizontal dotted line) with two cross hairs, and at the top another coverslip with a round dot upon it. Both the hairs and the dot are centered in the tube. When the dot at the top coincides with the cross hairs below, the line of vision extends directly through the center of the tube which rests upon the horizontal glass plate *m*. When the dot and cross hairs are made to coincide with the black wax point on the glass capillary attached to the plant (which is for the purpose of amplifying the nutation movements) a direct line of vision is obtained and recorded by means of a pen on the glass plate (*m*). The glass capillary is secured to the plant in the usual manner by means of wax, and the multiplication of the nutation movements can be increased or diminished by lengthening or shortening it. Professor Wiesner used two horizontal glass plates instead of one, but since the lower part of the diopter is cut out for the purpose of inserting a pen, only one plate is necessary.—G. E. STONE, *Massachusetts Agricultural College.*

# EDITORIAL.

**Botanical Meetings in Buffalo.**

THE BOTANICAL MEETINGS in Buffalo in connection with the American Association were remarkably successful. American botanists were present in large numbers, and the attendance was well sustained throughout the almost continuous sessions of six days. During two days preceding the meeting of the Association the Botanical Society was represented by eleven of its twenty-three members, and the papers presented were of a type that justified the existence of the organization. With the opening of the Association, however, it became evident that the Section of Botany and the Botanical Club were to have the most largely attended sessions of their existence. In Section G more than forty papers were upon the programme. These papers, moreover, were notably strong, representing well the great increase of botanical activity in this country. The most notable feature of the meeting was the presence of a large representation of our younger botanists, who have been trained in the newer methods, and whose crisp and clear presentations of important work augured well for the future of American botany. The Botanical Club, also, was full of papers which would rank better than most of the papers in the Section a few years ago. To one in familiar contact with American botany for a number of years there could be no better evidence of wonderful development than the Buffalo meeting. It seems to the GAZETTE a serious mistake on the part of the botanist as an individual, and as the representative of an institution which seeks botanical students and influence, to neglect such meetings. Such neglect must reflect upon the individual and the institution and weaken any hold upon a botanical constituency. We would especially commend such meetings to the younger race of botanists. The older botanists, who have cultivated a habit of neglect, doubtless will continue to do so, but it is at the expense of declining to be of great service in personally stimulating the progress of botanical science.

**Scientific Chief Department of Agriculture.**

THE MATTER of the director of the scientific work in the Department of Agriculture came before the American Association for the Advancement of Science at the Buffalo meeting. The proposition to create such an office received the warm endorsement of the Association, as it has of almost every body of men to which it has been presented. It is worthy of note that the action was vigorously advocated by the only chief of division in the department who was present at Buffalo, indicating that other divisions, if not the botanical ones, favor the plan.

The open letter opposing the creation of this office is its own best answer. The writer acknowledges that the botanical divisions have, like Topsy, "jes' growed." Unfortunately the conditions did not—perhaps could not—conduce to symmetrical development and the gardener's hand is needed to prevent lopsided, ragged, and unsightly forms. This does not mean that the vigorous plant is to be clipped into a geometrical figure, but that it is to be brought to the highest degree of natural symmetry.

When it is so that one division cannot have opportunity to grow the plants it needs, though other divisions have abundant greenhouse facilities, it is quite evident that someone, with the same functions as a college president, is required to coordinate—not to subordinate—the divisional work. How proper coordination could interfere with, instead of promoting, research and "practical" work, is difficult for us to understand.

# OPEN LETTERS.

## BOTANICAL WORK OF THE DEPARTMENT OF AGRICULTURE.

*To the Editors of the Botanical Gazette:*—In the editorial pages of a recent number of the GAZETTE, attention is called to the botanical investigations of the Department of Agriculture, the statement being made that under the present arrangement there is a dissipation of energy and a duplication of work, which would be overcome by combining the divisions of botany, forestry, agrostology, and vegetable physiology and pathology. I feel sure the writer of the article in question is not fully conversant with all the facts in the case, else he would see that such a plan as proposed would be a most decided step backward.

Strictly speaking, the work of the divisions mentioned is for the most part botanical. They all deal with plants, and botany is the science of plants, both wild and cultivated. If we accept this definition we might include the branches of the department engaged in horticultural work, for horticulture has for its very foundation botany pure and simple. These branches, however, may be omitted from the discussion, and on the ground that botany is the science of plants, the four divisions mentioned, representing the scientific study of plant culture in the department may logically be included in one group, call it bureau, division, or any other name. While this would be a logical arrangement according to the definition of the term botany, the same would hold true for a grouping of the bureau of animal industry, the division of entomology, and the division of the biological survey (ornithology and mammalogy), on the ground that their work is zoological. Botany, in other words, is as broad a field as zoology, and the various branches are as distinct in one case as in the other. The men engaged in the forestry work, for example, are authorities in their line and are recognized everywhere as such by both scientific and practical men. They are not supposed to know any more about vegetable pathology than they do about entomology, chemistry, or any of the kindred sciences. Vegetable pathology, on the other hand, as a science has nothing more in common with forestry than it has with agriculture or horticulture, using these terms in their broadest sense.

Every botanist in the country is aware that the division of botany proper does not cover the whole field of botany, and doubtless, as the editor says, it should be rechristened, to indicate more definitely the scope of its work. In the past this has largely been a systematic study of our flora, and as a result one of the largest and most valuable collections of plants in the world has been built up. The Smithsonian Institution has recently assumed charge of this collection, for which it has always been responsible, and thus relieved of this part of the work, the division of botany, of the Department of Agriculture, can continue its important economic investigations on weeds, pure seed, the geographic distribution of plants and their relation to environment, etc., all of which are distinct from those being pursued by other branches of the department.

Omitting further argument, the chief reasons for maintaining the present autonomy of the divisions may be summarized as follows:

(1) The work of each division is distinct and well defined, having been the result of gradual growth and in accordance with the natural development of the department as a whole.

(2) There is no duplication of work, not even in office or routine matters. The division of vegetable physiology and pathology may receive and answer 5,000 letters a year, all of which relate wholly to its work and involve a certain amount of labor, which could in no wise be saved by a concentration of effort. The same is true of its bibliographical work and such necessary labor that must be given to the collection of fungi, representing the economic phase of the division's investigations.

(3) The chief incentive which keeps good men in the department is that they have freedom in their investigation. The men in charge know the details of their own lines of work perhaps better than any one that could be put over them. They are in direct touch with the people for whose benefit the investigations are made, and it is only since this has been brought about that the work of the department in the main has come to be looked upon as a credit to the country. The moment the autonomy of the divisions is destroyed, which would certainly be the case if the plan proposed were carried out, the principal incentive for good work will be at an end.

B. T. GALLOWAY, *Washington, D. C.*

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## LOCAL FLORAS.

*To the Editors of the Botanical Gazette:*—I am interested in what you say editorially in regard to the scope of local floras. I agree very heartily with the proposition that a local flora should be more than a mere list and should not be confined by artificial bounds. Everyone who has worked faithfully on a local flora has felt this trouble. Much more could be printed in our floras were it not for expense of publication. I see no excuse whatever for the publication of lists that say nothing about the plants themselves and the problems of their distribution, and yet devote hundreds of dollars to printing long lists of synonyms, dates, and references to prior publication.

Some time we shall all do better in this kind of work, but there is an immense amount of work to be done before the ground can be cleared for more valuable investigation. When much of the work now going on is put together as a whole, I think it will appear more valuable than it does at present.

EDWARD L. RAND, *Boston, Mass.*

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## THE AUTHORSHIP OF CERTAIN NAMES.

*To the Editors of the Botanical Gazette:*—Contribution U. S. Nat. Herb. 3: no. 9, just to hand, suggests a query as to the authorship of two new names proposed therein. On page 572 we have "*Salix barrattiana tweedyi* Bebb, var. nov.;" but it is explained by Mr. Rose in a footnote that the late Mr. Bebb gave the variety another name, which was preoccupied, and that he (Mr. Rose) substituted *tweedyi*. It appears to me that we cannot possibly cite as Bebb's a name he never wrote, or even thought of, and the status of the matter is the same as if Bebb had published his description with the preoccupied name, and Rose had offered a substitute in a later publication. Consequently it must be *S. barrattiana tweedyi* Rose.

A more difficult question arises in regard to "*Crepis barbigera* Leiberg, sp. nov," page 565. From the appearance of the description, and the absence of quotation marks or any statement to the contrary, we are led to suppose that it was written wholly by Mr. Coville. Now if Mr. Leiberg merely ticketed specimens of a new Crepis with the name *barbigera*, this name would be nothing but a *nomen nudum*, and the author of the species would be he who first gave or cited a description in connection with the name. Nevertheless, we may, I think, still regard *Crepis barbigera* as Leiberg's species, even allowing the description to be Coville's, by assuming that the latter prepared a diagnosis, to which the former gave a name. The status of the matter then is the same as if Coville had published a nameless description, and Leiberg had in a later paper proposed a name.

T. D. A. COCKERELL, *Mesilla, N. M.*

# CURRENT LITERATURE.

## BOOK REVIEWS.

### An American illustrated flora.

STUDENTS of American plants have been wont to regard their transatlantic associates with envy on account of their numerous helps in determining plants. It seems as though no European should go astray in the recognition of the plants about him. In America, however, we have, of necessity, accustomed ourselves to bare texts, expressive as they could be, but not half expressive enough. The Gray Manual region is certainly our best known region, but to the average student of wild plants there remain in it more plants that he is uncertain about than those that he absolutely knows. He probably names almost all of them, but the mental question mark is appended to more of them than he would like to acknowledge. Most of this has arisen from the lack of that clearest of all kinds of presentation, accurate illustration. Illustrated works upon American plants have been projected, and have advanced to various stages of completion, but even had they all reached a happy conclusion they have either been too elaborate for common use or too popular to be of scientific value. The work we were waiting for was one that should be complete in illustration, scientifically accurate, and still of moderate cost. That such a work has appeared[1] will be a surprise to many and a great boon to all.

The field of this work is entirely unoccupied, and its publication marks a new impulse in the study of the so-called "manual plants." The order of presentation, beginning with the lowest forms, is but an expression of modern methods, and should have been adopted by manuals long since. The sequence of orders follows the same tendency and gives us, so far as any lineal arrangement can, the best we know concerning natural sequence. The distinct policy of multiplying families and genera is followed, these groups being regarded as matters of convenience, and convenience being increased by segregation. There can be no question as to the convenience of the plan if the determination of the plants be the sole object. The question may be

[1] BRITTON, NATHANIEL LORD and BROWN, HON. ADDISON.—An illustrated flora of the northern United States, Canada and the British Possessions, from Newfoundland to the parallel of the southern boundary of Virginia, and from the Altantic ocean westward to the 102d meridian: in three volumes. Vol. I. Ophioglossaceæ to Aizoaceæ. Pp. xii+612. New York: Charles Scribner's Sons. 1896. $3.00 a volume.

raised, however, whether this recognition of all easily separable groups may not suppress too much the fact of larger groupings which any natural scheme must involve. Perhaps it is not possible to carry out one purpose well without distorting something else, and it becomes a question of judgment as to what must be sacrificed.

Every species is illustrated, and when one is reminded that about 4,000 species of pteridophytes and spermatophytes are found within the region covered, the undertaking seems enormous. The illustrations are set in the text, opposite the description, and in most cases three species fill a page. The figures are excellent and clearly printed, showing just the features needed for discrimination, and eliminating all the unnecessary "picture" element. In the first volume the figures number 1,425, and more than three-fourths of them are of species that have never been figured before.

In such a work the question of nomenclature is a mere incident. It need only be remarked that the nomenclature is a consistent carrying out of the principles enunciated in what is known as the Rochester code and exemplified in the "Check-List," and that its embodiment in a work of this character will go far towards establishing it. The prominence given to synonymy easily offsets the inconvenience of new names.

To this first volume Professor Underwood has contributed the text on the Pteridophyta, Mr. F. V. Coville that of the Juncaceæ, Dr. John K. Small that of the Polygonaceæ and Euphorbiaceæ. Mr. Arthur Hollick has had supervision of the drawings in general, and Professor F. Lamson-Scribner of those of Gramineæ. The work of the late Dr. Morong is also seen in the groups to which he paid chief attention, many of which are included in the present volume.

When all the assistance has been accounted for, however, the fact remains that it represents an enormous amount of hard and patient work on the part of the authors. It is to be hoped that the gratitude which is their due will find its expression in the immediate exhaustion of the first edition. Certainly no American botanist, who has any occasion to determine plants, can afford to be without this greatest help since the original publication of Gray's Manual. We look forward with great interest to the succeeding volumes, an interest all the greater as they will contain a better representation of Professor Britton's own work, and will deal with groups of larger general interest. It is to be hoped that nothing will delay their speedy appearance, so that the volumes may be practically synchronous, although the amount of work involved would seem to make this well-nigh impossible.—J. M. C.

# NEWS.

Dr. Douglas H. Campbell has spent the past summer in Japan.

The officers of Section G of the A. A. A. S. for the next year are G. F. Atkinson, *Vice President;* F. C. Newcombe, *Secretary.*

In the absence of Mr. Coville, President of the Botanical Club at its Buffalo meeting, Professor W. A. Kellerman was appointed.

The officers of the Botanical Club for the next year are S. M. Tracy *President;* L. R. Jones, *Vice President;* E. S. Burgess, *Secretary.*

Mr. C. H. Peck and Mr. B. T. Galloway were elected members of the Botanical Society of America at its Buffalo meeting, bringing the number of members to twenty-five.

Edwin B. Copeland, of the University of Wisconsin, has returned from a year's study in the botanical institutes of Tübingen and Halle, from the latter of which he received the doctor's degree *summa cum laude.*

The Botanical Society at its Buffalo meeting was represented by the following members: Atkinson, Bailey, Barnes, Bessey, Britton (E. G.), Britton (N. L.), Coulter, Hollick, MacMillan, Trelease, and Underwood.

Mr. A. P. Anderson, assistant in botany at the University of Minnesota, who has been studying abroad for two years, received the doctor's degree from the University of Munich in August, and has since returned to this country.

Mr. O. F. Cook has been appointed curator of the cryptogamic collections of the National Herbarium, under the Division of Botany. He has the privilege of leave of absence to visit Africa whenever his duties there demand it.

The officers of the Botanical Society of America for the next year are John M. Coulter, *President;* C. S. Sargent, *Vice President;* C. R. Barnes, *Secretary;* Arthur Hollick, *Treasurer;* B. L. Robinson and F. V. Coville, *Councillors.*

Professor A. N. Prentiss, formerly Professor of Botany at Cornell University, died at his home in Ithaca, Aug. 14th. A biographical sketch of Professor Prentiss, prepared by his successor, Professor Atkinson, was published in Bot. Gaz. **21**: 283. 1896.

In response to a suggestion by Professor S. M. Tracy, Section G of the A. A. A. S., at the Buffalo meeting, appointed Professors N. L. Britton and John M. Coulter as a committee to take under consideration the subject as to what should be the usage of the phrase "type specimen."

THE MEXICAN BOTANICAL CLUB is an organization which can be made very useful to botanists who desire to cultivate Mexican plants for study. Those who wish for a fuller knowledge of its purpose and of its ability to serve botanists should communicate with William Brockway, Tuxpan, Michoacan, Mexico.

ATTENTION IS CALLED to the circular issued by the Pasteur Monument Committee and distributed with this number of the BOTANICAL GAZETTE. The opportunity to honor the memory of Pasteur in a most effective way is one that botanists will not pass by. The senior editor of the GAZETTE has been asked to collect and forward subscriptions.

IN ALL PROBABILITY the next meeting of the American Association for the Advancement of Science will be held in Toronto in connection with the meeting of the British Association. As it is understood that British botanists will be well represented at that meeting large numbers of American botanists will doubtless take advantage of the opportunity to welcome their transatlantic friends.

THE ADDRESS of Dr. N. L. Britton as Vice President of Section G of the A. A. A. S. at its Buffalo meeting was an admirable presentation of the history and status of botanical gardens, made still more attractive by numerous lantern slides. The GAZETTE would have been glad to publish the address in full, according to its usual custom, but Dr. Britton's connection with the New York Botanic Garden made other publication seem desirable.

A BEQUEST has been made to the Swedish Academy of Sciences to promote the study of the Brazilian flora. Every eight years it yields about $5,500, which is applied in sending two Swedish botanists to Brazil for a period of two years. One payment has already become available, and Dr. C. A. M. Lindman and Dr. G. O. A. Malme undertook the first expedition (1892–4), exploring especially the Rio Grande, Paraguay and Matto Grosso. The donor and originator of the enterprise was Dr. A. Regnell, a Swedish physician, who lived for fifty years in Brazil, and made important collections and studies of the phanerogamic flora.

THE BUFFALO BOTANIC GARDEN was established in 1894, replacing what was known as South Park. It contains 160 acres of finely situated and very diversified surface, and although planting began only last year, it has already in cultivation nearly two thousand plants. It is the design to arrange the plants in families, so far as conditions will permit. Mr. John F. Cowell is the very competent director, and Judge David F. Day is one of the park commissioners, facts which augur well for the future of the garden as a scientific establishment. It is due to Mr. Day's influence that the garden was established, and it is a fitting monument to this long time lover and student of plants.

*BOTANICAL GAZETTE*

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# THE BOTANICAL GAZETTE



ISSUED OCTOBER 20

CHICAGO, ILLINOIS

Published by The University of Chicago

The University of Chicago Press

VOLUME XXII NUMBER 4

# BOTANICAL GAZETTE

*OCTOBER 1896*

## THE PHALLOIDEÆ OF THE UNITED STATES.

### I. DEVELOPMENT OF THE RECEPTACULUM OF CLATHRUS COLUMNATUS Bosc.

EDWARD A. BURT.

(WITH PLATES XI AND XII)

In working out in *Anthurus borealis* the structural details of its imperfectly known genus, quite unexpected results were obtained with regard to the development of the receptaculum, which made it desirable to include in the investigation other representative genera of the Phalloideæ. A suitable range of additional forms was presented by *Mutinus caninus* (Huds.), *Dictyophora duplicata* (Bosc), and *Clathrus columnatus* Bosc, the two former of these belonging to the subfamily Phalleæ, and the Clathrus and the Anthurus to the Clathreæ. The papers on Anthurus[1] and Mutinus[2] have been published already. With the present paper on Clathrus it becomes possible to present more clearly the important developmental differences between the two subfamilies.

During the winter of 1894–5, a supply of alcoholic material of *Clathrus columnatus*, provided by Dr. Farlow, was studied

[1] A North American Anthurus, its structure and development. *Memoirs Boston Soc. of Nat. Hist.* 3:487. 1894.

[2] The development of Mutinus caninus (Huds.) Fr. *Annals of Botany* 10:343 1896.

under his direction in the Cryptogamic Laboratory of Harvard University. While fully substantiating the conclusion reached in the case of *Anthurus borealis* with regard to the origin of the chamber- and pseudoparenchymatous tissues of the receptaculum from different systems of primary tissues, nevertheless the range of stages was not great enough for a complete account of the development of the receptaculum. During the summer of 1895, a more abundant supply of young stages of *C. columnatus* was collected for me through the kindness of Professor P. H. Rolfs, of the Agricultural College, Lake City, Fla. With this the investigation has since been completed.

The methods of staining, etc., are given in detail in my former papers.

MATURE STAGE, INTRODUCING THE TERMS TO BE EMPLOYED.

The fructification of *Clathrus columnatus* has a receptaculum consisting of from two to five vertically ascending columns, which are quite separate where they arise from the volva, but join together at their apices. Usually there are only four such columns. These are joined together in pairs, the two opposite pairs being then connected together by a short and broad arch of the same nature as the columns. In the earlier stages the receptaculum is compressed into a small space in the interior of the fructification and enclosed by a fleshy bag called the volva. In such early stages the fructifications of this, and other members of the Phalloideæ, are called "eggs" on account of their general appearance.

By the time the spores mature, the egg attains a diameter of from 3 to $5^{cm}$. The receptaculum then elongates and bursts out through the apex of the volva, thus raising the spores to a height of from 5 to $8^{cm}$ above the surface of the ground for more favorable dispersal. After elongation of the receptaculum, the spore-mass, or gleba, as it is called, may be seen as a spherical mass in the upper part of the main central cavity of the receptaculum, hanging from the under side of the arch and the proximate portions of the columns.

Of the three layers of the volva, the middle, or gelatinous layer, is not one continuous sheet as in the Phalleæ, but consists of as many meridionally arranged masses as the receptaculum has columns. These gelatinous masses alternate in position with the columns and are completely separated from each other by the cortical plates (*C'*, *figs. 4, 5*, and *6*). The cortical plates extend from the base to the apex of the egg and connect each column of the receptaculum throughout its entire length with the outermost, or cortical layer (*C*). The peculiar arrangement of alternating cortical plates and gelatinous masses arises in the early differentiation of the egg, as will be shown further on.

COURSE OF DEVELOPMENT.

The eggs are borne at the ends of short branches of the subterranean mycelial strands. In cases where the egg has arisen as an outgrowth on the side of a mycelial strand, the portion of the strand beyond the egg seems to have ceased its further growth so that the egg becomes practically seated at the end of the strand running into it. The mycelial strands consist of two systems of tissues: a central or medullary bundle of fine hyphæ running in a longitudinal direction, and an outer or cortical layer of coarser hyphæ forming a loose but very interwoven structure.

The cortical layer of the strand is continued upward in the egg as its outer covering (*C*, *fig. 1*). This figure is from a median longitudinal section of an egg 1.5$^{mm}$ long by about 1$^{mm}$ in diameter. The more compact medullary bundle is marked *M*. As in the strand, so here, its hyphæ run in a prevailingly longitudinal direction lying close together. By the double stain used these two layers of the egg are sharply separated from each other in color as well as by the more open structure of the cortical layer. Although so well marked, still they are in intimate connection in their region of contact by means of hyphæ which spread out laterally from the medullary layer and branch and interlace with the cortical hyphæ and become indistinguishable from them. In *fig. 2* a cross-section of an egg in the same stage of development as that of *fig. 1* is given under the same magnification. The medullary bundle *M* is nearly circular in cross-section.

A developmental change now sets in through which the outline of the medullary portion becomes lobed. These lobes alternate in position with the later formed columns of the receptaculum and extend longitudinally from near the base of the egg almost to the apex of its medullary bundle. The four such lobes usually formed in *C. columnatus* are shown in the cross-section of an egg in this stage (*G, G, fig. 4*). *Fig. 4* is drawn with the same magnification as *figs. 1* and *2*, the diameter of the egg having become only slightly greater. Many eggs of about the same diameter as these were sectioned and examined in order to find intermediate stages between those of *figs. 1* and *2* and *fig. 4*, which would show the mode of differentiation of the medullary lobes *G, G*. It seems probable that their differentiation occupies only a short interval of time, for only one egg in the intermediate stage was found. It is shown in cross-section in *fig. 3*, and under the same magnification used in the other cases. In this stage (*fig. 3*) the medullary and cortical layers are less sharply distinct from each other than in the earlier or later stages. At three points, perhaps four, hyphæ seem to be invading the cortical region of *fig. 2* and forming masses (*G*). These masses are the rudiments of the gelatinous layer of the volva of later stages. Only three such lobes can be made out with certainty in this stage, while four are present in the more advanced stage of *fig. 4*. The absence of the fourth may indicate that the differentiation of all four lobes does not begin at exactly the same time; but it seems more probable, however, that this is an early stage of a Clathrus having three columns for its receptaculum. In such a plant only three gelatinous masses are present in the gelatinous layer of the volva. Specimens having only three columns did occasionally occur in this material.

The rudiments (*G, G, G, fig. 3*) of the gelatinous layer of the volva are most intimately connected with the central medullary mass and must undoubtedly be regarded as belonging to the medullary system, as they have been heretofore.[3] As shown in this stage the manner of formation of these lobes seems to be that of a general growth of medullary hyphæ along three or four longitudinal lines outward among the cortical hyphæ of the layer *C* of the youngest stage. That this is the actual mode of formation of the lobes is shown by the fact that their marginal portions are less sharply set off from the cortical layer than is the case in later, and even earlier stages. In this stage many cortical hyphæ can be followed into the marginal portions of the lobes, and the color reactions by the double stain used are less sharp in those portions than they are between the cortical and medullary systems in other stages.

It is to be observed that in this stage the surface of the egg does not conform to the surface of the medullary portion, but has in cross-section the nearly circular outline of the youngest stage (*fig. 2*). In later stages a gelatinous accumulation in the lobes (*G, G*) causes them to swell outward and laterally towards each other so as to give to the egg a surface with a broad rounded longitudinal ridge, extending outside of each lobe from the base of the egg nearly to its apex. These lobes are separated by shallow furrows, each of which marks the position of a column of the receptaculum, and is of great help in orienting the eggs for sectioning. Were such longitudinal ridges and furrows present on the surface of the egg in the stage of *fig. 2*, they would have favored the view which I formerly held that the medullary lobes originate by outward protrusion of medullary tissue along four longitudinal lines, such protrusion being due to vigorous growth within the medullary portion merely pushing the cortical layer further outward in those regions.

The columns of the receptaculum arise in the angles (*C′*, *C′*) between the medullary lobes (*G*, *figs. 3* and *4*). Ed. Fischer[4] in his study of *Clathrus cancellatus* has called the tissue *C′* of these angles *Zwischengeflecht*, and has referred it to the medullary sys-

[3] *Cf.* Ed. Fischer, Untersuchungen z. vergleich. Entwicklungsgeschichte u Systematik der Phalloideen. Denkschr. d. Schweiz. naturf. Gesellsch. 32:4. 1890; also Burt on Anthurus, *l. c.* 494.

[4] *Ibid.* 4.

tem of tissues, although pointing out that its hyphæ are coarser, more highly refractive, more loosely arranged, and more irregularly intertwined than is the case in the rest of the medullary system. In all of these points of difference which have been enumerated, the tissue in question agrees with that forming the surface of the egg. As it is also more intimately connected with such cortical tissue than with the medullary tissue, stains the same as the former, and in the youngest stages (*figs. 1* and *2*) is the direct continuation upward in the egg of the cortical tissue of the mycelial strand, it should be regarded as belonging to the cortical system. It will be referred to in this article as the tissue of the cortical plates, as in my earlier paper on Anthurus.

In the earliest stages the cortical layer is closely adnate to the medullary layer. In the stage of *fig. 4* separation of these two layers begins along the inner edge of each cortical plate, the two tissues seeming to be pulled slightly apart, although very numerous hyphal connections still exist between the two surfaces. In the older stage of *fig. 5* this separation has become more complete and a decided fissure has been produced between the two systems along the inner edge of the cortical plate ($C'$). While it is possible that the rapid growth of the medullary lobes ($G$) and their distention with the gelatinous accumulation may have carried the cortical system outward bodily and, to some extent, may have loosened the cortical plates from their connections along their inner edges, it seems more probable that the separation has been caused chiefly by changes in the medullary structure facing against the cortical plates, as shown in *fig. 5*. Medullary hyphæ reaching to the edge of a cortical plate become swollen at the outer end and become arranged side by side in a palisade-layer. Branches of a similar nature crowd their way in between the members of this palisade-layer and so increase its surface that the layer becomes thrown into folds ($t$, *fig. 5*) and torn away from its connections with the edges of the plates ($C'$). In some of the sections of this stage occasional hyphal connections of this kind still persisted.

Examination of the surface of contact of medullary lobes (*G*) of the volva with the cortical layer (*C*) and the cortical plates (*C'*) shows that the hyphæ in this surface now lie in the plane of the surface, indicating that, in the great increase in the volume of these lobes since the stage of *fig. 4*, their distention (partly due to gelatinous accumulation no doubt) has been pushing their surface bodily against the cortical layer. The same distention of these lobes has also brought them closer together, laterally compressing the masses *C'* of *fig. 4* into the narrower plates of *fig. 5*, and into still narrower plates in the more advanced stage of *fig. 6*.

With the further growth of the egg, the medullary surface (*t*, *fig. 5*) becomes thrown into a very complicated series of folds, causing passages to extend in a labyrinthine manner into the main central medullary mass. The cells of the palisade-layer facing the deeper lying passages differentiate into basidia and bear spores. This portion constitutes the gleba (*Gl*) of older stages. Hyphæ from the cortical plates penetrate into the passages situated in front of the edges of the cortical plates, become adnate to the surfaces of the medullary masses (*t*) forming the walls of those passages, differentiate into pseudoparenchyma, and prevent the differentiation of basidia and spores on the surfaces covered. The pseudoparenchyma so formed constitutes the walls of the receptaculum of later stages; the medullary tissue (*t*) enclosed by these walls is the tissue of the chambers of the receptaculum, and it gelatinizes and becomes torn up in the elongation of the receptaculum, leaving the chambers empty for the most part. The relation of these tissues to each other are represented in *fig. 6*. At the right the medullary tissue (*t*) is shown with its hymenial layer of basidia lining the cavities or passages of the gleba. Just to the right of the cortical plate (*C'*) a column of the receptaculum is developing; cortical hyphæ from *C'* have grown into the passages between the medullary masses (*t*) and, in contact with those masses, are developing into pseudoparenchyma. The depth to which the cortical hyphæ have invaded these passages is shown by the position of the continuous line *q* in the figure. Beyond that line basidia line the passages. At *r*, *r*, *r*, medullary masses may be seen crossed by the line; these masses lie partially in the gleba and partially in the column. In their glebal portion they bear a layer of basidia; on the ends in the column they are covered with the cortical tissue. It is by such connecting medullary masses that the gleba hangs suspended within the cavity of the receptaculum after elongation of the latter.

In the same figure (*fig. 6*) many medullary masses (*t*) may be seen in the column not connected with the other masses to the right. These unconnected masses are in general smaller toward the edge of the cortical plate (*C'*) and, in some stages, they are more closely surrounded by the adhering cortical tissue than are the masses at a greater distance from the edge of the plate. Ed. Fischer has described the occurrence of such isolated masses,[5] which he calls hyphal knots (*Hyphenknäuel*) in *Clathrus cancellatus*, and has concluded that they arise from the differentiation of the tissue of the cortical plates.[6] In this opinion I cannot concur. As already stated, my preparations show that a continuous cavity is first formed between the edges of the cortical plates and the medullary tissue. Hyphæ from the one side of this cavity grow into it. Along the opposite side of the cavity branching masses of medullary tissue extend into the cavity, partially filling it and causing its irregularity in form. Such medullary masses are represented by the dark areas in *figs. 10–13*. They are highly gelatinous, having the same microscopic structure as that of the gelatinous layer of the volva and the main central mass of medullary tissue, and they take the same orange-red stain in my preparations. *Figs. 10–13*, in the order of their numbering, represent serial cross-sections, of which *fig. 10* is of the section at the lower end of the series, or nearest the base of the egg. They are from below the level of the gleba. The examination of such a series of cross-sections affords reason

[5] *Ibid.* 5, *figs. 3* and *4*.

[6] Fischer calls this tissue *Zwischengeflecht*. It is, however, a wholly different tissue from that to which he applies the same name in the Phalleæ.

for believing that these gelatinous masses are all connected with each other and with the main central mass of medullary tissue. In *fig. 10* an irregular mass occurs consisting of five main parts, each of which is marked *1*. Upon following this mass upward through the series, it is found that its five parts finally become separate from each other, and that the outermost part of the original mass does not reach up into the plane of the highest section (*fig. 13*). The small mass marked *2* also fails to reach up into that section. The attempt to follow in serial sections the apparently isolated masses (Fischer's "hyphal knots") of any one section leads to the conclusion that such masses are portions of a highly branched structure arising from the inner main medullary mass, and that the ramification of this mass is outward and chiefly upward. Such a branched structure along the medullary side of the cavity has arisen, without doubt, partly from the folds produced by the formation of the palisade-layer, as already described; but there is evidence that it may be due in part also to an irregular splitting downward and inward into the medullary tissue, as shown by the changes that occur in the connections of the cavity *3* (*figs. 10–13*), and by the fact that masses, joined together into one in some sections, become separate in others, and then join again into one. Other evidence is afforded by the distribution among the medullary masses of hyphæ from the cortical plates. In this stage such cortical tissue is found in greatest abundance in the marginal portions of the cavity; it is almost wholly absent from some, but not all, of the spaces between the more centrally situated masses.

The medullary masses which we have been considering occupy spaces which become the chamber-cavities of the receptaculum in later stages. Although portions of *t*, they are more definitely indicated by *b* in *figs. 6–9*, and *14*.

*Walls of the receptaculum*.—The tissue of a cortical plate ($C'$) forms a broad layer of loosely interwoven and branching hyphæ, divided into short cells. This tissue is quite similar to that of the cortical layer ($C$) with which it has unbroken connection. Along the inner edges of the cortical plates, their tissue passes into the cavity which has formed there, and spreads about in it, and between the medullary masses (*b*), and over the surfaces of those masses and on that of the cavity. For some reason (which may, perhaps, be proximity to a supply of available food) these cortical hyphæ find the conditions for their further differentiation most favorable on the surfaces of the masses of gelatinous tissue, and they become closely adherent to such surfaces and grow very luxuriantly there. Still, many of the hyphæ are found in the more open space, running irregularly through such spaces or crossing from one side to the other. It is this tissue which finally fills the spaces between and about the gelatinous masses and becomes the chamber walls of the receptaculum.

An older stage of the rudiment of a column of the receptaculum and of the tissues about it is shown in cross section in *fig. 7*. On the right is the tissue of the gleba with its chambers lined by the hymenial layer (*H*). On the left is the inner edge of a cortical plate (*C′*); its hyphæ may be seen passing among and against the medullary masses (*b*) of the future chambers. These cortical hyphæ are becoming laterally inflated in this region and are plainly recognizable as early stages of pseudoparenchyma. Along the surfaces of the larger cavities, the development of these hyphæ is giving rise to pseudoparenchymatous plates (*p, p*) which in later development have the intervening space more filled in with this tissue, forming a more compact partition wall. Near the gleba, large masses (*b*) of the tissue of the chambers are connected, as in *fig. 6*, with the tramal tissue (*t*) and with the tissue on the inner flanks of the column of the receptaculum, tissue just on the border between the gleba and the gelatinous layer of the volva. At places in the cross-section where the two systems of tissues come into most intimate contact and where the plane of the section may happen to give a cross-section of the pseudoparenchymatous hyphæ, it becomes very difficult to determine the true relations to each other of the adnate tissues *p* and *b*. I have examined such places with the utmost care and find no connections between the tissues of the chambers and the pseudoparenchyma of the walls. If such connections exist in *C. columnatus*, they should show as distinctly as they do in *Mutinus caninus* or in *Dictyophora duplicata*.

At other places in the preparation the pseudoparenchymatous hyphæ may happen to lie in the plane of the section. In such places, in preparations double-stained with paracarmine and safranin, the true relations of the pseudoparenchyma and the tissue of the chambers become clearly shown, as in *fig. 8*. In this figure the wall (*p*) is shown with the tissue of a chamber (*b*) on one side and with the gelatinous layer of the volva (*G*) on the other. The pseudoparenchyma of the wall has no connection with either the tissue of the chamber or with that of the gelatinous layer of the volva. It has merely taken possession of a space between the two. If this figure is compared with *figs. 11, 12* and *15* of my paper on *M. caninus*, the contrast between the Clathreæ and the Phalleæ in the origin of the pseudoparenchyma becomes very evident. There is also a difference in appearance between the gelatinous tissue in the chambers of *C. columnatus* and that in the chambers of the Phalleæ which I have seen. In the former there is a very marked resemblance to the tissue of the gelatinous layer of the volva. This may be seen also in *fig. 8*.

Ed. Fischer[7] has asserted that the pseudoparenchyma of the walls of Clathrus is homologous with the hymenial layer, being merely a sterile hymenium. The portion of the section drawn in *fig. 9* is of great importance in this connection. It represents a portion of a column and the adjacent gleba. In the upper part of the figure, the basidia of the hymenium (*H*) are seen projecting radially outward from the tramal tissue (*t*) into a chamber of the gleba. The wall (*p*), consisting of pseudoparenchymatous hyphæ, is situated between the tramal tissue and the gelatinous tissue (*b*) of a chamber. The hyphæ of the wall are slightly laterally inflated. They are not connected with the tissue of the chamber or with the gleba. If the homology put forth by Fischer were well-founded, the pseudoparenchyma should have the same connection with the tissue of the chamber

[7] *Ibid.* 7.

that the basidia have with the tramal tissue, and should also project from the chamber surface perpendicularly outward into the cavity between the chamber masses.

*Advanced stages.*—A median longitudinal section through an old egg is given in *fig. 14.* The section is also median with respect to the columns of the receptaculum, one of which is shown on the right. The beginning of elongation of the receptaculum has torn the glebal mass away from the lower part of the medullary mass. Near the upper end of the column, along its inner side, many more openings show in the wall than further down toward the base. Through these openings the medullary tissue passes into the chambers and firmly attaches the gleba to this portion of the receptaculum. The figure shows how in the mature stage the ball of glebal tissue comes to be suspended from the under side of the apex of the receptaculum.

A more important point presented by *fig. 14* is the manner in which the cortical and medullary systems of tissues are dovetailed together in the receptaculum. From the left an originally continuous mass of medullary tissue sends branches towards the right; from the right an almost continuous mass of pseudoparenchyma sends branches towards the left, filling in all space between the first set of branches.

This section does not show many of the openings in the wall near the base of the receptaculum, through which the medullary hyphæ pass into the lower chambers. Openings of that nature do, however, exist, although they are not so numerous there as higher up. One such passage into a chamber is shown on the left side of the figure.

REFERENCE TO ANTHURUS BOREALIS BURT.

In my account of the structure and development of *Anthurus borealis*, one of the Clathreæ, it was shown that cortical plates extend from the base of the egg upward almost to the apex, and inward from the cortical layer to the receptaculum. In the region below the level of the base of the arms, the inner edges of the plates are united into one cylindrical mass which forms a sheath of cortical tissue (the cortical sheath) surrounding the stipe for its whole length.

The pseudoparenchyma of the walls of the stipe and of the arms was found connected with and arising from the tissue of the cortical sheath and· cortical plates. Medullary tissue from the main central mass was found passing into the chambers of the receptaculum at the base of the stipe and then passing upward from chamber to chamber. At the base of the arms, the ascending masses of medullary tissue are collected into six large masses, each of which is the gelatinous tissue of an arm. No connection could be found between the pseudoparenchyma and the gelatinous tissue of the chambers nor did the pseudoparenchyma stand out from the sides of the chambers so as to indicate any such connection.

The conclusion was reached that in *A. borealis* the receptaculum is formed by the joint action of both cortical and medullary tissues; that the cortical constituent develops into the pseudoparenchyma of the walls, and that the enclosed medullary bundles finally become gelatinous and disappear, thus forming the chambers of the wall.

## CONSIDERATION OF FISCHER'S VIEW OF THE ORIGIN OF THE RECEPTACULUM IN THE CLATHREÆ.

Ed. Fischer[8] has stated in his study of the development of *Clathrus cancellatus*, to which references have been made:

1. That the fundament of the receptaculum consists of knots of hyphæ separated from one another by small spaces.

2. That these hyphal knots are formed from the *Zwischengeflecht* (in this case the tissue of the cortical plates *C'* of my figures).

3. That the tips of the hyphæ composing the knots radiate outward from the knots into the narrow spaces between the knots and become constricted and abjointed into pseudoparenchyma, thus forming a plate about each knot.

4. That the tissue in the central portions of the knots

[8] *Ibid.* 5–8.

becomes gelatinous and finally disappears, giving rise to the chamber cavities.

5. That since the tissue of the knots is found to be in connection with the tramal tissue of the gleba at some points, therefore it follows that the receptaculum and the gleba are homologous, that the tissue of the chambers of the former is identical with the tramal tissue of the latter, and that the pseudoparenchymatous walls of the receptaculum chambers are homologous with the hymenial layer of the gleba.

Comparison of Fischer's *figs. 5* and *7* with my *figs. 6* and *7* shows that we both see the same general structure and that our difference is in its interpretation. That Fischer's interpretation of the structure is not the correct one seems to me to be shown by the following considerations:

1. The existence in the Clathreæ of the supposed hyphal knots is very doubtful. My experience is that if the attention is fixed upon one of them, and this is then followed through section after section of the series, the supposed "knot" is soon found to be connected with other masses, and so on with the main medullary mass.

2. The tissue of the cortical plates *C′* (*Zwischengeflecht* of Fischer) does not form hyphal knots. About small medullary branches located in the densest portion of the tissue *C′*, as at *2*, *fig. 9*, it often happens that the plane of the section will be unfavorable for displaying the true relations of the two closely adnate tissues. At such a place one needs all of the aid to be had from good double-stained preparations.

3. If pseudoparenchyma of the chamber walls arises from the hyphæ of the chambers by the projection of the swollen hyphal tips outward into the narrow intervening spaces, it ought to be found distinctly connected with the tissue of the chambers, as in the Phalleæ, and its short hyphæ should also be found projecting from the sides of the chamber masses into the narrow spaces in directions perpendicular to the surfaces of the chambers. Such a direction of the pseudoparenchymatous hyphæ should be shown distinctly, as it is in the Phalleæ. In

some parts of the section, where the pseudoparenchymatous hyphæ are closely crowded against the chamber tissue, and where the plane of the section has cut these hyphæ transversely, one must be on his guard against mistaking the cut ends of adjacent pseudoparenchymatous hyphæ for pseudoparenchymatous bodies standing out perpendicularly from the sides of the chambers. Such closely crowded cut ends, with their looser arrangement toward the middle of the space, form a block-like structure very well adapted for giving the familiar optical illusion of radiation.

I fail to find hyphal connection between the pseudoparenchyma and the tissue of the chambers, nor is there an arrangement of the pseudoparenchymatous hyphæ perpendicular to the surface of the chambers. On the contrary, wherever the plane of the section discloses the arrangement, these hyphæ are found lying parallel with the surfaces of the chamber masses, as shown in *figs. 8* and *9*. If Fischer's theory were true, such an arrangement should not be found at any point.

4. Since the homology claimed between the pseudoparenchyma and the hymenial layer of Clathrus depends upon the origin of pseudoparenchyma from the tissue of the chambers, it ceases to be tenable.

The theory of the origin of the receptaculum enunciated by Ed. Fischer has been accepted by A. Möller[9] in his interesting and instructive work on the Brazilian Phalloideæ. His investigation seems to have been completed and his work in process of publication when my paper on Anthurus reached him, as his references to it are in footnotes.

SUMMARY FOR THE CLATHREÆ.

In the earliest stage, the egg consists of cortical and medullary systems continued upward from the mycelial strand.

The cortical layer gives rise to the outer layer of the volva, the cortical plates, and the pseudoparenchyma of the receptaculum. The medullary portion gives rise to the gelatinous masses

[9] Brasilische Pilzblumen. Jena, 1895.

of the gelatinous layer of the volva, to the gleba, and to the gelatinous tissue of the chambers of the receptaculum.

In such differentiation, the gelatinous masses of the volva are the first to be set off. They arise by growth outward into the cortical region of the hyphæ from several areas of the medullary mass.

The masses of cortical tissue which separate the medullary gelatinous outgrowths from each other retain their connection with the outermost layer through all the later development of the egg. They may be called cortical plates; their position is indicated by shallow furrows on the surface of the egg.

Along the inner edge of each cortical plate, a cavity forms by the separation of the two systems of tissue in that region. The medullary tissue facing these cavities gives rise to the gleba and to branching hyphal masses, which project outward and upward into the cavities and become the chamber tissue of the receptaculum.

The receptaculum is formed through the joint participation of the two systems of tissue and differs in its origin and mode of formation from that of the Phalleæ. Its chambers have the position originally occupied by a branched structure of medullary origin, while its pseudoparenchymatous walls form by ingrowth of cortical tissue about and between the chamber masses.

The pseudoparenchyma of the walls is not homologous with the hymenial layer.

The elongation of the receptaculum in *C. columnatus* begins at the base. After elongation of the receptaculum, the gleba hangs suspended from the arch of the receptaculum by medullary tissue constituting chamber masses of the receptaculum.

RELATIONSHIP OF PHALLEÆ AND CLATHREÆ.

The Phalleæ and the Clathreæ, the two usually accepted suborders of the Phalloideæ, resemble each other:

1. In gross structure. Both have a volva of the same general structure, which becomes ruptured by the same means and from which there issues the receptaculum.

2. In microscopic structure. Both have a gleba of the same chambered structure, with basidia lining the chambers and bearing numerous (4–8) very minute spores. Both have a receptaculum of chambered structure, with walls of irregularly laterally inflated hyphæ, the pseudoparenchyma.

3. In biological adaptation for combining a safe early development with a good means of dissemination of the mature spores. In both the early development is subterranean, in the form of a compact egg covered by a thick gelatinous coat retentive of moisture and probably protective. When the spores are mature they are quickly raised above ground, and an attractive lure for insect agency in their dissemination is then offered by the fetid odor and saccharine composition of the deliquescing mass in which they lie, as well as by the bright colors of the receptaculum which supports them.[10]

The differences between these two subfamilies are no less significant. They are shown:

1. In the mature stage. The position of the gleba is outside the receptaculum in the Phalleæ, while it is within that structure in the Clathreæ. The gelatinous layer of the volva is a continuous sheet in the Phalleæ, while in the Clathreæ it is separated by the cortical plates into several more or less connected masses, wholly separate from each other in Clathrus, but joining above into one in Anthurus.

2. In early development. (*a*) In early differentiation of the Phalleæ, the steps by which the lower and lateral portions of the sheaf-like head (those portions bearing the future hymenium) lose their original direct connection with the medullary bundle *M* and become split away, as it were, from the stipe from below, have no parallel in the Clathreæ, and remind one rather of the changes that occur in the formation of the pileus in some Agaricineæ. (*b*) The hymenium of the Phalleæ arises underneath the gelatinous layers of the volva on the inner (under)

[10] (*a*) W. R. Gerard, Bull. Torr. Bot. Club **7**: 30. 1880; (*b*) Rathay und Haas, Ueber *Phallus impudicus*, (L.) und einige Coprinus-arten, Sitzungsb. d. Mathem.-Natur wiss. Akad. zu Wien **87**[1]: 18. 1883; (*c*) Fulton, Dispersion of spores of fungi by insects, Annals of Botany **3**: 207. 1889.

side of the peripheral portions of the sheaflike head, while in the Clathreæ its portions alternate with the gelatinous lobes of the volva. (*c*) The basidia of the young hymenium of the Phalleæ face towards the axis of the plant; in the Clathreæ they face in the opposite direction, towards the periphery. (*d*) In the Phalleæ, tissue of medullary origin gives rise both to the pseudoparenchyma of the receptaculum and to the tissue of its chambers; in the Clathreæ, cortical tissue continuous with that of the mycelial strand forms the pseudoparenchyma,[11] while the tissue of the chambers is of medullary origin and connection.

The marked resemblances that have been pointed out between the mature stages of the Clathreæ and Phalleæ have been regarded in systematic botany as sufficient for joining them into a well-marked order, the Phalloideæ. The difference in the position of the gleba, whether on the outside of the receptaculum or within it, has been made the basis of their separation as suborders.

Rehsteiner's work[12] on *Hysterangium clathroides* and *Hymenogaster decorus*, both belonging to the Hymenogastreæ, led him, on the ground of the position of the hymenium and the direction in which it faces, to point out a probable origin of the Clathreæ from a Hysterangium-like ancestor, and a possible origin of the Phalleæ from one of the Hymenogastreæ near Hymenogaster, a view Ed. Fischer has also since expressed.[13]

Thaxter's account of *Phallogaster saccatus*[14] indicates that this may be a species somewhat closer to the Clathreæ than *Hysterangium clathroides* is, on account of having a gelatinous layer

[11] That the pseudoparenchyma of the receptaculum of the Clathreæ is cortical in origin is not strange. A. Möller states that in *Clathrus columnatus* and *Blumenavia rhacodes* the cortical layer of the mycelial strands is pseudoparenchymatous (Brasilische Pilzblumen 143), and that in the latter species it is so highly pseudoparenchymatous as almost to lose its hyphal characters (*ibid.*, 61). Both of these species are Clathreæ.

[12] Rehsteiner, Beiträge z. Entwicklungsgeschichte d. Fruchtkörper einiger Gastromyceten. Botanische Zeitung. **50**: —(38–40). 1892.

[13] Neue Untersuchungen d. Phalloideen. Denkschr. d. schweiz. naturf. Gesellsch. **33**$^{1}$: 44. 1893.

[14] Note on *Phallogaster saccatus*. Bot. Gaz. **18**: 117. *pl. 9*. 1893.

between its gleba and peridium that is to be regarded, probably, as the forerunner of the gelatinous masses in the volva of the Clathreæ.

A. Möller's description of his *Protrubera Maracuja* makes a still closer connection.[15] He finds not only gelatinous masses next to the peridium, but also finds them arranged alternately with reference to the glebal masses, as in the Clathreæ, and separated from each other by cortical plates along whose inner edges the glebal masses develop. The development of the cortical plates from the peridium, and their connection with it, are made very probable by his *figs. 2–5, pl. VI.*

My studies, showing that the pseudoparenchyma of the receptaculum of the Clathreæ is of cortical (peridial) origin, supply another link in the chain connecting the Clathreæ with Hysterangium. By making known the early differentiation of the Phalleæ, and by showing that this subfamily differs wholly from the Clathreæ in the development of the receptaculum, they make it certain that the Phalleæ, although as highly a differentiated subfamily, cannot have arisen from the Clathreæ.

It seems safe to conclude:

1. That the Phalleæ are not directly related to the Clathreæ.

2. That both subfamilies have arisen from lower forms outside their family.

3. That the Phalloideæ consist of two parallel series of forms, which, through variations from unlike starting points, have attained to highly specialized structures adapted to the same ends.

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## EXPLANATION OF PLATES XI AND XII.

All figures were drawn with the aid of an Abbé camera lucida. The following letters are common to all the figures: *C*, cortical layer; *C'*, cortical plate; *G*, gelatinous layer of volva; *Gl*, gleba; *H*, hymenium; *M*, medullary bundle of young stages; *b*, tissue of the chambers; *i*, inner layer of the volva; *p*, pseudoparenchymatous wall of the chambers; *t*, tramal tissue.

[15] *Ibid.* 10.

FIG. 1. Median longitudinal section of the youngest egg. × 60.

FIG. 2. Cross-section of an egg in the same stage of development as that of *fig. 1*. × 60.

FIG. 3. Cross-section of a slightly older egg, in which differentiation of the gelatinous masses of the volva has just begun. It is doubtful whether this would give rise to three such masses or to four, in the former case with a receptaculum having three columns alternating with the masses, or in the latter to one with four. × 60.

FIG. 4. Cross-section of an egg in a still older stage, with four masses (*G*) forming the gelatinous layer of the volva. The four columns of the receptaculum arise in the angles between these masses along the inner edges of the cortical plate (*C'*). × 60

FIG. 5. Portion of a still older egg in cross-section, showing an early stage in the formation of a cavity between the cortical plate (*C'*) and the deep-lying medullary portion (*t*). One column of the receptaculum arises in a part of each such cavity; the hymenium arises along the surfaces of the remaining part. × 60.

FIG. 6. The same region of the egg shown in *fig. 5*, but in a more advanced stage. The column is now developing. The sharp continuous line, *q*, has been drawn to more clearly set off the column from the gleba. At the places marked *r*, *r*, *r*, medullary masses connect the tissue of the chambers of the receptaculum with the tramal tissue of the gleba. × 34.

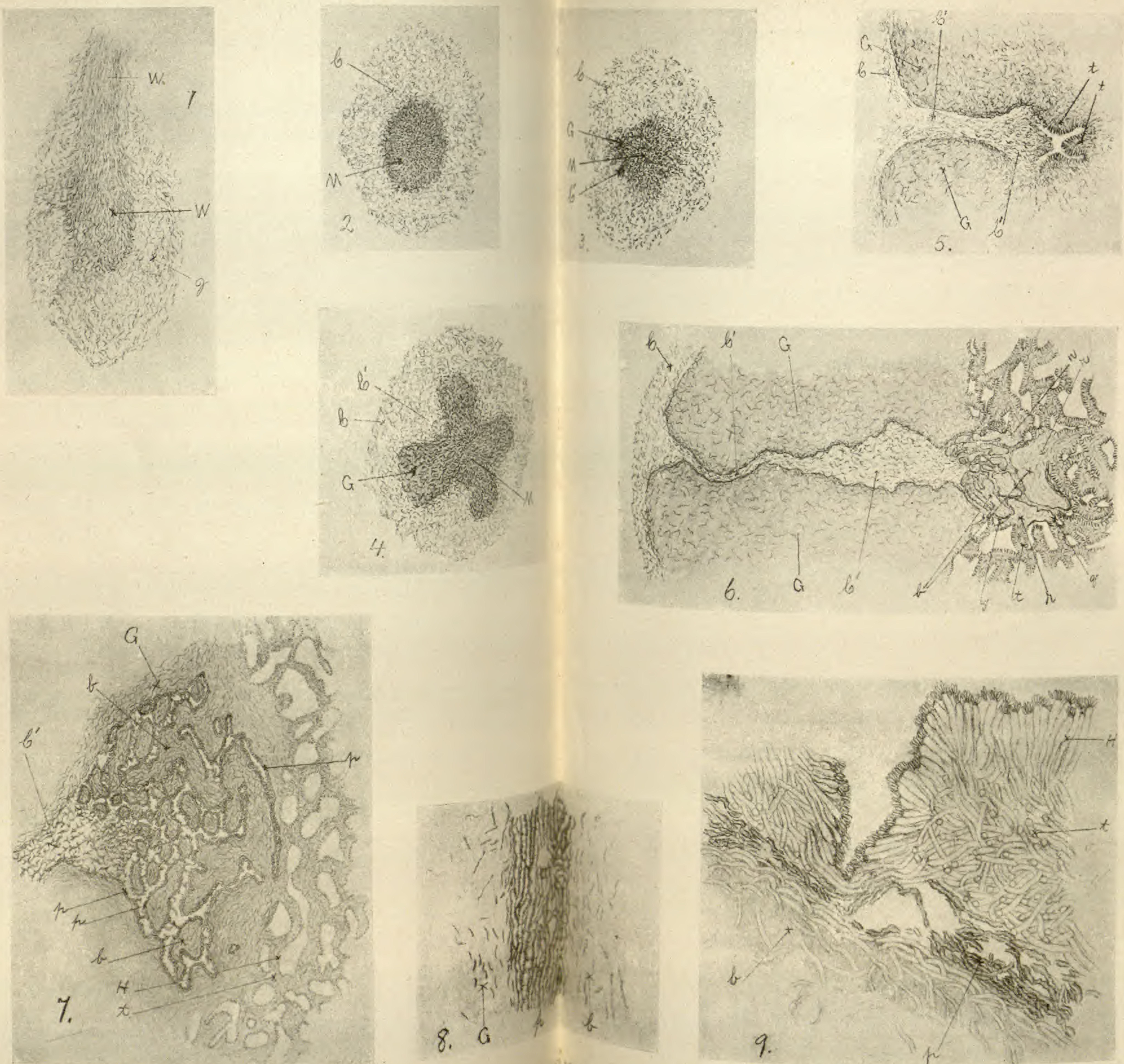
FIG. 7. Cross-section of a fundament of a column of the receptaculum, showing medullary connections of the chamber tissue towards the right and cortical connections of the pseudoparenchyma towards the left. × 34.

FIG. 8. Portion of the wall, *p*, of *fig. 7*, more highly magnified. × 670.

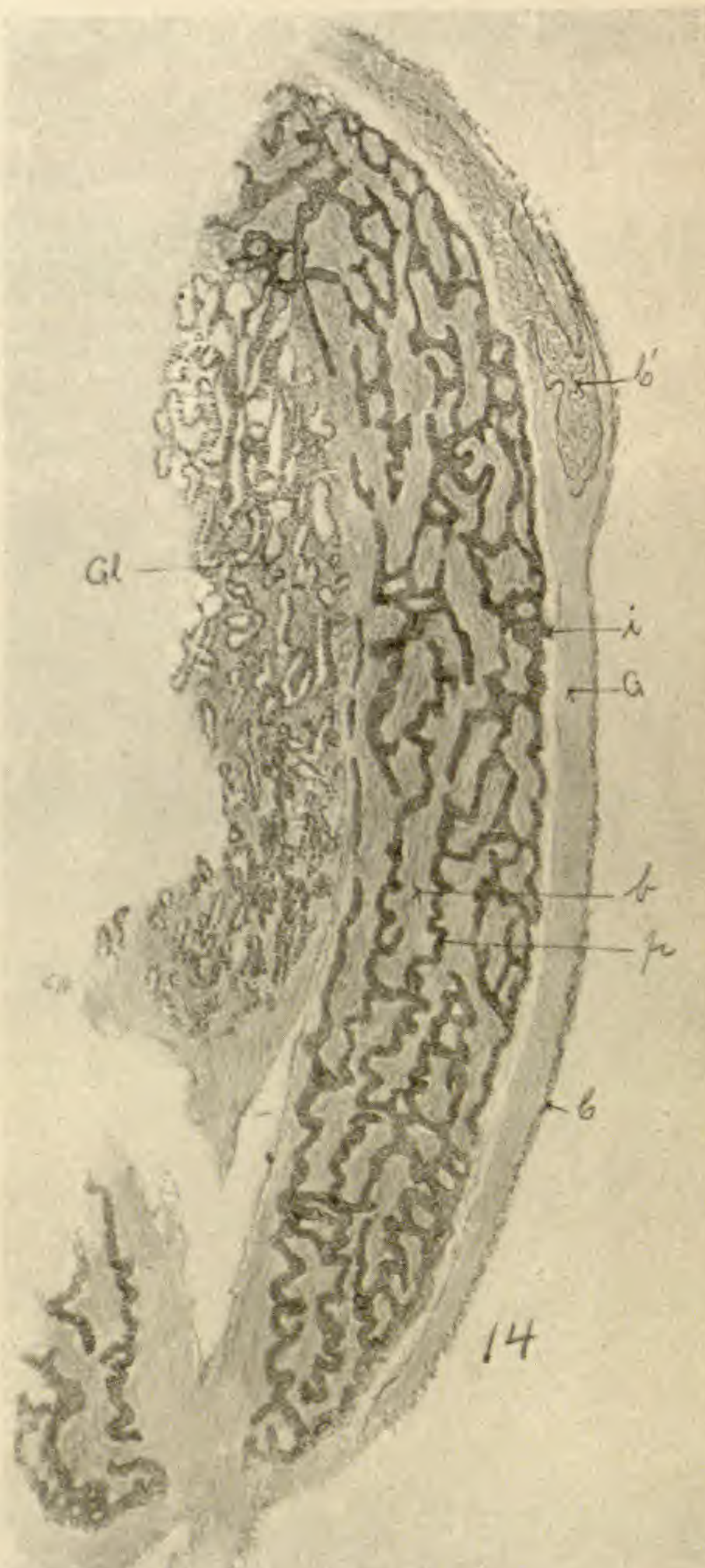
FIG. 9. Portion of the wall, *p*, between the gleba (*Gl*) and a chamber mass (*b*) of *fig. 7*. × 325.

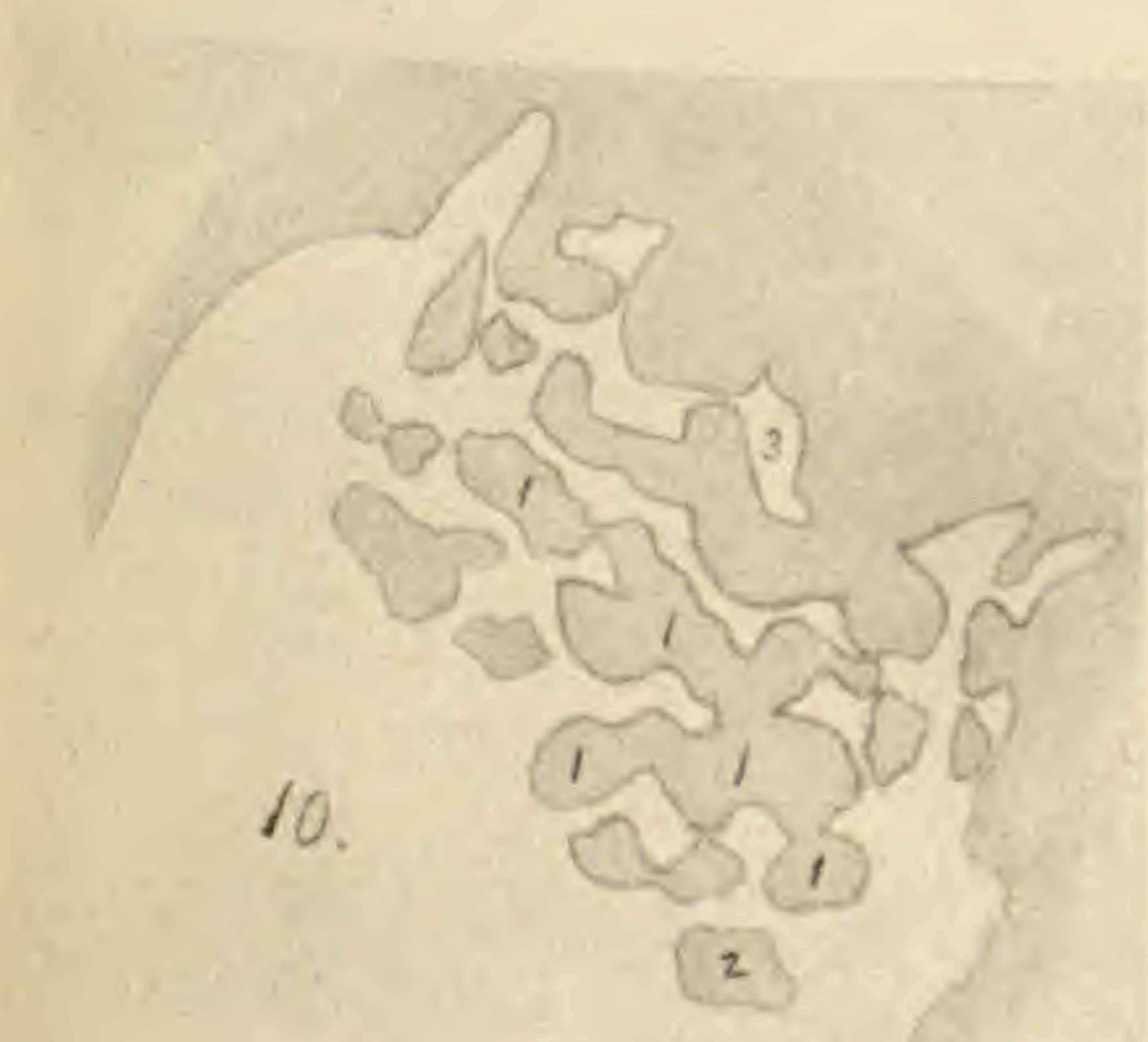
FIGS. 10–13. Serial sections of chamber-masses of a column, with adjacent tissues, in the lower part of the egg. *Fig. 10* represents the lowest section. The series shows how the small and apparently isolated masses ("hyphal knots") are in reality connected with the main medullary mass. × 106.

FIG. 14. Median longitudinal section through an egg in which elongation of the receptaculum is beginning. Shows a column in longitudinal section displaying its relations to other structures. × 6.






BURT on CLATHRUS.

# THE MECHANISM OF MOVEMENT AND TRANSMISSION OF IMPULSES IN MIMOSA AND OTHER "SENSITIVE" PLANTS: A REVIEW WITH SOME ADDITIONAL EXPERIMENTS.

D. T. MacDougal.

(WITH PLATE XIII)

The history of investigation of the transmission of impulses in "sensitive" plants begins with the work of Lindsay on Mimosa in Jamaica in 1790, which for some reason was not published until 1827.[1] During the century following the subject received no attention except that given it in the north temperate zone, in warm houses, and for the greater part under highly artificial conditions. In such manner it has been the object of numerous series of experiments, and of many highly ingenious speculations.

Briefly summarized, the aggregate results of both methods embrace nothing beyond a delineation of the anatomical details, the chemical properties of some of the tissue systems, an immense number of the features of reaction under artificial conditions, "working theories" of the mechanism of the motor organs and metaphysical explanations of the transmission of impulses, and general relation of such highly specialized forms of sensitiveness to the developmental history of the plant.

The work upon the subject under conditions necessarily artificial has been so futile in real results that it has come to be admitted on all hands that a satisfactory solution of the problems presented may be accomplished only by researches prosecuted in the tropics, in the habitat of plants which have acquired a high degree of sensitiveness.

[1] Quart. Jour. Sci. Lit. and Art **24**: 79. 1827, and **25**: 434. 1828.

As an account of such an attempt the recent work of Cunningham deserves attention.[2]

As a basis for the theory upon which this author seeks an explanation of the mechanism of pulvini he devotes a large proportion of his work to the demonstration of the novel idea "that the great majority, if not all, of the transient spontaneous movements of higher vegetable organisms, whether of a nyctitropic character or arising in connection with other conditions than the incidence or removal of sunlight, are not dependent upon the presence of any specially irritable and contractile protoplasts within the motor organs, but on purely physical processes connected either with fluctuations in the osmotic capacities of the tissue-elements, or with alterations in the relations existing between local and general supply and loss of water." In support of this remarkable statement, but very little evidence obtained by an examination of the cell is advanced, but dependence is placed upon the external consistency and color of organs subjected to various reagents. Thus flowers of Hibiscus with the peduncle in water were exposed to ammonia gas in a moist chamber, and as they did not lose their form, while flowers similarly exposed to chloroform wilted, the conclusion was drawn that the osmotic activity of the dead cells was increased by the ammonia in the first instance. A final conclusion derived from similar experiments was that "there is no direct relation between turgidity and the presence of living protoplasm in the turgid elements," but in some instances turgidity may be indirectly dependent on the protoplasm because of the necessity for the manufacture of osmotically active substances; a conclusion certainly at variance with almost all of the known facts concerning the physiology of the cell. Not only does the author deny the possibility of changes in the filtrative properties of protoplasm, but he disregards the simple physical properties of this colloidal substance. He proposes a design

[2] CUNNINGHAM, D. D.: The causes in the fluctuations in the motor organs of leaves. Annals of the Bot. Gard., Calcutta **6**: 1–145. 1895. 4to. 7 lith. col. plates.

for the construction of a machine which shall react similarly to Mimosa.

All pulvinar movements are supposed to be due to a loss of water from the portion of the pulvinus in which contraction ensues, either directly by transpiration, or by withdrawal by the action of neighboring tissue so affected.

Scant attention is paid to the results of Pfeffer and his students, but the author gives the records of a very large number of experiments which, as he rightly points out, show reactions quite different from those obtained in northern latitudes. The thermometric records are meager in certain series, but it is possible that the temperature variations do not exert such an important influence in the tropical habitat of the plant.

According to Haberlandt[3] and others, the transmission of impulses and reaction in Mimosa bears a direct relation to the conditions securing an excessive root supply of water and hindered transpiration. Cunningham, however, finds the relation an inverse one, that plants in a saturated atmosphere react least readily. In a comparison of the three most important forms of stimuli he says: "In cases of 'contact stimulation' we induce mere local distributions of liquid within the tissues; in cases of incision we give rise to temporary exudations from the general supply of liquid; in cases of heating we secure not only this, but in addition we establish temporary increase of transpiratory loss and a site of persistent abnormal drain." In what manner a contact stimulus may cause alterations in the transpiration of a cell without the interposition of protoplasmic action is not explained. It must be said, however, that Dr. Cunningham's observational results are of great value, and are very suggestive as to methods useful in a continuance of the work.

ADDITIONAL EXPERIMENTS.

During the summer of 1895 I was enabled to make a number of experiments with a view of determining the chief factors

[3] Reizleitende Gewebesystem der Sinnpflanze. 1890.

in the transmission of impulses by Mimosa and other plants, in the Botanical Institute at Leipsic by the courtesy of Geh. Professor Pfeffer, to whom I am also indebted for his untiring attention and advice.

A number of the tests were repeated in the Botanic Institute at Tübingen in the present year, and I am indebted to the director, Professor Vöchting, for the opportunity. Some of the tests have also been repeated in the plant houses of the University of Minnesota.

Haberlandt's conclusions as to the transmission of impulses by means of hydrostatic disturbances in a series of elongated cells (the "Schlauchzelle") lying externally to the xylem have been received with general favor, and accounts for such a large number of the phenomena of transmission that certain of the experiments were arranged in such manner as to test the capacity of this theory for final explanation.

In the first place, repetitions were made of the well known experiments in which impulses were transmitted through portions of stems and petioles which had been killed by steam or dry heat in such manner as to allow the dead portions to remain mechanically intact. In my own work this was accomplished by winding soft cloth around the portion to be killed and saturation with water at 90–100° C. for five minutes. In some instances the dead portions were allowed to desiccate and in others a wrapping of tinfoil or a sheath of oiled plaster of Paris prevented undue loss of moisture.

I was able to transmit impulses from an incision or flame through dead portions of stems $3^{cm}$ in length; in some instances in which desiccation had proceeded to such an extent that the cell lumina of the dead portion were quite devoid of liquid contents, and in one instance through a portion bent at right angles by the weight of the leaf.

I was able to obtain similar transmissions in the midrib of the multipinnate leaf of *Oxalis sensitiva*, which offers many of the features of Mimosa.

In a few instances a reaction was obtained when incisions were made in the dead portion of a stem or petiole of Mimosa, but no great reliance is placed in such results.

Dr. Cunningham has repeated the tests of transmission through dead portions of stems, and was able to send an impulse through stems consisting of alternating living and dead sections.

The above experiments, giving similar results in the hands of a great number of workers, demonstrate conclusively that transmission may be accomplished in portions of the plant in which no turgid cells occur, and consequently in which no hydrostatic disturbance is possible.

With such facts in evidence the next step was naturally the determination of the question as to whether or not a hydrostatic disturbance constituted an impulse. Three methods were used. A number of young, healthy plants $40^{cm}$ in height were brought into the experiment room, and after being cut off near the surface of the soil, the bases of the excised stems were set in beakers of distilled water. The immersed portion ($10^{cm}$ long) of the stem was split and stripped in such manner that a large surface composed of active cells was exposed. When the leaves had regained their normal position half an hour later, with the air temperature at 28–30° C., the water in the beaker was withdrawn and quickly replaced by a saturated solution of potassium nitrate without mechanical disturbance to the shoot. Although the endosmotic action of the potassium must have resulted in the almost instantaneous withdrawal of a large quantity of water from the "Schlauchzelle" and other exposed tissues of the base of the stem, no reaction followed. The leaves were found to be in their usual sensitive condition after the experiment, when contact or incision stimuli were applied.

The bases of the stems of small plants were sealed securely into a glass tube $10^{cm}$ long, $1^{cm}$ internal diameter, filled with water, which connected at the other end with a leaden tube $30^{cm}$ long leading into a receiver of a capacity of 4 liters, with a vacuum of $70^{cm}$ of mercury. When the leaves had regained their normal position, with the temperature at 28–32° C., the stopcock leading into the vacuum was turned, allowing the full force of the vacuum to act on the base of the stem. In no instance was a reaction obtained. The usual tests showed a normal degree of sensitiveness in the plant.

The two experiments above described must lead one to conclude that diminished hydrostatic pressure does not constitute an impulse. It is, of course, open to belief that greater variations in pressure or a more sudden application of the same might be followed by a reaction.

To avoid a misconception of the effects of such diminution of pressure on the cell contents, attention is called to the fact that the "Schlauchzelle" form a series of continuous tubes, the contents of which freely communicate by openings in the cell walls, and that variations in pressure on any part of the system are quickly distributed through the entire system, as is demonstrated by the following experiment.

In order to test the effect of increased pressure on the plant, shoots were securely sealed into a short section of glass tubing, as above, by means of a rubber stopper bound in place by wires. The tube was filled with water and the other end connected in a similar manner with a leaden tube, with an internal diameter of 3–4$^{mm}$ and 1.5$^{m}$ in length, leading to the chamber of a compression air-pump (see plate). When the leaves had regained a normal position in an air temperature of 26–32° C., by a sudden stroke of the handle of the pump a pressure of 3–8 atmospheres was suddenly exerted on the base of the stem, but no reaction followed. That the increased pressure was exerted throughout the plant was proven by the manner in which water poured from the clipped end of a distant leaflet, and that it passed through the "Schlauchzelle" was shown by stripping away the tissues external to these cells. The pressure was thus communicated to distant parts of the plant within a second from the time of its application.

As another test, with its object similar to the above, a compressive pressure was quickly applied to various parts of the plant by the fingers, forceps, or other appliances. In some instances reactions were obtained. It is extremely difficult to compress the stem quickly without communicating a mechanical disturbance to the plant. It is also difficult to give the compression without crushing the tissues of the plant. It seemed, however, that in the instances where the above faults were avoided no reaction followed the compression, though no conclusions are based on this result.

In conclusion it may be said that the following points are somewhat firmly established: (1) Impulses may be transmitted by Mimosa and Oxalis through dead portions of stems and petioles in which the conditions are such that a transmission by the cell-wall or the water in the wall only is possible. (2) Great variations in the pressure exerted on portions of the plant in such manner as to set up hydrostatic disturbances extending throughout the entire plant are not followed by reactions; hydrostatic disturbance therefore does not constitute an impulse.

It is to be noted, however, that while it is proven that an impulse may be transmitted by a wall of a dead cell, it does not follow that the entire transmission from the point of reception to the motor organ is accomplished by such means alone. It seems quite possible that protoplasmic action plays a part at both ends of the chain connecting the two points, and that while a hydrostatic disturbance does not constitute an impulse, it may play a minor part in its transmission.

The entire problem, together with that of the developmental history of such highly specialized forms of "sensitiveness" as those exhibited by Mimosa, must be followed to their solution in the tropical habitats of the plants.

THE STATE UNIVERSITY OF MINNESOTA.

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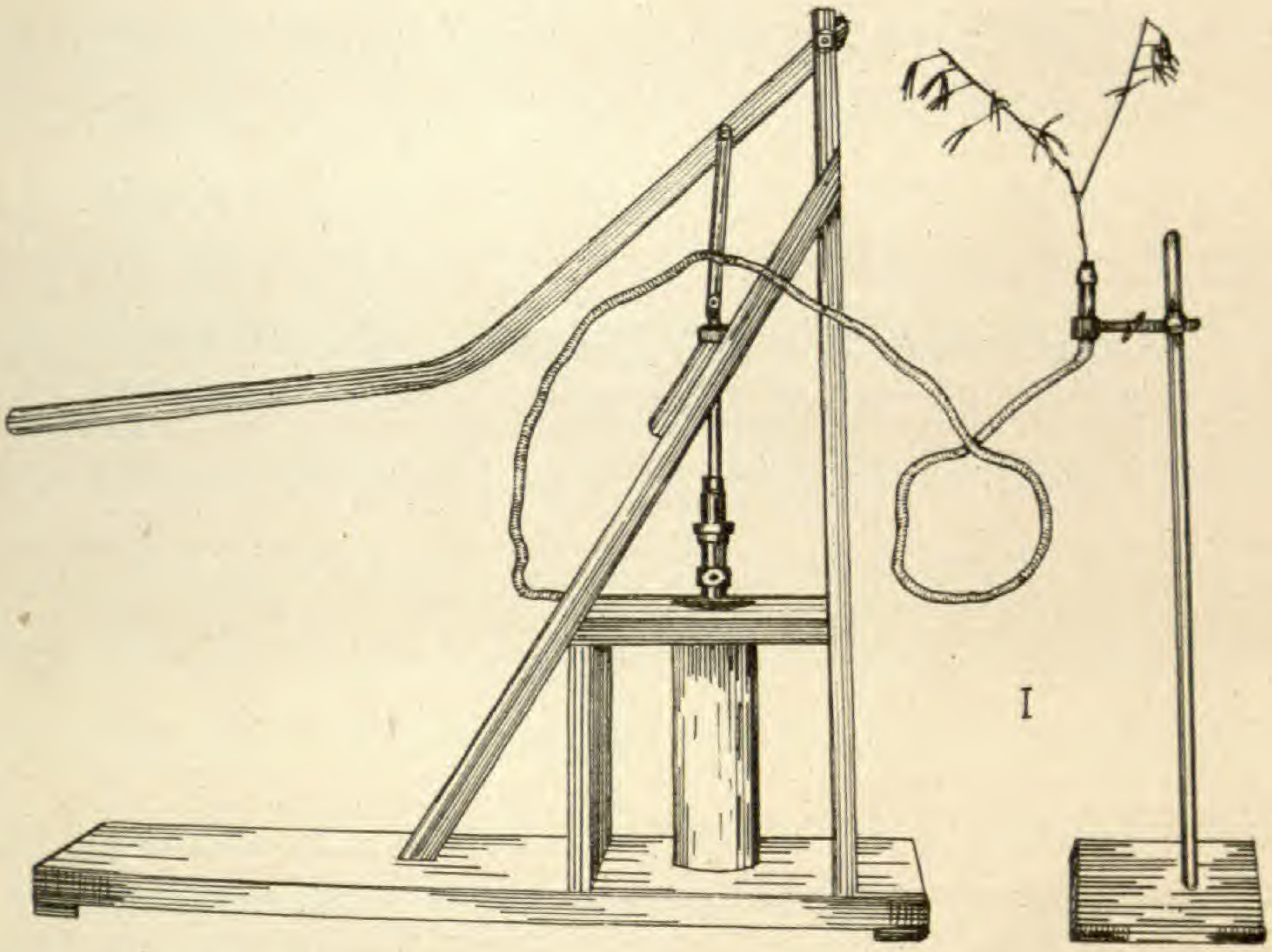
## EXPLANATION OF PLATE XIII.

FIG. 1. Showing branch of Mimosa attached to compression pump. A downward stroke of the piston has been given, resulting in the sudden increase of pressure on the base of the excised branch with no reaction of the leaves in consequence. The leaves were then stimulated by a stroke from a pencil, resulting in a normal reaction. The leaden tube in which the

plant is fixed connects with the cylinder at *5* in *fig. 2*. Drawn from a photograph. One-sixteenth natural size.

FIG. 2. Section of compression pump. 1. Fitting around piston rod. The piston rod is driven by the lever handle to which it is connected above. 2. Stopcock leading into the open air; not closed when the pump is used for compression. 3. Piston head moving "air tight" in a metal cylinder. 4. Valve. 5. Outflow pipe through which compressed air is forced. This pipe is extended horizontally in the opposite direction and upward to a point near the base of the crooked lead tube leading to the plant, in the apparatus shown in *fig. 1*. At a point near the juncture with the lead tube it is furnished with a stopcock leading into the open air, which is to be closed during the compression stroke and opened when the stroke is reversed. In *fig. 1* the cylinder is surrounded by a safety casing not shown in *fig. 2*. One-eighth natural size.

The plate for *fig. 2* was copied from the original drawing of the apparatus, and was kindly furnished me by the designer, Mr. Eugene Albrecht, Universitäts-mechaniker, Tübingen, and I am indebted to him for permission to reproduce it here.

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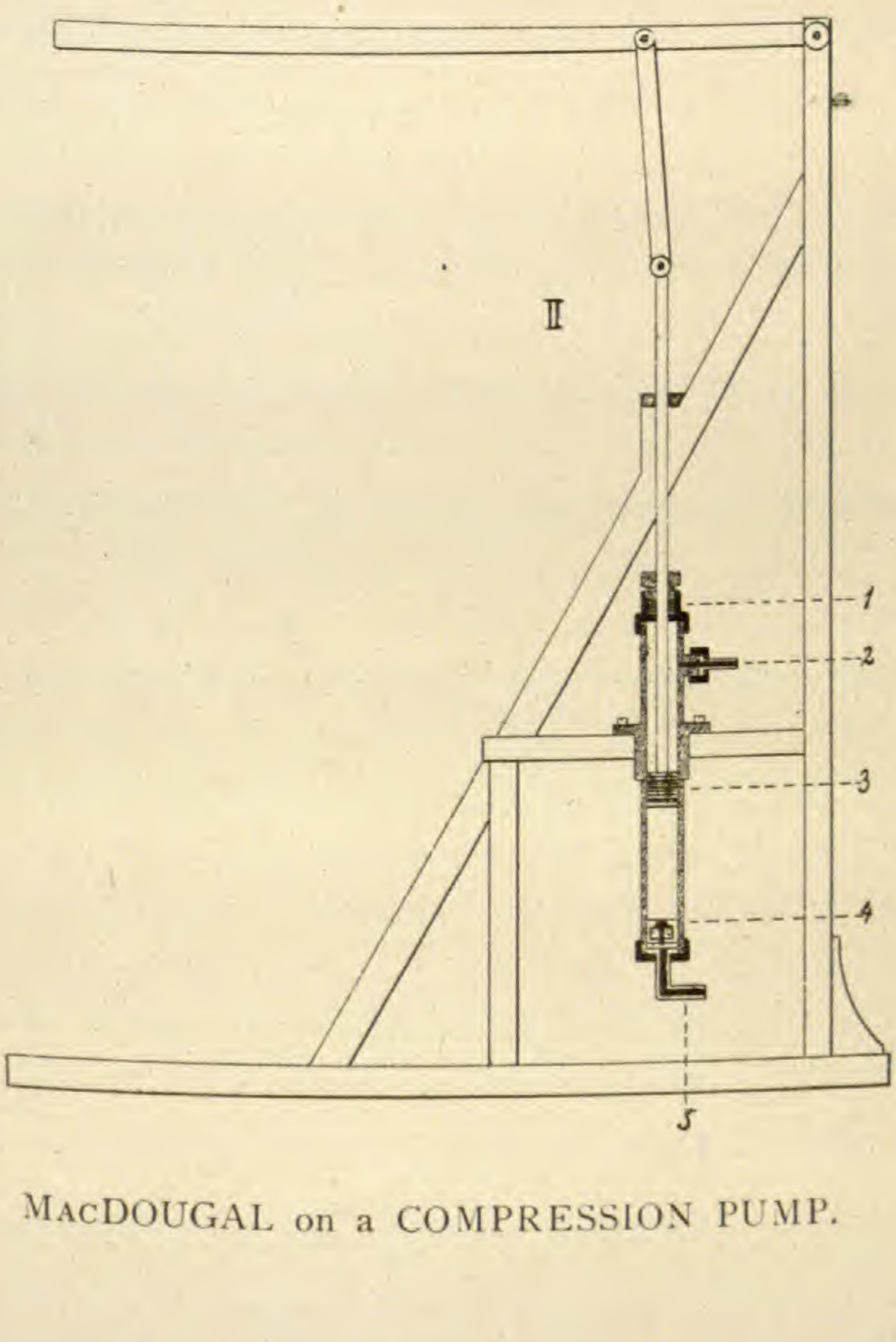


MacDOUGAL on a COMPRESSION PUMP.

# THE MORPHOLOGY AND DEVELOPMENT OF CERTAIN PYRENOMYCETOUS FUNGI.

MARY A. NICHOLS.

(WITH PLATES XIV–XVI)

THE study of the morphology and development of the ascomycetous fungi comprises four essential questions: (1) sexuality; (2) structure of sporocarp; (3) origin and development of spore; (4) presence, structure, and behavior of nuclei. The literature includes the results of many valuable investigations dealing with one or more of these questions throughout the great class Fungi. The thoroughness and accuracy of this work has advanced steadily with the improvement of methods, and much of the earlier work has been disproved later. In the meantime two opposed schools have arisen, one maintaining the sexuality of the higher fungi and their relation to the Florideæ, the other denying the presence of sexual organs and tracing the development of the compound sporocarp through an asexual line of ancestry.

Throughout the Phycomycetes there remains little doubt of the existence of a distinct sexual process. Representative forms in the different families have been described by De Bary (1) and many others. The structure of the sporocarp, and origin and development of the spore in this group are comparatively simple processes, and have been more or less thoroughly demonstrated. Nuclear phenomena here have also received some attention. Among the later and more complete articles may be cited that of Istvánffy (2) treating of numerous different species.

The Mesomycetes (Brefeld) seem to lend themselves to either line of development. Those leading toward the Ascomycetes furnish some instances of undoubted cytoplasmic fusion at least, while in the Ustilagineæ and Uredineæ Dangeard (3) and

Sappin-Trouffy (4) describe certain nuclear fusions which they explain as sexual processes. No details of nuclear structure and division in these forms have as yet been described.

In the Basidiomycetes the only process analogous to conjugation is the fusion of nuclei in the basidium before the formation of spores. Nuclear studies in this group have been more numerous and complete than elsewhere among the fungi. De Bary (1) in three species has observed the presence of nuclei in the basidium. Rosenvinge (6) has demonstrated the same in thirty-five species. Strasburger (7) has observed the nuclei in Agaricus and found that they divide. Wager (8) in 1893 published the results of extensive nuclear studies upon Agaricus and Amanita. According to his statements, the nuclei of the basidia fuse in pairs before spore formation, and after this fusion successive bipartitions of this fused nucleus occur to furnish nuclei for each of the four sterigmata. During division the nuclear membrane is gradually dissolved and the nucleolus and chromatin masses left free in the cytoplasm. The latter have previously arranged themselves in an equatorial plate. A spindle is now formed, at the poles of which are dark rounded bodies, probably centrosomes, but he fails to find any radiating striæ. During the division the nucleolus disappears. After division of the chromosomes the spindle disappears and the daughter chromosomes at either pole fuse together and, he states, "apparently form the daughter nucleole." At the same time the linin network becomes more strongly differentiated, new membranes are formed, the daughter nuclei assume the size and appearance of the parent nucleus and are again ready to divide.

In the Ascomycetes minute study becomes much more difficult, the investigations are more meager and less reliable, and the conclusions are more at variance. Of the generalizations made by De Bary (1) and others it is only necessary to call special attention here to those on the sphæriaceous Pyrenomycetes. De Bary cites only Xylaria and Sordaria as having unmistakable sexual organs, and in these conjugation has not been observed. In Xylaria the archicarp, he says, seems to disappear before the formation of the asci, and hence no relation can be traced between fertilization and the origin of the spore. In Sordaria also, according to Woronin (9), the origin of the ascus cannot be traced certainly to the archicarp. "In Claviceps, Epichloe, Pleospora, and perhaps also Nectria, no cooperation of the above named organs (archicarp and antheridium) has been observed, and no distinct ascogonium." . . . "The young perithecium, as at present known, is a body consisting of similar hyphæ or parenchymatous cells, and its elements are gradually fashioned and differentiated into the parts of the perithecium."

"Hartig's (10) conjecture with regard to Nectria, that special ascogenous initial organs are really present on the very young stoma, but up to the present time have been overlooked, may certainly hold good of Claviceps and Epichloe." (De Bary, *l. c.* 200.) Hartig (10) finds sexual organs in Rosellinia. Woronin (9) claims sexuality for Sphæria and Sordaria, and Harper (5), in a recent article on Sphærotheca, shows conjugation and traces the origin and development of the ascus from the fertilized archicarp.

Thus far we have shown strong support for the theory of the presence of sexuality in the Pyrenomycetes. But Brefeld (11), with a school of well known workers, opposes this view, tracing the development of the compound sporocarp through an asexual line and denying the significance which the De Bary school attach to certain characteristics of these plants.

Concerning the nuclei of the Ascomycetes we learn from De Bary that the young asci in both Discomycetes and Pyrenomycetes, so far as studied, contain each a primary nucleus, and later one smaller nucleus is present in each of the eight spores. Sadebeck (12), in 1883, published certain details of nuclear behavior in the Exoascaceæ. He indicates that karyokinetic divisions take place in the ascus, increasing the number of nuclei from one (the primary nucleus) to one for each of the spores. His karyokinetic structures are, however, very rudimentary, and are represented in his figure by two rounded granular bodies at the poles of a spindle consisting merely of three lines. No details of karyokinesis are given.

Fischer in 1885 goes somewhat more deeply into detail regarding the structure of the nucleus in Exoascus. According to his observations the nucleus is a round granular mass in which smaller and darker rounded bodies appear just before division. Next a spindle is formed, consisting of four threads converging slightly toward the poles. In the equatorial plane of the spindle four chromosomes now appear, which divide and pass to the poles of the spindle, where they form themselves into daughter nuclei. This description is of course crude, as were the methods of observation upon which it was based. Gjurasin (13) in 1893 published the first detailed account of karyokinesis in the Ascomycetes. It is based upon a study of *Peziza vesiculosa*. He describes the nucleus as consisting of a distinct round granular nucleolus surrounded by a layer of hyaloplasm in which an indistinct network is present. At the time of division the nucleus elongates, the nucleolus becomes eccentric, the chromatin aggregates into small masses, and two centrosomes with radiating striæ appear. Between these are drawn the nearly parallel threads of the spindle. The chromatin masses collect in the equatorial plane of the spindle and divide, and the daughter chromosomes very quickly seek the poles and soon are surrounded by new nuclear membranes, the membrane of the parent nucleus having meantime disappeared. In these daughter nuclei the nucleoli appear after the formation of the membrane, and with their appearance the mother nucleus, which up to this time has persisted lying free in the cytoplasm, disappears. Second and third divisions occur in like manner. Gjurasin states that he spent two years in the search for these karyokinetic structures, obtaining his final results by means of the Hermann and Flemming methods of fixing and staining.

Harper (5) in 1895, by methods similar to those adopted by Gjurasin, observed karyokinesis in *Peziza Stevensoniana* Ellis, and *Ascobolus furfuraceus* Pers. From studies of these and various allied Discomycetes he concludes that the members of this group are especially favorable for the study of nuclei in the ascus. The results of his work may be summarized as follows:

there exists in the young ascus four nuclei which fuse in pairs to form a single primary nucleus. This nucleus divides in a true karyokinetic manner to furnish a nucleus for each spore. In the process of division (1) the chromatin collects in masses on the network; (2) the nucleolus becomes eccentric; (3) centrosomes with radiating striæ appear; (4) the chromosomes arrange themselves in the equatorial plane, divide in halves and seek the poles; (5) the nuclear membrane is ruptured and the threads from pole to pole become very much elongated and parallel. The nucleolus meantime has gradually diminished and by the time the daughter nucleoli are formed it entirely disappears. The daughter nuclei attain normal size and structure and undergo two further successive divisions, providing one nucleus for each spore.

The foregoing summarizes briefly the work so far done along the lines of morphology and development in the higher fungi. As may be seen, the first two divisions of the subject (sexuality and structure of sporocarp) have received a comparatively large share of attention, but the conclusions even here are contradictory and unsatisfactory. Spore development and nuclear phenomena have been worked out to some extent in the Basidiomycetes and Discomycetes, Harper's work on one genus stands alone for the Perisporiaceæ, while nothing at all has yet appeared for the sphæriaceous Pyrenomycetes. Hence certain members of the last named group have been made the basis for the investigations of which the results are here presented.

## METHODS.

*Growing.*—The material used for study was grown in artificial cultures and examined either in sections or by growing it upon glass slips immersed in nutrient media and transferring these slips directly to the stage of the microscope. The latter method served as a check on the former, since in sections the numerous cut ends of the mycelium are likely to lead to erroneous conclusions. As soon as pure cultures of the desired species were obtained by ordinary dilution methods, the spores were sown in infusions of bean stems or mushrooms in Petri dishes. In these dishes had been placed carefully sterilized glass slips and cover-slips. The spores germinated sometimes upon the slips, sometimes floating free in the liquid, in which case the colonies rested upon the surface. Where they germinated on the slips, the mycelium adhered closely to the glass and made the process of fixing and staining much less difficult. On the other hand, the colonies which floated on the surface of the liquid seemed to take on more natural characteristics and they could be lifted out on a slide and prepared for the microscope. Many of the colonies thus grown developed mycelium in such abundance as to make observation very difficult. This was especially true of colonies grown in mushroom infusion, which seemed a most favorable medium, but it was also true that in these dense colonies the fruit was most abundant. The material for sectioning was grown in potato agar slightly acidulated to suppress bacteria.

*Fixing and staining.*—Slides bearing colonies were lifted carefully from the Petri dishes at different stages in their development and washed in water. Various methods of fixing and staining were tried. The most satisfactory was to fix with a cold 1 per cent. acetic saturate solution of mercuric chloride, stain with alum-eosin and mount in glycerine. The mercuric chloride fixes this material almost instantly and when washed off well with water leaves it in condition to take a clear decisive stain in the alum-eosin. This stain does not bring out nuclear structures with great distinctness, but cell walls come out sharp and clear. It stains the young mycelium and perithecia almost instantly, the latter taking a slightly deeper stain than the former. Good results were also obtained by staining with carmalum the material fixed in this way. Ehrlich-Biondi, hæmatoxylin and fuchsin were also found fairly good. The efficiency of any stain was found to depend largely upon the age of the fungus. Young mycelial threads stain very readily, while the very mature ones refused the stain altogether.

*Sectioning.*—Small blocks of potato agar containing colonies were cut out from the Petri dishes, dropped for a few minutes into the mercuric chloride and then allowed to wash in running water over night or at least for six to eight hours. In this process much of the agar was washed away, but the colonies were sufficiently compact to hold themselves together. They were then passed through successive alcohols, infiltrated and embedded in collodion, and cut with a microtome in sections from $6\mu$ to $12\mu$ thick. No other fixative tried seemed to leave the material so susceptible to stains as the mercuric chloride. Among others used may be mentioned chromic acid, Flemming's stronger solution, Hermann's solution, and Fish's picro-aceto-sublimate. The solutions of Flemming and Hermann were perhaps equally good when cleared with hydrogen peroxide, but without this additional trouble the sections so fixed were useless because of the discoloration of the protoplasm. With Fish's mixture some very good sections were prepared, but they were in no way superior to those fixed in the more simple corrosive sublimate.

In all the earlier part of the work the sections were stained with Mayer's carmalum. This produced no differentiation of nuclear structures, and much time was spent in experimenting with various stains and combinations of stains in the hope of getting a color differentiation. This was not accomplished, but in the later work upon nuclei Hermann's safranin-gentian-violet method as given by Zimmerman (17) was employed with very satisfactory results. Gjuarsin's methods as given in his article on Discomycetes were also found valuable.

The greater part of the observations were made with a Bausch and Lomb microscope, one-twelfth inch objective and one inch ocular, but for nuclear study this was found insufficient, and a Zeiss instrument with a one-twelfth inch objective and no. 8 ocular was employed.

TEICHOSPORA.

This fungus was found growing upon dead branches of oak in the vicinity of Ithaca, N. Y., late in November 1895. The perithecia were then past maturity and many had discharged their spores. Closely associated with the perithecia were numerous pycnidia, appearing as much smaller rounded black bodies. A dilution culture was made in potato agar from the ascospores which were supposed to be free from the pycnospores. The ascospores soon germinated and camera lucida drawings of the germinating spores were made (*fig. 1*). Numerous colonies now appeared in the plates. They were circular, showing radiations from the center, and in concentric rings, a little later, the beginnings of perithecium like bodies appeared. These colonies were then transferred to infusions of bean stems in tubes where they continued to develop. Contrary to expectation, however, when the round black perithecia like bodies matured they contained not asci, but pycnospores. The pycnidia were rounded or oval in form, opening usually by two apertures (sometimes by more, sometimes by only one), and extruding their spores in the typical worm like manner. The spores are fusoid-elliptical, hyaline, continuous, about half the diameter of the mycelium. In the colonies the pycnidia appear first near the center and may be found in all stages of development along a radius of the colony, the youngest stages nearest the circumference. The beginnings of these structures are shown in *figs. 4* and *5*. No pycnospores had been observed in the agar plates in which the sowing was made, and since the ascospores were known to have germinated, the natural conclusion was that ascospores had produced pycnidia, but this conclusion was found to be doubtworthy later. Meantime, there had appeared in the bean tubes, associated with these pycnidia, a grayish white mycelium with erect branching hyphæ upon which were borne multiseptate conidia (*fig. 6*). The hyphæ were closely septate and the spores varied from the diameter of the hyphæ, when they were hyaline or yellowish in color, to twice that diameter as they became dark brown. Although these were normally borne on the tips of hyphæ, as true conidia, they sometimes appeared as intercalary growths in the mycelium. When these conidia were quite mature a sowing of them was made in potato agar. Colonies soon began to form around the spores, but whether the growth began from the germination of the spores or from attached fragments of mycelium was not determined. As only pycnidia and conidia were produced from these sowings, the cultures were abandoned. Sowings of pycnospores were next tried, but in several successive generations only pycnidia and gonidia appeared and there seemed no hope of reproducing the ascigerous fruit. This failure of the ascospores to reproduce themselves even in alternate generations seemed unnatural and another culture was attempted from the original material. This had meantime been kept in the laboratory and had become old and dry and resisted all efforts to make it germinate. On January 25, 1896, some fresh material was collected by Professor Atkinson and from this ascospores were obtained which germinated readily in potato agar. Certain spores in the plates were marked and watched carefully until February 1, when they had attained distinctive characters and the numerous other colonies in the plates could be safely and certainly identified as the same. They appeared to the naked eye as dark spots with a light radiating fringe. With a carefully sterilized scalpel transfers of these colonies were made to bean stems in tubes. Ten such tubes were prepared. The transfers were made in a close culture-room and with the utmost precaution to avoid contamination. There was no doubt that these colonies grew from the ascospores, but probably none of these colonies developed. For a long time no growth appeared. Finally, in two tubes, a few pycnidia were found, and in one or two other tubes non-related forms appeared. In the plates from which the ten transfers had been made there were found (Feb. 3) a few colonies much in advance of those which had been traced from the ascospores, but very strongly resembling the pycnidia bearing colonies of previous cultures. These, however, contained the beginnings of perithecia in some of which asci had already developed. These colonies had apparently grown from fragments of mycelium or of the perithecia. They were removed piecemeal at short intervals of time (about three hours) and fixed and embedded for sectioning. It was hoped by this means to get all the successive stages of development (see account of sections below). Transfers of these larger colonies were also made to the bean stems in tubes, where they continued to develop perithecia and March 5 a culture was made from the ascospores contained in these perithecia. These spores, although full grown, were still hyaline in color, but they possessed unusual vigor. The colonies grew very rapidly and developed to maturity. Perithecia only were produced and the same was true in a third generation of this series. Another culture was now made from the pycnidia and conidia but again they produced only their own kind. This failure to connect the ascospores with the other forms led to the conclusion that they are probably distinct forms. The ascospores obtained from the oak in the fall germinated but failed to produce thrifty colonies, probably because they had lost vitality or because they were not readily adaptable to artificial conditions. Those sown in the first cultures very probably germinated and then died, as did those transferred to the ten tubes. The pycnidia found in these first cultures no doubt originated from pycnospores which were associated with the asci but overlooked in making the culture. This might easily have been the case, since the pycnospores are very small and scarcely distinguishable in potato agar. The study of the pycnidia and conidia has been included here because of interesting points of resemblance in the development of the pycnidium and the perithecium, and also because in nature the two forms are found so intimately associated. Indeed their connection is not disproved, although it has been impossible to establish artificially a life cycle including the three forms.

The ascigerous colonies which were finally obtained started, as has been said, from fragments of the mycelium or perithecia, and the ascospores thus obtained, being fresh and vigorous and perhaps also somewhat inured to conditions, germinated readily and reproduced themselves. This is further evidenced by the fact that during the winter two or three attempts were made to get cultures of the following species from herbarium specimens: *T. trimorpha*, *T. fusispora*, *T. aspera*, and *T. nitida*. The first named species had been in the laboratory but a few months and its spores germinated but developed no further. The others were older and refused even to germinate.

Attention was now confined to the ascigerous colonies of the species in hand, and with methods previously described the following observations were made. The mycelium is composed of septate threads, each cell of which contains several nuclei. With alum-eosin and carmalum stains, the nuclei are distinguishable merely as round points stained more deeply than the cytoplasm and lying at or near the center of a circular clear space. In the mycelium nothing more minute than this could be determined in regard to the structure of the nucleus. None of various stains tried succeeded in differentiating any elements. Any stain which affected the nucleus also attacked the protoplasm of the cell. The nuclear membrane was usually sharply defined as a dividing wall between the clear circle and surrounding cytoplasm.

At various intervals in the mycelium certain cells were found which were more or less swollen (*fig. 7*). The protoplasm in these was more dense than in the adjoining cells as shown by the deeper staining. This over-staining made observations upon nuclei in these cells very uncertain, but the cells proved to be the beginnings of perithecia. The first dividing wall is thrown across parallel to the septa which delimit the original cell (*fig. 8*). Each of the two daughter cells then divides by a wall perpendicular to this, forming a four-celled spherical body. As this grows, further divisions occur somewhat irregularly (*figs. 9* to *11*) until we have a body consisting of a solid mass of irregular cells as yet without any differentiation. Sometimes at this stage the young perithecium is surrounded by a single layer of mycelial threads which have arisen in the neighborhood of the original cell and interwoven themselves, forming a sort of wall for the perithecium. The wall proper in this species is not more than a single layer of cells thick and in many cases it seems to be formed by the thickening of the cell walls of the outer layer of the spherical mass, without the assistance of any surrounding filaments. It does not become dark and hard until the perithecium is nearly or quite full grown. When the growing perithecium has attained a little more than half the normal diameter of the mature fruit there may be seen at its center an oval sac containing a single nucleus and filled with densely granular protoplasm which stains very deeply. This sac is simply a swollen cell of the interior of the sphere. Simultaneously with its appearance a part of the loose parenchymatous tissue surrounding it breaks down so that the young ascus lies in a more or less disorganized, gelatinous mass. Very soon the other asci appear one by one. In many cases the sections showed two large ovoid sacs lying side by side and almost filling the interior of the perithecium. The later asci developed as the growth of the sphere made room for them.

Earlier investigators have attempted to find the connection between the origin of the asci and a supposed fertilized archicarp (see Woronin, De Bary, and Hartig, *l. c.*). In this case there exists no probability of a process of fertilization. In many cases the entire sporocarp may be traced from a single cell around which no other filaments are present even to take part in the construction of the wall, and in cases where extraneous filaments are applied to the archicarp it happens after several divisions of the original cell have taken place. If we consider the single swollen cell in the mycelium as the mother cell of the entire perithecium it is a question of some interest what determines which of the daughter cells become asci and which are disorganized. Harper (5) finds in Sphærotheca a structure consisting of from five to seven cells, arising directly from the fertilized archicarp, and a certain one of these containing two nuclei and giving origin to the ascus. We might consider the entire cellular structure of the fruit of Teichospora homologous with this five to seven-celled growth in Sphærotheca, in which case we should expect to find in the former certain binucleated cells functioning as mother cells of the asci. This may indeed be true but the observations so far made do not warrant such a statement. It is only in exceptional cases that the nuclei in these cells can be distinguished at all, on account of the density of the protoplasm and consequent deep staining. In the earlier stages, when the structure consists of two to four cells, faint outlines of nuclei can sometimes be seen, and in one or two cases division was suspected, but no positive statements are warranted regarding the nuclei in the perithecium prior to the formation of the ascus. As soon as the ascus is differentiated, however, the nucleus becomes very distinct. No fusion has been observed, and in the youngest stages each ascus contained one large clearly defined nucleus. This nucleus is much larger than those found in the mycelium, but is otherwise similar.

That some process of nuclear division takes place is apparent. As before stated, the young ascus contains a single nucleus. This has been called by De Bary the "primary nucleus." It does not, however, as he says, lie always in the end of the ascus. Its position is variable, but it is found oftenest near the center of the ascus and in a bed of very dense protoplasm. Its diameter is often equal to half that of the ascus. Neither does this primary nucleus disappear and eight daughter nuclei appear simultaneously, as has been stated. All the successive stages of division have not been observed, but an ascus containing two nuclei was found, and another with eight. In the latter case they were arranged in pairs, the two largest having moved a greater distance apart than any other pair (*fig. 19*). This, with the further evidence about to be given, was considered sufficient proof that the eight nuclei are provided by successive bipartitions of the primary nucleus. On this point the ascus next to be described was indirectly very instructive (*fig. 20*). In its protoplasmic content could be discovered, by careful focusing, the outlines of eight spores. The protoplasm in the spores was more dense than that surrounding them, and hence they were stained more deeply. The two spores nearest the base of the ascus contained one nucleus each and were not divided. A third spore contained two nuclei, lying near the ends of the spore, but no dividing wall had yet appeared. Four other spores contained two nuclei each, situated at various distances from a central septum. This septum was unstained, appearing like an open space in the protoplasm, but was more distinct than the outlines of the spores. The eighth spore of this ascus was in such a position that only part of its outline could be seen. In another ascus (*fig. 21*) there were found eight well defined spores, the walls being now distinct. Seven of these were divided by single central transverse walls into two cells each. Each cell contained a single nucleus. The eighth spore was bent upon itself in such a way as to conceal one end and only one nucleus was visible in it. There can be little doubt, however, that another was present in the concealed end, and it may be asserted safely that at this stage the ascus contains uniseptate spores having a nucleus in each compartment. The septa in this case had been formed soon after the first nuclear division in the spore. In preparations from material slightly more mature, spores were found in which the number of nuclei varied from two to ten, corresponding in number usually to the number of cells in the spore. An exception to this occurred in the case of one entire perithecium (*fig. 16*). Here each spore contained from four to ten nuclei but no dividing walls could be seen. Either the staining was at fault, which seems improbable, or the formation of the wall does not always follow immediately upon nuclear division, but takes place instead after all the successive bipartitions of the nucleus are complete.

The foregoing evidence, together with the fact that the nuclei occur constantly in pairs throughout the mycelium as well as the fruit, seemed conclusive proof that nuclear division does take place, but for a long time no details of the process of division could be discovered. Later, cases were found in which the hyaline court had become elliptical in outline and contained sometimes one eccentric dark spot, and sometimes one at each end of the ellipse. These at first seemed very similar, and the nucleus in this condition corresponds closely with Trow's (14) figures of what he calls "fragmentation" in the nucleus of Saprolegnia. If his theory be correct then the central stained spot is probably a chromatin plate, and by simple fragmentation furnishes a half plate for each daughter nucleus, and this grows quickly to full size. This must be based upon the assumption that the two stained bodies at the foci of the ellipse are similar in structure. This indeed seemed at first to be true, since no differentiation resulted from the use of the ordinary differential stains. On the other hand, it seemed quite as possible and more probable that the original dark spot of the nucleus is the nucleolus. In a resting condition this alone is visible, but preparatory to division the nucleolus moves off to an eccentric position, the hyaline court elongates, and the chromosomes accumulate to form the second chromatin mass in the opposite end of the ellipse. With more exact staining methods and greater magnification this possibility proved to be the fact. The resting nucleus contains a large nucleolus in the center of the cell sap. In this sap in some cases can be seen an indistinct linin network of very fine threads (*fig. 27*). Preparatory to division the nucleolus becomes eccentric and the circular space elongates. The linin now becomes more distinct, the threads having grown thicker at certain points (*fig. 28*). In the next stage small deeply stained chromatin bodies (not more than four have been counted) appear at the end of the ellipse opposite the nucleolus, arranged in what might be the equatorial plane of a spindle, but no spindle threads have been distinguishable in any case. At the poles of this plane were two small rounded bodies which were probably centrospheres, although no radiating striæ could be seen (*fig. 29*). Again, two groups of chromosomes, of four each, were found near the positions previously occupied by the centrospheres (*fig. 30*). By this time the nuclear membrane had become partially dissolved. The nucleolus was now vacuolated and less deeply stained and lay partially out in the surrounding cytoplasm. The cell sap was still present but constituted a somewhat distorted mass, and in it were the outlines of two new hyaloplasmic circles each surrounding a group of daughter chromosomes. In the next stage the ascus contained two new nuclei, somewhat smaller than the original but having the same structure (*fig. 31*). No secondary division was observed. Upon these cases, which have been illustrated from camera lucida drawings, may be based the conclusion that the nuclei in these asci divide karyokinetically. The failure to discover the spindle may have been due to inadequate staining or insufficient magnification. In other essential details the process agrees with Harper's description of karyokinesis in the Discomycetes. If the details seem incomplete it must be remembered that the largest nuclei measured only five or six micromillimeters in diameter, and minute structure was extremely difficult to determine with the instruments available.

The general sequence in the process of the development of the ascigerous fruit of Teichospora may now be summarized as follows:

1. A single cell of the mycelium by successive divisions and growth forms a solid sphere of parenchymatous tissue.

2. Certain of the interior cells of this tissue become enlarged and differentiated into asci.

3. Each ascus contains at first a single large nucleus, which by successive karyokinetic divisions furnishes a single smaller nucleus for each compartment of the multiseptate spores.

## TEICHOSPORELLA.

An undescribed species of Teichosporella, found by Miss Stoneman on oak and studied in a similar way, was found to develop in almost exactly the same manner as the Teichospora. So similar are the steps that it seems unnecessary to repeat the description in detail. A few figures are given showing the early stages of the perithecia (*figs. 7a, 10a, 11a*) as confirmatory evidence of the rather unusual way in which the sporocarps in this group arise, and also to call attention to a slight peculiarity which may have some significance in the question of phylogenetic relationships. This peculiarity is shown at *x* in *figs. 10a* and *11a*. It consists of a protuberance in the region of the archicarp, which by its shape and position suggests the possibility that it may be a degenerate rudiment of an antheridium. This feature is quite constant, and in general appearance not unlike the antheridia found later in Ceratostoma. If this explanation of its presence be accepted, then this genus furnishes a connecting link between forms having more or less complete sexuality and the Teichospora where all trace of an antheridium has disappeared.

Teichosporella exhibits another peculiarity in the development of the ascus. Instead of an evenly granular protoplasmic content filling the ascus from the time of its origin, there exists here, at first, an apparently empty sac formed, not by the swelling of a cell as in Teichospora, but as a papillate and then somewhat inflated outgrowth from a cell. Into this sac the protoplasm seems to push its way through a comparatively narrow opening at the base. The process may be understood best by reference to *figs. 22* to *26*, in which successive stages of the process are shown. The same conditions were found in the living material, hence it could not have been due to the action of reagents. The appearance may be due to an abnormal swelling of the ascus wall which recedes with its growth, or to the presence in the young ascus of a non-chromatic plasma or cell sap. At certain stages a zone of this same colorless sap may be seen enveloping the spores (*figs. 25* and *26*) after the ascus itself has become filled with the normal protoplasm.

The nuclear processes in this species agree, so far as studied, with those in Teichospora, but the work on this form was not repeated with the better stains and higher magnification used in the later work on Teichospora.

The development of the sporocarp as above given for these two genera is indeed widely different from any process heretofore described for the perithecia of any of the Pyrenomycetes. It is interesting to note, however, that it corresponds very closely with what has frequently been described as the normal course of development of pycnidia. This and the apparent loss of sexuality here suggests that these may be more degenerate forms than some others, and further that extreme degeneracy leads to the production of pycnidia only, these last named fruit forms being merely reduced perithecia.

### CERATOSTOMA BREVIROSTRE.

This fungus was found growing upon decayed mushrooms in a garden near the university. In artificial cultures it produced fruit so rapidly and in such abundance that it seemed a specially favorable subject for developmental study. The large dark brown spores in germinating extruded an endospore through a tiny pore at the more pointed end of the spore. The endospore contained a large vacuole and many nuclei, and from it arose one or more germ tubes (*fig. 32*). These germinating spores have been drawn large to show the nuclei, which are very distinct, occurring usually in pairs, but so small as to require great magnification in order to be seen at all. Spores sown in potato agar or upon bean stems produced colonies of whitish mycelium, sending out from the center strong primary radiating filaments which become plumose at their tips.

The colonies spread flat upon the substratum, and when grown in tubes the radiating threads pushed far out upon the glass, bearing fruit at some distance from the medium upon which the spore had germinated. This fact proved of great advantage in the later microscopic study, since the thin weft of mycelium grown on slides in Petri dishes could be easily transferred to the stage of the microscope and afforded excellent opportunity for study of the material in the best possible condition. The mycelium was comparatively scanty and no conidia or pycnidia appeared at any time during the many successive cultures that were made. The necks of the perithecia furnished a noticeable example of heliotropism. Those grown in tubes standing in boxes, and hence lighted only from above, turned strongly upward. A tube was then wrapped in dark paper, leaving only about an inch at the bottom exposed to the light, and suspended by a string. In this the necks turned sharply downward. Those grown in plates inclined always towards the window.

The first microscopic study was directed specially toward determining, if possible, whether there exists here any sexual organs such as have been described by Woronin (9) for the closely related genus Sordaria. For this purpose the fungus was grown upon bean stems and prepared for sectioning in collodion. Various methods of fixing and staining were tried, but nothing concerning the earliest stages of the perithecia could be discovered. Colonies grown in agar were next tried. These were fixed, hardened, and embedded in much the same manner as those grown on stems. This also proved unsatisfactory. The cut ends of the mycelial threads were deceptive, and although some very suggestive features appeared no positive conclusions could be drawn. An attempt was next made to study the colonies in cell-cultures and in the agar plates in which they grew. The latter proved more nearly successful than any of the former methods, but still much was concealed by the cloudiness of the agar and the fact that few colonies grew close enough to the surface to be focused upon with the higher power objectives. Finally the plan of growing on glass slips was adopted and gave the desired results. Slides bearing colonies were removed from the dishes at successive short intervals and treated as before described. The greatest caution was necessary to keep the colonies *in situ.* Unless they had grown very close to the slide they were speedily tumbled into a tangled, shapeless mass by the action of the fluids. The colonies which grew floating in the liquids required endless patience in preparation, but in this delicate material, when it was successfully prepared and mounted in glycerine, the long sought beginnings of perithecia were finally discovered. They occurred in such abundance as to leave no doubt of their function. They were noticeable first as deeply stained spots scattered thickly through the mycelium and varying in size from a little more than the diameter of the mycelium to one-fourth that of the diameter of a normally mature perithecium. This amount of variation in size could be seen usually in a single preparation, and so slight and uniform were the gradations from the larger to the smaller that there remained no doubt of the two being identical structures. The smallest of these bodies consisted of a short swollen branch arising from a primary branch of the mycelium and immediately becoming curved. From this short slightly curved branch (*fig. 33*) to the several coiled type (*fig. 34*) all intermediate stages were found. The size and shape varied greatly, and from the various assortment only the more typical forms were chosen for illustration. In most cases, an antheridial branch in contact with this curved structure (which was evidently the archicarp) could be plainly seen. This was a slender branch arising usually, though not always, from another filament and applying itself to the archicarp. In some instances the antheridia traveled comparatively long distances to reach the archicarps, and some were found coiled once or twice upon themselves in their courses. In most cases the two gametes were so interwoven that they could not be exactly traced, but in two instances unmistakable fusion of antheridium with archicarp was discovered (*figs. 35* and *36*). In both cases the antheridial branch is applied just at the tip of the female organ and the walls of both at the point of contact are dissolved. Many nuclei are usually present in both gametes, but they have not been seen fusing. The antheridium does not lose its protoplasmic content. It is usually less deeply stained than the archicarp, but this is also true before the two organs meet, and means probably only that the latter is richer in protoplasm than the former. The antheridium, moreover, is not always present. Numerous instances occurred, as shown in *fig. 33*, where the archicarp seemed to be developing without fertilization. There is, of course, no positive proof that these non-fertilized cells would ever produce asci, but the evidence given by the older stages of these points very conclusively toward the existence of parthenogenesis. Other peculiarities such as those shown in *figs. 37* and *38* were very interesting. In *fig. 38* the antheridium, while certainly present, has turned entirely away from the female branch, while the latter has continued to coil very much beyond the limit at which fusion usually takes place. *Fig. 33* also has become septate in accordance with the normal plan of development after fertilization. *Fig. 37* shows a tendency in another direction. Here the archicarp, having failed of fertilization, has been produced into a vegetative filament in a manner suggestive of what the writer (19) finds occurs at times in Vaucheria. These vegetative outgrowths were comparatively rare, but still were of sufficiently frequent occurrence to demand attention. They might indeed be caused quite as easily by insufficient nutrition as by lack of fertilization.

About the time that fusion of the two gametes occurs, in normal cases numerous branches arise in the neighborhood of the young fruit and become intimately interwoven around the sexual organs to form the wall. For a time the swollen archicarp can be seen in the center of this knotted mass of sterile filaments, but as the wall thickens and the threads of which it is composed become more closely septate this interesting structure is lost from sight. For further steps in the process it is therefore necessary to refer to sections. To get very early stages it was necessary to fix the growing material before any sign of color appeared on the outside of the tiny rounded bodies which were just becoming visible in the mycelium. The rate of growth varied so much that no definite age could be established as the proper one for sectioning, and repeated trials were made before sections containing the desired information were secured. By means of a long series of observations it was at last determined that in the stage just preceding the origin of the asci, the perithecium consists of a spheroidal mass of cells of three kinds. First is an outer layer two or three cells thick of thick-walled, nearly isodiametric cells, made up of the sterile hyphæ which envelop the young sexual organs. Inside this is a layer, two to three cells in thickness, of tabular cells which appear to have been laterally compressed by growth from within. These two have evidently been formed from the enveloping hyphæ. The center of the sphere is entirely filled with loose, spongy tissue composed of parenchymatous cells, well filled with protoplasm. These cells show no differentiation of form, and nothing exists to indicate where the asci will originate save that in certain sections a small group of these cells, lying about midway between the center and circumference of the spongy tissue on one side, takes a slightly deeper strain. Even in the very young stages no sign of the sexual organs imbedded in the spongy tissue could be found. It is at this point that De Bary and others have been obliged to leave gaps in their records of perithecial development. De Bary (1) says of Xylaria that the hyphal coil, or "Woronin's hypha" as it has been termed, seems to disappear before the formation of the asci begins. Hartig (10), in his study of Rosellinia, states that the asci seem to spring from a certain gelatinized zone, but whether they originate in the sexual apparatus or in the *Wandparenchyma* he is unable to determine. Woronin (9), too, fails to trace the exact origin of the ascus in Sordaria or to find the connection between it and the "hyphal coil." That a structure so prominent as this sexual apparatus, if it persists throughout the later development, should elude the notice of so many observers is quite incredible. It seems quite as improbable that this fertilized archicarp should fail to play any part in the production of the ascospores Harper (5) finds in Sphærotheca that the oosphere grows out into a branch of five to seven cells, from a certain one of which the ascus arises. The existence of the sterile cells of this branch suggests a solution of the problem in the true Pyrenomycetes, which has already been partially verified in the case of Teichospora, and is further confirmed by what is found here. Before the enveloping weft of threads, which are to constitute the wall, becomes too dense it may be observed that the coiled archicarp is becoming septate. Even in very young stages this septation has gone so far that in section the interior of the perithecium appears as a homogeneous mass of cells in which the outline of the coil cannot be distinguished. It now seems logical to conclude that this entire mass of parenchyma which forms the interior of the immature perithecium is formed by successive cell divisions in the archicarp. Instead of the five to seven-celled branch, giving rise to one ascus in Sphærotheca, we have here an indefinite number of cells giving rise to a variable number of asci. This is strictly analogous with the process in Teichospora, which was more easily traced because of the absence there of enveloping threads. It is in no way contradictory to the observations of Woronin, De Bary, and Hartig, though it fills in the gap which they have left open. It is true that only a comparatively very small number of these cells give birth to asci and the question as to what determines the fertile cells is still open. Here, as in Teichospora, no binucleated cells were discovered, but it was also true, as in the former case, that either because of the density of the protoplasm in these cells, or because of some fault in manipulation, no nuclei at all were discovered in any of these cells. As has been said, the only differentiation is a slightly deeper stain in a certain group of cells, the position of which corresponds with that from which the asci arise. It may be argued that only this group of deeply staining cells are formed by division of the archicarp, but if this were true we should certainly expect in some cases to be able to trace the outlines of the fertile hypha. Moreover this latter theory would fail to account for the existence of the sterile cells. The marked difference in structure between these cells and those of the wall make it highly improbable that both arise from the enveloping hyphæ. Then, too, when the sections become mutilated by the rolling of the collodion or by rough handling it is a noticeable fact that this central tissue breaks out intact, leaving the inner surface of the wall quite smooth. This theory of development tends also to harmonize what first appeared to be a very peculiar condition in Teichospora. The archicarp in Teichospora is not fertilized and is not specialized in form, but the further processes of development are essentially homologous. There remains only to prove that the mother cells of the asci contain two nuclei which fuse before entering the ascus in order to establish a line of development analogous not only to that described for Sphærotheca but also to what is found in many cases in the Florideæ. This intervention of vegetative tissue between fertilization and the production of spores, provides a sporophyte phase in the life cycle of these fungi which has not hitherto been known.

From the deeply stained group of cells in the central parenchyma the asci arise as papillate outgrowths, densely filled with protoplasm and staining much more deeply than the surrounding tissue. Their bases lie close together and the asci, which are long narrow-cylindrical and very numerous curve upward toward the ostiolum. Their protoplasm is densely granular and usually somewhat vacuolated. As they grow they become slightly constricted at the base. Certain ones advance more rapidly than others, so that in a single perithecium all stages of development may frequently be seen. The "bouquet" of variously sized asci lies embedded in the loose surrounding parenchyma, a part of which persists until the asci are quite mature. A distinct layer of this tissue is present between the bases of the asci and the basal part of the wall. In the center of the perithecium, between the asci, these vegetative cells become disorganized and probably furnish nourishment for the growing asci.

Meantime the wall has also undergone some changes. With the growth of the asci the entire sporocarp enlarges, the cells of the outer wall become thicker walled and darker, while those of the inner wall undergo still more lateral compression. At a point opposite the base the ostiolum begins to appear. Its beginning is marked by a slight protuberance, beneath which first the cells of the inner then those of the outer wall begin to separate schizogenetically. The ends of these elongated inner wall cells after separation round off and look like filaments converging toward the canal of the ostiolum. As the neck increases in length these filaments also lengthen and extend up into the neck canal parallel with its sides. The growth of the ostiolum continues after the development within is quite complete. Indeed the asci often are broken down, leaving the spores free within the cavity before the neck reaches its normal length.

The nuclei of the mycelium have already been noticed. They seem essentially the same in structure as those found in Teichospora, consisting, so far as could be seen, of a nucleolus in a clear circular court. The fact that no linin has been seen in the nuclei of the mycelium is probably due to the small size of these nuclei and the fact that they are seen through the wall of the mycelium. In the ascus the nuclei of Ceratostoma are smaller than in Teichospora and fewer details were made out. The drawings were reproduced free-hand, as those made from the camera lucida were too small for satisfactory illustration. In these nuclei there may be seen a linin network of very fine threads within the hyaline court (*figs. 40* and *41*). The first step toward division is the elongation of the court. The nucleus then becomes eccentric and the chromatin collects in masses on the threads. Then the network disappears. In the next stage that could be found the chromosomes had evidently divided and were arranged in two groups at some distance apart (*figs. 40* to *42*.) No centrosomes or spindle figure could be certainly distinguished, though in one or two cases something very like a spindle figure was faintly visible. Many of the intermediate stages are wanting. What becomes of the nucleolus cannot be certainly stated, but enough of the steps have been observed to warrant the conclusion that there is here a karyokinetic division, the more minute details of which might be detected by higher magnification. The stages found are illustrated in *fig. 40*, nos. 1–4.

### HYPOCOPRA.

As Teichosporella served to confirm the observations made on Teichospora, so Hypocopra served as a check upon Ceratostoma. The species studied was obtained from dung and separated by transferring with a sterilized needle first to dung infusions and then to bean stems, where it grew and fruited abundantly. From the bean it adapted itself readily to different media. The germination of the spores (*fig. 42*) was studied by transferring small quantities of the agar in which they grew to slides, where they were stained with Mayer's carmalum and mounted in glycerine. They did not, as in Ceratostoma, extrude the endospore. The protoplasm exudes through a tiny pore at the end of the spore and pushes out into a germ tube. The division and growth of the nuclei takes place with startling rapidity. Before the germ tube attains half the length of the spore, from four to eight nuclei have appeared. The colonies of mycelium grown in agar are characterized by the appearance of the first perithecia in a definite ring at a short radius from the center of the colony. The sexual organs are essentially similar to those of Ceratostoma. Some of the more typical forms are shown in *figs. 43* and *44*. The hyphal coil may be traced for a longer time here than in the other genus. In *figs. 45* and *47* it is shown somewhat straightened out and several times septate. For want of time the study of this form was not carried through to the end, but enough observations were made to furnish convincing proof that the course of development is essentially the same as in Ceratostoma. The process is somewhat more complicated than in Teichospora, and may be summarized as follows:

1. The spores upon germination send out polynucleated mycelial threads which become septate, branch, and form circular colonies.

2. Upon the mycelium are borne short thick branches which become curved, or sometimes several times coiled, and function as archicarps.

3. Near these archicarps are usually found long slender branches, the antheridia.

4. The antheridia intertwine with the archicarp, their tips meet and fuse.

5. The archicarps in some cases appear to develop without fertilization.

6. The archicarp by growth and division furnishes the cells which make up the interior of the perithecium.

7. From certain of these cells of the interior the asci arise.

8. In each young ascus there is a single primary nucleus.

9. The primary nucleus divides karyokinetically and the daughter nuclei in the same manner, to furnish a nucleus for each spore.

10. Nuclear division probably continues within the spore after the formation of the spore wall.

11. The wall of the perithecium is formed from surrounding filaments.

The evidence furnished by the foregoing investigations tends o corroborate the theory of De Bary that marked analogies exist between the higher fungi and the Florideæ. In the Pyrenomycetes we may expect to find sexual organs and sexual processes in different stages of degeneracy. In Ceratostoma we have distinct sexual organs, but the first sometimes develops without the fertilization of the archicarp. In Teichosporella there remains only a possible rudiment of an antheridium, while in Teichospora this organ has entirely disappeared.

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## EXPLANATION OF PLATES XIV–XVI.

Figs. 1, 2, 3, germinating spores of Teichospora.

Figs. 4 and 5, young stages of pycnidia.

Fig. 6, conidia.

Figs. 7 to 12, successive stages in early development of perithecium of Teichospora; *7a*, *10a*, *11a*, early stages of perithecia in Teichosporella.

Fig. 13, later stage of perithecium of Teichospora in which certain cells have begun to differentiate into asci and contain primary nuclei.

Fig. 14, perithecium showing young asci.

Fig. 15, part of a perithecium with several asci each containing primary nucleus.

Fig. 16, fragment of a perithecium in which all the nuclear divisions in the spores seem to have occurred without the formation of dividing walls.

Figs. 17 to 21, successive stages in development of the ascus in Teichospora, showing nuclear phenomena.

Figs. 22 to 26, stages in development of ascus in Teichosporella. Magnification not sufficient to show nuclei.

Figs. 27 to 31, successive stages in nuclear division in Teichospora.

Fig. 32, germinating ascospores of Ceratostoma brevirostre.

Figs. 33 and 34, archicarps or beginnings of perithecia without attendant antheridia.

Figs. 35 and 36, archicarps with antheridia attached, showing fusion.

Fig. 37, unfertilized archicarp produced into vegetative filament.

Fig. 38, archicarp and functionless antheridium.

Fig. 39, young perithecium in which the archicarp is still visible in optical section.

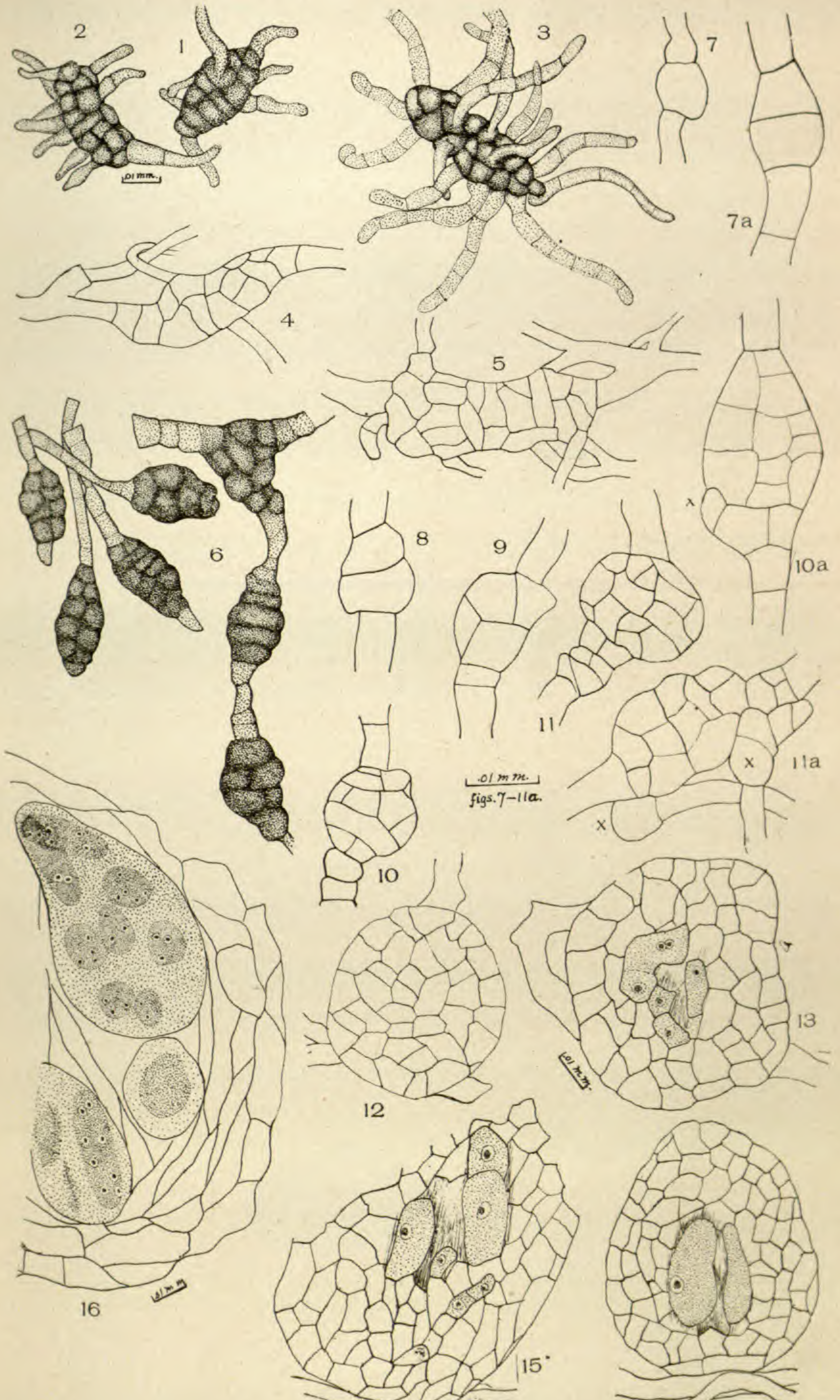
Fig. 40, fragment from the base of perithecium in which asci have begun to appear; *w. p.*, wall-parenchyma; *t*, tabular layer or inner wall. Asci are numbered to indicate successive stages in nuclear division.

Fig. 41, further development of asci.

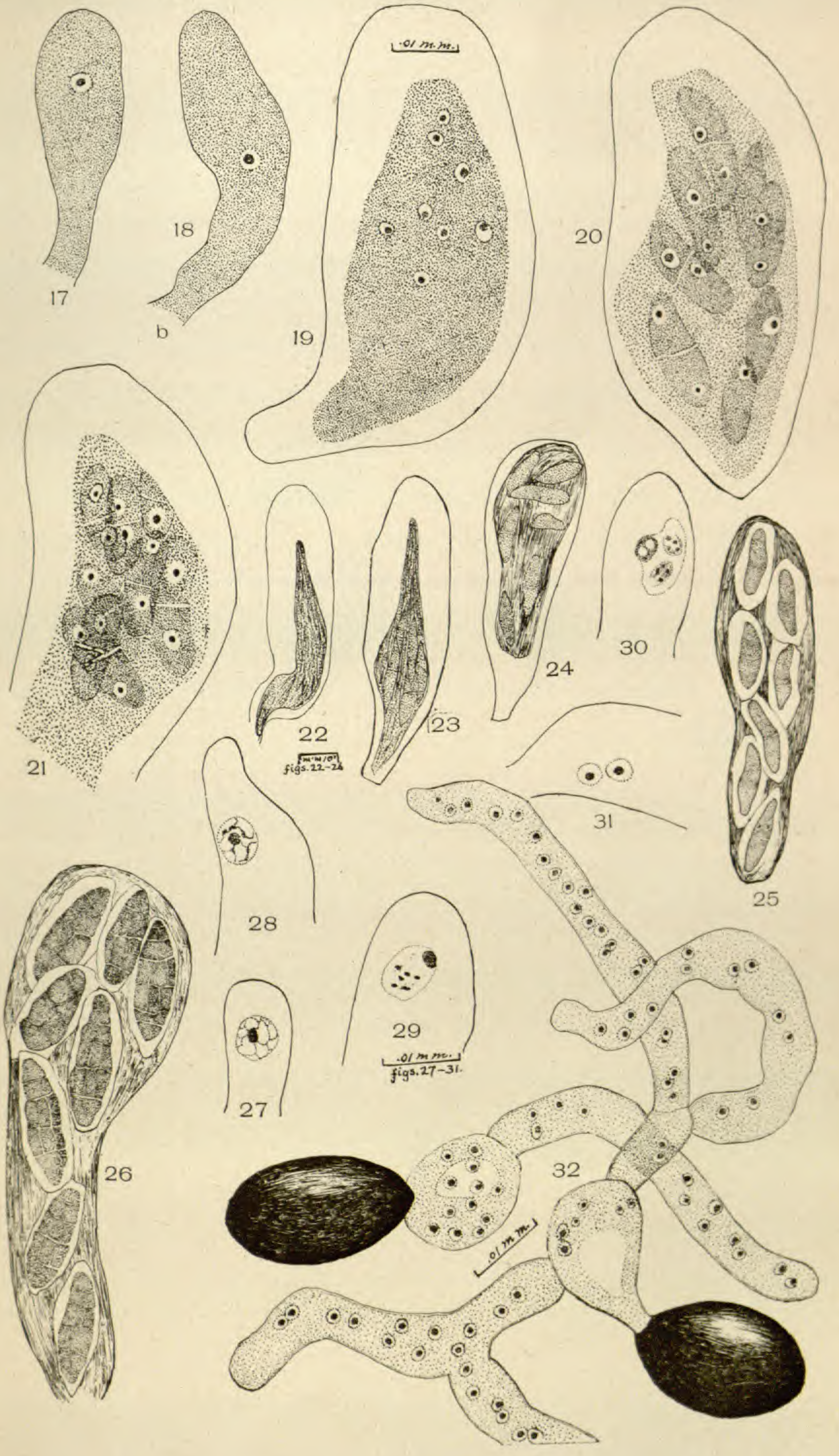
Fig. 42, germinating spores of Hypocopra.

Figs. 43 and 44, archicarps of Hypocopra with antheridia present.

Figs. 45 to 47, young perithecia in optical section showing enclosed archicarp.




NICHOLS on PYRENOMYCETES.

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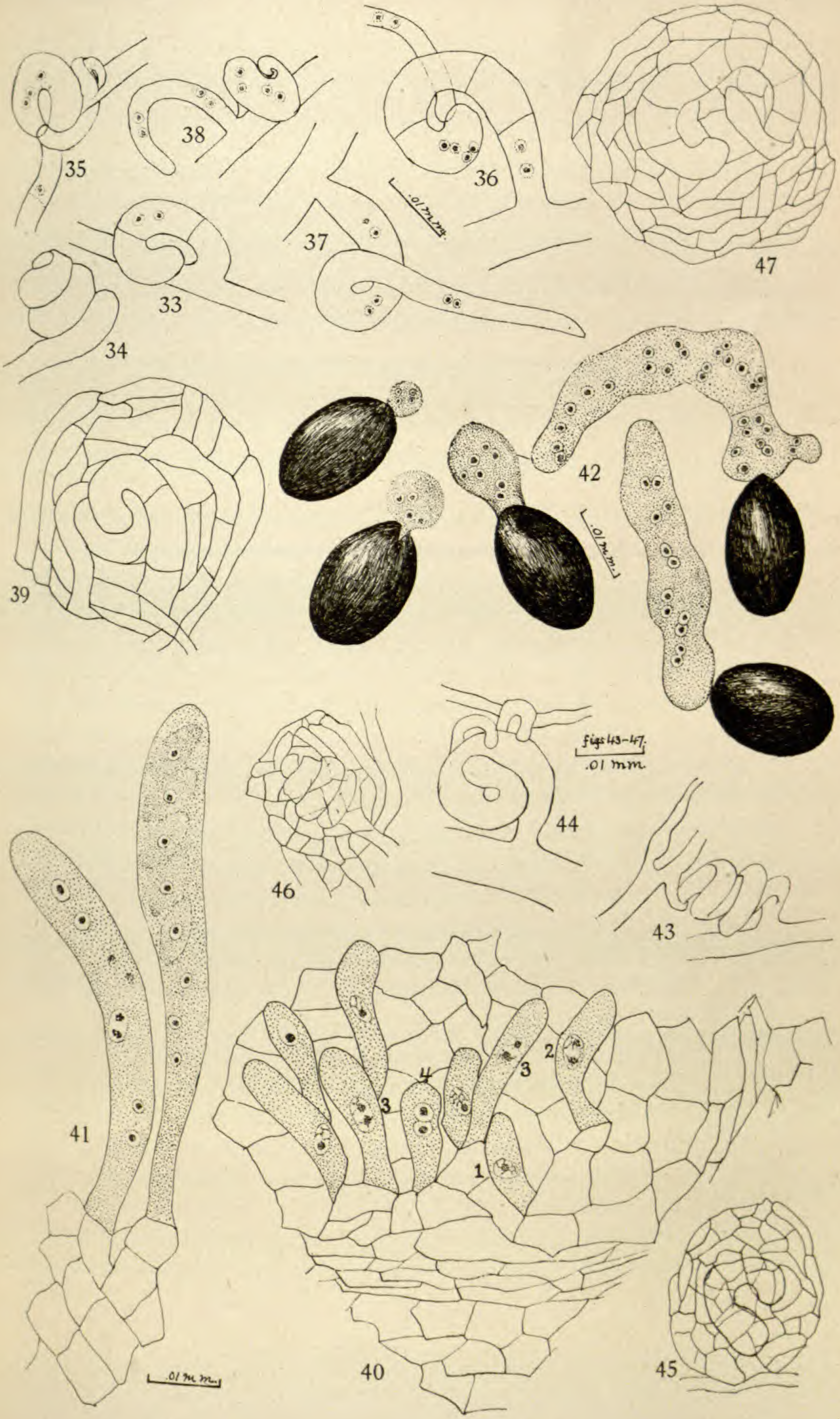


NICHOLS on PYRENOMYCETES.

# BRIEFER ARTICLES.

## THE ORGANS OF ATTACHMENT IN BOTRYTIS VULGARIS.

(WITH PLATE XVII)

WHILE engaged during the present year with a series of cultures of the common greenhouse fungus familiarly known as *Botrytis vulgaris*, the attention of the writer was attracted by the facility with which conidiophores and organs of attachment mutually replace each other as the result of changes of external conditions. The interest of such facts from a theoretical standpoint makes it seem worth while to record the following observations which were conducted under the direction of Professor V. M. Spalding.

Preliminary artificial cultures were prepared, each in a drop of malt solution on a glass slide. The first two, although as nearly alike as possible, showed very different results. One in the course of three days was completely covered with conidiophores (*fig. 1*), while in the other these were almost entirely absent, a development of peculiar cellular masses, the so-called organs of attachment, having taken place instead (*fig. 6*). The phenomenon suggested at once a relation of some kind between the organs of attachment and the conidiophores.

Other cultures were then prepared on slides, both plane and with concave centers, in test tubes, flasks, Petri dishes, etc., with the result that whenever the hyphæ came in contact with the hard surface of the culture dishes, these peculiar bodies appeared, and whenever the hyphæ grew upward without contact, conidiophores developed.

In order to determine with certainty whether or not the formation of conidiophores and organs of attachment could be controlled at will, the following cultures were prepared: In a drop of malt solution, placed on each of several slides with concave centers, were sown one or more conidia, and over the drop was suspended, by means of strips of damp blotting paper, a coverslip ($2 \times 1^{in}$). These cultures were then transferred to moist chambers until wanted. The slips were placed at various heights, if close to the drop ($1-2^{mm}$ above) in two or three days the entire overhanging surface was covered by organs of attachment, while conidiophores were formed only where hyphæ escaped at the sides and grew freely upward. When the slips were placed at greater heights ($3-7^{mm}$), a greater development of conidiophores followed with a corresponding decrease of organs of attachment.

Next slips of mica were perforated with the point of a fine needle and placed at various heights as in the above cultures, with the result that organs of attachment were formed where hyphæ came in contact with the overhanging surface, and conidiophores where they grew opposite or through the perforations. The fungus seemed to be entirely indifferent to light and gravity, and the formation of organs of attachment to be conditioned solely by the contact of hyphæ with a hard surface.

The development of the conidiophores and organs of attachment throws still farther light on their relation to each other. For the study of the developing conidiophores rather old perianths of *Lilium candidum* were inoculated with conidia from a clean culture and placed in moist chambers. In the course of three or four days the entire substratum was covered by the fleecy mycelium. From time to time this was examined until all the stages of development were obtained. Briefly stated they are as follows: Strong erect hyphæ, rich in protoplasm, branch two or three times, and from these branches repeated secondary divisions are sent out (*fig. 2*). Ultimately the apices of the branches swell, and peg like protuberances (*fig. 2 a*) appear which rapidly increase in size and number so that in a comparatively short time mature ovoid conidia (*fig. 2 b*) are developed from them. This formation of conidia was in progress at 3 o'clock P. M. April 14. Thus, with respect to the time of spore formation, this fungus differs from the one described by Klein.[1]

For the study of the successive stages of development of the organs of attachment, the following agar-agar cultures were prepared: malt solution, 2 per cent.; malt solution, 3 per cent.; geranium decoction, 2 per cent.; potato decoction, 2 per cent.; grape sugar, 2 per cent. In all of these media the fungus grew luxuriantly, producing organs of attachment when contact was possible, and conidiophores when this was impossible. The actual development of the organs of attachment was traced from a single conidium sown in 2 per cent. potato agar medium, as follows:

[1] Ueber die Ursachen der ausschliesslich-nächtlichen Sporenbildung von Botrytis cinerea. *Bot. Zeit.* 43: 6. 1885.

After germination of the conidium, the fungus grew rapidly, branching in every direction, and whenever an upright hypha came in contact with the cover of the shallow Petri dish ($5.5^{mm}$ inside depth) repeated branching took place as in case of the conidiophores. As the organs increased in size the branches became shorter so that ultimately they were of no larger size than ordinary conidia of this species. The successive stages in the development are represented in *figs. 3–6*. *Fig. 3* shows the condition of things at 3:15 P. M.; *fig. 4* at 4:15 P. M.; *fig. 5* at 5:07; and *fig. 6* at 6 P. M. of the same day. After this the branching became so rapid and the organ so complex that accurate drawings were out of the question.

When we compare the successive stages in the development of the conidiophores and organs of attachment, we find them essentially alike in origin and mode of branching, but ultimately in the case of the developing conidiophore the tips swell and peg like projections are sent out which grow and become mature conidia, while in case of the organ of attachment the branching continues irregularly and indefinitely. Farther, when conidia are sown in nutrient solutions germ tubes are sent out, and when a nutrient solution is supplied to one of the organs of attachment each ultimate division sends out a tube resembling a germ tube. In both cases these hyphæ branch and develop into a complex mycelial mass. The resemblance therefore is a physiological as well as a morphological one.

The connection between conidiophores and organs of attachment is farther emphasized by the intermediate forms found in almost every culture. *Fig. 7*, drawn accurately, as the others are, with the camera lucida, represents a prostrate branch with a young organ of attachment at *b*, and short, erect branches bearing conidia at *a*. It was a common occurrence for a hypha to bear conidia in successive clusters until it came in contact with the cover of the Petri dish, when it produced an organ of attachment.

Up to this time the organs of attachment were studied under artificial conditions, but later attention was directed toward their formation and significance in nature. Leaves in connection with vigorously growing plants were tied in such a manner as to be from $2–4^{mm}$ above each other, conidia having been sown previously, either in a small drop of water or malt solution, on the under leaf. The plants were then placed in an atmosphere saturated with moisture, under a large bell jar. In no case was penetration observed where conidia were sown in a drop of water simply, but where they were started in nutritive media, whether malt solution or a very small dead insect, in two or three days the fungus had penetrated both leaves, the one on which the conidia were sown as well as the one from 2–$4^{mm}$ above it. Organs of attachment formed freely on the overhanging surface here as in the artificial cultures already described, while on the lower surface they were rarely met with. Whenever organs of attachment had thus formed tubes were sent out from them into the host in the manner described by former writers. But that the fungus is not confined to this means of entering the host was seen in sections of a leaf on which conidia had been sown in a drop of malt solution four days previous to sectioning. Here contact with other leaves was impossible, so that the erect hyphæ bore conidia, while the prostrate ones ran over the surface of the leaf until a stoma was found for entrance (*fig. 8*). Again, some of the conidia produced by this mycelium had germinated and sent germ-tubes directly into the leaf between the lamellæ of two adjacent cells (*fig. 9*). In the latter case the tissue of the leaf was probably weakened by the presence of the fungus in some other part, since after entrance the tissue is rapidly consumed.

From the foregoing experiments, and others not recorded, the writer concludes that with this fungus the formation of organs of attachment is determined by external conditions which may be artificially produced by placing in proximity to the hyphæ a hard surface for contact, or they may be met with in nature where plants are crowded together so that the leaves of different plants lap over each other; that when this condition is not present conidiophores will be developed instead of organs of attachment; that in general conidiophores and organs of attachment are both physiologically and morphologically equivalent; that biologically the fungus makes use of the organs of attachment to penetrate a neighboring leaf, or it has the alternative, after starting saprophytically, of entering the host either through the stomata or by sending germ tubes directly into the tissue.

The literature of *Botrytis vulgaris* and allied forms is considerable, yet comparatively little has been said concerning the morphology of the organs of attachment. Brefeld[2] classes them, on account of their manner of attaching themselves to a substratum, with other "Haftorganen," while De Bary[3] throws more light on their biological rela-

[2] Schimmelpilze 4: 112.

[3] Bot. Zeit. 44: 382, 412. 1886.


HORN on BOTRYTIS.

tion to the host, saying that they are first formed as the result of a mechanical stimulus, and that by means of a poisonous secretion they injure the tissue, draw nourishment from it, and as soon as this is obtained send out branches which for the most part do not penetrate the host directly, but spread over the surface surrounding the organ. Later Marshall Ward[4] described their development, and speaks of them as being "of the same morphological nature as those figured by Brefeld in *Peziza sclerotiorum*, and explained by De Bary subsequently as organs of attachment," while J. E. Humphrey[5] describes them as compact cellular masses which cling closely to the surface with which they are in contact, but that their real significance is not yet understood. —MARGARETHA E. C. HORN, *University of Michigan.*

## EXPLANATION OF PLATE XVII.

Fig. 1. A branch of an upright hypha bearing conidia.

Fig. 2. Young developing conidiophore with small projections at *a*, and mature conidia at *b*.

Figs. 3–6. Successive stages of a developing organ of attachment.

Fig. 7. A prostrate branch bearing mature conidia at *a* and a young organ of attachment at *b*.

Fig. 8. Hypha entering a leaf of geranium through the stoma.

Fig. 9. Germ tubes penetrating the host between the lamellæ of two adjacent cells.

## NEW WEST VIRGINIA LICHENS.

**Lecidea Virginiensis** Calk. & Nyl., sp. nov.—Thallus glaucescens tenuis laevigatus rimulosus citrino-flavus; apothecia fusca aut nigra convexiuscula immarginata latit. circ. $0.5^{mm}$, intus medio sordida; spora oblonga incoloris, long. 0.009–0.012, crass. $0.004-6^{mm}$; epithecium et pars media hypothecii dilute fuscescens. In toto gelatina hymenialis coerulescens, dein theca vinose rubescens.

E stirpe videtur *Lecidea sanguineo-atra*, prope *Lecideam delineatam* Nyl.

On sandstone rock under the drip of a wet cliff. West Virginia, near Nuttallburg, L. W. Nuttall coll. no. 1779. *Flora of West Virginia*, Millsp. & Nutt., 181.

[4] Ann. Bot. 2: 327. 1888.

[5] Ninth Ann. Rept. 1891 and Tenth Ann. Rept. 1892. Mass. Agr. Exp. Station.

**Lecidea Nuttallii** Calk. & Nyl., sp. nov.—Apothecia nigra parva; epithecium impressum; spora fusca oviformis 1-septata, long. 0.014–16, crass. 0.005–6$^{mm}$; hypothecium fuscum. In toto gelatina hymenialis vinose rubescens.

Super thallum *Ricasolia sublævis* Nyl. West Virginia, near Nuttallburg, L. W. Nuttall coll. no 1781. *Flora of West Virginia*, Millsp. & Nutt., 181.

**Arthonia aleuromela** Nyl., sp. nov.—Thallus albus subfarinaceus chrysogonidicus tenuissimus; apothecia subrotundata vel oblonga, prominula, latit. 0.4–0.5$^{mm}$; spora oblongo-oviformis parte inferiore attenuata, 1-septata, long. 0.010–11, crass. 0.003$^{mm}$. In toto gelatina hymenialis cœrulescens, dein obscurata.

Thallus detritus subaureus, CaCl vix reagens. Gonidia chroolepoidea fulvescentia.

On bark of *Quercus sp.* West Virginia, near Nuttallburg, alt. 2000 feet, L. W. Nuttall coll. no 1182. *Flora of West Virginia*, Millsp. and Nutt., 182.

**Lecanora deplanans** Nyl., sp. nov.—Thallus glauco-cinerascens tenuis areolato-rimosus determinatus; apothecia badio-rufescens · (satis diluta) innata subconcaviuscula, latit. 0.5–0.7$^{mm}$; spora ellipsoidea, long. 0.015–16, crass. 0.009–1.010$^{mm}$; epithecium inspersum. In toto gelatina hymenialis fulvo-rubescens.

Videtur species e stirpe *Lecanora cervina*, spermatiis ellipsoideis.

On rocks in bed of creek. West Virginia, Short Creek, alt. 1300 feet, L. W. Nuttall coll. no. 1126. *Flora of West Virginia*, Millsp. & Nutt. 178.—C. F. MILLSPAUGH, *Field Columbian Museum, Chicago*, and L. W. NUTTALL.

# EDITORIALS.

THE SUBJECT of botanic gardens is happily coming into prominence in the United States. The recent address of Dr. Britton at Buffalo has put into our hands a succinct account of what has been done abroad and what has been begun in this country. The showing for America is better than was expected, and the promise of the immediate future seems to be very large. The two essential features of a botanic garden, popular education and botanical research, have been lost sight of for the most part in the numerous so-called gardens of many cities. Unless under scientific control they become merely places of cheap display, pleasant enough but not specially instructive, and certainly offering no facilities for research. Probably the only possible condition in which a botanic garden can be made to fulfill its real mission is to develop it in connection with a university, but if left to the university alone it will seldom command sufficient income to become largely effective. If a combination can be made between a university and a city, as in the case of the New York Botanical Garden, the largest results are possible. The growing demands of botanical science have brought every university face to face with the problem of a botanic garden, and it seems likely that the solution of this problem in America lies in the combination of university and municipality.

**Botanic Gardens**

THIS COMBINATION may not be so difficult as some suppose. Almost every municipality has one or more parks in various stages of cultivation. In most cases, if under high cultivation, the same monotonous succession of a few common plants in beds of conventional form appears. It is astonishing to note the limited range of plants ordinarily selected for parks, to the exclusion of the hosts of forms awaiting cultivation and of far more interest even to the park frequenting public. In such a case an arrangement might be made between the park commissioners and the university by which a certain portion of the park area should be under the control of the university as to the plants to be cultivated. The advantage to the commissioners would be the securing of expert advice in reference to the plants adapted to interest and instruct the public; the advantage to the university would be the securing of abundant illustrative material without the cost of its maintenance. Certainly the parks need to command a certain amount of botanical knowledge, and the universities are equally in need of a larger contact with plants in their various relations.

ASIDE FROM the ordinary uses by the university of what is styled illustrative material, any large control of planting would secure the possibility of experimental work in various biological lines without interfering with the legitimate uses of a park. Problems connected with heredity would be perfectly feasible, such as otherwise would demand the large outlay connected with the equipment of a special experiment station. In case of too great distance between the park and university a small "field laboratory" would make possible such work as would suffer by transportation. It is often said that most of our universities have about them wild areas that are a sufficient botanic garden. This is true in case botanical instruction and research is to go no farther than it has in this country, but it certainly is not true if it is to advance in the directions indicated by the signs of the times. Botanical laboratories, to properly maintain themselves as centers of current instruction and research, are compelled to provide for plants in masses, grouped with a purpose, and subject to control.

**Duplication of Publication**

THE PUBLICATION of articles upon the same research in different journals under the same or slightly different titles is a growing custom and an evil one. When a subject is a many sided one, with relations to several branches of science, there is justification for such duplication. The paper in the August number of the GAZETTE, by Kahlenberg and True, for example, is a most suggestive one, not only in chemistry, but also in medicine, bacteriology, and physiology. The editors felt that its botanical bearing was sufficient to justify its publication in the GAZETTE, though it is to appear afterward in full in another form and though a brief abstract of it had already been printed.

BUT WE WERE not aware that Mr. Maxwell's paper upon the growth of banana leaves, which was printed in our June number, was to be republished in the *Botanisches Centralblatt* about July 1, and we doubt very much whether the editor of that journal knew that it had already been published. Its importance did not justify republication. The paper was received by the GAZETTE through Dr. Goodale, whom the author requested to have it published in an American journal, with no intimation that he was sending another copy elsewhere. This is not the first time that the GAZETTE has been imposed upon in this way, which speaks better for the faith of the editors in botanists than for the good faith of the authors. Certainly common honesty requires that authors give editors an opportunity to refuse papers which they expect to duplicate thus.

IF WE ARE not mistaken, the publication of one paper stating fully the nature and results of a research ought to end publication until further research has been made and new results reached. Some eminent botanists have in late years followed a different course, and have worked over the same studies into three or four different papers in different journals. But if results are of real value one adequate publication is all they need to receive recognition and all that ought to be unloaded upon already burdened bibliographers. We go so far as to say that the "preliminary paper" with its half prepared diagnoses or ill-digested generalizations is an unmixed evil and ought to be suppressed by botanical opinion. We are glad to join *Natural Science* in its vigorous opposition to such makeshift methods.

# OPEN LETTERS.

## SOME RECENT PAPERS ON NOMENCLATURE.

*To the Editors of the Botanical Gazette:* — Although the Rochester rules have given American botanists some tangible guide in nomenclature, and the recommendations of the Harvard Memorandum have provided the believers in letting bad enough alone with some means of mitigating the chaotic conditions to which they have become accustomed, it does not seem advisable to cease all agitation upon the subject of nomenclature. It may be true that the time so spent would be better spent in other lines. But if the enormous waste of time which will eventually be entailed by the establishment of four or five distinct nomenclatures in as many botanical centers may be obviated by a slight expenditure of time now, surely such use of it will not be entirely vain.

My only purpose in this note is to call attention to some recent publications of that indefatigable and zealous reformer, Dr. Otto Kuntze, who is endeavoring to secure a competent international congress and through such a congress an international nomenclature. The botanical world, as Dr. Kuntze points out, now has at least four more or less distinct systems of nomenclature. Each is gaining currency in the regions under its peculiar influence, and each, he asserts, is obstinately maintained by its promoters, who in consequence are unwilling to take any active interest in securing an international code. The world has the basis of such a code in the Parisian laws, which are to a greater or less extent at the foundation of each of the present systems. But the interpretation and application of the Paris code is a matter of generaldis agreement, and its insufficiency in its present form is unquestioned.

In 1895 Dr. Kuntze published an article entitled "*Les Besoins de la Nomenclature botanique*" in which, after pointing out the danger to nomenclature arising from the existence of local codes or systems at Berlin, at Kew, and in America, he puts forward nine propositions for a congress to be held at Paris in 1900. Dr. Kuntze's idea of what such a congress should be deserves more attention than it has received. He does not believe in a gathering of men fresh from other studies which, without having given the matter more than passing attention, shall proceed to settle all disputed points at once. To anyone who has had experience with the numberless unexpected and complicated problems which a settlement of the subject must dispose of, if it is to be a settlement at all, it is apparent that a great deal of preliminary work must be done in the way of testing the application of various rules suggested so that those who are to decide upon them may do so intelligently, and in ascertaining just what are the defects to be remedied and what are the disurbing elements in our present nomenclature so that the settlement may reach all of them. Dr. Kuntze believes that this work can hardly be done in a thorough manner between now and 1900.

In a circular to the Société Botanique de France, published in March of the present year, Dr. Kuntze reiterates the importance of preparation for the projected congress. He says: "It (the congress) cannot honestly inscribe in its order of the day the revision of the Parisian code without a necessary international preparation lasting three years at least." When it is remembered that Dr. Kuntze's scheme of such a congress involves the putting out of a "Nomenclator Plantarum omnium," it will be seen that the importance of preparation is not exaggerated. Dr. Kuntze possesses qualifications both of experience and otherwise that point him out for the compiler of such a nomenclator. It would be a great pity to throw away the opportunity of securing his services in constructing one upon the lines of an international code. He will doubtless go on with his work of preparing it in any case.

In the *Oesterreichische Botanische Zeitschrift* for May of this year, in the *Journal de Botanique* of May 16, in the *Bulletin de l'Herbier Boissier* for July, and the *Journal of Botany* of the same month, are articles by Dr. Kuntze, in each of which he urges the necessity of a congress and points out the danger of the present state of things. It seems proper to call attention to these articles if only because of the sincerity and admirable zeal of their author.

The repeated protests of Dr. Kuntze against the establishment of four or five distinct nomenclatures in as many places are not to be treated lightly. One great object of nomenclature is to secure international currency for plant names. If we are not to have this, we may as well throw Latin nomenclature over and use the vernacular. The condition of things in which "sage brush" gets into European works as "Salvia" is not greatly bettered by one in which four or five nomenclators will have to be used and cross references made in order to be sure what a given binomial refers to. I have followed and shall continue to follow the Rochester rules because I see no other rules available for American botanists, and because I prefer rules to caprice as a guide, whether I entirely agree with the rules or not. But if American botanists are to be content with legislation for their own needs and are to remain indifferent to or even to hinder international action, will Dr. Kuntze's taunt that we are anarchists be wholly unwarranted?

In Mr. Erwin F. Smith's "Protest" against the check-list, he says: "What we need is the speedy convening of a representative international botanical congress, which shall amend the Paris code . . . . and shall settle once for all certain disputed interpretations of this code." Those of us who have been unwilling to abide in anarchy till such a congress is convened should not be less active in urging competent international action than our more conservative brothers.— ROSCOE POUND, *Lincoln, Nebraska.*

# CURRENT LITERATURE.

## MINOR NOTICES.

THE PLANTS of various regions in the state of New York have formed the basis for good catalogues. The latest of these is that issued by the Rochester Academy of Science.[1] It is the region studied from 1836 to 1867 by Dr. Chester Dewey, and occupied ever since by an aggressive race of botanists. It is more than a catalogue, as all the features of the area which have any relation to plant distribution are discussed, and interesting comparisons are made with the Cayuga and Buffalo floras. The native species of phanerogams enumerated are 948 in number, the introduced species 250; but including well marked varieties the phanerogamic flora as now constituted is made up of 1,314 distinct forms.—J. M. C.

THE LAST contribution from the National Herbarium [2] contains a variety of material. A. S. Hitchcock reports upon a collection of plants of 193 numbers made by C. H. Thompson in southwestern Kansas in 1893. F. V. Coville discusses *Crepis occidentalis* and its allies, seven species being described and figured, four of which are new. J. N. Rose reports upon a collection made by Mr. Frank Tweedy in 1893 in the Big Horn mountains of Wyoming. John M. Coulter and J. N. Rose describe and figure a new umbelliferous genus, Leibergia, from Idaho and Washington. Alfred Cogniaux describes and figures Roseanthus, a new cucurbitaceous genus from Mexico, dedicated to Mr. J. N. Rose. As this number completes the volume a very full index is given.—J. M. C.

A FORM of plant association which he calls *protrophy* has been described at length by Dr. Arthur Minks in a recent volume from the press of Friedländer.[3] In 1892 a new *Lebensgemeinschaft*, with the name syntrophy, was described by the same author, which, however, does not seem to have

[1] BECKWITH, FLORENCE, and MACAULEY, MARY E., assisted by Joseph B. Fuller.—Plants of Monroe county, New York, and adjacent territory. Large 8vo. pp. 150. Published by the Rochester Academy of Science, June 1896. $1.00.

[2] Contributions from the U. S. National Herbarium 3:537–612. 1896.

[3] MINKS, ARTHUR:—Die Protrophie, eine neue Lebensgemeinschaft, in ihren auffälligsten Erscheinungen. 8vo. pp. viii+247. Berlin: R. Friedländer & Sohn. 1896.

impressed morphologists as sufficiently important to be included in modern texts. The reader will find the present work a mine, from which we doubt whether he can take out any ore of value. Certain it is that what he does get he will have to dig for amid the intricacies of involved sentences and the obscurity of a technical terminology that will daunt him from the very beginning. As nearly as we can understand Dr. Minks' protrophy is an association between two species of lichens; one, the protroph, being unable at the beginning of its existence to nourish itself and needing therefore to fasten upon the body of the other independent species which precedes it, and to utilize this so far as necessary as a protection and support until it also can become independent. Protrophy is thus a special case of syntrophy, in which this dependent relation of the syntroph upon the other species is lifelong.

Readers who wish a fuller summary of the work will find a preliminary paper under the same title as the work in the *Oesterreichische botanische Zeitschrift* for February and March of this year.—C. R. B.

AN ACCOUNT of the history, types of variation and cultivation of the chrysanthemum has been published as an independent pamphlet by Henry L. de Vilmorin,[4] the well known horticulturist. The paper contains nothing new, but is an interesting description of the flower which has achieved a popularity never equaled.—C. R. B.

A WORK quite similar to Willkomm's for the Iberian peninsula[5] is the paper by Diels reprinted from Engler's *Botanischer Jahrbücher* on the "plant biology" of New Zealand.[6] Islands, of course, offer the best limited regions for a study of plant distribution, especially if it be a mountainous one like New Zealand. Two general regions are recognizable in this island, viz., forest and alpine. Under each of these Diels discusses the plant formations, with full attention to the ecology of the plants under consideration, treating such topics as water absorption and storage, assimilation, dorsiventrality, etc. The peculiar structural adaptations of several species are figured. A page of rosette plants from the alpine region is especially striking. Finally the vegetation of the remaining islands of the same faunistic zone (Lord Howe, Norfolk, Kermadec, the Chatham group and the Antarctic islands) is discussed. The paper closes with a section showing how the present flora of New Zealand is the outcome of the geological history of the island.—C. R. B.

[4] DE VILMORIN, HENRY L.:—Le chrysanthème; histoire, physiologie, et culture en France et a l'étranger. Imp. 8vo. pp. 28. figs. 10. Paris: the author. 1896.

[5] See BOTANICAL GAZETTE **22**: 62. 1896.

[6] DIELS, L.:—Vegetations-Biologie von Neu Seeland. Separat-Abdruck aus Engler's Bot. Jahrb. **22**: 202–300. Pl. *3*, figs. 7. 1896.

FAMILIAR TREES AND THEIR LEAVES[7] is the name of a popular book by F. Schuyler Mathews, in which are described over 200 trees of the eastern half of the United States, including not only native but commonly planted species. These descriptions are not at all technical, yet give the characteristics of the tree, its general habit and distribution, and point out the features by which it is separated from similar ones. The illustrations of leaves and generally also of fruits, which accompany the descriptions, will enable one to identify most of the common trees. The difficult task of rendering *texture* in the black and white sketch has not been accomplished by the author-artist, but the outlines are accurate. Less than one-third have been drawn from living specimens and others from herbarium material.

The *raison d'être* of the brief introduction by Professor Bailey, except for the value of his name on the title page, does not appear. The book is certainly to be warmly commended to those, to use Professor Bailey's words, who desire to know the tree as an entirety and to have some knowledge of its kinship and names, and who simply want an introduction to the trees which they meet.—C. R. B.

IN THE REPORT of the botanical department of the State Agricultural college of Michigan for 1895, Dr. W. J. Beal describes the botanic garden designed and planted by him upon the college grounds. A list of the species growing therein and a map of the garden on a scale of about 50 feet to the inch are given.—C. R. B.

MISS MINNIE REED has adapted Barnes' *Key to North American Mosses* to the 165 species found in Kansas, prefixing to it an account of the structure of the mosses (which is not without a number of errors) and adding nine well drawn but poorly printed plates, illustrating thirty-six species. Each generic key is also followed by an account of the geographical distribution within the state. The list, only recently received, is dated by the author June 1893 and is reprinted from the *Transactions of the Kansas Academy of Science for 1893–4*, pp. 152–199.—C. R. B.

RECENT BULLETINS from the Department of Agriculture are these: The Chief of the Division of Vegetable Physiology and Pathology, Mr. Galloway, writes, in the *Experiment Station Record*,[8] a suggestive though brief paper on

[7] MATHEWS, F. SCHUYLER: Familiar trees and their leaves described and illustrated, with over 200 drawings by the author and an introduction by Professor L. H. Bailey of Cornell University. 12mo pp. x + 320. New York: D. Appleton & Co. 1896. $1.75.

[8] Reprinted as a separate, and issued by the office of experiment stations as a bulletin.

the "lines of investigation that might be undertaken by experiment stations." These words need emphasis: "One of the serious drawbacks to advanced research work is this very matter of continued duplication of work already being done by other stations and the running along in the same old grooves year after year. We cannot hope to have this difficulty remedied, however, until there is some attempt at unification of purpose or specialization on the part of stations."

Dr. Walter H. Evans writes of "Copper sulfate and germination,"[9] that fungicide being commonly used to prevent smut by soaking the seed. Many contradictory observations are recorded regarding the effect upon germination of soaked seed. He finds that 0.5 and 1 per cent. solutions do no serious injury in 1–2 hours, which is adequate to kill smut spores, and that much stronger solutions can be used if seed are planted at once. Some of his statements need revision in the light of Kahlenberg and True's work on the "Toxic action of dissolved salts." [10]

Mr. Jared G. Smith has brought together[11] brief untechnical descriptions of the "Fodder and forage plants exclusive of the grasses," including 200 species, both native and exotic, illustrated by fifty-six figures. It forms a very convenient reference list.—C. R. B.

A SECOND EDITION of the catalogue of the plants of Los Angeles county, California,[12] is said on the cover to be a reprint from the *Proceedings of the Southern California Academy of Sciences* but gives no other indication of being anything but an independent pamphlet. Dr. A. Davidson, who prepared the first list in October 1892, is also the author of this. In this county, embracing 4,000 square miles, 100 miles of seacoast, the San Gabriel mountains reaching 6,000 feet, a part of the Mojave desert and the islands San Clemente and Catalina, 934 species and varieties of spermatophytes and 27 of pteridophytes are known. A second part, listing the remaining cryptogams is promised, some day.— C. R. B.

IN A PAMPHLET of eighteen pages with the curious title *Labrador*, published at Munich under date of July 1896, Dr. F. Arnold has given a list of the lichens collected in late years on the east coast of Labrador by Mr. J. W. Eckfeldt and Rev. Arthur Waghorne. One hundred and twenty-seven species are enumerated.— C. R. B.

[9] Bulletin no. 10, Division Veg. Phys. and Path. 1896.

[10] BOT. GAZ. **22**:81. 1896.

[11] Bulletin no. 2, Division of Agrostology. 1896.

[12] DAVIDSON, ANSTRUTHER: Catalogue of the plants of Los Angeles county. Part I — Phænogamia. Reprint from the *Proceedings of the Southern California Academy of Sciences*, 8vo. pp. iv + 36, *pl. 1*. 35 cents.

## NOTES FOR STUDENTS.

CARDOT has described[1] five new species of Fontinalis from North America: *F. patula* (§ TROPIDOPHYLLÆ), from Vancouver near Victoria, collected by Macoun; *F. Missourica* (§ HETEROPHYLLÆ), from Benton county, Missouri, collected by Demetrio; *F. Dalecarlica Macounii* (§ LEPIDOPHYLLÆ), from Athabasca Lake, collected by Macoun; *F. Waghornei*, from Trinity Bay, New Harbor, and Witter's Bay, Newfoundland, collected by Waghorne; *F. MacMillani* (§ MALACOPHYLLÆ), from northern Minnesota, collected by MacMillan.—C. R. B.

STUDENTS of forest distribution will be interested in Professor T. H. MacBride's discussion of forest distribution in Iowa.[2] He shows that all the students of the forest problems in his state have been right, but only partially so. His own conclusions, which combine views which seemed to be in conflict, are as follows: (1) the immediate agent in the limitation and distribution of Iowa forests was fire; (2) the sweep of fire was determined by a modicum of moisture and by the presence of fuel upon the ground; (3) the drift being especially adapted to gramineous vegetation furnished fuel in such amount as to prevent the development of tree seedlings, while the loess, using the term in a broad sense, less suited to gramineous species, furnished less fuel, hence gave to tree seedlings on loess regions opportunity to rise; (4) special localities, as swamps, alluvial flood-plains, etc., present special cases and require special explanations.

THE FOLLOWING items are of taxonomic interest: Dr. John K. Small[3] has prepared a synopsis of the North American species of Ilysanthes, recognizing six species, one of which is new. Mr. Eugene P. Bicknell[4] recognizes two species in the well known Scrophularia of the eastern states, the segregated one being called *S. leporella*. Mr. H. N. Ridley[5] has described a new genus of Commelinaceæ from the Malay Peninsula, under the name Spatholirion. M. A. Franchet has described eight new species of Saxifraga[6] and ten new species of Sedum[7] from China, and proposes a new section[8] (Xyphosandra) of Parnassia, in which the very acuminate connective is produced far beyond the loculi, giving to the anther the appearance of a dagger. Miss Alice Eastwood[9] has described ten new species from southeastern Utah. Mr. J. G. Baker[10] has published an illustrated synopsis of the genus Brodiæa, as

[1] Revue Bryologique — : 67. 1896.
[2] Reprint from Proc. Iowa Acad. Sci. **3**: 96–101. 1895.
[3] Bull. Torr. Bot. Club **23**: 296. 1896.
[4] *Ibid.* **23**: 314. 1896.
[5] Jour. Bot. **34**: 329. 1896.
[6] Jour. de Botanique **10**: 261. 1896.
[7] *Ibid.* **10**: 284. 1896.
[8] *Ibid.* **10**: 267. 1896.
[9] Proc. Calif. Acad. Sci. II. **6**: 270. 1896.
[10] Gard. Chron. **20**: 213 and 238. 1896.

defined in Bentham and Hooker's *Genera Plantarum*. American plants recently figured, and with full descriptive text, are *Clematis Addisonii*,[11] *Lonicera hirsuta*,[12] *L. hirsuta* × *Sullivantii*,[12] *Aquilegia Jonesii*,[13] *Rhododendron Vaseyi*.[14]

DR. B. L. ROBINSON, in a recent discussion[15] of the fruit of Tropidocarpum, calls attention to its great variability, and its consequent uselessness for taxonomic purposes, a fact which militates strongly against certain proposed species. Aside from the taxonomic features of the discussion the fact of greatest general interest is the occurrence of the internal capsule which frequently appears in what is known as the *capparideum* type of capsule. This internal capsule is variable in size, "from the merest obscure rudiment to a capsule half the length of the outer one." The outer capsule is always 3 or 4-valved, and the inner one always 2-valved, and when well developed contains two seeds, "which mature in just the same way as those in the surrounding capsule." The embryo also is apparently perfect, and the capsule regularly dehisces. As Dr. Robinson suggests, the fertilization of these innermost ovules is a very interesting problem. If they are reached by pollen tubes, these tubes must penetrate two styles. The inner capsules are usually axial in position, but sometimes arise near the base of the outer capsule. The author suggests that these inner capsules "represent a second whorl of carpellary leaves." Similar internal capsules have been noted by Peyritsch in *Draba alpina*.— J. M. C.

HUGO DE VRIES[16] has convinced himself by a long series of cultures that a large part of the teratological anomalies in plants are in their nature hereditary. His already known observations on the hereditary nature of fasciation and torsion are now followed by a discussion of adhesions and cohesions, or symphyses.

Having transplanted from a wheat field to his garden some individuals of *Hypochœris glabra* showing adhesions, he found the second generation with about 9 per cent. of similar adhesions, and the seventh with 64 per cent. A similar selection of *Helianthus annuus* with united cotyledons produced in the third generation plants showing 76, 81, and 89 per cent. of syncotylous embryos.

To these De Vries adds a host of similar facts from cultures and many observations of the repetition of teratological variations upon shrubs and trees. All, he thinks, point to the hereditary nature of the phenomena.

This heredity, he adds, sometimes appears "lateral," *i. e.*, it shows itself

[11] Gard. and For. 9: 324. 1896.
[12] Gard. and For. 9: 344. 1896.
[13] Gard. and For. 9: 365. 1896.
[14] Gard. Chron. 20: 71. 1896.
[15] Erythea 4: 109. 1896.
[16] Botanisch Jaarboek 7: 129–197. 1895.

in lateral branches of the genealogical tree, as in clover. It is hard, too, to get rid of it. The adhesions may skip an entire generation in annuals and reappear in the next, just as in perennials they may skip a year. The manifestation of the property depends to a high degree upon external conditions.

All the facts show that the heredity of adhesions is ordinarily latent, manifesting itself only occasionally.

The fact of heredity obliges us to suppose for the symphyses material carriers (pangens) in the protoplasts. But neither the number nor the influence of these appear to be ordinarily great enough to assure more than an occasional appearance of the anomalies. A concurrence of very favorable conditions seems always to be necessary to their manifestation, at least unless they have been fixed and accumulated by selection.— C. R. B.

MR. GEORGE MASSEE has made an exhaustive study of the genus Coprinus,[17] recognizing 165 species, 34 of which are credited to the United States and 20 of them peculiar to it. The evolution of form in the Agaricineæ is represented as proceeding from such primitive types as Marasmius, etc., in which "the pileus is sessile or stemless and fixed by its back to the substratum, the gills being uppermost and consequently entirely unprotected from the earliest stage of development." From this primitive type of structure there are three leading lines of departure: (1) turning the hymenium downwards; (2) the acquisition of a central stem; (3) the freedom of the gills from the stem. The Agaricineæ do not form a single group showing the above sequence, but are broken up into four series, each running through the lines of development indicated. These four series are characterized by the color of the spores (black, brown, pink or salmon, white), the Melanosporæ being the oldest and the Leucosporæ being the youngest. The chief biological feature of Coprinus is the deliquescence of the gills at maturity into a liquid which drips to the ground, carrying the mature spores along with it. This primitive and relatively imperfect mode of spore-dissemination, as compared with the minute, dry, wind borne spores of the other Agaricineæ, indicates that in Coprinus we have the remnant of a primitive group of fungi from which have descended the entire modern group of Agaricineæ with wind borne spores; and which can be traced back to the still more primitive subterranean fungi which are the common ancestors of the entire group of the Basidiomycetes. Evidences of the antiquity of Coprinus are seen in the world wide distribution of the genus, and the limited area occupied by species. Of the modern agarics the Melanosporæ are most closely allied to Coprinus, being directly derived from it, and, in fact, the gills of many species of Melanosporæ show a tendency to deliquesce. Attention is also called to the fact that while liquefaction of the elements of the hymenium was abandoned

[17] Ann. Bot. 10: 123–184. 1896.

at a very early stage in the evolution of the agarics, it persisted throughout the entire sequence of development in the parallel group of Gastromycetes. Among the Phalloideæ the semi-liquid product has a decided smell and sweet taste, attractive to insects; "thus the feature which proved a failure in the Agaricineæ has been an important factor in raising the Phalloideæ to their present position as head of the fungal subkingdom."—J. M. C.

PROFESSOR T. KIRK has long been a student of the New Zealand flora. Aside from the great interest which attaches to the flora itself, the influence of the presence of man is exceptionally open to study. This phase of the subject was presented recently by Mr. Kirk in a presidential address before the Wellington Philosophical Society, entitled "The displacement of species in New Zealand."[18] Many interesting ecological features of this displacement are presented, some of which deserve mention here. The destruction of the great "kauri" forests has resulted in the absolute desolation of the areas. It seems that the bushmen fired the dead branches after the logs were removed, not only destroying all young growth, but also all fallen seeds, since the soil is charged with resin and becomes intensely heated. Next to the direct operations of man the chief agents in destructive work are sheep and rabbits, whose close feeding has all but extirpated the more delicate plants over large areas. The pig and rat have proved destructive also, and a curious orchid (Gastrodia) is cited whose nutritious tubers are particularly attractive to the black rat, and which has become very rare wherever the black rat is plentiful. A small native beetle has greatly reduced many species of Compositæ by depositing eggs among the disk flowers, the larvæ from which destroy the ovary before it reaches maturity. The great increase of this insect in recent years is thought to be due to the frequent burning of the surface vegetation, thus destroying the lizards and predatory insects which kept the beetle in check. In many cases introduced plants have taken possession of sea-beaches, completely displacing the original vegetation. A most notable case of displacement is that of the New Zealand flax (*Phormium tenax*), *Cyperus ustulatus*, and the common *Pteris esculenta*, all robust plants, by European grasses and clovers. In other cases certain native grasses have succeeded in maintaining themselves associated with the foreigners, "to the great benefit of the stock-grower." Special attention is called to the invasion of three species of Epacris, all natives of New South Wales, which have been observed within the last thirty or forty years to enter New Zealand and rapidly take possession of large areas. So rapidly were they extending their area in the direction of the prevailing winds that Mr. Kirk is convinced that they "would be able practically to replace the indigenous vegetation over the entire area if not interfered with by man."

[18] Jour. Bot. 34: 338. 1896.

In this case there is clear evidence of the transportation of seeds by atmospheric currents over a distance of from 1200 to 1400 miles, and of their establishment in a new country. The number of naturalized species has now reached more than five hundred, and if the rate of increase of the last few years be continued for the next fifty years the naturalized and indigenous species will be about equal, a condition of things very unlikely to be reached, as favorable conditions for encroaching species must be reduced rapidly with their increase. The distribution of naturalized plants follows the same lines as that of the indigenous flora, the number rapidly decreasing southward. The Auckland district is much more favorable for the naturalization of plants from warm temperate climates than any other portion of the colony. An interesting illustration of this is given. A large quantity of ballast from Buenos Ayres was discharged at Wellington, and more than one hundred species of plants made their appearance before the close of the second summer, the great majority of which had been naturalized already in the Auckland district. Not more than two, most likely but one, of these will become naturalized on the stiff Wellington clay, while it is certain that fully one-third of them would have become established on the light scoria soil of the Auckland isthmus. Mr. Kirk draws a good distinction between displacement and replacement, and does not anticipate the absolute extermination of any large number of indigenous plants.—J. M. C.

TWO RECENT paleobotanical reports of interest are those upon the flora of the Potomac formation, by Professor L. F. Ward, and upon the Tertiary floras of the Yellowstone National Park, by Mr. F. H. Knowlton. Professor Ward discusses[19] the Potomac formation in general, and then takes up in detail the several floras into which it has been divided. These lower cretaceous floras present some striking features, aside from the ordinary lists of paleobotanical material. Certain specimens are thought to be the remains of a species of Casuarina, which has been called *C. Covillei*. The plate representing a single specimen of this plant also contains the figures of two living species of Casuarina, and the resemblance certainly is striking; but with Ephedra and other jointed and fluted fossil genera in the background, to say nothing of Equisetum and its associates, the certainty of this reference is not convincing. As the author remarks, "it would certainly be an interesting fact if it were proved that this anomalous type of vegetation lived in America during lower cretaceous time." Even if the genus did occur here, however, it is not so clear that its association with Ephedra is at all significant of an intermediate position between gymnosperms and angiosperms, or that angiosperms have been derived from gymnosperms. The most interesting of the ferns are the species of Thyrsopteris, a living genus of but a single

[19] Fifteenth annual report of the U. S. Geol. Survey, 307. 1895.

species and confined to the island of Juan Fernandez. The conifers are abundantly represented, and among them the new genus Nageiopsis, so closely resembling a cycad. Naturally, Sequoia occurs in the formation, as it seems to in cretaceous and tertiary deposits over nearly the whole globe. The dicotyledons are abundant enough, but the monocotyledons are very rare, but seven forms being referred to them doubtfully. Attention is also called to the important part played by the genus Populus in the geological history of plants. It is one of the most widespread genera of fossil plants, and seems to have developed along several distinct lines, and, "historically considered, is the most interesting of all dicotyledonous genera."

Mr. Knowlton's paper[30] is a brief preliminary statement concerning a full report which will appear later. It seems that the most remarkable fossil forest known occurs in the Yellowstone National Park, and it has yielded abundant material in excellent condition for study. The author contrasts the flora of the park today with this tertiary flora. "The dominant elements of the living flora are the abundant coniferous forests, but these involve a very meager display of species; the tertiary forests, however, were characterized by the dicotyledonous trees, such as walnuts, hickories, oaks, beeches, chestnuts, elms, magnolias, sycamores, sumacs, lindens, azalias, persimmons, and ashes. There seems to be little relation between the two floras, and they are certainly not related by descent. The tertiary flora has its affinities at the south, while the present flora is evidently of northern origin."—J. M. C.

[30] Amer. Jour. Sci. IV. **2**: 51. 1896.

# NEWS.

DR. N. BUSCH, of Dorpat, is about to make a botanical investigation of certain unexplored regions in northern Caucasus.

DR. F. KOHL, assistant professor of botany in the University of Marburg, has been advanced to the professorship.

DR. K. MÜLLER, privat-docent in the technical high school in Berlin, has been appointed assistant professor of botany.

DR. M. WESTERMAIER, professor of botany in Freising, has been appointed to the same chair in the University of Freiburg, Switzerland.

MR. J. H. MAIDEN has been appointed Government Botanist and Director of the Botanic Gardens at Sydney, to succeed Mr. Charles Moore.

IN THE RECENTLY organized department of biology in the graduate school of Georgetown University Mr. M. B. Waite has been appointed professor of botany.

MR. W. ALPHONSO MURRILL has recently discovered the rare *Asplenium ebenoides* at Blacksburg, Va. His field notes are published in the *Linnæan Fern Bulletin* for October.

DR. A. ZIMMERMANN, privat-docent in the University of Berlin, has gone to the Botanic Garden of Buitenzorg, Java, where he began October first his duties as botanist to the new department of coffee culture.

THE RICHEST COLLECTION of palms in the world is said[1] to be in the Botanic Garden at Buitenzorg, Java. It contains three hundred species that are determined, one hundred probably new and still undescribed, and one hundred varieties of known species.

THE BOTANICAL SOCIETY OF AMERICA, at its recent meeting in Buffalo, took the following action in reference to the death of Mr. M. S. Bebb:

"The Botanical Society of America desires to place upon record an expression of esteem for its deceased member, Michael Schuck Bebb, who died December 5, 1895, at San Bernardino, California. His published studies upon the difficult genus Salix have brought him to high rank as a professional botanist, and American botany owes to him a debt of gratitude as one of its most distinguished representatives."

[1] Garden and Forest 9:360. 1896.

A NEW QUARTERLY devoted to the art of brewing made its appearance in July. It is the *Journal of the Milwaukee Brewing Academy*, edited by Alfred Lasché. It is likely to contain matter of interest to bacteriologists and students of yeasts and other simple fungi. Considerable improvement in typographic style ought to be made, and in particular the authorship of the articles ought to be indicated. The first number of the *Journal* consists of 48 pages. Its price is $5.00 per year.

THE RUST (*Puccinia Asparagi*) which affects the asparagus plant has become so abundant in parts of New Jersey as to cause much alarm among growers of this vegetable. The State Experiment Station has just issued a circular advising the burning of affected plants. It will be interesting to learn how widespread and abundant the rust is at the present time in the United States. Botanists who have observed it will do a favor by reporting to Dr. B. D. Halsted, New Brunswick, N. J., or to the BOTANICAL GAZETTE.

TWELVE STATES have laws of some sort for the prevention of the spread of plant diseases. They are as follows: California, a general law; Connecticut, peach yellows; Delaware, peach yellows; Kentucky, black knot of plum and cherry; Maryland, peach yellows; Michigan, peach yellows and black knot of plum and cherry; New Jersey, for a cranberry disease, and of general application under special conditions; New York, peach yellows and black knot; Oregon, a general law; Pennsylvania, peach yellows; Virginia, peach yellows; Washington, a general law. These various laws are given in full in a compilation prepared by Erwin F. Smith and printed as Bulletin 11 of the Division of Vegetable Physiology and Pathology, Department of Agriculture.

RECENT ANNOUNCEMENTS of new books of botanical interest to be published by The Macmillan Co. in the course of the winter include *An elementary botany for high schools*, by L. H. Bailey, professor of horticulture in Cornell University, with numerous illustrat.ons by Holdsworth; *The survival of the unlike*, by the same author; *Physiology of plants*, by J. C. Arthur, of Purdue University; *Grasses*, by W. H. Brewer, of Yale University; *Bush fruits*, by F. W. Card, of the University of Nebraska; *Plant diseases*, by B. T. Galloway, E. F. Smith and A. F. Woods, of the U. S. Department of Agriculture; *Seeds and seed growing*, by G. H. Hicks, of U. S. Department of Agriculture; *Leguminous plants*, by E. H. Hilgard, University of California. All but the first two are to be issued in the Rural Science Series.

MR. J. G. JACK will conduct a series of fifteen lectures and field meetings at the Arnold Arboretum during the autumn for the purpose of supplying popular instruction about the trees and shrubs which grow in New England. The class will assemble each day in the lecture room of the Bussey Institution, where a review will be given of certain groups of trees and shrubs. It will then adjourn to the Arboretum for an informal outdoor study of the plants. The instruction given in these meetings is not to be technical, but the intention is to indicate by comparison the easiest means of distinguishing the common native trees and shrubs as they appear in eastern Massachusetts, and of recognizing the foreign species which have been introduced into our gardens. An hour and a half to two hours will be devoted to each meeting. During the season the class will meet once or twice outside of the Arboretum at some favorable place for the study of trees.

THE FOLLOWING report was presented at Buffalo to the Botanical Club by the committee on nomenclature, and adopted:

The committee on nomenclature, which was requested at the Springfield meeting to prepare a report, would respectfully submit the following preamble and resolutions:

WHEREAS, A large number of requests for a list of all North American Pteridophyta and Spermatophyta has been received, and publication of such a list, when prepared, has been informally offered by the Assistant Secretary of the Smithsonian Institution,

*Resolved*, That the committee be and hereby is authorized to prepare for publication a list of Pteridophyta and Spermatophyta occurring in the United States and the British Possessions of North America.

*Resolved*, That the committee be and hereby is authorized to prepare and publish a supplement to the "List of Pteridophyta and Spermatophyta of northeastern North America," such supplement to contain additions and published corrections to the list. Such publication has been promised by the Editor of the Torrey Botanical Club.

*Resolved*, That the committee be and hereby is authorized to prepare a fuller statement of the rules adopted at the Rochester and Madison meetings, with examples illustrating their operation, and submit it to the club at a subsequent meeting, for publication in the proposed List of North American Pteridophyta and Spermatophyta.

*BOTANICAL GAZETTE*

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Vol. XXII NOVEMBER 1896 No. 5

THE

# BOTANICAL GAZETTE



ISSUED NOVEMBER 23

CHICAGO, ILLINOIS

Published by The University of Chicago

The University of Chicago Press

[Entered at the Post Office at Chicago, Ill., as second-class postal matter.]

VOLUME XXII NUMBER 5

# BOTANICAL GAZETTE

*NOVEMBER 1896*

## DEVELOPMENT OF THE PROCARP AND CYSTOCARP IN THE GENUS PTILOTA.

BRADLEY MOORE DAVIS.

(WITH PLATES XVIII AND XIX)

THE following account of the structure and development of the procarps and cystocarps in the genus Ptilota is the result of the writer's studies begun in 1892 upon two Pacific coast forms. Later the points then worked out were verified in an Atlantic coast species, *P. serrata*, and this form, for reasons of convenience, was chosen as the type for the detailed description of the anatomy and development of the cystocarpic fruit. The account of *P. plumosa* and *P. plumosa filicina* is of the nature of a comparison with *P. serrata*. Most of the work was carried on in the cryptogamic laboratory of Harvard University under the direction of Dr. Farlow.

### PTILOTA SERRATA Kütz.

This species is very abundant on the Atlantic coast north of Cape Cod, and fruiting specimens, either cystocarpic or tetrasporic, may be obtained readily in the proper season. The writer's material has all come from Nahant, Mass., and the cystocarpic plants have been found there as early as March and as late as May. Although cystocarpic fronds are abundant and covered with fruit in all stages of development, the writer has never succeeded in finding any antheridial plants, although he has carefully searched all sorts of specimens, nor have any such ever been found on this coast to his knowledge.

For convenience the subject-matter of this description will be grouped under the following heads: (*a*) structure and mode of growth of the frond; (*b*) morphology and development of the procarpic branches; (*c*) development of the group of procarps; (*d*) minute structure of the procarps; (*e*) development of the cystocarp. The subjects included in the first two divisions will be treated in the briefest possible manner. At the end of the descriptions will be found a section which treats of the relation of the type of cystocarp found in Ptilota to that of allied genera, and also some remarks upon the physiological character of this method of carposporic reproduction.

## STRUCTURE AND MODE OF GROWTH OF THE FROND.

The writer can add nothing to the thorough description of the structure of the frond of this genus first presented by Nägeli (47), and later more exhaustively considered by Cramer (63). However, a short account seems necessary to make clear the morphology of the parts of the fruit.

The branches of the frond, styled pinnæ, consist of a central axial siphon of large oblong cells or segments covered by a thick cortex of small cells. A large apical cell (*fig. 1, x*) terminates the axial siphon of the pinna, and by its repeated transverse division new segments are added to the axial siphon.

On the pinnæ, attached to alternate segments of the axial siphon, one on each side, are borne pairs of lanceolate structures called pinnules. In this species the pinnules are usually unequal in size, one being quite small, and their distribution is such that when a certain segment bears its large pinnule on the right hand side of the pinna, the next large pinnule above or below is attached to the left side of a segment. As the small pinnules are borne opposite the large pinnules, upon the same segments, their arrangement is of course exactly the same as the latter.

The segments of the axial siphon which bear the pinnules are called nodes and the segments between them internodes.

The larger pinnule of the pair begins to develop from the node almost immediately after the latter has been cut off from the apical cell. The nodal segment first grows out to one side, the side that is opposite to that of the young pinnule on the node just below it, and a cell is cut off. This cell is the earliest stage of a pinnule. It assumes the rôle of an apical cell, and by successive transverse divisions gives rise to a row of cells which becomes the axial siphon of the pinnule. When the larger pinnule is well under way in its development, the node gives rise to another cell on the opposite side of the pinna, and from this cell is developed the second pinnule, which rarely becomes as large as the first and sometimes remains quite abortive. Stages illustrating the above description may be seen in *fig. 1.*

Cells are cut off laterally from both sides of the axial siphon of the pinnule, and these by successive transverse divisions develop a system of lateral branches. The young pinnule then has the structure of a membranous tissue the thickness of a single cell, but it really consists of an aggregation of filaments, all in the same plane, each of which grows in precisely the same manner as the axial siphons of pinnæ and pinnules, viz., from apical cells.

The three systems of filaments, (1) the axial siphons of the pinnæ, (2) the axial siphons of the pinnules, and (3) the lateral branches from the axial siphon of the pinnules, are the framework which determines the shape of the frond. All other cells are part of the cortex proper. There is no cortex on the young pinnules and at the tips of the pinnæ, but on older portions of the frond its gradual development may be easily traced. Short branches grow up over the axial siphons in older parts, covering them with several layers of cells. This collection of cells constitutes the cortex.

The entire frond then consists of an elaborate system of filaments, and the growth of all parts is strictly from the terminal cells (apical cells) of the branches. A segment cut off from the apical cell of a filament never divides except to give rise by lateral outgrowths to a new branch of the filament.

## MORPHOLOGY AND DEVELOPMENT OF THE PROCARPIC BRANCHES.

The procarps of the genus Ptilota are found in certain specialized portions of the frond called procarpic branches. In *P. serrata* the procarpic branches for the most part take the place of the smaller pinnules usually found on sterile plants. They are therefore attached to the nodes of the pinnæ and situated opposite well developed pinnules. Procarpic branches are sometimes to be found on the edge of the pinnules, but they are not common in this species. The structure of the procarpic branches clearly shows their homology with the smaller pinnules, and their development is so similar that it is impossible to distinguish the younger stages from one another. Each adult procarpic branch contains an axial siphon which consists of from nine to twelve (typically ten) segments. Pairs of short lateral filaments arise from the segments in the same manner as in ordinary pinnules, and as the branch grows older a rather insignificant system of corticating filaments is developed. Several early stages of procarpic branches are shown in *fig. 1*, the cells being shaded. Those attached to the II, III, and IV nodes consist of but a single cell. Later stages are shown attached to nodes V, VI, and VII. A typical adult procarpic branch is illustrated by *fig. 3*, the specimen from which the figure was drawn being situated on the twelfth node of a pinna.

When procarpic branches are found on the pinnules they are seen to take the place of the teeth that usually occur along the edge of these structures, and to be continuations of the lateral branches from the axial siphon of the pinnules.

The extremity of the adult procarpic branch has the same structure whether the latter is situated on a pinna or pinnule. There is always a terminal cell, the former apical cell (*fig. 3*, cell 11), and it is from this that the group of procarps is derived. The apical cell and all structures derived from it are numbered eleven in the figures because it is usually the eleventh cell of the axial siphon of the procarpic branch.

### DEVELOPMENT OF THE GROUP OF PROCARPS.

The group of procarps is always situated at the tip of a procarpic branch. The number is somewhat variable, but typically five. In order that the reader may follow more readily the account of the development of this structure it will be best to describe first the appearance of mature specimens. It is suggested that he glance at *fig. 10* where an adult group of procarps is shown.

There appear in this figure five trichogynes (numbered 11, $10'$, $10'^{a}$, $10''$ and $10'''$), each of which terminates a short branch consisting of three or four cells. Three of these branches are figured; the other two could not appear in this view. Each branch with its trichogyne is a procarp. Three of the procarps, those numbered 11, $10''$, and $10'''$, are solitary. The other two procarps are peculiar in that they form a pair united together at the basal cells. The three lower cells of the solitary procarps and one of the basal cells of the pair are all united to the terminal segment of the procarpic branch (*fig. 10*, no. 10). The procarps may then be said to form a group around this terminal segment.

The union between the basal cells of the procarps and the terminal segment of the procarpic branch is effected by the strands of protoplasm so generally found between the cells of Florideæ.

Bearing in mind the structure of the tip of an adult procarpic branch we may now consider the development of the group of procarps. A transverse division of the terminal cell of the procarpic branch (*fig. 2*, cell 10) initiates the development of the group of procarps. The division is somewhat oblique, so that the new terminal cell (*fig. 3*, cell 11) is pushed over towards the axis of the pinna, and the curvature of the procarpic branch is thus made more pronounced. This division is really simply a continuation of the apical growth of the procarpic branch, but we are justified in laying emphasis upon it for the new terminal cell (*fig. 3*, cell 11) now developed immediately into a procarp. Therefore the segment 10 (*fig. 2*) may be said to terminate the procarpic branch, although really its axis continues through this procarp and only ends with its trichogyne. This procarp is the inner one of the group of procarps, the one nearest the pinna, and in all figures it has been numbered 11.

The development of this individual procarp may be taken as the type for all. The cell that gives rise to it (*fig. 3*, cell 11) divides transversely. The upper cell then elongates and also divides, and the terminal division becomes specialized into the trichogyne. The different stages in the development of this procarp are illustrated as follows. A two-celled stage is shown in *fig. 6*, no. 11, and the same condition appears again in *figs. 7* and *8*, except that in both cases the upper cell is much elongated preparatory to the development of the trichogyne. A half grown trichogyne appears in *fig. 9* (numbered 11) and the mature procarp is shown in *fig. 10*. It must be apparent that the position of this procarp, whether to the right or left of the center of the group, depends upon the side from which the procarpic branch is viewed. Its situation is always on the inside of the group, that is the side nearest the axis of the pinna. It is evident that the procarp follows the same type of growth as other parts of the frond. That is, the growth is from the terminal cell, and the structure is a short branch of three cells, one of which becomes specialized into the trichogyne. The number of cells in the different procarps varies, but the method of development is the same in all.

We may now consider the peculiar pair of procarps on the outside of the group. Beginning with the stage shown in *fig. 3*, we see that a cell (no. 10′) has been cut off from the terminal segment of the procarpic branch. This cell quickly develops into a short branch, usually of four cells, which curves inwards somewhat as is shown in the later stage (*fig. 4*). The cells of this branch are short and thick and lie closely pressed against one another. The terminal cell eventually becomes a trichogyne. However, before this takes place the basal cell of the branch, that which is attached directly to the terminal segment of the procarpic branch (*fig. 4, c*) gives rise to a cell laterally. This condition is shown in *fig. 5*, cell 10′[a]. From this last is developed another branch of three or four cells. The two-celled stage is shown in *fig. 7*, and the three-celled condition in *fig. 8*, in both cases numbered 10′[a]. By the elongation of the terminal cell of this second branch the structure becomes a procarp. We have now two procarps of three or four cells each, lying side by side, united to the cell that was first cut off from the tenth segment. By examining the later stages of this pair of procarps (*figs. 7, 8*, and *9*) it will be seen that the trichogyne of the first procarp (procarp 10′) develops before the second. In fact it is usually the first of all the trichogynes in the group of procarps to mature.

It is well to call attention now to the fact, which will receive more detailed treatment later in the paper, that the cystocarp of *P. serrata*, in all cases that the writer has examined (some 112 in number), has always developed from the cell at the base of the pair of procarps. This carpogenous cell (*c* in *figs. 3–9*) is the first to be derived from the terminal segment of the procarpic branch, and therefore next to the basal cell of procarp no. 11 is the oldest cell of the group.

There remain to be considered the two procarps that lie between the inner procarp and the pair on the outside. As is shown in *fig. 10*, these two procarps are attached laterally to the terminal segment of the procarpic branch in such a manner that when viewed from the side one appears in front and the other behind this cell. Their development is precisely like that of the procarp on the inside of the group. A cell is cut off first on one side of the terminal segment and then on the other side (*figs. 5* and *6*, cell 10″). Each of these two cells then develops into a procarp of three cells in exactly the same manner as the other procarps develop. This is well shown in the figures of later stages (*figs. 7, 8*, and *9*). These two procarps are the last of the group to mature.

Contemporaneous with the development of the group of procarps is the luxuriant growth of the whorl of short filaments from the segment of the procarpic branch just below the terminal segment. Some of these filaments become the large bracts that surround the mature cystocarp. They develop, as do all the structures of the frond, by growth from the terminal cells of filaments, and *figs. 5, 6*, and *10* illustrate the appearance of the chief stages.

The typical number of procarps in the group is five, but instances of over or under production are not infrequent. In cases where the number is less than usual the second procarp of the pair is most likely to be absent, and occasionally one or both of the lateral procarps may be suppressed. Examples of over production are more frequent, and perhaps the most common instance is that in which a pair of procarps is found in place of the inner procarp of the group. Sometimes an additional procarp may be attached to the basal cell of the pair. None of these irregularities transgress the law of development that we have advanced, for in all cases the procarps are short branches, the terminal cells of which have become specialized into trichogynes.

MINUTE STRUCTURE OF THE PROCARPS.

Now that we understand something of the development and arrangement of the procarps in the group, we are in a position to consider the minute structure of the cells. The material had been well fixed in chromic acid, and proved excellent for the examination.

In the first place, we may refer to the peculiar structure of the cell-wall often found around the young procarps, which is different from anything that the writer has ever seen described. Unlike the cell-walls on other portions of the frond, which are perfectly homogeneous in structure, the wall is here distinctly differentiated into an inner and an outer zone. *Fig. 4* may be taken as an excellent illustration of this peculiarity. This specimen had been stained with Böhmer's hæmatoxylin, and the inner zone was much more strongly tinted than the outer. Even in fresh material and unstained specimens, the inner zone appears of a denser consistence. A most interesting peculiarity of this cell-wall is a series of radiating strands which arise from the edge of the inner zone and pass through the outer zone to the outer edge of the cell-wall (*figs. 4, 5, 6,* etc.). These radiating strands stain about as deeply as the inner zone, and appear to be of the same substance. This complex cell-wall is very common around the developing procarps, and is sometimes found, but not in such a characteristic form, at the apical cell of the pinnæ. The peculiar swollen appearance of the outer zone suggests the phenomena of gelatination, and to test this point the writer treated specimens with a hot solution of potassic hydrate. The consistence of the outer zone was quite unaffected by this treatment, instead of swelling or dissolving as substances of a gelatinous nature would have done. The writer was quite unable to obtain a cellulose test (using iodine and sulphuric acid), either with this curious cell-wall or with the ordinary cell-walls of this plant. But there are reasons from its general appearance and reaction towards stains for believing it to be at least closely related to cellulose, if it be not that substance.

Adopting the terminology of Bornet and Thuret we may divide the procarps into three portions: (1) the trichogyne, (2) the carpogenous cell, and (3) the portion of the procarp lying between these two, consisting of one or two cells, which we may call the trichophoric apparatus (*l'appareil trichophorique*).

We know certainly of but one carpogenous cell in the group of procarps, and this is the basal cell of the first procarp of the pair on the outside of the group. However, it is probable that the basal cell of each procarp is morphologically a carpogenous cell. At all events the following remarks on the structure of the cell that does give rise to the cystocarp are equally true of the basal cells of all procarps. The carpogenous cell at the time when the trichogyne is mature is the largest one in the procarp. It is slightly tinted with the red color of the Florideæ, but a well defined chromatophore cannot be made out distinctly. The central portion of the cell is a cavity containing cell sap, and the protoplasm with the irregular chromatophore forms a layer next the cell-wall. There is a distinct nucleus imbedded in the protoplasm, and as a rule a well defined nucleolus is apparent in specimens stained with hæmatoxylin (*figs. 11* and *12*, *c*). The carpogenous cell is connected below with the terminal segment of the procarpic branch, and above with the cell of the trichophoric apparatus, by a strand of protoplasm at each end.

The trichophoric apparatus consists of one or two cells according as the total number of cells in the procarp is three or four. There is a distinct nucleus in each cell, and the general appearance of the cell contents is very similar to that of the carpogenous cell, *i. e.*, the protoplasm containing more or less of the red pigment lies next the cell-wall and encloses a vacuole. In *figs. 11*, *12* and *13* the cell of the trichophoric apparatus is lettered *ta*. The position of the nuclei in the cells of the procarps has been shown in many of the figures. In some of the specimens (*figs. 5–10*) the stain was eosin, in others (*figs. 11–16*) the stain was hæmatoxylin.

The structure and development of the trichogyne now remain to be considered. This organ is very small and delicate, in this species of Ptilota measuring from 40–70$\mu$ long and 4$\mu$ wide in the thinner upper portions. The base of the trichogyne ("carpogonium," as Schmitz applied the term) is about as wide as the cell of the trichophoric apparatus directly under it, but it grows narrow very rapidly and runs into the very delicate and attenuated upper portion. The base of the trichogyne is not at all swollen, nor is there any constriction between it and the upper portion. The cell contents are hyaline in living specimens, and quite homogeneous. Stains do not bring out any differentiation of the protoplasm aside from a granular structure in the lower portion, and the writer has never seen anything that could be interpreted as a definite nucleus.

Such peculiar cytological structure of the trichogyne cell merits a farther examination, and the gradual development and withering of the organ will now be described. Starting with the earliest stage, we find a cell at the end of a procarp closely attached to the cell of the trichophoric apparatus (*fig. 11, t*). Such a cell contains no distinct nucleus, but the cell contents often show a certain degree of differentiation into vacuoles and aggregations of granular matter. This cell begins to elongate, and as it does so carries up with it the substance of the inner zone of the cell-wall. Finally it pushes through the outer zone of the cell-wall (*fig. 12*), and then simply elongates until the full size is reached. The cell-wall of the upper portion of the trichogyne is composed entirely of the substance of the inner zone, the outer zone remaining around the base of the trichogyne as a sort of collar (*fig. 13*). As the trichogyne elongates the cells-contents become more homogeneous, until aside from some granular matter in the base of the structure there is no differentiation of the protoplasm. The trichogyne is united to the cell of the trichophoric apparatus by a narrow strand of protoplasm.

The first indication that the trichogyne is about to wither appears in the formation of a cap like layer of cellulose, staining deeply with hæmatoxylin, over the cell of the trichophoric apparatus, severing the protoplasmic connection between these two structures. An early stage in the differentiation of this cap is shown in *fig. 14*, and a later stage in *fig. 15*. Contemporaneously with the formation of this cap begins the disintegration of the trichogyne, and this latter process is always associated with the development of a zooglœa of rod-shaped bacteria (*figs. 14* and *15*), with sometimes Leptothrix and Beggiatoa filaments around the ends of the trichogynes. The end of the trichogyne gradually collapses, and the cellulose wall appears to gelatinize, for the outline becomes vague and at last we cannot distinguish the end in the mass of slime. The contents of the trichogyne either disappear entirely, or there are left only small masses of organic matter in the basal portion of the structure.

While the trichogyne is withering the cell of the trichophoric apparatus usually begins to push out at one side of the base of the trichogyne, and assuming the functions of an apical cell it converts the procarp into a filament of several cells that forms one of a whorl of small bracts around the cystocarp. These filaments with the remains of the trichogynes at one side are frequently met with, and appear in some of the figures illustrating the development of the cystocarp.

We may say at this point that we have never seen any bodies attached to the trichogynes that could be identified as antherozoids. Such observations must be made before the trichogynes begin to wither, as then the bacteria and slime put a stop to all examination of this point. Sometimes the group of procarps contains much foreign matter around the trichogynes, but much of the writer's material was quite clean, and it seemed impossible that the presence of antherozoids should escape notice, yet such material was covered with developed fruit.

## DEVELOPMENT OF CYSTOCARP.

We have already stated that the cell at the base of the pair of procarps is the carpogenous cell (*figs. 4–11, c*). It is very curious that the cystocarp should be developed so uniformly from a particular cell, and yet this proved true of every specimen that the writer examined. This cell is one of the first of the cells composing the group of procarps to be formed, and consequently is one of the oldest at the time when the cystocarp begins its development. It is likewise associated with the procarp that as a rule is the first of the group to mature. The development of the cystocarp was studied almost exclusively from serial sections cut from paraffin, the specimens being stained *in toto* with Mayer's acid hæmalum, and on the slide with eosin.

The earliest stage of the cystocarp is frequently met with It consists of a large cell rich in protoplasm, and containing a prominent nucleus, situated in the midst of the group of procarps and united to the carpogenous cell of the outer pair. A glance at *fig. 16* will make plain what is meant. The large cell numbered 10 is the terminal segment of the procarpic branch On the left side of the figure drawn in detail is one of the procarps of the outside pair, and from its carpogenous cell (*c*) has arisen the first cell of the cystocarp ($x$). On the right side of the figure drawn in outline, only the position of the nuclei being indicated by shading, are the remains of some of the other procarps of the group with the basal portions of their withered trichogynes. Whenever dotted lines appear in the figures, they mean that the structures indicated were present in the section of the series next the one from which the drawing was made.

The carpogenous cell does not give rise to this first cell of the cystocarp until the trichogyne has begun to wither, and is therefore entirely separated from the cell of the trichophoric apparatus. The first cell of the cystocarp increases in size until it quite fills up the space between the procarps, and then by a transverse division it cuts off a small cell at its base. (*fig. 18*). The lower cell takes no further part in the development of the cystocarp; the upper cell gives rise to the lobes of the favella.

At this point it may be well to consider the possibility of there being cross-fusion between any of the cells of the procarps and those of the young cystocarp. The cells of the young cystocarp are separated from all the cells of the procarps by walls which stain heavily, as has been indicated in *fig. 17*. In none of the many specimens examined was there any indication of the presence of ooblastema filaments or of fusion processes budded out from any cell of the procarps. As the sections were serial the relation of all the cells of the procarps and cystocarps to one another might be studied, and it seems to the writer quite impossible that there could be any connections formed between any of the cells that would not appear on the slides.

The favella consists of a variable number of lobes, from two to five, which as a rule are in widely different stages of maturity. They are quite separated from one another, but are all attached to the second cell (cell $x^2$ in *figs. 19* and *20*) of the cystocarp. A lobe develops in the following manner. The second cell of the cystocarp pushes out in the form of a pear shaped process that becomes cut off as a cell. This cell by forward growth and a few irregular divisions gives rise to a short filament of thick segments (*fig. 19*). Branches arise from these segments in profusion and secondary branches from the first, so that ultimately there results an oval body consisting of roundish cells, closely packed together, and yet really constituting a system of filaments. As the lobe matures the connections between the cells are severed and finally they separate as carpospores, quite distinct from one another. *Fig. 20* shows a section through a maturing cystocarp. Here there are three lobes shown in section and the attachment of two of them to the second cell of the cystocarp ($x^2$) is evident. The largest lobe was made up of ripe spores which were about ready to escape from the cystocarp; the other lobes were much younger. The remains of the procarp (*ta*) with the base of the trichogyne may be seen on the right of the figure.

As the cystocarp develops it frequently happens that the strands of protoplasm between the terminal cell of the procarpic branch and the carpogenous cell and between this last and the first cell of the cystocarp become much wider than they were originally. There is evidently an absorption of the cell-wall between these cells. In *fig. 20* the cell-wall between the terminal segment of the procarpic branch (no. 10) and the carpogenous cell (*c*) has been so far absorbed that were it not for the fact of a nucleus being present in the carpogenous cell, and its position in reference to the procarp and cystocarp, one would be likely to consider it a part of the terminal segment.

### PTILOTA PLUMOSA C. AG. AND P. PLUMOSA FILICINA FARL.

The material upon which this examination is based was collected by the author in the month of July 1892 at Pacific Grove, California. In the following account of the structure and development of the procarps and cystocarps of this species and its variety we take it for granted that the reader is familiar with the main points of the account of *Ptilota serrata*. Accordingly the subject is considered under the same divisions and in the same order as those of the preceding description, and the remarks will be in the nature of a comparison of these two Pacific coast forms with *P. serrata*.

## STRUCTURE AND MODE OF GROWTH OF THE FROND.

The structure of the frond of *P. plumosa* and its variety *filicina* is in all essentials identical with that of *P. serrata*. The differences that exist are purely minor peculiarities of size and shape of pinnules and pinnæ, color, habit, etc. The structure of the framework upon which the corticating filaments are laid is quite the same in both species, and the method of growth of all parts of the frond is absolutely identical in the two forms.

## MORPHOLOGY AND DEVELOPMENT OF THE PROCARPIC BRANCHES.

There is a more luxuriant production of fruit in the Californian species than on *P. serrata*. While procarpic branches are not rare on the pinnules of *P. serrata*, they are very commonly so situated in *P. plumosa* and *P. plumosa filicina*, and the greater part of the fruit is to be found on those portions of the frond. The procarpic branches on the pinnules, from one to five in number, are usually situated along the inner edge of that structure, where they take the place of the teeth found along the edge of sterile pinnules. The procarpic branches of the Pacific coast forms are shorter than those of *P. serrata*, in *P. plumosa* consisting of only five or six segments, and in *P. plumosa filicina* of eight or nine segments, the number of course being somewhat variable. The procarpic branches of the variety *filicina* are not only longer, but also stouter than in the typical form *plumosa*, in keeping with the coarser texture of the frond. Occasionally a procarpic branch will itself bear procarpic branches, that is, a lateral branch from the axial siphon, instead of developing into a vegetative filament, will give rise to a short branch upon the end of which a group of procarps will be developed.

## DEVELOPMENT OF THE GROUP OF PROCARPS.

The group of procarps in its development follows exactly the same steps in *P. plumosa* and its variety as in *P. serrata*. A comparison of *fig. 22* with *fig. 7* will show that the two groups of procarps are identical in all the essentials of structure. There was no tendency towards an increase of the typical number of procarps in the Californian plants, but frequently the full number was not present.

The appearance of the pair of procarps on the outside of the group requires a word of notice. The second procarp of the pair is sometimes very small, and its position such that the question might arise as to whether it really is a filament or a number of cells cut off from the basal cell by radial divisions (*fig. 21*). In several such cases, specimens were treated with lactic acid and ammonia, when by carefully crushing the specimen and manipulating the cover glass, the two procarps were separated at all points excepting where the second joined the first at the basal cell. After such treatment it was apparent that the two procarps were distinct branches.

A very exceptional case was observed in the presence of a single procarp on the frond near the base of a pinnule, and in no way connected with a procarpic branch. It was attached to one of the lateral branches of a pinnule of *P. plumosa*, and consisted of three cells, the trichogyne projecting beyond the edge of the pinnule. This was the only exception noted to the rule that in the genus *Ptilota* the procarps are borne at the ends of procarpic branches.

## MINUTE STRUCTURE OF THE PROCARPS.

With the general agreement in structure that we have found to exist between the different portions of the frond of the California plants and *P. serrata*, we should hardly expect to find great differences in the minute structure of the procarps. There are no essential differences in the structure of the carpogenous cells and the trichophoric apparatus. The trichogynes of *P. plumosa* and *P. plumosa filicina* are somewhat longer than in *P. serrata*, measuring about 62 $\mu$ long and 3 $\mu$ wide above the trichophore. In most cases it was quite impossible, after carefully staining, to make out any differentiation of the protoplasm in this organ beyond a slight granular structure. However, the writer did find occasionally a body in the narrower portion of the trichogyne that had something of the appearance of a very small nucleus. There was a tendency toward a differentiation of the cell-wall around the procarps, manifest in the manner in which the upper portions of the trichogyne arose from a sort of collar, but the writer observed nothing that could be compared with the complex cell-wall of *P. serrata*.

No antherozoids were found attached to the trichogynes, and as yet no antheridial plants of this Pacific coast species have been found. However, the writer did not make the same determined search for male plants in this species as he did in the case of *P. serrata*.

## DEVELOPMENT OF THE CYSTOCARP.

There is a perfect agreement in the structure of the cystocarp of *P. serrata* and the two forms we are considering. Not only do the lobes of the favella arise in the same manner, but they are developed from the same cell in both cases, this cell being the second cell of the cystocarp.

There does not appear to be the same uniformity as to the position of the carpogenous cell in *P. plumosa* and its var. *filicina* as in *P. serrata*. Out of thirty-five specimens of cystocarps examined, twenty-nine were developed from the basal cell of the pair of procarps on the outside of the group, the homologue of the carpogenous cell of *P. serrata*; four cystocarps came from the basal cell of the procarp on the inside of the group, and in two instances they had arisen from the terminal segment of the procarpic branch.

Three figures of different stages of the cystocarps have been introduced, which make clear certain points about their development that are not shown in the illustrations of *P. serrata*. In *fig. 23* we have an instance where the carpogenous cell (*c*) of the procarp on the inside of a group has pushed out towards the center and contains two nuclei. This the writer considers to be the earliest stage in the development of a cystocarp. The distinct nuclei of the cells of the trichophoric apparatus (*ta*) are shown, and above them the trichogyne, which has just begun to wither, may be seen. In *fig. 24* we have the one-celled condition of a cystocarp, and the specimen is of particular interest because the chromatin of the nucleus is very well defined, having apparently gathered together into the chromosomes preparatory to nuclear division. *Fig. 25* illustrates beautifully the manner in which a new lobe ($b^1$) arises from the second cell ($x^2$) of the cystocarp when an older lobe may be well along in its development.

COMPARISON OF THE TYPE OF PROCARP AND CYSTOCARP OF PTILOTA WITH THOSE OF ALLIED GENERA.

We have fortunately very good descriptions of the types of procarps and cystocarps of the genera most closely allied to Ptilota. The following have been carefully studied: Callithamnion,[1] Pterothamnion,[2] Griffithsia,[3] Ceramium,[4] Lejolisia,[5] Spermothamnion,[6] Ptilothamnion,[7] and Spondylothamnion.[8]

There are many differences in the precise cell arrangements of the procarps in the genera just mentioned, each having its peculiarities, and in none of them are the conditions very much like those of Ptilota. However, in the following two cases certain resemblances are worth noting.

In *Callithamnion elegans* Schousb., according to Bornet and Thuret (76), one of the segments of a branch gives rise to a cell from which is developed a three-celled procarp, the basal

[1] *Callithamnion corymbosum* Lyngb. Bornet and Thuret (67) 145; Thuret (78) 67. *pl. 33–35*. *C. tetricum* Ag. Janczewski (77) 117. *C. elegans* Schousb. Bornet and Thuret (76) fasc. 1: 32. *pl. 10*.

[2] *Pterothamnion plumula* Näg. Schmitz (83) 23, 24.

[3] *Griffithsia corallina* Ag. Janczewski (77) 122. *G. Bornetiana* Farl. Smith (96) 35.

[4] *Ceramium decurrens* Harv. Janczewski (77) 120.

[5] *Lejolisia Mediterranea* Born. Bornet and Thuret (67) 148.

[6] *Spermothamnion flabellatum* Born. Bornet and Thuret (76) fasc. 1: 27, *pl. 9*. *S. hemaphroditum* Näg. Janczewski (77) 115.

[7] *Ptilothamnion pluma* Thuret. Bornet and Thuret (76) fasc. 2: 179, *pl. 46*.

[8] *Spondylothamnion multifidum* Näg. Bornet and Thuret (76) fasc. 2: 182, *pl. 47*.

cell of which is the carpogenous cell. Often this segment from which the procarp is developed gives rise to one or two cells that are ordinarily vegetative, but that sometimes become changed into procarps. When this is the case a group of procarps results somewhat resembling the group in Ptilota. The cystocarp consists of several lobes, but unlike Ptilota they all arise directly from the carpogenous cell.

In the genus Ceramium, according to Janczewski, there are found two procarps connected with one carpogenous cell. In Ptilota the pair of procarps situated at the outside of the group appears to have but one carpogenous cell. However, the manner in which the procarps of Ceramium develop is quite different from that of Ptilota, and a morphological relationship seems very unlikely.

### REMARKS ON THE CHARACTER OF THIS TYPE OF CARPOSPORIC REPRODUCTION.

Physiologically considered there is a great resemblance between the type of carposporic reproduction of Ptilota and of the several genera previously mentioned. They all agree in that the carpogenous cell is separated from the trichogyne by a trichophoric apparatus consisting of one or more cells. This characteristic of the type is very important from a physiological standpoint, and so considered it matters little what is the precise number and arrangement of the cells of the trichophoric apparatus. Furthermore, if the writer is not mistaken in his interpretation of what has been published by the different writers on the subject, in the genera above named and also in the case of the species of Ptilota studied by him, no actual fusion of the base of the trichogyne with the carpogenous cell has been observed. In most of these genera and also in Ptilota the trichogyne is so far removed from the carpogenous cell that fusion would hardly be possible, except through the agency of an ooblastema filament. However, in spite of very careful search on my part no such filament could be found in Ptilota, nor have I seen in the literature any figure showing an ooblastema filament or any explicit statement on the part of botanists that they have ever observed one in any of the genera just mentioned.

An exception to the above statement may perhaps be found in some remarks in a recent paper by Professor Fr. Schmitz,[9] in which he expresses the belief that the hitherto accepted accounts of the fertilization in Callithamnion are incorrect. It may be gathered from this statement of his opinion that he was inclined to believe that ooblastema filaments or their equivalent exist in Callithamnion, but the brevity of the account there given and the absence of figures prevents my comparing the complicated condition of things there described with what I have observed in Ptilota.

To bring clearly before the reader the conditions that make a satisfactory explanation of the fertilization of the carpogenous cell in Ptilota so difficult let us examine some of the figures. In the specimen shown in *fig. 24* the trichogyne had clearly begun to wither, and the carpogenous cell was in process of division. *Figs. 15, 17,* and *24* illustrate the one-celled stage of the cystocarp, the trichogyne in all instances having withered to a certain degree. *Figs. 18* and *19* show later stages of the cystocarp with the withered trichogynes at one side of the procarps, and in *fig. 20* we have a section of an adult cystocarp that illustrates very well the relation between the cell of the trichophoric apparatus (*ta*) and the cell of the cystocarp when the latter is mature.

A glance at these figures must make it apparent that the trichogyne is so far distant from the carpogenous cell that fusion with it would hardly be possible except by means of an ooblastema filament. The writer has never seen anything to indicate the presence of such a filament, and it does not seem to him possible that such a structure could be present and escape notice in serial sections such as he had to study. There was

[9] *La Nuova Notarisia,* III.—: 114. 1892. The first view of Professor Schmitz (see *Untersuchungen über die Befruchtung der Florideen* 23, 24) was that in the majority of the Ceramieæ there is direct fusion between the base of the trichogyne and the carpogenous cell, brought about by the bending of the trichophoric apparatus so that the trichogyne is brought into close proximity to the carpogenous cell.

likewise no evidence of fusion between the cells of the developing cystocarps and the cells of any of the trichophoric apparatuses or the trichogynes. As is shown in all the figures, the cells of the cystocarp are separated from the trichophoric apparatuses by walls of considerable thickness, and cross-fusion of any sort certainly ought to have appeared in the sections. The fact that the sections were serial enabled the writer to examine all sides of the specimens, and would seem to have prevented the possibility of an ooblastema filament or fusion process escaping notice because it lay in such a plane that it could not appear in the median section. However, to guard against error of method the writer crushed out many of the young cystocarps in lactic acid, thus separating the procarps from the central developing cystocarp, and in such specimens saw no indication of an ooblastema filament.

A satisfactory explanation of a sexual process in the case of Ptilota must then be one which answers the following question: viz., How can a sexual impulse be transmitted from a trichogyne to a carpogenous cell when the two structures are separated by a trichophoric apparatus of at least one cell (often more) through which the impulse must pass? From the literature it certainly seems as if the conditions above mentioned were essentially the same in the genera Callithamnion, Griffithsia, Ceramium, Spermothamnion, Spondylothamnion, and Lejolisia, but the writer cannot in most cases speak from a personal study of the forms.

Accepting the dictum that biology now lays down as to the requirements of a sexual act, there must be a transmission of nuclear substance from the antherozoid through the trichogyne to the cells of the trichophoric apparatus, and thence on to the carpogenous cell. Any explanation of sexuality which satisfies the above condition must base its argument upon the fact of there being a continuous mass of protoplasmic matter from the trichogyne to the carpogenous cell, because of strands of protoplasm connecting the cells one with another.

The difficulties that a satisfactory hypothesis must overcome, even though it rest on the above mentioned fact of an unbroken passage from trichogyne to carpogenous cell, are very great. It must postulate a process, the complexity of which, if the writer is not mistaken, is not to be found in the sexual reproduction of any organism. So far as the writer is able to judge, the union of sexual elements in both the animal and plant world is facilitated as much as possible by simplicity of conditions, *i. e.*, the two elements are given every opportunity to unite directly, and the direct union of the protoplasmic masses of two cells is the characteristic phenomenon of a sexual act. In this case it is necessary to assume the transmission of nuclear substance through cells which are themselves nucleated, and apparently are not specialized for this purpose, at least they are not materially different in structure from ordinary vegetative cells. The evidence upon this last point, it will be remembered, was that the cells of the trichophoric apparatus after the withering of the trichogynes increase in size and frequently give rise to a small filament or bract, thus showing that they have not lost the potentialities of vegetative cells. The passage of nuclear substance from one cell to another by way of one or more cells would be a fact quite contrary, the writer believes, to the usual conception of the individuality of the cell. Botanical science as yet furnishes no instance of such a phenomenon.

The writer carefully studied the cells of the trichophoric apparatus, endeavoring to find indications of a change in appearance before and after the development of the cystocarp, but in the many specimens he examined there was nothing to indicate a change of structure of the cells themselves, and nothing was ever seen that could be interpreted as nuclear substance *en route* to the carpogenous cell.

It must be apparent to the reader that we have to deal with a very difficult problem. From the observations here recorded an explanation of sexuality in this genus must overcome some serious obstacles. Investigators in this field of study have always considered that the sexuality of the Florideæ was an established fact. Yet in this genus the cytological conditions of the procarps are such that it is difficult to conceive the mechanism by which the nuclear substance of the antherozoid could be carried to the female cell. But to make the problem still more complex there is the fact that the antherozoids are apparently rare, if not wanting, and yet cystocarpic fruit is very abundant. From the present examination, somewhat unsatisfactory as including only two species, the writer cannot but think it very probable that the cystocarp in this genus develops non-sexually.

The evidence in favor of a theory of apogamy may be briefly summarized as follows:

1. The entire absence of bodies attached to the trichogynes that could be identified as antherozoids impressed the writer as being very significant.

2. Cystocarpic plants of *P. serrata* and *P. plumosa* with its variety *filicina* are common and bear immense quantities of fruit, there being as a rule a cystocarp at the end of every abortive pinnule (procarpic branch), and sometimes borne along the edge of the pinnules. Immense quantities of antherozoids, particularly as they are non-motile in the Florideæ, would be required to insure the development of such a profusion of cystocarps arranged in such a regular manner upon the frond, yet no antheridial plants of *P. serrata* or *P. plumosa* have been reported. It is natural to expect that antheridial plants will be found, as has been the case with *Ptilota elegans* Bonnem, but they ought to exist in great quantity to produce such a profusion of fruit if the cystocarp is to develop as the result of a sexual act.

3. The uniformity with which the cystocarp is developed from one carpogenous cell in the case of *P. serrata* and one of two cells in the case of *P. plumosa* can be explained in two ways. Either the cell has been specialized as the female cell, of which there is no evidence in its structure or position, or it is the cell which by virtue of its age and situation is best fitted to give rise to the fruit apogamously. As has been pointed out, the carpogenous cell is one of the oldest in the group of procarps, and perhaps for that reason it may be the cell strongest in potentialities, best prepared to develop the fruit. At all

events the uniformity of the position of the carpogenous cell adds another difficulty to be explained by a theory of sexuality, while it is but reasonable to suppose that when a plant adopts a method of apogamous development of its fruit certain cells, because of position or age affording perhaps greater nourishment, would be best fitted to undertake reproductive functions.

4. The absence of facts pointing to a fertilization of the carpogenous cell through the trichophoric apparatus, and the difficulty of understanding such a process, while affording simply negative evidence on the subject, nevertheless deserves attention, and appears to the writer as a point in favor of the hypothesis of apogamy.

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THURET (78): Études phycologiques. 1878.

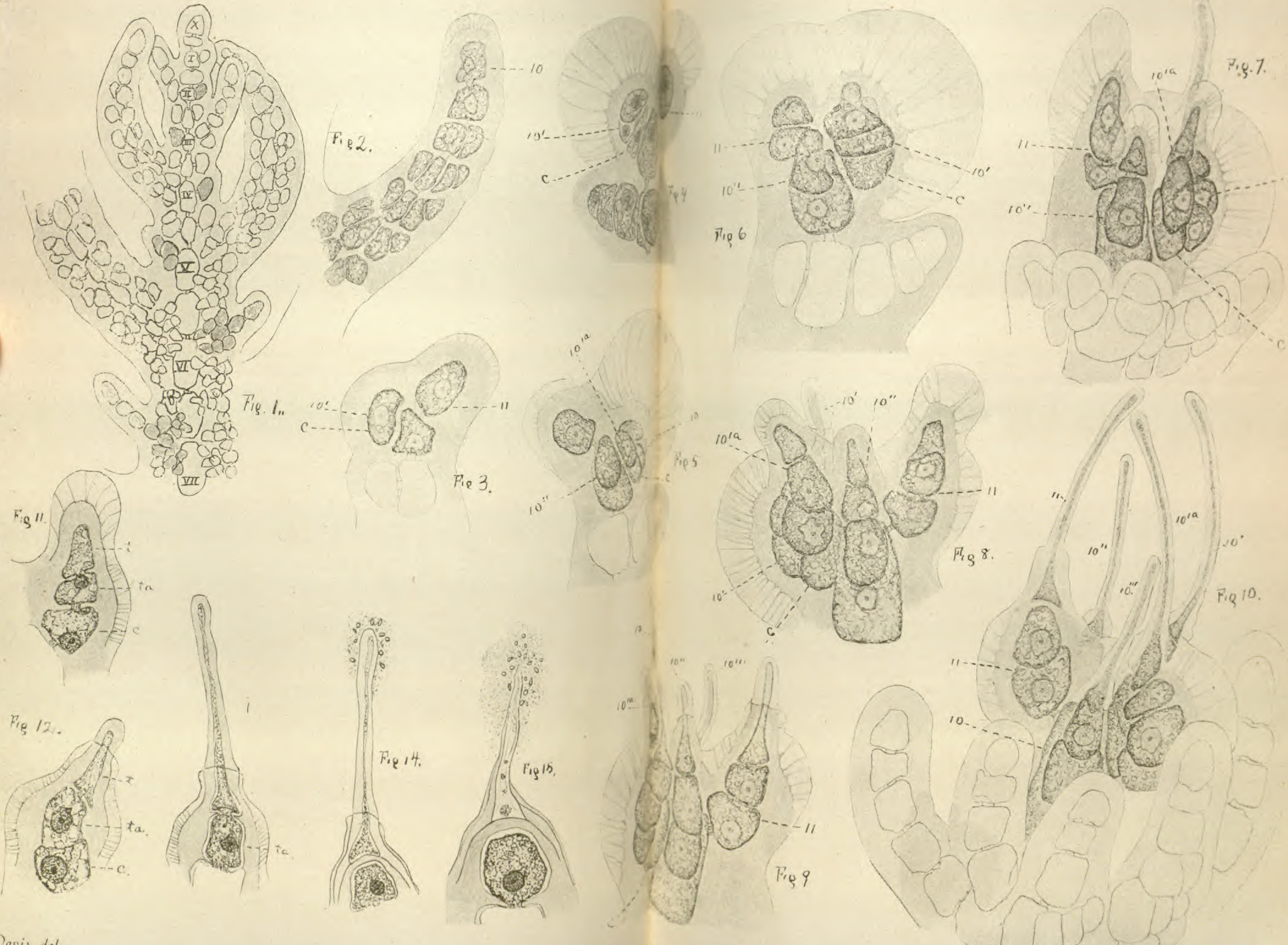
## EXPLANATION OF PLATES XVIII AND XIX.

All figures sketched with the Abbé camera: *fig. 1*, × 300; *figs. 2 and 3*, × 800; *figs. 4–15*, × 1100; *figs. 16–22*, × 800; *figs. 23–25*, × 1100.

*Ptilota serrata* Kütz.

FIG. 1. End of a pinna; *x*, apical cell; I–VII, nodes; early stages of procarpic branches shaded.

FIG. 2. An adult procarpic branch from the twelfth node; stained with eosin.

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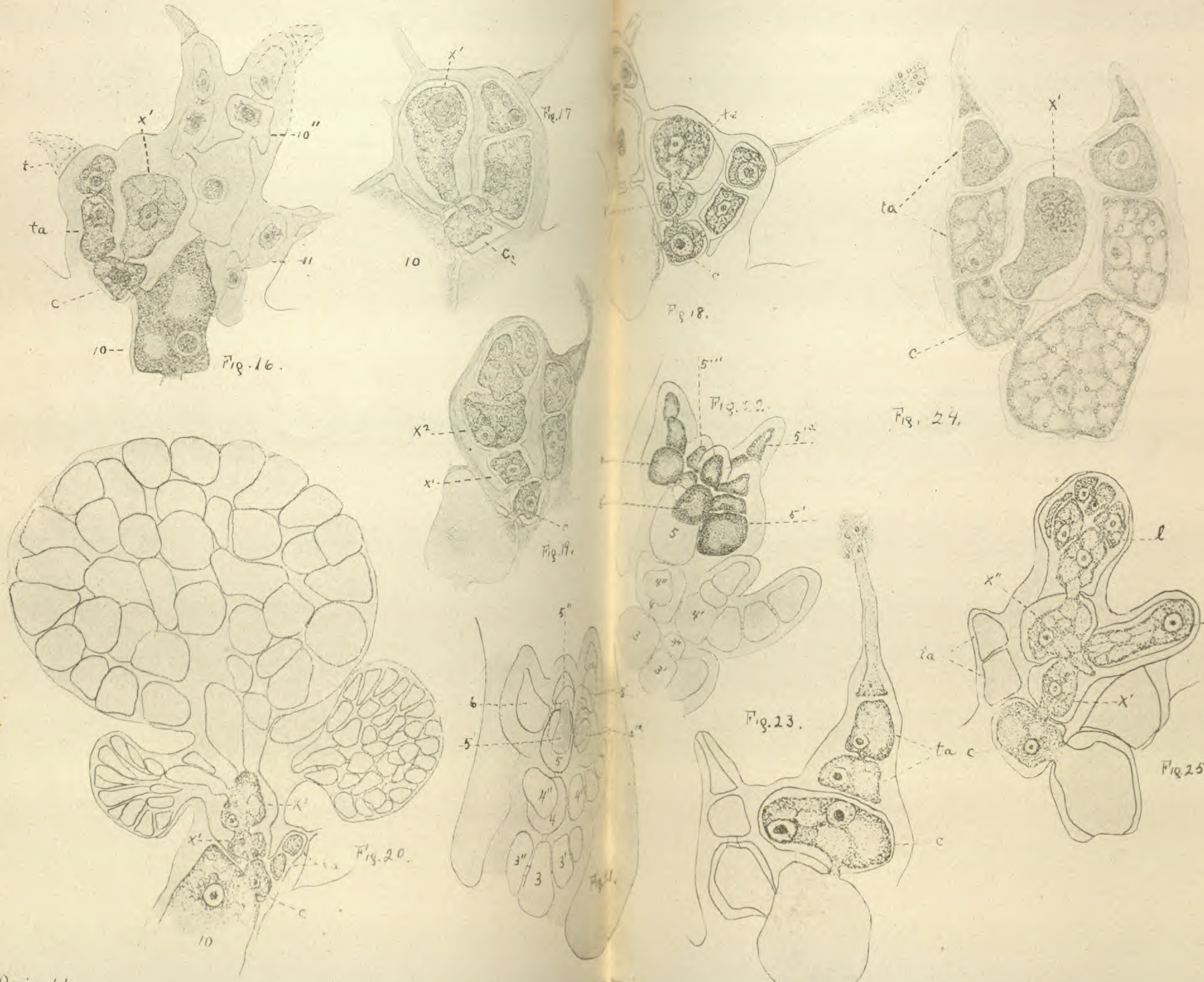


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FIG. 3. End of procarpic branch showing first stage in the formation of the group of procarps; cell 11 gives rise to the inner procarp; cell *c* is the carpogenous cell; stained with eosin.

FIG. 4. End of procarpic branch showing structure of the cell-wall; branch 10′ becomes first procarp of the pair; stained with Böhmer's hæmatoxylin.

FIGS. 5–10 from specimens stained with eosin.

FIG. 5. End of procarpic branch: cell $10'^{a}$ gives rise to the second procarp of the pair; cell 10′′ develops into a lateral procarp.

FIG. 6. Stage very similar to *fig. 5*, inner procarp (no. 11) consists of two cells.

FIG. 7. Stage somewhat older in development than *fig. 6*; a trichogyne (10′) has developed from the terminal cell of the first procarp of the pair.

FIG. 8. A stage very similar to *fig. 7*, but viewed from the opposite side; lateral procarp 10′′ consists of three cells.

FIG. 9. Group of procarps illustrating development of the trichogynes.

FIG. 10. An adult group of procarps; shows the appearance and arrangement of the bracts below the group.

FIGS. 11–16 from specimens stained with Böhmer's hæmatoxylin.

FIG. 11. A single immature procarp; terminal cell (*t*) becomes the trichogyne; *ta*, the cell of the trichophoric apparatus; *c*, the carpogenous cell.

FIG. 12. Trichogyne pushing through the outer zone of the cell-wall.

FIG. 13. A mature trichogyne.

FIG. 14. The protoplasmic connection between the trichogyne and the cell of the trichophoric apparatus has been severed, and a wall of cellulose has been formed between the two structures.

FIG. 15. Withered trichogyne with zooglœa of bacteria at the tip.

FIGS. 16–22 from specimens stained with Mayer's acid hæmalum and eosin.

FIG. 16. First stage in development of cystocarp; *x*, first cell of cystocarp; *c*, carpogenous cell; *ta*, trichophoric apparatus; on the right side drawn in outline are other procarps.

FIG. 17. First stage of cystocarp with old trichogyne attached to the procarp.

FIG. 18. Two-celled stage of cystocarp with old trichogyne attached to the procarp.

FIG. 19. Four-celled stage of cystocarp with old trichogyne attached to the procarp.

FIG. 20. A cystocarp with one mature lobe and two similar structures partially developed; *ta*, trichophoric apparatus; *c*, carpogenous cell.

*Ptilota plumosa* C. Ag.

FIG. 21. Early stage in development of group of procarps; about the same stage as is shown in *fig. 6* of *P. serrata*: cell 6 homologous with cell 11; 5′ with 10′; 5′′ with 10′′.

FIG. 22. Somewhat later stage than *fig. 21*, very similar to *fig. 7* of *P. serrata*; numbered to correspond with *fig. 21*.

*Ptilota plumosa filicina* Farl.

FIGS. 23–26 stained with Böhmer's hæmatoxylin.

FIG. 23. Carpogenous cell of procarp (*c*) with two nuclei; *ta*, trichophoric apparatus; probably a stage preliminary to the formation of the first cell of the cystocarp.

FIG. 24. One-celled stage of cystocarp; nucleus with a network of chromosomes.

FIG. 25. Cystocarp with early stages of two lobes of the favella, the younger (*l*′) still a single cell having just been formed from the second cell of the cystocarp (*x*′′).

# THE PHALLOIDEÆ OF THE UNITED STATES.

## II. SYSTEMATIC ACCOUNT.[1]

EDWARD A. BURT.

### PHALLOIDEÆ, Fries. Syst. Myc. 2:281. 1823.

Terrestrial fungi with mycelium forming ropelike strands and bearing spherical or ovoid fructifications—the "eggs"—which consist of a receptaculum and gleba enclosed by the volva; volva with thin outer and inner layers separated from each other by a broad gelatinous layer; receptaculum of various forms, with a pseudoparenchymatous wall of chambered structure, bursting through the apex of the volva at maturity and carrying aloft the spores; gleba deliquescing into a syrupy mass containing the very minute ($3–8\ \mu \times 1–2.5\ \mu$) ellipsoidal spores.

#### KEY TO THE GENERA.

I. Gleba borne on the outer surface of the receptaculum - PHALLEÆ
1. Receptaculum consisting of a stipe along the upper portion of which the gleba is borne - - - - *Mutinus*
2. Receptaculum consisting of a stipe and pileus joined together at their apices; gleba on the upper surface of the pileus - - - - - - *Ithyphallus*
3. Receptaculum consisting of a stipe, pileus, and veil; gleba on the upper surface of the pileus - - - *Dictyophora*

II. Gleba borne on the inner surface of the receptaculum - CLATHREÆ
4. Receptaculum lacking a stipe, consisting of obliquely anastomosing bars or of vertical columns joined together above - - - - - - *Clathrus*
5. Receptaculum clathrate above, stipitate - - *Simblum*
6. Receptaculum consisting of a stipe divided at its upper end into free arms whose inner surfaces and flanks between neighboring arms are covered by the gleba - - - *Anthurus*

[1] Contribution No. XXXVII from the Cryptogamic Laboratory of Harvard University, prepared under the direction of Dr. W. G. Farlow.

Subfamily PHALLEÆ (Fries).

MUTINUS Fries Summa Veg. Scand. 2:434. 1849.

Receptaculum consisting of a hollow stipe and lacking pileus and veil. Gleba borne on the outer surface of the upper portion of the stipe.

MUTINUS CURTISII (Berk.) Ed. Fischer.

*Corynites Curtisii* Berkeley, Grevillea 2: 34. 1873. Compare James in Bull. Torrey Bot. Club 15: 314. *pl. 86*. 1888.

*Mutinus Curtisii* (Berk.) Ed. Fischer, Saccardo's Syll. Fung. 7: 13. 1888.

*Mutinus bovinus* Morgan, Journ. Cincinnati Soc. Nat. Hist. 11: 147. *pl. 3*. 1889. Ed. Fischer, Untersuch. Phall. 92. 1890.

(?) *Caromyces elegans* Montagne Herb. 1850.

(?) *Corynites elegans* Montagne Sylloge Cryptogamarum 281. 1856.

(?) *Mutinus elegans* (Mont.) Ed. Fischer, Saccardo's Syll. Fung. 7: 13. 1888. Neue Untersuch. Phall. 39. 1893.

Stipe horn shaped, tapering gradually from the base to the apex, sometimes subtriangular in cross-section, hollow, white or pinkish below and bright red above, perforate at the apex, spore bearing part with the same structure as the rest of the stipe.

Plant 4 to $7^{in}$ in height with a stipe $\frac{3}{4}^{in}$ thick (10 to $17^{cm}$ by $2^{cm}$). Growing in cultivated grounds and in woods. Ohio, *Morgan;* Connecticut, *Wright*, *Eaton*, *Thaxter;* Long Island, *Peck;* Massachusetts, *James*.

This plant is very distinct from the following species, being larger, with a stipe having its greatest diameter where it issues from the volva, and then tapering very gradually upward. Owing to an error in the dimensions of the plant as published by Berkeley in *Grevillea*, this species has been regarded as probably identical with *C. Ravenelii*. The authentic specimen upon which Berkeley's description was based is in the Curtis Herb. in a good state of preservation. It bears the following label and description which does not differ materially from that published:

"(5635) Corynites Curtisii, *Berk.!*

Hymenophorum stipitiform, tubular, thin, subtriangular, red, pitted above the middle, tapering to an obtuse point. Apex covered with a semifluid brown substance of a fetid smell.

Conn. C. Wright (222)."

This dried specimen measures $4^{in}$ in length and has a stipe $\frac{9}{16}^{in}$ in diameter at its widest part where it leaves the volva ($10^{cm}$ by $14^{mm}$). In the published description Berkeley adds that the spore-bearing part is confluent in structure with the portion below. This specimen agrees well with Morgan's description and figure of *M. bovinus.* An alcoholic specimen, collected by Thaxter in Connecticut, and a dried specimen collected by Peck on Long Island, agree well with the Berkeley specimen and with Morgan's figure. *Corynites Curtisii* and *Mutinus bovinus* are undoubtedly the same.

I have not seen specimens or figures of *Caromyces elegans* Montagne. The description, although rather imperfect, seems to indicate its identity with *C. Curtisii* and *M. bovinus.* Ed. Fischer[2] states that he has seen a figure of Montagne's plant in Herb. British Museum which agrees well with Morgan's figure of *M. bovinus.* If this identity is established Montagne's specific name should be used for the plant.

## Mutinus caninus (Huds.) Fries.

*Phallus caninus* Huds. Angl. **2** : 630.

*Phallus inodorus* Sowerby, Fung. *pl. 330.*

*Phallus* (*Cynophallus*) *caninus* Fries, Syst. Myc. **2** : 284. 1823.

*Mutinus caninus* (Huds.) Fries, Summa Veg. Scand. 2. 1849. *Cf.* Ed. Fischer, Vers. e. syst. Uebers. 55. 1886. Sacc. Syll. Fung. **7** : 12. 1888. Untersuch. Phall. 90. 1890. Morgan in Jour. Cincinnati Soc. Nat. Hist. **11** : 147. 1889.

*Corynites Ravenelii* B. & C. Trans. Linn. Soc. **21** : 149. *pl. 19.* 1855.

*Corynites brevis* B. & C. Curtis in Geol. and Nat. Hist. Surv. N. C. *Pt. 3. Botany:* 110. *Cf.* Bull. Torr. Bot. Club **7** : 30. 1880.

*Mutinus brevis* B. & C. Morgan, Jour. Cincinnati Soc. Nat. Hist. **11** : 147. 1889.

*Mutinus Ravenelii* (B. & C.). Ed. Fischer, Saccardo's Syll. Fung. **7** : 13. 1888.

Stipe hollow, cylindrical-fusiform, 2½ to $6^{in}$ long by $\frac{1}{2}^{in}$ or less thick (6 to $15^{cm}$ by $1^{cm}$); spore bearing part one-third to one-sixth the total length of the stipe, oblong-ovoid or conical,

[2] Neue Untersuch. Phall. 39. 1893.

flesh-colored, perforate or imperforate at the apex; portion below spore bearing part tapering downward, white or reddish, mostly one layer of chambers thick. The chambers of the spore bearing part of the stipe have very massive walls—perhaps twenty layers of cells thick—and open as pits or winding tubes into the central cavity of the stipe; below this part they are thin walled, opening, if at all, through the outer wall.

Growing about buildings and in gardens and thickets. New England, New York, Pennsylvania and South Carolina, *various collectors*; Ohio, *Morgan;* Indiana, *Underwood;* Wisconsin, *Pammel.*

This fungus is quite variable with us. I have examined several collections made at points about Cambridge and Somerville, Mass., at Newport, R. I., and at East Galway, N. Y. Mr. C. H. Peck has kindly shown me the specimens in the New York State Herbarium of *Corynites Ravenelii* B. & C., collected by himself in New York, and of *Cynophallus caninus* (Huds.) collected by Warne in the same state. Authentic specimens of *Corynites Ravenelii* B. & C. and of *Corynites brevis* B. & C. in the Curtis Herbarium were examined. My thanks are also due to Professor Ed. Fischer of Bern and Professor Chodat of Geneva for alcoholic specimens of European types of *Mutinus caninus* (Huds.) collected by Professor Chodat in Biel, Switzerland, in 1894, and procured for me by Professor Fischer.

The careful examination and comparison of all of this material shows that there is no well marked character or group of characters by which *M. Ravenelii* (B. & C.) may be separated from *M. caninus* (Huds.). Upon superficial view the European types of *M. caninus* show the spore-bearing part to be rather more abruptly distinct in color ("determinate") from the lower part of the stipe than is generally the case in our specimens. But upon splitting the plants longitudinally, both show the same massive wall for the spore-bearing part with pits or tubes opening into the central cavity of the stipe in that region and with the same chambered structure lower down. For this reason, "spore-bearing part determinate" for *M. caninus* does not seem to be of value for separating it from *M. Ravenelii.*

One of the dried specimens of *C. Ravenelii* in the Curtis Herbarium discloses a portion of the surface of the spore-bearing part next to the central cavity of the stipe. The pits may still be seen. The specimens collected at Somerville, Mass., the structure of which has been shown in my account of the development of *M. caninus*, are undoubtedly the same as those of *Corynites Ravenelii* B. & C., and they show that, while the stipe is usually distinctly perforate at the apex, it may, nevertheless, be so minutely perforate and with the lips of the orifice so closely drawn together as to be fairly described as imperforate.

The variations observed in the abundant supply of material at Somerville show very clearly that our forms, called sometimes *Mutinus* (*Corynites*) *Ravenelii* and sometimes *Mutinus caninus*, are really the same species and cannot well be separated from *M. caninus* of Europe. The spore-bearing part may be quite as short in proportion to the total length of the stipe as it is in the European types, or it may vary to one-third the total length of the stipe in the same lot of material. The shorter the spore bearing part, the more acute it is likely to be in our specimens which I have seen. As the plant is much more frequent with us than it is in Europe, more variation would be expected in our form. It has therefore seemed best to slightly modify the old description so that it may comprehend as well the relative proportions in size of parts shown by our plant.

The specimen of *Corynites brevis* B. & C. in the Curtis Herbarium is identical with those of *C. Ravenelii* B. & C. and thus confirms Ravenel's statement[3] that *C. brevis* was merely an herbarium name for *C. Ravenelii* and was probably printed by an oversight of the author in Dr. Curtis's catalogue in the Geological and Natural History Survey of North Carolina.

ITHYPHALLUS Fries Syst. Myc. 2. 1823 (subgenus).

Receptaculum consisting of a hollow stipe and of a pileus bearing the gleba upon its outer (upper) surface. Veil wanting.

[3] See Gerard, Bull. Torr. Bot. Club 7 : 30. 1880.

ITHYPHALLUS IMPUDICUS (L.) Fries.

*Phallus impudicus* Linn. Suec. *n. 1261.*

*Phallus vulgaris* Micheli, Nova plantarum genera 201. 1729.

*Phallus fœtidus* Sowerby Engl. Fungi, *pl. 329.*

*Hymenophallus Hadriani* Nees, System der Pilze und Schwämme, 1817.

*Phallus* (*Ithyphallus*) *impudicus* Fries, Syst. Myc. **2**: 283. 1823. Morgan, Jour. Cincinnati Soc. Nat. Hist. **11**: 146. 1889.

*Ithyphallus impudicus* (L.) Fr. Ed. Fischer, Saccardo's Syll. Fung. **7**: 8. 1888. Untersuch. Phall. 84. 1890.

Stipe hollow, tapering at each end, with a wall several layers of chambers thick, joined at its upper end with the pileus by a recurved border; pileus conic-campanulate, showing its outer surface sculptured with reticulated ridges and crests after deliquescence of the gleba; veil wanting; volva white or pinkish.

Total height of plant 6 to $12^{in}$ (15 to $30^{cm}$): stipe $1\frac{1}{4}^{in}$ ($3^{cm}$) thick; pileus $2^{in}$ ($5^{cm}$) high. Growing on the ground in woods. New England, *Farlow, Frost;* New York, *Peck, Gerard;* South Carolina, *Schweinitz;* Ohio, *Lea, D. L. James;* Missouri, *Trelease;* Nebraska, *H. J. Webber;* California, *Harkness.*

The size and form of *Dictyophora duplicata* and the surface of its pileus are so similar to *I. impudicus* that there is danger of mistaking that plant for *I. impudicus* in young stages if the veil of the former plant has not yet lost its connections with the under face of the pileus so as to hang freely below the pileus about the stipe.

ITHYPHALLUS RUBICUNDUS (Bosc) Ed. Fischer.

*Satyrus rubicundus* Bosc, in Magaz. des Gesellsch. naturf. Freunde zu Berlin 5: 86, *pl. 6, f. 8.* 1811.

*Phallus* (*Leiophallus*) *rubicundus* Fries, Syst. Myc. **2**: 285. 1823.

*Phallus* (*Ithyphallus*) *rubicundus* Bosc. Morgan, Jour. Cincinnati Soc. Nat. Hist. **11**: 146. 1889.

*Ithyphallus rubicundus* (Bosc) Ed. Fischer, Saccardo's Syll. Fung. **7**: 11. 1888. *Cf.* Untersuch. Phall. 90. 1890.

Stipe fusiform, red, 6 to $7^{in}$ long by $\frac{3}{4}^{in}$ thick in the middle (15 to $18^{cm}$ by $2^{cm}$), perforate at the apex; pileus conic-campanulate, with surface even; volva small, gray.

Growing on the ground in dry fields. Massachusetts, *Frost;* New York, *Schweinitz;* North Carolina, *Curtis;* South Carolina, *Ravenel;* Alabama, *Peters.*

Bosc's illustration and description of this plant suggest, except in coloration of the stipe, a form of *Phallus Ravenelii* B. & C., if the latter species ever occurs without its veil-like appendage under the pileus, or with this veil so reduced as to be overlooked. The outer surface of the gleba in Bosc's figure is quite even, showing, as in *P. Ravenelii,* no such reticulation of lines as exist in *D. duplicata* on the surface of its gleba, and which there mark the position of the reticulate crests and ridges of the surface of its pileus. The dried specimens in the Curtis Herb., marked *Phallus rubicundus,* show a striking resemblance to those of *P. Ravenelii,* even in their size. One of the specimens is so old that its pileus has become bared through deliquescence of the gleba. It shows the granulate or minutely wrinkled surface characteristic of the pileus of *P. Ravenelii.* It is greatly to be hoped that whoever may have the good fortune to find *I. rubicundus* will preserve in alcohol specimens of the mature plant and of its eggs for a study of its structural relationships.

DICTYOPHORA Desvaux, Jour. de Bot. (Paris) **2**:88. 1809.

Receptaculum consisting of a stipe, a pileus and a veil, the latter being formed from the same tissue that gives rise to the stipe and hanging from the upper part of the stipe as a conical, campanulate, or cylindrical net or membrane.

### DICTYOPHORA RAVENELII (B. & C.) Burt.

*Boletus phalloides* John Ray, Herb. Vaillant (Herb. du Musée d'hist. nat. in Paris), according to Ed. Fischer, Untersuch. Phall. 87.

*Phallus Ravenelii* B. & C., Grevillea **2**:33. 1873. *Cf.* Farlow, Bull. Bussey Inst. **2**:247. 1878. Peck, Bull. Torr. Bot. Club **9**:123. *pl. 25.* 1882.

*Phallus* (*Hymenophallus*) *Ravenelii* B. & C. Morgan, Jour. Cincinnati Soc. Nat. Hist. **11**:146. 1889.

*Ithyphallus Ravenelii* (B. & C.) Ed. Fischer, Saccardo's Syll. Fung. **7**:11. 1888. *Cf.* also Ed. Fischer in Untersuch. Phalloideen 30 and 86, and in Neue Untersuch. Phalloideen 15 and 34. *f. 64–68.*

*Ithyphallus cucullatus* Patouillard, Jour. de Bot. 198. 1890. *Cf.* Ed. Fischer in Neue Untersuch. Phalloideen 34.

Stipe slender, tapering at each end, hollow; pileus conic-campanulate, with its surface granulate or minutely wrinkled after disappearance of the gleba; veil membranaceous, usually less than one-half of the length of the pileus, loosely attached to the stipe in the angle between the stipe and pileus; stipe closed at the apex by a thin membrane or finally perforate; volva pinkish.

Plant 4 to $7^{in}$ long (10 to $17^{cm}$); stipe $\frac{3}{4}^{in}$ thick (15 to $20^{mm}$); pileus $1\frac{1}{2}^{in}$ high (2.5 to $3.5^{cm}$). Growing in woods and fields about rotting wood. New England, *various collectors;* New York, *Peck;* South Carolina, *Ravenel;* Ohio, *Morgan.*

This species has been placed in the genus Dictyophora on account of its having a persistent membrane hanging about the stipe from the angle between the pileus and the stipe. This membrane is composed of the same tissue, the intermediate tissue *A* of my figures, which gives rise to the veil in *D. duplicata.* Differentiation of this tissue does not advance in *D. Ravenelii* to the final stage of making this membrane pseudoparenchyma, or is this final stage reached in the case of hyphæ composing the pileus in *I. impudicus* and in *D. duplicata,* yet no one would hesitate on that ground to use the term *pileus* in connection with those species. It seems best to apply the term veil to this membrane in *D. Ravenelii,* which looks like a veil, has the position of a veil, is composed of the tissue forming the veil in other species, and is likely to be regarded as a veil without question by every botanist meeting this fungus for the first time and attempting its determination.

I have as yet had no opportunity of studying this structure except in an advanced egg-stage, very kindly placed at my disposal by Professor Thaxter, but that a differentiation towards the stage of pseudoparenchymatous hyphæ exists in the structure seemed to be indicated by some laterally inflated hyphæ which were observed in the section, as well as by the persistence of the structure in a membrane which becomes torn away from the under surface of the pileus on the one side and from the wall of the stipe on the other, during elongation.

DICTYOPHORA DUPLICATA (Bosc) Ed. Fischer.

*Phallus duplicatus* Bosc, Magaz. des Gesellsch. naturf. Freunde zu Berlin 5 : 86. *pl. 6, f.* 7. 1811.

*Hymenophallus duplicatus* Nees, System der Pilze u. Schwämme. 1817.

*Hymenophallus togatus* Kalchbrenner, Gasteromycetes novi v. minus cogniti 6. *pl. 1.* 1884. *Cf.* Rau, A new Phallus, BOT. GAZ. 8 : 223. *pl. 4.* 183. Farlow, BOT. GAZ. 8 : 258. 1883.

*Phallus* (*Hymenophallus*) *dæmonum* Rumph. Morgan, Jour. Cincinnati Soc. Nat. Hist. 11 : 145. 1889. *Cf.* Tight, Bull. Sci. Lab. Denison Univ. $8^2$ : 7. *pl. 6.* 1894.

*Dictyophora duplicata* (Bosc) Ed. Fischer, Saccardo's Syll. Fung. 7 : 6. 1888.

*Dictyophora phalloidea* Desvaux, var. *Dictyophora duplicata* (Bosc) Ed. Fischer, Untersuch. Phalloideen 83. 1890.

Stipe cylindrical, tapering at each end, hollow, white, wall thick, with several layers of chambers; pileus campanulate, with surface sculptured with strong reticulating ridges and crests, which pass into the recurved border or collar formed by the union of the apex of the stipe with the pileus; veil reticulate, variable in length, but reaching down, usually, about half way from the apex of the stipe to its base. Meshes of the veil become smaller towards the lower border and the bars wider, so that the border is almost membranaceous. Apex of the plant with a large collar (truncate) and perforate, or more acute. Gleba dark green, with an extremely fetid odor.

Growing on the ground about buildings and about stumps in fields and thickets. Plant 6 to $9^{in}$ high (15 to $24^{cm}$); stipe 1 to $1\frac{1}{4}^{in}$ thick ($2\frac{1}{2}$ to $3^{cm}$); pileus $2^{in}$ high ($5^{cm}$). This is a frequent species in the eastern United States and is reported from Ohio by Morgan, and specimens from Iowa have been contributed by Professor Fink. It has sometimes been confused by American botanists with the tropical *D. dæmonum* (Rumph.) and is frequently met with in collectors' lists under that name. The affinities of *D. dæmonum* (Rumph.) seem to be rather with *D. phalloidea* var. *typica* Ed. Fischer than with *D. duplicata*.

Ed. Fischer has regarded *D. phalloidea* Desvaux as a comprehensive species including four subspecies or varieties, of which *D. duplicata* is one. This seems to be too sweeping a combination. A. Möller's[4] excellent photographs of *D. phalloidea* var.

[4] Brasilische Pilzblumen, Jena, 1895.

*typica*, the variety nearest to *D. duplicata*, seem to afford sufficient ground for regarding the two as distinct species on account of the difference in the form of the pileus and in the almost membranaceous character of the marginal portion of the veil of *D. duplicata*.

### Subfamily CLATHREÆ (Fries).

CLATHRUS Micheli, Nova plantar. genera 214. 1729.

Receptaculum wanting a stipe, consisting of a hollow clathrate structure of obliquely ascending and anastomosing bars, or consisting of a few vertical columns joined together at the apex (Laternea). Gleba inclosed within the receptaculum.

### CLATHRUS COLUMNATUS Bosc.

*Colonnaria urceolata, truncata*, etc., Raf. Med. Repos. 1808, according to Gerard in Bull. Torr. Bot. Club 7:30. 1880.

*Clathrus columnatus* Bosc, Mag. Gesell. naturf. Freunde zu Berlin 5:85, *pl. 5. f. 5*. 1811. *Cf.* Ed. Fischer, Saccardo's Syll. Fung. 7:18. 1888.

*Clathrus colonnarius* Leman, Dict. Sc. Nat. 9:360. 1817.

*Laternea columnata* Nees, Nees and Henry's System der Pilze 2:96. 1858.

*Laternea angolensis* Welwitsch and Currey, Trans. Linn. Soc. London 26:286. 1870.

*Clathrus angolensis* (Welw. and Curr.) Ed. Fischer, Saccardo's Syll. Fung. 7:19. 1888.

*Laternea columnata* (Bosc) Morgan, Jour. Cincinnati Soc. Nat. Hist. 11:149. 1889.

*Laternea pusilla* B. & C. Jour. Linn. Soc. Bot. 10:343. 1869.

*Clathrus Berkeleyi* Gerard in litt. Ed. Fischer, Saccardo's Syll. Fung. 7:18. 1888.

*Clathrus triscapus* Mont. Gay Historia fisica y politica de Chile Bot. 7:497. 1850.

*Clathrus Brasiliensis* Ed. Fischer, Versuch. e. syst. Uebers. 68. 1886.

(?) *Laternea triscapa* Turp. Morgan, Jour. Cincinnati Soc. Nat. Hist. 11:149. 1887.

*Clathrus* (*Laternea*) *australis* Spegazzini, Anales de la Sociedad cientifica Argentina 24:66. ——

*Clathrus cancellatus* Tourn., vars. *Berkeleyi, Brasiliensis, columnata,* and *australis*. Ed. Fischer, Untersuch. Phalloideen 55. 1890.

*Laternea columnata* (Bosc) A. Möller, Brasilische Pilzblumen. 1895.

Receptaculum consisting of 2 to 5 massive vertical columns separate below but joined together at the apex; columns cinnabar-red; gleba suspended from underneath the apex of the receptaculum. Odor very fetid.

Plant 2 to 5 $^{in}$ in height. Growing in sandy soil. N. Carolina, *Curtis;* S. Carolina, *Bosc*, *Ravenel;* Georgia, *Le Conte;* Florida, *Ravenel*, *Mrs. Curtis*, *Underwood*, *Rolfs;* (?) Texas, *Ellis.*

The number of columns composing the receptaculum has been regarded by some botanists as a sufficient distinction for making several species from this plant. The variations in the number of columns in plants from the same locality and even in the same lot of material show that this character is not of the importance assumed. I have followed A. Möller in slightly modifying Bosc's original description so as to include the forms with two and five columns which occur in the tropics. Ed. Fischer seems to have gone too far in combining *C. columnatus* with *C. cancellatus*. *C. columnatus* in all of its forms seems to be sufficiently distinct from the other species in the massive structure of its columns and in their vertical position, the latter difference dating back in its origin to the earliest stage in the differentiation of the egg.

Judging from Morgan's description, the *Laternea triscapa* Turp., collected by Ellis in Texas, hardly seems distinct from the three-columned form of *C. columnatus*, which occurs in Florida.

## CLATHRUS CANCELLATUS Tourn.

*Clathrus cancellatus* Tourn. (see Tulasne in Expl. Scien. d'Algerie, Bot., Acotylédones 434). *Cf.* Ed. Fischer, Saccardo's Syll. Fung. 7:19. 1888. Morgan, Jour. Cincinnati Soc. Nat. Hist. 11:148. 1887.

*Clathrus ruber*, *albus*, *flavescens*, Micheli, Nova plantar. genera 214. 1729.

*Clathrus volvaceus*, Bull. Champignons. *pl. 441*.

*Clathrus nicæensis* Barla (see Luerssen Handbuch d. sys. Bot. 1:275. 1879.

*Clathrus cancellatus* Tourn. var. *typica* Ed. Fischer, Untersuch. Phalloideen 58 1890.

Receptaculum spherical or obovoid, cancellate in all parts; bars transversely wrinkled, from 4$^{mm}$ to 1$^{cm}$ wide, cinnabar-red or white or yellowish on their outer surface, inner surface of bars red; meshes irregularly polygonal. Odor very fetid.

Plant 3 to $5^{in}$ in height. Growing on the ground in woods. New York, *Clinton;* Georgia, *Le Conte;* Florida, *Faxon.*

SIMBLUM Klotzsch, Hook. Bot. Misc. $79^2$: 164.

Receptaculum consisting of a hollow stipe, which passes above into a hollow clathrate structure inclosing the gleba.

SIMBLUM SPHÆROCEPHALUM Schlechtendal.

*Simblum sphærocephalum* Schlecht. Linnæa 31: 154. *d. pl. 1.* 1861–62.

*Simblum pilidiatum* Ernst, Grevillea 6: 119. 1878. *Cf.* Ed. Fischer, Saccardo's Syll. Fung. 7: 16. 1888. Untersuch. Phalloideen 50. *f. 47.* 1890.

*Simblum rubescens* Gerard, Bull. Torr. Bot. Club 7: 8. *d. pl.* 1880. *Cf.* Ed. Fischer, Saccardo's Sylloge 7: 16. 1888. Untersuch. Phalloideen 59. *f. 46.* 1890. Morgan, Jour. Cincinnati Soc. Nat. Hist. 11: 148. 1889.

*Simblum rubescens* Gerard, var. *Kansensis* Cragin, Bull. Washburn Coll. Lab. Nat. Hist. 34. 1885.

Receptaculum long-stipitate; the clathrate portion depressed-globose, red or flesh-colored; the bars compressed, thinner than the stipe-wall, transversely wrinkled; meshes polygonal; stipe flesh-colored above, paler below, tapering towards the base, strongly constricted at the place of union with the clathrate portion.

Plant 3 to $5^{in}$ in height (7 to $12^{cm}$); stipe ½ to $¾^{in}$ thick (12 to $15^{mm}$); clathrate portion with greater diameter than the stipe. Growing in grassy ground. Long Island, *Gerard, Trask,* and others; Nebraska, *Webber.*

ANTHURUS Kalchbrenner, Grev. 9: 2. 1880.

Receptaculum consisting of a hollow stipe divided above into arms, which are unconnected at their apices. Gleba covering the inner faces of the arms.

ANTHURUS BOREALIS Burt.

*Anthurus borealis* Burt, Memoirs Boston Soc. Nat. Hist. 3: 504. *d. pl. 49, 50.* 1894.

Solitary or subcespitose. Stipe white, divided above into six, usually, but sometimes five or seven, narrowly lanceolate hollow arms; arms incurved above, with pale flesh-colored backs traversed their entire length by a shallow furrow; cavity of the stipe nearly closed at the base of the arms by a diaphragm through which there is an opening upward into a closed chamber with a dome-shaped wall; gleba supported on the dome and closely embraced by the arms; spores 3 to $4\mu \times 1.5\mu$, borne on cross-septate basidia constricted at the septa.

Total height of plant 4 to $5^{in}$ (10 to $12^{cm}$). Growing in cultivated fields. New York, *Burt*, 1893, *A. E. Burt*, 1894, in an asparagus bed, *Peck*, 1896; and in a low meadow, Westboro, Mass., *F. L. Sargent*, 1894. Mr. Sargent states that in the specimens found by him the arms varied in number from five to seven.

One of the mature plants of the original collection has three of its six arms joined together at the upper ends, showing an approach toward the conditions in the genus Colus. The plant is quite normal in all other respects, and the conditions under which it was collected preclude the idea of its being more than a variation of *A. borealis.*

*Lysurus Texensis* Ellis. Gerard in Bull. Torr. Bot. Club 7: 30, 1880, mentioned a plant to which this name was given provisionally. The description has not been completed.

I am under great obligation to Dr. Farlow for the use of books and for access to the specimens of the Phalloideæ in the Curtis Herbarium; and also to Professor Peck for the privilege of examining the Phalloideæ in the New York State Herbarium at Albany, N. Y.

MIDDLEBURY COLLEGE, MIDDLEBURY, VT.

# SALIX CORDATA × SERICEA.

N. M. Glatfelter.

The general aspect and specific characters of *Salix cordata* and *S. sericea* serve to distinguish them quite readily. There have sprung up between them numerous intermediate forms, hybrids, and races, crossing with each other and with the parental forms, resulting in an almost inextricable confusion, on the one hand approaching *S. sericea*, on the other *S. cordata*. This free intermixture resulting in more or less good varieties in different localities is no doubt the sufficient explanation of the confusion that results from reading the various descriptions of *S. cordata*. As in all probability the descriptions were all founded upon specimens collected from regions where both of the species are native, it is absolutely certain that about the same complications must have been present as are found prevailing in the vicinity of St. Louis.

During the preparation of my paper last year on *S. Missouriensis* and *S. cordata*[1] I gradually got the feeling of the great necessity of further investigation of this subject. I therefore made collections in bud, in flower, and in mature leaf, of several hundred marked plants, taking notes of every detail. The summary at the end of this paper is but a partial transcript of the notes of eighty-two of those collected. In the Engelmann Herbarium of the Missouri Botanical Garden there is a long letter written about 1880 by the late M. S. Bebb, in which he refers to the frequent hybridization of *S. cordata* with *S. sericea*. He gives a fairly good description of these hybrids, but appears to have limited too much the extent of their influence. For example, he limits the height to 9$^{ft}$, while some of our specimens here rise to 25 or 30$^{ft}$. The specimens he contributed all

[1] Trans. St. Louis Acad. Sci. 7 : —. 1895.

show more or less silkiness of capsules, and where there is silkiness of capsule or leaf, even but sparingly, the problem is easy. The evidence now at hand, however, compels the extension of the idea of contamination. By taking account of every possible character, we find that hybrids, or rather intermediate races, include many examples having capsules perfectly smooth, and all but the youngest leaves likewise perfectly smooth.

Upon the *S. cordata* side of our problem it is perhaps impossible as yet to form a proper conception as to its typical character, either from description or observation. An intelligible and comprehensive description of it is yet to be written, and must be founded upon specimens collected from regions where *S. sericea* is not found.

Fortunately in the characters of *S. sericea* we have rigid stability, a fact which furnishes us an invaluable guide to a partial exploration of the mazes of hybridization. Having examined specimens from Massachusetts, New York (Ithaca), southern Pennsylvania, Ohio, Michigan (Detroit and Port Huron), Illinois (Chicago), Missouri (Pilot Knob and St. Louis), and the Rocky mountains, I have found no noteworthy variation. Specimens of *S. cordata* were examined from New Brunswick, Niagara Falls, Ohio, Illinois, Iowa, Missouri, Minnesota, Colorado, Idaho, Oregon, California, and Kew Gardens.

Notwithstanding the variability of *S. cordata*, taking a general view of it together with its varieties, including var. *vestita* and its hybrids with *S. sericea*, there is presented as a whole such an *ensemble* of stem, spread, color, foliage, flower and fruit as to enable one to distinguish it easily from all other species. The interest in this paper must lie therefore rather in biology than in systematic botany.

Assuming but one form of *S. cordata*, and one good variety, viz., var. *vestita*, and knowing the freedom with which each crosses with *S. sericea*, we shall have, theoretically, the following combinations: cordata × sericea, cordata × vestita, sericea × vestita, and cordata × sericea × vestita. I think these combinations are recognizable in the vicinity of St. Louis. But a more nearly correct idea of the true state of the case may be realized if the reader will bear in mind the two parent species and then imagine every possible form of gradation and combination producing races capable of self-propagation. If left to themselves without further contamination from their surroundings many would develop into good species. Var. *vestita* (*S. Missouriensis* Bebb) may thus be accounted for, which will be noticed later.

The modification of characters generally proceeds along the whole line with more or less equal pace, though often strong and weak modifications of one parent will be found indiscriminately combined with strong or weak modifications of the other, on the principle stated by Darwin "of augmentation, obliteration and reversion of characters when well defined varieties are crossed." When the departure from pure *S. sericea* is not too great, the increasing size of the stipules, the degree of discoloration in drying, the basal variation from the acute towards the cordate, the amount of silvery pubescence on the leaves are tolerably fair measurements of the distance. Beyond this the problem becomes more complicated. Taking our point of view from *S. sericea*, the important change first occurring is in the capsule. It loses its silvery pubescence, enlarges, lengthens in style and pedicel, assumes a somewhat flattish subrhomboidal base supporting a long or short beak with often a tendency to curve, ripens a pale tawny color, and has stigmas less deeply notched, often remaining entire.

The next important character early lost is the short, silvery, hairy coating of the under surface of the leaves. Instead, the leaves become more or less glaucous beneath, or the short hairs are transformed into the longer softer hairs seen on the young leaves of *S. cordata*. Var. *vestita* affords an extreme illustration of this process of change. No other character has received or demanded so much study as the one of pubescence or hairiness. Extremely variable in amount as to leaf, bud, shoot or twig, or absent altogether, variable also on scale and rachis, it is not a character of much value.

The third important change is in the scales. The scale with broadly rounded apex and upper half black with sharp line of demarcation becomes narrower, oblong or obovate, with obtuse or acute apex dark to light brown, the line of demarcation less sharp and descending lower until it may be lost altogether.

Other changes follow, or are coincident with the preceding. The decided brittleness of *S. sericea* changes to semi-brittleness, to be finally lost in the toughness of *S. cordata*. The leaves become thicker, more glaucous beneath, subglossy above, losing the dull dark green upper surface, the prominent primary veins beneath, and the regular looping near the margin. They become larger, often long narrow lanceolate and long acuminate, the base changing from acute to obtuse, to round, and finally to cordate. The equilateral form in some instances becomes elliptic, in others oblanceolate or obovate, but in any case gradually loses the equilateral character.

From a total absence of stipules, or mere rudimentary processes, the change is rapid towards large semiovate or semicordate sharply pointed or acuminate, then to mixed, and finally to obtuse reniform forms, nearly all more or less stalked, this last being a new character not existing in either parent.

The bud of *S. sericea* is oblong, blunt, relatively short, notched at the apex, very finely exhibited in bursting. While the shape is soon lost in numerous variable forms, a common one being long wedge acuminate, the notch, though lessening in distinctness, often becomes a valuable aid in determining hybrids. The adherent inner membrane of the buds of *S. sericea* detaches itself in hybrids spontaneously, as in *S. cordata*, and is frequently carried as a cap on the apex of the ament.

The red color of the anthers of *S. sericea* is transmitted to the well marked hybrids, gradually changing, however, through brown or pale pink, into the yellow of *S. cordata*. The numerous prominent circular lenticels of *S. sericea* are still abundant in the better hybrids, becoming more and more mixed with the oval form as we approach *S. cordata*.

In *S. sericea* the epidermis of one and two year old twigs scales longitudinally, a character well retained by hybrids.

In this vicinity there is found on *S. sericea* a leaf gall, pyriform or globular in shape, about ¼$^{in}$ in diameter, enclosing a single larva of a species of saw-fly (*Nematus Salicis-pomum* Walsh), kindly identified for the writer by Miss Mary E. Murtfeldt of Kirkwood, Missouri. The same has been observed on some of the hybrids and on var. *vestita*, on two trees of the latter in extraordinary abundance. Not a single one have I seen on *S. cordata*, or on specimens approaching near to it, though growing side by side with those just mentioned! This fact is of the greatest importance, because it unites with a number of other facts showing that var. *vestita* is closer to *S. sericea* than to *S. cordata*.

Besides the transformations above noticed, the tendency to abnormalities has to be added. "Complexity of inheritance, like complexity in a chemical substance, gives instability to the offspring and thus liability to variation in the offspring."[2] The adnateness of filaments to the extent of 40 per cent. in hybrids, and 73 per cent. in var. *vestita* as shown in the summary, may be one of these abnormalities, but may be the usual character of *S. cordata*, though not heretofore noticed by any writer consulted. Related to this are cases where partly adnate filaments divide, making four filaments, each with a single anther cell; or the two filaments free, one of them dividing, thus making three stamens; or but a single stamen; or single stamen divided, each half filament bearing a cell; or the two stamens wholly united, bearing a double anther of four cells. More rare than the foregoing is the doubling of the ovary. There are also a few cases of strictly two-lobed styles, but more common are instances presenting both two and four-lobed styles on the same ament. In var. *vestita* the style is occasionally undivided, presenting a merely circular stigma, or with very indefinite divisions. The size of these hybrids may seem surprising, but all of our forms of *S. cordata*, as well as *S. sericea*, exceed the limits of the books. Pure *S. sericea* attains the height of 15$^{ft}$, with a diameter of 2½$^{in}$, though usually only 5 to 10$^{ft}$. As to our *S. cordata*, it is impos-

[2] LECONTE: Evolution, 218.

sible to assign limits, since it passes so gradually either into the hybrid form, or into var. *vestita*, this latter reaching a height of $40^{ft}$ and a diameter of $10^{in}$. A remarkable thing is that *S. sericea* is quite rare, a pure specimen being found only amongst hundreds. I have spent a day in a region of some extent collecting undoubted hybrid forms, *S. cordata.*, and var. *vestita*, without meeting with one pure *S. sericea*. This seems to prove clearly that these forms are not direct crosses but races. Indeed, I have been struck with the tendency of the plants in different localities to assume a sort of family resemblance.

The flowering period of *S. sericea*, its nearer hybrids, and var. *vestita*, is about the same; that of *S. cordata* and of hybrids approaching it is some days later. Honey bees appear to be the chief agents of pollination. In so many of the larger hybrids I have observed the bark of the lower portion of the trunk to be check-fissured, though of moderate depth, as to incline me to consider this as somewhat characteristic; but I have seen the same occasionally in trees which would be classed as var. *vestita*. The color is a dark gray or blackish. The bark of the *S. sericea* stem is smooth, and of light gray color. The arcuate primaries or looping near the margin of the leaf of *S. sericea* is a strong character, and is quite persistent in most of the hybrids; in other respects the venation generally resembles that of *S. cordata*.

In respect to the form named *S. Missouriensis* Bebb, I may be pardoned for regarding it as simply a race not separable either from *S. cordata* or the near hybrids, with nothing to distinguish it from these excepting, perhaps, its greater size or more tree-like form, and even this may be largely accounted for by the fact of the large trees being found growing in the richest soil. I have observed the same tree-like form, with hairy leaves, and of the same general aspect, growing in poorer soil, reduced to small stature. Its characters throughout are a compromise between *S. cordata* and *S. sericea*, with a closer leaning towards the latter. When compared with proven hybrids or races of those parents the resemblance is striking. The shape, color, vesture, thickness, drying color, want of gloss of the leaf, all point towards *S. sericea*, as do the mostly round lenticels, the pointed stipules, the brittleness, the lithe twigs, the unfolding of the leaves towards the tip of the spray, and the leaf galls mentioned above. The instinct of the insect does not fail to detect the close alliance. I found this variety growing over the county wherever I collected: at Allenton and Valley Park belonging to the Meramec basin (trees $40^{ft}$ high); north of Clayton, at the River Des Peres (trees $35^{ft}$ high); near Fergusson, on upland ravine emptying into Moline creek (tree $30^{ft}$ high and $7^{in}$ in diameter). It can no longer be said, therefore, that it is confined to the rich bottom lands of the Missouri. I deem it unnecessary to say more on this point, as a reference to the summary will bear out the claims here made. It will be observed that having set down the variations of a character relating to a specimen the totals of such character will exceed the number of plants represented in that group.

In the comparison presented of *S. sericea* with *S. cordata* it is believed that a tolerably fair exhibit is given, at least sufficient to make evident the strong contrast between the two. Yet the writer has to confess the wish that his knowledge of *S. cordata* were more definite, and hopes that some one who has it in his power to secure sufficient material will undertake the task of a thorough review of this species remarkable for its free miscegenating proclivities, for besides *S. sericea* it also hybridizes with *S. petiolaris*, *S. candida*, *S. adenophylla*, *S. incana*, and *S. discolor*, none of which grow in this vicinity. I am under special obligations for specimens loaned by the following gentlemen: Professor J. Fowler, Canada; Mr. E. P. Sheldon, Minnesota; Professor F. D. Kelsey, Ohio; Professor L. H. Pammel, Iowa; Dr. William Trelease, Missouri Botanical Garden.

COMPARISON OF THE CHARACTERS OF SALIX SERICEA AND S. CORDATA.

| *S. sericea.* | *S. cordata.* |
|---|---|
| Usually small shrub, with slender stems, not over 15 feet high. | Larger, tending to the tree form. |

| | |
|---|---|
| Twigs lithe, very brittle, nearly smooth, brown or olive green to light gray. | Tough, heavy, tomentose, blackish or blotched, changing to red or yellowish green and dark green. |
| Epidermis thin, scaling. | Thick, firm, unbroken, not scaling. |
| Buds brown, oblong, blunt, notched at apex, inner membrane adherent. | Larger, ovate or wedge acute or the point flat, not notched, tomentose, then bright red or brown, inner membrane separating, being often carried to apex of ament. |
| Lenticels circular, numerous, prominent, brown or cinnamon color. | Oval, relatively few, not prominent, color the same. |
| Leaves lanceolate, equilateral, base and apex acute; primary veins strong, prominent beneath and looping very regularly; upper side very dark green, under side subglaucous, coated with short silvery hairs; thin, drying black, and mostly affected with leaf galls; young leaves without color; serrulate. | Apparently two forms: (1) long lance acuminate, (2) oblong-lanceolate, narrow or broad, cuspidate-acuminate; both obtuse to cordate, thick, inequilateral, glossy green above with a tinge of yellow, glaucous or subglaucous beneath; primaries relatively weak and looping only towards apex; drying yellowish green or light brown; young leaves downy above, hairy beneath, reddish. |
| Stipules none. | Large, auriculate or reniform, obtuse (rarely acute), persistent. |
| Aments about 1 inch long, with 2 to 5 leaflets, not tufted at base; scales short, broadly rounded, upper half black and clothed with rather stiff white hairs. | Staminate 1.5 to 2 inches long, pistillate 2 to 4 inches, with 2 or 3 leaflets, tufted at base with long white hairs; scales narrower, oblong, obtuse to acute, light to dark brown, with softer more woolly hairs; gland longer. |
| Filaments entirely free; anthers red. | Mostly more or less adnate; anthers yellow. |
| Capsules short, oblong, blunt, clothed with short silvery hairs, bursting early; pedicel and style short; style 4-parted. | Mostly with subrhomboid, somewhat flattish base and narrowing to a beak of about equal length, or ovoid conical, not maturing so early; style long or medium, usually 4-lobed. |
| Blooming probably a week earlier. | |
| A fixed, rigid species, with constant characters. | Variable with change of locality, and in same locality. |

SUMMARY OF THE RECORD OF FIFTY-ONE SPECIMENS OF SALIX CORDATA × SERICEA, AND THIRTY-ONE SPECIMENS OF S. "MISSOURIENSIS."

| | | S. CORDATA × SERICEA | | | S. "MISSOURIENSIS" | | |
|---|---|---|---|---|---|---|---|
| | | STAMINATE [1] | PISTILLATE [2] | PER CENT. | STAMINATE [3] | PISTILLATE [4] | PER CENT. |
| Number recorded | | 28 | 23 | | 15 | 16 | |
| Twigs | brittle | 13 | 12 | 53 | 9 | 5 | 47 |
| | semibrittle | 6 | 6 | 25 | 7 | 11 | 60 |
| | tough | 6 | 4 | 21 | 2 | 2 | 13 |
| Buds notched | | 11 | 14 | 49 | 5 | 4 | 39 |
| Lenticels | round | 23 | 20 | 90 | 14 | 15 | 94 |
| | oval | 19 | 14 | 69 | 13 | 11 | 80 |
| Leaf form | lanceolate | 15 | 15 | 59 | 7 | 8 | 48 |
| | narrow lanceolate | 16 | 12 | 55 | 2 | 1 | 10 |
| | oblong lanceolate | 11 | 7 | 35 | 12 | 10 | 71 |
| | elliptic | 2 | 4 | 12 | 9 | 7 | 51 |
| Leaf texture | thin | 15 | 5 | 54 | 9 | 9 | 62 |
| | thickish | 9 | 8 | 46 | 5 | 6 | 38 |
| Leaf surface (under) | glaucous | 6 | 2 | 16 | 13 | 14 | 87 |
| | subglaucous | 22 | 21 | 84 | 2 | 2 | 13 |
| Leaf surface (upper) | dull dark green | 10 | 13 | 45 | 8 | 8 | 53 |
| | yellowish green | 5 | 4 | 18 | 0 | 0 | 0 |
| | glossy | 13 | 7 | 39 | 6 | 8 | 47 |
| Leaf base | acute | 21 | 21 | 82 | 9 | 13 | 71 |
| | obtuse | 25 | 18 | 84 | 15 | 16 | 100 |
| | cordate | 6 | 1 | 14 | 5 | 5 | 32 |
| | subcordate | 3 | 4 | 14 | 9 | 4 | 42 |
| | round to truncate | 5 | 7 | 23 | 1 | 5 | 19 |
| Leaf apex | acuminate | 27 | 23 | 98 | 9 | 10 | 61 |
| | cusp.-acuminate | 1 | 0 | 2 | 9 | 11 | 64 |
| Stipules | pointed, semiovate | 24 | 20 | 86 | 11 | 10 | 68 |
| | obtuse, reniform | 11 | 5 | 31 | 13 | 14 | 87 |
| | stalked | 16 | 7 | 68 | 5 | 4 | 35 |
| | sessile | 9 | 2 | 32 | 7 | 10 | 65 |
| Color of young leaves | purplish | 8 | 4 | 32 | 8 | 4 | 39 |
| | reddish | 5 | 1 | 15 | 0 | 2 | 6 |
| | slight tinge | 9 | 1 | 26 | 2 | 2 | 13 |
| | colorless | 6 | 4 | 26 | 5 | 8 | 42 |
| Filaments | free | 24 | 0 | 60 | 4 | 0 | 27 |
| | adnate | 16 | 0 | 40 | 11 | 0 | 73 |
| Anthers | red or brown | 23 | 0 | 80 | 9 | 0 | 64 |
| | yellow | 15 | 0 | 54 | 12 | 0 | 86 |
| Stigmas | 4-lobed | 0 | 15 | 70 | 0 | 9 | 56 |
| | 2 to 4-lobed | 0 | 7 | 32 | 0 | 7 | 44 |

ST. LOUIS, MISSOURI.

[1] Flowering March 29 to April 14; 15 were 15 to 25 feet high and 2 to 6 inches in diameter.

[2] Capsules ripe April 18 to 21; 12 were 15 to 25 feet high and 2 to 5 inches in diameter.

[3] Flowering March 29 to April 12; 11 were 20 to 30 feet high and 3 to 7 inches in diameter.

[4] Capsules ripe April 18 to 21; 13 were 20 to 35 feet high and 4 to 7 inches in diameter.

# BRIEFER ARTICLES.

## BRASSICA JUNCEA.

DR. ROBINSON'S note on page 252 of the September GAZETTE, recording the rapid dissemination of *Brassica juncea* in the eastern states, recalls the fact that this species is a common inhabitant of gardens. It is known as a pot-herb, and is variously called Chinese broad-leaved mustard, brown mustard, and Chinese mustard. A somewhat full account of this and related oriental brassicas, which are now cultivated in this country, is given in Bulletin 67 of the Cornell Experiment Station ("Some recent Chinese vegetables"), with illustrations. It is now a question whether these naturalized plants are introductions of the weedy *Brassica juncea* from the Old World, or whether they are spontaneous derivatives from the garden forms. A study of the plants in the field could no doubt settle this question.—L. H. BAILEY, *Cornell University*.

## NORTH AMERICAN SPECIES OF EUPHRASIA.

IN preparing my monograph of the genus Euphrasia[1] I tried to make clear the extremely polymorphic forms which are to be found in North America. In this connection I wish to correct an error in one of the maps of the memoir, caused by a very unfortunate mistake, and one which I did not observe in the proof. I can distinguish three species of the genus Euphrasia in North America, as follows:

1. *E. Americana* Wettst. Near to the European *E. nemorosa* Pers., and as yet known only from eastern Canada.

2. *E. latifolia* Pursh. Distributed throughout the arctic regions of Asia and Europe, throughout Greenland, and extending into Cumberland and eastern Labrador.

3. *E. Oakesii* Wettst. A most distinct form, which as yet has been

[1] Monographie der Gattung Euphrasia. 4to, pp. 316, pl. 14. Leipzig, Engelmann, 1896.

found only in the White mountains of New Hampshire. By a mistake the range of this species was indicated in map I of my monograph as being in western North America. The error is not fatal, or even serious, as in the text (p. 173) the region is indicated properly. I should like to call special attention to the blunder, however, and to ask that area 12 on map I be stricken out.

A species which possibly occurs in North America, but whose presence cannot be proved as yet with certainty, is *E. hirtella* Jord. I found three specimens of it in the herbarium of the Royal Museum at Berlin, mixed with specimens of *E. Americana*, and ticketed "*E. officinalis*, flora boreal-Americ. (*Hooker*)."—RICHARD VON WETTSTEIN, *Prag, Austria.*

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## ABORTIVE FLOWER BUDS OF TRILLIUM.

DURING a course of study upon the development of pollen grains, an attempt was made to secure early spring buds of Trillium. Plants taken from beneath the still frozen soil near Ithaca on April 5 were examined. Among fifteen plants one bud was found about $15^{mm}$ in length, in which the pollen mother-cells had already separated from one another and were undergoing nuclear division. The other fourteen plants had minute buds $3^{mm}$ or less in length, in some cases the leaves of the perianth being distinguishable with the naked eye, in others only a slight projection above the receptacle being made out. Some of these small buds were treated with collodion and sectioned, when the sepals were found to be clearly differentiated, but within was only a confused mass of cells, many of them apparently dead, with almost no differentiation of petals, stamens, and pistil.

On April 15 a large number of plants just appearing above ground were collected. Only a small proportion contained healthy buds, and in these the pollen mother-cells were in the later stages of division, or, in some cases, the pollen grains were already formed. Sixty plants in which there were no growing buds were examined with a hand lens. In only three or four did the lens fail to show some traces of a bud, in some cases, as before, only a slight elevation. Usually the rudiment of a perianth could be distinguished, either as a white speck or as very evident floral leaves, sometimes 2 to $3^{mm}$ in length, but withered and evidently abortive.

As care had been taken to collect plants with indications of buds, it is not certain that there were not truly sterile plants in the field, but the observations were sufficient to show that a large number of those that would be regarded as sterile at a later date had made an attempt to produce blossoms and had been more nearly successful in the case of the outer leaves than of the sporophylls.

The early development of the buds of spring flowers has been referred to by different writers. Foerste[2] mentions among the buds collected in Vermont, August 22–28, one of *Trillium erythrocarpum* $5.5^{mm}$ in length. The present writer found in central New York, on July 11, a flower bud of *T. grandiflorum* $2^{mm}$ in length, with anthers $1.7^{mm}$ long. There was no opportunity to learn the stage in the development of the pollen.—ARMA A. SMITH, *Cornell University.*

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## A STUDY OF SOME ANATOMICAL CHARACTERS OF NORTH AMERICAN GRAMINEÆ. VII.

(WITH PLATE XX)

### THE GENUS AMPHICARPUM.

ONLY two species are known of this singular genus, *A. Floridanum* Chapm. and *A. Purshii* Kth., their geographical distribution being limited to the eastern United States, along the Atlantic coast. They both grow in sandy soil, but while *A. Floridanum* does not occur outside the semi-tropical Florida, the other species shows a larger range of distribution, from New Jersey as far south as Georgia. Their manner of growth is different, *A. Purshii* being cespitose, while *A. Floridanum* is stoloniferous, but otherwise they show a rather similar appearance, especially in regard to their floral characters, both developing their fruits underground, as true geocarpic plants. By comparing their leaf-structure we shall see that according to their distribution, and the character of the soil wherein they grow, the anatomical differences are but slight, and almost wholly dependent upon the development of the epidermis. These divergences, slight as they are, prove nevertheless sufficient to enable us to distinguish the two species anatomically.

AMPHICARPUM FLORIDANUM.—The epidermis of the superior face of the leaf (*fig. 2*) consists generally of thick walled cells, which vary considerably in size and shape according to their disposition, whether

[2] On the relations of certain fall to spring blossoming plants, BOT. GAZ. 17: 1. 1892.

they belong to the strata that cover the mesophyll or the stereome. Those covering the mesophyll are either developed as bulliform cells (*B C*, in *fig. 2*) with nearly straight walls, or as ordinary epidermis cells with numerous stomata (*S*, in *fig. 2*). The cells of the stomatiferous strata have distinctly undulate cell walls, and these strata form longitudinal bands on both sides of the bulliform cells. Very different from these strata are those which cover the stereome (*A*, in *fig. 2*). Here we find cells of very different size, short and almost fusiform, or rather long, but all showing numerous foldings of the cell walls. Two forms of epidermal expansions are to be found here, viz., some which are short, one-celled and thorn shaped, and small hairs consisting of two cells (*H*, in *fig. 2*). This structure is to be found on the entire surface of the leaf in regular alternation and with almost the same number of rows in each stratum (*fig. 2*). There is in this way nothing to indicate the median part of the blade, for it shows no larger development of the bulliform cells, and, as will be shown later, the median mestome bundle and its surroundings do not show any histological difference from those of the lateral parts of the blade.

If we consider the epidermis of the inferior face of the leaf we find only a few differences from that of the superior one. The hairs seem here to be most frequent in the stomatiferous strata; the cells which surround the stomata are exceedingly thick walled, and no proper bulliform cells are developed, so that the stomatiferous strata occupy the entire space between those which cover the stereome. As shown in *fig. 3*, the epidermis of the inferior face shows a certain development approaching that of bulliform cells, but widely different from *A. Purshii*, which exhibits true bulliform cells on the inferior face of the blade.

The mestome bundles are of a very uniform development, and, as stated above, the median bundle is not more prominent than the others. Only two forms may be distinguished, but the difference is relatively smaller than we have seen in the other genera described in our previous articles upon this subject. Both forms of mestome bundles are surrounded by a completely closed and colorless parenchyma sheath (*P*, in *fig. 5*), inside of which is a mestome sheath of thick walled cells. The larger bundles show the presence of a single layer of thick walled mestome parenchyma, separating the leptome from the hadrome; and in the smaller bundles this parenchyma is absent. The smaller bundles appear to be the more numerous.

The stereome (*St*, in *fig. 5*) is well developed in this genus, and forms groups above and below each mestome bundle. On the inferior face of the leaf the stereome is sometimes bordering immediately on the parenchyma sheath, but is also seen to be separated from this either by the adjoining mesophyll or by colorless parenchyma. The stereome of the superior face is constantly separated from the parenchyma sheath by one to three cells of colorless parenchyma. The stereome has attained its highest development, however, along the margins of the blade (*fig. 4*). We see here an enormous group of this tissue connecting the two faces of the leaf, and by this character Amphicarpum is readily distinguished from any of the other genera which we have previously examined and described.

The mesophyll occupies quite an extensive part of the leaf blade, and forms usually separate groups between the mestome bundles, excepting where it passes uninterruptedly underneath these, between the stereome and the parenchyma sheath. It forms a compact tissue with the cells radiating from the mestome bundles, and no lacunes are observable. The colorless parenchyma has already been touched upon above, and we have seen it developed as a closed parenchyma sheath and as small groups or single cells between the stereome and the mestome bundles. As shown in *fig. 1*, it has attained its highest development on the superior part of the leaf.

AMPHICARPUM PURSHII.—The epidermis of both faces of the leaf shows very nearly the same structure as we have described for *A. Floridanum*, but we note the following differences: The bulliform cells are here equally well developed on both faces (*fig. 6*); epidermal expansions as very long unicellular hairs are frequent on both faces, and are especially common in the bulliform strata. The thorn shaped expansions in this species seem to be most common in the stomatiferous strata, near the bulliform cells. The mestome bundles do not seem to differ from those of the other species, and the same is true of the mesophyll and the stereome. The colorless parenchyma is less developed on the superior face than we have seen in *A. Floridanum*. *Fig. 6* represents a transverse section of the median part of the leaf, and we see here only one single cell of colorless parenchyma above the parenchyma sheath, while below this the sheath borders immediately on the stereome.

In comparing the leaf structure of these two species of Amphicarpum, the principal anatomical differences are as follows:

*Epidermis—*

| | |
|---|---|
| Long unicellular hairs on both faces - - - - | *A. Purshii* |
| No long hairs - - - - - - - - | *A. Floridanum* |
| Bulliform cells well developed on both faces of the leaf | *A. Purshii* |
| These restricted to the superior face - - - | *A. Floridanum* |

*Mesophyll—*

| | |
|---|---|
| Forming separate groups between the mestome bundles | *A. Purshii* |
| Sometimes united - - - - - - | *A. Floridanum* |

*Colorless parenchyma —*

| | |
|---|---|
| Small groups separating the stereome of the superior face from the parenchyma sheath - - - | *A. Floridanum* |
| Frequently only a single cell - - - - - | *A. Purshii* |

The leaf is altogether thicker and of firmer structure in *A. Floridanum* than in *A. Purshii*, a fact that perhaps indicates the warmer and drier climate of the region to which *A. Floridanum* belongs.—THEO. HOLM, *Washington, D. C.*

## EXPLANATION OF PLATE XX.

FIGS. 1–5. Transverse sections of the leaf of *Amphicarpum Floridanum.*

FIG. 1. The median part of the blade, showing fine mestome bundles and fine groups of bulliform cells on the superior face; *Sup*, the superior face. × 165.

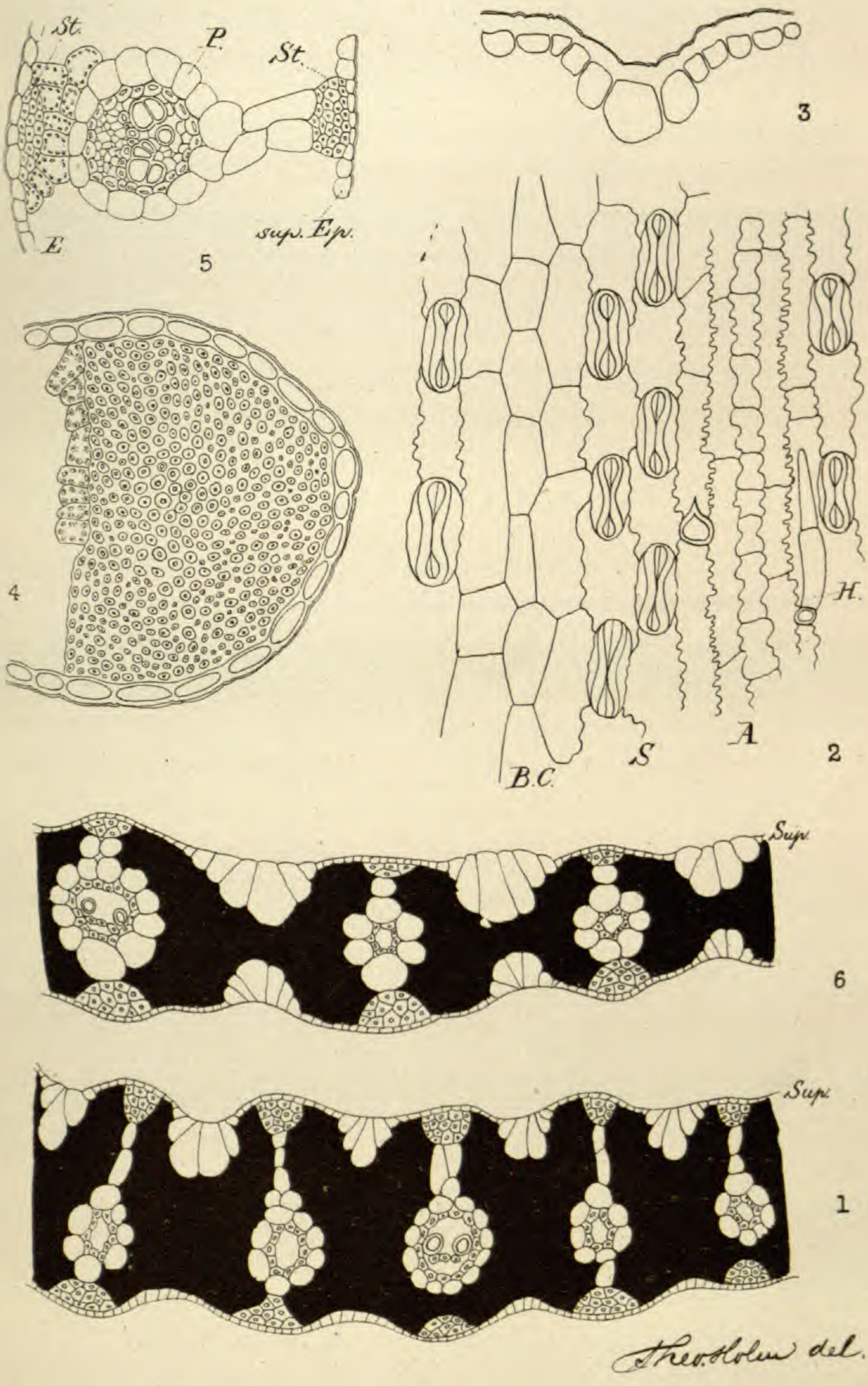
FIG. 2. Epidermis of the superior face, seen *en face; B C*, bulliform cells; *S*, the stomatiferous strata; *A*, the strata which cover the stereome; *H*, a hair. × 500.

FIG. 3. Group of epidermis cells from the inferior face, showing a structure somewhat similar to that of proper bulliform cells. × 500.

FIG. 4. The margin of the blade, showing the enormous development of stereome. × 330.

FIG. 5. One of the largest mestome bundles; *P*, the colorless parenchyma sheath; *St*, the stereome; *Ep*, the epidermis. × 330.

FIG. 6. Transverse section of the leaf of *A. Purshii*, showing three mestome bundles and three groups of bulliform cells on both faces; *Sup*, the superior face. × 165.




HOLM on AMPHICARPUM

## THE HABITATS OF THE RARER FERNS OF ALABAMA.

(WITH PLATE XXI)

INTEREST naturally attaches to any species of plants that grow near the borders of their geographic range. For this reason Alabama presents special interest to the student of ferns, because it is the southern limit of quite a number of ferns of the northern states, and also the northern limit of a few of the stragglers that come up from the south. The range of elevation, from the extreme lowlands of the Gulf region to the spurs of the Appalachian system that penetrate the state even beyond its center, is sufficient to give us a somewhat varied fern flora. Some forty species occur in the state exclusive of five species of Ophioglossaceæ.

The early exploration of the state was conducted by Judge Thomas M. Peters, and in later years Professor Eugene A. Smith and more especially Dr. Charles Mohr have the higher flora well in hand. I have been able to add to their list only a single species from the vicinity of Auburn, in the handsome swamp fern, *Dryopteris Floridana*, hitherto known only from Florida, where it is not uncommon. I am able also to reinstate a very distinct species of Botrychium which for many years has been masquerading under a false name. I give the characters and synonymy as follows:

### BOTRYCHIUM BITERNATUM (Lam.).

*Osmunda biternata* Lam. Encyc. Meth. Botanique **4**: 650. 1797.

*Botrypus lunarioides* Michx. Flora **2**: 274. 1803.

*Botrychium lunarioides* Swz. Syn. Fil. 172. 1806 (not Gray: Manual, etc.).

*Botrychium ternatum* var. *lunarioides* D. C. Eaton, Ferns of N. Am. **1**: 148. *pl. 20, f. 3.* 1879.

Sporophyte with fleshy roots from which rises a short common stalk 1.5 $^{cm}$ or less high, bearing a nearly sessile broadly triangular ternately compound leaf 8 to 10 $^{cm}$ wide, 5 $^{cm}$ long; middle division slightly larger than the lateral ones and like them nearly bipinnate; ultimate divisions somewhat lunate, usually not exceeding 5 to 6 $^{mm}$ in width, the outer margin crenulate, the lateral margins decurrent into the short branches of the rachis: sporophyll on a rather stout slightly elongate stalk (8 $^{cm}$ or more long), bipinnate, with a rather broad rachis: spores pale alutaceous, 39 to 44 $\mu$ in diameter: bud for the succeeding year enclosed in the base of the common stalk, smooth, the segments nearly erect or with the apices barely incurved.

Spores maturing in early spring (February or March in the latitude of southern and central Alabama). *Plate XXI.*

The plant was first collected by Michaux in South Carolina, and was described by Lamarck under the name of *Osmunda biternata.* Seven years later Michaux himself described it under the name of *Botrypus lunarioides*, while Swartz referred it to *Botrychium*, but unfortunately under the later name. Later writers confused all our northern forms that now constitute the somewhat variable *Botrychium ternatum* of our manuals under Michaux's name. Professor D. C. Eaton clearly distinguished this form and figured it in his *Ferns of North America,* but overlooked its very distinct leaf and bud characters, and supposed that its time of maturity was due to its southern station. As a matter of fact the true *Botrychium ternatum* is comparatively common in central Alabama, and produces its mature spores late in the season (August to October), the same as it does farther north. In Alabama the stations where *B. ternatum* is found are very different from those affected by this species. *B. ternatum* grows in moist places, frequently near the smaller water courses, while *B. biternatum* is found on dry, usually grassy, knolls, or dry pastures.

My attention was called first to the unusual fruiting time of this species by Dr. Mohr, while looking through his collection of ferns last winter. He regarded the form as found at Mobile as a distinct species. In the following March I found a single plant growing on a grassy knoll in Auburn, when I recognized clearly the distinctness of the species, and this conclusion has been fully confirmed by the bud characters as well as the spores. I find several specimens from South Carolina in the collection of Columbia University, and shall be glad to know of its further occurrence, since our present knowledge of its distribution limits it to these two states and Georgia, which was the source of Eaton's figure above cited.[3] Judging from the single specimen found by myself, collectors will have to get down on their knees more if they expect to find this plant, and the same is true of some of the other small Ophioglossaceæ of the Gulf states.

The species is readily distinguished from *B. ternatum* by its nearly sessile and more compound sterile leaf, as well as by the form of its ultimate divisions, which are distinctly rounded and short, lacking the

[3] Eaton's figure represents a small and possibly immature plant.

characteristic long, more or less pointed form common to that species. Its time of maturing its spores also clearly distinguishes it from *B. ternatum*. Moreover, *B. ternatum* is characterized by its hairy bud, a character which is constant in Alabama specimens, while the bud of *B. biternatum* is smooth.

There are some other distinct species that have been lumped with *B. ternatum* which must be separated, if indeed our northern species is the real *B. ternatum* Thunb. originally described from Japan; one of these species at least is American, but I wait for additional material to confirm this view. It is almost incomprehensible how such entirely distinct species can be thrown together in composites as has been repeatedly done by the English authorities on ferns. This is the common condition met with by any one who undertakes the study of these plants in their native haunts the world over. Jenman has found this true in Jamaica; Mr. Davenport and myself in Mexico; and I have found the same thing in a recent study of Hawaiian ferns.

Another interesting find in the vicinity of Auburn is the rare *Ophioglossum crotalophoroides*, which occurs in low grassy bottoms, and is occasionally found on gentle grassy slopes. It grows with its bulb deeply buried in the earth, the base of the sterile leaf barely rising above the surface. This station is the farthest inland the plant has yet been found.

The common ferns of central Alabama, aside from the ubiquitous *Pteris aquilina*, and *Polypodium polypodioides* on tree trunks and rocks, are *Woodwardia areolata*, *Asplenium filix-fœmina*, *A. platyneuron*, and *Dryopteris acrostichoides*, the latter almost at its southern limit. *Cheilanthes lanosa* is abundant on metamorphic rocks, *Woodsia obtusa* is occasional along streams, while *Dryopteris Noveboracensis* is occasionally found in damp woods; rarely *Dryopteris patens* will be found in exceptionally moist places; *Dryopteris Thelypteris* regularly and *Onoclea sensibilis* and *Phegopteris hexagonoptera* occasionally inhabit the open marshes. Of the Osmundaceæ, *O. regalis* and *O. cinnamomea* are not uncommon. These data apply more especially to the eastern central portion, and more particularly to the vicinity of Auburn in Lee county. Here we have an elevation of something like eight hundred feet, and this ridge forms almost the extreme extension of the Appalachian chain. As we descend from this elevation a few miles to the southward and westward, the more northern species disappear and only the species of the southern lowlands remain.

It is, however, the northern and northwestern portion of the state that presents more of interest to the fern hunter as well as to the botanist interested in any branch of the subject.

Two exceedingly interesting localities were visited during the months of May and June of the present year, and a considerable series of rare and interesting species were obtained, which have been distributed to the leading herbaria.

The first of these localities visited was Havana glen, which had been known as one of the stations of the rare *Asplenium ebenoides*, collected here many years ago by Miss Julia Tutwiler. Havana is a hamlet of a half dozen houses and shanties, in Hale county, and is reached by private conveyance either from Stewart's or Akron on the Alabama Great Southern railway. The glen is a deep gorge cut in a conglomerate rock, well wooded and shaded. Here, in addition to the ferns mentioned above, we find *Dryopteris marginalis*, commonly reduced in size so that mature spore-bearing fronds six inches long are not uncommon; also *Adiantum pedatum*, and on the rocks *Asplenium trichomanes* and *Camptosorus rhizophyllus;* here, too, we find *Botrychium Virginianum* of normal size. But the object of our search is here in considerable quantity, in fact the commonest fern of the glen, *Asplenium ebenoides*, originally discovered along the Wissahickon near Philadelphia, reported from a dozen stations ranging all the way from Canaan, Connecticut, to Hanover, Indiana, and southward, but, so far as I can discover, nowhere found in any quantity. Many have regarded it a hybrid, but the display of the species at Havana clearly demonstrates that it is not a hybrid at all. Its nearest congener is *Asplenium pinnatifidum*, but the frond is much thinner and more irregular than that species. In habit, however, it is very close to that species, growing far under overhanging rocks; in this respect it is totally unlike both *A. platyneuron* and *Camptosorus rhizophyllus*, its supposed parents. It appears to be multiplying, as many young plants were seen in the rock crevices. This myth of hybridity may be put aside, for *Asplenium ebenoides* is as clearly defined a species as we possess in the genus Asplenium, and has no near relations outside of its own genus.

The other habitat for the rarer ferns of Alabama is the old collecting ground of Judge Peters, and the type locality of *Trichomanes Petersii*, which will rank as the rarest as well as the most minute representative of its order in the country. Winston county, Alabama, noted for being one of the few Republican counties in the state and for the possession of only a single family of blacks, is a wild unsettled region toward the northwestern portion of the state, with a railroad crossing it at its southwestern corner. It must therefore be reached, if at all, by private conveyance. It is about equally near to Cullman and Decatur, and from either place would require a ride of about forty miles over a rough mountain road. It could also be reached from Haleysville, whence we made our exit, but railroad connection is uncertain in this direction, as we found, being obliged to wait twenty-one hours for a train. The distance in this direction is only about twenty-five miles, but the means of transit are mostly in the form of sharp-angled mules, and if the streams are "swimming" you are not certain to reach your destination the same day, or even the same week, particularly if you have any desire to keep your collections dry.

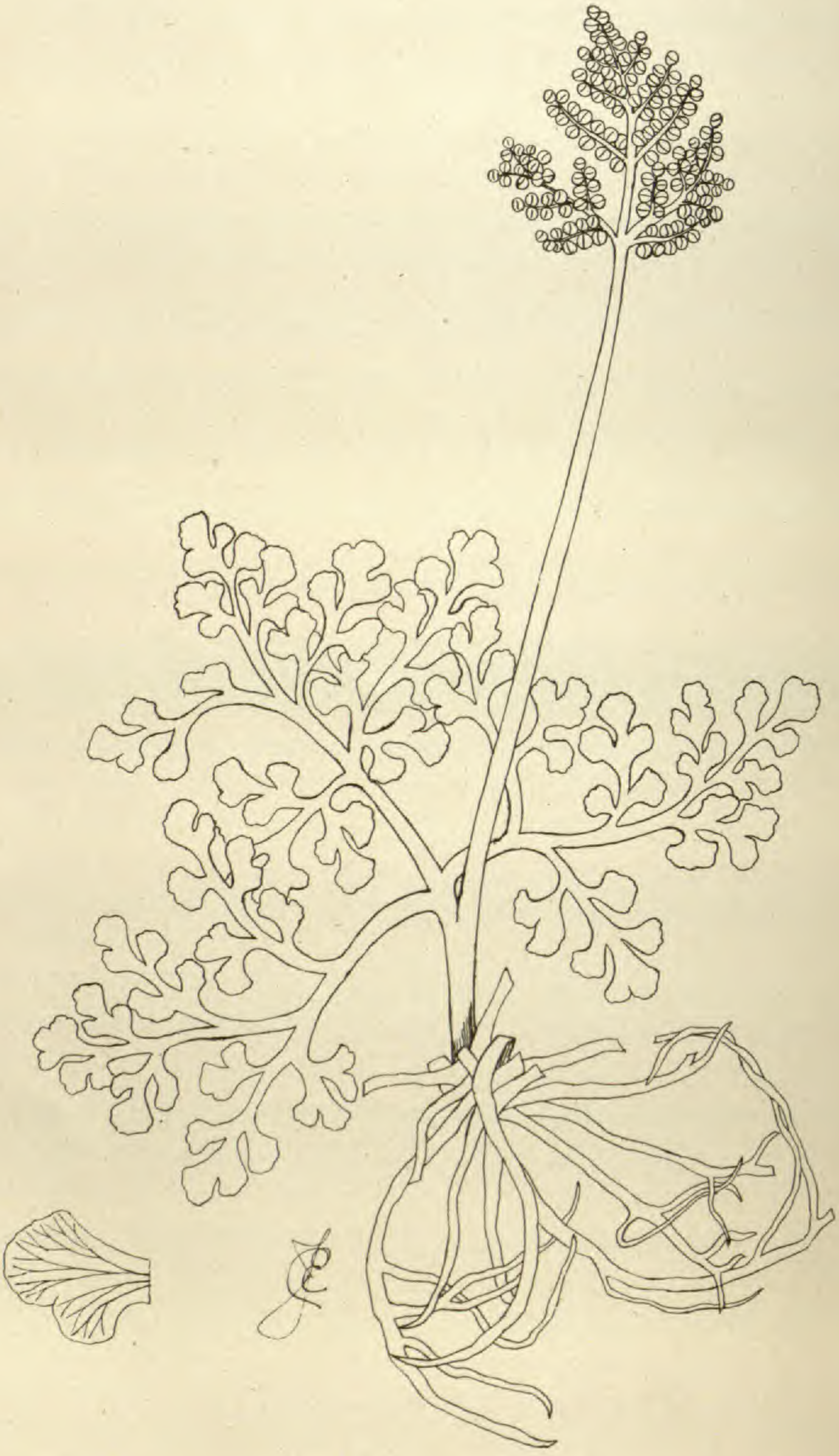
The people, as might be supposed, are primitive in their habits as well as quaint in their language, but are hospitable, and will share with you their best accommodations, and treat you well if you are not prone to show too much anxiety as to the place where they manufacture "mountain dew," a product of the mountains which is not mythical! In their gardens they cultivate old English herbs that are rarely seen elsewhere in this country, and they preserve many of the old English expressions and forms of speech. The region is heavily timbered, with very little cleared land, and the flora is of exceeding interest. It is the home of the magnolia, no less than five species growing here, one of them with leaves that often measure three feet in length and nearly half as wide as long. Most of the trees are of the deciduous types, with occasional areas of pine and a few hemlocks scattered among the ravines.

Here we find more of the northern types of ferns, among them many of the common ferns of the northern states. Among them are *Polypodium vulgare*, *Dryopteris spinulosa intermedia*, *Asplenium thelypteroides*, *A. angustifolium*, in addition to most of those mentioned above which are here in greater abundance. Nowhere, however, do we find anything of the profusion of ferns so common in the woodlands of the New England and Middle states. On the rocks, if limestone, we find *Pellæa atropurpurea*, which a little farther east (near Huntsville and Fort Payne) rendered us a most interesting series of young plants, commencing with cordate entire leaves, varying with age to broadly triangular hastate, and later developing forms that are made up of three pinnæ, the terminal one often very broad and hastate, as in the case of the earlier simple ones.

On the sandstones and shales we find *Asplenium pinnatifidum* and *A. montanum* in great abundance. In similar formations, usually in dark shaded ravines and underneath broad shelving rocks, deep in the darkest recesses, *Trichomanes radicans* grows in the greatest profusion. Nowhere within our experience in this country does the tropical character of fern vegetation manifest itself more strikingly than it does here under these dark and gloomy shelves where, in a minimum of light, beds of this filmy fern twenty feet long and two or three feet wide thrive in the slight but perpetual drip of the water that percolates through the rocks. Not even in the swamps and sink-holes of southern Florida, where the ferns of the tropics still persist in greater variety, is there so striking an impression of tropical luxuriance and the peculiar clammy moisture that one expects in tropical vegetation.

The rarest fern to find, however, even when you are near its station, is the elegant *Trichomanes Petersii.* Within the section[4] that contains the type locality it took two days of very earnest search to find it. From the description of the original station I had expected to find it "on rocks wet with the spray of waterfalls," but all such over moist localities yielded no returns. When I had almost given up the search I found it at last creeping under the roof of shelving rocks, sending up at intervals of one or two centimeters its tiny fronds that look more like the leaves of a large *Mnium* than a fern ; it occasionally forms matted masses of fronds like those distributed by Judge Peters years ago, but it is distinctively a creeping plant. I learn from Dr. Mohr that the plant is found at one or two other stations, but so far it is not known outside of Alabama. Its minute size, however, and its unusual habitat would evade one not familiar with its habits, and it may have a wider distribution than I now suspect for it. But before these things will be known we need any number of people, call them botanists or what you may, who know plants, their haunts and habits, who love the fields and woods and search them with the zeal that prompted Peters and Beaumont and the other earlier botanists of Alabama to make known their native flora.—LUCIEN M. UNDERWOOD, *Auburn, Ala.*, now of *Columbia University.*

[4] T. 8. R. 9. Sect. 10, Winston county.



BOTRYCHIUM BITERNATUM (Lam.) Underw.

## EXPLANATION OF PLATE XXI.

*Botrychium biternatum* (Lam.) Underw., natural size, with segment enlarged. Drawn by Miss Julia E. Clearwaters, from herbarium specimen collected at Auburn, Ala.

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## A NEW SMUT.

I WISH to call the attention of mycologists to one of the Ustilagineæ which presents some features of interest. It is of the Doassansia group and occurs in the culms of *Glyceria fluitans*, the white mycelium ramifying through the tissues and in the central cavity. The wall of the young sorus is formed of coherent brown hyphæ arching from base to apex. Outside of the wall are a few white unmodified hyphæ extending from the base to or toward the apex. When the young sorus is crushed in water under a cover glass the contents are seen to consist of a transparent substance which protrudes from the rent in the wall of the sorus like the ascus of a Sphærotheca, and which is immediately withdrawn into the sorus when the pressure is removed. When the sorus is mature the spores are irregularly one to three deep on the surface, lying upon dark brown pseudoparenchyma which constitutes the greater part of the sorus, but which is limited internally by a narrow layer of hyphæ lining a central cavity into which the free ends of the hyphæ project a few micra. It may be that the parenchymatous tissue in time fills the sorus, as I have not sectioned sori that had germinated.

The sori are most readily found in the central cavity of the host, loosely attached to its walls, and are most common in the lower internodes. It was collected at Racine, Wisconsin, and Mr. H. F. Lueders kindly searched for and found it at Sauk City, Wisconsin.

I found it difficult to induce the spores to germinate. Material, however, that had been collected the previous year and kept continuously exposed to the weather was found to be germinating in the latter part of September. Sori from this material placed in distilled water on a slide in a moist chamber showed slender promycelia projecting from the sori, each of which bore at its apex a globule of fluid within which the sporidia were formed, the globules increasing in size as the sporidia developed. When two globules came in contact they coalesced, and thus the sporidia of two or more promycelia would lie in a single globule. These globules resemble oil droplets in appearance. One germinating sorus from which the culture drop had receded put forth long hyaline somewhat sinuous filaments, the branches (lateral) of which resembled promycelia and bore globules at their tips. The after development of the sporidia I have not seen. The structure of the mature sorus of this fungus seems to approximate it to the genus Burrillia, established by Dr. Setchell for a species growing in the leaves of Sagittaria.[5] It may be characterized as follows:

**Burrillia globulifera,** n. sp. Sori globose to elliptical, dark brown or black, surface uneven, 250–450 $\mu$ in diameter. Spores one to three deep on the surface of the sorus, dark brown, closely compacted, irregularly polyhedral, 6–9 $\mu$ in diameter. Sorus beneath the spores composed of dark brown pseudoparenchyma limited within by a narrow layer of hyphæ enclosing a central cavity. Development of the sorus centripetal. Germination of the spores in the sorus. Promycelia about 2 $\mu$ in diameter, 30–80 $\mu$ long, brownish, studded with numerous minute rounded prominences. Sporidia 4 to 8 or more, terminal, whorled, cylindrical, 12–18 $\times$ 3 $\mu$, formed in a globule of fluid.

In the culms of *Glyceria fluitans* R. Br. Racine and Sauk City (*Lueders*), Wisconsin. October and later. To be distributed in Ellis and Everhart's *North American Fungi*, no. 3481.—J. J. DAVIS, *Racine, Wisconsin.*

[5] Annals of Bot. **6**: 36–37. 1892.

# EDITORIALS.

**An American Tropical Laboratory**

THE WORK that has been done and undertaken at Buitenzorg, and the various problems in which American botanists are interested and which need tropical conditions for their proper investigation, constrain us to believe that the time has come for the establishment of a laboratory in the American tropics. The science of botany in general, so far as morphology, physiology, and ecology are concerned, rests largely upon the results of researches carried on in the north temperate zone, in gardens and laboratories situated between the parallels of 40° and 55°. While taxonomy has had world-wide material for its superficial diagnoses, and has reached a fair measure of knowledge concerning the general relationships of plants, knowledge of these other great divisions of the science has been derived from a study of the plants indigenous to a strip of territory fifteen degrees in width and extending across one continent and partly across another, and of those introduced from other regions and growing under abnormal conditions of climate or substratum in the open air and in conservatories. That many of the conclusions reached under such circumstances are not capable of general application is becoming more and more apparent.

IN ORDER to come in contact with the problems that are now pressing, the botanist must establish his laboratory in the midst of the normal conditions, and no condition is so vitally needed by botanical research, and so overwhelmingly lacking, as that furnished by the tropics. In consequence of this, the garden and laboratories at Buitenzorg already have furnished opportunities for many important discoveries, and have become a sort of Mecca to the botanists of the world. But to an American botanist Java is a hemisphere away, and a visit to Buitenzorg is equal to a trip around the globe. A month is necessary for the journey each way, and the cost of it, including but a brief stay at the laboratory, is about twelve hundred dollars.

THE AMERICAN BOTANIST needs to make no such journey. At the distance of a week's travel from almost every important laboratory there lies a tropical region whose teeming flora is but little known, even to taxonomists. At our very door there lies a vast *terra incognita*, with excessively luxuriant vegetation, and inviting endless research. The duty seems to be laid upon American botanists to establish and maintain an international laboratory in the American tropics, one which American botanists can visit at small expense during a summer vacation, or upon a short leave of absence, and in which the observer in the oriental tropics would find still other revelations. It is impossible to overestimate the value of such an institution, not only to American botany, but to the science in general.

THE ESTABLISHMENT of such a laboratory might be accomplished most easily by the cooperation of several universities, for its intercollegiate character should be maintained. Perhaps the original cost should be borne by private subscription, and the running expenses met by the different universities pledging themselves for so many tables. At least the subject deserves to be taken in hand by a committee of botanists and investigated in all of its bearings. A study of the map will show that the conditions to be met favor either the eastern coast of Mexico or the islands near the Caribbean Sea. It is estimated that a trial station might be maintained on one of these islands for one year at a cost of $5000; and after the selection of a permanent station the laboratory buildings might be constructed and extended according to the demand. The use of grounds necessary could be obtained from the government, and the area should embrace all possible levels so far as possible, a feature at Buitenzorg which is nearly ideal.

IT IS TO BE HOPED that a reconnoissance party of American botanists will soon visit the region proposed and report as to possible sites. Such a visit should be made before the botanical meetings of next summer, to which the report would be most appropriately made.

# OPEN LETTERS.

## SCIENTIFIC CHIEF FOR THE DEPARTMENT OF AGRICULTURE.

*To the Editors of the Botanical Gazette*:—The editorial in the GAZETTE for September relative to a scientific chief of the Department of Agriculture gives an entirely wrong impression as to the position of those in charge of the botanical work here. So far as I am aware, the entire scientific corps of the Department are in favor of a chief such as is contemplated. My open letter in the GAZETTE for September has no bearing upon this question, but was written in answer to the statement that there is a dissipation of energy and a duplication of work in the botanical branches of the Department, and that this could be avoided by certain changes, which, in the judgment of the writer, would destroy the autonomy of the present divisions.—B. T. GALLOWAY, *Washington, D. C.*

## THE CHECK-LIST[1] AND THE NEW ILLUSTRATED FLORA OF NORTH AMERICA.[2]

*To the Editors of the Botanical Gazette*:— Ever since the publication of the above cited *Check-list* many and very diverse opinions have been expressed as to the advisability of adopting this work with its numerous changes in nomenclature. The various discussions upon this subject have, however, been largely confined to the question whether such changes are advisable or not, while very little has been said about the possibility of making all these changes. We should like, therefore, to submit to American botanists a brief statement of this phase of the question: the possibility of correcting old names.

It appears to the writer that some of the requirements that are most needed for undertaking this kind of work are: (1) access to the type-specimens, (2) a broad linguistic knowledge, (3) a thorough familiarity with botanical terminology, (4) a long continued study of systematic botany in field and library.

[1] List of Pteridophyta and Spermatophyta growing without cultivation in northeastern North America. Prepared by a committee of the Botanical Club. New York: 1893–4.

[2] N. L. BRITTON and HON. ADDISON BROWN: An Illustrated Flora of the Northern States and Canada. New York: 1896.

We would ask whether the lately published volume of the illustrated *Flora of North America* is really sufficient to satisfy American botanists in regard to these requirements, so that the *Check-list* may be unanimously adopted. That the *Check-list* and the new *Flora* are closely connected is evident when we look at the names of the authors and contributors, although two have withdrawn from the former publication. We can, therefore, with good reason compare the character of the *Check-list* with that of the illustrated *Flora*, and we feel inclined to think that the order of publication ought to have been first the *Flora* and afterwards the *Check-list.*

Without going into details as to these publications, at least not in this place, we desire to submit the following questions in order to secure an early discussion of the matter:

1. Does the family diagnosis in the illustrated *Flora* seem sufficient to separate closely related families, and have the most important distinctions been given ?

2. Does the terminology correspond with well recognized usage at home and abroad ?

3. Are the descriptions correct in regard to morphology, as adopted in leading systematic works ?

4. Does a consideration of this *Flora* with these questions in mind satisfy the botanist that the authors of the *Check-list* were in full possession of the necessary requirements ?*—THEO. HOLM, *Washington, D. C.*

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## THE NATIONAL HERBARIUM AND THE DIVISION OF BOTANY.

*To the Editors of the Botanical Gazette:*—In view of an evident lack of correct information regarding the recent change in the custody of the National Herbarium it has seemed desirable that a brief sketch of the present relationship and work of the Division of Botany and the Herbarium be presented to your readers.

During at least the past three administrations, covering a period of nearly twelve years, there has been a feeling among the authorities of the Department of Agriculture that the Division of Botany should be relieved of the custody of the National Herbarium, that institution having grown beyond a mere consulting herbarium to the dimensions of a great governmental repository of botanical collections, thereby becoming a fit charge for the Smithsonian Institution. As a result of negotiations between the two establishments, the herbarium was transferred about two years ago from the Department of Agriculture to quarters in the fireproof building of the National Museum, which is under the direction of the Smithsonian Institution, the Department, however, continuing to furnish the money for its maintenance.

* See Holm's letter in Herb., under Hypericum.

But on July 1, 1896, the Museum assumed complete charge of the Herbarium, being enabled to provide for it through an increase of $10,000 in the appropriations of the Museum, added by Congress for this special purpose. The disbursement of this sum for the National Herbarium is made, therefore, through the Smithsonian Institution. Two assistant curators, Dr. J. N. Rose and Mr. C. L. Pollard, have been transferred from the Department of Agriculture to the Museum, with the necessary clerical help, and a new assistant curator of the cryptogamic collections, Mr. O. F. Cook, appointed, the botanist of the Department of Agriculture, Mr. Frederick V. Coville, continuing to serve, without salary, as curator. Provided with a force of ten people, in addition to the curator, situated in fireproof quarters, and managed by the Smithsonian Institution, the National Herbarium is now favorably situated to continue its development as the repository of the botanical collections acquired by the various branches of our government.

The Division of Botany in the Department of Agriculture has now a force of twenty persons, including clerks and laborers, and funds to the amount of $29,000 available for the expenditures of the present fiscal year. Mr. Frederick V. Coville is botanist and chief of division and is especially engaged in work upon the native plant resources of the United States and upon the geographic distribution of plants. Mr. G. H. Hicks is assistant chief and has special charge of seed investigations and the laboratory equipped for that purpose. Mr. L. H. Dewey has charge of all matters relating to weeds, information about the damage done by them, their present distribution and means of dissemination, ways of holding them in check, and warnings about newly introduced species. Mr. V. K. Chesnut has charge of the pharmacological laboratory and conducts investigations on poisonous plants, more particularly those native species which are a common cause of poisoning in man or domestic animals. Mr. A. J. Pieters has charge of the anatomical and photographic work of the division, and is conducting a special series of experiments on the germination of weed seeds. Mr. W. W. Tracy, recently appointed from the seed farm of D. M. Ferry & Co., has charge of greenhouse and outdoor variety tests of seeds and of the cultivation of native food and other economic plants. Mr. J. C. Dabney is assisting in experiments in seed selection and is making studies of the effect of various chemicals upon germination. Mr. Sothoron Key has charge of laboratory germination tests, is conducting practical trials of the relative merits of various kinds of laboratory apparatus, and is making studies in regermination. Mr. John B. Leiberg is carrying on the greater part of the field work connected with the special studies of the botanist. Mr. F. A. Walpole is the artist of the division, recently appointed after passing the highest examination among twenty-one competitors.

The Division of Botany as at present organized is an establishment equipped with the best scientifically trained men obtainable, and with the best modern applicances, for the investigation of agricultural botanical problems.—FREDERICK V. COVILLE, *Washington, D. C.*

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## THE FLORA OF ALABAMA.

*To the Editors of the Botanical Gazette:* Having just returned from a three months' trip through the north my attention was called yesterday (Sept. 4) for the first time to the severe criticism of my bulletin in the BOTANICAL GAZETTE issued in July. The article would give me little concern but for the unjust charge that I had treated Dr. Mohr with unfairness because he "granted me a favor that has been abused." Eliminate this feature of the "review" and there is little for me to complain of. The article of which I complain is so cruelly unjust and there is such a tone of keen sarcasm pervading the entire paragraph I cannot refrain from entering my protest and demanding at least a fair statement of the facts. There is the most friendly relationship existing between Dr. Mohr and myself, and if there has been any complaint on his part of slight or "favor abused," I am yet to hear of it. A careful reading of the bulletin will show that I have been very punctilious in giving Dr. Mohr ample credit for all the assistance he has rendered me; not only after each species is his name printed, but on page 279 the following occurs: "The author acknowledges with pleasure material assistance from Dr. Chas. Mohr of Mobile in locating many of the species mentioned in this bulletin." In several instances his name is given alone, although I had also gathered specimens in the same county. It seems to me there is no injustice done Dr. Mohr in giving him credit for all information secured from him, and there can be no interference with his proposed work on the botany of Alabama, since my bulletin is simply a list of localities and nothing more, while his book will give full details in all matters relating to the plant. I am confident from what I know of Dr. Mohr he cannot consider my list as antagonistic to his work. Before publishing my bulletin I sent the list of species to Dr. Mohr and requested him to examine it carefully and give me the names of other counties if possible. I stated in my letter that it was my intention to publish the list as one of the bulletins of the state station, and I would like to get his consent to use his information. In reply to this letter he not only gave me the additional counties asked for, but was kind enough to add a few other species to my list (he added 19). I give below a copy of his letter which clearly shows his willingness to permit me to use his information as requested in my letter to him.—P. H. MELL, *Auburn, Alabama.*

MOBILE, March 13, 1896.

PROFESSOR P. H. MELL, *Dear Sir:* Your favor of the 11th came duly to hand. It gives me pleasure to return herewith your list of Leguminosæ and Rosaceæ, according to your request, with the localities known to me in Alabama. I have added several species of these orders not mentioned by you. I am anxious to learn if any of the plants enumerated by you, and which I could not locate in the state, have been observed by you within its limits, and if you have collected any specimens of them, I shall be greatly obliged to you if you will give me the localities of such to be inserted in my forthcoming Flora of the state. Any contribution will be gladly received and I need scarcely say that due credit will be given to all whom I have to thank for their kind assistance. I remain yours very truly.

CHARLES MOHR.

[The above is an extract from a private letter from Professor Mell, only those parts being omitted which pertain to the other features of the criticism referred to. This publication has been delayed by a desire to discover the real facts in the case. The GAZETTE is glad to say that Professor Mell should be exonerated from any intention to abuse the information received from Dr. Mohr. He certainly has acted in good faith as he understands it. The GAZETTE can only add that as it has been known for a long time that Dr. Mohr has had in preparation a "Flora of Alabama" the appearance of an independent publication under the same title, and using much material obtained from Dr. Mohr, seemed to need explanation, especially as no reference to the forthcoming work of Dr. Mohr was made. It is true that the information obtained from Dr. Mohr is credited, but the more important statement concerning the use Dr. Mohr was expecting to make of his material, and that the present list was intended in no way to interfere with it, would have explained the situation. Professor Mell has worked for many years in a botanical region peculiarly rich, and there is no reason why he should not have made large contributions to our knowledge of the flora of Alabama, contributions which when substantiated by herbarium material would justify the publication of a state list contemporaneous with another prepared by a very competent botanist.—EDS.]

# CURRENT LITERATURE.

## MINOR NOTICES.

MR. A. P. MORGAN has just published his fourth paper upon the Myxomycetes of the Miami valley (Ohio),[1] containing the Physaraceæ. Out of Physarum of Persoon's *Synopsis* (1801) seven genera have come, which with Fuligo and Craterium makes this family the largest one of the Myxomycetes. Mr. Morgan has followed Lister in discarding Tilmadoche of Fries, but he has separated from Physarum a new genus, *Cytidium*, characterized by the presence of a columella, and composed for the most part of very closely related species. Both Leocarpus and Craterium have been enlarged to receive two or three species of Physarum. Scyphium of Rostafinski is restored, being characterized by the form of the sporangium and the prolongation of the stipe into a columella. Examination of the forms merged by Rostafinski under *Fuligo varians* has decided the author to return to the species of Persoon. A fifth paper is intended to close the series.—J. M. C.

MR. P. A. RYDBERG has published the results of his study of the North American species of the perplexing genus Physalis.[2] No genus was in greater need of careful revision, as the species are difficult to separate, and apparently most of those recognized were composites. To their disentanglement Mr. Rydberg has brought great patience, a good insight, and an abundance of material. His examination of herbarium material has been unusually complete, and much field work has served to make this examination profitable. When many accepted species are represented by a plexus of species the synonymy becomes peculiarly difficult, and the author confesses to the chaotic condition in which he found the synonymy of Physalis. A full and critical discussion of the species precedes their synoptical presentation, in which are included the five allied genera Margaranthus, Quincula, Leucophysalis, Chamæsaracha, and Orcytes. Margaranthus contains four species, one of which (*M. purpurascens*) is new. Of Physalis thirty-nine species are recognized, with the statement that many remain undescribed, notably Mexican forms. *P. pubescens*, as formerly recognized, is broken up into *P. pubescens* L., *P. pruinosa* L., *P. Neo-Mexicana*, n. sp., *P. Barbadensis* Jacq., and *P. Lagascæ* Roem. & Sch. *P. lanceifolia* Nees is separated from *P. angulata* L. *P. ixocarpa* Brot. replaces *P. æquata* Jacq. *P. lanceolata lævigata* Gray becomes *P. longifolia* Nutt., and the allied *P. Texana* is described

[1] MORGAN, A. P.—The Myxomycetes of the Miami valley, Ohio. Jour. Cincinnati Soc. Nat. Hist. 19: 73–110. *pl. 13–15.* 1896.

[2] RYDBERG, PER AXEL.—The North American species of Physalis and related genera. Memoirs of the Torr. Bot. Club 4: 297–374. 1896.

as new. *P. lanceolata hirta* Gray is *P. pumila* Nutt., and *P. Virginiana* Mill. is separated from *P. lanceolata* Michx., while *P. Virginiana* Gray and *P. viscosa* Pursh become *P. heterophylla* Nees. *P. ciliosa*, n. sp., is from the Gulf states, *P. rotundifolia*, n. sp., is from the West, *P. hastata*, n. sp., is from Lower California. The genus *Quincula* Raf. is recognized, and includes *Physalis lobata* Torr. *Leucophysalis* is a new genus constructed upon *Physalis grandiflora* Hook. It seems that *Chamæsaracha Coronopus*, as recognized, was a plexus, from which the author has separated *C. crenata*, n. sp., and *C. conoides* Britton (*C. sordida* Gray). *Orcytes* Wats. still remains a monotypic genus.—J. M. C.

## NOTES FOR STUDENTS.

THE FIRST FASCICLE of *Pringle's Mexican Fungi* has recently been distributed by the Cambridge Botanical Supply Company. It consists of ten numbers, as follows: 1. *Puccinia heterospora* B. & C. on Anoda; 2. *P. heterospora* B. & C. on a malvaceous plant; 3. *Uromyces effusus* (Pk.) DeToni on Rhus Mexicana; 4. *U. Sophoræ* Pk. on Sophora sericea, uredospores; 5. Same, teleutospores; 6. *Æcidium Solani* Mont. on Solanum torvum; 7. *Æcid. Anisacanthi* Pk. on Anisacanthus virgularis; 8. *Parodiella perisporioides* (B. & C.) Speg. on Indigofera; 9. *Puccinia Tetramerii* Seym. on Tetramerium aureum; 10. *Leptostroma vestita* S. & P. on Agave vestita. The specimens are well put up and bear printed labels. The publication is edited by Mr. A. B. Seymour. Nos. 9 and 10 are new species; the descriptions accompany the specimens. They are also described in the *Botanical Notices*[3] of same date. As neither of these publications are likely to have a wide circulation, the descriptions are reproduced here.

*Puccinia Tetramerii* Seymour (Pringle's Mexican Fungi, No. 9, September 1, 1896).—Spots none; sori amphigenous, varying from minute to $5^{mm}$ in diameter, very dark; spores elliptical, covered with coarse blunt warts, dark, with broad and blunt apiculus somewhat lighter and occasionally a similar less prominent projection at side of spore; size of spore $11-15.5 \times 33-42\,\mu$; pedicels about $78\,\mu$ long, colored at junction with spore, otherwise hyaline, rough below.

On leaves of *Tetramerium aureum* Rose. Tomellin Cañon, Oaxaca, Mexico, November 30, 1895. Collector, C. G. Pringle.

*Leptostroma vestita* Seymour & Patterson (Pringle's Mexican Fungi, No. 10, September 1, 1896).—Amphigenous, mostly epigenous, stromata numerous, imbedded and slightly depressed, orbicular to oblong, $.5-1^{mm}$ (rarely to $2.5^{mm}$), covering most of the upper leaf surface, distinct or often confluent, olive with a narrow black margin; conceptacles 2 to 5 in a stroma; spores hyaline, linear, multiguttulate, guttulæ often elongated and appearing like vacuoles; size of spores $30-85 \times 4\,\mu$.

On leaves of *Agave vestita* Watson. Barranca near Guadalajara, Mexico, May 1891. Collector, C. G. Pringle.—J. C. A.

[3] A trade publication in the form of a card catalogue issued monthly by the Cambridge Botanical Supply Co.

MANY BULLETINS of the agricultural experiment stations contain matter that borders more or less directly upon botany, or have botanical matter interspersed among other subjects, thus rendering them of some interest to botanists. Of recent issues of this character are the following: A. D. Selby has mapped out the distribution of peach yellows in Ohio (Bull. 72), showing it to occur along the shores of Lake Erie in the north and in one county in the south part of the state. Considerable information is given regarding this disease, and also that of black knot of plum, with remarks upon some other diseases of fruit trees. L. H. Bailey (Cornell Bull. 117) figures and describes root galls upon apple trees, and also discusses some causes of winter injuries to fruit trees. The relation of loss of moisture through the bark to hardiness is examined with some original data on the loss of moisture from twigs of apple. F. C. Stewart (N. Y. Bull. 101) gives results of spraying potato plants, describes the internal browning of the tubers, which was found experimentally not to be due to bacteria or fungi, and not to be transmissible to the succeeding crop, and also describes two new stem blights of which the cause was not ascertained for one, and for the other a new species of Fusarium (*F. acuminatum* E. & E.) was detected. Thomas A. Williams reports (S. D. Bull. 48) tests with corrosive sublimate, eau celeste, and Bordeaux mixture for prevention of potato scab, the first being found most effective. Luther Foster gives results (Mont. Bull. 9) of trials in growing potatoes, including treatment for scab. L. F. Kinney (R. I. Bull. 38) treats of the use of Bordeaux mixture in preventing the phytophthora disease of potatoes. F. M. Webster (Ohio Bull. 69) examines the claim that *Sporotrichum globuliferum* and similar fungi can be used to hold the spread of the chinch bug in check, and comes to the conclusion that "these fungous diseases, in order to work sufficiently rapidly and effectually to benefit the farmer, require peculiar meteorological conditions and a superabundance of insects at the same time." In a bulletin by H. H. Nicholson and T. L. Lyon (Neb. Bull. 44) some good data are recorded on the use of large and small beet seed, and also on heavy and light seed. In a bulletin on apple culture by L. F. Kinney (R. I. Bull. 37) record is made of the number of flower buds on limbs fully exposed to the light and those in shade on the same tree, the average of ten examinations, including several varieties, giving 182 buds upon limbs in full light to 136 buds upon limbs in partial shade. The relation of the Burrill cornstalk (bacterial) disease and of corn smut to the cornstalk disease of cattle is quite fully treated in a bulletin by N. S. Mayo (Kans. Bull. 58), with the conclusion that both these plant diseases cause no derangement or disease in animals. R. J. Davidson (Va. Bull. 50) gives the chemical analyses of different parts of the tobacco plant taken at different stages of development. B. C. Buffum (Wy. Bull. 29) describes, with illustrations, some experiments upon the effect of alkali upon germination and growth, to show the nature of alkali soils. The relation of soil moisture to vegetation is touched upon in a bulletin by L. A. Clinton (Cornell Bull. 120), and in one by F. W. Rane (N. H. Bull. 34), the latter treating of irrigation. —J. C. A.

THE BOTANICAL SEMINAR of the University of Nebraska has published, as a special brochure, an address recently delivered under its auspices by Professor Conway MacMillan, entitled "Some considerations on the alternation of generations in plants." The discussion is interesting and suggestive, and the "main contention" is summarized by the author as follows:

"The definition of rudimentary alternation should be widened so as to include rejuvenescence of the syngamete."

By "rudimentary alternation" is meant that form of it in which the indirect development of the sexually formed cell (syngamete) does not result in a distinctly organized body. In this category the author would include not merely the cases in which the syngamete produces directly several zoospores, as in Sphæroplea, but also those in which there is merely rejuvenescence, as in the zygospore of Spirogyra.

"Indirect development of a cell resulting from a sexual process is most fundamentally a sensitization and serves to compensate for that general sexual immobility which arises from the preponderant constructive chemism of plants."

Alternation of generation is generally spoken of as a device by which the product of the sexually formed cell is multiplied, and hence the more highly developed the sporophyte the greater the advantage. Our author, however, sees in it something deeper, which he calls "sensitization," by which he means the bringing of a syngamete cell "into more intimate reciprocal relations with the environment," as seen in a primitive way in rejuvenescence. This, he thinks, is an offset to the general stability of plants, a stability which follows from their essentially constructive character, as opposed to the destructive character of animals.

"Further development of alternation is accentuated by cleavage phenomena in the egg, and eventually a group of blastomeres becomes integrated as such and is the sporophyte. This body is peculiarly a plant product and in its origin and progressive specialization is as distinctly a structural response to the plant type of chemism as the head is a structural response to the animal type of chemism. Sporophytization, therefore, in the plant phylum, is a phenomenon of coordinate importance with cephalization in the animal, and homologies between the vegetative tracts of the higher plants and higher animals lie below the plane of the cell unit."

The author also presents a "classification of alternation of generations," which may be of interest to some as a new setting for old facts.

Alteration types.
- A. Recapitular alternation.
- B. Heteroblastic development.
- C. Sprout alternation.
- D. Homologous alternation.

Alternation types.
- A. Rudimentary alternation.
  - I. Rejuvenescence alone.
  - II. Rejuvenescence with segmentation.
  - III. Segmentation alone.
- B. Discrete alternation.
- C. Concrete alternation.
- D. Symbiotic alternation.

"Recapitular alternation" refers to "the passage from the vegetative multicellular to the reproductive unicellular condition;" "heteroblastic development" refers to such an alternation as that of Chantransia and mature Batrachospermum forms; "sprout alternation" defines itself; "homologous alternation" occurs where a potential gametophyte alternates with an actual gametophyte. These are styled "alteration types." The true alternation types are defined as follows: "Rudimentary alternation," defined above;" "discrete alternation," as in archegoniate plants (exclusive of gymnosperms); "concrete alternation," as among the Florideæ; and "symbiotic alternation," as in spermatophytes.—J. M. C.

MR. HAROLD WAGER has noted several new features in the development of the sexual organs of *Cystopus candidus*.[4] When these organs have reached their full size the oogonium contains 64 to 115 nuclei, and the antheridium 6 to 12. The protoplasm of the oogonium contracts toward the center, forming a central vacuolated mass surrounded by a denser layer, the periplasm. The nuclei divide and pass out into the periplasm, and one of these daughter nuclei moves toward the center and becomes imbedded in a dense mass of protoplasm which has collected there. Meanwhile the antheridial tube is being formed, and after nuclear division a daughter nucleus passes to the tip of the tube. When the tube reaches the dense mass containing the female pronucleus, the male pronucleus is discharged. A wall now appears around the oosphere, inside the periplasm. Fusion of the pronuclei soon follows. The fusion nucleus divides into two, and division continues until 32 nuclei are formed. This number is found in the resting oospore. Germination of the oospore was not observed. The division of nuclei in the sexual organs can hardly be regarded as a reduction process, for 20 to 24 chromosomes are found in the oosphere nuclei, and only 12 to 16 in the nuclei of the oogonium.—W. D. M.

MISS ETHEL SARGENT has investigated the formation of the sexual nuclei in *Lilium Martagon*.[5] The resting, vegetative nucleus contains a substance which she calls "amorphous chromatin." This is not present in the spirem stage, but the increased amount of chromatin in ribbon may account for its disappearance. The chromosomes split longitudinally after they have taken

[4] Annals of Botany 10: 295, 1896.

[5] Annals of Botany 10: 107, 1896.

their place to form the nuclear plate. In the resting stage the primary nucleus of the embryo-sac has the vegetative characters, but as division approaches the chromatin thread contracts to one side of the nuclear cavity, the nucleolus partially dissolves, and there is also a partial disappearance of the nuclear membrane. The nucleoli and membrane reappear in the spirem stage. The spirem of the embryo-sac nucleus differs decidedly from the vegetative type. The ribbon of the vegetative spirem stains like chromatin, but in this spirem there is an erythrophilous ribbon bordered by chromatin. Longitudinal fission of the entire ribbon takes place before segmentation into the lengths which become the chromosomes. The nuclei resulting from the second and third embryo-sac divisions resemble the primary nucleus in the staining of the ribbon, but otherwise they follow the vegetative type. After the second division the lower antipodal nucleus divides by the direct method.

The number of chromosomes in vegetative nuclei is generally about twenty-four; in the primary nucleus of the embryo-sac, twelve; but after its first division the micropylar nucleus has twelve, while the antipodal may have from twenty to thirty-two. Throughout the oogenesis twelve chromosomes seems to be a constant number for the micropylar end of the sac, but in the antipodal end the number varies from twenty to thirty-four. The transverse division of chromosomes, which Dr. Haecker suggested might precede the formation of the sexual nucleus, does not occur.—C. J. C.

SEVERAL physiological papers have recently been printed by Professor D. T. McDougal of the University of Minnesota, in part based upon experimental data, and in part upon critical deductions from the works of others. Additional papers on the same subjects are in course of publication, but those already upon the table are of sufficient importance to merit present attention.

His initial study, the mechanism and procedure of tendrils by which coiling is effected, has given, perhaps, the most important results.[6] Begun in the physiological laboratory of Purdue University in 1891, and continued as occasion permitted since, it has illuminated a number of obscure points, and done much toward making the whole matter of tendril movement understandable. The complex nature of the phenomenon is shown by the previous lack of discrimination between the act of coiling of the free part of the tendril, a function of maturity, and the sensitive response to contact.

The generalization is especially helpful that a class of plant movements dependent upon rapidity for effectiveness are only indirectly associated with

[6] For the earlier papers see this journal **17**: 205–212. *pl. 14.* 1892; **18**: 123–130. *pl. 10.* 1893; and Bot. Centralblatt **66**: 145, 146. —. The recent papers are two: "Ueber die Mechanik der Windungs- und Krümmungsbewegungen der Ranken," Ber. d. d. bot. Gesellschaft **14**: 151–154. 1896, and "The mechanism of curvature of tendrils," Annals of Botany **10**: 373–402. *pl. 19.* 1896.

growth and are brought about by the contraction of the concave side, while a class of movements where position is secured slowly, as heliotropic and geotropic curvature, are directly associated with growth and are brought about by elongation of the convex side. In Passifloreæ the region of maximum growth never coincides with the region of maximum irritability.

The morphological nature of tendrils is various, and the assumption that they may have various methods of producing movement is well made. The chief study has been given to tendrils of Passifloreæ and Cucurbitaceæ, which have similar structure. It is found that the pull of a stimulated tendril amounts to less than one-half gram, while that of a free coiling tendril is twenty to sixty times as great. In the first case rapidity of movement is the essential feature, and in the second the production of strains. By a variety of studies, including plasmolysis, it was ascertained that tendril movement in the two families named is always due to shortening of the concave side, a point which has been much in controversy.

The author brings support from various sources, including anatomical, for his conclusion that the cause of coiling resides in the irritability of protoplasm of the concave side, by which the protoplasts are rendered more permeable, water passing into the intercellular spaces, thus allowing the previously stretched cell walls to contract. Space does not permit mentioning other parts of the investigations.

A summary of present knowledge on the physiology of color in plants[7] shows that non-green colors convert the sun's rays into useful heat and in some parts of the plant promote transpiration, or are occasionally waste products of metabolism. Colors in some cases, as is well known, also hold relation to insect pollination and to protection from injury. Chlorophyll is also to be included as a very useful color.

The influence of carbon dioxide on the living protoplasm[8] appears to be characteristic. Its effects do not result from the simple exclusion of oxygen, but its action is upon the nutritive processes. Its stimulating action, if any, appears to be small.—J. C. A.

ITEMS OF TAXONOMIC INTEREST are as follows: Five new North American species of Saxifraga have been described by Dr. John K. Small.[9] A good figure of the very rare *Berberis Nevinii*, from the sandy plains near Los Angeles, has just been published.[10] *Lindauea* is the name of a new genus of African Acanthaceæ, dedicated by Dr. Donaldson Smith[11] to Dr. Gustav Linden. Professor E. L. Greene has issued another fascicle[12] of new and noteworthy species, describing two new species of Ranunculus, three of

[7] Pop. Sci. Monthly 49:71. 1896; Science 4:350. 1896.

[8] Science 3:689. 1896.

[9] Bull. Torr. Bot. Club 23:362. 1896.

[10] Garden and Forest 9:415. 1896.

[11] Jour. Bot. 34:411. 1896.

[12] Pittonia 3:91–98. 1896.

Delphinium, three of Roripa, and one of Berberis. He also takes up Sophia for *Sisymbrium incisum* and its allies, as an older generic name than Descurainea, adopted by Engler and Prantl, and proposes a new genus, Neobeckia, to include the watercress and horse-radish types of Nasturtium (Roripa), *N. lacustre* of the *Synoptical Flora* becoming *Neobeckia aquatica*. Miss Alice Eastwood[13] has described seven new Californian species belonging to the genera Sedum, Anemone, Hosackia, Lupinus, Heuchera, Brodiæa, and Cynoglossum. Mr. Robert Ridgway has suggested[14] the possibility of two native species of Tecoma, describing the forms as they have come under his observation, but applying no names. Mr. J. G. Baker[15] has concluded his synopsis of the genus Brodiæa, the last part touching upon several North American species. Mr. J. W. Toumey has described[16] a new Opuntia from Arizona, one of the shrubby cylindropuntias. M. A. Franchet has concluded his account of new Chinese plants.[17] The last part contains descriptions of twelve new species of Lonicera. Dr. C. Hart Merriam has described[18] a new Abies from Arizona. It is from the San Francisco Mountain region, and is remarkable for the color and character of its bark, being one of the most conspicuous trees on the mountain between the altitudes of 8950 and 9500 ft. The substance of the technical description is as follows:

ABIES ARIZONICA. About $15^{m}$ high: bark a highly elastic fine grained cork, whitish or grayish (usually creamy white), with irregularly sinuous grayish ridges: leaves of cone bearing branches thick, subtriangular in section, sharp-pointed at apex, about $2^{cm}$ long; leaves of lower branches much longer, flatter, blunt and notched at apex, 2.5 to $3^{cm}$ long: cones dark purple, slender, medium or rather small; scales much broader than long, strongly convex laterally, purple on both sides; bract (without awn) reaching to or past middle of scale, its body much broader than long.

A full account of *Aspidium cristatum* × *marginale* Davenport, published in this journal,[19] has just been given[20] by the author in connection with a Faxon illustration. A revision of the North American species of Cephalozia has been published by Professor L. M. Underwood.[21] In the fourth part[22] of Mr. P. A. Rydberg's Notes on Potentilla four new species are described. In his studies in the botany of the southeastern United States Dr. John K. Small[23] describes a new Rumex from Louisiana, revises the genera Polygonella and Warea, and substitutes Yeatesia for the previously used Gatesia of Gray.

[13] Proc. Calif. Acad. II. **6**: 422–430, *pl. 53–59*. 1896.

[14] Garden and Forest **9**: 453. 1896.

[15] Gardener's Chronicle III, **20**: 459. 1896.

[16] Garden and Forest **9**: 432. 1896.

[17] Jour. de Botanique **10**: 309. 1896.

[18] Proc. Biol. Soc. Washington **10**: 115–118. 1896.

[19] Bot. Gazette **19**: 494. 1896.

[20] Garden and Forest **9**: 444. 1896.

[21] Bull. Torr. Bot. Club **23**: 381. 1896.

[22] Bull. Torr. Bot. Club, *l. c.* 394.

[23] Bull. Torr. Bot. Club, *l. c.* 405.

# NEWS.

MR. JOHN S. WRIGHT has been appointed lecturer in botany at the Indiana Medical College, a department of the Indianapolis University.

THE PROPOSED ESTABLISHMENT of an international botanical station at Palermo, Italy, under the direction of Professor Borzi, is announced by *Nature*.

AN ADDRESS upon "Grasses" by Professor F. Lamson-Scribner, delivered before the Massachusetts Horticultural Society, has been published by the society for distribution.

DR. A. P. ANDERSON is spending the present year at the Missouri Botanical Garden, where he finds suitable facilities for the further prosecution of his researches in connection with the resin ducts of conifers.

MR. M. A. LAWSON, botanist and director of cinchona plantations to the Madras government, died at Madras February 14th last. From 1868 to 1882 he was Sherardian Professor of Botany in the University of Oxford.

MR. WALTER T. SWINGLE returned in October to resume his duties in the United States Department of Agriculture after a year spent abroad. He studied chiefly in the laboratories of Bonn and the Biological Station at Naples.

ATTENTION is called by the biographer to an inaccuracy in the sketch of the late Professor Prentiss which appeared in this journal for May last. He was born May 22, 1836, in Cazenovia, Madison county, N. Y., not in Oneida county, as stated in the sketch.

DR. HERBERT M. RICHARDS, who has been studying in Professor Pfeffer's laboratory at Leipzig during the last year, having held a traveling scholarship from Harvard University, returned to this country in August, and is now installed as lecturer in botany at Barnard College, New York city.

NUMBERS 11 AND 12 of Lloyd's *Photogravures of American Fungi*[1] have recently been distributed. They represent respectively *Lepiota Morgani* Peck and *Sparassis Herbstii* Peck, two interesting species. The first was photographed as it grew in the field, and makes an unusually attractive and characteristic picture.

DURING A CYCLONE in the early part of October the roof of the main building of the Agricultural College at Lake City, Florida, was partly blown

[1] For notices of previous issues of this series see this journal **20**: 330, 556; and **22**: 75.

away and the interior deluged with water. The valuable private library of Professor P. H. Rolfs, especially rich in works on fungi and citrous fruits, suffered severely. The herbarium in an adjoining part of the building was but little damaged.

MR. GEORGE J. BURCH, of Oxford, England, has been experimenting upon plants with Röntgen photography. He finds that flower-buds and seed-vessels are especially favorable objects. He believes that if the photograph could be made upon a magnified scale the outline of every cell would be seen. The capsules of hyacinth and the flower-buds of fuchsia are reproduced in the account.[2]

A NOTABLE CACTUS GARDEN has been established at the University of Arizona. It is the purpose to bring together eventually all the Cactaceæ indigenous to the United States, and already more than a hundred species are represented. The region could not be more favorable for such a purpose, and for the first time there will be large opportunity for studying the group in its natural environment.

MISS ARMA ANNA SMITH, a graduate from Mt. Holyoke in 1891 (A.B.), and afterward Professor of Natural Science for three years in the American College for Girls in Constantinople, was engaged in botanical study at Cornell University last year, and received the degree of M.S. in June. Miss Gertrude Gibbs, a graduate of the University of Minnesota, also a student in botany the past year at Cornell University, received the degree of M.S., and is now Principal of the Jamestown High School, Jamestown, North Dakota.

DR. HENRY TRIMEN died at Peradeniya, Island of Ceylon, October 16th, in his 53d year. During his connection with the botanical department of the British Museum (1872 to 1879) he was the well known editor of the *Journal of Botany*, which commonly bore his name. In 1882 he became the director of the Royal Botanic Gardens at Peradeniya, and undertook to publish the *Flora of Ceylon*, three parts of which have appeared. His recent retirement from his official position, on account of ill health, has been noted already in this journal.

AN UNUSUALLY large fasciated stem of meadow thistle (*Cnicus altissimus* Willd.) was sent to the museum of Purdue University a short time ago from northern Indiana. When dry it measured twelve inches broad at the top and three inches at the base. The thickness of this greatly flattened stem was normal, that is, less than one-fourth inch. It was covered evenly with normal leaves, and bore a score or more of immature flower heads sessile along the upper edge. It stood three feet high. The interest in it lies in the size and perfect wedge form, as fasciated stems are usually irregularly developed.

[2] Gardeners' Chronicle III. **20**: 491. 1896.

THE DAILY PRESS has brought the news of the death of Auguste Trécul, the venerable French botanist. He was born in 1818, and died October 16 in a hospital in Paris, and is reported to have been in a very destitute condition. His name as an anatomist was a more familiar one to botanists of a generation ago than to those of today, his principal papers dealing with the vascular system. During 1848 and 1849 he explored various regions of North America, and many of the cactus species of European gardens were first obtained by him during his travels in Texas and Mexico, as well as the beautiful Yucca which bears his name.

BARON FERDINAND VON MUELLER died at Melbourne, Australia, October 9th, in his 72d year. His is the most distinguished name in Australian botany, and his long and zealous study of that isolated flora has been of the greatest service to science. He left Europe in 1847, and never returned to it, but his enormous correspondence and his great collections always kept him in close touch with his foreign associates. His publications are very numerous, and many of them are noteworthy in presenting the most complete accounts of certain notable Australian groups, as Eucalyptus, Acacia, etc. An interesting biographical sketch will be found in *Gardeners' Chronicle* of October 17.

A VERY COMPLETE historical account of taxonomic nomenclature is presented by Dr. Theodore Gill in his vice-presidential address before the A. A. A. S. at its recent Buffalo meeting. The address is published in *Science* of October 23. In conclusion he seems to think that we must make the best of a too firmly fixed system. "The best thing to do now is to accept the current system, purified as much as possible by judicious and inexorably applied laws. Doubtless in the distant future a less cumbrous and changeable system of notation will be devised, but in the meantime we had best put up with the present, inconvenient though it be." In the same journal for November 6 Mr. J. A. Allen calls attention to the mischievous practice of determining priority by the date of printing, rather than by the date of publication, which is frequently quite a different date.

THE SECOND PART of volume sixth of the *Flora Capensis* has been issued from Kew, and, like the first part, is the work of Mr. J. G. Baker. It contains the continuation of the Amaryllideæ and part of the Liliaceæ, to the completion of which the whole of the third and concluding part will be devoted. A considerable number of species appear to have been collected but once. Many are still known only from descriptions and figures published in the last century, and are unrepresented in herbaria. It is difficult, however, to believe that they are really extinct. The fact is more probably accounted for by the extremely local limitation of species in South Africa, which is hardly paralleled in this respect by any other flora in the world.—W. T. T. DYER, in *Kew Bulletin.*

*BOTANICAL GAZETTE*

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Vol. XXII DECEMBER 1896 No. 6

# THE BOTANICAL GAZETTE



ISSUED DECEMBER 24

CHICAGO, ILLINOIS

Published by The University of Chicago

The University of Chicago Press

# Botanical Gazette

**A Monthly Journal Embracing all Departments of Botanical Science**

**Subscription for 1896, $3.00** **Single Numbers, 30 Cents**

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VOLUME XXII NUMBER 6

# BOTANICAL GAZETTE

*DECEMBER 1896*

## A RUST AND LEAF CASTING OF PINE LEAVES.

BEVERLY T. GALLOWAY.

(WITH PLATES XXII AND XXIII)

### INTRODUCTION.

SOMETHING over five years ago the writer briefly described a Coleosporium,[1] or rust, occurring on the leaves of *Pinus Virginiana*, the scrub or Jersey pine.[2] The rust was found in considerable abundance on many trees, and owing to its interesting habits and its effects on the host, it was made the subject of more or less extended studies during the spring, summer, and autumn of 1891. In 1892 some additional investigations were made, this work being mainly a comparative study of the anatomy and physiology of healthy and diseased trees. In 1893 and 1894 some of the previous work was repeated and additional points in regard to the life history of the fungus and its effects on the host were brought out. Last year (1895) further studies were made. In these studies special attention was given to the shedding or casting of the leaves, a phenomenon which is known to follow the attacks of a number of fungi, and which it was thought of interest, in this case at least, to explain if possible.

[1] The systematic position of this fungus may be questioned, but as this is a matter of minor importance in the present paper it may be allowed to stand provisionally with the Coleosporiums.

[2] A new pine leaf rust, Jour. Mycology 7: 44. 1891.

I am indebted to Mr. Albert F. Woods for much assistance in the later stages of the work, and to Mr. Theo. Holm for a number of the anatomical drawings, and aid in finishing my own figures.

## DISTRIBUTION OF THE HOST AND PARASITE.

*Pinus Virginiana* is a native of the eastern United States, being found in considerable abundance from central Pennsylvania southward to middle Georgia and westward to western Kentucky and Tennessee. Under favorable conditions the tree attains a height of 20 to $30^{m}$, with a trunk 25 to $75^{cm}$ in diameter. In the District of Columbia and country immediately adjacent this is the most common species of pine, many of the old fields and waste grounds being overgrown with trees ranging in height from 3 to $5^{m}$. It is on these that the Coleosporium is usually found, the parasite as a rule being especially prevalent on trees 2 to $4^{m}$ high.

The fungus has been found in more or less abundance in the District of Columbia, Maryland, and Virginia, and has also been collected by the writer on Lookout Mountain, in Tennessee, and at Asheville, N. C. No attempt has been made to collect it elsewhere, but there is no reason to doubt its occurrence wherever the host is found. Although careful examinations have been made the Coleosporium has never been seen upon any other host but the one under consideration.

## APPEARANCE OF AFFECTED TREES.

During the winter the leaves of Pinus, in common with other evergreen plants, change color, the dark green fading out to a reddish yellow as the season advances.[3] As spring approaches the foliage again resumes its normal color, growing brighter as the conditions for growth become more favorable. In the early part of May, when the trees have fully recovered their normal

[3] For an account of the physiological changes involved in the winter coloring of evergreen leaves, together with a review of the literature on the subject, see G. HABERLANDT: Untersuchungen über die Winterfärbung ausdauernder Blätter, Sitzungsber. d. Acad. d. Wiss. zu Wien **72**: —. Ap. 1876.

color, those affected by the Coleosporium may be readily detected for perhaps $100^m$ or more by the pale yellowish hue of the leaves and the general thinness of growth. An examination of the affected trees shows that the yellowish color is due to the effects of the fungus, which is confined almost entirely to or near the tips of the needles formed the previous season. The thin appearance is owing largely to lack of leaves, those on the tree being mainly of the previous year's growth, all the others having prematurely fallen.

The changes in the host and parasite which precede the effects noted will now be discussed, attention being called first to some of the anatomical and physiological questions connected with the normal leaves, in order that what is said in regard to the effects produced by the fungus may be better understood.

## ANATOMY OF THE NORMAL MATURE LEAF.

The leaves of *Pinus Virginiana* are as a rule borne in pairs. They are of a bottle-green color,[4] vary in length from 2.5 to $7.5^{cm}$, and are nearly semicircular in outline, the dorsal side being curved and the ventral nearly flat. Cross sections of numerous leaves from trees grown under varying conditions show that the needles are nearly the same size throughout, namely, from 0.60 to $0.62^{mm}$ in diameter. Transverse sections of the leaf show that it is divided into three well-defined regions, namely, cortical, mesophyll, and fibro-vascular (*fig. 1*).[5] The cortical region occupies the periphery, and varies in thickness and structure according to the part of the leaf under observation; the part of the tree, with respect to sun and shade, from which the leaf is taken; and the condition of the soil, as regards moisture, where the tree is grown.

The cortical region is separable into three parts: (1) the epidermis, consisting of thick-walled cells quite regular in size

[4] ROBERT RIDGEWAY, Nomenclature of colors, 1886.

[5] ARTHUR, BARNES, and COULTER: Handbook of Plant Dissection, 1886; also COULTER: Synopsis of the North American pines based upon leaf anatomy, BOT. GAZ. 11: 258, 259. 1886.

and shape, the outer walls being strongly cuticularized (*fig. 2, ep*); (2) thin-walled stereomatic cells (*fig. 2, st*); and (3) thick-walled stereomatic cells (*fig. 2, st*). Both the thin-walled and the thick-walled stereomatic cells give the characteristic reaction for lignin with thallin sulfate, phloroglucin, and anilin sulfate.[6]

Neither the thick-walled nor the thin-walled stereomatic cells occur with any great degree of regularity in the cortical region. Frequently only the thin-walled cells are present, and then again there may be a definite layer of thin-walled cells next to the epidermis proper, with scattering thick-walled cells beneath. The more common arrangement is that in which both thick-walled and thin-walled cells are indiscriminately mixed, the whole forming a ring of tissue, which gives strength and rigidity to the needles.

At various points the stereomatic tissue is interrupted by the stomata (*fig. 2*). These occur on both sides of the leaf and are generally considerably depressed, as is the case with the other pines and plants having thick epidermal parts. The stomatic furrows are filled with a waxy substance, which probably plays an important part in preventing the entrance of fungi, and also, as Wilhelm[7] has pointed out, serves as a check to transpiration.

The mesophyll region occupies the median portion of the leaf, occurring in a zone which varies in thickness from 200 to 300 $\mu$. The cells composing it are large and thin-walled, and contain, among other things, chlorophyll, starch, and the usual contents of assimilative tissue. In cross-sections the cells are seen to be nearly polygonal in shape and joined more or less closely in rows arranged at right angles to the cortical region. The number of rows vary according to the conditions under which the leaf is grown, those in intense light having, as Stahl[8]

[6] BEHRENS: Tabellen zum Gebrauch bei mikroskopischen Arbeiten, 1892.

[7] Ueber eine Eigenthümlichkeit der Spaltöffnungen bei Coniferen, Ber. d. deutsch. Bot. Ges. 1: 325. 1883.

[8] Ueber den Einfluss der Lichtintensität auf Structur und Anordnung des Assimilationsparenchyms, Bot. Zeit. 38: 868. 1880.

has shown, a greater proportion of assimilative tissue than those grown in the shade. The cells of the tissue under consideration are, in almost every case, provided with peculiar infoldings (*fig. 3*), hence the name *Armpallisadenzellen*, adopted by Haberlandt, Strasburger, and others.

In longitudinal sections the rows of mesophyll cells are seen to be separated by more or less space, which often extends without interruption from the cortical to the fibro-vascular region (*fig. 4*). The infoldings are not easily distinguishable in sections of this kind, but are usually seen as apparent partitions, and in some cases do not appear at all.

Within the mesophyll region and completely surrounded by the cells composing it occur the two resin ducts. The ducts are nearly opposite each other, being placed about equidistant from the radius of the leaf. They are cylindrical, completely inclosed by a sheath of thick-walled stereomatic cells arranged in a single row, and are lined with thin-walled epithelium (*fig. 5*). The central portion of the leaf is occupied by the fibro-vascular region. Separating this from the mesophyll is a closed sheath, the endodermis of Oudemans.[9] This consists of a single row of more or less suberized, elongated, thin-walled cells, closely joined at the horizontal or oblique ends (*fig. 6, end*). The walls also contain lignin, as shown by staining with indol.

Within the endodermis occur the mestome bundles (two in number), tracheids, and fundamental tissue, the latter consisting of thin-walled parenchymatous cells. The orientation of the bundles is normal, *i. e.*, the hadrome is directed toward the center and the leptome toward the periphery (*figs. 1* and *7*).

## LIFE OF NORMAL LEAVES.

The length of time the leaves live varies according to a number of conditions, the most important being the age and size of the tree and cold and drouth. On trees 15 to $20^m$ high, growing in good soil, leaves may remain on three, four, and even five

[9] Ueber den Sitz der Luftwurzeln der Orchideen, Abhandl. d. Acad. Amsterdam, Math. Phys. Klass. 9: —. 1861.

years. On comparatively young trees, 1 to $5^m$ high, the leaves may fall the second year. As a rule the average length of life may be placed at two years, that is, the leaves fall the summer or autumn of the second year. The time of falling, however, is not constant, as in some cases it may occur in the spring.

Numerous physiological changes take place during the period of from three to four weeks preceding the actual fall of the needles. First, the contents of the mesophyll cells gradually disappear, this being accompanied by a change in the color of the needle from green to reddish yellow. With the disappearance of the chlorophyll bodies, large oil globules appear in the mesophyll cells, and at the same time the walls of the latter become considerably thickened. Not until a week or ten days before the pair of needles fall is it possible to make out clearly the separative layer, the formation of which does not materially differ from that which takes place in most of the ordinary deciduous plants. In case of high wind or rain the leaves are frequently blown or knocked off before the separative layer is fully developed. Usually they remain on, however, until the process is fully completed, after which they dry up and fall from their own weight.

DEVELOPMENT OF THE FUNGUS AND ITS EFFECTS ON THE TREE.

An examination of an affected tree early in April shows on the needles of the previous year's growth pale yellowish bands, which vary in width from 2 to $4^{mm}$. The discolorations seldom if ever extend to the extreme tip of the needle, this point as a rule remaining normal in color up to a certain time, despite the action of the fungus on the tissues below. Close examination of the diseased areas at this time reveals numerous brown and yellow pustules, which are only slightly elevated above the surface of the leaf (*figs. 8* and *9*). The pustules are the sori of the fungus, and mark the point where the spores will eventually break through. The sori vary in width from 0.2 to $0.5^{mm}$, and are from 0.2 to $1^{mm}$ long. As the season advances the sori increase in size, many of them coalescing and forming long bands parallel to and including, of course, the rows of stomata. The color of the diseased part of the leaf and the sori also becomes brighter yellow. By the middle of May, if the season is a normal one, the sori reach their full development, the color at this time being bright orange. As long as the weather is dry there is little change in the sori, but at the first rain or fog they rupture the cortical tissue, forming long, bright orange red, waxy, or granular elevations, 0.5 to $1^{mm}$ high. If the weather continues wet the sori retain their bright color, but upon close examination they are seen to be overrun with minute cobweb-like threads. Lack of rain causes these threads to disappear, but for a time at least the sori lose none of their characteristic color, size, or shape. Rain or fog will again cause the sori to swell, to become granular and waxy, and to show the growth of colorless threads, as already described. This alternate drying up and breaking out of the sori may continue two and sometimes three weeks, or it may continue but a few days, the length of time varying with climatic conditions and different trees. In case of a spell of a week or more of rainy weather the sorus will often complete its development and collapse completely as soon as the sun comes out for a few hours. Occasional rains, followed by several days of fair weather, prolong the life of the sorus in all cases.

Under ordinary conditions of humidity the sori for the most part complete their development by the middle of June, or about one month after they first break through. The diseased portion of the leaf at this time assumes a brownish hue and becomes more or less shrunken. The sori also turn brown, collapse, and soon dry up entirely. The tissues below and immediately adjoining the diseased areas now begin to turn yellow, this discoloration gradually extending downward until the whole leaf is involved.

If both needles are affected by the fungus both change simultaneously from the normal green to yellow. If, however, only one of the needles is affected the change extends from the tip downward on the affected one and from the base upward on the other. From yellow there is a gradual change to brownish red, the tissues in the meantime becoming considerably shrunken. Finally the pair of needles fall, this often being hastened by rain, wind, or any sudden jarring or shaking of the tree. In from three to six weeks after the fungus breaks through the tissues most of the leaves have fallen. Trees badly affected are the first to shed their leaves, defoliation being very rapid and often completed before the last-formed needles have attained full size.

MICROSCOPIC STUDIES OF THE FUNGUS.

Turning our attention to the fungus itself and the manner in which it produces the changes described, a microscopic study of transverse and longitudinal sections through the pale yellow spots found early in April shows, growing between the cells composing the mesophyll region, a coarse, colorless, septate mycelium, containing numerous granules and vacuoles (*figs. 10* and *11*). The mycelium is confined wholly to the intercellular spaces of the mesophyll region. It never penetrates the walls of the mesophyll cells, but in many cases adheres very closely to the latter, producing changes in the cell contents which will be described as we proceed. Wherever it comes in contact with the cells composing the endodermis or the resin ducts it is effectually turned aside (*fig. 18*). A comparison of the diseased and healthy tissues at this time will show no essential difference so far as thickness and size of cells are concerned. In unstained sections the entire cortical and fibro-vascular regions, as well as the resin ducts, appear intact. The contents of the mesophyll cells of the diseased leaf, however, are seen to be disorganized. The chlorophyll bodies have disappeared and in their place many large oil globules are seen. In the healthy cells the chlorophyll bodies are numerous and distinct, while there are few or no oil globules. In the cells around some of the stomata of the diseased leaf the contents are not only disorganized, but are yellow and partially opaque. The V-shaped cell below the stoma is usually not involved, but those around, and especially below, show the change in a marked manner.

At certain points, which do not seem limited to any particular region, the mycelium pushes its way toward the cortical region, and between the latter and the mesophyll cells it begins to form a sorus or spore bed (*figs. 10* and *11*). This is effected by a continued interweaving of the mycelium, which at the same time becomes more septate and brown or orange yellow. As the spore beds increase in size the cortical region is pushed upward, thus giving rise to the pustules already described. With increasing age the spore beds become more compact, so that by May 10 to 15, or just before they break the tissue, they show, beneath the cortical tissue, compact rows of rounded septate bodies (*fig. 11*), the sporophores.

The sporophores are formed in the following manner: The hyphæ, which push toward the surface, begin to enlarge at their tips (*fig. 12*). Soon a septum forms just below the swollen portion, the result being the formation of a more or less rounded cell. By successive abjunction other cells are formed, until the sporophores appear in compact rows, as already described. When mature and the proper conditions of moisture are present the upper cell of each sporophore gives rise to a mass of gelatinous substance, which has no very definite structure, so far as can be ascertained from a study of transverse sections (*fig. 13*). It is the sudden development of these gelatinous masses that ruptures the cortical tissue, thus bringing the sorus into direct contact with air, moisture, and more intense light. In from three to four hours after the cortical tissues are ruptured, cylindrical bodies, which later develop into teleutospores, begin to shape themselves out of the mass of gelatinous material (*fig. 14*). These bodies soon begin to turn yellow and in a short time their walls may be definitely made out. The outer walls of each teleutospore consist of an enormously thickened, colorless, gelatinous membrane, and it is the massing of these membranes that gives to the young sori the characteristics already described. At this time it is very difficult to make out the transverse walls separating the teleutospores. Treatment with potash solution and with nitric acid, however, brings these out distinctly.

In from four to ten hours after the sorus breaks the cortical tissues the teleutospores attain full size. By this time the gelatinous membrane has mostly disappeared, and consequently the contents and septum separating each teleutospore is plainly apparent.

The teleutospores are arranged in rows of from two to four, one above the other. They do not separate, however, from each other, and it is with some difficulty that they are removed from their attachment in the sorus. When fully mature the compound teleutospores vary in length from 75 to 150$\mu$ and in diameter from 18 to 30$\mu$.

The spores begin to germinate as soon as mature, the process taking place only in water or saturated air. The first evidence of germination is a small protuberance, which may appear at the apex or at any of the septa. Usually the topmost cell germinates first and the others follow in the order of their arrangement (*fig. 14*). The protuberance rapidly elongates into a tube, which may grow to a length several times that of the compound spore, or may remain quite short. The length, however, depends largely on the amount of moisture present, the tube attaining its greatest length if the spore is in water and its shortest if in moist air. The contents of the spore flow out into the tube, the greater portion being near the tip and the rest more or less in groups throughout its entire length. The vacuoles in the cell flow out with the contents and may usually be found at the upper extremity of the tube.

When the tube attains its full length, this, as already indicated, depending in large part on the amount of moisture present, it begins to swell at the tip (*fig. 15*). The swelling rapidly increases in size and at the same time the walls directly below it become more or less constricted. At this point a septum is formed, this process usually lasting not more than twenty-five or thirty minutes. The body thus cut off by the septum is the sporidium, which now begins to increase in size and assumes various shapes. Occasionally the sporidium will send out a germ tube while still attached to the supporting promycelium.

Usually, however, the sporidium separates from the promycelium in about thirty or forty minutes after the partition forms, and then almost immediately begins to germinate by sending out a short, thick germ tube. All or nearly all the contents of the sporidium flow into the germ tube. Occasionally this tube grows out to a considerable length, cutting off a secondary sporidium (*fig. 16*) upon its free end in much the same way that the original was formed.

After the spore germinates the walls remain turgescent for a short time, and then collapse and dry up, the spore in the meantime becoming perfectly colorless. The entire contents of the cell seem to be used up in the formation of the promycelium and the sporidium, and if this is not the case the formation of secondary sporidia goes on until there is no protoplasm left.

Germination as here described takes place in nature only when the leaves are wet, the spores themselves seldom if ever escaping from the sorus. The sporidia, however, when cut off from the promycelia either fall or are washed down to the leaves below or to the ground, where they may be found in great abundance after a damp or foggy night. In all infection experiments, which will be referred to later, the sporidia were obtained in abundance by placing sterilized Petri dishes under the diseased branches confined in a moist chamber. After several hours an abundance of sporidia may be obtained from the dishes.

## INFECTION OF THE HOST.

On closely examining the diseased trees the sporidia may be found on the young leaves, which at this time are just beginning to show their tips. The usual place for lodgment is between the tips of the two young needles, which at the time the spores are forming project about $0.33^{cm}$ above the sheath which incloses them. The needles are slightly spread open, thus allowing a small drop of water to be retained. The water that collects in this way drips from the old leaves above, upon which the spores and sporidia are being formed. In dropping down it carries the sporidia with it, depositing the latter in a position where they may, under the very best conditions, germinate and infect the young needles.

For several years the time of the appearance of the spores and young leaves has been watched, and in every case a most remarkable similarity in dates has been observed. If the leaves are late or early in coming out the spores will be correspondingly late or early. This is exceedingly important in the economy of the fungus, for it has been proved by successive infections that a difference of but two days in the age of the leaf will enable it to resist the fungus. Infection, in other words, must take place when the parts of the needles are from 0.33 to $0.66^{cm}$ long (*fig. 19 a*, too old; *b*, proper age), otherwise the cortical region will be developed to such an extent that the germ tubes from the sporidia cannot force their way through.[10]

The needles are infected wholly by means of the germ tubes boring through the cortical tissue before the stereomatic, thick-walled cells have formed. These tubes make their way to the mesophyll region, where they immediately begin to lengthen, in eight or ten days assuming all the characteristics of the mycelium already described. The orifice, however, through which the germ tube enters the leaf, soon disappears, leaving no trace of the manner in which the fungus reaches the mesophyll region. In about three months, or by the middle of August, the fungus has developed to such an extent that its presence may be determined by the condition of the tips of the needles. Pale yellowish spots may be seen at these parts, and microscopic examination of the tissue reveals the mycelium growing in all directions between the cells of the mesophyll region. As the season advances the spots or bands become more prominent, and by the middle of November, or even earlier, pustules, indicating the formation of sori, begin to appear. By the first of April, or ten

[10] For the sake of brevity the details of the experiments are omitted. Briefly, in this case one hundred pine branches were bagged with paper bags, the work being carried on for two successive years. From time to time a bag was removed and the young leaves received a small drop of water containing germinating sporidia, after which the leaves were marked and the bag replaced. About 75 per cent. of the inoculations made when the leaves were the proper age were successful.

months after infection, the fungus is found in the condition already described. A month or six weeks later it again produces spores, thus completing its cycle of development in one year.

## CASTING OF THE LEAVES AND ITS CAUSE.

As already pointed out, we have in the case of the *Coleosporium* a fungus producing first purely local injuries, which later result in the death and casting of the leaves. The phenomena involved in this process may now be considered. An examination of the diseased leaves soon after the sori collapse shows that the conductive tissue has not been injured at all, the endodermis being intact and the fibro-vascular bundles abundantly able to conduct water. That they do this is evident from the fact that, even though the mesophyll invaded by the fungus be brown and shriveled, the tip of the leaf above this part remains green for a considerable time. In the tissue where the fungus has been at work there are large rifts which extend unbrokenly to the endodermis. The cell contents of the mesophyll region immediately below the part attacked by the Coleosporium, and where there is no mycelium at all, are broken up, showing that changes are taking place which are not directly attributable to the fungus. These changes are manifested externally by the yellowing, already described, which gradually extends downward until both needles are involved. Even before this the separative layer begins to form and in a week or ten days more the pair of needles fall. Of course, the fungus itself is the primary cause of the leaf fall, but that it acts only as a power to set other causes at work was early shown by cutting off the affected portions of the leaves. In every instance this treatment caused the leaves to remain on the tree and perform their functions in a normal manner until death came from old age. In all cases, however, it was found necessary to make the cuts through normal green tissues, *i. e.*, below the point where the yellowing showed. If only one needle was allowed to become partly yellow and the cut was made through the discolored portion the changes eventually leading to the fall of the leaf were not checked at all.

It was thought that possibly the fungus by its action might have produced chemical changes in the cell contents and that these changes alone were sufficient to produce the effects described. It was reasoned, however, that if there was anything in the nature of a ferment present it should be capable of propagating itself when brought in contact with the cells of healthy pine leaves. To obtain a definite answer to this question a series of experiments were made, which need not be entered upon in detail here. Suffice it to say that after more than two hundred trials with juices from diseased leaves rubbed on broken and unbroken tissues of healthy foliage and brought into contact with the healthy cells in other ways, not a single case of leaf casting or leaf yellowing occurred.

It is unnecessary to go over the ground which led to the belief that the changes, as already described, were due to excessive loss of water. The large rifts in the cortical and mesophyll regions, the uninjured conductive tissue, and the fact that no cork layer, cutting off the injured portion of the leaf, was formed, all pointed to a derangement of the water supply.

To obtain information upon this matter a number of experiments were made, some of which will now be described. The first experiments were with cobalt paper[11] to determine the relative evaporation of water from the parts affected by the fungus and the uninjured portions. The tests were made before and after the fungus had broken through, the usual method being to fasten strips of dry paper to the leaves by means of glass slides. It was found that before the fungus broke through the diseased areas lost less water than the healthy portion of the leaf. This was due to the permanent closing of the stomata over the diseased areas, owing to the action of the fungus on the adjacent tissue. The fact that the diseased spots lost less water than healthy portions of the leaf explains why such spots remain

[11] For a discussion of the cobalt method, see STAHL, Bot. Zeit **52** : 117–145. 1894; reviewed in BOT. GAZ. **21** : 26–33. 1895.

green longer than other parts when a branch is cut from the tree and allowed to die through lack of water.

As soon as the Coleosporium has ruptured the cortical tissues evaporation rapidly increases, until it exceeds that from a corresponding area of healthy tissue. This was proved by the

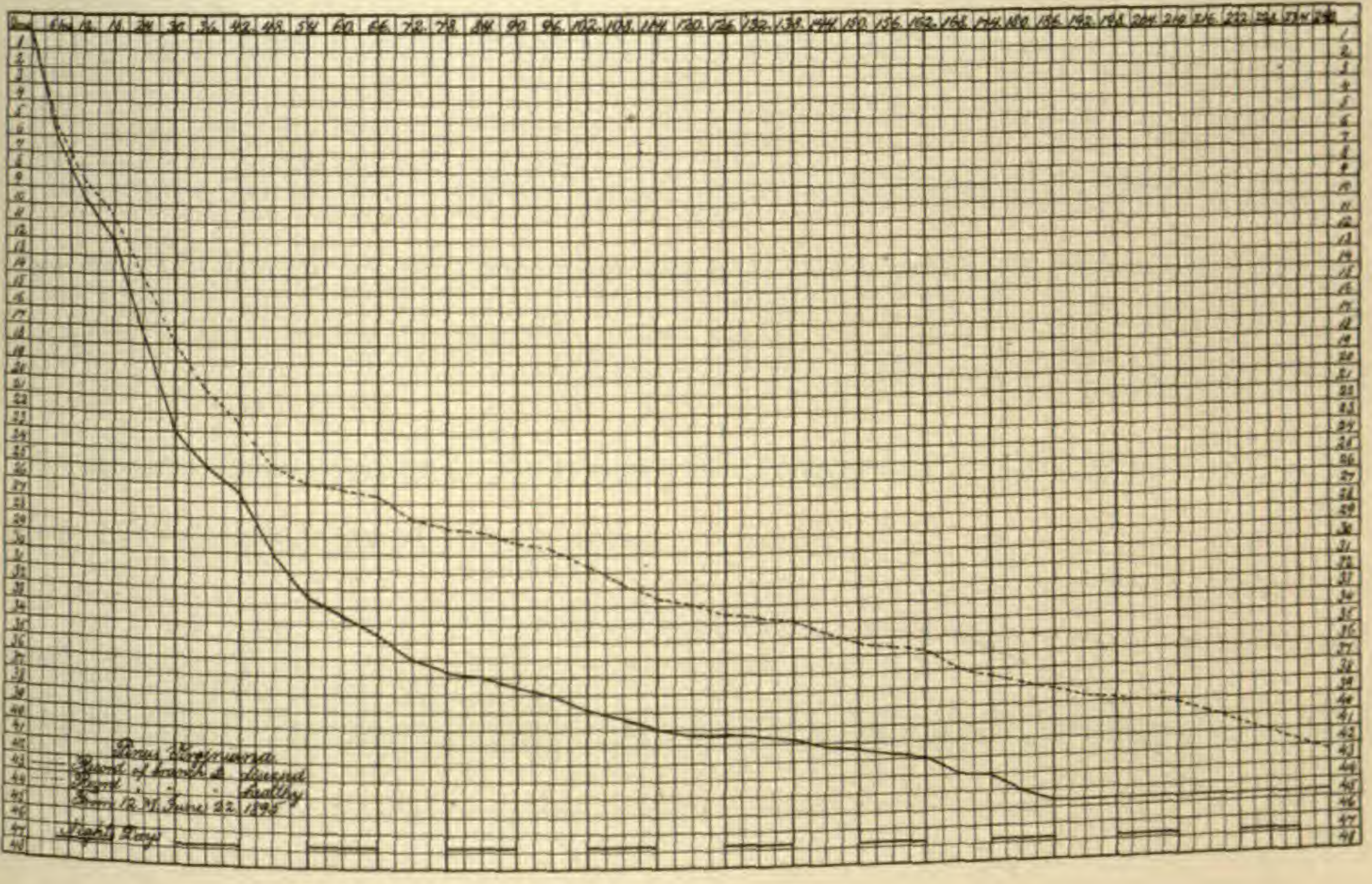


FIG. 1. Diagram showing evaporation from diseased and healthy branches.

cobalt paper test and also by the following experiments: Two branches, as nearly alike as possible, were secured and cut off under water and the cut ends sealed into a flask of normal culture solution, so that no water could escape except through the leaves. Each branch had 206 leaves. The leaves on one branch were healthy and on the other the Coleosporium had just broken through the diseased areas. Starting at 12 M. June 22, the curves in the accompanying diagram show the loss in grams in periods of six hours for ten days, as determined by a recording balance. The water supply was not as good as the dry air surrounding the leaves demanded. This lack of water was due to the accumulation of resin on the cut ends of the branches and the development in the same place of bacterial slimes. The unbroken line represents the loss from the diseased branch and the broken line the loss from the healthy branch. It will be observed that the loss during the first forty-eight hours was rapid in both cases, namely, $25^{gm}$ from the healthy branch and 30 from the diseased. At the end of this time both the healthy and the diseased leaves showed an evident lack of water. This lack, however, was more marked in the diseased leaves, the tips of many of which were shrunken above the diseased area. This lack of water had caused the stomata of both the healthy and the diseased leaves to close as far as possible, thus cutting down the loss through them to a minimum. During the next forty-eight hours the healthy branch lost $4.5^{gm}$ while the diseased lost $8^{gm}$. It was evident that from this time the leaves were able to obtain very little if any water from the stem. During the next three periods of forty-eight hours each the healthy branch lost 5, 4.5, and $2.5^{gm}$ respectively, while during the same periods the diseased branch lost only 3.25, 3, and $0^{gm}$. The leaves of the diseased branch were completely dry at the end of 186 hours, while the healthy plant was not yet dry at the end of 240 hours, but was still losing at the rate of $1.5^{gm}$ per day. The more rapid drying out and death of the diseased leaves than of the healthy is therefore evident. As a further evidence of this the following experiment may be cited:

Six pairs of leaves, three of which were diseased and three healthy, were removed from the same branch and immediately cemented into a piece of cork to keep them from tipping over. Weighings were then made at given periods, with results as shown in the accompanying diagram, the broken lines representing the diseased and the unbroken the healthy leaves. It will be seen that the average loss for the healthy leaves for the first twenty-four hours was about $5^{mg}$, while from the diseased leaves it was $16^{mg}$. This rate of loss continued nearly constant for the healthy leaves for 174 hours, while the loss from the diseased leaves kept gradually diminishing. At the end of 120 hours the healthy had lost about $24^{mg}$ and the diseased $32^{mg}$. The latter were now becoming quite dry, so that during the next twenty-four hours they lost an average of only $3^{mg}$, while the healthy lost about $11^{mg}$. At the end of this period (174 hours) the diseased leaves were air-dry, and being hygroscopic their weight increased and diminished with the ordinary changes in atmospheric humidity. The healthy leaves continued to lose at a diminished rate and at the end of 288 hours were not yet dry.

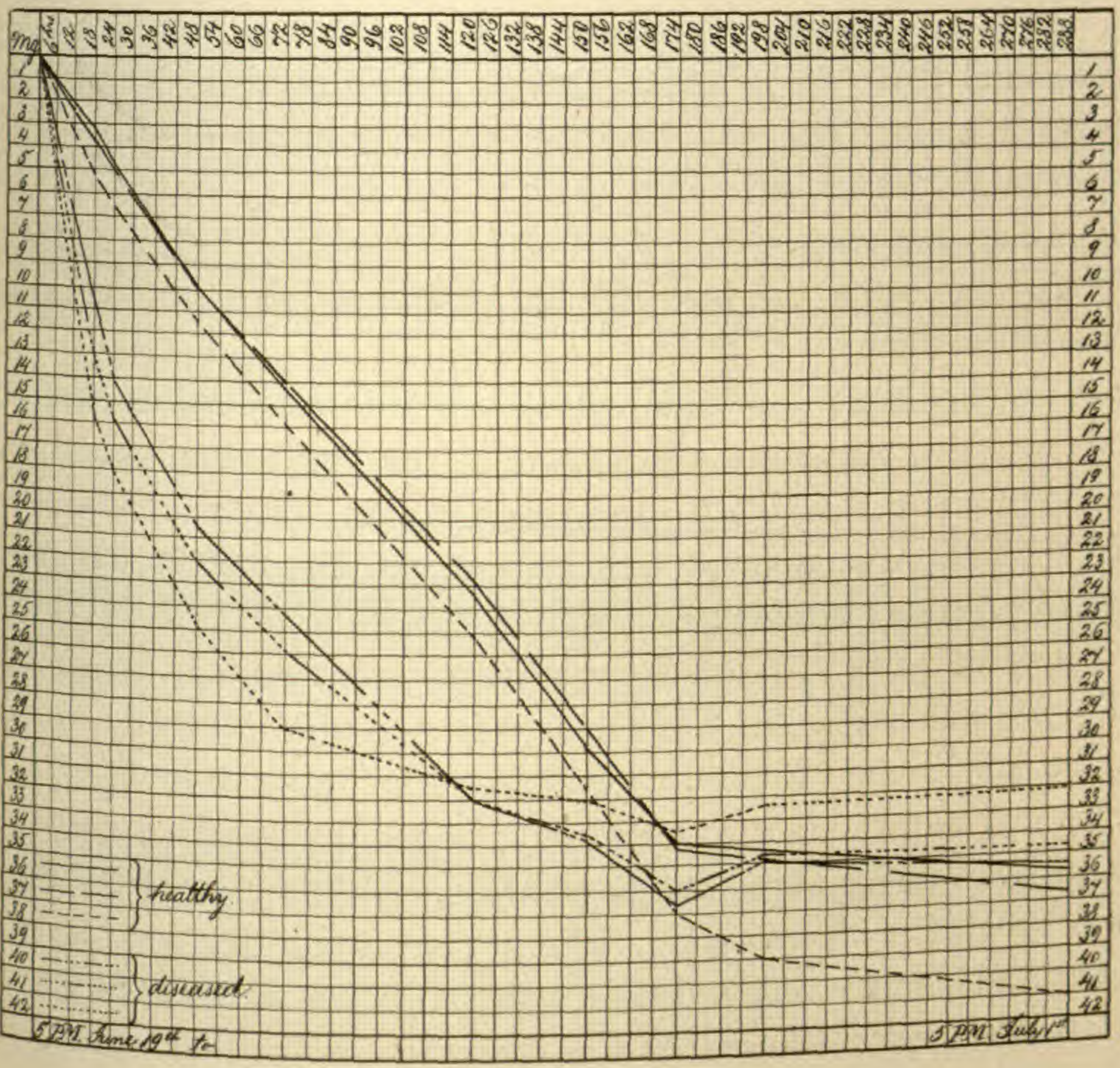



FIG. 2. Diagram showing evaporation from diseased and healthy leaves.

One additional experiment in this connection may be of interest. It was carried on during the casting of the leaves for three successive years and each time with practically the same results. Twenty-five small branches, containing about fifty pairs of leaves each, were cut during the night from a diseased tree, and immediately the cut end of each branch was pushed through a small hole in a cork and into a bottle containing water. After being fastened into the neck of the bottle, the cork and branch were sealed with paraffin, so that no water could escape except through the leaves. Twenty-five healthy branches, taken from the same tree which furnished the diseased ones, were prepared in a similar manner. All the bottles were then brought into the laboratory and weighed twice daily for ten days. At the end of this time the branches and leaves were weighed and the amount of water evaporated per gram of dry weight was calculated. It was found that the diseased leaves evaporated approximately one-fifth more than the healthy, these results holding good through all the experiments, as will be seen by a study of the preceding diagrams.

The fact that cutting off the diseased parts of the leaves prevented them from falling has already been pointed out. It was assumed that the removal of the injured portions stopped the excessive evaporation and enabled the leaf to heal the wound made by the cut, which it could not do in case of the fungus. To prove this a number of experiments were made, of which the following is an example:

Twelve pairs of fresh leaves were selected, six pairs being diseased and six healthy. These were divided into four sets of three pairs each. Set no. 1 (healthy) had one-half inch cut from each leaf and the tips charred with red hot glass to prevent an excessive loss of water and turpentine. After charring, the tips were coated with a varnish, which prevented the entrance of fungi and slightly reduced the evaporation of water from the cut ends. Set no. 2 (diseased) was treated in the same way, the diseased ends being removed. Set no. 3 were healthy uncut leaves and set no. 4 diseased uncut leaves. All these sets were weighed at given periods and the loss in weight determined. The results are shown in the accompanying diagram.

During the first twenty-four hours the healthy cut leaves lost $9^{mg}$, the diseased cut and the healthy uncut exactly $7^{mg}$ each, and the diseased uncut $11^{mg}$. The same relative loss held good through the next forty-eight hours.

The ends of the healthy cut leaves lost water more rapidly than the ends of the diseased cut leaves, making the loss approximate more closely to that of the diseased uncut leaves. The ends of the diseased cut leaves were more securely closed, so that they dried out only a little more rapidly than the healthy ones. This experiment shows that cutting off the diseased parts reduces evaporation to the normal amount. It appears there-

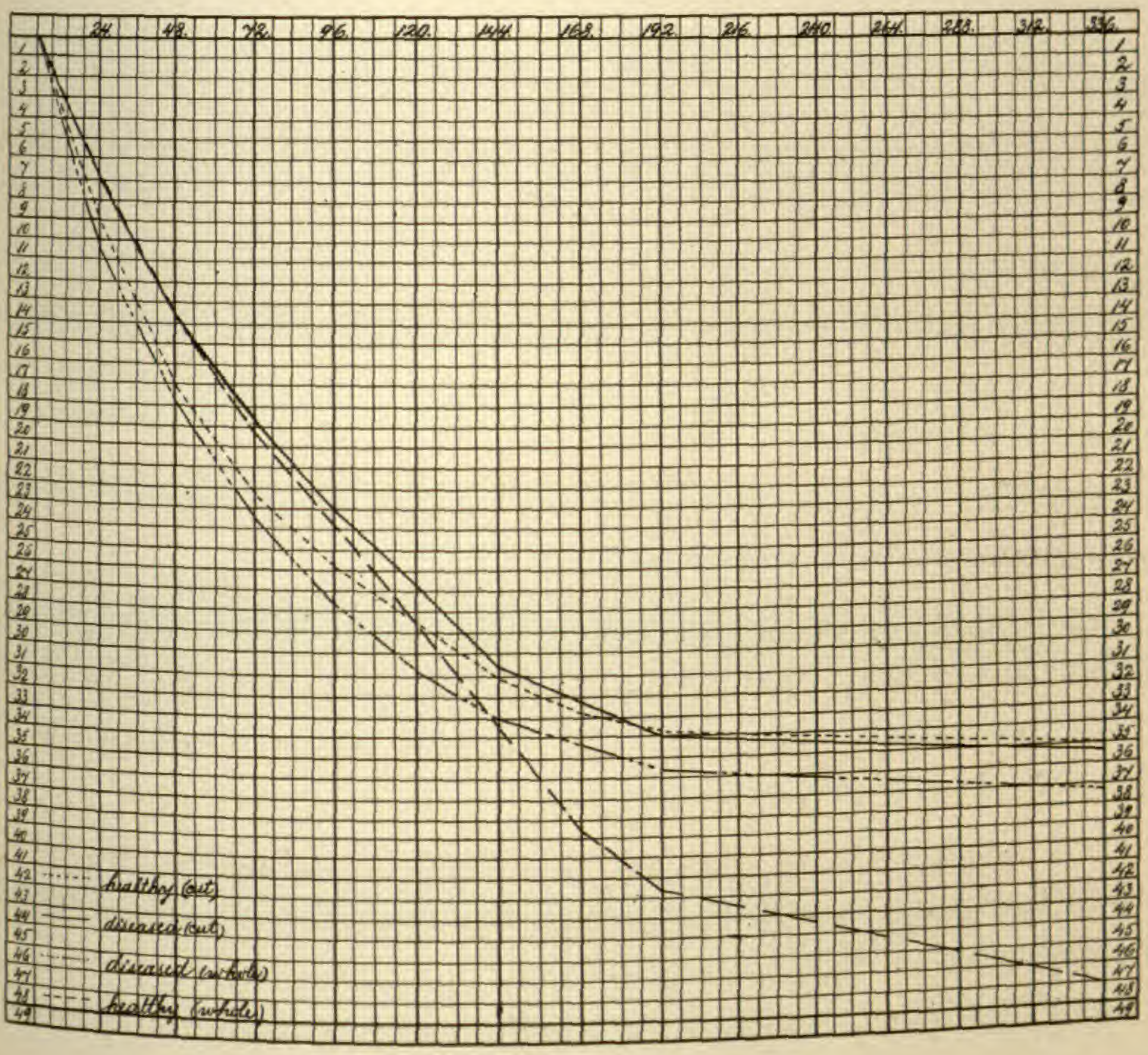



FIG. 3. Diagram showing evaporation from healthy and diseased leaves from which the tips had been cut.

fore that as soon as the fungus ruptures the cortical tissues of the leaves normal evaporation is increased about one-fifth. The physiological significance of this fact is great, as it affects the entire economy of the plant.

Without entering upon a discussion of all the processes involved it may be said that this constant loss of water from the leaf cannot be supplied by the conductive tissue. Drawing on the reserves of water in the cells is therefore necessary, and this is followed by loss of turgidity, cessation of growth, and finally death. The strain is so gradual, however, that the changes preceding death do not differ from those which take place in a dying leaf after having lived its allotted time.

## SUMMARY.

To recapitulate, the investigations here described have shown that:

(1) *Coleosporium pini* occurs abundantly in Maryland, Virginia, and the District of Columbia, attacking only *Pinus Virginiana*.

(2) It requires twelve months to complete the development of this fungus, and during a large part of that time it does not seriously interfere with the functions of its host.

(3) The fungus is disseminated by means of sporidia, which develop only during wet weather.

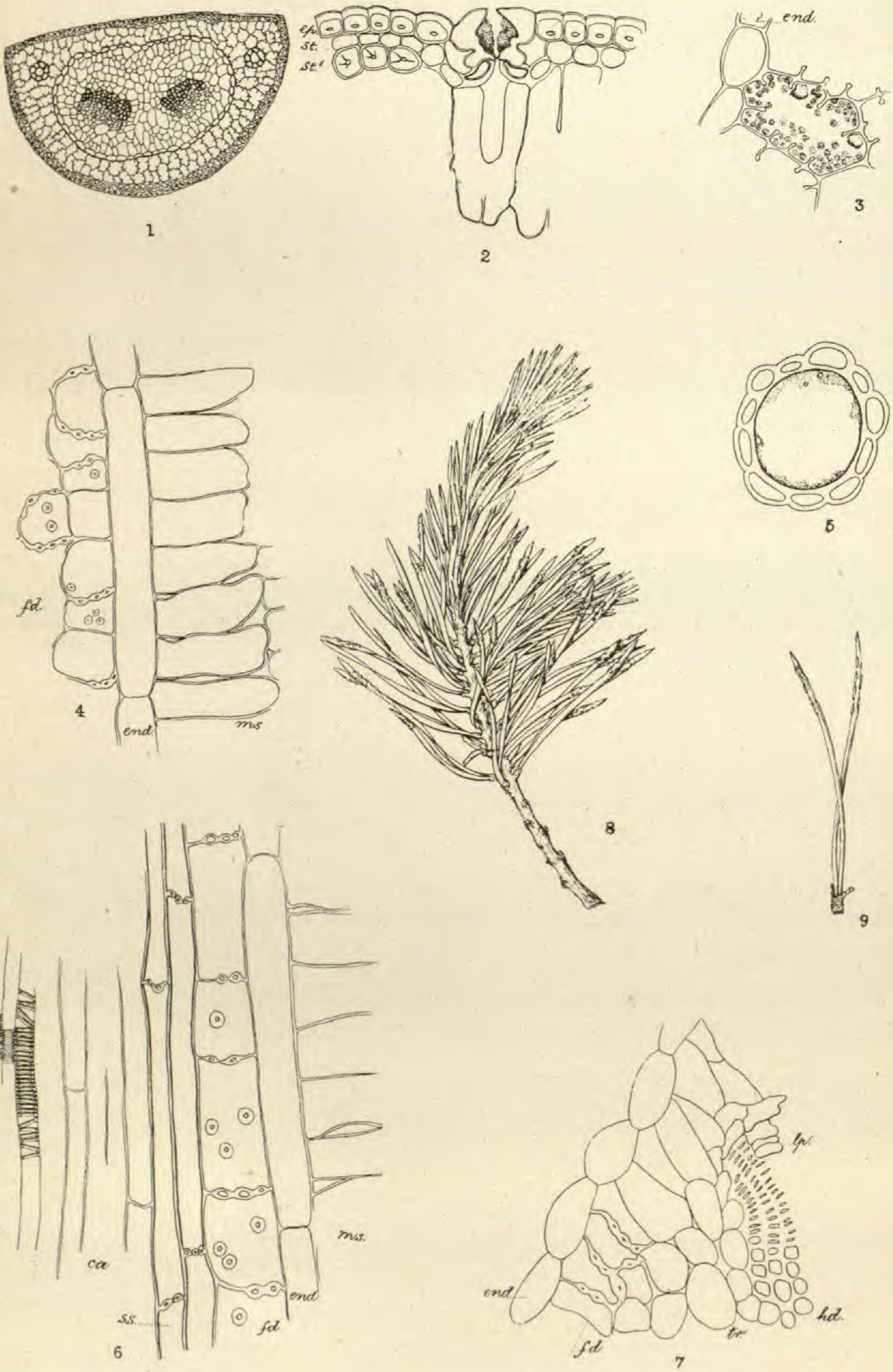
(4) From the leaves on which they are borne the sporidia are washed or drop to the young needles just showing their tips, which they infect. No evidence of this infection, however, is apparent for two or three months.

(5) Regardless of the season, there is a marked similarity in the time of the appearance of the sporidia and the time of the appearance of the young leaves.

(6) Before the fungus ruptures the cortical tissue evaporation from the diseased areas is less than that from healthy parts of the same leaf. This is due to the permanent closing of the stomata and may result in keeping the diseased parts alive longer than the healthy in case the leaf or branch is removed from the tree.

(7) As soon as the fungus ruptures the tissues evaporation is increased about one-fifth above the normal. In consequence of this the reserve water in the cells is gradually used up. This is followed by loss of turgidity and other physiological changes which lead to the gradual death and casting of the leaves.

U. S. Department of Agriculture,
Washington, D. C.,




GALLOWAY on RUST and CASTING of PINE LEAVES.


GALLOWAY on RUST of PINE LEAVES.

## EXPLANATION OF PLATES XXII AND XXIII.

FIG. 1. Cross-section of leaf of *Pinus Virginiana*, showing cortical, mesophyll, and fibrovascular regions.

FIG. 2. Cortical region and stoma; *ep*, epidermis; *st*, stereomatic thin-walled cells; *st'*, stereomatic thick-walled cells.

FIG. 3. Mesophyll cell and portion of endodermis, *end*.

FIG. 4. Longitudinal section of portion of leaf; *fd*, fundamental tissue; *end*, endodermis; *ms*, mesophyll cells.

FIG. 5. Resin duct.

FIG. 6. Longitudinal section of leaf; *ms*, mesophyll; *end*, endodermis; *fd*, fundamental tissue; *ss*, sieve tubes; *ca*, cambium; *sc*, scalariform vessels.

FIG. 7. Cross-section of a portion of leaf; *end*, endodermis; *fd*, fundamental tissue; *tr*, tracheids; *hd*, hadrome with scalariform vessels; *lp*. leptome.

FIG. 8. Branch of *Pinus Virginiana* showing Coleosporium on one year old leaves.

FIG. 9. Pair of leaves from the branch shown in *fig. 8*.

FIG. 10. Cross-section of pine leaf showing development of hyphæ.

FIG. 11. Portion of sorus of fungus showing sporophores and mycelium

FIG. 12. Various stages in the development of sporophores.

FIG. 13. Beginning of the formation of two spores.

FIG. 14. Mature spores and spores in various stages of germination.

FIG. 15. Development of sporidia, *a* to *g*.

FIG. 16. Sporidium forming a secondary sporidium.

FIG. 17. Section through a sorus showing mature spores.

FIG. 18. Mycelium turned aside by the endodermis, which it never penetrates.

FIG. 19. Two pairs of young pine leaves, *a* too old for infection, *b* the proper age for infection (both natural size).

# THE PHILOSOPHY OF SPECIES-MAKING.[1]

L. H. BAILEY.

1. THE SPECIES-CONCEPTION.—It is probable that the forms of life have sprung from one common or original point. At all events, there seems to be a general series of convergent histories in organic nature, when one attempts to trace genealogies. These multitudes of forms seem to bear some definite and intimate relation to the circumstances under which they live and grow; in fact, they appear to have resulted from the splitting up and modification of the original plasma by means of the contest of numbers and the changes and diversifications in the physical characters of the earth. There are as many forms or kinds of life as there are diverse and disputed places upon the earth, and the forms no doubt are still, for the most part, slowly adjusting themselves to the continuing changes in the conditions in which they grow. We now have the best of reasons for believing that the organic creation is a plastic one, and that it will continue to be modified so long as it is possible for life to exist upon the globe. If the forms of life shall finally perish, the extinction will be preceded by a long process of diminution of virility coming as an adjustment to increasingly untoward conditions.

When *men* first began the serious study of the forms of life, they were still convinced that the creation is a congeries of objects which had come directly from the hand of the Creator, a collection or a patchwork of most curious things. The intellectual grasp of the creation was not yet comprehensive enough to suggest, to many minds at least, that the universe is one thing, one conception, a unity in method; the mind therefore rested upon the individual objects and logically exalted them into the sphere of units in the creation. In other words, the ultimate units, the entities, in organic nature were, to the early

[1] Read by title before The Botanical Society of America, August 1896.

naturalists, the things which were to be seen. If the forms of life were the entities, then the units must have one common designation; and the technical expression applied to them was the word *species*. To make names and descriptions for these units was really to know nature; so there arose a desire to make inventories of nature, and the organic creation was speedily cut up into coordinate units. All this resulted in a species of versification or paragraphing of nature; and it would not be unfair to say that, in this conception, the species is the organic paragraph.

The reader will now perceive that the two attitudes of mind which are sketched in these two paragraphs are antagonistic and incompatible. If one is true, the other is necessarily untrue. Evolution, as a method, is either true or it is not true. It cannot be half true. If evolution is true, then the forms of life are not the units or entities in the organic creation; they are the disjoined remaining results of the world-long process of elimination, the incidental outcomes of a vicarious history. In some lines of ascent, notably in the mammals, these forms are, to be sure, exceedingly well marked, but these only attest the more strongly to the survival of the most specialized types. In other words, there are no species as understood by Ray and Linnæus and Cuvier and the older naturalists.

It is unnecessary to argue for the truth of evolution before this constituency; although I suspect that there are still botanists who accept evolution as true only in those particular groups in which they can observe some direct evidences of it, without seeing that such limitation of its action is a denial of its universality and therefore of its truth as a principle. Yet I suppose that I should not meet strong opposition if I say that naturalists now regard species as the final, that is, the present, adjustment of forms of life to circumstances; and yet the greater number of naturalists seem still practically to look upon the species as the organic unit. Even the definitions in our latest and best lexicons insist upon the intrinsic merits of species. The *Century Dictionary* defines a species, in biology, to be "that which is specialized or differentiated recognizably from anything else of the same genus, family, or order ; an individual which differs, or collectively those individuals which differ, specifically from all the other members of the genus, etc., and which do not differ from one another in size, shape, color, and so on, beyond the limits of (actual or assumed) individual variability, as those animals and plants which stand in the direct relation of parent and offspring, and perpetuate certain inherited characters intact or with that little modification which is due to conditions and environment." The *Standard Dictionary* defines a species as "a classificatory group of animals or plants subordinate to a genus, and having members that differ among themselves only in minor details of proportion and color, and are capable of fertile interbreeding indefinitely." *Webster* is as follows: "In science, a more or less permanent group of existing things or beings, associated according to attributes, or properties determined by scientific observation." Stormonth's *English Dictionary* says that a species is "a group of individuals or objects sufficiently identical in all their natural qualities to justify the conclusion that they may have sprung from a common stock."

In all these definitions the idea of genetic continuity seems to be fundamental, and in this respect they are not greatly unlike the definitions which were current in pre-Darwinian times. They all seem to be descendants of Cuvier's conception that a species is "the reunion of individuals descended from one another, or from common parents, or from such as resemble them as closely as they resemble each other." This really amounts to little more than Linnæus' phrase, "We reckon as many species as there were forms created in the beginning."

Although we are driven to abandon the conception that the immediate forms of life are the units in the organic creation, we must nevertheless arrive at our knowledge of this creation by means of these forms. It is these forms which we take hold of when we study nature. They are the tangible objects with which we deal. Then they should be described and named; but the important point is that the forms of life serve as a convenient means of classifying our knowledge of nature, and are not entities in themselves. Species are, therefore, a human contrivance, and the only value which the modern naturalist can attach to them, as such, is their temporary convenience as a means and vehicle of thinking and writing about the organic creation. They should be defined only in terms of classification, not in terms of structure and genealogy, that is, in terms extrinsic, not terms intrinsic. Modern naturalists have largely eliminated genealogy from the definitions of species, but I do not recall any who define it solely as a convenience of taxonomy. Huxley writes that "a species is the smallest group to which distinctive and invariable characters can be assigned." Haeckel's definition is one of the very best but is too indefinite to be workable. In his conception the word species "serves as the common designation of all individual animals or plants which are equal in all essential matters of form, and are only distinguished by quite subordinate characters." Unsatisfied with the current definitions, I defined species, in *Survival of the Unlike*, as "a term used to classify animals and plants, by designating or grouping together all those forms or individuals which are very much alike in taxonomic marks." But this is too indefinite to be of much use. As I now conceive of it, I should define a species as follows: *The unit in classification, designating an assemblage of organisms which, in the judgment of any writer, is so marked and so homogeneous that it can be conveniently spoken of as one thing.*

II. The Art of Species-making.—When we come to the practical application and use of the word species, we must admit that the more carefully we distinguish the forms of life, the smaller or narrower must be the assemblages to which, for reasons of perspicuity, we apply the word. The smaller the classificatory divisions, the more exactly can we speak of organic life. We elucidate our subject more by dividing it than we do by massing it. I therefore look with favor upon the tendency in some quarters to make specific names for forms which have heretofore been regarded as well marked varieties, although I admit that it is easy to acquire the tendency to give specific names to forms which are of such small taxonomic importance that the student may be confused rather than enlightened by the subdivision. The remarks in this paragraph represent Asa Gray's later conviction, a position which he once summed up to me, with his characteristic forcefulness, in the remark that "species are judgments." I remember his saying to me, in effect, that he should consider the Atlantic Ocean to be a good distinguishing mark between certain species; that is, that forms which would scarcely be considered to be specifically distinct when occupying the same or coterminous areas might properly be called species if they were separated distinctly by great natural barriers. I am quite sure that he looked upon very similar forms in very unlike geographical regions as tending towards greater differentiation, and whenever it was possible, in perspicuous treatment, to draw fairly good characters of separation between them he thought that it was expedient to do so. In other words, Gray would not make quantitative characters supreme in his designation of species.

I would not for a moment make it a test of a species that there should be no intergradient forms. If the intermediate forms are so few that they do not seriously obscure the mental conception of the type, then all interests will be subserved by disregarding them for purposes of nomenclature. In fact, I should expect very few species of plants to be perfectly free from aberrant and entangling forms. The groups of plants are rare in which one can say that the types are unique. Soil, exposure, climate, contest with fellows, and a hundred incidental circumstances leave their impress upon the plant forms.[2]

If the making of species is an expediency, then it follows that it is not necessary, or even desirable, that we should search for obscure or anatomical characters with which to separate them. These characters belong to anatomy, physiology, embry-

[2] It would seem that some exception might be made to these remarks in the lucid genus Carex, for Britton, in describing a new species, was able to find "crucial proof of its distinctness." Bull. Torr. Bot. Club **22**:220.

ology, and the like, not to taxonomy. At all events, it seems to be clear that the species-division will be useful in proportion as it is founded upon obvious and easily ascertained attributes.

My own convictions respecting the art of species-making may be illustrated by a concrete example, which I have elsewhere published.[3]

"If this position is well taken, it follows that the naturalist should not describe new species with the idea of adding another item or organism to the inventory of nature, but for the purpose of classifying and clarifying our knowledge of the kind and extent of variation which the given group presents. A new species, therefore, is made simply for convenience's sake. In very variable groups it is perfectly justifiable to make species when it is known that occasional forms are intermediates, if thereby we are enabled to understand the relationships of the various forms more clearly. This is particularly true in narrow groups which have many forms of varying taxonomic importance. An illustration may be taken from the genus Carex. The *echinata* group contains four more or less coordinate main types, the *echinata* proper of the Old World, and three types in the United States. It has been the fashion to throw these all together into a composite species, calling it *Carex echinata*. In this arrangement, the subgroups or sub-forms do not stand out clearly, and it is impossible to contrast them forcibly. Moreover, the characters which separate the most marked sub-forms are of as great or even greater classificatory importance than characters which are used to separate *Carex echinata* itself from its fellow species. The old arrangement might be graphically presented as follows:

"*Carex echinata*.
- Group B.
  - Subgroup *a*.
  - Subgroup *b*.
  - Subgroup *c*.
- Group C.
- Group D.
  - Subgroup *a*.

"This classification, from a taxonomic standpoint, is untrue, for, as Carex species go, groups B, C, D are coordinate with *C. echinata*, and not subordinate to it. The mere fact that there are now and then intermediate forms between these various groups should not deprive us of the privilege of expressing the taxonomic facts. In nearly every instance specimens can be clearly referred to one or the other of the groups by one who is familiar with

[3] Survival of the Unlike, 134, 135.

them; but so long as the various groups are represented to be of minor and variable importance—as the above arrangement does represent them to be, to a botanist's mind—so long will they remain to be comparatively little distinguished and understood. Consequently I have erected (Bull. Torr. Bot. Club **20**: 422) the four groups into coordinate species, as follows:

A. *Carex echinata*. Old World.

B. *Carex sterilis*. New World.

*a*. var. *excelsior*.

*b*. var. *cephalantha*.

*c*. var. *angustata*.

C. *Carex Atlantica*.

D. *Carex interior*.

*a*. var. *capillacea*."

III. THE HYBRIDITY COROLLARY.—Intermediate forms are the most confusing and disturbing elements in species-divisions. These forms may be (*a*) normal intergradients, (*b*) unusual or sportive aberrations, or (*c*) hybrids. The marks of hybrids are generally inconstant and evasive, and yet it is of the utmost importance to perspicuous taxonomy that one shall be able to determine hybrids from normal variations. There are certain general evidences of hybridity which the student may apply with very satisfactory results to intermediates of which he suspects a hybrid origin. I have been in the habit of giving seven categories of tests to my students. These have been suggested mostly by a study of known hybrids in domestic plants. The student must be cautioned that the satisfying of any one of these tests is not a proof of hybrid origin, but if the suspected forms answer more or less closely to three or more of them hybridity generally may be inferred with some confidence. These tests are as follows:

A. *Evidences of variation.*

1. Intermediateness of characters between any two species is an evidence of hybrid origin, and this evidence is the greater the more unvariable the suspected parents normally are.

2. Variation or gradation towards one or two related species arouses a very strong suspicion of hybrid origin, and the evi-

dence is the stronger the more numerous the variant individuals are.

3. Monstrous, sportive, and scattering variations are often evidences of hybridity. These evidences are especially significant when they pertain to the inflorescence, or to the essential organs of the flower.

4. Seedlessness, or greatly reduced seed-bearing, is very good evidence of hybridity in cases where related species are fructiferous.

B. *Evidences of distribution.*

5. Intimate association of the suspected forms with species which appear to be their parents is one of the strongest proofs of hybrid origin. It is not essential, as evidence, that the suspected forms grow actually amongst or with the supposed parents, for hybrids often occur at a distance of several rods, and sometimes even a mile or more, from their parents. It often happens, too, that one of the parents will disappear from the neighborhood before the hybrids do. In some instances the two parents are not known in the association because one of them has been overlooked. Some time since I suggested that a certain Carex which a collector sent me was a hybrid, but the collector denied it because one of the supposed parents had never been detected anywhere near his locality. I predicted that it would be found. The next year it turned up close at hand.

6. Rarity of the suspected individuals should be considered to indicate generally hybrid origin if the related species are common.

7. Localness and absence of "range" are most excellent suggestions of hybridity, particularly when the related species have well marked ranges. In other words, hybrids are generally accidental and spasmodic. Examples of my conception may be taken from the native apples and plums. My *Pyrus Soulardi* has a most disjointed distribution, whilst *Pyrus Ioensis* and *P. Malus* have continuous ranges in the same geographical region. My *Prunus hortulana* is similarly dismembered in distribution, whilst

*Prunus Americana* and *P. angustifolia* have good ranges. These facts first led me to suppose a hybrid origin for *Pyrus Soulardi* and *Prunus hortulana*, a conviction which is reinforced by other evidence, as I expect to publish shortly in detail.

My contention, therefore, is that since we agree that the species is not, as a matter of fact, an entity, we must abandon the conceptions of it which define it upon intrinsic characters; and we must look upon it as a more or less arbitrary division which it is expedient to use in taxonomy and nomenclature.

CORNELL UNIVERSITY.

# LABORATORY APPARATUS IN VEGETABLE PHYSIOLOGY.

J. C. ARTHUR.

(WITH PLATES XXIV AND XXV)

In the development of the laboratory methods in any department of science a need arises for convenient pieces of apparatus of special construction, and also of new adaptations of apparatus already on the market. It takes some time for the need and the supply to become adjusted, and suggestions and information in the earlier stages or days of development are particularly helpful. It is with a desire to contribute to this demand that the following descriptions of apparatus for work in vegetable physiology are given.[1] The several pieces have been devised in the laboratory of Purdue University to supply the requirements of the classes in physiology.

**Auxanometer.**—The main features of this apparatus were worked out by Miss Katharine E. Golden, while assistant in the laboratory in 1889–93, aided somewhat in the preliminary construction by her brother, Professor Michael J. Golden, of the Mechanical Department of Purdue University. Minor changes in perfecting it have been made as they occurred to those who used it, and especially by Mr. C. W. Meggenhofen, an unusually ingenious and painstaking mechanic, who for two years gave his best efforts to the construction of apparatus for this laboratory, and is still giving some time to it. He is to be credited also with much of the successful detail in other apparatus to be described, especially of the centrifuge.

[1]Some of the apparatus here described in detail was exhibited to the Botanical Club of the A. A. A. S. in 1893 and 1894. It has been in part briefly described also in the Proceedings of Indiana Academy of Science for 1894, not yet generally distributed, and in a descriptive circular and price-list of physiological apparatus, dated January 1, 1895.

The object has been to secure a piece of apparatus that will be simple, easily adjusted, giving so small an amount of tension to the tender part of the plant being studied as to be inappreciable, record with accuracy, and withal comparatively inexpensive.

The apparatus (*pl. XXIV*) stands about $45^{cm}$ high, and consists of two separate parts. The recording part supports a clock (either a twenty-four hour or eight-day clock) above, with its dial uppermost. To the lower end of the shaft which carries the minute hand is attached a frame supporting two glass rods, each $30^{cm}$ long. These rods are blackened by holding them over burning camphor gum, and receive transverse marks from a descending needle as they revolve once an hour.

Blackened glass rods in place of a revolving drum were first used on this apparatus, so far as the writer knows. They are very easily handled, and permanent records are readily secured by making blue prints, or the rods themselves can be kept. The principal value of two rods, rather than one, is to act as a control or duplication of the record, although separated by a half-hour interval.

The other part of the apparatus carries the multiplying pulley and needle. The pulley is made of aluminum for sake of lightness, and runs on carefully adjusted parallel bearings. There are one large and two small wheels upon the pulley shaft, permitting a magnification of the amount of growth either eight or fifteen times.

In the earlier machines, shown at the Madison meeting of the American Association for the Advancement of Science in 1893,[2] and illustrated in plate XXIV, the recording needle was a bristle adjusted in an aluminum holder, which slid upon a vertical glass rod, a second glass rod acting as a guide. This was found to be too heavy and clumsy, and has been replaced by a needle of fine brass wire attached to a skeleton carriage of similar wire, running upon two parallel tight wires in place of the glass rods. The needle and carriage together are barely heavy enough to straighten the slender thread used to suspend them, and it is

[2]See BOT. GAZ. 18: 348. 1893.

usually necessary to put weights of a few milligrams upon the carriage in order to make the machine run uniformly.

Many trials have been made to secure a satisfactory thread for the pulleys. The material found to work best is sewing silk A sufficient length is taken and untwisted, and only a part of one strand used. All attempts to secure a smoother thread by employing wax of some sort have met with indifferent success, and finally have been abandoned. The thread which leads from the plant to the small pulley is carried through a bent glass tube which offers but the slightest possible friction, and obviates the necessity of placing the plant directly underneath.

To adjust the apparatus the thread from the needle carriage is threaded through an opening in the rim of the large pulley wheel and fastened in a slit, the carriage remaining at the bottom of the guides. A thread from the plant is then passed through the glass rod and once around one of the smaller pulley wheels, and after the pulley is turned so that the needle carriage is at the top of the guides, the thread is fastened in a slit at the side of the small wheel. The carriage is now weighted enough to keep the threads barely straight. The recording part is next brought into place, and set so that the point of the needle will make a mark as the blackened rods pass it. To have the recording rods parallel to the path of the needle the apparatus should be set upon a level surface, preferably on a piece of plate glass. As the plant grows the needle descends at a multiplied rate, and leaves the record on the blackened rods.

There are no hanging weights, and no unnecessary pull upon the plant in this machine. The needle carriage and its riders constitute the sole weight for turning the pulley. As the plant grows the thread which leads from it is wound up on the small pulley wheel, and the thread attachèd to the needle carriage is unwound from the large wheel, permitting the needle to descend.

The small excess of weight permissible above that necessary to overcome the friction of the machine, in order not to influence perceptibly the growth of the organ under observation, makes it imperative that the movable parts of the machine should be kept in perfect order. It is especially necessary that the pulley bearings be clean and carefully adjusted, and that the guide wires for the needle carriage be kept polished. As the machine is intended to record increments of growth too small to be seen by the unaided eye, it is obvious, moreover, that it should be kept free from tremor or jar. It must, in fact, be treated as a machine of delicate precision in order to secure results of the highest value.

**Centrifuge.**—This machine (*pl. XXV*) is for the purpose of applying to small plants a force, in connection with or independent of gravitation, that shall induce a strain within the organ of the same physiological nature as that brought about by gravity. A disk of cork $10^{cm}$ in diameter, to which germinating seeds may be pinned is made to revolve at considerable speed in a moist chamber. The moist chamber consists of a shallow metal pan, into which a deep glass cover is fitted. The bottom of the pan is pierced by two openings, one of which conducts a constant supply of water into the chamber through a rubber tube terminating in a bent glass tube within. The glass tube can be adjusted from without so as to permit the water to fall in drops upon any part of the disk. An opening at the opposite side of the pan takes away the surplus water through a rubber tube.

The revolving disk is turned by a small electric motor, supplied with current from two Edison-Lalande cells of type Q. These batteries are the most satisfactory for small motors yet devised. When setting them up it is best to put the jar into a vessel of water, and let it remain there until the potash has fully dissolved and the excessive temperature abated, to avoid breaking the jar. After the cell is in readiness it requires no further attention until exhausted, when the potash, oil, zincs and carbon must be replaced with new ones. Although this is by far the best motor battery known, yet, like all batteries, it is likely to prove treacherous at times. Where suitable water power, or other more reliable motive power is available, it should be adopted.

When the cork disk is whirled horizontally the centrifugal force acts in a plane at right angles to that of gravity, and the direction of growth is a resultant of the two forces ; when the disk is whirled vertically gravitation is neutralized. In order to secure these positions the first machines made, which were exhibited[3] at the same time as the auxanometer already mentioned, had the moist chambers supported on a metal arc, and held in place by a set screw in the base (*pl. XXV*). But it was found difficult to accurately center the pulley wheel for the different positions, and later machines have been made with the chamber supported on a pinion (*fig. 1*).

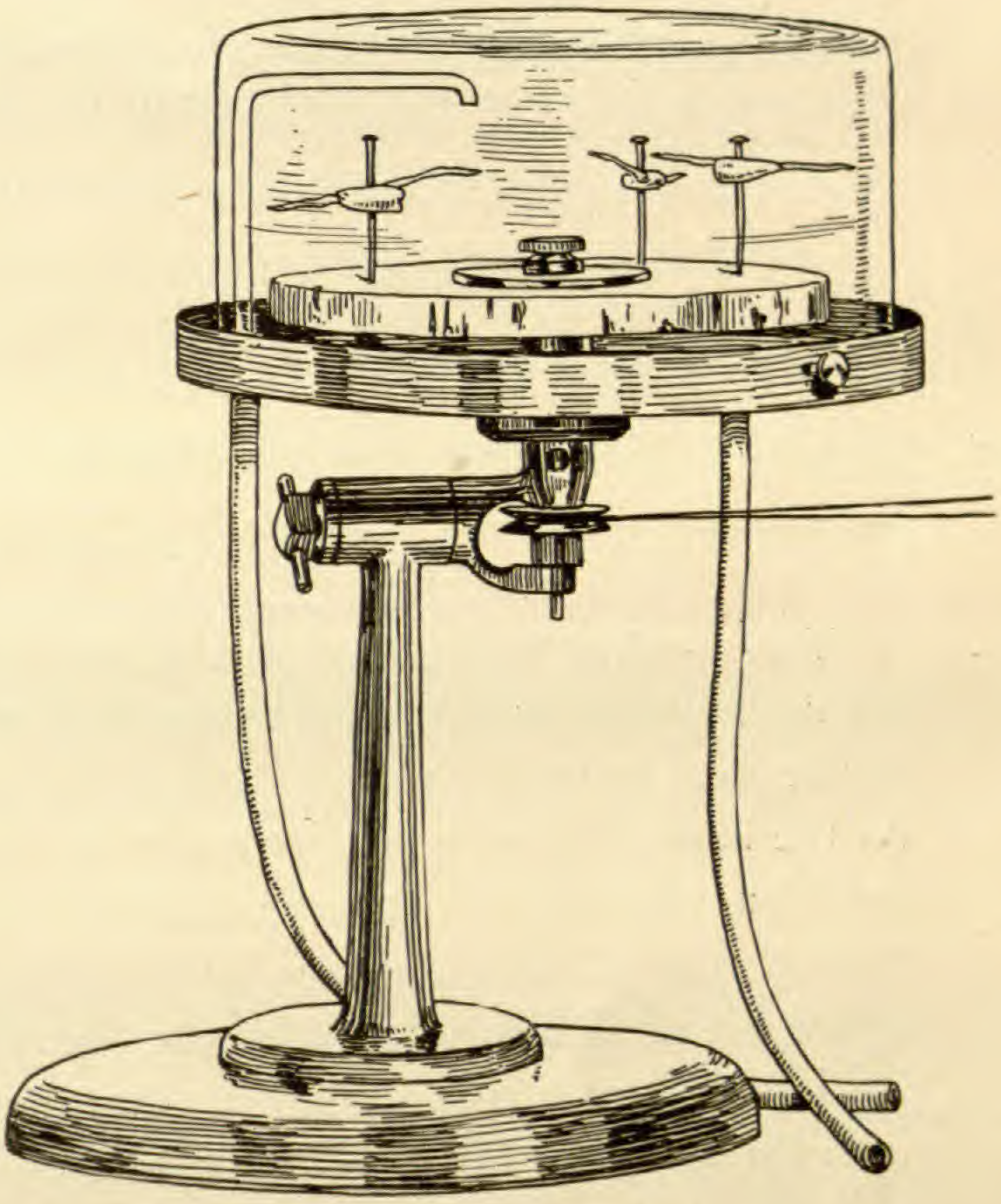


FIG. 1. Centrifuge with iron base.

When the electric motor is used it is mounted, along with the chamber, on a wooden base (*pl. XXV*); when other motive power is employed the chamber is mounted on a heavy iron base (*fig. 1*). To ascertain the speed of the disk a piece of paper is passed over a revolving pencil point for an exact number of seconds. The pencil point is attached eccentrically to the lower end of the spindle carrying the cork disk (*pl. XXV*) and describes a spiral as the paper is moved over it. By counting the number of turns of the spiral, the number of revolutions of the disk for the time is found.

[3] *Ibid.* 344.

**Respirometer.**—This piece of apparatus (*fig. 2*) is a modification of one employed by Pfeffer,[4] which in turn was adapted from Pettenkofer's apparatus for experiments upon the respiration of animals. It consists of a small chamber in which germinating seeds or other living material is placed, surrounded by water to keep the temperature uniform. A thermometer is plunged in the chamber, and one in the water outside.

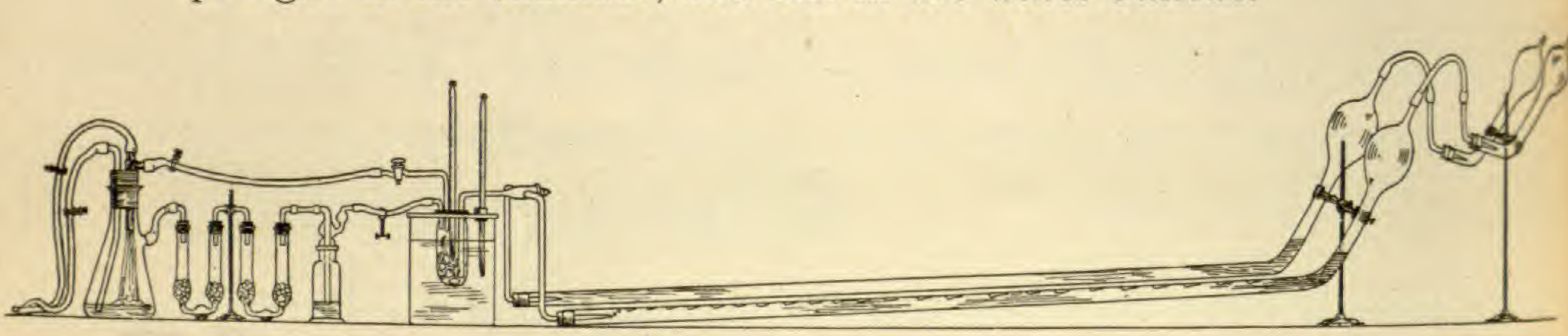


FIG. 2. Respirometer.

Two U-tubes containing potash, and a wash bottle containing barium hydrate solution, are connected in series with the chamber at one end and with an aspirator, or water pump, at the other. At the beginning of an experiment the aspirator draws the air out from the chamber through a direct connection, and forces it through the potash tubes and wash bottle back into the chamber, freeing it of carbon dioxide in the operation. When the chamber is sufficiently free of carbon dioxide, the direct connection with the aspirator is broken, and a stopcock opened which permits the carbon dioxide free air, forced into it by the aspirator, to pass into and traverse a long tube (about a meter) partly filled with a solution of barium hydrate (made by adding $15^{gr}$ of barium chloride to $5^{l}$ of distilled water, and after it has largely dissolved adding $105^{gr}$ of barium hydrate), the gas then passing through a short supplementary tube, also containing barium solution. The bulbs at the distal ends of these tubes are to prevent an overflow, if a sudden increase in pressure should occur. There are two sets of tubes so that continuous observations may be carried on as long as desired. When the test has been in progress for the first period (usually an hour), a three-way cock

[4] Unters. a. d. bot. Inst. zu Tübingen 1: 637.

is turned, directing the stream of gas into the other set of tubes. During this period the first set of tubes is emptied and refilled and made ready for the third period, and so on. The object in having the barium solution in long tubes is to bring the gas well in contact with the solution, so that any carbon dioxide given off by the living material under observation will be taken up and precipitated as barium carbonate. The supplementary tube is to catch any carbon dioxide that may escape precipitation in the the longer tube, usually a very small amount, if any. A definite amount of solution is used in each tube, generally $100^{cc}$ in the long tube and $20^{cc}$ in the short one, or enough to fill the straight portions of the tubes. The two are emptied together at the close of the period into a closed vessel, and allowed to stand until the precipitate has fallen to the bottom.

To determine the amount of carbon dioxide that has been absorbed by the barium solution during one period, an integral part of the solution ($20^{cc}$ is a convenient amount), after standing until clear, is titrated. A few drops of rosolic acid are added to the solution to be tested, as an indicator, and a standard acid solution ($1.4318^{gm}$ of dry oxalic acid in $500^{cc}$ distilled water) is run into it from a graduated burette until exactly neutralized, as shown by the change of color. The same amount of the original barium solution is similarly titrated. The difference in the number of cubic centimeters of the standard solution used for each represents the number of milligrams of carbon dioxide absorbed by the integral part of the barium solution titrated, for one cubic centimeter of the standard acid solution will convert as much barium into an oxalate as one milligram of carbon dioxide will change to a carbonate. To find the total number of milligrams of carbon dioxide given off during the period, multiply the difference just obtained by the factor that represents the ratio of the full amount of barium solution employed in the trial to the amount titrated (six in the case supposed).

This apparatus is found to work with a steady water pressure, but sudden changes in pressure are very detrimental. Its accuracy is also all that is usually required.

The temperature of the respiration chamber can readily be changed by cooling or heating the water surrounding it.

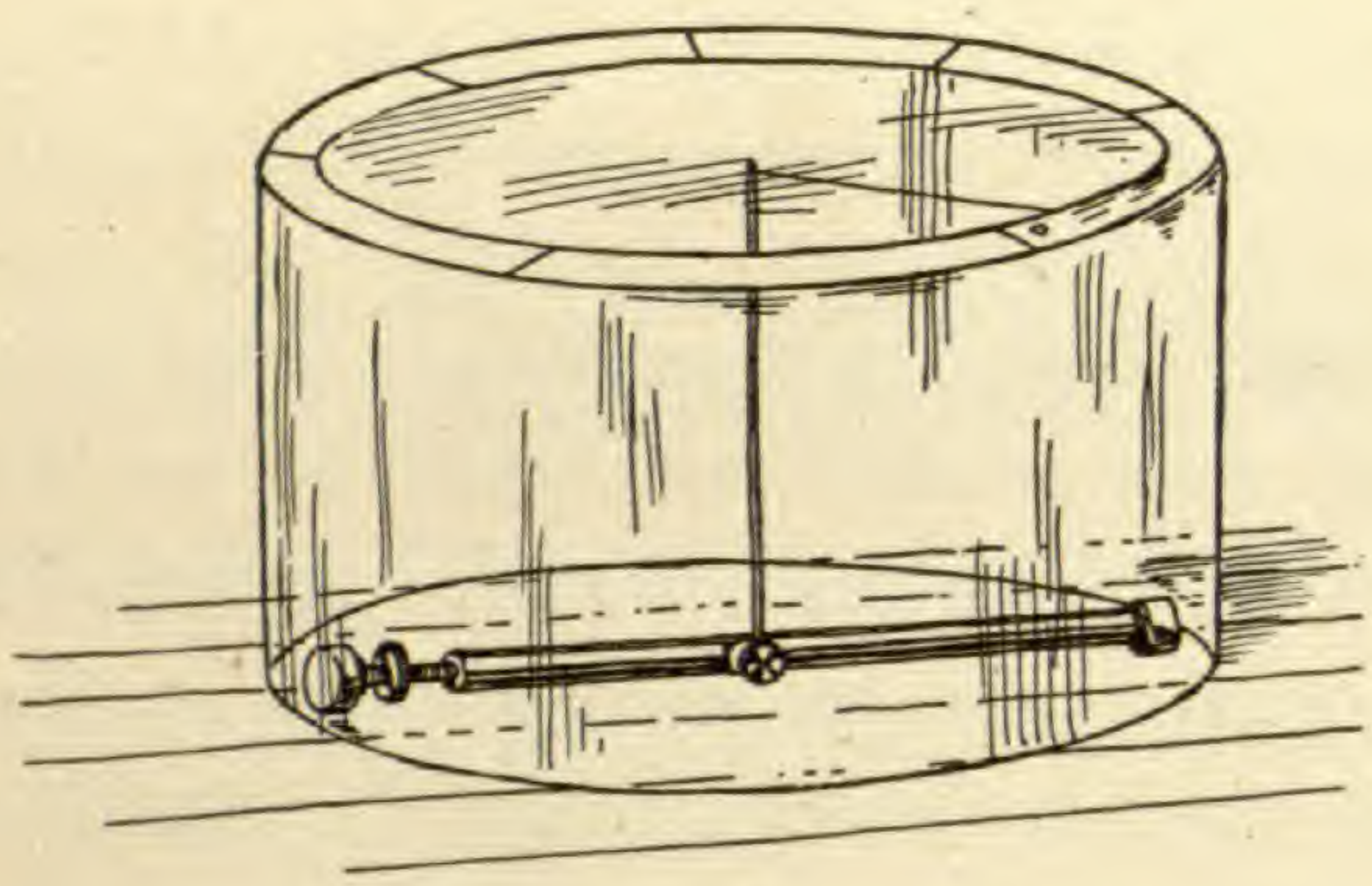


FIG. 3. Awn hygrometer.

**Hygrometer.** — When the writer was in the laboratory of Francis Darwin at Cambridge in 1888, he was shown a roughly made hygrometer,[5] which has since been used in the Purdue laboratory and modified into the form shown in *fig. 3*. It consists of a small thin glass vessel with a metal bar across the mouth bearing a part of a Stipa (*S. spartea* Trin.) awn. To the free end of the awn is attached an index of fine brass wire. When the air becomes moist, the awn untwists and the index is carried around. To use it two are selected with awns that untwist at the same rate, and fastened to opposite sides of a leaf by means of a mixture composed of wax, oil, and tallow. The leaf may be attached to the plant, or separated from it and kept from wilting by placing the end in water (*fig. 4*). The position of the index on each side of the leaf is marked at the start, and again when one of them has made a complete revolution. The ratio between the number of degrees of the circle traversed by the two indices during the interval is approximately the ratio of transpiration from the two sides of the leaf.

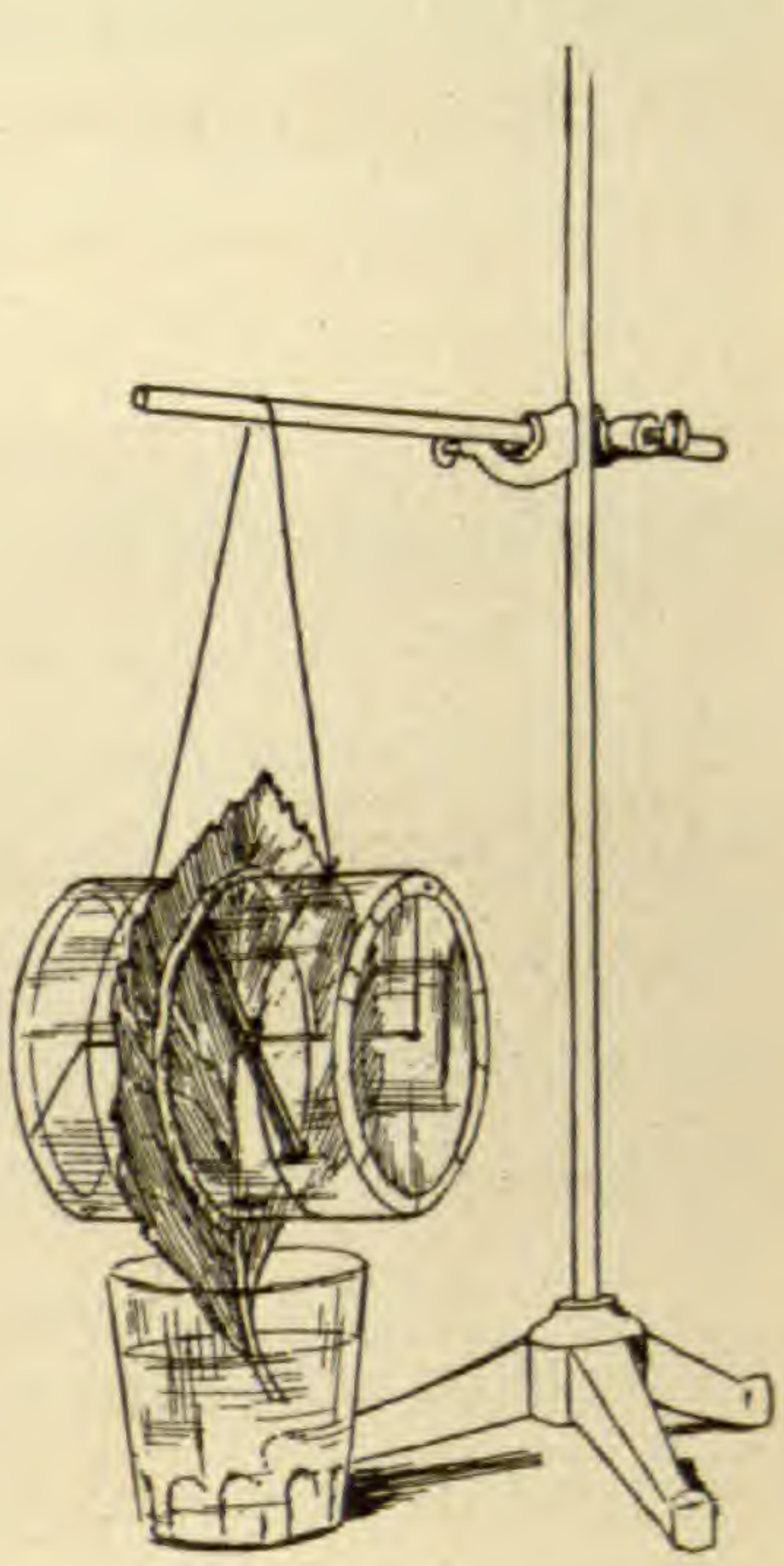


FIG. 4. Hygrometer in use.

[5] Since described and its use fully explained; see Darwin and Acton's Practical Physiology of Plants

The apparatus is not accurate, but makes an interesting demonstration of the general difference in transpiration between the two sides of different kind of leaves.

**Slide with binding posts.**—The difficulty in attaching wires to tin foil, when wishing to use an electric current under the microscope, has led to the device shown in *fig. 5*. An ordinary microscope slide is provided with a pair of small brass binding posts, each bearing a clip. When in use two wedge shaped pieces of tin foil are placed under the clips with their points near together. The object to be examined is mounted in a drop of water between the points, and covered with a cover slip in the usual manner. It is then placed on the stage of the microcope and the wires from the battery passed into the binding posts.

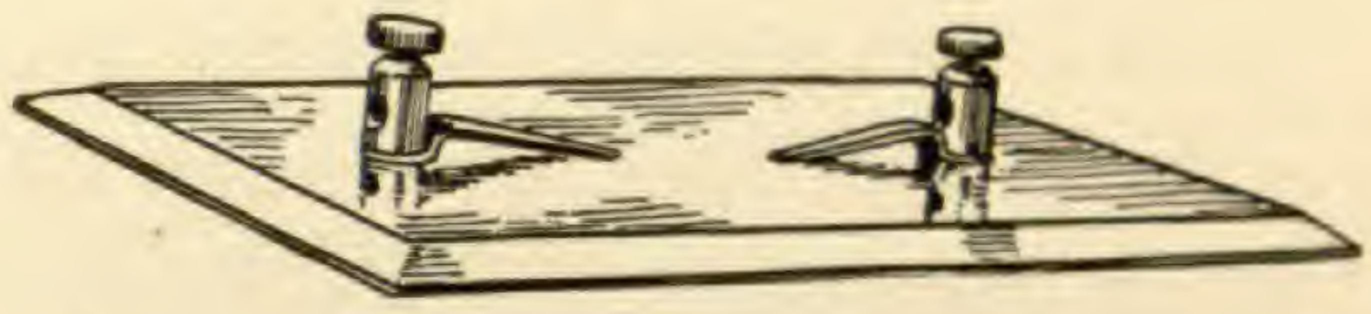


FIG. 5. Slide with binding posts.

**Mercury reservoir.**—Mercury is often serviceable and occasionally indispensable in physiological work. Sometimes, as in eudiometric experiments, it must be dry and perfectly clean. The several ways of cleaning mercury are mostly tedious and unsatisfactory, and repeated trials led finally to the adoption of a reservoir that keeps the mercury always dry, clean, and ready for use.

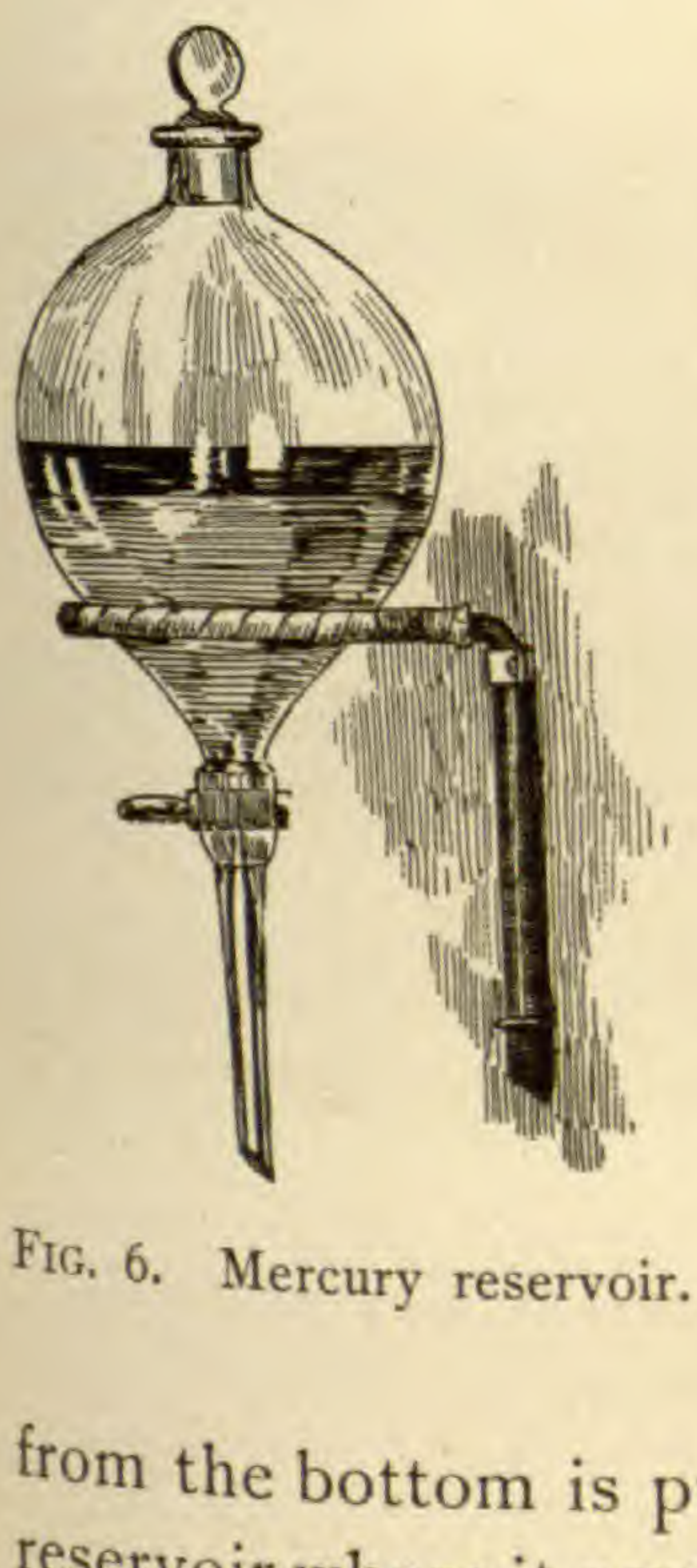


FIG. 6. Mercury reservoir.

The reservoir consists of a thick walled glass separatory funnel, about $15^{cm}$ in diameter (*fig. 6*). In this the mercury with some mercurous sulfate is placed, together with enough concentrated sulfuric acid to make a quarter-inch layer over the surface. To begin with it is shaken up several times, and in twenty-four hours is ready for use. Mercury drawn from the bottom is pure and dry. After use it is returned to the reservoir where it again becomes usable, without further attention.

The reservoir should be about half full in order to have as much surface of mercury exposed to the action of the acid as possible, and should be kept always stoppered. If mercurous sulfate is not at hand, it can be made by gently heating mercury with concentrated sulfuric acid ($1^{cc}$ mercury to $10^{cc}$ acid), being careful that there is always an excess of acid. This should be done in a hood.

The reservoir may be placed against the wall by using a ring supported by staples, as shown in the cut.

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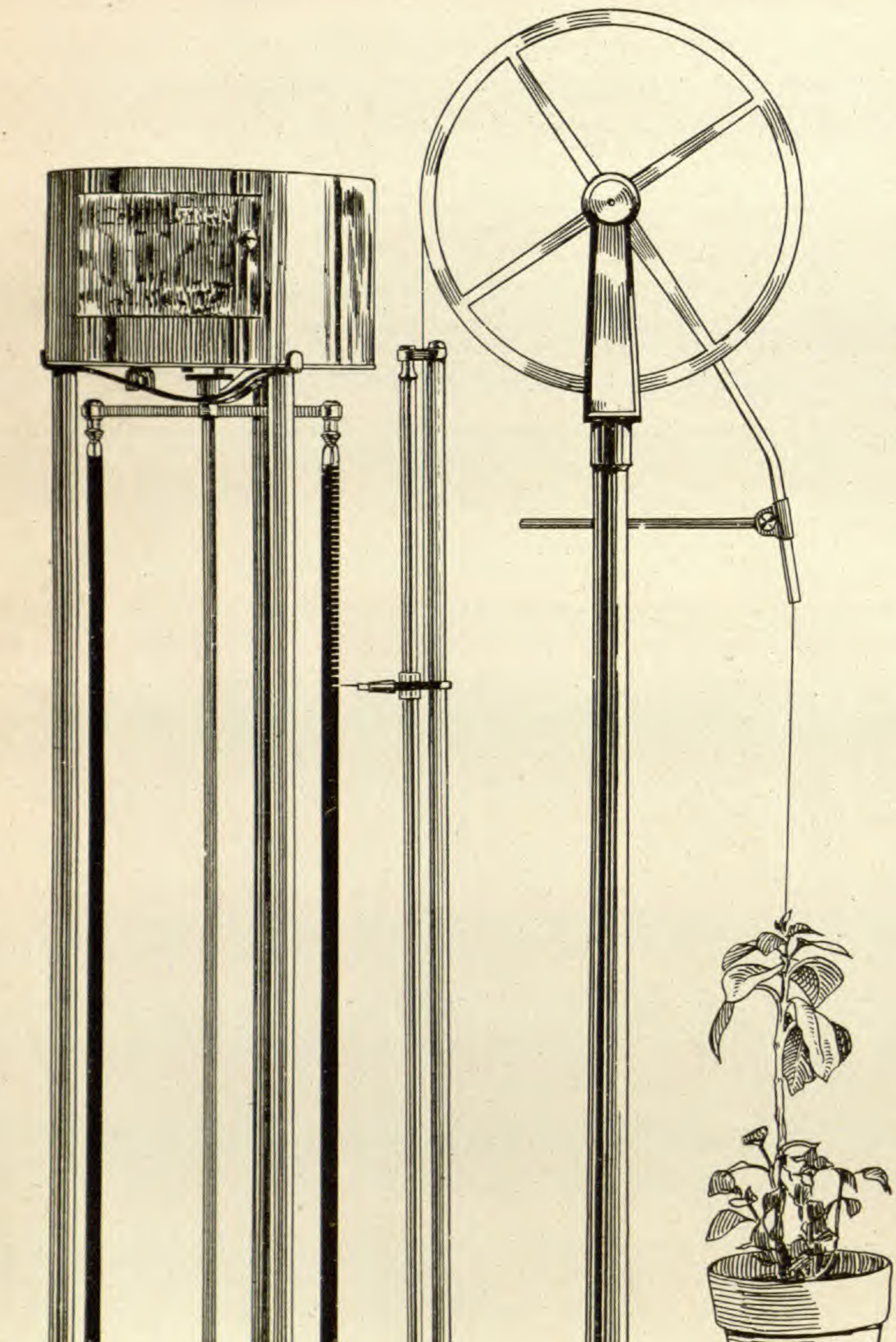
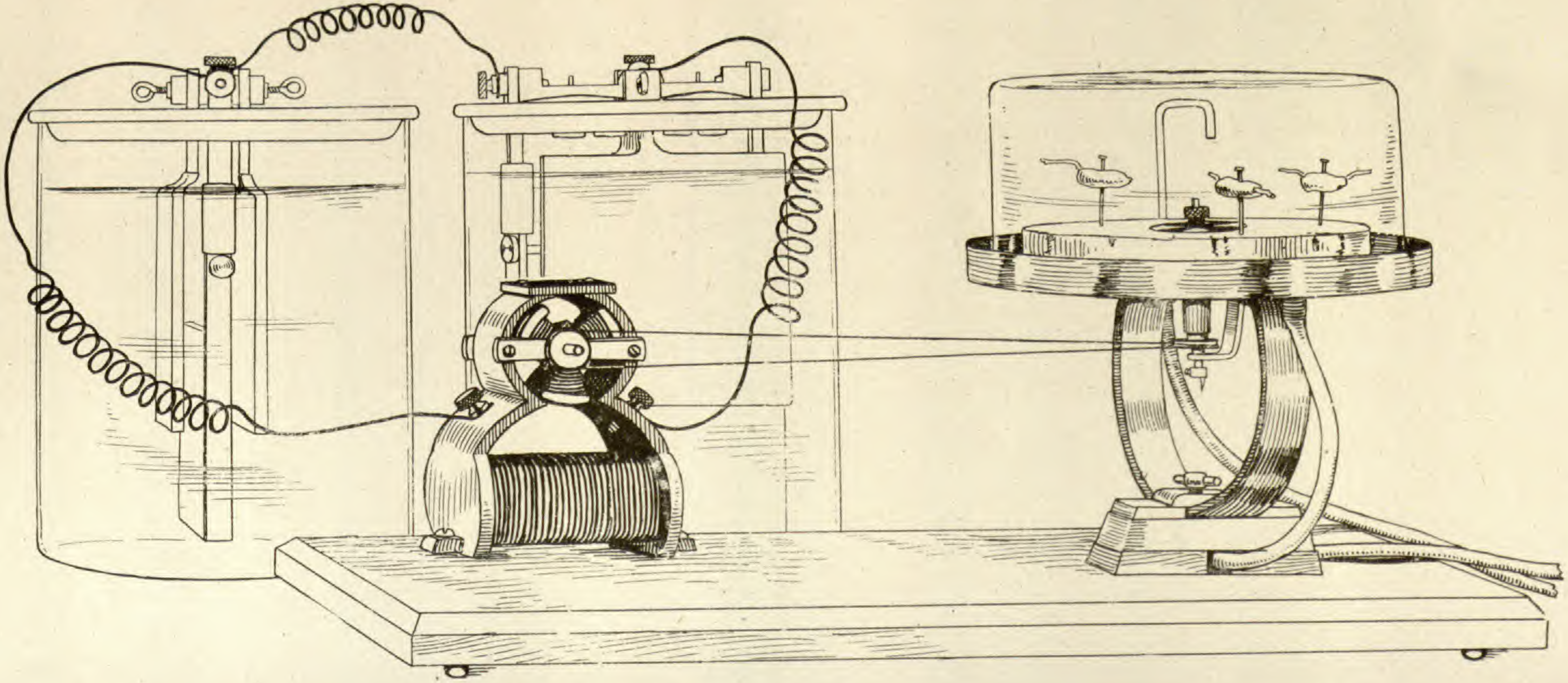
LAFAYETTE, IND.



ARTHUR on PHYSIOLOGICAL APPARATUS.
GOLDEN AUXANOMETER.



ARTHUR on PHYSIOLOGICAL APPARATUS. CENTIFRUGE with MOTOR.

# POPULAR AMERICAN PLANT-NAMES. IV.

FANNIE D. BERGEN.

[Reprinted by request from plates kindly furnished by the editor of the *Journal of American Folk-lore.*—EDS.

RANUNCULACEÆ.

*Aconitum Napellus,* L., Adam-and-Eve-in-the-bower, Deering, Me.
*Actæa alba,* Bigelow, white cohosh, blue cohosh, Paris, Me.
*Actæa spicata,* L., var. rubra, Ait., black cohosh, Paris, Me.
*Actæa,* sp., necklace-weed, Me. (W).[1]
*Anemone Caroliniana,* Walt., mayflower, Burnside, S. Dak.
*Anemone Myosurus,* var. *minimus* (?), mouse-tail, Cal.
*Anemone nemorosa,* L., snow-drops, Lynn, Mass.
*Anemone patens,* var. *Nuttalliana,* Gray, wind-flower, rock-lily, wild crocus, Madison, Wis.
rock-lilies, Brodhead, Wis.
badger, general in Wis.
*Anemone Pennsylvanica,* L., crowfoot, Burnside, S. Dak.
*Anemone Pulsatilla* (?), prairie crocus, Mont., Colo., and N. Dak.
*Anemone trifolium,* spring beauty, Oxford County, Me.
*Anemonella thalictroides,* Spach., anemone,[2] Sulphur Grove, Ohio.
*Aquilegia Canadensis,* L., honeysuckle, Madison, Wis.
bells, Sulphur Grove, Ohio.
Jack-in-trousers,[3] Lynn, Mass.
jacket-and-breeches.
*Aquilegia truncata,* Fisch. & Mey., wild columbine, Cal.
*Aquilegia vulgaris,* L., blue bells, No. Ohio.
Same, white variety, fairies,[4] Norridgewock, Me.
*Caltha palustris,* L., coltsfoot, Me.
coltsroot, Sulphur Grove, Ohio.
crowfoot, South Berwick, Me.
capers, Berwick, Me.
*Clematis ligusticifolia,* Nutt., var. *Californica,* Wats., virgin's bower, wind-flower, Cal.
*Clematis Virginiana,* L., woodbine, wild hops, Hartford, Oxford County, Me.
*Coptis trifolia,* Salisb., canker-root, Oxford County, Me.
*Delphinium cardinale,* Hook., scarlet larkspur, Santa Barbara, Cal.
*Delphinium decorum,* Fisch. & Mey., blue larkspur, Santa Barbara, Cal.

[1] Names marked thus (W) are taken from Williamson's *History of Maine.*
[2] Sometimes, also, rue-anemone.
[3] Children's name.
[4] Pressed by schoolgirls and carried for a time.

*Helleborus viridis*, L., Christmas rose, Chris root,[1] Sulphur Grove, Ohio.

*Hepatica acutiloba*, DC., pass blummies,[2] Alcove, N. Y.
spring beauty, Brodhead, Wis.

*Hepatica triloba*, Chaix., noble liverwort, Sulphur Grove, Ohio.

*Nigella Damascena*, L., Jack-in-the-bush, Worcester, Mass.
ragged sailor, Jack-in-the-pulpit, Rutland, Mass.
maid-in-the-mist, Acton, Mass.

*Ranunculus acris*, L., kingcup, Me. (W).

*Ranunculus acris*, L., var. *plena*, queens-button, Sulphur Grove, Ohio.
bachelors' buttons, Bethlehem, Pa.

*Thalictrum polygamum*, Muhl., silver weed, musquash weed, celandine, Oxford County, Me.

CALYCANTHACEÆ.

*Calycanthus floridus*, L., spice-bush, Middleborough, Mass.
shrub, sweet-scented shrub, Sulphur Grove, Ohio.
sweet Betsies (plantation negroes). Ala.

MAGNOLIACEÆ.

*Magnolia glauca*, L., sweet bay, Mo.

MENISPERMACEÆ.

*Menispermum Canadense*, L., sarsaparilla, Parke County, Ind., Sulphur Grove, Ohio.

BERBERIDACEÆ.

*Achlys triphylla*, DC., May apple, Cal. and Wash.

*Berberis aquifolium*, Pursh, Oregon grape, Oregon and Wash.
grape-root, No. Utah.

*Berberis pinnata*, Lag., barberry, Cal. and Oregon.
Oregon grape, Cal.
leña amarilla,[3] Cal.

*Berberis vulgaris*, L., pipperidge-bush,[4] So. N. H.

*Podophyllum peltatum*, L., hog-apple,[5] Iowa.

[1] Evidently for Christmas root.
[2] Probably corrupted from *Pasque Blumen*.
[3] Name used by Mexicans and Americans.
[4] A name now almost obsolete.
[5] "Fruit mawkish, eaten by pigs and boys," Gray's *Manual*, earlier editions.

NYMPHÆACEÆ.

*Nelumbo lutea*, Pers., wonkapin,[1] So. Ind.
*Nuphar advena*, Ait., kelp, South Berwick, Me.
horse-lily, Hartford, Me.
yellow pond-lily, Millersburg, Ind.

SARRACENIACEÆ.

*Sarracenia purpurea*, L., foxgloves, Woodstock, Me.
whippoorwill's shoes, meadow-cup, fore-father's pitcher, Me. (W).
whippoorwill's boots, Philadelphia, Pa.
skunk-cabbage, St. Paul, Minn.

PAPAVERACEÆ.

*Argemone hispida*, chialote (Span.).
thistle-poppy, Santa Barbara, Cal.
*Eschscholtzia Californica*, Cham.,[2] torosa (Span.).
cups of flame, cups of gold, Cal.
*Sanguinaria Canadensis*, L., puccoon, Vt.
red puccoon, Sulphur Grove, Ohio.
red root, Me. (W).
sweet slumber, Delaware County, Pa.

FUMARIACEÆ.

*Adlumia cirrhosa*, Raf., mountain fringe, wood fringe, Paris, Me.
canary vine, Madison, Wis.
*Corydalis glauca*, Pursh, Roman wormwood, Paris, Me.
Loridales plant, Me. (W).
*Dicentra cucullaria*, DC., kitten breeches, Sulphur Grove, Ohio.
Indian boys and girls, Madison, Wis.
*Dicentra spectabilis*, DC., love-lies-bleeding, bleeding hearts, No. Ohio.
ear-drops, Sulphur Grove, Ohio.

CRUCIFERÆ.

*Capsella bursa-pastoris*, Moench, wind-flower, Fairhaven, Mass.
*Dentaria laciniata*, Muhl., crow-toes, Sulphur Grove, Ohio.
*Erysimum asperum*, DC., orange mustard, Cal.
*Erysimum officinale*, hedge-mustard, Cal.
*Hesperis matronalis*, L., sweet rocket, Paris, Me.
*Lepidium intermedium*, Gray, wild tongue-grass, S. W. Mo.

[1] Supposed to be an Indian name.
[2] The California state flower.

*Lunaria biennis*, L., matrimony vine, Paris, Me.

*Raphanus raphanistrum*, cadlock (corruption of charlock), Nova Scotia.

*Raphanus sativus*, L., black mustard, Cal.

*Sisymbrium officinale*, Scop., California mustard, Rumford, Me.

*Thysanocarpus curvipes*, Hook., lace-pod, Cal.

*Thysanocarpus laciniatus*, Nutt., var. *crenatus*, Brewer, fringe-pod, Cal.

CISTACEÆ.

*Hudsonia tomentosa*, Nutt., poverty-grass, heath, dog's dinner, Wellfleet, Mass.

VIOLACEÆ.

*Viola palmata*, L., chicken-fighters, Newton, N. C., children.[1]

*Viola palmata*, var. *cucullata*, Gray, fighting-cocks, New Brunswick.
Johnny jump-up,[2] Sulphur Grove, Ohio.

*Viola pedata*, L. (and related species), Johnny jump-up,[2] Sulphur Grove, Ohio.

*Viola tricolor*, L., none-so-pretty, Abington, Mass.

POLYGALACEÆ.

*Polygala paucifolia*, Willd., bird-on-the-wing, Me.
ladies' slipper, Gardiner, Me.
purple May wing, Me.

CARYOPHYLLACEÆ.

*Dianthus Armeria*, L., grass-pink, Paris, Me.

*Gypsophila paniculata*, L. (and other species), mist, babies' breath, E. Mass.

*Saponaria officinalis*, monthly pink, Greene County, Mo.
sweet Betty, Parke County, Ind.
world's wonder, E. Mass.
lady-by-the-gate, N. C.

*Saponaria vaccaria*, L., cockle, Blue Earth County, Minn.

*Silene acaulis*, L., moss pink, Paris, Me.

*Silene Armeria*, L., mice pink, Hennepin, Ill.

*Silene Californica*, Durand., Indian pink, Cal.

*Silene Cucubalus*, Wibel., devil's rattle-box, Stockbridge, Mass.
maiden's tears, Orono, Me.

*Silene regia*, Sims., wild pink, Greene County, Mo.

*Spergula arvensis*, L., devil's guts, Paris, Me.

*Spergularia*, bedsandwort, West.

[1] From a custom with children of locking their spurs to see which head pulls off.

[2] This name is applied to all our native violets.

PORTULACACEÆ.

*Portulaca grandiflora*, Lindl., rose-moss, Kentucky moss, Sulphur Grove, Ohio.
*Portulaca oleracea*,[1] L., purslane, Cal.
pursley,[2] Sulphur Grove, Ohio.
pusley,[2] Minn.
pursley or pusley, Parke County, Ind.
*Talinum calycinum*, Engelm., rock pink, Greene County, Mo.

HYPERICACEÆ.

*Hypericum prolificum*, L., paint-brush,[3] near Oakdam, Ind.

MALVACEÆ.

*Abutilon Avicennæ*, Gærtn., butter-print,[4] Iowa, Central Ill.
pie-print,[5] S. W. Mo.
pie marker, Indian hemp, Sulphur Grove, Ohio.
*Abutilon*, sp., mountain lily, Maine.
*Hibiscus Trionum*, L., modesty, Sulphur Grove, Ohio.
*Lavatera assurgentiflora*, Kellogg, tree-mallow, Santa Barbara, and Santa Barbara Islands, Cal.
*Malva moschata*, L., musk (or mush), Me.
*Malva rotundifolia*, L., cheeses, Cumberland County, Me.
cheesetts, Oxford County, Me.
*Malvastrum coccineum*, Gray, moss rose, Burnside, S, D.
*Sphæralcea Emoryi*, Torr., cimarona (Span.), cheese-weed, Cal.

TILIACEÆ.

*Tilia Americana*, L., lin tree, Sulphur Grove, Ohio.
white wood, West.

GERANIACEÆ.

*Erodium cicutarium*, L'Her., alfillarilla or filaree,[6] Berkeley, Cal.
pin clover, Cal.
*Erodium moschatnm*, Willd., alfillarilla or filaree, Berkeley, Cal.
musky filaria, pin clover, Cal.
*Geranium incisum*, Nutt., crane's bill, Sierra Nevada Mountains, Cal.

[1] Used as food by the Indians.
[2] Evidently corruptions of purslane.
[3] From resemblance of flowers to a small paint-brush.
[4] Alluding to the form of the seed-pods.
[5] Used to stamp pie-crust.
[6] A name used by the Spanish Californians.

*Geranium maculatum*, L., old maids' night-caps, Madison, Wis.
alum root, alum bloom, crow foot.[1]
*Geranium Robertianum*, L., mountain geranium, Hancock, N. H.
*Impatiens fulva*, Nutt., celandine, kicking horses,[2] Paris, Me.
cowslip, wild touch-me-not, Sulphur Grove, Ohio.
*Oxalis corniculata*, L., yellow sorrel, Cal.
*Oxalis corniculata*, var. *stricta*, Sav., toad sorrel, Kennebec County, Maine.
sheep's clover, Waverley, Mass.
poison sheep sorrel, Greene County, Mo.
sheep's sorrel, Sulphur Grove, Ohio.
sour grass, Ind.
lady-sour-grass.
*Oxalis acetosella*, var. *Oregana*, Trelease, redwood sorrel, Cal.

SIMARUBACEÆ.

*Ailanthus glandulosus*, Desf., devil's walking stick, Sulphur Grove, Ohio.

ILICINEÆ.

*Ilex verticillata*, Gray, white alder, Oxford County, Me.

RHAMNACEÆ.

*Ceanothus Americanus*, L., wild pepper, Greene County, Mo.
*Ceanothus divaricatus*, Nutt., lilac, Santa Barbara County, Cal.
*Ceanothus prostratus*, Benth., mahala-mats, Cal.
*Ceanothus thyrsiflorus*, Esch., California lilac, wild lilac, Cal.
*Rhamnus alnifolia*, L'Her., dwarf alder, West.
*Zizyphus Parryi*, Torr., lotophagi, lotus tree, San Diego County, Cal.

VITACEÆ.

*Ampelopsis quinquefolia*, Michx., five-finger.
*Vitis cordifolia*, Michx., winter grape, Greene County, Mo.

SAPINDACEÆ.

*Acer dasycarpum*, Ehrh., soft maple, Minn.
white maple, Southwestern Mo.
*Acer Pennsylvanicum*, L., moosewood, whistlewood, Paris, Me.
*Acer rubrum*, L., soft maple, Minn.
white maple, Paris, Me.

[1] From shape of root.

[2] From the manner in which the ripe seed-vessel bursts open when touched.

*Acer rubrum*, L., red maple, hard maple, Southwestern Mo.
*Acer saccharinum*, Wangenh., sugar tree, Ohio, Ind., and Ill.
*Acer spicatum*, Lam., swamp maple, Paris, Me.
*Cardiospermum Halicacabum*, L., puffball, balloon-vine, Sulphur Grove, Ohio.

ANACARDIACEÆ.

*Rhus copallina*, L., black shumack, Southwestern Mo.
*Rhus diversiloba*, T. and G., poison oak, yeara, Cal.
*Rhus glabra*, L., white shumack, Southwestern Mo.
*Rhus integrifolia*, Benth. and Hook.; and *rhus ovata*, Watson, lemonade and sugar tree, lentisco, San Diego County, Cal.
*Rhus toxicodendron*, L., poison vine, Ind. and No. Ohio.
poison ivy or poison vine, Sulphur Grove, Ohio.
mercury (marc'ry), picry, Hartford, Me.
*Rhus venenata*, DC., poison ash, Vt.
*Schinus molle*, L., pepper tree, Cal.

LEGUMINOSÆ.

*Acacia Greggii*, Gray, cat's claws, Cal.
*Algarobia glandulosa*, mesquit, N. Mex. and Ariz.
*Amorpha canescens*, Nutt., shoe-strings,[1] Minn.; Burnside, S. Dak.
*Amorpha fruticosa*. L., river locust, Minn.
*Amorpha microphylla*, Pursh, shoe-string, Burnside, S. Dak.
*Apios tuberosa*, Moench, pig-potato, West.
Dakota-potato, Minn.
*Astragalus caryocarpus*, Ker., Buffalo-apple, N. Dak.
Buffalo-bean, N. Dak.; Burnside, S. Dak.
*Astragalus Mexicanus*, DC., prairie-apple,[2] Southwestern Mo.
*Astragalus mollissimus*, Torr., rattle-box weed, loco-weed,[3] Cal.
loco-weed,[3] Neb.
*Canavalia obtusifolia*, DC., wild hop or "'op," Florida Keys.
*Crotalaria sagittalis*, L., loco-weed, Neb.
*Glycyrrhiza lepidota*, Nutt., licorice root,[4] Cal.
*Gymnocladus Canadensis*, Lam., Kentucky coffee bean, Sulphur Grove, Ohio.
*Lathyrus palustris*, L., wild pea.
*Lathyrus splendens*, Kellogg, pride of California, Cal.

[1] From the long, tough roots.
[2] Fruit eaten by children.
[3] Pods poisonous to horses; produce a disease in cattle and sheep known as loco.
[4] Roots used by the Indians as medicine.

*Leguminosa formosus*, sand lupine, Cal.
*Lupinus arboreus*, Sims., sun dial, tree lupine, Cal.
*Lupinus perennis*, L., wild pea, Burlington, Vt.
old maids' bonnets, Southampton, Mass., Southold, L. I.
sun dial, Eastern N. Y.
*Lupinus*, sp., sun dial, monkey faces, Sulphur Grove, Ohio.
*Medicago denticulata*, Willd., bur-clover, Cal.
*Medicago sativa*, L., Lucerne, alfalfa, Cal.
*Melilotus alba*, Lam., honey clover, Greene County, Mo.
*Oxytropis Lamberti*, Pursh, loco,[1] loco-weed. Neb., Iowa, and Mo.
*Parkinsonia Torreyana*, Watson, green wood, Ariz.
*Petalostemon violaceus*, Michx., thimble-weed, St. Joseph, Mo.
*Petalostemon violaceus* and *P. candidus*, Michx., red and white tassel-flowers, Southwestern Mo.
*Prosopis juliflora*, DC., honey-mesquit,[2] algarola (Span.), Ariz.
*Prosopis pubescens*, Benth., curly mesquit, N. Mex.
screw-bean, N. Mex., Ariz., and Cal.
screw-pod mesquit, fornillo,[2] Ariz.
*Psoralea esculenta*, Pursh, tipsin, Dakota tipsinna,[3] Burnside, S. Dak.
Dakota turnip, Minn.
*Schrankia uncinata*, Willd., sensitive rose, Burnside, S. Dak.
sensitive brier, shame-faced brier, Southwestern Mo.
*Tephrosia Virginiana*, Pers., wild pea, Southwestern Mo.
*Trifolium arvense*, L., pussies, pussy-cats, bottle-grass, Mass.
pussies, pussy-cats, calf-clover, Southold, L. I.
*Trifolium incarnatum*, L., crimson clover, Cal.
*Trifolium megacephalum*, Nutt., large-headed clover, Cal.
*Trifolium repens*, L., honeysuckle, honeysuckle-clover, Oxford County, Me.
*Vicia Americana*, Muhl., buffalo pea, Burnside, S. Dak.
*Vicia cracca*, L., Canada pea, Paris, Me.

ROSACEÆ.

*Amelanchier Canadensis*, T. and G., sugar-pear, Oxford County, Me.
dogwood, boxwood, wild pear, June plum, West.
*Amygdalus pumila*, flowering almond (flowery ammon), No. Ohio.
*Cercocarpus ledifolius*, Nutt., mountain mahogany, Cal.
*Chamæbatia foliolosa*, Benth., tar bush, tar weed, Cal.

[1] From poisonous effects upon grazing animals. See article II. of this series.
[2] Pods used by Arizona Indians as food.
[3] An Indian name.

*Cratægus tomentosa*, L., red haw, Sulphur Grove, Ohio, Central Ill.
*Dalibarda repens*, L., robin-run-away, Franklin plant, Oxford County, Me.
*Fragaria vesca*, L., sow-tit, sheep-nose, Central Vermont.
*Geum rivale*, L., chocolate, Paris, Me.
maidenhair, Brodhead, Wis.
*Geum triflorum*, Pursh, prairie smoke, Me.
*Nuttallia cerasiformis*, T. and G., oso berry, California and Oregon.
*Potentilla Canadensis*, L., running buttercup, Oxford County, Me.
*Potentilla fruticosa*, L., hardhack, Stockbridge, Mass.
*Potentilla Norvegica*, L., barren strawberry, Hartford, Me.; Medford, Mass.
*Potentilla*, sp., star-flower, Waverly, Mass.
*Prunus ilicifolia*, oak-leaved cherry, California.
*Prunus hortulana*, Bailey, hog plum, S. W. Mo.
*Prunus nigra*, pomegranate, Orono, Me., West.
*Prunus Pennsylvanica*, L., fire cherry,[1] Franklin County, Me.
*Prunus pumila*, L., beach plum, Aroostook and Somerset counties, Me.
*Pyrus arbutifolia*, L., choke-berry, Oxford County, Me.
*Rosa cinnamomea*, L., primrose, Paris, Me.
*Rosa humilis*, Marsh (and other species), wild rose, S. W. Mo.
*Rosa minutifolia*, Parry's Mexican rose, San Diego County, Cal.
*Rosa setigera*, Michx., rose blush, S. W. Mo.
*Rubus cuneifolius*, Pursh, sand blackberry, Mo.
*Rubus odoratus*, L., mulberry, Paris, Me.
*Rubus spectabilis*, Pursh, salmon-berry, Cal., Oregon, and Wash.
*Rubus triflorus*, Richards, running raspberry, Oxford County, Me.
pigeon berry, West.
*Spiræa tomentosa*, L., purple hardhack, West.

## SAXIFRAGACEÆ.

*Ribes gracile*, Michx., Illinois gooseberry, Ky.
*Ribes prostratum*, L'Her., skunk currant, Oxford and Washington counties, Me.
*Saxifraga sarmentosa*, L., Otaheite, Paris, Me.
*Saxifraga Virginiensis*, Michx., everlasting,[2] Lynn, Mass.; sweet Wilson,[3] Abington, Mass.
*Saxifraga*, sp., Mayflower, Auburndale, Mass.

[1] Always appears on newly burned land.
[2] Children's name.
[3] Named by Mrs. Ward fifty years ago, to please Wilson Ward, who complained that there was a sweet William but no sweet Wilson. Name still extant.

CRASSULACEÆ.

*Sedum acre*, L., treasure of love, Boston, Mass.
*Sedum pulchellum*, Michx., rock moss, S. W. Mo.
*Sedum telephium*, L., Aaron's rod, Paris, Me.
life-of-man, live-forever, Oxford County, Me.

MELASTOMACEÆ.

*Rhexia Virginica*, L., handsome Harry, Eastern Mass.

ONAGRACEÆ.

*Epilobium angustifolium*, L., wickup, Paris, Me.
purple rocket, Sally-bloom, York County, N. B.
Siberian flax, Westmoreland County, N. B.
pig weed, Canada.
*Gaura*, sp., wild honeysuckle, Tex.
*Ludwigia palustris*, Ell., water purslane, West.
*Œnothera biennis*, L., scabish, South Berwick, Me.
*Zauschneria Californica*, Presl., wild fuchsia, Santa Barbara County, Cal.

LOASACEÆ.

*Mentzelia ornata*, T. and G., Gunebo lily,[1] No. Dak.

PASSIFLORACEÆ.

*Passiflora Warei*, Nutt., devil's pumpkin, Florida Keys.

CUCURBITACEÆ.

*Echinocystis lobata*, T. and G., creeper, creeping Jenny, Oxford County, Me.
*Sicyos angulatus*, L., wild cucumber, Sulphur Grove, Ohio; Central Illinois.

CACTACEÆ.

*Cereus giganteus*, Engelm., giant cactus, Ariz.
*Cereus Greggi*, Engelm., three-cornered cactus, Ariz.
*Cereus pectinatus*, Engelm., rainbow cactus, Ariz.
*Echinocactus Wislizeni*, Engelm., niggerhead cactus, barrel cactus, fish-hawk cactus, Ariz.
*Mamillaria Goodridgii*, Scheer., strawberry cactus, So. Cal.
*Mamillaria Grahami*, Engelm., pin-cushion cactus, Ariz.
*Opuntia arborescens*, Engelm., tree cactus, Ariz.

[1] Grown in Gunebo Hills.

*Opuntia Engelmanni*, Salm., prickly-pear cactus, Ariz.
*Opuntia frutescens*, rat-tail cactus, Ariz.
*Opuntia fulgida*, Engelm., straw cactus, Ariz.

FICOIDEÆ.

*Mollugo verticillata*, L., devil's grip,[1] No. Berwick, Me.

UMBELLIFERÆ.

*Cicuta maculata*, L., snake weed.
*Daucus carota*, L., bird's nest, Penobscot County, Me.
*Daucus pusillus*, Michx., rattlesnake-bite cure, *yerba del vibora* (Span.), Cal.
*Erigenia bulbosa*, Nutt., turkey pea, pepper and salt, Ind.[2]
*Eryngium Leavenworthii*, T. and G., briery thistle, Waco, Tex.
*Hydrocotyle Americana*, L., penny post, West.
*Osmorhiza longistylis*, DC., sweet anise,[3] Sulphur Grove, Ohio.
*Osmorhiza brevistylis* and *O. longistylis*, DC., sweet jarvil, Hartford, Me.
*Peucedanum ambiguum*, Nutt., kouse root, bread and biscuit,[4] Cal.

ARALIACEÆ.

*Aralia hispida*, Vent., pigeon berry, Oxford County, Me.
*Aralia nudicaulis*, L., sasapril or sasafril, Me.
saxapril and sasafafarilla, Bath, Me.
*Aralia racemosa*, L., old man's root, spikenard, Oxford County, Me.
*Aralia trifolia*, Decsne. and Planch., ground nut, Oxford County, Me.

CORNACEÆ.

*Cornus alternifolia*, L. f., green osier, Paris, Me.
*Cornus sericea*, L., red willow, Mo.
red brush, Morgan County, Mo.
squaw bush, West.

CAPRIFOLIACEÆ.

*Diervilla trifida*, Moench, life-of-man, Oak Bay, N. B.
*Lonicera ciliata*, Muhl., medaddybush, Weld, Me.
*Sambucus Canadensis*, L., sweet elder, West.
*Sambucus pubens*, poison elder, Oxford County, Me.

[1] Name given by section-hands along the railroad, because the plant is so hard to eradicate.
[2] Eaten by children and fowls. Called "pepper and salt" from the white petals and dark stamens.
[3] Odor and taste like true sweet anise.
[4] Made into bread by the Indians.

*Symphoricarpos vulgaris*, Michx., buck bush, S. W. Mo.
*Triosteum perfoliatum*, L., wild ipecac, West.
*Viburnum acerifolium*, L., squash-berry, Newfoundland.
*Viburnum dentatum*, L., withe-wood, So. Berwick, Me.
*Viburnum lanlanoides*, Michx., moose bush, moose berry, Paris, Me.
dogwood, Bath, Me.
*Viburnum lentago*, L., tea plant, Madison, Wis.
*Viburnum nudum*, L., possum berry, Ocean Springs, Miss.

RUBIACEÆ.

*Galium* (various species), beggar lice, S. W. Mo.
*Galium*, sp., robin-run-ahead, cleavers, Sulphur Grove, Ohio.
*Houstonia*, sp., Venus' pride, wild forget-me-not, star violet, Waco, Tex.
*Houstonia cærulea*, L., forget-me-not, Oxford County, Me.
little washerwomen, Bethlehem, Pa.
blue-eyed grass, Brodhead, Wis.
*Mitchella repens*, L., two-eyed plum, snake plum, Oxford County, Me.
pigeon berry, Mass.
fox berry, Lynn, Mass.
chicken berry, West.
one berry, Central N. Y.
*Morinda Roioc*, L., red root, Florida Keys.
*Randia clusiæfolia* (? *Gardenia clusiæfolia*, Jacq.), seven-year apple, Florida Keys.

VALERIANACEÆ.

*Valeriana edulis*, Nutt., tobacco root, kooyah, Cal.
*Valeriana officinalis*, L., hardy heliotrope, summer heliotrope, Sulphur Grove, Ohio.
garden heliotrope, Middleborough, Mass., Northern Ohio.

DIPSACEÆ.

*Scabiosa atropurpurea*, L., mourning bride, mourning widow, Sulphur Grove, Ohio.
*Scabiosa succisa*, pin cushions, Sulphur Grove, Ohio.

COMPOSITÆ.

*Achillea Millefolium*, L., gordolobo, Cal.
*Ambrosia Artemisiæfolia*, L., hogweed, West.
blackweed, Long Island.
bitter-weed,[1] Sulphur Grove, Ohio, Eastern Pa.

[1] From its effect on the milk when eaten by cows.

*Ambrosia trifida*, L., horseweed, Sulphur Grove, Ohio.
*Anaphalis margaritacea*, Benth. and Hook., ladies' tobacco, Hartford, Me.
*Antennaria plantaginifolia*, Hook., love's test,[1] Ind.
dogs' toes (staminate flowers), Auburndale, Mass.
pussies' toes (pistillate flowers), Auburndale, Mass.
mouse's ear, Oxford County, Me.
poverty weed, Paris, Me.
four toes, mouse-ear, pearly everlasting, Salem, Mass.
*Anthemis Cotula*, DC., chigger weed,[2] Ind.
balders, (from Hardinge's "With the Wild Flowers").
*Arctium Lappa*, L., buzzies, Southold, L. I.
*Aster cordifolius*, L., tongue, So. Berwick, Me.
*Aster Novæ-Angliæ*, L., Michaelmas daisy, hardy aster, Sulphur Grove, Ohio.
*Aster* (all forms), frost weed, Paris, Me.
frost flowers, N. H.
*Aster* (native species), daisies, Sulphur Grove, Ohio.
*Aster* (cultivated varieties), fall roses, Sulphur Grove, Ohio.
*Bidens Beckii*, Torr., water marigold, St. Louis County, Mo.
*Bidens frondosa*, L., old ladies' clothes-pins, Mass.
*Bidens frondosa*, L., *cernua*, L., and *connata*, Muhl., beggars' ticks, Paris, Me.
pitchforks, Rumford, Me.
*Bigelovia venata*, Gray, rheumatic plant,[3] *damiana* (Span.), Cal.
*Centaurea Cyanus*, L., French pink, Sulphur Grove, Ohio, Ala.
ragged robin, Ohio, Baltimore, Md.
barbeau,[4] Louisiana.
*Centaurea Melitensis*, L., pasture weed, tocolote, Cal.
*Chrysopsis villosa*, Nutt., rosinwood, No. Dak.
*Cichorium Intybus*, L., wild bachelors' buttons, Worcester, Mass.
ragged sailors, blue daisies, Southold, L. I.

[1] The test is in this wise: A leaf is taken by the ends, a person of the opposite sex is thought of, and the ends are pulled apart. If the tomentum beneath is drawn out long, the affection is supposed to be proportionate. Sometimes this is varied by naming both ends, when the relative length of the tomentum determines the stronger love.

[2] So called because supposed to harbor the "chigger," a troublesome mite which burrows under the skin.

[3] Medicinal, cure for rheumatism.

[4] A name common along the Mississippi a generation and more ago, from a M. Barbeau, who brought it from France.

*Coreopsis Drummondii*, T. and G., lady's breast-pin, Sulphur Grove, Ohio.

*Coreopsis tinctoria*, Nutt., wild flax, Burnside, So. Dak.

*Cotula vulgaris*, manyanilla,[1] Cal.

*Dysodia chrysanthemoides*, Lag., prairie-dog weed, Burnside, So. Dak.

*Echinacea angustifolia*, DC., and *Lepachys columnaris*, T. and G., respectively comb and brush, Burnside, So. Dak.

*Erigeron annuus*, Pers., white-top weed, Sulphur Grove, Ohio.

*Erigeron Canadensis*, L., horse weed, *yerba el pasmore* (Span), Cal.

*Erigeron Philadelphicus*, L., daisy, Sulphur Grove, Ohio; Burnside, No. Dak.

*Erigeron pumilus*, Nutt., daisy, Burnside, So. Dak.

*Eupatorium ageratoides*, L., stevia, Madison, Wis.

*Eupatorium perfoliatum*, L., throughgrow,[2] Eastern Pa.

*Eupatorium purpureum*, L., queen of the meadow, Oxford County, Me.
king of the meadow, N. H.

*Gnaphalium*, sp., ladies' tobacco, Madison, Wis.

*Gnaphalium polycephalum*, Michx., Indian posy, Southold, L. I.
poverty weed, Paris, Me.

*Gnaphalium uliginosum*, L., mouse-ear, Paris, Me.

*Grindelia robusta*, Nutt., gum plant,[3] Cal.

*Gutierrezia Euthamiæ*, T. and G., broom weed, Waco, Tex.

*Helenium puberulum*, DC., rosilla, Cal.

*Helianthus multiflorus*, dahlia sunflower, Sulphur Grove, Ohio.

*Hemizonia ramosissima*, tar weed, balsamio, Cal.

*Hieracium aurantiacum*, L., missionary weed,[4] E. Sangerville, Me.

*Inula Helenium*, L., starwort, West.

*Lactuca Canadensis*, L., butter weed, wild lettuce, Sulphur Grove, Ohio.

*Lactuca leucophæa*, Gray, milk weed, Paris, Me.

*Layia platyglossa*, Gray, tidy tips, Cal.

*Matricaria Parthenium*, fever-few or feather-few, Sulphur Grove, Ohio.

*Othonna crassifolia*, cabbage worm,[5] noodle moss, Sulphur Grove, Ohio.

*Pectis papposa*, Gray, manzanilla coyote,[6] Cal. Desert.

*Parophyllum gracile*, Benth., sweet-scented herb, *yerba del vernada*, Cal.

[1] Medicinal and sweet-scented.

[2] Evidently from the perfoliate leaves.

[3] Cures poison from ivy.

[4] A recent introduction.

[5] Leaves shaped like a cabbage worm.

[6] So called by the Mexicans.

*Prenanthes* (any species), gall of the earth, Southern Me.
*Rudbeckia hirta*, L., yellow daisies, Southold, L. I.
black-eyed Susan, Sulphur Grove, Ohio.
brown-eyed Susan, Brockton, Mass.
bull's eyes, ox-eyed daisies, Paris, Me.
English bullseye, York County, Me.
*Solidago bicolor*, L., silver rod, belly-ache weed, Paris, Me.
*Solidago Canadensis*, L., yellow weed,[1] Sulphur Grove, Ohio.
*Solidago* (any species), flower of gold, yellow tops, Cal.
*Sonchus oleraceus*, L., milk thistle, Cal.
*Troximon cuspidatum*, Pursh, dandelion, Burnside, So. Dak.
*Zanthium Canadense*, Mill., cuckle-bur,[2] Sulphur Grove, Ohio.
*Zinnia elegans*, Jacq., old maid's pink, Sulphur Grove, Ohio.

*Fanny D. Bergen.*

CAMBRIDGE, MASS.

[1] The species of solidago are rarely called goldenrod by the common people.
[2] Never called cockle-bur.

# BRIEFER ARTICLES.

## NEW AND NOTEWORTHY WASHINGTON PLANTS.

**Cardamine callosicrenata,** n. sp. Perfectly glabrous throughout: stems erect, 60 to $70^{cm}$ high, purplish below, shining above, coarsely striate: leaves all similar and pinnately trifoliate, or some of the radical rarely simple; terminal leaflets orbicular, 3 to $5^{cm}$ long and nearly as broad, closely crenate or the uppermost lobed, the crenations tipped with a short blunt callous point; lateral leaflets ovate, entire, mostly obtuse, 10 to $15^{mm}$ long: raceme ample: flowers white: pods 25 to $30^{mm}$ long, erect on widely spreading pedicels $10^{mm}$ long: style stout: seeds light brown, about twenty in each pod.

In springy places, Spokane, July 2 and September 27, 1896.

This species has much the aspect of *C. Lyallii* Wats., but is more nearly related to *C. Breweri.*

DRABA AUREOLA Wats., described from Lassen's Peak, California, is found sparingly in volcanic scoria on Mt. Rainier at 10,000 feet altitude. Only two other plants, *Smelowskia calycina* Meyer and *Poa Lettermani* Vasey, occur at higher altitudes on this peak.

ERYSIMUM ARENICOLA Wats. has yellow flowers like others in the same group. It is not rare in its type locality, Mt. Steele, Olympic mountains, and grows either in loose sand or in rock crevices.

ARENARIA PALUDICOLA Rob. (*A. palustris* Wats.). This interesting species, first found in swamps near San Francisco, California, and later at San Bernardino by Parish, has been detected by Mr. J. B. Flett growing in sphagnum swamps near Tacoma. The Washington plants agree well with the specimens distributed by Parish, save that the stems are sparingly branched and the leaves are not at all flaccid. Some of the specimens are peculiar in that the leaves on the uppermost branches are decidedly reduced, but more of the specimens do not exhibit this character. Dr. Behr's note in *Erythea* (Nov. 1896), predicting that this plant will some day be found in Alaska, seems likely to be fulfilled now that it is known to occur in Washington.

STELLARIA OBTUSA Engelm. is not a rare plant in the Blue mountains, at the head of Touchet river. Single specimens of this species form dense cespitose mats often a foot in diameter.

SIDALCEA HENDERSONI Wats. This species was described from a single plant, supposed by its discoverer to be a waif, collected in 1886 at Clatsop beach, Oregon. As long ago as 1887 I collected a single specimen of it on the sea beach near Seattle, and last year found it in abundance in the brackish marshes at the mouth of the Snohomish river near Everett. It is a beautiful species with deep rose flowers nearly an inch in diameter. Apparently it is confined to the immediate proximity of the sea.

**Astragalus Palousensis,** n. sp. Perennial from a stout woody caudex: stems several, 40 to $60^{cm}$ high, simple or branched above, striate, sparingly pubescent with short appressed hairs, these white below and blackish above: leaves 8 to $12^{cm}$ long; leaflets 25 to 31, elliptical or lanceolate, obtuse or even truncate, appressed pubescent beneath, glabrous above, 5 to $20^{mm}$ (usually about $15^{mm}$) long, nearly sessile; petioles sparsely hirsute; stipules deltoid-acuminate: racemes elongate, 5 to $12^{cm}$ long; flowers 20 to 25, erect on short pedicels, $12^{mm}$ long; bracts lanceolate, shorter than the calyx: calyx obliquely campanulate, the slender teeth nearly as long as the tube, pubescent with short appressed black hairs: corolla pale yellowish, with or without a black spot on the wings: pod $2^{cm}$ long, crustaceous, narrowly oblong, tipped with a slender short beak, its surface transversely reticulated and sparsely pubescent with short white hairs; stipe as long as the calyx tube or shorter.

Common on rich loess hillsides about Pullman.

Very closely related to *A. reventus* Gray, and *A. arrectus* Gray. From the latter it differs in the much shorter stipe and beak of the pod; from the former in its more elongate raceme, in the leaves being glabrous above, and in the much shorter and sparser pubescence of the flowers.

RIBES PROSTRATUM L'Her. This species has not hitherto been reported from west of the Rocky mountains. It has been collected by Whited at the head of Twisp river, Cascade mountains, and by the writer near the source of the Duckaboose river, Olympic mountains. The specimens from the latter place are very well developed, some of the leaves being three inches in diameter.

**Valeriana Columbiana,** n. sp. Stems erect from a rather slender caudex, $20^{cm}$ high, minutely puberulent especially below: radical leaves ovate, entire, obtuse at apex, $2^{cm}$ long, glabrous, their petioles 2 to 3 times as long, narrowly margined, puberulent ; cauline two pairs, 3-divided ; the basal segments ovate-lanceolate, obtuse, entire ; the terminal segment 3-cleft into ovate acutish lobes ; petioles as long as the blade or shorter, nearly glabrous : inflorescence loosely cymose, the whitish flowers sessile in the cymules ; peduncles puberulent : corolla $15^{mm}$ long, the tube twice the length of the limb, hairy at base within : bracts linear-subulate, as long as the glabrous fruit : stigma minutely 3-lobed : stamens glabrous.

Wenatchee, June 9, 1896. *Kirk Whited*, no. 140.

BIDENS BECKII Torr. The range of this species is given in the *Synoptical Flora* as "Canada to New Jersey and Missouri." Strangely enough it occurs in Green lake, King county, where it is undoubtedly native, but it has not been detected elsewhere on the Pacific coast. Equally surprising is the occurrence of *Hypericum Canadense majus* Gray on the shores of the same lake. The western limit of the species is given in Gray's Manual as "Lake Superior."

Such a remarkably isolated station for these two plants seems difficult to account for, but I cannot resist the suggestion that it may have been brought about through the agency of migratory water birds.

CAMPANULA AURITA Greene, described from Alaskan specimens, is an abundant plant on the perpendicular cliffs of Mt. Steele, Olympic mountains. The flowers are much deeper blue than those of the common *C. rotundifolia*.

**Pentstemon Whitedii**, n. sp. (§ EUPENTSTEMON). Stems several from a lignescent base, 2 to $3^{dm}$ high, puberulent below and glandular pubescent above : radical leaves glabrous or sparingly puberulent, narrowly spatulate-lanceolate, acute, saliently dentate with large obtuse teeth, or rarely entire or nearly so, 4 to $8^{cm}$ long ; cauline leaves about four pairs, ovate-lanceolate, acute, entire or sparingly dentate, clasping at base, the lower puberulent, the upper glandular pubescent especially on the upper side, 3 to $4^{cm}$ long : thyrsus virgate, interrupted ; peduncles and pedicels short : sepals broadly lanceolate, acute, 7 to $8^{mm}$ long : corolla bilabiate, 15 to $20^{mm}$ long, "light blue," glandular pubescent without, the lobes puberulent within, throat sparsely bearded : stamens glabrous, the sterile filament secundly bearded for nearly its whole length with golden yellow hairs : entire inflorescence viscidly hirsute : fruit not seen.

Collected in rocky soil near Wenatchee, Kittitas county, July 7, 1896. *Kirk Whited* no. 131.

This species is near *P. ovatus* Dougl. and *P. pruinosus* Dougl., but is easily distinguished by its peculiar radical leaves, viscid pubescence and rather larger flowers.

PINGUICULA VULGARIS L. is apparently not a rare plant in the mountains of Washington. We have it from three stations in the Cascades and it occurs plentifully in the Olympics. All the specimens belong to the form *macroceras*.

EMPETRUM NIGRUM L. forms great mats on wet rocks at altitudes of 7000 to 8500$^{ft}$ on Mt. Rainier. It has not hitherto been reported from south of Alaska.

HIPPURIS MONTANA Ledeb. This Alaskan plant was collected several years since by Macoun in the Selkirk mountains, B. C. It also occurs in abundance in the Olympic mountains, at 5000$^{ft}$ altitude, and on Mt. Rainier at from 4000 to 5000$^{ft}$ altitude. Its occurrence on this peak at so low an altitude indicates that it extends much farther south in the Cascade range. In all probability it has been overlooked or mistaken for a moss, as it resembles in no small degree a sterile Polytrichum. — C. V. PIPER, *Agricultural College, Pullman, Wash.*

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## ANOTHER "COMPASS" PLANT.

SEVERAL years ago I noticed the fact that *Wyethia amplexicaulis* was a "compass" plant, and its peculiarities are marked enough to deserve description. The radical leaves of this plant are from twelve to eighteen inches in length, lance-oblong, perfectly glabrous and minutely resiniferous. Usually they number from six to ten, and if the plant is shaded are widely spreading. However, when the plant is growing in open situations the whole blade may be perfectly erect and turned so as to face east and west. More commonly only the terminal portion of the blade is affected, which in this case is sharply twisted to bring it into position.

The stem of Wyethia is from one to two feet high and bears from three to five leaves which are shorter and broader than the radical, and sessile by a clasping base. Owing to their more favorable position, these cauline leaves exhibit their peculiarity well. They are always rigidly erect and so twisted at base that any leaf usually faces the leaf immediately above it and the one immediately below it; in other words, the leaves face alternately east and west. On open gravelly prairies this is especially noticeable, as the plants are so much more conspicuous when seen from the east or west than they are when seen from the north or south.

Microscopic examination of the leaf of Wyethia shows the palisade tissue equally developed on each side. The average of a number of counts indicates about forty stomata to the square millimeter on the upper surface of the leaf and about fifty-five on the under surface.

In comparison with the introduced *Lactuca Scariola* Wyethia proves to be a decidedly better "compass."— C. V. PIPER, *Agricultural College, Pullman, Wash.*

# EDITORIALS.

**Botany for Secondary Schools**

IT HAS SEEMED to the GAZETTE that botanists should interest themselves in the various movements among teachers for the proper teaching of science in secondary schools. The problem as to the kind of botany to be taught is not yet settled, and we fear that the advice obtained from the universities has not shown a full knowledge of the necessities and the conditions. Botanists combined to scout at the old "analysis" as an utterly inadequate presentation of botany even as a young student should see it, and they did well. Such work is not merely partial, but misleading; an injustice to both pupil and subject. But has the proposed substitute proved any more beneficent in its results? Has the swing of the pendulum from analysis to morphology done for the schools what was hoped? The university laboratories were ready enough to show how morphology should be taught, to point out the types useful for study, to name the appliances needed, and even to write guides and text-books so that no one need go astray. But what has been the result of it all? The writer is free to acknowledge, from a careful inspection of much of the best work done in the best equipped secondary school laboratories, that the advice was a blunder. The reason is not far to seek. It does not lie in lack of preparation on the part of the teacher, for universities are annually sending into the schools teachers who are trained to do just this kind of work. It lies in the age of the pupils and the structure of the schools. Such work has not resulted in a clear elementary conception of botany, but in a clear conception of nothing. The pupil is taken away from any possible experience of his own in reference to plants, and is introduced to structures which he can fit to nothing. The time limits for laboratory work are so short even in the most liberal schedules that his observations cannot be related properly in his own mind, and hence become perfunctory and meaningless. He is hurried rapidly from type to type, obtains glimpses of things through the microscope, and if the teacher is university bred and young his instruction will take such a philosophical turn that the pupil is hopelessly befogged. It has been forced upon us, against our will and preaching and former best judgment, that botanists must recommend something else.

We believe that the botanical field for the secondary school is that of ecology, and that modern morphology should be left to the colleges and universities, where maturity, and time, and apparatus, and teachers, are all adequate. The preparatory student needs to come in contact with plants in their general relations, to learn to look upon them intelligently in the mass, before he begins the continuous study of minute structures. The introduction of pure morphology has removed him from contact with plants as living things inhabiting the world, a contact which the old "analysis" gave in a sentimental rather than scientific way. He can be introduced to plants as a whole, not to "flowers" merely; he can study their habits of life, their adaptations to various conditions, the societies which they form. Certain intimate structures must be studied to make relations and adaptations significant, and so the microscope cannot be banished, but it can be made an incidental piece of apparatus, rather than the necessary aperture through which every glimpse of botany must be obtained. With ecology as the main purpose, and a certain amount of physiology and morphology as necessary adjuncts, such an impression of plants in general can be made that the more formal university courses will be much more significant than they are. In our judgment such work in the secondary schools not only will show better results in the schools themselves, but will send better prepared students into our university laboratories.

**The American Tropical Laboratory**

It is a cause for congratulation that American botanists seem to be much interested in the tropical laboratory suggested in an editorial of the November Gazette. An expression of interest, however, to be effective, must be followed by a definite plan vigorously prosecuted. In the present number we publish an open letter from Professor MacDougal, whose research work is peculiarly in need of development in a tropical environment. As Mr. MacDougal has already planned a visit to the American tropics, the Gazette proposes that he be appointed chairman of a committee on inspection, associating with himself such other botanists as he may be able to secure. It should be the work of such a committee not merely to examine suitable locations, but also to learn the conditions under which a grant from the government could be obtained, the conditions and cost of living, in short, all those facts, botanical, financial, governmental, and hygienic, which must enter into any plan of action. It is further suggested that a report be made by this committee next summer to the various botanical organizations which meet in convention with the American Association. In the meantime the GAZETTE would be glad to hear from those institutions and individuals who are willing to cooperate in the establishment of such a laboratory.

# OPEN LETTERS.

## A TROPICAL LABORATORY.

*To the Editors of the Botanical Gazette:*—The recent editorial in the GAZETTE concerning the establishment of a laboratory in the tropics, in the opinion of the writer, calls attention both to the most pressing needs of American botany, and to the most important means of advancement and preservation of the integrity of the science in general. Previously to the appearance of your editorial I had sent to press in the *Popular Science Monthly* an article in which I had touched upon this point. Partial notes upon several problems, the solution of which may only be accomplished in the tropics, have accumulated in my laboratory, and an expedition to the West Indies in the summer of 1897 has been planned for the purpose of beginning work and selecting a suitable locality for its annual continuance. Necessarily temporary quarters would have been secured each year. I would welcome the establishment of a permanent tropical laboratory open to students during the entire year and free from the inconvenience of temporary facilities, to say nothing of the manifold advantages afforded by such an institution in the matter of equipment and accessibility of material.

I would gladly put aside plans already formed and cooperate in any effort leading to the organization and selection of a locality for a laboratory of this character, or aid in any movement leading to its establishment.—D. T. MACDOUGAL, *State University of Minnesota.*

## THE BUITENZORG GARDENS.

*To the Editors of the Botanical Gazette:*—The following excerpts from a letter recently received from Mr. David G. Fairchild, who is making some special studies at the Botanic Gardens, Buitenzorg, Java, may be of interest to the readers of the GAZETTE:

"Dr. Treub, the director of the gardens, is taking steps to establish an international affair here, similar to that at Naples, except that the whole expense of running such a place will be borne by the Dutch government. I am anxious to see a table here and hope when I return to get assistance in bringing this about. What is needed is a yearly or bi-yearly grant which will enable a botanist or zoologist to spend six or eight months at the gardens. Tickets are now sold from Hong Kong to New York for forty-five pounds sterling, and it is very probable that if proper steps were taken round trip fares could be obtained for seventy-five pounds. It will require another hundred pounds to support a man here for six or eight months. Board, room, washing, and servant cost about $45 per month. It must of course be remembered that the table is free, providing we get a grant which will enable a man to come here. There is no question as to the wealth of material, and I trust that sufficient interest can be aroused to give Americans a chance to utilize it. Various German societies have already acted in the matter."

"As for climate and its effects on one's health, I need only say that I work with the microscope from 6:30 A.M. to 8:30 A.M., and from from 9:30 A.M. until 1:30 P.M. After 8 P.M. attempts at work bring on sleeplessness, which must be avoided. . . . . I find it easy to get everything needed here in the way of apparatus, literature, etc. There are chemical, entomological, and botanical laboratories within easy reach, and a fine library, where most of the important botanical journals are kept on file. Everything is conducive to good work; in fact in this respect the place is the best I have so far seen."—B. T. GALLOWAY, *Washington, D. C.*

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## ON THE USE OF THE TERM "FROND" AS APPLIED TO FERNS.

*To the Editors of the Botanical Gazette*:—One of the greatest annoyances of my early experience with fern literature was caused by the use of terms in a double sense. This was especially objectionable and confusing in the use of the term *frond* which was applied indiscriminately to the leafy portion and footstalk combined, and to the leafy part alone, so that it was not always possible to tell just which was meant by the use of the term.

It seemed to me that botanical terms should have but one definite meaning and be used in that sense alone.

Accordingly when in 1881 I prepared a rough plan for a text-book and synopsis of North American ferns I adopted the method of using terms in a single sense only, and I have adhered to that method in my own practice ever since.

Recently I have taken up my manuscript again with the hope of being able to get it ready for publication, but as I may not be able to do so and as the adoption of the word *leaves* for *fronds* in the same objectionable double sense by the new flora in its treatment of the ferns is only another method of retaining the same confusion, I offer the following extract from my manuscript as an expression of my views:

"A frond in its highest state of development consists of two parts, a leaf-like expansion that is the equivalent of the blade of a leaf, and a footstalk that is the equivalent of the petiole of a leaf. The expanded leafy portion is always the most conspicuous part, just as the blade of a leaf is its most prominent feature, and it is very generally regarded as the frond itself. The term frond, therefore, is generally used in that sense as well as in its own. But the objection to this is that in practice it does not express clearly enough the exact meaning intended. This is especially true when the term frond is used in descriptions of proportion, as for example, when it is said that a frond is six inches tall, meaning thereby the leafy portion only, and the length of the stalk is given separately at four inches, as if it was distinct from the frond, whereas the stalk is an essential part of the frond itself, which would be described better by saying that it was ten inches tall, thus including its footstalk and giving its true length. Then if the proportion of each part was wanted it could be given separately under special terms, and the sum of both would conform to the total of the whole."

"We may thus avoid all the ambiguity arising from the use of terms in a double sense by restricting the term frond to its legitimate definition, and employing special terms for the different parts of the frond itself. This method will prevail throughout the present work, and whenever the term frond is used it is to be understood as meaning the entire leaf, with or without a stalk. Whenever a stalk is present its presence will be recognized by the special term *stipe*, the equivalent of footstalk (Latin *stipes*, plural *stipites*), and the leafy portion will be called the *lamina* (plural *laminæ*). Thus we shall have definitely fixed terms, with clearly defined limitations, no one of which can trespass upon the province of the other" (ex Mss. ined. 1881).—GEORGE E. DAVENPORT, *Medford, Mass.*

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## DUPLICATION OF CONTRIBUTIONS.

*To the Editors of the Botanical Gazette:*—That European botanists may occasionally overlook contributions from laboratories on this side of the Atlantic if brought out in ephemeral or obscure journals is naturally to be expected. The American botanist, in turn, may be pardoned for similar mistakes, if not of too frequent occurrence, in regard to publications on the other side. The neglect of the literature bearing upon a distinctively American plant, to be found in the oldest and most widely known botanical journal in the country, is a fault not so easily condoned, however.

Dr. Homer Bowers published in the BOTANICAL GAZETTE [1] a thorough and accurate account of the morphology and life history of *Hydrastis Canadensis*, obtained by ten years of work upon the plant, under cultivation, and in its habitat in central Indiana.

Dr. Julius Pohl has recently duplicated this contribution in a manner which admits of no extenuation.[2] He worked upon a stock of material con-

[1] BOT. GAZ. **16**:73. 1891.

[2] Botanische Mitteilung über Hydrastis Canadensis. Bibliotheca Botanica 29, 1894.

sisting of thirty plants grown from rhizomes taken from the soil during the previous year, four two-year-old seedlings and two seedlings (presumably in the first year of growth) and a few ill developed seeds, according to his own account, in the Botanic Institute at Marburg, May–June 1893. His article exhibits no reference to Dr. Bowers' splendid work, which he has repeated, and not always in an accurate manner, since his results are a most striking example of the faulty conclusions which may be obtained from material under abnormal conditions. Dr. Pohl deals also with the minute anatomy of the plant, and the three pages devoted to this subject may be considered as the only original portion of his paper. The sections devoted to the systematic position of the species, its drug extracts and their adulterations, may be compiled from the common text-books and technical dictionaries, and are furthermore notably incomplete.

It is, of course, safe to assume that Dr. Pohl was unaware of Bowers' work. His ignorance may be directly due to the fact that "the file of the BOTANICAL GAZETTE is not to be found in the Marburg Institute," but it is a logical outcome of the assumption that the boundaries of botanical science are identical with those of Germany. Our brethren across the water would do well to rid themselves of this erroneous idea, once more nearly true than at present. Their repeated disregard of outside literature will certainly do much to lessen the prestige of the German Institute.

The above criticisms apply with peculiar force to the editors of the *Bibliotheca Botanica*. This publication consists of a series of "Originalabhandlungen," and the long interval between issues would certainly allow the verification of the eligibility of any manuscript. A regard for the ethics of the science, and simple justice to their subscribers, demands no less.— D. T. MACDOUGAL, *State University of Minnesota.*

# CURRENT LITERATURE.

## BOOK REVIEWS.

### The survival of the unlike.

THE making of books is easy to Professor Bailey, if one may judge from the number and rapidity with which they come from his pen. Besides new editions of the *Nursery book* and the *Horticulturist's rule-book*, the ink is hardly dry upon *Plant breeding* until the *Survival of the unlike* appears. The *Evolution of our native fruits* is said to be in press, and we are promised shortly a book on pruning, one on the apple, and a school text-book of botany! Professor Bailey is a living disproof of the doctrine that overproductiveness is at the expense of the quality of fruit.

The present book[1] has involved recently only the labor of revision, since it is a collection of essays which have been read from time to time in the last six years before various scientific bodies. All of them have been published before, but are scattered from Dan to Beersheba in all sorts of reports, proceedings, and journals. Were there nothing but the question of convenience involved it were well to bring them together.

But the botanist and horticulturist will find both interest and instruction in these essays. To the botanist they are particularly suggestive, for his studies too often cease at the garden fence. As a study in variation they bring to his attention many facts new to him, of which he would do well to take heed lest he teach theories which facts are against. Professor Bailey's thesis—it may almost be called—is this: "Heredity is an acquired force; normally and originally unlike produces unlike." He "denies the common assumption that organic matter was originally endowed with the power of reproducing all its corporeal attributes, or that, in the constitution of things, like produces like." Now this view is at first somewhat startling, but botanists know already many facts which support it, and Professor Bailey introduces many facts in the course of the essays to strengthen it.

In the second and third essays, respectively "Neo-Lamarckism and neo-Darwinism" and "The philosophy of bud variation," the author shows clearly the untenability of Weismann's germ-plasm theory as concerns plants. The latter essay is particularly striking in setting forth the idea that bud variation is not rare and exceptional, but common; that it is of great

[1] BAILEY, L. H.—The survival of the unlike: a collection of evolution essays suggested by the study of domestic plants. 12mo. pp. 515. figs. 21. New York: The Macmillan Co. 1896. $2.00.

importance in the production of new garden varieties (no less than 300 of such origin being grown at present in this country); and that it is of the same fundamental nature as seed variation. The key to this is to be found in the sentence, "The truth is . . . . that every branch or phyton is a bud variety, differing in greater or lesser degree from all other phytons on the same plant."

But the book must be read to be appreciated. There are too many fruitful ideas to permit discussion of them in detail. We have further space only to quarrel with two.

We doubt whether the idea of the phyton, of which the author makes a point, is of any real value, morphologically or physiologically. Will not rather the idea of the shoot, whether primary, secondary, or of higher order, answer Professor Bailey's purpose better? That shoots as a whole, and the phytons taken from different shoots, are unlike every one knows. But do noteworthy differences exist between the successive internodes of a shoot? It is not unlikely that our author would assent to this change, for we find him saying on p. 250, "We are bound to look upon every branch as in some sense a distinct individual, since it is unlike every other branch." Yet recently we found the conception of the phyton about to be introduced into an elementary book on botany for horticultural students "because Professor Bailey uses it in his writings." Wherefore the query.

There is one essay which we think the author would have done a service either by omitting or by radically altering, the one on sex in fruits. Professor Bailey, in an earlier part of this volume, reprints his note from *Science* on the "Untechnical terminology of the sex relation in plants," and reasserts his conviction that the ascription of sex-relations to the sporophyte by the use of sex terms is "perfectly proper," and often necessary for perspicuity. Of course he is entitled to this opinion, in spite of the botanists who hold it to be erroneous. But can he justify the use of sex terms correctly and (as he himself acknowledges) incorrectly in the same essay? And can he permit himself to reason regarding the evolution of sex from premises that are not only false but that are incomparable, as he does on pp. 347–9? Can such reasoning lead to "a perspicuous treatment of the subject"? We feel sure that when Professor Bailey gives this matter the consideration it deserves he will be as unwilling to have his philosophy shut in by the garden fence as he is desirous that botanists should not have theirs stop at it.—C. R. B.

## MINOR NOTICES.

WE HAVE just received separates of two papers from the Transactions of the Kansas Academy of Science for 1893–4, one on the Erysipheæ of Riley county, Kansas, by Lora L. Waters, and the other a list of the grasses of Kansas, by Professor A. S. Hitchcock.

MR. C. J. ELMORE reviews[1] the several systems of classification of the diatoms, favoring Petit's as approaching "most nearly to a natural one, because based on characters having a physiological significance," viz., on the structure of the endochrome and the mode of forming auxospores. In higher plants these are unstable characters; are they not likely to be so also in the diatoms?

FOR SOME TIME before his death, Professor D. C. Eaton had been preparing to issue a set of *Sphagna* in collaboration with Mr. Edwin Faxon. That work has now been completed by Mr. Faxon, and a set of 172 specimens, representing 39 species, their varieties and forms, has been issued by Mr. Geo. F. Eaton with the title Sphagna Boreali-Americana Exsiccata. Most of the determinations are by Warnstorf, and no pains have been spared to make the set first-class in every particular. Those who already know the beauty of specimens prepared by Mr. Faxon need not be assured that these are fine and abundant. For the credit of American bryology it is only just to say that no previous issue of moss exsiccati anywhere to our knowledge surpasses this one in the abundance and beauty of the specimens or in careful labeling. Sixty sets will be issued at $15 per set.—C. R. B.

IN HIS ADDRESS upon "grasses," before the Massachusetts Horticultural Society last March, Mr. F. Lamson-Scribner gave a brief account of the uses, form, structure, and distribution of grasses, and then discussed the economic grasses of Massachusetts, concluding with a short statement of the work of the division of agrostology.

As a part of this work we note the recent issue of a bulletin (No. 3) upon useful and ornamental grasses of all countries. In the introduction a number of the most important economic grasses are classified according to their uses, while the body of the bulletin enumerates about 375 species, illustrated by eighty-nine figures, with a short account of their qualities, value, and culture. The compilation is a very useful one.

## NOTES FOR STUDENTS.

A LIST of parasitic fungi, occurring in the state of Mississippi, supplementary to the one printed in May 1895 (Miss. bulletin no. 34), has been issued from the Mississippi Experiment Station (Bull. no. 38) by S. M. Tracy and F. S. Earle. It adds 85 species to the former list, of which 21 are new to science. The descriptions of the new species have also been published in the *Bulletin of Torrey Botanical Club* for May of this year. *Cercospora flexuosa* Tracy & Earle, and *C. Diospyri ferruginea* Atkinson, are reduced to synonyms of *C. Diospyri* Thümen, the three names having been applied to different stages of growth of the same fungus.—J. C. A.

[1] American Naturalist 30: 529–536. 1896.

UNDER THE TITLE, "The suction-force of transpiring branches," S. H. Vines gives[2] a review of earlier experiments to show the means by which a current of water is maintained between the roots and the leaves of plants, and the results of some recent experiments to determine the suction-force of the leaf, which force has been suggested as the probable cause of sap elevation.—S. C. S.

SEPARATES have been distributed by Professor M. C. Potter,[3] of Durham College, England, detailing the development and nature of the conidial stage of *Botrytis cinerea*. It appears to be a saprophyte, which grows less readily as a parasite, and is the initial cause of the rotting of stored turnips, etc. The conidia germinate readily in moist air, and infection takes place best through wounds or injury due to freezing. The fungus is more aggressive as a parasite after growing for a time saprophytically.—J. C. A.

KRAUS has studied at Buitenzorg[4] the heat produced in flowers of cycads, palms, and arums. His measurements in the spadices of *Ceratozamia longifolia* and *Macrozamia Mackenzi* showed a daily period repeated for several days, with a mid-afternoon maximum, the maximum temperature excess being 11.7° C. Among the palms, *Bactris speciosa* showed a rise of temperature for several days, continuing through the night also. In the Araceæ a daily period with an evening maximum was observed, coincident with which was the intensity of odor.—C. R. B.

NESTLER has communicated to the Royal Academy of Sciences in Vienna the results of researches upon the excretion of liquid water by leaves.[5] He finds that the special tissue often developed between the end of the tracheids and the water pore does not act as a secreting tissue, as has long been taught, but that the extrusion is due wholly to filtration under pressure. Many experiments show this ; the following one may be cited as illustrative. If the excretion of water from young grass blades is checked by choking the water clefts or by killing the tips with hot water, the excretion appears in different places along the margin, probably through air pores.—C. R. B.

ITEMS OF TAXONOMIC INTEREST are as follows : F. V. Coville has published[6] a new Ribes, *R. erythrocarpum*, from Crater Lake, Oregon, a region of the southern Cascades that seems never to have been explored botanically.

[2] Ann. Bot. **10**: 429–444. 1896.

[3] Rottenness of turnips and swedes in store. Reprinted from Jour. Bd. Agric. 3:—[1–14]. 4 plates.

[4] Physiologisches aus dem Tropen. III. Ueber Blütenwärme bei Cycadeen, Palmen, und Araceen, Annales du Jard. bot. de Buitenzorg 13[2]: 217–275. *pl. 3*. 1896. Cf. Bot. Cent. **68**: 119. 1896.

[5] Œsterr. bot. Zeits. **46**: 371. 1896.

[6] Proc. Biol. Soc. Washington **10**: 131–132. 1896.

The same author has published[7] also a new rush from the Rocky mountain region, *Juncus confusus*, which has heretofore been confounded with *J. tenuis congestus* Engelm. In the same connection a synopsis of *J. tenuis* and its allies, seven species in all, is given. Professor E. L. Greene's last fascicle of "new or noteworthy species"[8] contains descriptions of new species in the following genera: Cratægus, Mentzelia (2 sp.), Coleosanthus, Solidago (2 sp.), Chrysopsis, Grindelia (3 sp.), Aster, Arnica (4 sp.), and Senecio (4 sp.). Among the numerous new species which Mr. Hemsley has described[9] from an interesting collection received from central Tibet is a new genus of grasses which he has named *Littledalea*.—J. M. C.

DR. W. ARNOLDI has obtained some interesting results from his study of Isoetes and Selaginella.[10] The species used were *I. Malinverniana* and *S. cuspidata*, and their association under the title indicates the author's conclusion that Isoetes is to be regarded as a heterosporous lycopod. In the formation of the prothallium of Isoetes the macrospore nucleus passes to the apex of the spore and divides, the daughter nuclei again dividing. At this time the arrangement and staining of the striations of protoplasm about the nuclei indicate that cell walls are about to be formed. The spore wall becomes double and walls are formed about the nuclei, usually leaving the nucleus unenclosed on the side toward the center of the macrospore. The unenclosed nucleus divides, and the daughter nucleus nearest the periphery of the macrospore becomes enclosed by a wall. The free nucleus continues to divide in the same manner, one of the resulting nuclei constantly passing outward and toward the center of the macrospore, until all are enclosed. The enclosed nuclei near the apex of the spore continue dividing, and become separated by new walls. New cells are formed more rapidly along the periphery of the macrospore, but are more tardily extended toward the center. Cell formation is not usually completed in the basal and central parts of the macrospore when archegonia are fully formed at the apex.

The process in Selaginella is so similar to that in Isoetes that the same figures might easily serve to illustrate both. The nuclei divide and become enclosed in the same way, the prothallia are in about the same stage of development when the archegonia appear, and even the comparative size of cells in homologous portions of the prothallia is the same. In Selaginella no diaphragm appears separating the prothallium into vegetative and reproductive parts. In Isoetes the archegonia do not become green.

It becomes evident that the processes here observed are very similar to endosperm formation in the spermatophytes. Much more evidence upon

[7] *Ibid.* 127–130.

[8] Pittonia 3 : 99–106. 1896.

[9] Kew Bulletin 119 : 207–215. 1896.

[10] Die Entwickelung des weiblichen Vorkeimes bei den heterosporen Lycopodiaceen. Bot. Zeit. 9 : 159–168. 1896.

this point may be obtained when the early stages in the endosperm formation of gymnosperms has been more thoroughly worked out. It is to be regretted that Dr. Arnoldi did not extend his work into the embryogeny of the sporophyte. Additional evidence upon the suspensor formation in this group may help to answer the question concerning the supposed relationship of lycopods and gymnosperms.—O. W. C.

MR. J. H. HART discusses briefly[11] the so-called "irritability" of the flowers of *Catasetum tridentatum* Hook., of which Darwin gives an account in his *Fertilization of Orchids.* In opposition to Darwin's observations he says:

"The ejection of the pollinia can be caused by other means than the irritation of the antennæ by touch . . . . A concussion of the flower, the removal of the anther cap, and pressure exerted on almost any part of the column, and especially any irritation on the margins of the stigmatic pit will effect this readily if the flower is at a favorable stage of maturity.

" . . . . the expulsion of the pollen does not depend upon any special irritability, but upon *mechanical action alone.*"

"The antennæ are seen to be merely a prolongation of . . . . the edges of the stigmatic pit . . . . A part of this curl . . . . holds the margin of the caudicle . . . . The antennæ at . . . . anthesis become turgid, stiff, and non-elastic. In this state they furnish levers which are amply sufficient to cause a disturbance of the grip they hold upon the margin of the caudicle."

The question needs further study. It is one which can only be satisfactorily examined in a tropical laboratory.—C. R. B.

A BRIEF SUMMARY of MacDougal's work on the mechanism of curvature of tendrils[12] is as follows: Those tendrils which are irritable to contact are of such great difference in morphological derivation, anatomy, and degree of irritability, that it is unsafe to assume their mechanism to be identical. The curvature of a tendril about a support as a direct reaction to irritation, and the coiling of a free portion, are entirely distinct and largely independent processes.

Curvature in the tendrils of Passifloreæ is due to the contraction of the tissues of the concave side, which theory is not in harmony with that of De Vries, viz., that increased osmotic activity of the convex side results in an accelerated growth extension of the tissues of the same side.

The structure of the protoplasm of the convex and concave sides is quite different, that of the concave side being more richly granular, and more nearly filling the cell cavity. The density of the protoplasm of the concave

[11] Bull. Misc. Inform. Roy. Bot. Gard. of Trinidad **2**: 225. 1896.

[12] Annals of Botany **10**: 373–402. 1896.

side increases from the base toward the tip, apparently corresponding with the degree of irritability to contact.

During curvature the parenchymatous cells of the concave side decrease in size from 20 to 40 per cent. of their original volume, and become irregularly globoid or ovoid; which is to be explained by an increase in the permeability of their protoplasts, with a consequent extrusion of water into the intercellular spaces, and a release of their stretching tension exerted upon their walls, the elastic contraction of which causes the resultant curvature.—W. R. M.

DR. EMIL KNOBLAUCH, the German translator of Warming's *Geographical Botany*, has published from Tübingen a paper upon the "Ecological anatomy of the woody plants of the South African evergreen bush-region." A review by Dr. E. Roth[13] gives a brief summary of the results. The rainy winters and dry summers of the Cape Colony region result in a peculiar vegetation, in which dwarf shrubs dominate, both in species and individuals, trees being almost wholly absent. The woody plants are first treated, as, on account of their long duration, they show best the influence of external conditions upon vegetation, notably their adaptation to withstand drought. The anatomy of the leaves is especially considered, as they show most clearly these influences. The many evidences of a direct adaptation of the South African woody plants are enumerated as follows: (1) lignification; (2) evergreen habit; (3) dwarf growths, associated with thick branching, small branches, very short internodes and small leaves; (4) leaves more or less densely aggregated; (5) leaves more or less erect on the branches, thus avoiding direct rays of the sun at midday; (6) leaves with very small cross-section; (7) small leaf surface; (8) ericoid, pinoid, or involute leaves; (9) thick outer epidermal walls; (10) inner epidermal walls mucilaginous, swelling more or less when water is taken up; (11) epidermal cells of large capacity, allowing considerable water storage; (12) leaf symmetry dorsiventral and radial; (13) long palisade cells; (14) spongy mesophyll much less open than in mesophytes; (15) a brown coloring matter, probably tannin, present in the strongly illuminated peripheral portions of the leaves, forming a protection against too strong light; (16) presence of hairs on the furrowed side of ericoid leaves and of the dorsiventral involute leaves to protect against excessive transpiration. Any given species ordinarily has but few of the above characteristics, and all plants do not have them developed to the same degree. Another set of characters is not general, but is confined to certain groups of plants. These special characters are given as follows: (1) depression of stomata; (2) hypodermal aqueous tissue; (3) internal aqueous tissue; (4) sclerenchyma, which increases the rigidity of the aqueous and chlorophyll tissues; (5) oil reservoirs; (6) bud scales.—H. C. C.

[13] Bot. Centralb. **67**: 391. 1896.

F. DELPINO has just published[14] a discussion upon the classification of monocotyledons, based upon certain new criteria. A review by Solla[15] furnishes the basis for the following statement of his views. Engler's classification[16] of 1892 has seemed to morphological taxonomists to be by far the most natural one yet proposed, and it remains to be seen whether Delpino has proposed anything better in the way of natural grouping. He recognizes the two monocotyledonous groups, the eucyclic (trimerous pentacyclic floral structure) and the polycyclic (unstable floral structure and varying number of whorls). The eucyclic monocotyls are not regarded as primitive, but as derived from the polycyclic groups, which are believed to be the "connecting link" between eucyclic monocotyls and dicotyls. In both the monocotyl groups there are forms which have retrograded, giving rise to four taxonomic groups, viz., normal and reduced polycyclic forms, and normal and abnormal eucyclic forms.

The group of "normal polycyclic monocotyls" includes Alismaceæ, Butomaceæ, and the higher genera of the Hydrocharideæ. The author makes the Butomaceæ his starting point, and considers *Butomus umbellatus* to be the oldest form, because it resembles several polycyclic dicotyls. Connected with these is the group of "reduced polycyclic monocotyls," which includes the lower Hydrocharideæ, Juncagineæ, Aponogetonaceæ, Potamogetonaceæ, and Naiadaceæ.

The "eucyclic monocotyls" include all the rest of the families with pentacyclic structure. The nectary furnishes a biological and phylogenetic character by which they are subdivided into three groups: the *Anadenien*, which have no nectaries; the *Carpadenien*, which have nectaries in connection with the carpels; and the *Petaladenien*, which have nectaries in connection with the floral leaves.

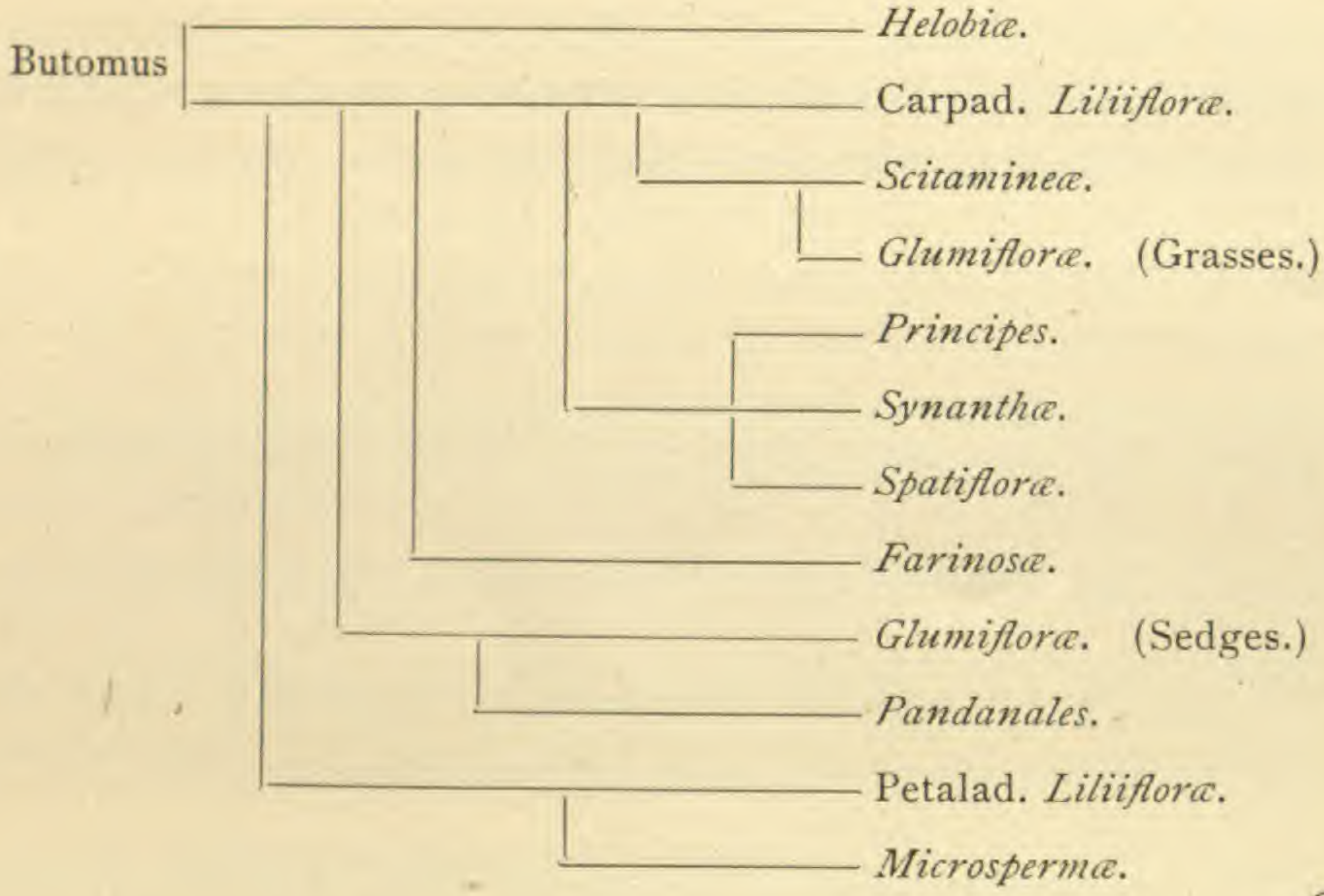
The author regards the leaves as of taxonomic value in large groupings. These groups are as follows: (1) those with sword-shaped leaves, subdivided into Gladiatæ and Hemigladiatæ; (2) those with three-sided leaves, all of which may be derived from the genus Dracæna; (3) those with ligules (Gramineæ, etc.)

It will be noted that Delpino, like Engler, makes two groups of monocotyls, but only the Helobiæ are regarded as polycyclic, all the rest being eucyclic. The author also regards monocotyls as monophyletic, while Engler's scheme makes them triphyletic. The following tabular statement presents Delpino's scheme, which certainly has the merit of being quite different from others.

[14] Mem. Real. Accad. Sci. Bologna V. **6**: 83–116. 1896.

[15] Bot. Centralb. **67**: 370. 1896.

[16] Die systematische Anordnung der monokotyledoneen Angiospermen: Abhandl. König. Preuss. Akad. Wissen. Berlin, 1892.




—C. J. C.

Although the existence of acid secretions by roots has been known for nearly forty years, no exact knowledge of the chemical composition of these secretions was at hand. To fill this gap, and to reinvestigate the opinion of Molisch that diastatic and inverting enzymes are secreted by the root, Czapek undertook the investigations to which brief reference has already been made on p. 65 of this volume. In the full paper[17] the excretions of roots are exhaustively discussed. A translation of the author's own summary is here given.

The roots of the higher plants, under culture either in a saturated atmosphere or in water, secrete a series of dissolved substances, partly inorganic, partly organic.

The droplets which are generally seen on root hairs in a saturated atmosphere are produced by filtration under pressure, and appear only when the hair cells are highly turgescent.

Of inorganic substances which roots give off in water may be named: potassium, calcium, magnesium, hydrochloric acid, sulfuric acid and phosphoric acid. Only potassium and phosphoric acid are present in any considerable quantity; they are found in the form of primary potassium phosphate, in many cases by far the predominant constituent of the residuum upon evaporating the root excretions.

The mono-potassium phosphate ($KH_2PO_4$) arises in all probability in great part from living cells of root hairs, the epidermis, and the outer cortex in the piliferous region.

Neither acetic acid nor lactic acid, as was asserted on many sides, is found in the root excretions. Formic acid, in the form of its potassium salt, is of not

[17] Jahrbücher f. wiss. Botanik **29**: 321–390. 1896.

uncommon occurrence. It diffuses from living cells in the youngest part of the root and is therefore not a product of destructive processes.

The detection of oxalic acid as primary potassium oxalate is at present limited to the excretions of the root of *Hyacinthus orientalis.*

The well known permanent reddening of litmus paper depends as a rule upon the acid reaction of mono-potassium phosphate. Its intensity varies, and these differences are parallel with the amount of phosphate excreted. The acid reaction of the hyacinth roots to litmus paper has, on the contrary, another source, which is referable to the primary oxalate.

If the phenomena of the corrosion of stone plates by roots are studied by using artificially prepared plates consisting of substances of known solubility in certain acids, it becomes evident that the carbonic acid excreted must play the principal rôle in all the etching observed. One may say in general that substances which cannot be dissolved by carbonic acid cannot be attacked to any extent by the root excretions, so that corrosive action does not appear. It is to be observed that we have to deal not with the action of carbonic acid in free gaseous condition, but with the solvent actions of fluid saturated with carbonic acid, as the water of imbibition of the outer layers of the membrane of the root cells and the adjacent films of the soil water. Moreover, all known phenomena of corrosion can be completely explained by the action of carbonic acid. Hence it results that the reddening of litmus and the corrosion of stones depend upon the action not of the same but of two different substances (mono-potassium phosphate and carbonic acid). No other free acid is secreted, normally at least, by roots. Acid action upon the substratum by substances secreted by roots, however, is probable from a series of empirically established facts, and it occurs, as a matter of fact, without relation to the effects produced by carbonic acid. The mono-potassium phosphate excreted by the roots takes a prominent part in bringing about this action, since it enters into reaction with neutral salts of the stronger acids and thus leads to the production of smaller amounts of the mineral acids concerned. Especially is this the case with the chlorides and the formation of hydrochloric acid. A condition for such acid action upon the substratum is that the dissociated neutral salt shall not be readily taken up and consumed by the plant, but may enter in more or less undiminished amount into reaction with the phosphate. Naturally the amounts of acids thus formed are very small, yet they are sufficient in a long period of time to produce noteworthy effects in large masses of soil thoroughly permeated by roots, by means of which its insoluble constituents are unlocked and made available to plants.

An excretion of diastatic or inverting enzymes by the roots is physiologically not inconceivable, but certainly does not occur normally. Critical repetition of the researches of Molisch, who has asserted a normal occurrence of these ferments in root secretions, shows instead a negative result when one carefully considers the sources of error.— C. R. B.

THE ANATOMY of the vascular plants has been treated from the standpoint of physiology by several writers, notably Schwendener and Haberlandt. The comparative anatomy of the lower plants has dwelt chiefly upon the reproductive processes. Istvánffi published in 1891 in Hungarian a short paper entitled "Contributions to the physiological anatomy of fungi," [18] and now offers a further contribution [19] in which he pays particular attention to the conducting system in the Hydneæ, Thelephoreæ, and Tomentelleæ. Necessarily he deals chiefly with the fructifications.

Following the general plan of Schwendener and Haberlandt he classifies the false tissues of the fungi into four systems: (1) the merismatic, (2) the protective, (3) the nutritive, (4) the reproductive.

The tissues corresponding to the meristem of higher plants are very rarely differentiated. The tips of many rhizomorphs, as in *Armillaria mellea*, show an extraordinary resemblance to the tips of phanerogamous roots, which is heightened by the mucilaginous sheath, corresponding to the root cap. Besides these growing points may be enumerated the merismatic pycnidia, the margin of the pileus and similar growth zones.

The protective system is manifold. (1) To the epidermal system are to be referred the superficial tissues, whether formed of parallel hyphæ or of pseudo-parenchyma; the various scales and similar structures of the higher Hymenomycetes; the cortex, which may be as much as four-layered, as in *Lactarius resimus;* the colossal cortex of the woody *Polypori;* the paraphyses and cystidia which prevent the stripping of the spores and are often stiffened by mineralization; and the various thickenings about sporangia and spores. (2) The mechanical system includes all arrangements for maintaining bodily form. These are: in single celled species the elasticity of walls and turgor; in multicellular ones transverse walls; thickening of walls; the protective tissues, sometimes forming an outer skeleton; the rosette-like or cylindrical groups of bladdery hyphæ as in the Agaricineæ; and the palisade-like grouping of the basidia.

The nutritive system includes (1) an absorptive system, (2) a conducting system, (3) a storage system, (4) an aerating system, and (5) an excretory and secretory system.

The absorptive tissues include the general mycelium when submerged, the haustoria and appressoria, and the various compound forms into which hyphæ are united (bands, cords, strands, or membranes), serving also a mechanical function.

The conducting system, to which Istvánffi has given chief attention by

[18] Adatok a gombák physiologiai anatomiájához, Természetrajzi Füzetek **15**: 52–67. *pl. 1.* 1891.

[19] Untersuchungen über die physiologische Anatomie der Pilze mit besonderer Berücksichtigung des Leitungssystems bei den Hydnei, Thelephorei und Tomentellei, Jahrb. f. wiss. Botanik **29**: 391–440. *pls. 5.* 1896.

detailed descriptions, includes the structures generally known as latex and oil reservoirs, and vascular hyphæ. These contain both plastic and by products of metabolism. They are emptied in connection with the formation of the fructification. The elements of the conducting system are short club shaped cells, or long thin tubes, or very long much branched and anastomosing tubes, all multinucleate. They arise as lateral outgrowths from the ordinary hyphæ and when mature have many connections with them. When the fructification is very young they form a dense coil in the center. In rhizomorphs and band like mycelia they appear in a similar way. There is no regularity in their distribution, but they usually form one or several layers at the margin of the stipe and beneath the hymenium.

Since the earlier researches of Istvánffi and Olsen, Van Bembeke has examined fifty-three species of ten families and Istvánffi sixty species of the three families above named, both European and exotic. The extent of these researches justify a classification of the elements of the conducting system into six groups, the first five of which include the tubular reservoirs : (1) *Hymenochaete* type, undulate, with pointed ends protruding from the hymenium ; (2) wholly internal (only in two species); (3) *Stereum* type, parallel with the surface, bending out into the hymenium, their ends not or scarcely swollen : (4) *Thelephora* type, vertical to the surface, often in several zones ; (5) *Corticium* type, in several layers, the ends clubbed (*keulig aufgeschwollen*); (6) round reservoirs.

A considerable number of examples of each of these types are described in detail. Istvánffi thinks the character of the conducting system may be used systematically.

The storage system of tissues includes chiefly the sclerotia.

To the aerating system are referred the air spaces in the interior of the stipe and pileus, as in Agaricineæ and Phalloideæ, which increase in size toward the center.

The excretory and secretory system comprehends the structures excreting resin-like materials, reservoirs of coloring matters and poisons, a part of the cystidia (especially those with crystalline contents), and the glandular hairs upon the absorbing system of *Schizophyllum* spp.—C. R. B.

# NEWS.

DR. F. CZAPEK has been called to the assistant professorship of botany and technical microscopy in the German Institute of Technology in Prag.

PROF. DR. HUGO DE VRIES has been called to the directorate of the botanical garden at Amsterdam made vacant by the recent retirement of Dr. Oudemans.

PROF. DR. K. MÜLLER of the royal school of technology at Berlin has undertaken, as a side duty, the botanical instruction in the royal horticultural institute in Potsdam-Wildpark.

PRINCETON UNIVERSITY at its recent sesquicentennial conferred the degree LL.D. upon George Lincoln Goodale, Fisher professor of natural history and director of the botanical garden in Harvard University.

DR. A. HANSGIRG will discuss in a large work which he is preparing for the press, upon the general lines of his *Phytodynamische Untersuchungen*, ombrophoby in flowers, resistance of pollen to water, gamo- and carpotropic movements, and similar curvatures.

THE CATALOGUE of microscopes and laboratory apparatus just issued by the Bausch & Lomb Optical Co. is more than a mere trade list and will well repay examination by those interested in laboratory appliances. Among the novelties the Hastings' aplanatic triplets and the attachable mechanical stage may be commended most heartily.

ON OCTOBER 10th the botanical seminar of the University of Nebraska celebrated its decennial. There have been only twenty members of various ranks in the ten years, of whom ten are in residence in 1896. It is truly remarkable how much valuable work this society has done under the inspiration of its indefatigable leader, Dr. Bessey.

THE TREE, *Saccoglottis Amazonica* Martius, which produces one of the "drift fruits" that long puzzled West Indian botanists, has been rediscovered upon Trinidad. The source of the fruits was established by the sketches of Crüger who collected specimens of the tree upon Trinidad years ago. The superintendent of the Trinidad gardens, Mr. J. H. Hart, sent a collector to hunt up the trees, and after two expeditions he was successful in securing not only good herbarium specimens but also flowers and fruits in alcohol, and seeds from which the gardens have raised some healthy plants.

# GENERAL INDEX.

The most important classified entries will be found under Contributors, Diseases, Geographical Distribution, Personals, Reviews. Names of new species are printed in **bold-face** type; names of synonyms in *Italics.*

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*BOTANICAL GAZETTE*

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