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Errata

Page 3, line 11, *for* VIRGINICA *read* VIRGINIANA.
Page 41, last line, *for* Brainard *read* Brainerd.
Page 70, line 15 from bottom, *for* qiu *read* qui.
Page 111, line 21, for *P. parviflorus* read *S. parviflorus.*
Page 209, line 3, for Greenii read Greenei.
Page 502, lines 15 and 30, *for* Mocino *read* Mociño.
Page 513, last line, and page 514, lines 1 and 2, *for* **Mocino** *read* **Mociño.**
Page 637, line 9 from bottom, *for* VACCININIUM *read* VACCINIUM.

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Vol. 36 No 1

BULLETIN

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The ferns and flowering plants of Nantucket. — IV

EUGENE P. BICKNELL

ARACEAE

ARISAEMA PUSILLUM (Peck) Nash.

Locally rather common in low or wet shaded thickets, mainly in the northeast quarter: Quaise; Polpis; Pocomo; Squam. In fresh flower June 7, some fruit turning red Aug. 13, 1906; mature fruit Sept. 17, 1907.

The Nantucket plant is more especially the state or form known as *A. Stewardsonii* Britton. This, in its representative development, shows a considerable divergence from typical *A. pusillum* but, in localities on Long Island where it grows in abundance, the evidence appears unmistakable that the two plants are extreme variations of a single species. The corrugated spathe, although a noteworthy character, is an unstable one and may or may not be shown by plants growing together in the same colony. I have not, however, seen it as strongly emphasized in plants from anywhere on the coastal plain as in the type specimens from the mountain region of east Pennsylvania.

On Long Island, *A. pusillum* is essentially a plant of the coastal plain, where it replaces *A. triphyllum* of the hilly country. The two species are not at all constantly different in size, and *A. pusillum* when stoutly grown fully gains the proportions of good-sized examples of *A. triphyllum*. Nor is the color of the spathe always distinctive, that of *A. pusillum*, normally of an uninterrupted black-purple, being sometimes greenish and purple-striped or, exception-

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ally, as destitute of any purplish tinge as the palest-flowered examples of *A. triphyllum.* The essential points of distinction in *A. pusillum,* in addition to such variable differences as smaller size and more slender habit, narrower leaf-segments, deeper-colored and more narrowly lanceolate spathe, which is less decurved forward and with relatively narrower and longer tubular portion, is the slender, non-clavate spadix and brighter green color of the leaves which are more shining on the lower surface and never become distinctly pale or glaucous-whitened beneath as in *A. triphyllum.*

The largest example of *A. pusillum* found on Nantucket had the stem 1.5 cm. thick at the base and measured 32 inches to the tip of the longest leaf.

Arisaema triphyllum does not appear to occur on the island.

ACORUS CALAMUS L.

Wet meadows, pools, and overflowed muddy places, common. Spadices nearly full size June 7.

LEMNACEAE

LEMNA MINOR L.

Common in Long and Miacomet ponds; ditches west of the town; Millbrook Swamp.

LEMNA TRISULCA L.

Common with the preceding in Long Pond and with it also in ditches west of the town.

XYRIDACEAE

XYRIS FLEXUOSA Muhl.

Rather common in sandy bogs and along pond shores; Maxcy's Pond; Shawkemo; Polpis; Watt's Run; Tom Never's Pond. Flowering through August and September, sometimes when less than 5 cm. high.

This small state of the plant was doubtless the basis of the record in Mrs. Owen's catalogue of *Xyris flexuosa* var. *pusilla* A. Gray (*X. montana* H. Ries). This species would scarcely be expected on Nantucket and careful search seems to show that it does not occur there.

XYRIS CAROLINIANA Walt.

Local, but common about some of the bogs in Polpis; Almanac Pond; bog west of Sankaty.

ERIOCAULACEAE

ERIOCAULON SEPTANGULARE With.

In shallow water or wet sand about the borders of a number of ponds, especially Tom Never's, Gibbs' and Maxcy's ponds, and smaller ponds in Polpis. Leaves beginning to show June 8; some fresh heads after the middle of September.

COMMELINACEAE

* TRADESCANTIA VIRGINICA L.

Sparingly established on roadside banks at several places near the town in dry sterile soil. First noticed Aug. 6, 1906 — leaves only; first flowers June 8, 1908.

PONTEDERIACEAE

PONTEDERIA CORDATA L.

Very common in ponds and pools. Leaves just appearing June 8; still some flowers late in September. In the autumn the leaves often become deep blackish-purple.

* PONTEDERIA CORDATA ANGUSTIFOLIA (Pursh) Torr.

The narrow-leaved pickerel weed may be merely a state or condition of the common species, but until this has been established by proof it seems proper to allow it separate recognition. On Nantucket it contrasts strikingly with typical *cordata* and seems to maintain its leaf characters under diverse conditions. The leaves, although often very narrowly triangular-lanceolate, may be equally broad with those of *cordata*, but they are more tapering and are truncate to openly cordate at the base instead of deeply sagittate-cordate as are the ovate to ovate-oblong leaves of the typical plant.

It is common in several of the Polpis ponds and I did not find it anywhere mixing with the cordate-leaved species.

HETERANTHERA DUBIA (Jacq.) MacM.

Reported by Mrs. Owen from Long and Miacomet ponds on the authority of Mr. Morong; I did not meet with it.

JUNCACEAE

JUNCUS EFFUSUS L.

Common; in great luxuriance and of unusual size in Tom Never's Swamp. Inflorescence just appearing June 7; mostly dried in August.

The cyme of this rush, like that of a number of our species, varies from open and diffuse to compact (var. *compactus* Lej. & Cour.), but its form is too unstable to be made the basis of any true distinction. Better characters for the subdivision of this species are to be found in the size and form of the perianth-parts and capsule. On Nantucket very typical examples of the close-flowered state are frequent, the inflorescence sometimes forming a dense glomerule not over 1 cm. in diameter; but the two states of the plant pass readily into each other and the close, subglobose head of the one may be seen opening out into the loose cyme of the other even among the clustered stems of the same tuft.

* JUNCUS BALTICUS Willd.

Sandy levels in the marshes along the "Creeks"; sparingly below the "Cliff." Nearly in flower June 7; cyme mostly dried by August.

Note. — *Juncus filiformis* L. is given in Mrs. Owen's catalogue as common, but it seems evident that some other species was mistaken for it.

JUNCUS BUFONIUS L.

Common on sandy pond shores, low roadsides, and wet places generally. In flower from early June until the end of September or later.

JUNCUS GERARDI Lois.

Abundant, forming a large part of the vegetation of the level salt marshes. In full flower in June; inflorescence dried in August.

JUNCUS TENUIS Willd.

Common and variable, presenting a number of distinct-appearing forms ranging from low and densely tufted (6–12 cm. high) with congested cymes 5–10 mm. long, to tall and lax (3–5 dm. high) with elongated, branched inflorescence 6–13 cm. long. Inflorescence just appearing June 7.

A shade form occurring in dry thickets is characterized by extremely slender culms, growing singly or a few together, and a very sparse inflorescence of only 1–9 flowers, some of them borne on thread-form branches or pedicels sometimes 7 cm. long; the lanceolate-subulate perianth-parts are unusually thin and membranous and conspicuously white-margined.

A very slender and somewhat rigid form which grew in sandy soil near Sachacha Pond has elongated very narrow and involute leaves and bracts, the latter erect and becoming 15 cm. long, and congested cymes, the perianth-parts thickened and somewhat shining. The ligule is shorter, firmer, and less scarious than in typical *tenuis* and the character and aspect of the plant suggests some involvement with *Juncus dichotomus*, a small form of which was associated with it.

An equally aberrant form has been determined by Doctor Wiegand, who kindly examined all of my Nantucket material of this group, as

* JUNCUS TENUIS ANTHELATUS Wiegand.

This was collected near Millbrook Swamp, Aug. 19, 1906.

JUNCUS GREENEI Oakes & Tuckerm.

A characteristic rush of Nantucket, occurring everywhere on the dry moors and commons or sometimes in low sandy places growing with *Juncus dichotomus.*

A rather noteworthy modification of this plant occurs in partly shaded grassy places among the pines near Miacomet Pond. The culms, unlike those of the typical plant, which are erect and stiffly clustered, rise singly or a few together and are very slender and elongated, becoming 8 dm. long and finally declined or prostrate; the inflorescence is sparse and few-flowered and subtended by bracts sometimes 2 dm. long.

* JUNCUS DICHOTOMUS Ell.

Very common in all quarters in low sandy places. Inflorescence just appearing June 7.

Two forms of this rush are to be especially noted — one, which appears to be the typical plant, becomes 8 dm. tall and bears somewhat open cymes of strictly secund, sessile flowers; the other form is lower and stiffer with more or less densely congested cymes mostly only 1–3 cm. high.

Another form, if it be not a distinct species, as I have long been inclined to regard it, is more slender than typical *J. dichotomus*, with fewer-flowered, less secund inflorescence, the flowers rather smaller, with shorter, less rigid perianth parts, 2.5–3.5 mm. long, and some of them distinctly pedicelled ; the capsule is somewhat more ovoid and smaller, 2–3 mm. high, and commonly of a deeper reddish-brown color ; the leaves are equally filiform-terete with those of the type but their auricles are usually less cartilaginous. This plant was found at several places and I have also collected it at Van Cortlandt Park, New York, and on Long Island.

JUNCUS MARGINATUS Rostk.

Infrequent but met with at several widely separated stations.

* JUNCUS ARISTULATUS Michx.

Further study of this rush on Nantucket (see Rhodora **6** : 174. 1904) shows that it occupies a general area extending nearly three miles in an east and west direction and about one and a half miles wide, lying east and north of the middle of the island. Within this section it was met with at a dozen or more localities, nowhere in abundance but often in a condition of exceptional vigor and fruitfulness. The largest examples were 1 m. tall with the larger leaves 7 mm. wide. It is to be found from Shimmo Creek to Pout Ponds, Wigwam Pond, several of the ponds in Polpis, and in Quaise. In September, 1907, two plants were observed at Maxcy's Pond within the western half of the island. In fresh flower Aug. 7, 1906.

JUNCUS PELOCARPUS E. Meyer.

Very common on sandy pond shores and in wet places.

JUNCUS MILITARIS Bigel.

Rather common, forming extensive growths in some of the ponds.

JUNCUS ARTICULATUS L.

Common in wet places and about the shores of ponds and pools.

Note. — *Juncus nodosus* L. is included in Mrs. Owen's catalogue on the authority of Professor Edward S. Burgess. In regard to this Professor Burgess writes me that he does not now recall having collected this plant on Nantucket and that there is quite possibly some mistake in the record.

JUNCUS CANADENSIS J. Gay.

Abundant in low grounds and widely variable, presenting very diverse-appearing forms.

Note. — *Juncus canadensis* var. *coarctatus* Engelm. [*J. brevicaudatus* (Engelm.) Fernald] is included in Mrs. Owen's list. The species may occur but, if so, should be attested as a Nantucket plant by a more specific record.

JUNCUS ACUMINATUS Michx.

Common on pond shores and in wet places generally. On Sept. 2, 1904, it was observed about ponds on the south shore, growing in wet sand and quite generally entering into a second flowering period, many fresh stems with unfolding inflorescence arising among the earlier stems on which the cymes had matured long before and become dried and brown.

JUNCOIDES CAMPESTRE (L.) Kuntze.

Common either in damp or in dry situations. In full flower June 7; by the middle of August it is scarcely to be found except for an occasional withered stem which may chance to persist.

In the recently published Gray's New Manual of Botany, it is pointed out that our plant is not the same as the European with which it has always been supposed to be conspecific, and it appears under the name *Luzula campestris* var. *multiflora* (Ehrh.) Čelak., also a European plant.

MELANTHACEAE

OAKESIA SESSILIFOLIA (L.) Wats.

In low thickets, apparently not common: Millbrook Swamp; Polpis thickets. No flowers remaining June 9.

LILIACEAE

HEMEROCALLIS FULVA L.

Occasional by fence-borders and roadsides and in old fields about and near the town. Large flower-buds June 20.

LILIUM PHILADELPHICUM L.

Somewhat locally common, mainly on the middle eastern side of the island, especially among the Shawkemo Hills; Saul's Hills; South Pasture; near Long Pond. In full flower during the first two weeks of August, 1906, indicating a much later flowering-period on Nantucket than on the mainland. The plants are mostly dwarf, often not over 12 cm. high, including the flower, which, even in such small plants, is of normal size and may be fully as long as the stem. Flowers often in pairs; in one instance, three together.

LILIUM SUPERBUM L.

Rather uncommon, in bogs and low grounds: Polpis; Pocomo; Squam; west of Sankaty; Trot's Swamp; never many plants together but some of large size. No flowers seen; green capsules observed from the middle of August to the middle of September.

ALETRIS FARINOSA L.

Locally common, especially in the southeast quarter and over the dry commons towards the south shore; also in Polpis and in Squam. Stems a few inches high by the middle of June; spikes of flowers dried by early August.

CONVALLARIACEAE

* ASPARAGUS OFFICINALIS L.

Frequent along field-borders and roadsides and in neglected places; apparently spreading and occasionally met with far from cultivated neighborhoods. In full flower June 7.

* VAGNERA RACEMOSA (L.) Morong.

Grows freely in a few thickets, as on Rattlesnake Bank, Shimmo Creek Bank, and in Polpis, and occurs very sparingly elsewhere, as in Tom Never's Swamp and in Squam. In full flower June 15; heavily fruited Aug. 7, 1906; fruit fully ripe Sept. 11, 1907.

VAGNERA STELLATA (L.) Morong.

Grows in close beds of considerable extent in openings among the pine scrub about the middle of the island; some dwarf plants on the commons towards Monomoy; Acquidness Point; cedar thicket on Coskaty. In flower June 7; fruit ripe Sept. 11, 1907.

UNIFOLIUM CANADENSE (Desf.) Greene.

Locally abundant in low thickets, especially about Tom Never's Swamp and in Polpis; Shawkemo; Rattlesnake Bank; Pocomo; Trot's Swamp; Long Pond. In flower June 7; fruit well developed June 15; some fruit remaining Sept. 15, 1907.

SALOMONIA BIFLORA (Walt.) Britton.

Scarce and local; Rattlesnake Bank; Polpis thickets. Some dried flowers remaining June 7; ripe fruit Sept. 11, 1907.

MEDEOLA VIRGINIANA L.

Infrequent; Rattlesnake Bank; low thickets in Shawkemo and Polpis. In flower June 7.

SMILACEAE

SMILAX HERBACEA L.

Shrubby banks and thickets, infrequent and met with only east and north of the middle of the island; sometimes growing with exceptional vigor. Shimmo Creek Bank; Rattlesnake Bank and thicket to the east; Squam, at Watt's Run and east along the Wauwinet road. Just in flower June 7; fruit ripe Sept. 17, 1907. On Rattlesnake Bank it had climbed to a height of 10–12 feet, producing peduncles 18 cm. long, borne down by the heavy umbels of as many as fifty-five berries, the larger umbels 7 cm. in diameter.

SMILAX ROTUNDIFOLIA L.

The fully typical plant is common in low thickets, becoming stout and high-climbing in favorable situations and sometimes forming an impenetrable thorny tangle. In flower and with young fruit June 9; no mature fruit seen.

SMILAX ROTUNDIFOLIA QUADRANGULARIS (Muhl.) Wood.

Common in dry places about the borders of thickets or among the low open growth covering sandy levels. Just in flower June 15.

In its extreme form this plant affords a pronounced contrast to typical *rotundifolia* and I would say of it that it remains to be determined whether it represents merely a state assumed by the species in dry and sandy soils or is a derivative now so independently established as to merit the specific rank accorded it by Muhlenberg.

Its habit is often erect and little climbing and it seems never to acquire the height and strong development of typical *rotundifolia.* The stem is more or less quadrangular, often definitely so throughout, and becomes numerously short-, zigzag-branched above. The leaves are narrower than in *rotundifolia* and less cordate, if at all so; the stem-leaves rarely if ever cordate-orbicular and broader than long, but ovate or somewhat triangular-ovate; those of the branches very small and numerous and often ovate-lanceolate from a truncate base, or even with slightly concave sides above a somewhat dilated base, showing an approach to the fiddle-shaped leaves of *Smilax tamnoides.* The leaves are also of a somewhat different texture from those of *S. rotundifolia,* firmer and more membranous and more shining beneath, the three primary veins more prominent and more or less roughened with cartilaginous or spinulose processes which extend along the petioles and sometimes also around the entire margin of the leaf. The petioles are shorter than those of *S. rotundifolia*, while the peduncles are longer — longer than the petioles in the one case, shorter in the other. Not many specimens were found in flower, however, and an extended comparison of these characters is not here possible.

Note. — Smilax tamnoides L. was attributed to Nantucket in Mrs. Owen's catalogue on the authority of Mr. Dame, and the supposed occurrence of this species in New England has been based upon this record. Not meeting with the plant in my earlier explorations, I searched carefully for it on repeated occasions and finally became convinced that it had never occurred on Nantucket and that *Smilax quadrangularis* had been mistaken for it. This conclusion has been confirmed by Professor Fernald, who writes me on the subject as follows: "In the herbarium of the New England Botanical Club is a sheet of sterile branches of the Dame material which was listed by Mrs. Owen as *Smilax tamnoides.* There is a smaller twig in the Gray Herbarium. Both sheets show the plant to be *S. rotundifolia* var. *quadrangularis.* They have the quadrangular branches and the spinulose-margined teeth and I think there is no doubt that they are, as you supposed, the var. *quadrangularis.* Some of the leaves are fiddle-shaped and this character doubtless misled Mr. Dame and Dr. Morong and others who started the records which have now been passed along."

SMILAX GLAUCA Walt.

Common, either in dry or in moist thickets, and more generally dispersed than *S. rotundifolia* or *S. quadrangularis*. Not found in flower or in fruit.

AMARYLLIDACEAE

HYPOXIS HIRSUTA (L.) Coville.

Apparently rare. Recorded by Mrs. Owen without mention of any locality. It was not observed by me until 1908, when it was found growing sparingly on dryish levels at the west side of Trot's Swamp, a small, slender form of the plant just in flower June 10.

IRIDACEAE

IRIS VERSICOLOR L.

Common in low meadows and in wet muddy places and about the borders of ponds and pools. In full flower June 7.

IRIS PRISMATICA L.

Common in low grounds, often in damp or even dry sandy soil. First flowers June 11.

* SISYRINCHIUM GRAMINOIDES Bicknell.

Frequent in damp grassy places or locally common, as in low grounds near "Ram Island," Pocomo; sparingly below the "Cliff," with *S. atlanticum*; near Shawaukemmo Spring; Polpis; towards Quidnet. In full flower June 7; belated flowers Aug. 10, 1906. Some specimens with unusually elongated peduncles up to 19.5 cm. long.

* SISYRINCHIUM ATLANTICUM Bicknell.

Common in low grounds in many parts of the island, by preference in damp sandy soil. In full flower June 7; mostly dried up and little noticeable by August. Near Trot's Swamp, with the flowers of adjoining plants, sky-blue or deep reddish-purple, in striking contrast.

SISYRINCHIUM ARENICOLA Bicknell.

One of the characteristic Nantucket plants, occurring in dry sandy places all over the island. In full flower June 7; belated flowers as late as Sept. 20, 1907.

ORCHIDACEAE

CYPRIPEDIUM ACAULE Ait.

Local, mostly within the southern half of the island from Hummock Pond to 'Sconset; pine grove east of Hummock Pond; east of Miacomet Pond; South Pasture; oak barrens in southeast quarter; borders of Tom Never's Swamp. Some fresh flowers in the shade of pines as late as June 17.

GYMNADENIOPSIS CLAVELLATA (Michx.) Rydb.

A close group of eleven well-fruited plants in open low ground near the head of Long Pond, Sept. 10, 1904; a scattered colony in wet sphagnum on the south side of Sachacha Pond, Sept. 19, 1907. Recorded from Long Pond by Mrs. Owen.

BLEPHARIGLOTTIS BLEPHARIGLOTTIS (Willd.) Rydb.

Common in sandy bogs: Tom Never's Swamp; 'Sconset; Polpis Bogs; Pout Ponds; Watt's Run. Some flowers left Aug. 16, 1906; a belated raceme of flowers Aug. 31, 1904; mature fruit Sept. 15, 1907. Mrs. Owen has recorded var. *holopetala* Gray from "Near edge of swamp opposite Bloomingdale."

BLEPHARIGLOTTIS CILIARIS (L.) Rydb.

Mrs. Owen has recorded a single plant found in 1872 between Siasconset and Polpis.

BLEPHARIGLOTTIS LACERA (Michx.) Rydb.

Frequent or rather common, occurring at widely separated points, but rarely more than a few plants in each locality. Some remaining flowers as late as the second week of August, 1906.

POGONIA OPHIOGLOSSOIDES (L.) Ker.

Abundant in open bogs. Small, precocious flowers in a drying bog June 11; generally coming into bloom June 18; some late flowers in the second week of August, 1906.

LIMODORUM TUBEROSUM L.

Common in bogs. Green flower buds June 18.

ARETHUSA BULBOSA L.

Frequent or rather common in low grounds, often about the borders of swamps. In full flower June 7.

IBIDIUM GRACILE (Bigel.) House.

Scattered plants are rather common in dry open places, sometimes growing in pure sand, occasionally with *I. Beckii.* First flowers Aug. 11, 1906, blooming through September. In August when *I. Beckii* is in full flower, this species, which has a rather later flowering-period, appears to be much the less common, or even rare, but in September when in full bloom, it seems to be equally common with *I. Beckii* or even somewhat more so.

IBIDIUM BECKII (Lindl.) House.

Common throughout in sandy open places, often in pure sand, usually single plants or a few together. In full flower early in August, continuing in bloom at least until after the middle of September.

IBIDIUM CERNUUM (L.) House.

Common in low grounds, coming into flower late in August.

ACHROANTHES UNIFOLIA (Michx.) Raf.

South Pasture, not far from the railroad at about the third mile — a scattered colony of perhaps a dozen plants, in full flower Aug. 6, 1906. Reported from hills west of Sachacha and west of Bloomingdale, 1886.

LEPTORCHIS LOESELII (L.) MacM.

Reported, like the preceding, on the authority of Mr. Dame, from wet bank on the shore of Sachacha, 1886. I met with it only at Watt's Run, where two plants were found growing in deep, wet sphagnum Sept. 17, 1907. One of these plants was of unusual size, bearing a closely fruited raceme of thirteen capsules; the plant was 26 cm. high, its larger leaf 24 cm. long, the larger capsules 1.5 cm. high.

SALICACEAE

POPULUS ALBA L.

Spontaneous and spreading in the neighborhood of the town and elsewhere; on the bluff at 'Sconset; many sprouts and groups of young trees about a long-abandoned farm in Polpis.

* POPULUS CANDICANS Ait.

Established and spreading here and there, especially about the sites of almost obliterated farms. On the border of Trot's Swamp is a scattered group of trees of various ages, the largest about twenty feet high and twenty-eight inches in girth a foot above the base.

POPULUS GRANDIDENTATA Michx.

Infrequent: Taupawshas Swamp; Shawkemo; boggy depressions along the northern border of Saul's Hills; Tom Never's Swamp; probably no trees seen over six or eight feet high.

* POPULUS TREMULOIDES Michx.

Occasional or frequent from the head of Long Pond across the island to 'Sconset and Polpis; small trees only.

Note. — It should be recorded that a few small trees of *Populus tremula* L., of Europe, occur scattered among the pines near Miacomet Pond. It would be a natural inference that these were accidentally introduced when the European pines were planted. But, if this be true, it is difficult to account for the small size and apparent youth of the poplars, the pines having been planted over thirty years ago. The largest of the poplars was less than ten feet high in 1907 and some were only a few feet tall. The same mystery attaches to the presence among the pines of some young trees of the Norway maple (*Acer Pseudo-platanus* L.) and a single small American chestnut [*Castanea dentata* (Marsh.) Borkh.] about ten feet in height. Among these pines also are a few small hickories which are certainly not native where they are established. A single small tree of *Populus tremula* was also found among the pines on the Surfside road which shelter as well scattered trees of the white ash (*Fraxinus americana* L.) and American elm (*Ulmus americana* L.), which are not known ever to have occurred on the island as native species.

* SALIX FRAGILIS L.

Introduced willows are established on Nantucket here and there along roadsides and meadows and about old farm lands. As a rule they have shown little ability to spread and some of the larger trees, of no great height in any case, which must have been planted generations ago, maintain a solitary existence still. Younger trees of most of the species testify to some slight progress in natural increase but, except in the case of *Salix Smithiana*, none of the European species can be regarded as really naturalized.

What appears to be typical *Salix fragilis* occurs at a few places, but it is not common and seems to be only casually spontaneous.

* SALIX ALBA × FRAGILIS Wimmer.

Less uncommon than typical *Salix fragilis* and less doubtfully spontaneous, occurring at widely separated localities sometimes in out of the way places. The trees from different stations show considerable variation in the size and form of the leaves and the pubescence of the younger parts, some individuals evidencing more of their *alba* parentage, others more that of *fragilis*. No unequivocal examples of the hybrids *Salix decipiens* Hoff. and *Salix Russelliana* Smith were found. As a matter of local interest, the willows of this group should be studied in their flowering and fruiting seasons and receive careful determination.

* SALIX ALBA L.

Infrequent; typical *Salix alba* was collected at the border of a swampy thicket in Polpis. *Salix vitellina* L. was not observed.

* SALIX BABYLONICA L.

In a swampy lot on the south side of the town, in a situation where it would scarcely have been planted, a tree of medium size grew in 1899 and 1904 but had disappeared in 1906. This tree was perhaps the parent of two young trees, one about five feet high, observed in 1907 in low fields not far distant. A tree near the cockspur-thorn lot to the west of the town, growing with other introduced trees, was doubtless planted, as well as another tree near it, apparently a hybrid with *S. fragilis*.

* SALIX SMITHIANA Willd.

Salix cinerea × viminalis Wimmer.

This strongly characterized willow seems to be better adapted to the Nantucket environment than any other of the introduced species, and more than any other may be considered as definitely established. It is frequent in the general town region as well as at outlying points and was met with in such uninhabited quarters as the "Woods" and east of Hummock Pond. It is well established on and below the bluff at 'Sconset, where groups of vigorous young trees were observed in 1904 and 1906, the larger being ten feet or more in height. In trees of this age the bark of the trunk and branches is smooth and pale greenish-gray, the younger twigs pale green and yellowish. That the tree was early planted in Nantucket is shown by some old trees in the outskirts of the town, in which the trunks are seamed and furrowed and gray with lichens. Not observed in flower or in fruit. The foliage of the Nantucket tree matches perfectly with that of Bebb's no. 55, Herbarium Salicum, grown at Fountaindale, Illinois, 1880.

Although this tree was undoubtedly introduced into Nantucket as a hybrid, and as such has maintained itself and increased its foothold, it is of particular interest to find that its parent species, *Salix cinerea* L. and *Salix viminalis* L., are also present on the island. A single tree of each was met with at points about six miles apart on opposite sides of the island. The detailed record of each follows.

* SALIX VIMINALIS L.

A single tree grows by a pond in a low field on the western side of the town. The tree is a very old one and is of large size for the species, the gnarled and sloping trunk thickly clothed with young shoots. It stands close to the rear yard of an old dwelling, where it may be supposed to have been originally planted, and it is referred to here only on account of its interest as one of the alleged parents of *Salix Smithiana.*

* SALIX CINEREA L.

A single thriving shrub of several stout stems about ten feet high on the border of Tom Never's Swamp, growing with *Salix Bebbiana* and *Salix petiolaris*. Bark of the stems smooth, and pale yellowish-gray. This shrub was first observed Sept. 15, 1907; on June 13, 1908, it bore many mature fertile catkins. Specimens collected agree closely with a sheet of Seringe's Swiss Willows in the herbarium of the New York Botanical Garden labeled as follows:

"*Salix cinerea δ obovata* Ser. rév. inéd.

S. acuminata Ser. saul. dess. n. 26–27.
S. acuminata obovata Ser. ess. 13.
S. aquatica Smith engl. bot. t. 1437, ex Borrer in litt.!
Berne, rives de l'Aar. 1824."

This species was not found in cultivation anywhere on Nantucket and its occurrence amid the native vegetation in the undisturbed surroundings of Tom Never's Swamp seems very noteworthy.

* SALIX PENTANDRA L.

Three trees 8 to 12 feet high in a low field below the "Cliff"; a group of more than thirty trees along the edge of a meadow near Lily Pond, the larger about eighteen feet high and smaller ones of a later generation among them. These trees had doubtless been planted originally at both stations and though now growing in natural surroundings have shown little disposition to become spontaneous. Some fertile catkins remained June 20.

* SALIX PURPUREA L.

Established at a few places in low meadows west of the town; a group of trees on the border of a damp field at 'Sconset.

* SALIX CORDATA Muhl.

Typical *Salix cordata* is found in abundance at Washing Pond, forming dense masses four to six feet high along the gravelly shore, the stems and branches often spreading and procumbent in the sand. It occurs also in Trot's Swamp. Not found in flower or fruit.

* SALIX RIGIDA Muhl.

Frequent in the neighborhood of Millbrook Swamp, sometimes forming close clumps eight or ten feet high; Trot's Swamp. Some fertile catkins remaining June 10.

SALIX DISCOLOR Muhl.

Except in the "Woods," where it is frequent, this is found only on the eastern side of the island; in the southeastern quarter from Tom Never's Swamp to Gibbs' Pond it is rather common and it occurs also in Polpis, inhabiting boggy spots along the northern side of Saul's Hills. A single tree at Watt's Run was fully twelve feet high and bore unusually large and thin, long-petioled leaves.

Certain specimens included here are perhaps referable to *Salix prinoides* Pursh.

* SALIX ERIOCEPHALA Michx.

Frequent or rather common in the same parts of the island where the preceding is found and often growing with it. Broad-leaved and narrow-leaved forms occur, one of the latter having the leaves and branchlets heavily invested with a soft ferruginous pubescence.

* SALIX BEBBIANA Sarg.

Frequent, occurring in the same localities as the two foregoing species. A few pistillate aments remaining June 13. On the border of Tom Never's Swamp a distinct-appearing form was met with, having unusually broad obovate leaves, densely velvety-pubescent on the lower surface and to some extent above.

* SALIX HUMILIS Marsh.

A single very typical shrub a little over three feet high met with on a dry spot at the border of Taupawshas Swamp. A few shriveled fertile aments accidentally persistent June 18.

SALIX TRISTIS Ait.

This low willow is frequent on the plains along the south side of the island east of Surfside, and large beds of it are found in the South Pasture. It was met with elsewhere only on the borders of Tom Never's Swamp and sparingly along the bluff at 'Sconset.

* SALIX SERICEA Marsh.

A single small shrub, about four feet high, in Gibbs' Swamp, Sept. 5, 1904.

* SALIX PETIOLARIS J. E. Smith.

Two low shrubs met with in Tom Never's Swamp, not far from the 'Sconset road, September, 1907 and June, 1908.

MYRICACEAE

* MYRICA GALE L.

A single strongly growing clump on the west side of Capaum Pond near the shore, covering a space about two yards in longer diameter. It is about two feet in height, and appears to be a cluster of small shrubs but is in reality from a single root, the lower branches at first widely spreading on and below the surface of the ground.

MYRICA CAROLINENSIS Mill.

Everywhere an exceedingly common shrub, much dwarfed in dry open places, in low thickets becoming eight feet high.

COMPTONIA PEREGRINA (L.) Coulter.

Common over the plains and in the oak barrens, mainly on the southern and eastern sides of the island.

JUGLANDACEAE

HICORIA ALBA (L.) Britton.

Frequent in thickets, mainly in the northeast quarter of the island: Shawkemo; Quaise; Polpis; Pocomo; Squam; barrens west of Sankaty. Sometimes fruiting well when not over six feet high. No trees seen over fifteen feet in height. In full flower June 11; fruit nearly full size the second week of September.

* HICORIA MICROCARPA (Nutt.) Britton.

South of Wauwinet, in a dense thicket, Sept. 2, 1904 — a single stout tree perhaps ten feet high with wide-spreading branches, the lowermost resting on the ground. Fruit abundant, definitely compressed, suborbicular in outline and mostly broader than long, the smaller, when dried, 18 mm. long and wide and 15 mm. thick, the larger 22 mm. long, 25 mm. wide, and 20 mm. thick. The bark of this tree was very pale and smooth like that of a beech, which seems to be a characteristic common to the three hickories native to Nantucket.

A single tree about seven feet high was found in a thicket in Pocomo, Sept. 21, 1907.

HICORIA GLABRA (Mill.) Britton.

Apparently rare, and certainly much less frequent than the mockernut. Found only in Shawkemo, and in Pocomo, fruiting rather sparingly. Fruit full size Sept. 11–21, 1907, obovoid-oblong or pyriform, the largest 28 mm. long, 24 mm. wide, 21 mm. thick. On June 9, 1908, it was much less advanced in foliage than was *Hicoria alba* growing with it and no aments were developed although its companion species was covered with them.

In the dense thicket in Shawkemo, is a group of several trees certainly fifteen feet high, the largest twenty-eight inches in circumference a foot above the base; their bark is close and white like that of a beech, although a little broken and darker low on the larger trunks.

Note. — The shag-bark hickory [*Hicoria ovata* (Mill.) Britton] is mentioned by Mrs. Owen as having been found on Coskaty by Mr. W. L. Foster. The tree would be rather unexpected on Nantucket and a more detailed record seems to be needed. A few young trees, one about eight feet high, grow among the Miacomet pines, where they are certainly not native, and their presence there affords no better reason for admitting the species into the Nantucket flora than for accepting the chestnut as a Nantucket tree on the strength of a single small sapling found growing like the hickories among the pine trees.

BETULACEAE

CARPINUS CAROLINIANA Walt.

Admitted in Mrs. Owens' list; I did not meet with it.

CORYLUS AMERICANA Walt.

Frequent or common in dry thickets from the east side of the lower harbor to Shawkemo, Quaise, Polpis, and Squam. As a rule it does not fruit freely but sometimes, as on Rattlesnake Bank, it is very prolific.

CORYLUS ROSTRATA Ait.

Much more common and generally distributed than the foregoing, entering freely into the composition of the woody growth over the moorland and on dry exposed hillsides, and fruiting prolifically often when only six to twelve inches high. In low thickets in Polpis it reached a height of several feet and was loaded with fruit, some of the branchlets only five inches long bearing as many as ten well-developed nuts. In these the body of the fruit was small, 10–13 mm. long, and densely bristly-pubescent, the beak varying from straight to much curved and from 10 mm. to 25 mm. in length. On some of these low fruiting shrubs the leaves were unusually small, sometimes only 3–5 cm. long throughout. In richer soils the shrub is taller with larger leaves and fruit, the latter becoming 18 mm. long with a stout beak 2-3.5 cm. in length.

BETULA POPULIFOLIA Marsh.

Rare near the town but well scattered locally over the island, mostly very small trees and none perhaps over 8 or 10 feet high: Shawkemo; Taupawshas Swamp; Quaise; Polpis; along the north side of Saul's Hills; Gibbs' Swamp; Tom Never's Swamp; west of Tristram Coffin's; head of Long Pond.

Note. — Some small stunted trees of the European birches, *Betula pubescens* Ehrh. and *Betula pendula* Roth, grow in a low, half-swampy thicket west of the town, together with several kinds of introduced oaks and native trees. This thicket adjoins the tract of land enclosed by cockspur thorns set out by William Henry Gardner about the year 1830, as recorded by Mrs. Owen (Cat. p. 25). The lot or thicket where these introduced oaks and birches now grow must have been utilized at one time as a sort of nursery, but either the trees were planted at a considerably later date than the thorn trees or else have been of very slow growth. Whatever their history, they have long been wholly neglected and have now united in a thick and tangled growth with the native trees and shrubbery, appearing as if they also were part of the natural vegetation of the region.

*ALNUS NOVEBORACENSIS Britton.

Two small shrubs grow on the western side of Capaum Pond and one on the south shore of Sachacha Pond; a single stout shrub grew just back of the shore on the east side of the lower harbor at Monomoy in 1904, but in 1907 was found to have disappeared.

The type of *Alnus noveboracensis* seems to be an aberrant form of a very common shrub which, on the one hand, almost unites with, or perhaps hybridizes with, *Alnus rugosa* (DuRoi) Koch and, on the other, approaches very close to *Alnus glauca* Michx. With the latter it seems to have been quite generally referred to *Alnus incana* (L.) Willd. of Europe, which, in my view, cannot properly be regarded as the same. The European shrub is, however, a very near relative of our *Alnus glauca*, but less closely related to the obscurely known shrub here discussed.

In accordance with this understanding of *Alnus noveboracensis*, it is characterized by leaves of thickish texture, ovate to broadly obovate, mostly rounded but sometimes narrowed to the base and acute at the apex, slightly repand and dentate-serrate, dull green above, paler green beneath and rusty-pubescent on the veins or becoming densely ferruginous-pubescent over the entire lower surface as well as on the branchlets. This character is remarkably pronounced on some of the Nantucket material. *Alnus glauca* differs in more membranous leaves, oftener subcordate at the base and more sharply undulate-lobed, the lower surface pale glaucous-blue and glabrous or nearly so except on the larger veins. The bark of *Alnus noveboracensis* is somewhat intermediate between that of *Alnus glauca* and *Alnus rugosa*.

FAGACEAE

FAGUS GRANDIFOLIA Ehrh.

Uncommon and often quite hidden from view among the dense thickets where it is usually found. A small strongly established colony in Quaise ; Shawkemo, east of Rattlesnake Bank ; an occasional small tree in Pocomo ; Watt's Run bank — a single old tree of clustered second growth trunks perhaps fifteen feet high, the tallest seen ; one tree about twelve feet high on Coskaty ; sparingly on both sides of Tom Never's Swamp, the stoutest tree measuring thirty-four inches in circumference below the nearly basal lower branches. A single tree in Quaise had developed a few imperfect fruits.

The leaves vary widely in shape and degree of dentition as well as in pubescence — from ovate with definitely cordate base to lanceolate-oblong with narrowed base and from nearly glabrous with silky-pilose hairs on the veins beneath to thinly silky-pilose on the upper face and densely soft puberulent over the entire lower surface without any silky hairs ; the margins are sometimes thickly pilose-fringed. These wide variations, almost in their extreme phases, may sometimes be found in leaves from the same tree.

Note. — A single slender sapling of the American chestnut, *Castanea dentata* (Marsh.) Borkh., grows in an opening among the pines near Miacomet Pond; on June 17, 1908, it was about ten feet high. (See note under *Populus tremula.*)

QUERCUS COCCINEA Wang.

A few small trees occur among the pines south of the fair grounds and a single tree at the edge of the pine grove on the Surfside road. On June 12, 1908, this tree was less than ten feet high, the upper parts dead, but, near the base, bearing many widely radiating prostrate branches closely pressing the ground and twelve to twenty-two feet in length; on some of these the terminal branchlets were so slenderly elongated as to appear trailing and theabundant foliage of erect or ascending branchlets gave the appearance of a low growth of scrub-oak completely surrounding the tree.

This oak was seen nowhere else than at the two points mentioned and it seems very doubtful if it is native to the island.

QUERCUS VELUTINA Lam.

Of the few arborescent oaks native to Nantucket this and the white oak are still common enough to show that they must have been among the prevailing trees before the wooded parts of the island were deforested generations ago. Both species usually occur together, mostly about the borders of dense thickets or surrounded on all sides by an almost impenetrable growth of low trees and shrubbery. In such situations they are often noticeable from a distance rising above the surrounding growth, although rarely more than eight or ten feet in height. Here and there, as in Quaise, Polpis, Pocomo, about Tom Never's Swamp, and on Coskaty, they are of larger stature, reaching a height of fifteen or twenty feet, and unite with the sour gum, sassafras, wild cherry, red maple, and other trees to form patches of low woodland. The stoutest black oak seen was in Tom Never's Swamp and measured thirty-six inches around near the base.

On Coskaty is a considerable tract of low, thickety, almost impenetrable woodland largely composed of this oak, compact heavily foliaged trees, which bear abundant fruit. Here the species separates into two remarkably diverse forms, which flourish side by side. One is the ordinary form of the tree having leaves with broad lobes mostly wider than the often shallow sinuses. Its companion form might easily be mistaken for the scarlet oak. The leaves are even more deeply cut, with the sinuses wide and deep, often much wider than the lobes, leaving the lamina along the midrib narrowed to a width of only 0.8 to 1.5 mm. These leaves were mostly wider than long, the median lobes divergent and spreading, about twice the width of the narrowed basal pair, widely dilated towards the end into divergent, triangular, entire lobes, the narrowed basal part often elongated and mostly 1 to 1.5 cm. wide. Many of these leaves as late in the season as the middle of August, with their petioles and the branchlets, were clothed with a fine stellate scurfiness; others were glabrous except in the axils of the primary veins.

* QUERCUS PAGODAEFOLIA (Elliott) Ashe.

Near Quaise Point, June 11, 1908 — a single tree in full flower growing in a low thicket. The tree was about twelve feet high and twenty-four inches around two feet above the base; the lowest branches, over six feet above the ground, were nearly horizontal and their widest spread about ten paces. The tree stood in an opening into the thicket and much of the bark of the trunk had at one time been destroyed, apparently by cattle; the wound had healed but the trunk had been nearly girdled and the living bark on one side reduced to a strip only three inches wide.

Doctor N. L. Britton has joined me in a study of the leaves of this tree and we have reached the conclusion that it can be referred to no other species than *Quercus pagodaefolia*. The leaves are not in all respects precisely identical with typical examples of *pagodaefolia* from the southern states, their lobes being often less acuminate and entire and the pubescence of the lower surface less firmly persistent and of a more yellowish tinge; but the form of many of the leaves is exactly that of the southern tree and quite unlike that of any of our northern oaks, the lobes being triangular-lanceolate and wholly entire. Other leaves approach in form those of the black oak but differ in the lobes being more narrowed towards the ends and more entire, the basal pair spreading as widely as the median ones, or nearly so, instead of being conspicuously shorter.

In Britton's Manual the range of *Quercus digitata* (Marsh.) Sudw. is given as extending north to Long Island. This northern limit was based on a single tree found by me near Hempstead, which is the same as the Nantucket tree and should now be referred to *Quercus pagodaefolia*. It may here be also recorded that an individual of precisely the same kind of tree was observed at Fair Haven, Mass., June 6, 1908; this tree was some 25 to 30 feet in height and about a foot in diameter near the base.

QUERCUS ILICIFOLIA Wang.

Abundant on the eastern side of the island, in many places forming extensive thickets of so dense and rigid an entanglement as to be almost impassable. Fruiting abundantly.

QUERCUS ALBA L.

Rare on the western side of the island; frequent or locally common in thickets on the eastern side in the section east and northeast of a line drawn from Quaise to Tom Never's Swamp. The trees are mostly 6 to 10 feet in height, but become at least fifteen feet high in low swampy woods in Polpis. No fruit was found.

The stoutest native tree of any kind met with on the island was a white oak in a dense thicket in Quaise which measured 40 inches in circumference a foot above the base.

* QUERCUS STELLATA Wang.

Met with at four stations on the eastern side of the island. The nearest of these to the town is about two and a half miles out on the Wauwinet road, where there is a group of straggling trees covering a space ten or twelve paces in longer diameter, the trunks mostly ascending and the tallest less than ten feet high; these were a second growth from old stumps that had been cut long before. They bore abundant immature fruit, Sept. 11, 1907. A single tree about six feet high was found in 1906 in Saul's Hills west of Altar Rock Hill, and a tree of about the same height in Tom Never's Swamp, less than a half mile southeast of 'Sconset. A close group of four trees less than ten feet in height was discovered in 1899, about a mile northwest of 'Sconset. In June, 1908, these trees seemed to be dying; the ground about them had been much trampled by cattle and the trunks much abraded; the largest trunk was 19½ inches around a foot above the base.

QUERCUS PRINOIDES Willd.

Common on the eastern side of the island in the same territory as *Quercus ilicifolia* and often associated with it. Fruiting freely. Staminate aments June 13.

* QUERCUS PRINOIDES RUFESCENS Rehder.

Met with at many points always in association with *Quercus prinoides* and *Quercus ilicifolia*; near Sankaty Head; Tom Never's Swamp; Plainfield; between the fourth and sixth mile along the railroad.

While there seems to be nothing in the habit or aspect of this oak to set it apart from typical *Quercus prinoides* it may always be readily distinguished by reason of its puberulent branchlets and the densely pubescent veins on the under surface of the leaves; the pubescence is also usually of a slightly fulvous tinge. Notwithstanding this greater pubescence below of the mature leaves, the unfolding leaves are commonly much less pubescent than are those of typical *Q. prinoides* of corresponding age. In general the leaves of *rufescens* are, as Mr. Rehder has pointed out, more obovate and less gradually narrowed to the apex and perhaps, also, more sharply undulate-lobed, but these differences, although often well-defined, are not at all constant.

On Long Island *rufescens* is common, as on Nantucket, inhabiting tracts where *Quercus prinoides* and *Quercus ilicifolia* are common also. In September, 1908, the fruit was collected at two places and presented well-defined differences from that of *Quercus prinoides* obtained at the same time, being considerably larger with a much deeper cup, more rounded below, and often covering more than half the acorn; the scales of the cup are also paler in color and more densely tomentulose-felted as well as longer and more narrowed to the apex, and form a perceptible erect fringe around the margin. The acorns measured when dry 15 mm. long by 12 mm. thick, the cups 12–15 mm. wide by 10 mm. deep; in *Q. prinoides* collected with it the acorns were 10–12 mm. long by 9–11 mm. thick, the cups 10–12 mm. wide by 4–6 mm. deep. The fruit of many of our oaks is, however, remarkably variable, and it is yet to be ascertained whether the differences here described are in any way constant. The actual status of this newly described oak remains to be determined. It may be merely a phase of *Quercus prinoides* or it may be a distinct although very closely related species.

Note. — Several species of introduced oaks, some appearing like native trees, grow in the long-neglected lot, near the present Benjamin Coffin farm west of the town, which has already been referred to as a station for the European birches, *Betula pubescens* and *Betula pendula.* These oaks are the following, there being from one to several small trees of each species: *Quercus bicolor* Willd.; *Quercus rubra* L.; *Quercus palustris* Muench.; *Quercus Robur* L.

ULMACEAE

* ULMUS AMERICANA L.

A few small scattered trees have sprung up among the pines on the Surfside road, where they appear to be wholly spontaneous. Two trees estimated to be about thirty feet in height grow together on the edge of Trot's Swamp on the north side. This part of the island is now quite uninhabited and these trees appear like part of the native vegetation, but they are not far from a long-abandoned farm, and some trees of *Populus candicans* near them, of considerable size, are unmistakable evidence of man's handiwork in generations gone. All of these elms are the form with pubescent branchlets with the leaves very scabrous on the upper surface.

Elms were early planted in the town, where they have thriven well and become a very beautiful feature of some of the main streets.

Note. — Some small trees and shoots of the European elm (*Ulmus campestris* L.) are found along the road to Surfside, beyond the outskirts of the town, but they are only sparingly spontaneous about trees that must have been originally planted.

MORACEAE

* HUMULUS LUPULUS L.

Along an old roadside fence and in an adjoining field west of the town; also on Crooked Lane, and at several places near cultivated ground, where it is less clearly spontaneous. First noticed in a wild state in 1906.

* HUMULUS JAPONICUS Sieb. & Zucc.

Found in 1899 trailing all over a rubbish-heap by a roadside north of the town; not seen again until 1907, when a single plant in full flower was observed Sept. 16, in waste ground less than a mile south of the town.

CANNABIS SATIVA L.

Two instances of the occurrence of this species in the town are recorded by Mrs. Owen. I did not meet with it.

Note. — A thick cluster of the white mulberry (*Morus alba* L.) about four feet in height, from two main shoots, grew on Sept. 11, 1907, on the edge of a field near a barn on the Wauwinet road about two miles from the town. The tree may have been originally planted at or near this station and the species is noted here only for the purpose of a record in the case of a tree which has shown a readiness to become naturalized in some parts of the country.

URTICACEAE

URTICA URENS L.

Mrs. Owen has reported this nettle as rare at the time her list was published in 1888, but a not uncommon garden weed fifty years earlier. I saw nothing of it.

* URTICA LYALLII Wats.

A vigorous patch in full flower growing by a fence near waste ground in 'Sconset June 13, 1908.

* ADICEA PUMILA (L.) Raf.

Rare, but growing in abundance in an open sphagnum bog in Shimmo valley; also in Watt's Run bog; in full flower Aug. 29, 1904 and Sept. 11, 1907.

BOEHMERIA CYLINDRICA (L.) Willd.

By the borders of several ponds and in low thickets west of the town; Trot's Swamp; Polpis; Watt's Run; in full flower Aug. 14, 1906.

* BOEHMERIA SCABRA (Porter) Small.

Rather common in weedy meadows and wet places across the northern side of the island from Long Pond to Polpis. In full flower in early September.

Typical examples appear very distinct from *Boehmeria cylindrica* but the two plants seem to run together and may prove to be only extreme conditions of one species.

PARIETARIA PENNSYLVANICA Muhl.

Mrs. Owen's list records "some half dozen" plants found in 1879 on Coatue "in beach sand close to a boulder near the water's edge."

SANTALACEAE

COMANDRA UMBELLATA (L.) Nutt.

Very common over the moorland, especially in the southeast quarter of the island. Some plants still in flower June 13.

A statistical criterion for species and genera among the bacteria *

C.-E. A. WINSLOW

The existence of an almost infinite number of minute variations in many groups of bacteria has so far almost nullified any attempt at a natural classification. Isolated bacterial cells, lying free in a liquid medium, are exposed in a high degree to the direct effect of the environment; and the extent to which virulence may be exalted or attenuated shows how easily they respond to such influences. The absence of the sex process probably magnifies any tendencies to variability. Amphimixis may well serve, as Weissmann holds, to promote minor variations; but on the other hand it is reasonable to believe that it checks more extreme deviations from the mean. Among asexual organisms, every variation that arises is preserved intact until acted on by some modifying cause. Finally, the rapid multiplication of the bacteria offers an exceptional opportunity for the action of selective influences. The immense number of generations which succeed each other in a short space of time makes boundary lines as shifting as they would become among the higher plants if a dozen geological periods were considered all at once.

In certain groups of the bacteria, among the Coccaceae for example, and in the group of *Bacillus Diphtheriae*, the inconstancy of characters is specially marked and it is possible by appropriate laboratory experiments to modify profoundly such important metabolic properties as acid-production and chromogenesis. Other groups, like that of the aerobic spore-formers, appear to be in relatively stable equilibrium. Even where the characters of any given strain are fairly constant, classification is often complicated by the fact that an almost infinite series of minutely differing strains may be found, each apparently constant under existing conditions but together forming a continuous series connecting widely separated types.

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* Read before Section G of the American Association for the Advancement of Science at the Baltimore Meeting, December 31, 1908.

The result of this condition of affairs is that systematic bacteriology has almost fallen into desuetude. After a brave beginning in the way of describing bacterial species the conviction gradually gained ground that of the making of species there is no end. Aside from the forms which are recognized by their association with well-defined diseases, there are hardly a score of bacteria that can be distinguished with any certainty among the hundreds which have been already described. Time and industry alone would be needed to produce as many thousands as there are now hundreds of paper species; but the condition of affairs would only be still more hopeless.

Refuge from the multitude of varieties has been sought, on the one hand, by ignoring all minor differences and massing the bacteria into a few main groups; and, on the other hand, by a frankly arbitrary schematic arrangement of cultures according to their plus-or-minus reaction in a few standard media, decimal numbers being used for the description of each combination of possible reactions. Neither of these expedients is very satisfactory. The first ignores real differences of much practical as well as theoretical importance. The second method, while convenient for the cataloguing of descriptions, only obscures the natural phylogenetic relationships of bacterial types. Organic individuals have not been created in symmetrical groups, differing in the presence or absence of character *A*, each group including two sub-groups, respectively possessing and lacking character *B*. They have been developed along irregular and complex lines, and are now related in family groupings of infinitely various kinds and degrees.

There is one method, and apparently only one, which promises to answer the puzzling question of bacterial relationships. This is the statistical method. If attention be given, not to the individual, but to the group, and if certain characters are quantitatively measured in a considerable series of cultures and statistically analyzed, order begins to emerge from chaos. Almost every degree of acidity or gelatin liquefaction may be found in some individuals; but the greatest number of strains group themselves about well-defined centers. The curve of frequency plotted for any character shows certain modes which are the types about which the bacteria as a group are varying. Furthermore, if several distinct characters are compared, it will frequently appear that on the average certain properties are correlated with each other and generally vary together. As mountain tops occur in ranges, so the peaks on the curve of frequency for any single bacterial character are grouped together, by the study of other characters, into larger complexes. Major and minor groups may rightly be considered as constituting genera and species among the micro-organisms. They are not separated by boundary lines but are fixed rather by the centers about which they group themselves. They are genera and species, characterized, not by the description of individual strains, but by the frequency of occurrence of a considerable series of such individuals.

This method of statistical classification is by no means novel. Ever since Quételet and Galton began to apply the statistical method to the solution of biological problems it has been recognized that species and varieties could be more or less satisfactorily fixed by a study of frequency of distribution. Davenport and Blankinship (Science II. **7**: 685) even went so far as to suggest a definite numerical criterion of a species, founded on this basis. According to their suggestion, if a bimodal curve is obtained, the ratio of the ordinate of the lesser mode to the minimum ordinate in the depression between the modes, may be considered as an index of the isolation between the two races. If this ratio is over two, the modes represent species; if under two, varieties. The numerical criterion fixed by these authors may be criticized as somewhat arbitrary. The general principle is sound, however, and has yielded good results in many fields. Notably in the study of the races of man the statistical method has proved of the highest service. Curiously enough, among the micro-organisms, where some method of this sort is most urgently needed, statistical study has until very recently been wholly lacking.

At the Massachusetts Institute of Technology we have been for some years working on the classification of the family Coccaceae, one of the most difficult groups of the bacteria, by this general method. We collected five hundred different strains of cocci from various sources, earth, water, air, and the normal and diseased human body. After some considerable preliminary study eleven characters were fixed upon as having probable systematic importance and as adapted to definite quantitative measurement. When the results obtained were analyzed from the statistical standpoint, groups and subgroups of various grades were obviously apparent; and it was possible to draw up on this basis a general outline of a classification for the group, which appears to correspond to true phylogenetic relationships (Winslow, C.-E. A., & Winslow, A. R., Systematic Relationships of the Coccaceae; New York, 1908). In the first place, two major divisions or subfamilies were distinguished, one saprophytic and the other parasitic. The cocci from the human body generally occurred in chains or small irregular groups of cells, stained by the Gram stain, formed a meager or only fair surface growth on media, produced acid in carbohydrates, and showed no pigment or a white or orange one. The cocci from earth and water, on the other hand, occurred in large cell groups or packets, decolorized by the Gram stain, grew well on solid media, failed to ferment carbohydrates and produced a red or yellow pigment. Each character was sometimes found in the group where it did not normally occur, but on the whole the average correlation was very strong. Within each subfamily several groups of a second grade of individuality were found, marked by the association of a smaller number of characters than the subfamilies, but still defined by the correlation of several independent properties. These were called genera. Finally, within the genera, species were defined by the distinct centers of variation which were manifest for single independent characters, such as the liquefaction of gelatin and the reduction of nitrates.

Curiously enough, while we were at work upon the relationships of the family of the Coccaceae as a whole, Andrewes and Horder in England were applying almost exactly the same principles to the classification of the subtypes included in the genus *Streptococcus*, a genus which is so marked in its characters that it has been one of the few groups of the Coccaceae long recognized as a result of common observation. What species should be included in the genus *Streptococcus* has been the subject of long and fruitless debate; and the "Vielheit" or the "Einheit" of the *Streptococci* seemed an insoluble problem. Andrewes and Horder, however, by studying the numerical frequency of occurrence of various forms distinguished seven type centers which they could properly recognize as species (Lancet 1906^2: 708). Their work greatly extended ours, as we had worked scarcely at all on the particular genus with which they dealt. The combined effect of the two investigations is to emphasize strongly the value of the statistical method in bacterial classification; and there seems no reason why the same principles should not be of similar value in the systematic study of algae and fungi and Protozoa and other simple and variable forms.

Among other things that these studies emphasized is the importance of physiological differences in bacterial classification. Systematic bacteriology has been greatly retarded by the undue emphasis laid on morphological characters. Reasoning from analogy with higher plants, many bacteriologists have refused to base generic distinctions upon anything but morphological differences. As there are very few morphological differences in the group, there has been no rational generic classification. The distinction between physiological and morphological characters is merely a superficial one. Both are presumably due to chemical modifications of protoplasm; and there is no reason to suppose that a protoplasmic property which manifests itself in the size and arrangement of parts is any more fundamental than one which manifests itself in the ability to utilize a certain food stuff. It is precisely along the lines of metabolism that the bacteria have attained their extraordinary degree of differentiation. The higher plants have developed complex structural modifications to enable them to absorb food materials of certain limited kinds and to utilize the sun's energy in building them up into protoplasm. Meanwhile the bacteria have maintained themselves by acquiring the power of assimilating simple and abundant foods of the most varied sorts. Evolution has developed gross structure in one case without altering metabolism; it has produced a diverse metabolism in the other case, without altering gross structure. There is as wide a difference in metabolism between the *Pneumococci* and the nitrifying bacteria as there is in structure between a liverwort and an oak. So-called physiological differences are quite as important in one case as so-called morphological differences in the other.

The characters which are of prime systematic importance will naturally vary according to the particular group of bacteria which is under consideration. One family or genus may have differentiated along the line of carbohydrate fermentation; another may have divided into groups adapted to a parasitic life on particular tissues of the human body, like the *Diplococci*; in a third, obvious differences in reproduction may have arisen, as in the anaerobic spore-formers. This is one reason why the conventional bacterial classifications are inadequate. Migula (System der Bakterien, II., Jena, 1900) and Chester (A Manual of Determinative Bacteriology, New York, 1901), for example, recognize only five morphological genera among the Coccaceae and divide them all into dichotomous classes by the same arbitrary plus-and-minus tests. Such an arrangement is very far from representing the complex facts of relationship. A difference of great systematic importance in one group may be valueless in another. In each group of the bacteria as many reactions as possible must be examined with an open mind in order to determine which are of systematic importance. In many groups the most helpful properties which mark their characteristic differentiation may be biochemical reactions not yet studied at all. It was the careful examination of fermentative power in various carbohydrate media by Gordon and his colleagues that made the classification of the *Streptococci* possible and it is quite probable that a similar detailed knowledge of the saprophytic *Micrococci* will be acquired only by the application of tests not now at our disposal.

The tests chosen for systematic study of the bacteria should, as far as possible, be susceptible of definite quantitative measurement. A great deal of the earlier confusion which has surrounded the subject has been due to descriptions of colony-formation, etc., which were expressed in terms wholly dependent on the personal equation of the author. For statistical study, records should, if possible, be capable of expression on a numerical scale. Where this is not feasible, as in comparing pigments of different hues, the observations may be divided into classes, defined as closely as possible by comparison with known standards. The cultures studied should include a considerable series of the particular group studied; and it should represent a wide variety of habitats, as the bacteria are usually closely adapted to their particular environment.

When the observations of several hundred cultures are finally obtained and tabulated, the first important thing is to determine the major groups included in the series. This may be easily done by a general study of the correlation of different characters, without any elaborate mathematical methods. In our work on the Coccaceae we constructed a correlation table for each pair of characters and noted the general coincidence of one with the other.

It must be remembered, in estimating the importance of the occurrence of correlated characters, that their common presence may be due to one of two causes. The characters may be correlated simply because ancestral forms developed them both, under the action of independent causes. Or, on the other hand, the properties in question may not be really independent but subtly bound up in the physiological balance of the organism so that a modification of one leads to a corresponding change in the other. In either case profound modifications which have altered the whole center of gravity of the organism may rightly be considered of generic or family rank.

Within the genera, specific types may be defined by variations in single or subordinate characters.

The final test as to whether two related organisms deserve recognition as species, or are only variants from a single type, must be made by an examination of the curve of frequency for the character on which their identity is supposed to rest. If there is a single center of frequency of occurrence it is fair to consider that the type is a simple one, however variable it may be. Thus Goodman (Journal of Infectious Diseases 5: 421) has recently made a study of the *B. Diphtheriae* group, which indicates that widely differing strains of these organisms belong to a single type. If on the other hand two distinct modal points indicate two separate centers of distribution each may well receive a specific name. Intermediate cases will of course be found, in which the curve of frequency has two peaks separated only by a shallow trough. In such cases Davenport and Blankinship's criterion, to which reference has been made above, may be helpful; although any such arbitrary standard is likely to be modified by enlarged knowledge.

It may be maintained with reason that genera and species of bacteria defined by the statistical method will not be invalidated by the discovery that the characters on which they are based may be modified, either experimentally or under natural conditions. Among the flowering plants the study of a long series of specimens from habitats separated in space or time often tends to make the boundaries between species almost indistinguishable. If we could modify and control the environment of these higher forms through countless generations, as we do in the case of the bacteria, there can be little doubt but that we could transmute one form into another. Yet for practical convenience, and in recognition of the existing preponderance of certain types, we recognize them as constituting species. So among the bacteria we may reasonably hold that even mutable types in certain unstable groups are deserving of systematic recognition.

It is a curious fact that some of the most variable characters among the Coccaceae, chromogenesis and reaction to the Gram stain, for example, proved to be most strikingly correlated with the modifications of other powers, associated respectively with the parasitic and saprophytic habitats. Among the higher plants the modifications due to environment are comparatively superficial. Among the plastic unicellular organisms on the other hand the adaptation to parasitic life, for example, may produce profound changes, which warrant generic rank. Among the more complex plants and animals, indeed, the same conception of purely environmental types is gaining ground. It is not in connection with bacteria that Jordan and Kellogg (Evolution and Animal Life, New York, 1907), speak of "Ontogenetic species held for a number of generations true to a type simply because the environment, the extrinsic factors in the development of all the individuals in these successive generations, are the same."

The main points which I have tried to emphasize as essential to a rational natural classification of the Schizomycetes may be briefly summarized as follows:

1. In groups like the bacteria and perhaps some classes of the fungi, which have differentiated along physiological rather than morphological lines, differences in metabolism may have the same systematic importance given to gross structural differences in other groups.

2. The characters of greatest systematic importance, whether morphological or physiological, vary in each particular group of

bacteria, according to the lines followed in recent evolution. The classificatory value of a particular character must be determined for each group by a preliminary survey of its relationships.

3. The most satisfactory method of studying the systematic relations of these simple and variable forms is by obtaining quantitative measurements of a number of characteristic properties in a large series of individuals and by statistical analysis of the results.

4. Generic names may conveniently be given to the larger groups of organisms having several apparently independent properties in common, as indicated by correlation between different measurements. Generally these groups will be found associated with certain definite habitats.

5. Specific names may be reserved for the smaller groups, characterized by variations in single uncorrelated properties. Each strongly marked mode on the curve of frequency, marking a type center about which variations are occurring, may be taken as a species.

6. Genera and species defined in this manner by frequency of occurrence are not invalidated by the variability of the organisms belonging to them. Stable or unstable, they are definite realities, and their recognition makes it possible to arrange the bacteria in convenient natural groups which approximate their true phylogenetic relationships.

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New hybrids in Dryopteris

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Fern students in the eastern United States can hardly expect to find new species in so well-known a region but the discovery that certain native species may hybridize, and that under favorable conditions they do so rather frequently, as in the case of *Dryopteris cristata* × *marginalis*, opens up a field for study which is as yet very little known. There is always the chance that a new one may be found, and there are problems connected with the variation and the reproduction of the known hybrids which are yet to be worked out. The subject is not a simple one. Indeed a thorough knowledge of the plants can be obtained only after much experimental research and laboratory investigation, but field observers can render service by collecting these plants and recording the facts of their distribution, habit, and habitat. Furthermore, the intensive study needed in identifying the hybrids will add greatly to our knowledge of the parent species.

The hybrids so far reported for eastern United States number eleven and are comprised in three genera. *Asplenium* has two, *A. Ruta-muraria* × *Trichomanes*, and the bigeneric hybrid *A. platyneuron* × *Camptosorus rhizophyllus* (*Asplenium ebenoides* Scott). The latter is especially interesting as the first of our native hybrids to have its origin experimentally demonstrated.* The remaining hybrids are found in the genus *Dryopteris*, which, in this region, contains six species whose habitats are frequently associated, and which seem to hybridize more or less readily with each other. The species are *Dryopteris Clintoniana*, *D. cristata*, *D. Goldiana*, *D. intermedia*, *D. marginalis*, and *D. spinulosa*. Given six units, the number of possible combinations, taking two at a time, is fifteen, and we may expect to find that number of hybrids in this group. The following diagram, adapted from one used by Dr. Ezra Brainard in his studies of violet hybrids, shows

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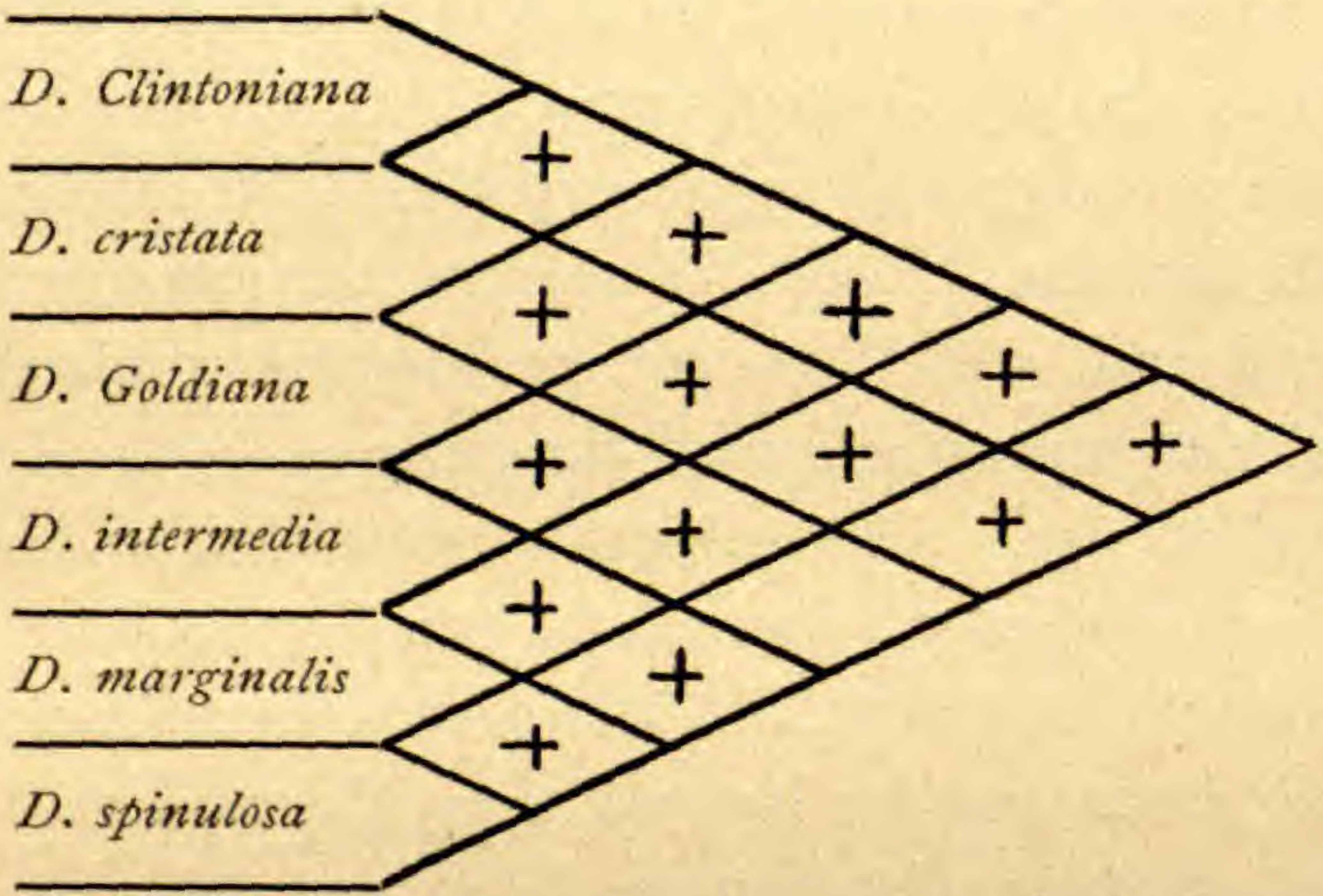
* Bull. Torrey Club 29 : 487–495. *f. 1–7*. 1902.

the present status of our knowledge of these plants. The known hybrids are marked with a cross.

The first of these to be described was *D. cristata* × *spinulosa*, which has been recognized in Europe since 1855, but in America has only recently been differentiated by Dowell * from *D. cristata* × *intermedia*, long known as *D. Boottii.* The first typically American hybrid to be described was Davenport's *D. cristata* × *marginalis*, which had been discovered and recognized by Raynal Dodge.



Following this came the hybrid between *D. marginalis* and *D. spinulosa*, described as *D. pittsfordensis* by Miss Margaret Slosson, whose experimental production of the Dodge hybrid and of *Asplenium platyneuron* × *Camptosorus rhizophyllus* has furnished a definite basis for a further study of these plants. Dr. Philip Dowell, the next in the field, besides recognizing *D. cristata* × *spinulosa* as an American plant, gave *D. Boottii* its proper name (*cristata* × *intermedia*), and described the corresponding *Clintoniana* cross, *D. Clintoniana* × *intermedia*, and three interesting *Goldiana* hybrids.† In addition to these, the hybrids described in the present paper and one between *Clintoniana* and *marginalis* to be described by Miss Slosson, and two others which are held for further study, bring the number known in this group to fourteen, leaving only the one between *Goldiana* and *spinulosa* yet to be found.‡

But there is no apparent reason why hybrids should not occur

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* Bull. Torrey Club 35: 135–140. 1908.

† *Loc. cit.*

‡ Since this was written, material has been seen which appears to be this hybrid, and a description of it is included below.

in genera other than *Dryopteris*. Indeed, several have been reported for *Asplenium*, principally in Europe, and in *Polystichum*, and we may expect such genera as *Athyrium* and others which contain groups of similar associated species to produce crosses when conditions are favorable.

The fern hybrids known at present are nearly all from temperate regions, but the damp forests of the tropics with their numerous related species and multitudes of individuals would seem to furnish ideal conditions for inter-specific crossing, and it is possible that many plants described as species are really hybrids. But as is noted hereafter, the determination of a hybrid requires a most thorough knowledge of the parent species and all their variations, not only in the herbarium but especially in the field, and until the intensive study necessary to the attainment of such knowledge can be given, the classification of the different forms as species is the only satisfactory method of treatment.

Fortunately for the study of our native hybrids, one of the commonest of them, *Dryopteris cristata* × *marginalis*, has been experimentally produced, so that its origin is undeniable, and we are justified in assuming that plants which possess the same general characteristics and are similarly intermediate between two known species are also hybrids. A knowledge, therefore, of the general features of *D. cristata* × *marginalis* is important in the study of other *Dryopteris* hybrids. These features may be considered under three heads: (1) intermediate character, (2) sterility, abnormality, and greater vigor, and (3) distribution.

1. The intermediate character of *D. cristata* × *marginalis* led Dodge and Davenport to suspect its hybrid origin, but a study of numerous specimens of the hybrids shows that they are not all intermediate to the same extent. As one might expect, some plants show greater resemblance to one parent and some to the other. It is interesting to note also that an occasional reverting frond is found which resembles one parent much more than the other fronds on the same plant. In determining whether a suspected plant is intermediate or not, it is necessary to take into consideration several characters.

A. The general habit of growth often attracts the attention before the more easily described diagnostic characters can be seen at all. This, of course, is likely to be especially marked if the parent species differ markedly in habit. But even in such cases one parent may predominate over the other to such an extent that the hybrid may be identified as one of the parent species.

B. The final tests depend then on an examination of the more critical characters and the value of these characters seems to vary inversely with the size of the part of the plant examined. For example, *D. Goldiana* and *D. Clintoniana*, which are often very similar in general leaf-form, differ in the shape and cutting of the pinnae and of the pinnulae, in the stipe-scales, and in the cell-structure of the indusia. The characters of the indusia have been very little used in fern classification, but they frequently furnish valuable tests in determining the identity of a given specimen, and are particularly useful in the class of ferns treated in this paper. *Dryopteris Goldiana* and *D. marginalis* have characteristic indusia, as can often be determined from a gross examination, and in cell-structure, these can easily be distinguished from the indusia of *D. Clintoniana* and *D. cristata*, and those of the spinulose ferns. The last-mentioned have indusia of the same general structure as have *D. Clintoniana* and *D. cristata*, but are much thinner, and in the case of *D. intermedia* are invariably glandular, a character which distinguishes this fern from all the other species of *Dryopteris* that occur in association with each other in this region. *D. dilatata*, which is occasionally glandular, is a fern of high altitudes in this latitude and need not be considered under ordinary circumstances, although where it does occur with other species, hybrids should be looked for. A hybrid between this fern and *D. Filix-mas* is already known in Europe. But aside from this possible exception, it seems safe to say that the presence of glandular indusia on a suspected plant indicates *D. intermedia* as one of the parent species. From what has been said, it will be seen that a primary requisite in the study of fern hybrids is a thorough knowledge of the parent species, not only of the general synoptical characters, but also of the more minute differences.

2. Sterility, greater vigor, and abnormality. The material of *D. cristata* × *marginalis* and also of the other plants considered to be hybrids, is almost uniformly sterile. This sterility manifests itself either in the form of abortive undersized sporangia, or, if the

sporangia attain full size, in abnormal, granulated spores. Only in a few mounts out of scores examined have any normal spores been seen, and in these few instances their presence may have been accidental. But as in hybrids generally, it is probable that the sterility is relative rather than absolute, and we may expect occasionally to find fern hybrids capable of reproducing by spores.

Correlated with the sterility is usually a greater vegetative activity. This may be expressed merely in the development of larger plants, or it may take the form of abnormal fronds in which some parts are greatly expanded while others remain of ordinary size or even abort. Such irregular fronds are of frequent occurrence in *D. cristata* × *marginalis* but are by no means invariable, as many plants are found in which all the fronds are symmetrical. Occasionally this irregularity is so marked as to obscure the general resemblances of the suspected hybrid, and in such cases, unless the identity of the parent species can be established beyond doubt by means of critical characters, a positive identification may be impossible. In this connection it should also be noted that irregular plants which are to be explained as due to ecological conditions or as sports rather than as hybrids, are not unusual.

3. In distribution, *Dryopteris* hybrids are rare or occasional in damp woods with the parent species. The general occurrence of hybrids has been doubted because of the presumed difficulty of the actual process of hybridization but the presence of numerous plants of *D. cristata* × *marginalis* in some especially favored localities is evidence that the difficulty may not be as great as has been imagined. The immediate presence of the parent species is not a necessity since fern plants are often long-lived and the greater vigor of the crosses might render them resistant to conditions sufficiently adverse to destroy the parent species.

Following are descriptions of hybrids already noted as new:

Dryopteris Clintoniana × spinulosa hyb. nov.

In habit resembling *D. Clintoniana*, the rootstock horizontal, the fronds of two sorts: (1) juvenile and sterile, and (2) mature and usually soriferous: mature fronds tall, about 70 cm. long; stipe light yellow above, dark brown below, clothed with thin pale brown scales; lamina oblong, acuminate, 30–40 cm. long, by 16–20 cm. broad, once pinnate, the rachis distinctly winged in the upper fourth;

pinnae oblong and sessile above, to deltoid and stipitate below (lowest pinnae 7–10 cm. long by 4–6.5 cm. broad), mostly deeply pinnatifid half way to the midveins or more except in upper fourth of the lamina, nearly pinnate below but with winged midveins; pinnulae oblong to oblong-lanceolate, straight or slightly falcate, somewhat acuminate, up to 4 cm. long by 1.6 cm. broad, entire, spinulose-dentate or pinnatifid (half way to midveins on basal pinnae), bases unconstricted above (upper third of lamina), to deeply constricted below (nearly to the midvein in basal pinnae), the lobes and teeth mostly inflexed: sori rather scant, midway between the margins and the midveins; indusia thin, glabrous: juvenile fronds low-spreading, the laminae oblong, about half as broad as long.

Type in the Underwood Fern Herbarium, New York Botanical Garden: *Benedict 68*, from Cornwall, Conn., July, 1907. Collected also by E. Brainerd at Middlebury, Vt., June, 1879, and July, 1908; by E. J. Winslow at Barton Landing, Vt., Aug. 16, 1908; and by Ph. Dowell *3928* (in part), at Suffern, N. Y., July 23, 1905.

As might be expected, this fern resembles *D. Clintoniana* × *intermedia* rather closely, but its relationship to *D. spinulosa* is shown not only in the glabrous indusia but also in the general habit and cutting of the fronds. From *D. cristata* × *spinulosa*, it differs usually in size and shape of the fronds, but even more decidedly in the amount of cutting.

Dr. Ezra Brainerd's early collection of this hybrid is of especial interest in view of the fact that as a rule the earlier collectors apparently paid little attention to these plants and either overlooked them or were satisfied to refer them to some previously described species. Fern hybrids had been recognized in Europe as early as the '50's, but in America little was done with them until near the close of the century. It is to be noted here that two specimens of what we now know to be a hybrid between *Dryopteris cristata* and *D. marginalis* were identified by the dean of American fern study, Professor Daniel C. Eaton, as his *Aspidium cristatum* var. *Clintonianum*, as can be seen in his herbarium today. The original collection of Judge Clinton is not represented in the Eaton herbarium but according to the late G. E. Davenport in a letter to Miss Margaret Slosson, it is represented in the Museum of Natural Science at Springfield, Massachusetts. As a small photograph of this Springfield material shows it to be somewhat different from what to-day is ordinarily known as *Dryopteris Clintoniana*, an inquiry as to the exact identity of the type of this species is much to be desired.

Dryopteris cristata × Goldiana hyb. nov.

Fertile fronds tall, up to 120 cm.; stipe pale, clothed with dark scales; lamina narrowly elliptic-lanceolate, acuminate, up to 73 cm. long, 18 cm. broad, once pinnate; pinnae lanceolate above, oblong-lanceolate in the median portion, and deltoid-ovate below, long-acute or slightly acuminate, short-stipitate except in the upper part of the frond, nearly pinnate; pinnulae 12–14 pairs on the median pinnae, oblong, acute or acutish, entire or slightly crenate-serrulate, the costal pinnulae constricted on both sides, the remainder merely notched above or wholly adnate: sori 6–8 on the larger pinnulae, nearer the midvein than the margin; indusia rather thin, glabrous, the cells about as broad as long and in fairly regular radial rows, the walls rather thin, straight or only slightly sinuate.

Type in the Underwood Fern Herbarium, New York Botanical Garden, *W. A. Poyser*, Swarthmore, Pa., June 20, 1908. Also *309 A* and *B* from the same locality and collector, July 15, 1906.

The critical characters on which the identification of this fern is based are, on the one hand, the cell-structure of the indusium, which shows its relationship to *D. Goldiana*, and on the other, its slender outline and broad lower pinnae, which relate it to *D. cristata*. But it shows its relationship to both parents, and is intermediate between them in its stipe-scales, in the shape of the pinnae, in the shape and number of the pinnulae, and in the number and position of sori on each. The type specimen was originally identified by Mr. Poyser as "*Dryopteris Clintoniana* (Eat.) approaching v. *silvatica*," but it differs from this fern in about the same degree that *D. cristata* differs from *D. spinulosa*. The sporangia are all abortive.

Dryopteris Goldiana × spinulosa hyb. nov.

Nephrodium cristatum Clintonianum f. *silvaticum* Poyser, Fern Bull. **16**: 13. [Mr] 1908.

Fronds up to 110 cm. long; stipes pale yellowish, clothed at the base with dark lanceolate scales; lamina elliptic or elliptic-lanceolate, 75 cm. long, 27 cm. broad, very nearly twice pinnate; pinnae mostly oblique to the rachis, varying from oblong-lanceolate in the upper portion of the frond to elliptic-lanceolate or elliptic in the median portion, and to unequally ovate-lanceolate below, acuminate, stipitate nearly to the apex of the frond; pinnulae about 12–16 pairs on the larger pinnae, narrowly oblong or lanceolate, long-acute, up to 4.5 cm. long, and 1.5 cm. broad, varying from constricted on both sides and serrate-lobed on one third to one half of the larger pinnae to wholly adnate and merely serrulate above, the lobes spinulose-serrulate: sori about 8–10 pairs, about midway between the midveins and margins; indusia glabrous, thin, the cells about as broad as long and in fairly regular radial rows, the walls rather thin, straight or only slightly sinuate.

A year ago when I first saw a specimen of this fern I was inclined to identify it as *D. Clintoniana* × *spinulosa*, assuming that Mr. Poyser had properly related it to the Clinton fern. Afterwards, however, I collected what is certainly *D. Clintoniana* × *spinulosa*, and had to give up this identification for Mr. Poyser's plant. My first valid clue to its identity came when I took occasion to examine the indusia under the microscope and found in them a strong resemblance to the *D. Goldiana* indusia, and corresponding differences from the indusia of the Clinton fern; even then I did not immediately correctly determine the other parent but, having at that time only a narrow frond of f. *silvatica*, referred it to *D. cristata* × *Goldiana*. Recently, however, Mr. Poyser has loaned me all his material, comprising several fronds, all of which have unmistakable *spinulosa* characters in the amount of cutting, in the unequally ovate-lanceolate lower pinnae, and in the oblique habit of nearly all the pinnae, and in the position of the sori. The relationship to Goldie's fern appears in the size and habit of the whole plant, the pinnae widest above the base, as is shown in the original illustration, the numerous pinnulae, together with the shape of the latter and the number of sori on each, and particularly in the structure of the indusia. The last-mentioned characters, with the exception of size, also serve to distinguish *D. Goldiana* × *spinulosa* from *D. Clintoniana*. The material was collected rather too early to allow the question of fertility to be certainly ascertained, but the indications are that the sporangia had aborted.

Dryopteris intermedia × **marginalis** hyb. nov.

Rootstock erect or ascending: fronds in a symmetrical crown, spreading, the stipes thickly clothed at base with lanceolate scales; laminae lanceolate, elliptical or oblong, acuminate, bipinnate or nearly tripinnate; pinnae lanceolate or oblong-lanceolate to narrowly deltoid, acuminate, rather flexuose, pinnate below; pinnulae oblong or lanceolate, usually blunt and rounded, entire to deeply pinnatifid or sometimes nearly pinnate on the lowest pinnae, the margins entire or dentate, the teeth blunt, entire or tipped with a few very short patent spinules: sori nearer the margins than midveins, the indusia coriaceous, convex, glandular.

Type in the Underwood Fern Herbarium, New York Botanical Garden; *Benedict*, near Solvay, N. Y., Aug. 9, 1905. Also collected by Underwood near Cambridge, Mass., Oct. 11, 1890; *Dowell 3622*, New Springville, Staten Island, N. Y., Nov. 27, 1904; and *Winslow*, Barton Landing, Vt., July 23, 1908.

D. intermedia × *marginalis*, as represented in the material examined, constitutes a very uniformly distinctive plant, which differs from the nearly related × *D. pittsfordensis* * in its obtuse pinnulae and segments, in its spreading flexuose pinnae, and in its glandular indusia. The material collected by Professor Underwood is more divided than the rest and in this respect perhaps shows a greater predominance of *D. intermedia* characters. In Dr. Dowell's collection cited above, some of the pinnulae are more or less acute, but the variation is slight. The hybrid is one of the most easily recognized in the whole series.

In conclusion, I wish to express my thanks to Dr. Ezra Brainerd, Dr. Philip Dowell, Mr. W. A. Poyser, and Mr. E. J. Winslow, for the loan of material.

COLUMBIA UNIVERSITY.

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* *Dryopteris pittsfordensis* Slosson, Rhodora 6: 75. 1904 = *Dryopteris marginalis* × *spinulosa* Slosson, nom. nov. The formal publication of this name is made here for the sake of convenience, as no authority has ever been assigned to the name, although Miss Slosson clearly should be considered responsible for it.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1908)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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THIS work is designed to present descriptions of all plants growing independently of cultivation, in North America, here taken to include Greenland, Central America, the Republic of Panama, and the West Indies, except Trinidad, Tobago, and Curaçao and other islands off the north coast of Venezula, whose flora is essentially South American.

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Professor George F. Atkinson, of Cornell University, Professors Charles R. Barnes and John M. Coulter, of the University of Chicago, Mr. Frederick V. Coville, of the United States Department of Agriculture, Professor Edward L. Greene, of the United States National Museum, Professor Byron D. Halsted, of Rutgers College, and Professor William Trelease, of the Missouri Botanical Garden, have consented to act as an advisory committee.

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BULLETIN

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FEBRUARY, 1909

Propositions relating to the amendment and completion of the International Rules of Botanical Nomenclature adopted by the International Botanical Congress of Vienna in 1905

The following propositions relating to the amendment and completion of the International Rules of Botanical Nomenclature adopted by the International Botanical Congress held in Vienna in 1905 are submitted for the consideration of the International Botanical Congress to be held in Brussels in 1910:

1. Motion to omit in Article 9 the words, "reserving special arrangements for fossil plants and non-vascular plants."

[It is most desirable that the principles of nomenclature should be uniform for all groups of plants. Even in the case of the metagenetic and fossil plants, special rules are not recommended.]

2. Motion to omit the word "vascular" in Article 19.

3. Motion to amend by omitting Article 20.

[Article 20 is in the highest degree arbitrary and thus controverts Article 3. Moreover, it is futile to attempt to conserve certain generic names without indicating a species with which each such name should be permanently associated. A much more philosophical result, not at all arbitrary, may be reached by accepting the method of types as outlined below in the proposed amendment to Article 45. Under this proposed amendment, many of the names now sought to be rejected by Article 20 will also be rejected.]

4. Motion to amend by striking out Article 36 and adding to the Rules the following as a recommendation:

The publication of names of new groups should be accompanied by a diagnosis in Latin, French, English, or German.

[The BULLETIN for January, 1909 (36: 1–54) was issued 29 Ja 1909.]

[The very great number of descriptions published in languages other than Latin prior to 1908, the manifest indisposition of many authors to regard Article 36 as desirable, and the progressive disuse of Latin in educational institutions and scientific literature, make this amendment necessary.]

5. Motion to amend Article 39 by omitting the words : "On and after January 1st, 1908, the date of publication of the latin diagnosis only can be taken into account in questions of priority."

[The remarks under Article 36 apply to Article 39 as well.]

6. Motion to amend Article 38 so that it shall read :

A genus or any other group of higher rank than a species is effectively published when its name has been printed and distributed (1) with a generic or specific description (or in palaeobotany a figure) and a binomial specific name, or (2) with a generic name and the citation of a previously published description, or (3) with a reference to a specific description which is associable by citation with a previously published binomial species.

EXAMPLES. — *Hydrodictyon* Roth, Tent. Fl. Germ. **3** : 531 (1800), is published with a generic and specific description and a binomial specific name ; *Odontoschisma* Dumort. Rec. Obs. Jung. 19 (1835) is published with a generic description and a binomial specific name ; *Brasenia* Schreb. ex Gmel. Syst. **2** : 853 (1791) is published with a generic description and a binomial specific name ; *Poacites* Schloth. Petrefact. 416. *pl. 26. f. 1, 2* (1820), a fossil genus, is published with figures and a binomial specific name, but without a description ; *Nyssa* L. Sp. Pl. 1058 (1753) is published with a generic and specific name and the citation of previously published descriptions ; *Acetabulum* Ludwig, Def. Gen. Pl. 504 (1760), a genus adopted from Tournefort, is published with a reference to a specific description associable by citation with the previously published *Madrepora Acetabulum* L. Syst. Nat. 793 (1758), inasmuch as both Ludwig and Linnaeus cite *Acetabulum* of Tournefort ; *Dryopteris* Adans. Fam. Pl. **2** : 20 (1763) is published with a reference to a specific description associable by citation with the previously published *Polypodium Filix-mas* L. Sp. Pl. 1090 (1753), inasmuch as both Adanson and Linnaeus cite *Filix mas* of Fuchs.

[There is no philosophical reason why the principle of accepting genera established by Linnaeus in "Species Plantarum" without a generic description, should not be extended to subsequent authors. These genera, if typified, are just as definite as pages of generic descriptions would make them. Philosophically, a genus is a group of one or more species rather than a description. There are a great many published descriptions of genera, unaccompanied by citations of species, which cannot be definitely interpreted.]

7. Motion to amend Article 45 so that it shall read :

When a genus is divided into two or more genera, the name must be kept and given to the division containing the nomenclatorial type. The nomenclatorial type of a genus or subgenus is the species originally named or designated by the author of the name. If no species was designated, the type is the first binomial species in order eligible under the following provisions:

1°. The type is to be selected from a subgenus, section, or other list of species originally designated as typical. The publication of a new generic name as an avowed substitute for an earlier invalid one does not change the type of a genus.

EXAMPLES. — *Diaporthe* Nitschke, Pyren. Germ. 240 (1870), is typified by *D. eres* Nitschke, the first species of the subgenus *Euporthe; Psilogramme* Kuhn, Festschr. 50-Jähr. Jub. Königs. Realschule zu Berlin 332 (1882), is typified by the first-mentioned species of the second section *Eupsilogramme*, and not from species included in the first section *Jamesonia*, which is based on a generic name previously published; *Phania* DC. Prodr. **5**: 114 (1826) is typified by *P. multicaulis* DC., the only species of the section *Euphania; Guignardia* Viala & Ravaz, Bull. Soc. Myc. Fr. **8**: 63 (1892), which was substituted for *Laestadia* Auers. Hedwigia **8**: 177 (1869) not *Laestadia* Kunth in Less. Syn. Compos. 203 (1832), is typified by *Laestadia alnea* (Fr.) Auers., which is the first of the three species given by Auerswald, and not by *Laestadia Bidwellii* (Ellis) Viala & Ravaz, the only species mentioned by Viala & Ravaz at the time the substitution was made.

2°. The application to a genus of a former specific name of one of the included species, designates the type.

EXAMPLES. — *Sordaria* Ces. & DeN. Comm. Soc. Critt. Ital. **1**: 225 (1863) is typified by *Sphaeria Sordaria* Fr., one of its twelve original species; *Roccella* DC. Fl. Fr. **2**: 334 (1805) is typified by *Lichen Roccella* L., one of its two original species; *Calypogeia* Raddi, Atti Soc. Ital. Sci. Mod. **18**: 42 (1818), is typified by *Jungermannia Calypogeia* Raddi, one of its three original species; *Amsonia* Walt. Fl. Car. 98 (1788) is typified by *Tabernaemontana Amsonia* L., one of its two original species.

3°. A figured species is to be selected rather than an unfigured species in the same work. In the absence of a figure, preference is to be given to the first species accompanied by the citation of a specimen in a regularly published series of exsiccatae. In the case of genera adopted from prebinomial authors (with or without change of name), a species figured by the author from whom the genus is adopted should be selected.

EXAMPLES. — *Perithamnion* J. Ag. Anal. Alg. 28 (1892) is typified by *P. ceramioides* J. Ag., as it is the only species figured; *Leptostroma* Fr. Obs. Myc. 1 : 196 (1815) is typified by *L. xylomoides* Fr. *loc. cit. pl. 1. f. 6a, b*, the only species figured; *Lespedeza* Michx. Fl. Bor.-Am. 2 : 70 (1803) is typified by *L. procumbens* Michx. *loc. cit. pl. 39*, the species first figured; *Stigmatea* Fr. Sum. Veg. Scand. 421 (1849) is typified by *S. Robertiani* Fr., the fourth species, as there are no species figured and this is the first in the list accompanied by the citation of a specimen in published exsiccatae, Scler. Suec. Exsic. *no. 423*.

4°. Where economic or indigenous species are included in the same genus with foreign species, the type is to be selected from (1) the economic species or (2) those indigenous from the standpoint of the original author of the genus.

EXAMPLES. — *Corallina* L. Syst. Nat. 805 (1758) is typified by *Corallina officinalis* L., a species of economic importance at the time of Linnaeus; *Agaricus* L. Sp. Pl. 1171 (1753) is typified by *Agaricus campestris* L., the most important economic species of the genus; *Poa* L. Sp. Pl. 67 (1753) is typified by *P. pratensis* L., the first of the economic species; *Sanguisorba* L. Sp. Pl. 116 (1753) is typified by *S. officinalis*, the species indigenous from the standpoint of the author.

5°. The types of genera adopted through citations of nonbinomial literature (with or without change of name) are to be selected from those of the original species which receive names in the first binomial publication. The genera of Linnaeus' Species Plantarum (1753) are to be typified through the citations given in his Genera Plantarum (1754).

EXAMPLES. — *Phallus* L. Sp. Pl. 1178 (1753), a genus adopted in a more extended sense from Micheli, is typified by *Phallus impudicus* L., the only species common to the genus *Phallus* of both authors; *Riccia* L. Sp. Pl. 1138 (1753), a genus adopted in a more restricted sense from Micheli, is typified by *Riccia crystallina* L., which is the first in Linnaeus of the species common to both authors; *Polytrichum* L. Sp. Pl. 1109 (1753), a genus adopted from Dillenius, is typified by *Polytrichum commune* L., the first in Linnaeus of the species common to both authors; *Cypripedium* L. Sp. Pl. 951 (1753), a genus adopted from Tournefort with a change of his name *Calceolus*, is typified by *Cypripedium Calceolus*, the only species common to both authors; *Seseli* L. Sp. Pl. 259 (1753), a genus adopted from Boerhaave, is typified by the second species of Linnaeus, *Seseli montanum*, which is the first in Linnaeus of the species common to both authors; *Silene* L. Sp. Pl. 416 (1753), a genus adopted from Dillenius with a change of his name *Viscago*, is typified by *Silene anglica*, the first in Linnaeus of the thirteen species figured by Dillenius; *Fritillaria* L. Sp. Pl. 303 (1753), a genus adopted from Tournefort, is typified by the fifth species of

Linnaeus, *Fritillaria Meleagris*, which is one of the three species included in *Fritillaria* by both authors, and is selected from these three because it is the one figured by Tournefort.

[We seek to make the principles treated in Article 45 more definite than the present wording provides for, and this can be accomplished through our general method of types.]

8. Motion to amend Article 47 so that it shall read:

When a species or subdivision of a species is divided into two or more groups of the same nature, the name must be kept and given to the division containing the nomenclatorial type.

The nomenclatorial type of a species or subspecies is the specimen to which the describer originally applied the name in publication.

EXAMPLES. — *Sphaeria megalocarpa* Plow. Grevillea **7**: 73 (1878) is typified by the designation of a single specimen, *no. 956*, on the bark of dead maple; *Prionolejeunea innovata* Evans, Bull. Torrey Club **31**: 215 (1904), is typified by the designation of a specimen collected by Heller in the Luquillo Mountains, Puerto Rico; *Polypodium marginale* L. Sp. Pl. 1901 (1753) is typified by the designation of a specimen collected in Canada by Kalm; *Stachys arenicola* Britton, Man. 792 (1901), is typified by the designation of a specimen from Staten Island, New York; *Carex intumescens Fernaldii* Bailey, Bull. Torrey Club **20**: 418 (1893), is typified by a specimen collected at Cedar Swamp, Aroostook County, Maine, by M. L. Fernald.

1°. When more than one specimen was originally cited, the type or group of specimens in which the type is included may be indicated by the derivation of the name from that of the collector, locality, or host.

EXAMPLES.—*Mystrosporium Curtisii* Berk. Grevillea **3**: 105 (1874) is based on two specimens, of which the one collected by M. A. Curtis is the type; *Jungermannia Dicksoni* Hook. Brit. Jung. *pl. 48* (1816) is based on several specimens, of which the one collected by Dickson in Scotland is the type; *Eriogonum Porteri* Small, Bull. Torrey Club **25**: 41 (1898), is based on several specimens, of which the one collected by T. C. Porter is the type; *Gaillardia arizonica* A. Gray, Syn. Fl. N. Am. **1**^{2}: 353 (1884), is based on several specimens, of which the one collected by Palmer in Arizona is the type: *Cenangium Magnoliae* B. & C. Grevillea **4**: 5 (1875) is based on specimens from two hosts, of which the one on *Magnolia* is the type; *Cuscuta Cephalanthi* Engelm. Am. Jour. Sci. **43**: 336 (1842) is based on specimens from several hosts, of which the one from *Cephalanthus* is the type.

2°. Among specimens equally eligible, the type is that first figured with the original description, or, in default of a figure, the first mentioned.

EXAMPLES. — *Alaria valida* Kjellm. & Setchell, Univ. California Publ. Bot. 1 : 278. *pl. 21* (1903), is based on specimens from two localities, and the plant figured, from Whidbey Island, Washington, is the type; *Calyptridium roseum* S. Wats. Bot. King's Exp. 44. *pl. 6. f. 6–8* (1871) is based on at least three specimens, of which the one figured is the type; *Hypoxylon notatum* B. & C. Grevillea 4 : 50 (1875) is based on three specimens, none of which is figured, and the one first mentioned, which is *no. 1910* on *Celtis* from South Carolina, is the type; *Arnica cordifolia* Hook. Fl. Bor.-Am. 1 : 331 (1833) is based on two specimens, neither of which is figured, and the one first mentioned, which was collected by Drummond in alpine woods of the Rocky Mountains, is the type.

3°. In default of an original specimen, that represented by the identifiable figure or (in default of a figure) description first cited or subsequently published, serves as the type.

EXAMPLES. — *Hydnum repandum* L. Sp. Pl. 1178 (1753) is based on three citations, of which the third is the type, being accompanied by a figure; *Marchantia polymorpha* L. Sp. Pl. 1137 (1753) is based on a number of citations, of which that referring to Micheli's figure indicates the type; *Trillium sessile* L. Sp. Pl. 340 (1753) is based on three citations, of which the second is the type, being accompanied by a figure; *Lycoperdon Bovista* L. Sp. Pl. 1183 (1753) is based on a number of citations, of which the first mentioned is the type, as no figure is cited; *Centaurea Scabiosa* L. Sp. Pl. 913 (1753) is based on a number of citations, of which the first mentioned is the type, as no figures are cited.

[The principles applicable to the typifying of species are similar to those outlined for genera under our proposed amendments to Article 45.]

9. Motion to amend Recommendation XXVI (under Article 46) by omitting paragraph 3 and by substituting for paragraph 2 the following:

Of names published in the same work and at the same time, those having precedence of position are to be preferred.

[Here we seek to establish more definitely the choice between names of the same date.]

10. Motion to amend Article 51 by substituting after the colon n the first line the following:

1°. When the name is preoccupied (homonym).

(*a*) A specific name is a homonym when it has been published for another species under the same generic name.

EXAMPLES. — *Caulerpa Lycopodium* Harv. Ner. Bor.-Am. 3: 19 (1858) is a homonym of *Caulerpa Lycopodium* J. Ag. Öfvers. Kongl. Vet.-Akad. Förh. 4 : 6 (1847); *Radula spicata*

Aust. Bull. Torrey Club **6** : 19 (1875) is a homonym of *Radula spicata* Mitt. Bonplandia **10** : 19 (1862); *Acer saccharinum* Wang. Amer. 36. *pl. 2. f. 26* (1787) is a homonym of *Acer saccharinum* L. Sp. Pl. 1055 (1753); *Vaccinium myrtilloides* Hook. Fl. Bor.-Am. **2** : 32 (1834) is a homonym of *Vaccinium myrtilloides* Michx. Fl. Bor.-Am. **1** : 234 (1803) and is rejected whether the latter species is regarded as distinct or not; *Chrysopsis pilosa* (Walt.) Britton, Mem. Torrey Club **5** : 316 (1894), is a homonym of *Chrysopsis pilosa* Nutt. Jour. Acad. Nat. Sci. Phila. **7** : 66 (1834) and is to be rejected notwithstanding the fact that *Erigeron pilosum* Walt. was published in 1788; *Brasenia antiqua* Daws. Trans. Roy. Soc. Canada 3^4: 15 (1885) is a homonym of *Brasenia antiqua* Newb. Proc. U. S. Nat. Mus. **5** : 514 (1883).

(*b*) A generic name is a homonym when previously published for another genus.

EXAMPLES. — *Rivularia* Ag. Syn. Alg. Scand. xxxviii (1817) is a homonym of *Rivularia* Roth, Cat. Bot. **1** : 212 (1797); *Sphaerella* Ces. & DeN. Schem. Sfer. Ital. 62 (1863) is a homonym of *Sphaerella* Sommerf. Mag. Naturvid. **4** : 249 (1824); *Torreya* Arn. Ann. Nat. Hist. **1** : 130 (1838) is a homonym of *Torreya* Raf. Am. Mo. Mag. **3** : 356 (1818), of *Torreya* Raf. Jour. Phys. **89** : 105 (1819), of *Torreya* Spreng. Neue Entdeck. **2** : 121 (1821), and of *Torreya* Eat. Man. ed. 5, 420 (1829).

(*c*) Similar names are to be treated as homonyms only when they are mere variations in the spelling of the same word; or in the case of specific and subspecific names, when they differ only in adjective or genitive termination.

EXAMPLES. — *Penicillus* and *Penicillium*, *Callitriche* and *Calothrix*, *Pterigophyllum* and *Pteridophyllum*, may be maintained; *Cyathophora* and *Cyathophorum*, *Asterocarpus* and *Astrocarpus*, can not be maintained. *Greenei* and *Greenii*, named for different persons, Greene and Green, may be maintained in the same genus; *virginicus*, *virginianus*, and *virginiensis*, *oreganus* and *oregonensis*, *Hookeri* and *Hookerianus*, cannot be maintained in the same genus.

2°. When there is an older valid name based on another member of the same group (metonym).

EXAMPLES. — *Chauvinia* Bory, Voy. Coquille, Bot. Crypt. 204 (1828), is typified by *Chauvinia paspaloides* Bory, and *Caulerpa* Lamour. Jour. de Bot. **2** : 141 (1809) is typified by *Caulerpa prolifera* (Forsk.) Lamour., consequently, if these species are regarded as congeneric, the name *Chauvinia* is rejected; *Boletopsis* P. Henn. Nat. Pflanzenf. 1^{1**} : 194 (1899) cannot stand as a genus to include a section bearing the name *Boletinus* Kalchb., the latter having been established as a genus in 1877; *Meibomia* Heist. ex Adans. Fam. Pl. **2** : 509 (1763) is based on *Hedysarum canadense* L. Sp. Pl. 748, and *Desmodium* Desv. Jour. de Bot. II. **1** : 122 (1813) is typified by *Hedysarum asperum* Poir. Encycl. Suppl.

6 : 408 (1804), consequently if these species are regarded as congeneric the name *Desmodium* is to be rejected; *Sisymbrium altissimum* L. Sp. Pl. 659 (1753), *Sisymbrium Sinapistrum* Crantz, Stirp. Austr. ed. 2, 52 (1769), and *Sisymbrium pannonicum* Jacq. Coll. **1** : 70 (1786), have different types, but if these are regarded as belonging to the same species, the two later names are metonyms of that of Linnaeus.

3°. When there is an older valid name based on the same type (typonym).

EXAMPLES. — *Coralliodendron* Kütz. Polyp. Calcif. **11** (1841) and *Corallocephalus* Kütz. Linnaea **17** : 95 (1843) are both typonyms of *Penicillus* Lamarck, Ann. Mus. Nat. **20** : 297 (1813), all being typified by the same species; *Pyrenochium* Link, Abh. Berl. Akad. **1824** : 171 (1826), is a typonym of *Dothiorella* Sacc. Michelia **2** : 5 (1880), both being based on *Dothidea pyrenophora* Fr.; *Asplenium Vincentis* Christ, Bot. Jahrb. **24** : 109 (1897), is a typonym of *A. Guildingii* Jenm. Gard. Chron. III. **15** : 70 (1894), both being based on H. H. Smith's *no. 1346* from St. Vincent; *Miegia* Pers. Syn. **1** : 101 (1805) is a typonym of *Arundinaria* Michx. Fl. Bor.-Am. **1** : 73 (1803), both being based on the same species.

4°. When the natural group to which it applies is undetermined (hyponym).

(*a*) A specific or subspecific name is a hyponym when it has not been connected with a description, identifiable by diagnostic characters or by reference to a type specimen, figure, or locality.

EXAMPLES. — *Pexisperma lutescens* Raf. Carat. Nuov. Gen. Sp. Sicilia 89. *pl. 20. f. 1* (1810) is a hyponym, as the description and figures are not identifiable; *Hydrophora tenella* Tode, Fung. Meck. Sel. **2** : 6 (1791), is a hyponym, as its description is not identifiable; *Gentiana hybrida* Raf. Med. Rep. II. **5** : 353 (1808) is a hyponym, as no diagnosis is published; *Lechea furfuracea* Raf. New Fl. Am. **1** : 92 (1836) is a hyponym, as its description is not identifiable; *Sigillaria centralis* Newb. Annals of Science **1** : 96 (1853) is a hyponym, as no description or figure is published.

(*b*) A generic or subgeneric name is a hyponym, when it is not associable, at least by specific citation, with a binomial species previously or simultaneously published; or when its type species is not indentified.

EXAMPLES. — *Adodendrum* Necker, Elem. **1** : 214 (1790) and *Calesiam* Adans. Fam. Pl. **2** : 446 (1763) are hyponyms, because their authors neither named a binomial species nor cited a species which had previously received a binomial name; *Sclernax* Raf. Carat. Nuov. Gen. Sp. Sicilia 90 (1810) is a hyponym, as its type species, *Sclernax truncata*, has not been identified; *Nudilus* Raf. Atl. Jour. 176 (1833) is a hyponym, as its type species, *N. paradoxus*, has not been identified.

[The general method of types above advocated provides simpler and more definite principles for the rejection of names than does the present wording of this article.]

11. Motion to amend by omitting Article 55, 2°.

[Article 55, paragraph 2° forms an unfortunate exception to the general law of priority. The rules require such binomials as *Cerastium cerastioides*, *Specularia Speculum*, *Atamosco Atamasco*, and *Leonotis Leonitis*, while excluding such as *Linaria Linaria* and *Catalpa Catalpa*.]

The above propositions are submitted by

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Propositions relatives à l'amendement et au complément des Règles internationales de la Nomenclature botanique, adoptées par le Congrès international de Botanique de Vienne en 1905

Les propositions suivantes relatives à l'amendement et au complément des Règles internationales de la Nomenclature botanique, adoptées par le Congrès international de Botanique de Vienne en 1905, sont soumises à la considération du Congrès international de Botanique devant se réunir à Bruxelles en 1910:

1. Motion d'omettre à l'article 9 les mots : "sous réserve des dispositions spéciales aux plantes fossiles et aux plantes non vasculaires."

[Il est fort désirable que les principes de nomenclature soient uniformes pour tous les groupes de plantes. Même dans le cas des plantes fossiles et des plantes à cycle évolutif pléomorphe, des règles spéciales ne doivent pas être recommandées.]

2. Motion d'omettre le mot "vasculaires" à l'article 19.

3. Motion d'amender en omettant l'article 20.

[L'article 20 est arbitraire au plus haut degré et ainsi contredit l'article 3. Toutefois, il est futile d'essayer de conserver certains noms génériques sans indiquer une espèce à laquelle chacun de ces noms doit être toujours associé. Un résultat bien plus philosophique et aucunement arbitraire peut être obtenu en acceptant la méthode de types ainsi qu'elle est définie ci-dessous dans l'amendement proposé à l'article 45. Dans cet amendement proposé, beaucoup de noms que l'on cherche maintenant à rejeter par l'article 20 seront aussi rejetés.]

4. Motion d'amender en effaçant l'article 36 et ajoutant aux Règles le suivant comme une recommandation :

La publication de noms des groupes nouveaux devrait être accompagnée par une diagnose en latin, français, anglais, ou allemand.

[Le très grand nombre de descriptions publiées en langage autre que latin avant 1908, la tendance évidente de beaucoup d'auteurs de considérer l'article 36 comme pas désirable, et l'abandon progressif du latin dans les institutions d'éducation et la littérature scientifique rendent cet amendement nécessaire.]

5. Motion d'amender l'article 39 en omettant les mots : " A partir du 1er Janvier 1908, la date de publication de la diagnose latine entre seule en ligne de compte dans les questions de priorité."

[Les remarques pour l'article 36 s'appliquent aussi bien à l'article 39.]

6. Motion d'amender l'article 38 de telle façon qu'on lise " Un genre, ou tout autre groupe supérieur à l'espèce, est valablement publié quand il a été imprimé et distribué (1) avec une description générique ou spécifique (ou en paléobotanique une figure) et un nom binaire spécifique, (2) avec un nom générique et spécifique et la citation d'une description publiée antérieurement, ou (3) avec un renvoi à une description spécifique, qu'on peut associer par citation à une espèce binaire publiée antérieurement.

EXEMPLES.—*Hydrodictyon* Roth, Tent. Fl. Germ. **3** : 531 (1800), est publié avec une description générique et spécifique et un nom binaire spécifique ; *Odontoschisma* Dumort. Rec. Obs. Jung. 19 (1835) est publié avec une description générique et un nom binaire spécifique ; *Brasenia* Schreb. ex Gmel. Syst. **2** : 853 (1791) est publi- avec une description générique et un nom binaire spécifique ; *Poacites* Schloth. Petreé fact. 416. *pl. 26. f. 1, 2* (1820), un genre fossile, est publié avec figures et un nom binaire spécifique, mais sans description ; *Nyssa* L. Sp. Pl. 1058 (1753) est publié avec un nom générique et spécifique et la citation d'une description publiée antérieurement ; *Acetabulum* Ludwig, Def. Gen. Pl. 504 (1760), un genre adopté d'après Tournefort, est publié avec renvoi à une description spécifique qu'on peut associer par citation avec *Madrepora Acetabulum* L. Syst. Nat. 793 (1758), publié antérieurement, puisque Ludwig et Linné citent tous deux *Acetabulum* de Tournefort ; *Dryopteris* Adans. Fam. Pl. **2** : 20 (1763) est publié avec renvoi à une description spécifique qu'on peut associer par citation avec *Polypodium Filix-mas* L. Sp. Pl. 1090 (1753), publié antérieurement, puisque Adanson et Linné citent tous deux *Filix mas* de Fuchs.

[Il n'y a pas de raison philosophique pour que le principe d'accepter des genres établis par Linné dans le " Species Plantarum " sans une description générique ne soit pas étendu aux autres auteurs. Ces genres, si typifiés, sont aussi bien définis qu'ils le seraient par des pages de description générique. Philosophiquement, un genre est un groupe d' une ou plusieurs espèces plutôt qu'une description. Il y a une grande quantité de descriptions de genres publiées, non accompagnées par citation d'espèces, qui ne peuvent pas être interprétées définitivement.]

7. Motion d'amender l'article 45 de telle façon qu'on lise Lorsqu'un genre est divisé en deux ou plusieurs, le nom doit être conservé et donné à la division contenant le type de nomenclature. Le type de nomenclature d'un genre ou sous-genre est l'espèce nommée ou désignée originellement par l'auteur du nom.

Si aucune espèce n'a été désignée, le type est la première espèce binaire après l'application des conditions suivantes :

1°. Le type doit être choisi dans un sous-genre, une section, ou autre liste d'espèces désignées originellement comme typiques. La publication d'un nom générique nouveau comme substitut avoué d'un nom antérieur non valable ne change pas le type du genre.

EXEMPLES. — *Diaporthe* Nitschke, Pyren. Germ. 240 (1870), est typifié par *D. eres* Nitschke, la première espèce du sous-genre *Euporthe* ; *Psilogramme* Kuhn, Festschr. 50-Jähr. Jub. Königs. Realschule zu Berlin, 332 (1882), est typifié par l'espèce mentionnée en premier lieu dans la seconde section *Eupsilogramme*, et non d'après des espèces comprises dans la première section *Jamesonia*, qui est basée sur un nom générique publié antérieurement ; *Phania* DC. Prodr. **5** : 114 (1826) est typifié par *P. multicaulis* DC., la seule espèce de la section *Euphania* ; *Guignardia* Viala & Ravaz, Bull. Soc. Myc. Fr. **8** : 63 (1892), qui était substitué pour *Laestadia* Auers. Hedwigia **8** : 177 (1869) non pas *Laestadia* Kunth in Less. Syn. Compos. 203 (1832), est typifié par *Laestadia alnea* (Fr.) Auers., qui est la première des trois espèces données par Auerswald, et non par *Laestadia Bidwellii* (Ellis) Viala & Ravaz, la seule espèce mentionnée par Viala & Ravaz au moment où la substitution a été faite.

2°. L'application à un genre d'un ancien nom spécifique d'une des espèces comprises, désigne le type.

EXEMPLES. — *Sordaria* Ces. & DeN. Comm. Soc. Critt. Ital. **1** : 225 (1863) est typifié par *Sphaeria Sordaria* Fr., une de ses douze espèces originales ; *Roccella* DC. Fl. Fr. **2** : 334 (1805) est typifié par *Lichen Roccella* L., une de ses deux espèces originales ; *Calypogeia* Raddi, Atti Soc. Ital. Sci. Mod. **18** : 42 (1818), est typifié par *Jungermannia Calypogeia* Raddi, une de ses trois espèces originales ; *Amsonia* Walt. Fl. Car. 98 (1788) est typifié par *Tabernaemontana Amsonia* L., une de ses deux espèces originales.

3°. Une espèce figurée doit être choisie plutôt qu'une espèce sans figure, dans le même ouvrage. En cas d'absence de figure, on doit donner la préférence à la première espèce accompagnée par la citation d'un spécimen dans une série d'exsiccata régulièrement publiée. Dans le cas de genres adoptés d'après prébinomial auteurs (avec ou sans changement de nom), une espèce figurée par l'auteur de qui le genre est adopté doit être choisie.

EXEMPLES. — *Perithamnion* J. Ag. Anal. Alg. 28 (1892) est typifié par *P. ceramioides* J. Ag., qui est la seule espèce figurée ; *Leptostroma* Fr. Obs. Myc. **1** : 196 (1815) est typifié par *L. xylomoides* Fr., la seule espèce figurée ; *Lespedeza* Michx. Fl. Bor.-Am. **2**: 70 (1803) est typifié par *L. procumbens* Michx. *loc. cit. pl. 39*, l'espèce figurée en premier lieu ;

Stigmatea Fr. Sum. Veg. Scand. 421 (1849) est typifié par *S. Robertiani* Fr., la quatrième espèce, puisqu'il n'y a pas d'espèces figurées et celle-ci est la première dans la liste accompagnée par la citation d'un spécimen dans un exsiccata publié, Scler. Suec. Exsic. *no. 423*.

4°. Lorsque des espèces économiques ou indigènes sont comprises dans le même genre avec des espèces étrangères, le type doit être choisi dans (1) les espèces économiques ou (2) celles indigènes au point de vue du premier auteur du genre.

EXEMPLES. — *Corallina* L. Syst. Nat. 805 (1758) est typifié par *Corallina officinalis* L., une espèce d'importance économique au temps de Linné ; *Agaricus* L. Sp. Pl. 1171 (1753) est typifié par *Agaricus campestris* L., l'espèce économique la plus importante du genre ; *Poa* L. Sp. Pl. 67 (1753) est typifié par *P. pratensis* L., la première des espèces économiques ; *Sanguisorba* L. Sp. Pl. 116 (1753) est typifié par *S. officinalis* L., l'espèce indigène au point de vue de l'auteur.

5°. Les types de genres adoptés au moyen de citations de textes nonbinaires (avec ou sans changement de nom) doivent être choisis parmi ceux des espèces originales qui reçoivent des noms dans la première publication binaire. Les genres du Species Plantarum de Linné (1753) doivent être typifiés au moyen des citations données dans son Genera Plantarum (1754).

EXEMPLES. — *Phallus* L. Sp. Pl. 1178 (1753), un genre adopté d'après Micheli avec une signification plus étendue, est typifié par *Phallus impudicus* L., la seule espèce commune aux deux auteurs ; *Riccia* L. Sp. Pl. 1138 (1753), un genre adopté d'après Micheli avec une signification plus étroite, est typifié par *Riccia crystallina* L., qui est la première des espèces de Linné communes aux deux auteurs ; *Polytrichum* L. Sp. Pl. 1109 (1753), un genre adopté d'après Dillenius, est typifié par *Polytrichum commune* L., la première des espèces de Linné communes aux deux auteurs ; *Cypripedium* L. Sp. Pl. 951 (1753), un genre adopté d'après Tournefort, avec changement du nom *Calceolus* qu'il emploie, est typifié par *Cypripedium Calceolus*, la seule espèce commune aux deux auteurs ; *Seseli* L. Sp. Pl. 259 (1753), un genre adopté d'après Boerhaave, est typifié par la seconde espèce de Linné, *Seseli montanum*, qui est la première des espèces de Linné communes aux deux auteurs ; *Silene* L. Sp. Pl. 416 (1753), un genre adopté d'après Dillenius, avec changement du nom *Viscago* qu'il emploie, est typifié par *Silene anglica*, qui est la première de Linné des treize espèces figurées par Dillenius ; *Fritillaria* L. Sp. Pl. 303 (1753), un genre adopté d'après Tournefort, est typifié par la cinquième espèce de Linné, *Fritillaria Meleagris*, qui est une des trois espèces de *Fritillaria* communes aux deux auteurs, et elle est choisie parce qu'elle est l'espèce figurée par Tournefort.

[Nous cherchons à rendre les principes traités à l'article 45 plus définis que sa présente expression ne le permet, et cela peut être accompli par notre méthode générale de types.]

8. Motion d'amender l'article 47 de telle façon qu'on lise : Lorsqu'on divise une espèce ou une subdivision d'espèce en deux ou plusieurs groupes de même nature le nom doit être conservé et donné à la division contenant le type de nomenclature. Le type de nomenclature d'une espèce ou sous-espèce est le spécimen auquel l'auteur de la description a appliqué le nom originellement, lors de la publication.

EXEMPLES. — *Sphaeria megalocarpa* Plow. Grevillea 7 : 73 (1878) est typifié par la désignation d'un seul spécimen *no. 956*, sur l'écorce d'érable mort ; *Prionolejeunea innovata* Evans, Bull. Torrey Club 31 : 215 (1904), est typifié par la désignation d'un spécimen recueilli par Heller dans les monts Luquillo, Puerto Rico ; *Polypodium marginale* L. Sp. Pl. 1091 (1753) est typifié par la désignation d'un spécimen recueilli au Canada par Kalm ; *Stachys arenicola* Britton, Man. 792 (1901), est typifié par la désignation d'un spécimen venant de Staten Island, New York ; *Carex intumescens Fernaldii* Bailey, Bull. Torrey Club 20 : 418 (1893), est typifié par un spécimen recueilli à Cedar Swamp, Aroostook County, Maine, par M. L. Fernald.

1°. Lorsque plusieurs spécimens ont été cités originairement, le type ou groupe de spécimens dans lequel le type est compris peut être indiqué par la dérivation du nom de celui du collecteur, de la localité, ou de l'hôte.

EXEMPLES. — *Mystrosporium Curtisii* Berk. Grevillea 3 : 105 (1874) est basé sur deux spécimens, dont le type est celui qui a été recueilli par M. A. Curtis ; *Jungermannia Dicksoni* Hook. Brit. Jung. *pl. 48* (1816) est basé sur plusieurs spécimens, dont le type est celui qui a été recueilli en Écosse par Dickson ; *Eriogonum Porteri* Small, Bull. Torrey Club 25 : 41 (1898), est basé sur plusieurs spécimens, dont le type est celui qui a été recueilli par T. C. Porter ; *Gaillardia arizonica* A. Gray, Syn. Fl. N. Am. 1^2 : 353 (1884), est basé sur plusieurs spécimens, dont le type est celui qui a été recueilli en Arizona par Palmer ; *Cenangium Magnoliae* B. & C. Grevillea 4 : 5 (1875) est basé sur des spécimens provenant de deux hôtes, dont le type est celui qui provient de *Magnolia ; Cuscuta Cephalanthi* Engelm. Am. Jour. Sci. 43 : 336 (1842) est basé sur des spécimens provenant de plusieurs hôtes, dont le type est celui qui provient de *Cephalanthus.*

2°. Entre les spécimens éligibles au même degré, le type est celui qui est figuré le premier avec la description originale, ou à défaut de figure le premier mentionné.

EXEMPLES. — *Alaria valida* Kjellm. & Setchell, Univ. California Publ. Bot. 1 : 278. *pl. 21* (1903), est basé sur des spécimens venant de deux localités, et la plante figurée, venant de Whidbey Island, Washington, est le type ; *Hypoxylon notatum* B. & C. Grevillea 4 : 50 (1875) est basé sur trois spécimens, dont pas un n' est figuré, et le premier mentionné, celui qui est le *no. 1910* sur *Celtis*, venant de la Caroline du Sud, est le type ; *Calyptridium roseum* S. Wats. Bot. King's Exp. 44. *pl. 6. f. 6–8* (1871) est basé sur au moins trois spécimens dont celui qui est figuré est le type ; *Arnica cordifolia* Hook. Fl. Bor.-Am. 1 : 331 (1833) est basé sur deux spécimens ni l'un ni l'autre figurés, et le premier mentionné, celui qui a été recueilli par Drummond dans les bois alpins des Montagnes Rocheuses, est le type.

3°. À défaut de spécimen original, celui qui est représenté par la première figure citée, dont on peut prouver l'identité, ou à défaut de figure, par la première description citée, ou publiée postérieurement, sert de type.

EXEMPLES. — *Hydnum repandum* L. Sp. Pl. 1178 (1753) est basé sur trois citations, dont la troisième typifie l'espèce, étant accompagnée d'une figure ; *Marchantia polymorpha* L. Sp. Pl. 1137 (1753) est basé sur un nombre de citations, dont celle qui renvoïe à la figure de Micheli indique le type ; *Trillium sessile* L. Sp. Pl. 340 (1753) est basé sur trois citations, dont la seconde typifie l'espèce, étant accompagnée d'une figure ; *Lycopodium Bovista* L. Sp. Pl. 1183 (1753) est basé sur un nombre de citations, dont la première mentionnée est le type, puisqu' on ne cite pas de figure ; *Centaurea Scabiosa* L. Sp. Pl. 913 (1753) est basé sur un nombre de citations, dont la première mentionnée est le type, puisqu' on ne cite pas de figure.

[Les principes applicables pour typifier les espèces sont semblables à ceux qui sont indiqués pour les genres dans nos amendements proposés à l'article 45.]

9. Motion d'amender la recommendation XXVI (sous l'articel 46) en omettant le paragraphe 3° et en substituant au paragraphe 2° le suivant :

Parmi les noms publiés dans le même ouvrage et en même temps, ceux qiu ont la précédence de position doivent être préférés.

[Nous cherchons ainsi à établir plus définitivement le choix parmi des noms de même date.]

10. Motion d'amender l'article 51 en substituant après les deux points : dans la 1ère ligne, ce qui suit :

1°. Quand le nom a été employé antérieurement (homonyme.)

(*a*) Un nom spécifique est un homonyme quand il a été publié pour une autre espèce sous le même nom générique.

EXEMPLES. — *Caulerpa Lycopodium* Harv. Ner Bor.-Am. **3** : 19 (1858) est l'homonyme de *Caulerpa Lycopodium* J. Ag. Öfvers. Kongl. Vet.-Akad. Förh. 4 : 6 (1847) ; *Radula spicata* Aust. Bull. Torrey Club **6** : 19 (1875) est l'homonyme de *Radula spicata* Mitt. Bonplandia **10** : 19 (1862) ; *Acer saccharinum* Wang. Amer. 36. *pl. 2. f. 26* (1787) est l'homonyme de *Acer saccharinum* L.

Sp. Pl. 1055 (1753); *Vaccinium myrtilloides* Hook Fl. Bor.-Am. 2: 32 (1834) est l'homonyme de *Vaccinium myrtilloides* Michx. Fl. Bor.-Am. 1 : 234 (1803), et doit être rejeté, que l'on considère cette dernière espèce comme distincte ou non ; *Chrysopsis pilosa* (Walt.) Britton, Mem. Torrey Club 5 : 316 (1894), est l'homonyme de *Chrysopsis pilosa* Nutt. Jour. Acad. Nat. Sci. Phila. 7 : 66 (1834), et doit être rejeté, malgré le fait que *Erigeron pilosum* Walt. fut publié en 1788 ; *Brasenia antiqua* Daws. Trans. Roy. Soc. Canada 3^4 : 15 (1885) est l'homonyme de *Brasenia antiqua* Newb. Proc. U. S. Nat. Mus. 5 : 514 (1883.)

(*b*) Un nom générique est un homonyme quand il a été publié antérieurement pour un autre genre.

EXEMPLES. — *Rivularia* Ag. Syn. Alg. Scand. xxxviii (1817) est l'homonyme de *Rivularia* Roth, Cat. Bot. 1 : 212 (1797) ; *Sphaerella* Ces. & DeN. Schem. Sfer. Ital. 62 (1863) est l'homonyme de *Sphaerella* Sommerf. Mag. Naturvid. 4 : 249 (1824) ; *Torreya* Arn. Ann. Nat. Hist. 1 : 130 (1838) est l'homonyme de *Torreya* Raf. Am. Mo. Mag. 3 : 356 (1818), de *Torreya* Raf. Jour. de Phys. 89 : 105 (1819), de *Torreya* Spreng. Neue Entdeck. 2 : 121 (1821), et de *Torreya* Eat. Man. ed. 5, 420 (1829).

(*c*) Des noms semblables ne seront pas considerés comme homonymes excepté quand ils ne sont que de simples variations de l'orthographe du même mot ; ou bien dans le cas de noms spécifiques et sous-spécifiques quand ils ne diffèrent que par la désinence adjective ou génitive.

EXEMPLES. — *Penicillus* et *Penicillium*, *Callitriche* et *Calothrix*, *Pterigophyllum* et *Pteridophyllum* peuvent être conservés ; *Cyathophora* et *Cyathophorum*, *Asterocarpus* et *Astrocarpus*, ne peuvent être conservés. *Greenei* et *Greenii* dérivés de noms d'hommes différents, Greene et Green, peuvent être conservés dans le même genre ; *virginicus*, *virginianus*, et *virginiensis*, *oreganus* et *oregonensis*, *Hookeri* et *Hookerianus*, ne peuvent être conservés dans le même genre.

2°. Quand il y a un nom valable plus ancien basé sur un autre membre du même groupe (métonyme).

EXEMPLES. — *Chauvinia* Bory, Voy. Coquille, Bot. Crypt. 204 (1828), est typifié par *Chauvinia paspaloides* Bory, et *Caulerpa* Lamour. Jour. de Bot. 2 : 141 (1809) est typifié par *Caulerpa prolifera* (Forsk.) Lamour., par conséquent, si ces espèces sont considérées comme congénériques, le nom *Chauvinia* doit être rejeté ; *Boletopsis* P. Henn. Nat. Pflanzenf. 1^{1**} : 194 (1899) ne peut être maintenu comme genre, une section portant le nom *Boletinus* Kalchb., ce dernier ayant été établi comme genre en 1877 ; *Meibomia* Heist. ex Adans. Fam. Pl. 2 : 509 (1763) est basé sur *Hedysarum canadense* L. Sp. Pl. 748 (1753), et *Desmodium* Desv. Jour. de Bot. II. 1 : 122 (1813) est typifié par *Hedy-*

sarum asperum Poir. Encycl. Suppl. **6** : 408 (1804), par conséquent, si ces espèces sont considérées comme congénériques, le nom *Desmodium* doit être rejeté ; *Sisymbrium altissimum* L. Sp. Pl. 659 (1753), *Sisymbrium Sinapistrum* Crantz, Stirp. Austr. ed. 2, 52 (1769), et *Sisymbrium pannonicum* Jacq. Coll. **1** : 70 (1786), ont des types différents, mais si ceux-ci sont considérés comme appartenant à la même espèce, les deux derniers noms sont des métonymes de celui de Linné.

3°. Quand il y a un nom valable plus ancien basé sur le même type (typonyme).

EXEMPLES. — *Coralliodendron* Kütz. Polyp. Calif. **11** (1841) et *Coraltocephalus* Kütz. Linnaea **17** : 95 (1843) sont tous deux les typonymes de *Penicillus* Lamarck, Ann. Mus. Nat. Hist. **20** : 297 (1813), tous étant typifiés par la même espèce ; *Pyrenochium* Link, Abh. Berl. Akad. **1824** : 171 (1826), est le typonyme de *Dothiorella* Sacc. Michelia **2** : 5 (1880), tous deux étant basés sur le *Dothidea pyrenophora* Fr. ; *Asplenium Vincentis* Christ, Bot. Jahrb. **24** : 109 (1897), est le typonyme de *A. Guildingii* Jenm. Gard. Chron. III. **15** : 70 (1894), tous deux étant basés sur le *no. 1346* de H. H. Smith, provenant de St. Vincent ; *Miegia* Pers. Syn. **1** : 101 (1805) est le typonyme de *Arundinaria* Michx. Fl. Bor.-Am. **1** : 73 (1803), tous deux étant basés sur la même espèce.

4°. Quand le groupe naturel auquel le nom s'applique est indéterminé (hyponyme).

(*a*) Un nom spécifique ou sous-spécifique est un hyponyme quand il n'a pas été rattaché à une description qui peut être identifiée par des caractères diagnostiques ou par renvoi à un spécimen, à une figure ou à une localité typique.

EXEMPLES. — *Pexisperma lutescens* Raf. Carat. Nuov. Gen. Sp. Sicilia 89. *pl. 20. f. 1* (1810) est un hyponyme, car on ne peut en identifier la description et les figures ; *Hydrophora tenella* Tode, Fung. Meck. Sel. **2** : 6 (1791), est un hyponyme, car on ne peut en identifier la description ; *Gentiana hybrida* Raf. Med. Rep. II. **5** : 353 (1808) est un hyponyme, car aucun diagnose n'en est publié ; *Lechea furfuracea* Raf. New Fl. Am. **1** : 92 (1836) est un hyponyme, car on ne peut en identifier la description ; *Sigillaria centralis* Newb. Annals of Science **1** : 96 (1853) est un hyponyme, car aucune description ou figure n' est publiée.

(*b*) Un nom générique ou sous-générique est un hyponyme quand on ne peut le rattacher, tout au moins par une citation spécifique, à une espèce binaire publiée antérieurement ou simultanément ; ou bien quand son espèce typique n'est pas identifiée.

EXEMPLES. — *Adodendrum* Necker, Elem. **1** : 214 (1700), et *Calesiam* Adans. Fam. Pl. **2** : 446 (1763), sont hyponymes, car leurs auteurs n'ont ni nommé d'espèce binaire, ni cité d'espèce qui ait reçu antérieurement un nom binaire; *Sclernax* Raf. Carat. Nuov. Gen. Sp. Sicilia 90 (1810) est un hyponyme, car son espèce typique, *Sclernax truncata*, n'a pas été identifiée; *Nudilus* Raf. Atl. Jour. 176 (1833) est un hyponyme, car son espèce typique, *N. paradoxus*, n'a pas été identifiée.

[La méthode générale de types présentée ci-dessus donne des principes plus simples et mieux définis pour le rejet de noms que ne le fait le texte actuel de cet article.]

11. Motion d'amender en omettant l'article 55, 2°.

[L'article 55, paragraphe 2° fait malheureusement exception à la loi générale de priorité. Les Règles demandent des noms binaires tels que *Cerastium cerastioides*, *Specularia Speculum*, *Atamosco Atamasco*, and *Leonotis Leonitis*, tout en excluant des noms binaires tels que *Linaria Linaria* et *Catalpa Catalpa*.]

Les propositions ci-dessus sont soumises par

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Phycological studies — IV. The genus Neomeris and notes on other Siphonales

Marshall Avery Howe

(with plates 1-8)

A. THE GENUS NEOMERIS

In an attempt to determine the relationships of a peculiar *Neomeris* collected on Atwood Cay in the eastern Bahamas and later on the Caicos Islands, it was found desirable to see the material on which *Neomeris dumetosa* Lamour., the original species of the genus, attributed to the Antilles, was founded. Having been allowed to see presumably authentic specimens of *N. dumetosa* through the courtesy of Monsieur P. Hariot of the Muséum d'Histoire Naturelle of Paris, we were further enabled, through the kindly interest of other European phycologists named below, to examine plants from the Friendly Islands, Singapore, the Dutch East Indies, etc., which had been identified with *Neomeris dumetosa.* A comparative study of these specimens and of our own collected in Bermuda, Florida, and the West Indies, indicates that the genus consists, so far as is known, of six living species. We have made no attempt to study the fossil forms that have been referred to the genus and we regret not being able to add anything as to the still unknown germination phenomena of the so-called "spore." The detailed life-history, not only of *Neomeris*, but of many other marine Siphonales of the tropics, remains to be worked out by some one so situated as to have the living plants under a more continuous and leisurely observation than has as yet fallen to the lot of the writer. A brief diagnosis of the genus and more detailed descriptions of the six species follow :

Neomeris Lamour. Hist. Polyp. 241. 1816.

Plants subcylindrical, clavate, or subfusiform, more or less calcified, consisting of an erect normally simple and unconstricted axis affixed at the base by branching or lobed holdfasts and bearing numerous close-set whorls of 12–56 or more branches.

Branches of the lowermost whorls commonly one or more times di-trichotomous and sterile; primary branches (branches of the first order) of the remaining whorls mostly giving rise to a terminal stalked sporangium and two (in *N. stipitata* sometimes three) sterile branches, the latter springing from near the base of the sporangium. Sterile branches of the second order in adult stage either enlarged and vesicular distally, the inflations strongly coherent and forming a unistratose cortex with more or less hexagonal facets, or in (*N. Cokeri*) merely subfusiform and imperfectly coherent, scarcely forming a cortex. Each of the sterile branches of the second order terminating in a single simple or one or more times di-trichotomous, soon deciduous hair. Sporangia subglobose, obovoid, pyriform, or somewhat cylindrical, enclosed in thick calcareous capsules, these sometimes coherent; the sporangium-stalk often at length cut off from the supporting primary branch by a basal constriction and plug. Each sporangium enclosing a single spore (gametangium?), this furnished with an operculum at its basal (proximal) end.

Type species *N. dumetosa* Lamour.

- Hairs monomorphous; ends of branches of the second order forming a cortex with distinct facets.
  - Sporangia strongly calcified but mutually free.
    - Primary branches 500–1000 μ long, 15–35 times as long as their median diameter.
      - Primary branches coherent by intercalary lime-deposits into flat, cuneate, flabelliform, or somewhat annular transverse scales or bands of mostly 3–8 branches, easily caducous; plants mostly 15–20 times as long as thick. 1. *N. dumetosa.*
      - Primary branches strongly calcified but free, or, at most, very irregularly and loosely coherent, persistent; plants mostly 6–12 times as long as thick. 2. *N. van Bosseae.*
    - Primary branches 240–410 μ long, 4–10 times as long as their median diameter.
      - Plants 26–40 mm. long; facets of the cortex firm-walled, not calcified on the outer surface, occasionally in threes; sporangia first appearing at about 15 mm. from base of mature plant. 3. *N. stipitata.*
      - Plants 8–20 mm. long; facets of the cortex thin-walled and very mucilaginous, strongly calcified at first on the outer surface, always in pairs; sporangia first appearing at about 2–6 mm. from base of mature plant. 4. *N. mucosa.*
  - Sporangia coherent laterally by their calcareous capsules, the plant thereby appearing transversely annulate in the lower fertile parts. 5. *N. annulata.*

Hairs dimorphous, the two forms in alternating zones; branches of the second order subfusiform, scarcely forming a cortex, surface of the plant after the fall of the hairs somewhat shaggy or minutely and irregularly punctate; sporangia free or coherent in short rows of 2–8. 6. *N. Cokeri.*

1. NEOMERIS DUMETOSA Lamour. Hist. Polyp. 243. *pl. 7. f. 8.* 1816; Expos. méth. Polyp. 19. *pl. 68. f. 10, 11* (*11* poor). 1821. — Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **30**: —(10–14, 38). *pl. 2. f. 13–15; pl. 3. f. 3.* 1887. Not *N. dumetosa* Cramer, *op. cit.* **32**: —(19–21). *pl. 1. f. 13; pl. 2. f. 7, 8.* 1890.

Plants gregarious or scattered, subcylindrical, elongate and slender, 20–40 mm. long, 1–2 mm. thick, mostly 15–20 times as long as thick, acute or acuminate at apex: successive whorls of primary branches about 300–400 in number, 80–90 μ apart near the middle of the plant, 135 μ near apex; number of branches in a whorl usually 28–40: hairs all of one form, sparingly persistent in an inconspicuous apical tuft:* ends of branches of the second order in the mature stage forming a cortex with irregular hexagonal facets in irregular, often scarcely recognizable, transverse and oblique rows, each pair of corticating branches commonly lying in a somewhat oblique plane, cortex easily deciduous, usually persistent only in upper fourth or sixth, reticulate-alveolate on drying: branches of the first order in adult fertile stage 500–680 μ long, 14–30 μ in diameter in their median and basal parts, slender, mostly 18–35 times as long as their median diameter, soon very strongly calcified and regularly coherent by heavy intercalary deposits of lime into flat, cuneate, flabelliform, or somewhat annular densely crowded transverse scales or bands, these consisting usually of 3–8 branches with the intercalary masses of lime 2–4 times as broad as the branches, very easily caducous, the main axis often becoming extensively naked in basal and median parts: branches of the second order capitate, the terminal inflations 100–185 μ in greatest diameter, outwardly rounded-obtuse, their walls moderately gelatinous, the pedicels scarcely calcified, the terminal inflations strongly calcified proximally and laterally but not on their outer surfaces: sporangia strongly calcified but mutually free, first appearing at 2–3 mm. from base of the mature plant, soon deciduous, persisting in irregularly crowded groups or loosely scattered, 150–200 μ long (decalcified and including stalk), the calcareous capsule 16–50 μ thick; spores subglobose, 135–

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* The apparently conspicuous apical tuft shown in Lamouroux's figure 3 consists quite largely, judging from specimens in the Paris Museum, of young uncalcified collapsed facets from which the hairs have already fallen.

160 μ × 130–154 μ, commonly a trifle longer than broad or occasionally *vice versa* (sometimes only 100–110 μ in diameter in the East Indian specimens). [PLATE 1, FIGURE 1; PLATE 5, FIGURE 20; PLATE 6, FIGURES 1, 2.]

TYPE LOCALITY: "Antilles." Probable type specimens in herb. Lamouroux, Institut Botanique, Caen, France, under the manuscript name "*Neomeris cespitosa*"; probable co-types in herb. Mus. Paris., under names "*Neomeris cespitosa*" and "*N. dumetosa* Lmx."

DISTRIBUTION: "Antilles," *Richard;* island of Fau (near the island of Gebee), Dutch East Indies, *A. Weber-van Bosse* (apparently associated with *N. van Bosseae*).

The only specimens found in the *Neomeris* cover in herb. Lamouroux are three plants attached to a slip of paper bearing the inscription "*Neomeris cespitosa*" in Lamouroux's hand, without indication of locality or collector. They are doubtless the three plants figured by Lamouroux in connection with the original publication of *Neomeris dumetosa*, though now occupying slightly different positions in relation to each other. In the herbarium of the Muséum d'Histoire Naturelle of Paris, in which the Richard herbarium is incorporated, is a single plant in a pocket marked "*Neomeris cespitosa*" without collector or locality, and also a group of seven individuals (six practically entire and one a basal fragment) marked "*N. dumetosa* Lmx.," also without indication of locality or collector. All of the specimens mentioned resemble each other closely and all have probably come from the one original collection. We examined all of these specimens in the summer of 1904, but then neglected to note certain characters which we have since found to be of importance in distinguishing the species of *Neomeris*. Recently, however, through the generous courtesy of M. Hariot, we have enjoyed the privilege of making a more critical study of the material in the Paris Museum. Cramer saw an authentic specimen of *Neomeris dumetosa* and gave an excellent description of it (with characteristic figures) in his first paper "Ueber die verticillirten Siphoneen besonders Neomeris und Cymopolia," but in his second paper "Ueber die verticillirten Siphoneen besonders Neomeris und Bornetella" he described under the same name some of Harvey's specimens from the Friendly Islands, which, we believe, are specifically distinct.

Later descriptions by other writers, also, have been based, in part, at least, on specimens agreeing with the true *N. dumetosa* in having mutually free sporangia but differing in various other particulars.

Just as the lateral coherence of the sporangia by their calcareous capsules forms a reliable and easily applied test for distinguishing *Neomeris annulata* from *N. dumetosa* and its near allies, so the similar coherence of the primary branches of the true *Neomeris dumetosa* by intercalated lime-deposits constitutes an apparently constant and reliable character for distinguishing the species from others which have hitherto been identified with it. This coherence was recognized by Lamouroux in his original description by the words "inferne squamosa" and "écailles presque cunéiformes" and was emphasized by Cramer in his first description, but has been generally ignored by subsequent writers. This character is well illustrated by Cramer (*pl. 2. f. 13*), his figure showing the calcareous scale perforated by the tubular branches, with the width of the connecting lime-masses commonly three or four times the diameter of the branches. Another peculiarity of the true *Neomeris dumetosa* is found in the very caducous nature of these scales. As Lamouroux well said, "le moindre frottement les arrache du tube membraneux qu'elles laissent alors à nu." In allied species which have been confused with *N. dumetosa*, the individually separate primary branches are persistent. Furthermore, the mature plants of *N. dumetosa* are more slender and more taper-pointed than those from the Friendly Islands, the Dutch East Indies, and Hawaii, which have hitherto been identified with it.

Neomeris dumetosa is said to have been brought from the Antilles by Richard and there is as yet no sufficient ground for doubting the accuracy of this statement in spite of the facts that it apparently has not since been collected in American waters and that something practically identical (except for smaller spores) has recently been brought from the East Indies by Madame Weber-van Bosse. *Neomeris Cokeri* is common enough in the Bahamas (we have it from fourteen stations and have seen it often when not collected), but the species has not yet been reported outside of this group of islands. *Neomeris mucosa*, described as new in the present paper, is known only from the Caicos Islands and the extreme eastern Bahamas. And *Neomeris dumetosa* will possibly be found again in the West Indies when some collector of marine algae visits the right island. And, furthermore, the occurrence of this species in both the West Indies and the East Indies may occasion no surprise in view of the fact that *Neomeris annulata* and various other marine Siphonales are now generally conceded to have a similar distribution. In connection with the original description of *Neomeris dumetosa*, it is said to grow associated with *Acetabularia crenulata*, a species which appears to be exclusively American. The Paris Museum material of the probably original *N. dumetosa* is intermingled with a few broken stalks of plants apparently belonging in the genus referred to, but without caps or sporangia a determination of the species is out of the question.

2. **Neomeris van Bosseae** sp. nov.

Neomeris dumetosa Sonder, Alg. trop. Austral. 36. *pl. 5. f. 8–13.* 1871. — J. Ag. Till. Alg. Syst. **5**: 147–151. *pl. 2. f. 4–7.* 1887. — Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **32**: — (19–21). *pl. 1. f. 13; pl. 2. f. 7. 8.* 1890. — Solms, Ann. Jard. Bot. Buitenzorg **11**: *pl. 8. f. 11.* 1893. Not *Neomeris dumetosa* Lamour. Hist. Polyp. 243. *pl. 7. f. 8.* 1816.

Plants gregarious or scattered, clavate, subcylindrical, or somewhat fusiform, 15–35 mm. long, 2–3.5 mm. thick, mostly 6–12 times as long as thick, often curved near the middle or toward the rounded-obtuse or subacute apex: successive whorls of primary branches about 290–350 in number, 50–80 μ apart in basal and median regions, 150–170 μ toward apex; number of branches in a whorl usually 32–44: hairs all of one form, persistent in a moderately conspicuous apical tuft: ends of the branches of the second order in the mature stage forming a cortex with the hexagonal facets in regular or irregular rows, each pair of corticating branches commonly lying in a transverse plane, the number of transverse rows of facets equaling, in consequence, the number of primary whorls, and the number of facets in a row being twice that of the elements in a primary whorl, or, the pairs of corticating branches lying in oblique planes and the arrangement of the facets then less manifestly regular, cortex rather brittle, yet usually persisting in upper third or half, reticulate on drying: branches of the first order 570–1000 μ long, 20–50 μ in diameter in their basal and median parts, mostly 15–30 times as long as their median diameter, soon strongly calcified but remaining distinct and free from each other, or very irregularly and loosely coherent, persistent: branches of the second order capitate, the terminal inflations 110–220 μ in greatest diameter, outwardly subtruncate or lightly arcuate, their walls rather firm, the pedicels well calcified as to their bases at least or sometimes nearly free from lime, the terminal inflations strongly calcified proximally and laterally, but their outer surfaces, with rare exceptions, uncalcified and nitent: sporangia strongly calcified but mutually free, first appearing at 1–4 mm. from base of mature plant, commonly long persistent, 135–220 μ long (decalcified and including stalk), the calcareous capsules 20–55 μ thick; spores subglobose or oval, 105–176 μ × 96–170 μ, their width often about $\frac{11}{12}$, rarely $\frac{4}{5}$, their length. [PLATE 1, FIGURES 4, 7; PLATE 5, FIGURES 17–19.]

Type from Sikka, Flores, Dutch East Indies, *A. Weber-van Bosse 1196*, in the herbarium of the New York Botanical Garden and in the herbarium of Madame Weber-van Bosse, Eerbeek, Holland. Known also from Savoe [Savu], Dutch East Indies, *Weber-van Bosse*; from Vavau and Lifuka, Friendly Islands, *W. H. Harvey*, August and October, 1855; and from Koolauloa. Oahu, Hawaii, *Josephine E. Tilden*, June, 1900, Am. Algae *445*. The specimens from New Guinea, *Beccari*, cited by Solms (*loc. cit.* 71), under *N. dumetosa* we have not seen, but it is quite possible that they belong here, as this seems to be the most common species of the group in that region.

It is a pleasure to associate with the present species the name of one of its collectors, Madame A. Weber-van Bosse, who had already recognized that her material of the *Neomeris dumetosa* group included two species, and to whom the writer, like many other students of the marine algae of the present day, is indebted for numerous most helpful courtesies. J. Agardh (*loc. cit.*) seems never to have seen Richard's West Indian plant and in describing *Neomeris dumetosa* from Harvey's material from the Friendly Islands he gave evidence of some doubts as to whether the two were really the same.

Neomeris van Bosseae agrees with *N. dumetosa* in its mutually free sporangia, but the two, so far as can be judged from the material now in hand, appear to be sufficiently and constantly distinct. The most obvious distinguishing character of *N. van Bosseae* is that the branches of the first order, though strongly calcified, remain mutually free. If there is any irregular or accidental coherence among them, there is no approach to the beautifully regular coherence of *N. dumetosa*, and the lime-masses between the branches are narrower than the branches, while in *N. dumetosa* they are, except at their bases (or sometimes, also, at their apices), 2–4 times as broad as the branches themselves. Moreover, the primary branches of *Neomeris dumetosa* are easily deciduous or caducous, while in *N. van Bosseae* they are persistent, and the sporangia also, show a similar tendency quite apart from branches on which they are borne. *Neomeris van Bosseae* is also a stouter plant than *N. dumetosa*, being mostly 6–12 times as long as thick, as opposed to 15–20 times as long as thick, and it is usually more rounded-obtuse at the apex.

The arrangement of the facets in the cortex appears to be somewhat variable in *N. van Bosseae*. When, as is often the case, the members of each pair of corticating branches are opposed to each other laterally, that is, lie in a transverse plane, the arrangement is manifestly regular, the number of transverse rows of facets corresponds exactly to the number of primary whorls, and the number of facets in each row is consequently just twice the number of elements in the corresponding primary whorl. But when, on the other hand, the members of each pair lie in an oblique plane, there are two possible ways of interpreting what shall constitute a transverse row of facets and, according to the method adopted, there may be either twice as many rows as there are primary whorls or only the same number. A change from the regularly transverse arrangement to the oblique may sometimes be noted in the different parts of a single individual plant.

3. **Neomeris stipitata** sp. nov.

Neomeris dumetosa Church, Ann. Bot. **9**: 581–608. *pl. 21–23*. 1895. Not *Neomeris dumetosa* Lamour. Hist. Polyp. 243. *pl. 7. f. 8.* 1816.

Plants cespitose or gregarious, elongate-clavate, lightly calcified, 26–40 mm. long, 2–2.5 mm. thick, mostly 13–20 times as long as thick, subacute at apex: successive whorls of primary branches about 300–500 in number, 90–120 μ apart in median regions; number of branches in a whorl in later stages usually 16–32: hairs all of one form, persistent in the apical fourth to sixth and making a rather conspicuous coma: ends of branches of the second order in the mature stage forming a cortex with irregularly hexagonal facets in mostly very irregular transverse rows or often without recognizable order, each pair of corticating branches lying in a transverse or somewhat oblique plane, the corticating branches occasionally in threes, cortex rather pliable, commonly persistent in the upper half, plants of a younger stage often somewhat extensively corticated by inflations of the primary branches: branches of the first order in adult fertile parts 240–410 μ long, 32–42 μ in diameter in their basal and median parts, mostly 6–10 times as long as their median diameter, lightly calcified, free, persistent, the main axis commonly clothed for a space of 10–15 mm. in the lower sterile half by clavate 2-scarred long-persistent scarcely calcified primary branches 150–240 μ long: branches of the second order mostly in pairs but now and then in threes, capitate, the terminal inflations 116–215 μ in greatest diameter, outwardly mammiform, subconical, domed, or merely arcuate, their walls firm, the pedicels uncalcified, the terminal inflations lightly or moderately calcified proximally, their outer surfaces uncalcified: sporangia rather strongly calcified, mutually free, first appearing at about 15 mm. from base of the mature plant, 185–210 μ long (decalcified and including stalk), the calcareous capsules 11–28 μ thick; spores subglobose or slightly obovoid, 142–172 μ × 132–144 μ. [PLATE 1, FIGURE 3; PLATE 5, FIGURES 15, 16.]

Neomeris stipitata was collected at Singapore by Mr. H. N. Ridley or one of his assistants and was described and figured with much thoroughness and detail by Dr. Arthur H. Church of Jesus College, Oxford, in the Annals of Botany in 1895, as quoted above. Type material of the species is preserved in the herbarium of the New York Botanical Garden and in the botanical department of the museum of Oxford University.

Neomeris stipitata differs rather strikingly in several particulars from the other members of the *N. dumetosa* group. The specimens, which have been preserved in alcoholic media (ours transferred lately to 50 per cent. glycerine), are, at the present time, at least, very much less calcified than those of any other known species of the genus. Dr. Church writes us that he believes they have lost fully 50 per cent. of their lime since he studied them in 1895, but even at that time (*loc. cit.* 582) he was impressed by their "delicately calcified" condition as compared with the "densely calcified" *N. Kelleri* Cramer. Another peculiarity of *N. stipitata* is found in its long sterile basal portion, constituting nearly half the length of the adult plant, while in the allied species the sporangia appear within 1–4 mm. of the base of the adult plant. The branches of the first order are short, 150–410 μ long as compared with 500–1000 μ long in *N. dumetosa* and *N. van Bosseae*, and are 6–10, instead of 15–35, times as long as their median diameter. The corticating branches of the second order are quite often in threes instead of being uniformly in pairs, a character which, apparently, was not observed by Church and which has thus far not been noted in any other species of the genus. Partly as a result of the interpolation of these trimerous elements in the cortex, the arrangement of the facets is commonly very irregular, rather more so than might be inferred from Church's figures, 17, 21, and 24. The hairs, also, are less gelatinous, more rigid, more persistent, and more conspicuous than in other species of the genus.

4. **Neomeris mucosa** sp. nov.

Plants cespitose, mostly in clusters of 3–20, subcylindrical or subfusiform, 8–20 mm. long, 1.5–2.5 mm. thick, mostly 4–8 times as long as thick, bright or yellowish green in upper tenth to third, becoming chalky- or dingy-white below, apex often appearing somewhat obtuse or truncate when living, but commonly acute or acuminate on drying: successive whorls of primary branches mostly 120–300 in number, 85–150 μ apart in median regions; number of branches in a whorl in later stages usually 28–48: hairs all of one form, soft and mucilaginous, di-trichotomous above, a rather conspicuous chlorophylose tuft persisting at the apex: ends of branches of the second order in the mature stage forming a cortex with irregularly hexagonal or somewhat rhombic or triangular facets in close rather regular or at length sometimes not easily recognizable transverse rows, each pair of corticating branches lying in an obliquely radio-vertical plane, there being consequently twice as many transverse rows in the cortex as there are primary whorls, the number of facets in each row equaling the number of members in the primary whorl, the cortex usually persisting in the upper half and deeply alveolate on drying: branches of the first order of the first 10–12 whorls of the juvenile stage cylindrical, each commonly bearing three di-trichotomous assimilatory filaments; the succeeding branches of the first order in the younger stages cylindrical, clavate, or somewhat fusiform, 275–400 μ long, 95–115 μ in diameter, each bearing a pair of deciduous di-trichotomous assimilatory filaments, the primary branches mostly persisting, soon strongly calcified and more or less coherent in well separated, often somewhat divergent or reflexed transverse rings or bands of 2–6 or more, the sheathing lime-tubes showing on drying conspicuous orifices about 80 μ in diameter, thickness of the lime-sheaths usually less than half the diameter of the branch; mature corticated plants sometimes reverting toward the apex and bearing there whorls of filamentous non-corticating branches; branches of the first order of the mature stage cylindrical or clavate, 275–400 μ long, 40–72 μ in diameter in their basal and median parts, mostly 4–9 times as long as their median diameter, moderately and rather diffusely calcified, scarcely coherent, persistent: branches of the second order capitate, the terminal inflations 100–220 μ in greatest diameter, outwardly mammiform, subconical. or subrostrate, their walls thin, very mucilaginous, and often not easily visible after decalcification, the pedicels scarcely calcified, the terminal inflations strongly calcified throughout their entire surface, proximally, laterally, and distally, the lime-coating of the outer surface soon flaking off, usually persisting a little longer than the hairs: sporangia strongly calcified but mutually free, commonly appearing within 2–6 mm. from base of adult plant, 178–215 μ long (decalcified and including stalk), the calcareous capsule 20–55 μ thick; spores obovoid, 140–160 μ × 104–121 μ, their width usually $\frac{4}{5}$ to $\frac{2}{3}$ their length. [PLATE 1, FIGURE 5; PLATE 5, FIGURES 1–14.]

Growing on moderately exposed rocks, at and near low-water mark, usually associated with *Neomeris Cokeri* and sometimes also with *N. annulata*: Atwood (Samana) Cay, Bahamas, *Howe, 5308* (type); Cockburn Harbor, South Caicos, *Howe 5548;* Great Ragged Island, Bahamas, *Howe 5771.*

Neomeris mucosa is a well-marked species, differing from the other known species of the genus in the extremely gelatinous diaphanous character of its membranes, particularly those of the corticating utricles. After decalcification it is often difficult to trace the outlines of the various members of the plant-body, with the exception of the sporangia. From *N. dumetosa*, it differs, furthermore, in being a shorter and relatively stouter plant (8–20 mm. *vs.* 20–32 mm. long; 4–8 times *vs.* 15–20 times as long as thick), in the shorter and stouter primary branches (275–400 μ *vs.* 500–680 μ long; 4–7 times *vs.* 18–35 times as long as their median diameter), which are persistent and scarcely cohere in scales if we except those that belong to the earlier phases of development (and even then the coherence is of a different sort), in the calcification of the outer surfaces of the corticating facets, and in the distinctly obovoid spores. From *N. van Bosseae*, it differs also in its usually smaller size, in the shorter and stouter primary branches (275–400 μ *vs.* 570–1000 μ; 4–7 times *vs.* 15–30 times as long as their median diameter), which commonly cohere in a peculiar fashion in the earlier stages of the plant's ontogeny, in the not unusual reversions to the branches of the primary form, in strong calcification of the outer surfaces of the corticating facets, in the more obovoid spores, etc.

The earlier stages in the development of *Neomeris mucosa* are quite different from those of *N. annulata* and *N. stipitata*, in which species alone the earlier stages have previously been described and figured. Church[*] has distinguished five stages in the development of the Singapore plant, which we have in the present paper named *N. stipitata.* In *N. mucosa* we have noted but two or, at most, three, recognizable stages. While the plant is bearing its first 10 or 12 whorls the primary branches are cylindrical and each bears, as a rule, three assimilatory filaments (FIGURES 1 and 2). This possibly might be called stage I, but it is poorly defined and passes very gradually into a condition that is continued for many successive whorls — one in which the primary branches become stouter, often at length somewhat elongate barrel-shaped, each bearing two deciduous assimilatory filaments (FIGURES 3–5). The transition from this condition to the corticated sporangium-bearing state is abrupt. It is possible that corticating branches of the second order sometimes spring from sterile primary branches (Church's stage IV) but we have been unable to demonstrate that such is the case in the present species. Church's stage II, in which what appears to correspond to the original branch is divided into two segments, and his stage III, in which the basal segments are irregularly dilated so as to form a sort of cortex, appear to be wholly absent in *Neomeris mucosa.* In *Neomeris annulata*, according to Cramer,[†] the primary branches of the earlier whorls each bear, with few exceptions, only a single deciduous assimilatory hair, and the primary branches, as shown also by Solms,[‡] are, in several

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[*] Ann. Bot. 9: 581–608. *pl. 21–23.* 1895.

[†] Neue Denkschr. Schweiz. Naturf. Ges. 32: — (14, 15). *pl. 1. f. 1, 2, 3, 5.* 1890.

[‡] Ann. Jard. Bot. Buitenzorg 11: *pl. 8. f. 1, 13.* 1893.

or many of the later whorls, irregularly dilated so as to form a kind of cortex much as in *N. stipitata.* In *N. mucosa* we have never seen a primary branch terminating in a solitary hair and we have never seen the primary branches inflated in such a way as to simulate a corticating layer. The material of *N. annulata* figured by Cramer in connection with the characters mentioned came from Bermuda, and that figured by Solms was from Mauritius. In specimens of *N. annulata* from Bermuda we are able to confirm the observations of Cramer and of Solms, so far as concerns the stages studied and figured by them, but in a juvenile condition, showing only the first two whorls of branches, we find the branches of the second order in pairs.

Neomeris mucosa is preserved less well by adding formaldehyde to seawater than is the case with *N. annulata* and *N. Cokeri.* After a few weeks in such a solution, the plants can scarcely be handled without breaking across the main axis.

5. NEOMERIS ANNULATA Dickie, Jour. Linn. Soc. Bot. **14**: 198. 1874. — Solms, Ann. Jard. Bot. Buitenzorg **11**: 62–71. *pl. 8. f. 1, 3, 4, 7, 8, 12, 13, 17.* 1893. — Börgesen, Bot. Tidsskr. **28**: *272. f. 1, 2.* 1908.

? Corallina vermicula Nelson & Duncan, Trans. Linn. Soc. Bot. II. **1**: 200, 201. *pl. 26. f. 14–17.* 1876.

Neomeris Kelleri Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **30**: — (3–10, 39). *pl. 1; pl. 2. f. 1–12; pl. 3. f. 1, 2.* 1887; **32**: — (9–19). *pl. 1. f. 1–12; pl. 2. f. 1–6; pl. 4. f. 15–24.* 1890. — Vickers, Phyc. Barbad. **1**: *pl. 46.* 1908.

Plants scattered or more often densely gregarious, subcylindrical or somewhat fusiform-clavate, 5–25 mm. long, 1–2 mm. thick, light or yellowish green in upper half or third, becoming chalky-white below, subacute, in dried condition often appearing rather gradually tapering: successive whorls of primary branches mostly 60–175 in number, 115–250 μ apart in median regions; number of branches in a whorl 20–56: hairs all of one form, soon deciduous, persisting in a small apical tuft: ends of branches of the second order forming a cortex with hexagonal facets in transverse rows, each pair of corticating branches lying in a radio-vertical or somewhat oblique plane, there being consequently twice as many transverse rows in the cortex as there are primary whorls, the number of facets in each row equaling the number of members in the primary whorl, the cortex persisting in the upper half or three fourths and regularly reticulate or reticulate-alveolate on drying; plants of the younger stages often more or less corticated by irregular inflations of the primary branches: branches of the first order in the adult stage 200–280 μ long, 11–20 μ in diameter in their basal and median parts, mostly 12–21 times as long as their median diameter, at length strongly calcified and often more or less coherent laterally, the width of the intervening lime-masses commonly less than the diameter of the branches, which are persistent or sometimes deciduous in basal parts: branches of the second order strongly calcified and coherent by a continuous lime layer, capitate, the terminal inflations 80–135 μ in greatest diameter, outwardly gently arcuate or rounded-obtuse, occasionally acute or subrostrate, rather firm-walled, their outer surfaces uncalcified: sporangia strongly calcified and coherent laterally by their capsules, forming nearly complete or more or less interrupted transverse rings, mostly 165–230 μ long (decalcified and including stalk), the calcareous capsules 15–60 μ thick; spores oblong-obovoid to oblong-ellipsoidal, 115–175 μ × 46–80 μ, usually about twice as long as broad. [PLATE 1, FIGURE 2.]

TYPE LOCALITY: Mauritius; type specimen in the herbarium of the British Museum (Natural History).

DISTRIBUTION: Bermuda, southern Florida, and the West Indies; Mauritius, Madagascar, Savoe (Dutch East Indies, *Weber-van Bosse*); reported by Solms also from Cobija, Bolivia (now Chile) and from Tongatabu, Friendly Islands. The Mauritius type of *N. annulata* we have seen in the herbarium of the British Museum, but we have not made a microscopic examination of it. Judging, however, from the excellent figures given by Cramer and by Solms, and from East Indian specimens kindly communicated by Madame Weber-van Bosse, there is nothing to indicate that the plant of the Atlantic Ocean can be distinguished even varietally from that of the Indian and Pacific oceans. We have thus far collected *Neomeris annulata* at twenty-one stations in Bermuda, southern Florida, the Bahamas, Porto Rico, and Jamaica; Börgesen has reported the species from four stations in the Danish West Indies; and Miss Vickers has figured it from Barbados specimens. It grows on rocks, stones, and shells, in sheltered or moderately exposed places, usually near the low-water mark, though Dr. Börgesen records a specimen from a depth of 50 m. in the Danish West Indies.

6. NEOMERIS COKERI M. A. Howe, Bull. Torrey Club **31**: 97. *pl. 6. f. 3–12.* 1904; **32**: 580. 1905.

Plants solitary or cespitose, rarely widely gregarious, subcylindrical or clavate, 7–37 mm. long, 1.5–3 mm. thick, dark green in upper third or fifth, becoming grayish white below, apex rounded-obtuse or subtruncate, often exhibiting a delicate, translucent apiculum formed of the mantle-caps: number of successive whorls of branches mostly 60–175; number of branches in a whorl 12–56: hairs of two forms in separate alternating zones, those of one form consisting of a single, clavate, often curved or somewhat hooked cell rich in chlorophyl and having a maximum diameter about equal to that of the supporting cell, the apex acute, obtuse, or more often apiculate; those of the second form consisting of a somewhat similar though slightly narrower basal cell bearing at its apex one or two earlier caducous, more slender branches, these in turn each bearing 2–4 branches; unicellular hairs and basal cells of the multicellular persisting in the upper third or fifth of the plant, the surface after their fall appearing somewhat shaggy or minutely and irregularly punctate, a cortex being scarcely developed: branches of the first order lightly calcified, scarcely coherent; branches of the second order more strongly calcified, irregularly and imperfectly coherent, subfusiform, often somewhat curved or gibbous, broadest (100–150 μ) a little above the middle, tapering to a conico-truncate apex 22–34 μ broad at the insertion of the hair: sporangia strongly calcified, free or coherent in short rows of 2–8, 180–260 μ long (decalcified and including stalk), calcareous capsule 25–40 μ thick; spores obovoid or oblong-ellipsoidal, 140–190 μ × 82–94 μ. [PLATE 1, FIGURE 6]

TYPE LOCALITY: Opposite Current Town, Eleuthera, Bahamas.

DISTRIBUTION: Bahamas; commonly under shelving rocks, near low-water line.

We now have this very peculiar species from fourteen stations, all within the Bahamian archipelago.

B. TWO WEST INDIAN SPECIES OF ACETABULUM* OF THE POLYPHYSA SECTION

Acetabulum pusillum sp. nov.

Plants minute, short-stalked, 1–3 mm. high, grayish green, well calcified throughout but with especially heavy deposits of

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* In the Botanisk Tidsskrift **28**: 274, 275. 1908, Dr. F. Börgesen has remarked upon the present writer's employment of the generic name *Acetabulum* instead of the more usual *Acetabularia*, giving there the impression that the use of 1753 as the initial date

lime between the rays, the lime-coating often flaking off at maturity: disc solitary, nearly flat, 1–2.5 mm. in diameter; sporangia (rays) 6–17 (mostly 11–15), obovoid-clavate to clavate-subfusiform, 2–3½ times as long as greatest width (which is at two thirds or three fourths of their length), bluntly subconical, obtusely taper-pointed, or occasionally rounded obtuse, rather easily separable and often more or less free on drying, mostly free in mature specimens after decalcification; coronal processes very small, short-cylindrical, slightly enlarged at the top and appearing oval or orbicular in surface view, 22–35 μ in greatest diameter, each bearing 2 (rarely 3) hairs, hair-rudiments, or hair-scars; hypopeltal processes wanting: aplanospores 15–60 in a sporangium, globose or ellipsoid, 68–82 μ in greatest diameter: stipe occasionally corrugated and enlarged in the upper part, 0.1–0.2 mm. in maximum diameter. [PLATE 6, FIGURES 13–15; PLATE 7, FIGURES 1–4.]

On a reef, near low-water mark, with *Neomeris annulata* and *Acetabulum polyphysoides*, Montego Bay, Jamaica, *Howe 5029a* (type), January 19, 1907; Mariguana, Bahamas, *Howe 5453;* Castle Island, Bahamas, *Howe 5731b.*

Acetabulum pusillum differs from *A. polyphysoides*, with which it is sometimes associated, in its smaller size, in being strongly calcified throughout, in the character of the coronal processes, which are only 22–35 μ instead of 75–150 μ in diameter and bear only 2 (rarely 3) instead of 5–13 hairs, and in the smaller aplanospores, which are 68–82 μ instead of 88–190 μ in diameter. It is one of the most minute of the species thus far described in the genus, the average diameter of the disc being about 1.6 mm.

The nearest relatives of *Acetabulum pusillum* are apparently two East Indian species, *Acetabularia exigua* Solms * and *A.*

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of botanical nomenclature would prevent the adoption of *Acetabulum*. As a matter of fact, the generic name in its original Tournefortian form was used in Boehmer's edition of Ludwig's Definitiones Generum Plantarum (p. 504) in 1760, Tournefort being there cited, as he was cited also by Linnaeus two years earlier, in establishing the binomial *Madrepora Acetabulum* (Syst. Nat. 793. 1758), so the name is technically free from whatever opprobrium there may be in prelinnaeanism. The generic name *Acetabulum* was used also by Lamarck in 1816 (Hist. Nat. Anim. sans Vertèb **2**: 149), though this fact has no bearing on the priority question, as it was four years later than Lamouroux's establishment of *Acetabularia* (Nouv. Bull. Sci. Soc. Philom. **3**: 185. 1812). However, *Olivia* (Bertol. Rar. Pl. Ital. Dec. **3**: 117. 1810), to which no valid exception can be taken, antedates *Acetabularia* and must be preferred to it under any enforcement of priority principles, unless a comparatively modern date be taken as a starting point. Under the circumstances, we prefer the original *Acetabulum*, which has a clear post-1753 claim upon our favor.

* Trans. Linn. Soc. Bot. II. **5**: 28. *pl. 2. f. 1, 4.* 1895.

parvula[*] Solms, described from material collected by Mme. Weber-van Bosse at Macassar, Celebes, and vicinity; yet the West Indian plants in our opinion cannot be well identified with either one of these East Indian forms, specimens of which we have seen through the generosity of the collector. Of the character of the calcification in *Acetabularia exigua*, Solms states "I am unable to say anything more definite as to the calcification of the sporangial membrane of this species than that the few sterile specimens from Macassar were uncalcified. The others came under my observation only after lengthened treatment with acid. However, their sporangial rays are so widely separated from each other that a union of these by means of lime-incrustation is scarcely likely." In the single specimen of *A. exigua* that we have seen the rays are entirely free, spore-bearing, and are well incrusted with lime over their whole surface except for their apices and small areas here and there which have been left naked and smooth by an evident flaking-off of the lime-crust. The aplanospores in this specimen are 82–91 μ in diameter. From *Acetabularia exigua* Solms, *Acetabulum pusillum* differs in its usually smaller size, in the more coherent, less pointed, commonly more numerous rays, which are broadest at two thirds or three fourths their length instead of near their middle, and in the smaller coronal processes, which nearly always bear two instead of three hairs or hair-rudiments.

In *Acetabularia parvula* Solms, the calcification of the disc is confined to the contact faces of the rays and to a narrow sharply defined zone involving the bases of the rays and flanking the coronal processes; the projecting interradial lime-buttons, described and figured by Solms, are apparently not always present, and such, so far as we have observed, are wholly wanting in *Acetabulum pusillum*. *Acetabulum pusillum* further differs from *Acetabularia parvula* Solms in its commonly smaller size, in the often fewer, usually pointed, instead of rounded-obtuse or subtruncate-obtuse, rays, which are broadest at two thirds or three fourths their length instead of at their extreme ends, and in the smaller coronal processes (22–35 μ *vs.* 42–55 μ), which in nearly all cases bear two instead of three or four (!) hairs; the aplanospores of the East Indian plant are still undescribed.

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[*] *Loc. cit.* 29. *pl.* 2. *f.* 3, 5.

ACETABULUM POLYPHYSOIDES (Crouan) Kuntze, Rev. Gen. Pl. **2**: 881. 1891

Acetabularia polyphysoides Crouan; Schramm & Mazé, Essai Alg. Guad. 101. 1866; Mazé & Schramm, Essai Alg. Guad. 84. 1870–77 (*nomen seminudum*); — Solms, Trans. Linn. Soc. Bot. II. **5**: 29. *pl. 4. f. 2, 6.* 1895; Vickers, Phyc. Barbad. **1**: *pl. 47.* 1908.

Plants small, short-stalked, 2–7 mm. high, light green, rays of the disc little calcified except in the contact-areas, the interradial lime-masses shorter than the rays and inconspicuous (sometimes almost wanting) or slightly projecting at the margin with flabelliform or inversely deltoid apical expansions: disc nearly flat or cup-shaped, solitary, 2–5 mm. in diameter, the margin subentire or stellate-dentate; sporangia (rays) 11–25 (mostly 11–18), varying from inflated-obvoid and about twice as long as broad to clavate-cylindrical or subfusiform and 3–5 times as long as greatest width, rather easily separable and often more or less free, rounded-obtuse at apex or obtusely taper-pointed, obtusely subrostrate or bluntly subconical; coronal processes knob-like, oval-elliptical in surface view, 75–150 μ in longest (radial) diameter, each bearing 5–13 (usually 8–10) hairs, hair-rudiments, or hair-scars arranged in an elliptical manner; hypopeltal processes wanting: aplanospores 6–50 in a sporangium, globose, ovoid, or ellipsoid, 88–190 μ in greatest diameter: stipe usually much corrugated, often enlarged in the upper part, reaching a maximum diameter of 0.35–0.70 mm. [PLATE 6, FIGURES 16–20; PLATE 7, FIGURES 5–9.]

Low littoral to at least 4–5 m. of water. Pointe-à-Pitre, Guadeloupe, *Mazé;* Atwood Cay, Bahamas, *Howe 5310, 5212;* Malcolm Road, Caicos Islands, *Howe 5652;* Castle Island, Bahamas, *Howe 5731a;* Montego Bay, Jamaica, *Howe 5029b.*

Acetabulum polyphysoides deltoideum forma nova. Sporangia (rays) mostly 7, vesicular-inflated, inversely deltoid or obovoid-deltoid when viewed from above, about as broad as long; coronal processes with 6–8 hairs or hair-rudiments. [PLATE 6, FIGURE 21; PLATE 7, FIGURE 10.]

Low littoral, with *Neomeris Cokeri* and *Acetabulum polyphysoides*, Atwood Cay, Bahamas, *Howe 5311*, December 4, 1907. Only six or seven plants of forma *deltoideum* were found; they were growing intermingled with our *5310* (see PLATE 7, FIGURE 9), which we are referring to *A. polyphysoides* without a distinctive form name, even though the rays are commonly narrower and more pointed than in the Guadeloupe plants. No connecting forms between our *5311* and *5310* were observed and the two are rather strikingly different in habit, but the specimens of the former are infertile and as some of the Guadeloupe representatives of *A. polyphysoides* have a somewhat intermediate appearance, we cannot do otherwise, for the present, than to consider *deltoideum* a form of this species.

C. A NEW HALIMEDA

Halimeda lacrimosa sp. nov.

Dark gray-green in the younger parts when living, becoming albescent or white with age, soon decumbent, weak and straggling in habit, estipitate, 2–5 cm. in height or length, very strongly calcified, the calcification soon involving the medulla and the entire length of the peripheral utricles; branching irregularly dichotomous or trichotomous, largely but not wholly in a single plane, the nodes in decumbent forms now and then rhiziniferous, or somewhat stoloniferous: segments obovoid, pyriform, or subglobose, occasionally subterete, 1–5 mm. long, 1–5 mm. broad or thick (those near base scarcely different or often a little smaller), solid, firm, and stone-like, or the larger very often more or less hollow or cavernose in the medullary region and easily crushed on drying, the surface compact, smooth, and commonly nitent: peripheral utricles mostly rather obconical, usually somewhat flaring at surface, 40–110 μ long, 33–37 μ in average maximum diameter in surface view, truncate or very slightly rounded at apex with apical walls often incrassate, retuse on drying, lateral walls in contact for only $\frac{1}{10}$ – $\frac{1}{30}$ their length but commonly coherent on decalcification: utricles of the subcortical layer in a single series, clavate-capitate, their subglobose or obovoid heads mostly 66–110 μ in maximum diameter, each bearing 6–18 peripheral utricles: filaments of the central strand fusing in twos, threes, or rarely fours at the nodes, the resulting filaments sometimes again incompletely fused in twos, threes, or fours: sporangia unknown. [PLATE 4, FIGURE 1; PLATE 6, FIGURES 3–11.]

In the Bahama Islands, from near low-water mark down to a depth, at least, of ten or twenty meters: Mariguana (near the Southeast Point), *no. 5524*, type (11 December, 1907, M. A. H.), and *nos. 5492* and *5504;* Great Ragged Island, *no. 5810;* and Ship Channel Cay, *no. 3947*.

A peculiar species, without close affinities among the species of the genus hitherto described. It is apparently more common in the sublittoral or elittoral zone than in the littoral, which perhaps accounts for the rarity with which it has been collected. In respect to the prevailing mode of fusion of the nodal filaments of the central strand, *H. lacrimosa* has most in common with the *H. Tuna* group, although there is sometimes also a secondary incomplete fusion of the fused filaments or perhaps it would be better to say that several or many (6–8 or more) filaments sometimes fuse imperfectly or for a very short distance into one. But in general habit and form, *H. lacrimosa* is little suggestive of *H. Tuna* or of any other *Halimeda* known to us. The subcortical utricles are chlorophylose and as a rule they become readily visible from the exterior after decalcification.

D. UDOTEA CONGLUTINATA AND UDOTEA CYATHIFORMIS

Udotea conglutinata (Ell. & Soland.) Lamour. and *U. cyathiformis* Decaisne have been quite commonly combined by students of the *Codiaceae*, a circumstance that easily is explicable, inasmuch as *Udotea cyathiformis* is often scarcely more cyathiform than *U. conglutinata* and inasmuch as some of the other more obvious ordinarily distinctive characters are subject to a considerable degree of variation. The writer has shared in this misconception, as he now considers it, and has distributed at least one series of specimens of *U. cyathiformis* * to various herbaria as *Udotea conglutinata*. But with added experience with both living and dried specimens, it has become increasingly evident that the *Udotea conglutinata* group in the West Indies embraces at least two species. The Ellis & Solander "types" appear to have been lost, but in view of the only figure of "*Corallina conglutinata*" given by them there can be no reasonable doubt as to which of the two forms was before them, even though their description is not altogether conclusive. The probable type material of *Udotea cyathiformis* Decaisne is represented in the herbarium of the Muséum d'Histoire Naturelle in Paris by two specimens now on one herbarium-sheet but fastened to separate smaller sheets. Below the lower, less cyathiform of the two specimens, is a "Herb. Mus. Paris." label, on which is inscribed in Decaisne's hand, "Udotea Acetabulum D^{ne}. Iles des Saintes, près la Guadeloupe. M. D'Avrainville, 1842." The specific name was apparently changed to *cyathiformis* on publica-

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* *No. 3976*, from the Cave Cays, Exuma Chain, Bahamas.

tion, without a corresponding change in the herbarium label. The two specimens agree essentially with the cyathiform plants from Bemini Harbor, Bahamas, shown in FIGURE 2 of our PLATE 3, which, by the way, were found growing with more numerous plants of *U. conglutinata*, one of which is photographed on PLATE 2 (the largest plant). The plants shown in the upper half of our PLATE 3 are rather strikingly different from the typical *Udotea cyathiformis*; they are, in fact, so *Penicillus*-like in habit that on finding them we were inclined for a time to look upon them as a probably new cyathiform species of *Penicillus*, but on a microscopic examination nothing could be found to distinguish them satisfactorily from the typical *U. cyathiformis.* They were growing on sand-covered rocks at the low-water line, a position that would presumably have been unfavorable to a full and normal development. Specimens from Culebra Island, Porto Rico (*no. 4338* in herb. N. Y. Bot. Garden), apparently bridge over the gap in habit between these short *Penicillus*-like plants and the normal *U. cyathiformis.* The plants from Key West, Florida, figured by W. H. Harvey (Ner. Bor.-Am. 3 : *pl. 40C*) as *Udotea conglutinata* are, with little doubt, *U. cyathiformis*, as would appear from the very distinct longitudinal striations of the flabellum in the natural-size figures and from the rather straight and rigid character of the filaments in the detailed enlargement.

Photographs of representatives of *Udotea conglutinata* and *U. cyathiformis* are given herewith and below are descriptions and a key which includes the more important diagnostic characters. The characters of the stipe-cortex, which we have illustrated by drawings (PLATE 8, FIGURES 8–13) we have found especially reliable in determining occasional forms whose relationships might otherwise seem a little doubtful.

Flabellum plane; transition from stipe to flabellum gradual; filaments of flabellum 28–60 μ in diameter, interwoven and tortuous, usually forming a superficial tomentulose nap; branches of the corticating filaments of the stipe somewhat loosely and irregularly fastigiate, the ultimate divisions mostly finger-shaped, subacute, or taper-pointed.. *U. conglutinata.*

Flabellum more or less cyathiform or open on one side and almost plane (then usually a little concavo-convex, at least at base); transition from stipe to flabellum abrupt; filaments of flabellum nearly straight and parallel, mostly 60–100 μ in diameter; branches of corticating filaments of stipe compactly cymose-fastigiate, the ultimate divisions scarcely longer than broad, truncate, truncate-obtuse, or commonly with expanded truncate-capitate apices..... *U. cyathiformis.*

UDOTEA CONGLUTINATA (Ell. & Soland.) Lamour. Hist. Polyp. 312. 1816

Corallina conglutinata Ell. & Soland. Nat. Hist. Zooph. 125. *pl. 25. f. 7.* 1786.

Flabellaria conglutinata Lamarck, Ann. Mus. Hist. Nat. **20**: 301. 1813.

Plants 3–9 cm. high, from a bulbous, subfusiform, or fasciculate-funicular rhizoidal base, light-, yellowish-, or albescent-green, more or less strongly calcified; stipe simple, subterete below, commonly flattened, expanded, and cuneate above, 0.5–3.0 cm. long, mostly 1.5–7.0 mm. wide, corticated, its surface very minutely tomentulose-spongiose or somewhat compact and smooth: transition in structure from stipe to flabellum gradual, the flabellum uncorticated except at the very base, plane, semiorbicular, cuneate-obovate, subreniform, spatulate, or rarely cuneate-ligulate, 1.5–7 cm. long, 0.5–11 cm. wide, subentire, erose-sinuate, or irregularly lobate, rarely with innovating conformable lobes, for the most part distinctly zonate, the base cuneate, cuneate-truncate, or occasionally subarcuate, the surface longitudinally strigose, or commonly spongiose or subvelutinous: filaments of the flabellum interwoven in several or many layers, in most cases forming a superficial tomentulose nap by repeated dichotomies, the ultimate branches usually short, tortuous, and often somewhat divaricate, each filament, except in a very juvenile state, enclosed in a porose calcareous sheath, destitute of lateral branches or appendages, constricted just above the dichotomies and sometimes here and there in intervening parts, rarely subtorulose, 28–60 μ in diameter (decalcified; often larger under a dichotomy); pits of the calcareous sheath rounded or angular, mostly 8–20 μ in diameter; branches forming the stipe-cortex slender, rather flexuous and tortuous, somewhat loosely and irregularly fastigiate, the ultimate divisions mostly finger-shaped, subacute or taper-pointed, 8–19 μ in diameter. [PLATE 2; PLATE 8, FIGURES 11–13.]

TYPE LOCALITY: Bahama Islands.

DISTRIBUTION: Bermuda, southern Florida, and the West Indies.

UDOTEA CYATHIFORMIS Decaisne, Ann. Sci. Nat. II. **18**: 106. 1842

Udotea conglutinata Vickers, Phyc. Barbad. **1**: *pl. 32.* 1908; probably also Harvey, Ner. Bor.-Am. **3**: *pl. 40C.* 1858.

Plants 2–17 cm. high, from a bulbous, subfusiform, or fasciculate-funicular rhizoidal base, usually dark- or yellowish-green when living, becoming more or less albescent on drying, moderately calcified and often remaining flexible, or more encrusted with age; stipe simple, mostly subterete, sometimes a little expanded and flattened above, 0.2–5.0 cm. long, 1–6 mm. wide, corticated, its surface compact and smooth: transition in structure from stipe to flabellum abrupt, the flabellum uncorticated, cyathiform, now and then 1–5 cleft nearly or quite to the base, or more often early divided to base on one side and becoming almost plane, but usually remaining more or less concavo-convex at extreme base, then mostly triangular-obovate, subcuneate-obovate, semiorbicular, spatulate, or spoon-shaped, 1–11 cm. long, 1–9 cm. wide, subentire, often becoming irregularly laciniate-fimbriate, rather faintly or occasionally not at all zonate, the surface longitudinally strigose: filaments of the flabellum in several or many layers, nearly straight, parallel and rigid, somewhat flexuous and interwoven, distinct, often suggesting those of *Penicillus*, each enclosed in a porose calcareous sheath, destitute of lateral branches or appendages, constricted just above the dichotomies, 40–135 μ (mostly 60–100 μ) in diameter (decalcified; often larger under a dichotomy), pits of the calcareous sheath rounded or angular, mostly 5–18 μ in diameter; branches forming the stipe-cortex in compact cymose-fastigiate clusters, the ultimate divisions scarcely longer than broad, truncate, truncate-obtuse, or very commonly with expanded truncate-capitate apices, 8–50 μ in diameter. [PLATE 3; PLATE 8, FIGURES 8–10.]

TYPE LOCALITY: Iles des Saintes, near Guadeloupe, West Indies.

DISTRIBUTION: Southern Florida and West Indies.

E. A NEW BAHAMIAN UDOTEA

Udotea spinulosa sp. nov.

Plants 7–8 cm. high from a fusiform or fasciculate-funicular rhizoidal base, grayish green, strongly calcified; stipe simple, subterete below, flattened above, 1–2 cm. long, 3–4 mm. wide, corticated, its surface nearly smooth or minutely velutinous-tomentulose: flabellum obovate with a subcuneate base, 5–6 cm. long, 4–6 cm. wide, 0.4–0.6 mm. thick, longitudinally furrowed or striate, not at all or very faintly zonate, rather rigid and brittle when dry, lateral margins subentire, apical margin more or less laciniate and commonly fractured, the surface appearing minutely corrugated or spongiose-velutinous under a lens, becoming compact and nearly smooth toward the base: filaments of the flabellum in 3–7 layers, nearly parallel or flexuose and interwoven, subcylindrical, sparingly dichotomous, strongly constricted just above the dichotomies, 46–84 μ in diameter, enclosed in a non-porose calcareous sheath especially in the outer parts, or irregularly incrusted, the superficial (or the interior wherever they touch the surface) thickly beset externally with short cylindrical, truncate-conical, subturbinate, or obconical processes 16–40 μ in diameter, each crowned with 2–8 acuminate prongs or spines formed by 1–3 close-set dichotomies, these lateral processes (mostly 55–160 μ long, including their spinulose crowns) forming an imperfect kind of cortex; medullary filaments of the stipe 70–110 μ in diameter, the lateral corticating branches 4–6 times dichotomous, their ultimate divisions taper-pointed, mostly 28–200 μ long and 8–24 μ in median diameter. [PLATE 4, FIGURE 2; PLATE 8, FIGURES 1–7.]

Collected on a sandy bottom near low-water mark in Bemini Harbor, Bahamas, *Howe 3272*, April 17, 1904.

Udotea spinulosa is most closely allied to *Udotea Palmetta* Decaisne,* but is sufficiently distinguished, we believe, by the

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* *Udotea Palmetta* Decaisne was misinterpreted and wrongly described by J. Agardh, who apparently never saw an authentic specimen of it, and his conception of the species has been adopted by most of the later writers who have referred to it, though A. & E. S. Gepp have seen the type specimens and have recently published critical notes upon them (Trans. Linn. Soc. Bot. II. 7: 175. 1908). The type in the herbarium of the Muséum d'Histoire Naturelle in Paris is represented by two plants accompanied by a loose label, on the bottom of which is printed "Herbier Du Petit-Thouars." This label is inscribed in ink "Udotea palmetta D^{ne}, Flabellaria" and "Decaisne scripsit" has been added below in pencil. No locality is given. Decaisne's description was brief, as are also the notes recently added by A. & E. S. Gepp, and the evident types are therefore described in a little more detail below:

UDOTEA PALMETTA Decaisne, Ann. Sci. Nat. II. 18: 105. 1842.

Plants 5.5 cm. high from a subterete or fusiform rhizoidal base, albescent, much calcified throughout; stipe simple, subterete, about 1 cm. long, 1–4 mm. wide, its surface minutely velutinous (nearly smooth under low magnification); flabellum orbicular or obovate, 4.2–4.8 cm. long and of about equal width, 0.09–0.16 mm. thick, rounded or subcordate at base, rather indistinctly and closely zonate (about 16 zones in 4 cm.), plane, longitudinally striatulate, soft and flexible, margins erose or shortly lacerate, the surface appearing strigulose or very minutely pulverulent-punctate under a lens: filaments of the flabellum in 3–5 layers, flexuose and interwoven or somewhat parallel, sparingly dichotomous, sometimes slightly constricted above the dichotomies, 22–30 μ in the major diameter, the superficial more or less flattened laterally (*i. e.* in a plane perpendicular to the surface) and often only 8–16 μ in the minor diameter, all irregularly and amorphously incrusted with lime, crested superficially, wherever they touch the surface, with a single or double usually secund series of simple, geminate or once furcate spines or sharp teeth, these 11–30 μ long, sometimes irregularly curved or subuncinate; medullary filaments of the stipe 19–33 μ in diameter, the lateral corticating branches 2–4 times dichotomous, the ultimate divisions taper-pointed, mostly 27–80 μ long and 8–11 μ in median diameter.

thicker (0.4–0.6 *vs.* 0.09–0.16 mm.), more rigid, less zonate flabellum and its subcuneate base, by the larger (46–84 μ *vs.* 8–30 μ), less flattened filaments, which are regularly and strongly constricted above the dichotomies, and by the character of their lateral appendages, which are closely 1–3 times dichotomous instead of simple or once furcate and are 55–160 μ long instead of 11–30 μ, long, the spines crowning a thick stump-like base or pedestal instead of being practically sessile.

From *Udotea argentea* Zanard., judging by the original description and figures, by a description recently published by A. & E. S. Gepp,* and by American plants which we are somewhat doubtfully identifying with that species, *U. spinulosa* differs in its much thicker, more rigid, less zonate flabellum, which is 3–7- instead of 1- or 2-stratose, in the filaments being constricted above the dichotomies, in their spine-like instead of obtuse, truncate, or capitate appendages, which are secund instead of commonly protruding in all directions, and in the taper-pointed instead of truncate or obtuse ultimate divisions of the stipe-cortex.

From *Udotea conglutinata, U. spinulosa* differs greatly in the presence of appendages on the filaments of the flabellum and in the calcareous sheaths of the filaments being non-porose.

From *Udotea Flabellum*, with its strongly marked zonations and highly differentiated cortex, the present species is so widely different that comparison is unnecessary.

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* Trans. Linn. Soc. Bot. II. 7 : 176. 1908.

Explanation of plates 1-8

PLATE 1

1. *Neomeris dumetosa.* Photograph of probably authentic specimens now preserved in the herbarium of the Muséum d'Histoire Naturelle of Paris.

2. *Neomeris annulata.* Photograph of fluid-preserved specimens from Bermuda (*Howe 320*).

3. *Neomeris stipitata.* Photograph of fluid-preserved type specimens from Singapore (*Ridley*).

4. *Neomeris van Bosseae.* Photograph of fluid-preserved type specimens from Sikka, Flores, Dutch East Indies (*A. Weber-van Bosse 1196*).

5. *Neomeris mucosa.* Photograph of fluid-preserved type specimens from Atwood (Samana) Cay, Bahamas (*Howe 5308*).

6. *Neomeris Cokeri.* Photograph of fluid-preserved specimens. The four large plants to the left (New Providence, Bahamas, *Howe 3075*) represent an unusually large condition of the species (see Bull. Torrey Club **32**: 580. 1905). The remaining specimens (Atwood Cay, Bahamas, *Howe 5309*) are of the normal form and size.

7. *Neomeris van Bosseae.* Photograph of dried specimens in the Muséum d'Histoire Naturelle of Paris, collected by W. H. Harvey in the Friendly Islands and distributed by him as *Neomeris dumetosa.*

The photographs all represent the plants in their natural size.

PLATE 2. *Udotea conglutinata*

The largest plant (fluid-preserved) is from Bemini Harbor, Bahamas (*Howe 3240a*); the smallest (dried), at the upper right-hand corner, is from Castle Island, Bahamas (*Howe 5741a*); the remaining (dried) are from Watling Island, Bahamas (*Howe 5237*); all are of the natural size.

PLATE 3. *Udotea cyathiformis*

1. The more or less *Penicillus*-like (fluid-preserved) plants photographed in the three upper rows are from Cockburn Harbor, South Caicos (*Howe 5547*). Natural size.

2. The five or six (fluid-preserved) plants of the lowest row (Bemini Harbor, Bahamas, *Howe 3240b*) represent the typical form of the species. The middle plant is almost perfectly cyathiform, with, however, a slit down one side of the cup-like flabellum; the plant at the extreme left has a merely concavo-convex or slightly spoon-shaped flabellum and approaches in form certain conditions of *U. conglutinata.* Natural size.

PLATE 4

1. *Halimeda lacrimosa.* The three larger plants at the left of the photograph, the type specimens, are from the island of Mariguana, Bahamas (*Howe 5524*), where they were dredged in 3 or 4 m. of water; the small plant at the right is from 10 to 20 m. of water on Great Ragged Island, Bahamas (*Howe 5810*). Natural size.

2. *Udotea spinulosa.* Photograph of type specimens (dried) from Bemini Harbor, Bahamas (*Howe 3272*). Natural size.

PLATE 5

1–14. *Neomeris mucosa*

1. A young stage, with the first four whorls of primary branches.

2. Two members of the fourth whorl of plant shown in Figure 1, showing trimerous branches of the second order.

3. Apical portion of a young plant before the beginning of cortication.

4. A portion of a plant in a similar young stage, showing the widely spaced divaricate or somewhat recurved primary whorls.

5. Five members of a somewhat younger whorl, showing form of the primary branches, their calcification, etc.

6. Parts of two whorls of a later stage, viewed from without, indicating the calcareous sheaths of the primary branches; the branches of the second order have fallen and the ends of the primary branches have to some extent collapsed and drawn away from the enclosing lime-tubes.

7. A portion of the cortex of adult stage in surface view. In the two upper rows the entire surface is calcified except the hair-scars; below, the superficial crust of lime has partly flaked off, leaving the surface of the plant more or less reticulate-alveolate.

8. A primary branch, with sporangium, decalcified.

9. Branches of the first and second orders of adult condition, in lateral view, decalcified, with sporangia; the sketch gives a suggestion of the oblique plane in which each pair of corticating branches lies.

10. A portion of the surface of the adult condition, decalcified, showing form and arrangement of the corticating inflations.

11. A portion of an older part of the cortex, decalcified, showing a less regular form and arrangement of the corticating elements.

12. Two calcified sporangia from the same whorl in proximal view, showing positions of the pedicels of the two corresponding pairs of corticating branches.

13. Parts of two whorls of sporangia, calcified, in distal view, showing their form, mutual relations, and the positions of the pedicels of the corresponding pairs of corticating branches.

14. A part of an adult fertile whorl, the shading indicating the distribution and extent of the calcification.

Figures 1–4, 7–12, and 14 are drawn from the type material (Atwood Cay, Bahamas, *Howe 5308*); 5, 6, and 13 are from *no. 5548* (Cockburn Harbor, South Caicos). Figures 1, 3, and 4 are enlarged 28 diameters; 2, and 5–14, 40 diameters.

15 and 16. *Neomeris stipitata*

15. A primary branch of adult fertile condition, bearing two secondary (corticating) branches, decalcified.

16. One of the not uncommon primary branches that bear three secondary (corticating) branches, decalcified.

Both figures are enlarged 40 diameters.

17–19. *Neomeris van Bosseae*

17. Portion of the decorticated surface of adult plant, showing the tips of the mutually free calcified primary branches. (The tips should be distinctly in pairs more often than the drawing indicates, for the stumps of the broken-off secondary branches often persist and show on the surface as independent tubes).

18. A single primary branch, with its lime-coating.

19. Portions of two primary branches, loosely coherent by the intercalary lime.

Figures 17 and 18 are drawn from the type material (Sikka, Flores, Dutch East Indies, *A. Weber-van Bosse 1196*); 19, from a specimen collected in the Friendly Islands by W. H. Harvey. Figure 17 is enlarged 40 diameters; 18 and 19, 55 diameters.

20. *Neomeris dumetosa*

Portion of the decorticated surface of an adult plant, showing the coalescence of the primary branches and intercalary lime-deposits into transverse scales. The figure is enlarged 40 diameters and is drawn from a fluid-preserved specimen collected on the island of Fau, Dutch East Indies, by A. Weber-van Bosse.

PLATE 6

1 and 2. *Neomeris dumetosa*

1. A scale formed by the coalescence of five primary branches and the intercalary lime-masses; from Fau, Dutch East Indies (*A. Weber-van Bosse*).

2. A similar scale from a presumably authentic specimen in the Muséum d'Histoire Naturelle of Paris (see Plate 1, Figure 1).

Figures 1 and 2 are enlarged 55 diameters.

3–12. *Halimeda lacrimosa*

3. Utricle of the subcortical layer, bearing six peripheral utricles.

4. Utricle of the subcortical layer, bearing twelve or more peripheral utricles.

5. Utricle of the subcortical layer with about twelve peripheral utricles.

6. Peripheral utricles in surface view, decalcified, the dotted lines indicating the form and position of the utricles of the subcortical layer, which are often clearly visible through the peripheral utricles.

7. Utricle of the subcortical layer of characteristic form, bearing probably twelve peripheral utricles, the latter showing incrassate outer walls.

8. Utricle of the subcortical layer, bearing fourteen peripheral utricles, the latter with only slightly thickened outer walls.

9. Filament from central strand of node, showing complete fusion of two filaments to form one.

10. Filament from central strand of node, showing complete fusion of four filaments to form one.

11. Filament from central strand of node, showing complete fusion of three filaments to form one.

12. Filaments from central strand of node, showing complete fusion of eight filaments to form four which, at their point of origin, are incompletely fused into one.

All the figures are drawn from decalcified type-material (Mariguana, Bahamas, *Howe 5524*). Figures 3–6 and 9–12 are enlarged 40 diameters; 7 and 8, 150 diameters.

13–15. *Acetabulum pusillum*

13. Bases of four sporangia from above, showing the coronal processes, each with two hairs or hair-scars.

14. Base of a single sporangium in lateral view, showing coronal process, etc.

15. Base of a sporangium from above, showing the coronal process with three hairs or hair-rudiments.

Figures 13 and 14 are drawn from the type material (Montego Bay, Jamaica, *Howe 5029a*); 15 is from *no. 5453* (Mariguana, Bahamas). All of the figures are enlarged 150 diameters.

16–20. *Acetabulum polyphysoides*

16. Base of sporangium from above, showing coronal process with twelve hairs (including rudiments and scars).

17. Bases of sporangia of common form, showing coronal processes with nine and ten hairs (including rudiments and scars).

18. A sporangium-base, similar to that shown in Figure 17, in lateral view.

19. A coronal process with seven hairs (including rudiments and scars).

20. A rare form of coronal process with only five hairs (including rudiments and scars).

Figure 16 is drawn from *no. 5310* (Atwood Cay, Bahamas); 17 and 18 from *no. 5731a* (Castle Island, Bahamas); 19 and 20 from *no. 5312* (Atwood Cay, Bahamas). All of the figures are drawn from decalcified material and are enlarged 150 diameters.

21. *Acetabulum polyphysoides deltoideum*

Coronal process, decalcified, viewed from above, and showing seven hairs (including rudiments and scars). Drawn from the type material (Atwood Cay, Bahamas, *Howe 5311*) and enlarged 150 diameters.

PLATE 7

1–4. *Acetabulum pusillum*

1. A mature plant, with lime coating.

2. A mature fertile plant, decalcified.

3. A large sterile plant, decalcified. (See Plate 6, Figures 13 and 14.)

4. A large fertile disc with unusually obtuse sporangia, decalcified. (See Plate 6, Figure 15).

Figures 1–3 are drawn from the type material (Montego Bay, Jamaica, *Howe 5029a*); 4, from *no. 5453* (Mariguana, Bahamas). All of the figures are enlarged 16 diameters.

5–9. *Acetabulum polyphysoides*

5. A disc, decalcified, from above, showing twenty-five lightly coherent, obtusely taper-pointed or subrostrate sporangia. (See Plate 6, Figures 17 and 18.)

6. Sporangia from another disc, natural, the shaded areas indicating the distribution of the lime.

7. A disc, decalcified, with seventeen free obtuse sporangia, showing also the corrugated upper portion of the stipe.

8. Sporangia, natural, the shaded areas indicating the extent and distribution of the calcification.

9. More inflated sporangia, decalcified. (See Plate 6, Figure 16.)

Figures 5–7 are drawn from *no. 5731a* (Castle Island, Bahamas); 8, from *no. 5029b* (Montego Bay, Jamaica); 9, from *no. 5310* (Atwood Cay, Bahamas). All of the figures are enlarged 16 diameters.

10. *Acetabulum polyphysoides deltoideum*

A sterile disc, with seven sporangia, decalcified, from above. (See Plate 6, Figure 21.) Drawn from the type material (Atwood Cay, Bahamas, *Howe 5311*) and enlarged 16 diameters.

PLATE 8

1–7. *Udotea spinulosa*

1. Cross-section of the flabellum, natural. The shading indicates rather too much lime for the medullary portions.

2. Cross-section of the flabellum, decalcified.

3. The tip of a filament from the apical margin of the flabellum, decalcified.

4. Portion of a superficial filament from near the middle of the flabellum, decalcified. The teeth form a part of the surface-covering of the flabellum

5. A crown of superficial spines from near the base of the flabellum, decalcified.

6. A dichotomy of a flabellum-filament, decalcified, showing the constrictions just above it. (The filaments are somewhat twisted and are viewed a little obliquely.)

7. A crown of spines from the stipe-cortex, decalcified.

All of the figures are drawn from the type material (Bemini Harbor, Bahamas, *Howe 3272*). Figures 1 and 2 are enlarged 40 diameters; 3–7, 150 diameters.

8–10. *Udotea cyathiformis*

8–10. Ultimate ramifications of the corticating filaments of the stipe.

Figure 8 is drawn from *no. 5547* (Cockburn Harbor, South Caicos, — see Plate 3, Figure 1); 9, from *no. 3976* (Cave Cays, Exuma Chain, Bahamas); 10, from *no. 3240b* (Bemini Harbor, Bahamas — see Plate 3, Figure 2 — filament taken from the lower plant of the two at the left). All the figures are enlarged 150 diameters.

11–13. *Udotea conglutinata*

11–13. Ultimate ramifications of the corticating filaments of the stipe.

Figure 11 is drawn from *no. 3240a* (Bemini Harbor, Bahamas — see Plate 2 — filament taken from the largest plant there shown); 13, from a dried specimen of the same number; 12, from *5237* (Watling Island, Bahamas — see Plate 2 — filament from the plant with the largest rhizoids). All of the figures are enlarged 150 diameters.

Some hitherto undescribed plants from New Mexico

Elmer Ottis Wooton and Paul Carpenter Standley

During the summer of 1904 and the spring of 1905, Mr. O. B. Metcalfe made a botanical collection of some six or seven hundred numbers about the south end of the Black Range in Grant and Sierra counties of New Mexico. The region is one that was almost unknown botanically before that time.

Most of the numbers were determined by Dr. E. L. Greene and distributed soon after their collection. They included a number of new species in various genera, most of which have been described by Dr. Greene in volume one of *Leaflets*. There remained, however, about two hundred numbers which have been recently determined by the writers. Among them a number of apparently undescribed plants were found, descriptions of which are here published.

The determination of a single species of *Sphaeralcea* led us to examine critically all the material of this genus found in the herbarium of the Agricultural College. A number of species were found which seemed to us worthy of description, and diagnoses of them are included in this paper.

Acacia constricta paucispina var. nov.

Plant almost twice the size of the typical form of the species; spines much less numerous, usually shorter, sometimes none on herbarium specimens; leaves larger with more numerous pinnae and leaflets; young parts much more pubescent and less glandular and resinous.

In the field this plant seems distinct enough from the typical *A. constricta* Benth., which is a shrub about 1 to 1.5 m. high, growing upon high gravelly mesas associated with *Condalia* and *Covillea*, at an altitude of about 1200 m. The proposed variety grows at considerably higher levels up to about 1700 m., in the foothills of the mountains and in the mouths of cañons. It usually occurs as separate shrubs, widely scattered and never forming thickets as the typical form does. It is not infrequently 4 m. high.

The difference may be due simply to environmental conditions, chief of which is a better water supply. Type: collected on Animas Creek, in the Black Range, Sierra Co., New Mexico, July 13, 1904, *Metcalfe 1123*, altitude about 1500 m.

Other specimens seen: Organ Mts., 1897, *Wooton 120*; Doña Ana Mts., Aug. 14, 1892, *Wooton*; Carlisle, Grant Co., Aug. 14, 1902, *Wooton*; Burro Mts., 1903, *Metcalfe 734*.

Ditaxis cyanophylla sp. nov.

Stems numerous, erect, herbaceous, from a perennial root, 30 to 40 cm. high, glabrous and shining, grooved; leaves alternate, sessile, 20 to 50 mm. long, 5 to 30 mm. wide, the lowermost broadly elliptic to ovate, gradually narrowing towards the upper part of the stem, where they are narrowly lanceolate, glabrous and smooth, or with a few scattering hairs along the margins, entire, obtuse or acute, prominently veined, drying bluish in some specimens, staining water red when allowed to soak; flowers in axillary 3- to 6-flowered racemes, slightly exceeding the leaves; bracts small, tipped with a small bunch of hairs; the two kinds of flowers very similar, the sepals in both kinds lanceolate, acuminate, 6 to 7 mm. long, persistent and somewhat enlarged in fruit, appressed-villous within; petals of the staminate flowers spatulate, light-yellow with reddish veins, about as long as the sepals; petals of the pistillate flowers oblanceolate, acute, about two thirds the length of the sepals, persistent in fruit; glands very small, depressed-globose, glabrous; stamens 8 to 10, monadelphous; style 3-parted, with expanded crispate stigmas; ovary appressed-villous; fruit generally 3-lobed, sometimes 2-seeded by abortion of one or more ovules; seeds spheroidal, smooth, blotched with blue and red.

This species is related to *D. mercurialana* (Nutt.) Coult., from which it may be separated by the absence of pubescence on nearly all parts of the plants, the shorter inflorescence, the larger petals, the generally broader leaves, and the slightly smaller size of the plant. Type, Metcalfe's *929* from Kingston, Sierra Co., New Mexico, May 25, 1904, growing in dry gravel; altitude about 2100 m.

Other specimens seen:

NEW MEXICO: Western Socorro Co., south of Rito Quemado, 1904, *Wooton 2890*, growing at the lower edge of the piñon zone on sandhills.

ARIZONA: Near Coyote Springs, southeast of Springerville, in the piñon zone, June 23, 1892, *Wooton*.

Sphaeralcea glabrescens sp. nov.

Plant 20–35 cm. high, forming a dense cluster of stems from a perennial ligneous root, densely covered with stellate pubescence, giving the whole plant an ashy gray color; leaves small for the genus, crowded on the upper parts of the stems; the blades 1–2 cm. long, less than one half as wide, narrowly triangular in outline with 2 salient teeth or small lobes at the obtuse base, the apex obtuse, margins sinuate and crispate, veins prominent below; young leaves densely covered on both sides with white stellate hairs, the branches of which are long for the genus and slender; the mature leaves glabrate and light green on the upper surface; petioles 1 cm. or less in length; flowers small, reddish, borne in short terminal clusters; calyculate bracts linear, about 1 mm. long; calyx 5–7 mm. long, the broadly lanceolate acute segments being slightly longer than the tube, persistent in fruit and partly enclosing the capsule; capsule almost spherical with 10 carpels, each of which contains 2 or 3 ovules and 1 or 2 seeds and is tipped with a very short mucro.

Type collected at Providencia Lake about 30 miles west of Las Cruces, New Mexico, July 3, 1900, by E. O. Wooton. The "lake" is merely a place where flood waters collect and is an alkaline flat most of the time, with a finely powdered soil. This is one of the few plants which grow near its edges. It is probably most nearly related to *S. hastulata* A. Gray but the connection is not very close.

Sphaeralcea leiocarpa sp. nov.

An erect perennial; stems branched, slender, minutely and sparingly stellate-pubescent throughout, the pubescence denser above; leaf-blades large, thin, 55 mm. long and 40 mm. wide or less, bright green on both sides, with fine, minute, scattered, white, stellate pubescence on both surfaces, truncate at the base, 3-lobed, the sinuses rather shallow; the terminal lobe oblong, and broadest near the obtuse or retuse apex, coarsely crenate near the apex but entire below; the lateral lobes smaller and coarsely crenate; petioles slender, finely stellate-pubescent, 3 cm. long or less; inflorescence narrowly subpaniculate, rather dense, the flowers on slender pedicels 10 mm. or less in length, each flower subtended by 2 or 3 filiform bracts which are about one third as long as the calyx; lobes of the calyx triangular-ovate, acute, the free portion longer than the tube, finely stellate-pubescent, about one third as long as the corolla and a little shorter than the carpels; petals about 8 mm. long; fruit about 5 mm. high and 5 mm. broad; carpels 10, densely and finely stellate-pubescent on the outer surface, 1- or 2-seeded, the inner faces smooth near the base and not pitted or only inconspicuously veined, carpels ending above in prominent divaricate cusps, which are about 2 mm. long; seeds brown, densely and finely stellate-pubescent.

Type collected at Mangas Springs, Grant Co., New Mexico, Sept. 24, 1903, at an altitude of about 1465 m., *Metcalfe 791* (in part at least), growing on a western hillside. This plant is easily distinguished from *S. Fendleri*, which it most resembles, by its broader, obtuse, less incised leaves, more prominent cuspidate carpels, and the smooth, not pitted, inner surfaces of the carpels.

Sphaeralcea tripartita sp. nov.

Stems finely stellate-pubescent throughout, densely so above; leaf-blades 3-parted, the lower ones almost to the base, the upper ones not quite so deeply, the lobes of the blade entire or the middle one again 3-lobed and the lateral ones 2- or 3-lobed, not crenate, the lobes when entire oblong, the lateral ones smaller than the terminal; blades 55 mm. long and 70 mm. wide or less, thin, bright green on both surfaces, finely stellate-pubescent above and more densely so below, the pubescence white; the uppermost leaves almost or quite entire and oblong-lanceolate, petioles rather stout, almost one third as long as the blades; inflorescence narrowly subpaniculate, rather loose; flowers on short, stout, densely stellate-pubescent pedicels, each subtended by 2 or 3 thick, filiform bracts, which are about one half as long as the calyx; calyx-lobes triangular-lanceolate, thick, acute, densely stellate-pubescent; corolla about 9 mm. long, 2 or 3 times as long as the calyx, the petals pink, obovate, rounded above; fruit 5 mm. broad and 4 mm. high, with 5 to 10 carpels, which are densely pubescent on their outer surfaces and more or less prominently pitted near the base of their inner surfaces, 1- or 2-seeded, pointed but not cuspidate, equaled or exceeded in length by the sepals; seeds dark brown, finely and very sparingly stellate-pubescent.

Type collected at Kingston, Sierra Co., New Mexico, growing in dry gravel, July 10, 1904, *Metcalfe 1103*; altitude about 2030 m. Nearest *S. Fendleri* and *S. leiocarpa* perhaps, but differing from both in the peculiar form of the leaves, whose lobes are mostly entire. There is no complete plant in the collection but only some of the upper branches. The plant is, no doubt, a perennial several feet high.

Sphaeralcea laxa sp. nov.

Stems erect, slender, much branched, about 5 dm. high, with rather dense and fine white stellate pubescence throughout, the stems appearing rather hoary; leaf-blades 27 mm. long and 25 mm. wide or less, 3-lobed, the sinuses deep, the lobes obtuse and coarsely crenate all along the margins, dull yellowish-green on both surfaces, with abundant, rather coarse, spreading, conspicuous, stellate pubescence on both sides; petioles slender, 20 mm. long or less; inflorescence axillary below and forming a very loose open panicle above; flowers on very slender pedicels, which are 55 mm. long or less, subtended by 2 or 3 short, filiform bracts; lobes of the calyx lanceolate or linear-lanceolate, attenuate, about 3 times as long as the tube, very densely stellate-pubescent, the entire calyx about 10 mm. long; corolla 14 mm. long or less, salmon-pink, the petals rounded or retuse; fruit about 6 mm. high and as wide, about one half as long as the calyx, composed of 10 or rarely more carpels, which are 2- or mostly 3-ovuled, and end above in a very short mucro; carpels densely pubescent on their outer faces.

Nearest *S. tripartita* and *S. Fendleri*, perhaps, but differing from both in its lax inflorescence, long-pedicelled flowers, and long and attenuate sepals. Type collected at Frisco, Socorro Co., New Mexico, July 25, 1900, *Wooton;* the plant was collected also at Graham, July 21, 1900, *Wooton.*

Sphaeralcea simulans sp. nov.

Plant low, diffuse, green, 1–2 dm. high, with numerous slender stems from a perennial root, densely scurfy throughout with yellow stellate scales; leaves 2–4 cm. long, triangular in outline, conspicuously 3-lobed, cuneate at base, obtuse, veins prominent, margins coarsely few-toothed; flowers axillary on short (2–5 mm. long) pedicels, becoming almost racemose at the ends of the stems, bright orange-scarlet, 1 cm. long or less; calyx-lobes narrowly lanceolate, acuminate, longer than the tube, enclosing the spheroidal capsule; fruit consisting of 10–12 1-seeded carpels which are strongly reticulated on the inner surfaces near the base, tuberculate-roughened on the back, short-mucronate.

Type collected on the plains both east and west of Deming, New Mexico, June 14 and 13, 1906, *Wooton.* Common on the plains of southwestern New Mexico. As is indicated by the name, it resembles *Malvastrum coccineum* in habit and general appearance but from the nature of the fruit it is evidently a *Sphaeralcea.*

Sphaeralcea ribifolia sp. nov.

Stems erect, slender, sparingly branched, with dense white stellate pubescence throughout, the whole plant having a grayish or hoary appearance; leaf-blades broadly cordate-ovate in outline, simple or 3-lobed, obtuse, coarsely crenulate throughout, small, 15 mm. long and 16 mm. wide or less, covered with a rather dense, whitish, stellate pubescence on both sides, of medium thickness; petioles slender, 22 mm. long or less, usually longer than the blades; inflorescence axillary, or fascicled near the ends of the branches, rather open; flowers on pedicels 16 mm. long or less, each subtended by 2 or 3 filiform bracts, which are about one half as long as the calyx; corolla about 14 mm. long, salmon-pink; calyx-segments ovate-lanceolate, acute or acuminate, almost twice as long as the tube, the calyx about one half as long as the corolla and somewhat longer than the fruit; fruit about 7 mm. high and 6 mm. broad, composed of about 10 carpels which are not at all cuspidate, densely pubescent on their outer surfaces and conspicuously pitted on their inner ones, 1-seeded; the seeds very sparingly and minutely stellate-pubescent.

Nearest *S. laxa* but differing in its smaller, entire or less divided, longer-petioled, cordate or subcordate leaves, shorter pedicels, and less attenuate sepals. Type collected at the Martin and Sloan Ranch, Grant Co., New Mexico, Aug. 13, 1902, *Wooton.*

Sphaeralcea pumila sp. nov.

Perennial from a slender ligneous root; stems slender, much branched, 15–25 cm. high, with scattered stellate pubescence throughout, the pubescence giving the stem a scaly and scurfy appearance; leaf-blades 2 cm. or less in length, thick, 3-parted to the base, the lobes often again divided and strongly pinnatifid; lobes rather obtuse, rather densely soft stellate-pubescent on both surfaces; petioles stout, 10 mm. long or less; inflorescence axillary, few-flowered; flowers on short, stout pedicels; corolla about 10–12 mm. long; calyx-lobes triangular-lanceolate, attenuate, twice as long as the tube, one half as long as the corolla and exceeding the fruit, densely pubescent; fruit about 5 mm. high and 7 mm. wide, composed of about 10 carpels whose outer surfaces are finely pubescent and the inner ones strongly pitted near the base; carpels shortly and inconspicuously mucronate; seeds 1 or 2 in each carpel, sparingly pubescent or almost glabrous.

Type collected at the Diamond A wells in the Silver City Draw, Grant Co., New Mexico, July 1, 1906, *Wooton;* the plant was collected also on dry hillsides on Bear Mt. near Silver City, Sept. 30, 1903, *Metcalfe.* Probably nearest *S. simulans*, but distinguished by its smaller, thick, pinnatifid leaves.

Sicyos ampelophyllus sp. nov.

Stems slender and weak, several feet long, sparingly and finely scabrate throughout or almost glabrous in parts; leaf-blades reniform-orbicular, 14 cm. long and 13 cm. wide or smaller, 3-lobed, the sinuses between the lobes narrow but rather deep, the lateral lobes sometimes again 2-lobed; the lobes sinuate-dentate, with mucronate teeth, obtuse, or the terminal one sometimes acutish and prominently mucronate; the basal sinus large and almost circular; the leaves scabrous on both surfaces; petioles as long as the blades or longer, scabrate or with a few scattered, soft, whitish hairs; pistillate flowers 5–10, 1.5–2 mm. broad, with ovate, obtuse corolla lobes, sessile at the end of a peduncle which is about 8 mm. long; staminate flowers in small, few-flowered racemes, on pedicels as long as the flower or longer, about 4 mm. in diameter, with rather obtuse petals; tendrils mostly 4-parted; fruit ovoid to ellipsoidal, about 5 mm. long and 4 mm. wide, the thin pericarp closely investing the smooth seed, which has 2 conspicuous scars at the base, the fruit conspicuously echinate with straw-colored, retrorsely barbed spines, which are about 3 mm. long.

Although not closely related to any other New Mexican species of *Sicyos* this plant is probably nearest *P. parviflorus* Willd. It is readily distinguished by the greater size and more robust habit of the plant and the larger leaves, which are different in shape. Type collected at Kingston, Sierra Co., New Mexico, in cultivated ground, Aug. 5, 1904, *Metcalfe 1195;* altitude about 2030 m. Also collected on Sapello Creek, southeast of the Mogollon Mts., Aug. 22, 1900, and near Gila, July 12, 1900, *Wooton.*

Phacelia similis sp. nov.

A diffuse annual with several ascending stems rising from a cluster of spreading basal leaves; stems 20–30 cm. high, sparingly leafy and terminating in compound helicoid cymes having 2–6 branches, the whole plant covered with a fine appressed pubescence with scattered spreading stiff hairs on the stems and midribs, somewhat viscid, especially on the inflorescence; leaves bipinnately parted, narrowly oblong in outline, 5–15 cm. long, 1–3 cm. wide, the segments oblong-elliptic, obtuse, 2–5 mm. long; the uppermost cauline leaves small, once pinnate with simple or toothed segments; flowers blue (?) (purplish in dried material), crowded, of moderate size for the genus, 6–8 mm. long and as broad; calyx of 5 equal spatulate sepals united for a short distance at the base, half as long as the corolla; corolla campanulate-funnelform, limb spreading, its segments broadly elliptic to rotund, their margins unevenly toothed and slightly crispate; stamens and pistil much exserted; fruit globular, mature seeds not seen.

Type, Metcalfe's *1665*, collected on the plains near Nutt Station, Sierra Co., New Mexico, May 12, 1905. This plant is most like *P. arizonica* A. Gray, which it closely resembles except in the following particulars: its flowers are almost twice as large, corolla- and calyx-lobes broader, corolla blue instead of white, and the leaves larger and more dissected. Mr. Metcalfe collected this plant and what Dr. Greene as well as the authors takes to be true *P. arizonica*, together on the same day, hence the two plants must have been easily separable in the field.

Pentstemon puberulus sp. nov.

Perennial from a slender, creeping root; stems few or single, erect or somewhat reclining at the base, slender, 4 dm. high or less, minutely puberulent throughout; leaf-blades entire, lanceolate or the lowest ovate, acute or the uppermost acuminate, thin, glabrous, the uppermost sessile and clasping, the lower ones sessile but not clasping, the radical leaves on slender, winged petioles which are as long as the blade or longer, the blades decurrent upon the petioles; inflorescence a short, interrupted thyrse, rather few-flowered, peduncles 2 at each of the upper nodes, 3–6 flowers on each peduncle, the flowers on pedicels 1 cm. long or less; sepals linear-lanceolate, separate almost to their bases, long-acuminate, 12 mm. long or less, pubescent; corolla 25 mm. long or less, rather light purple (when dry), straight, somewhat narrower and less inflated than in the related species, with a few scattered, silky hairs on the outside, rather conspicuously 2-cleft, the two lips about equal in length or the lower a little longer, the lower lips composed of 3 rather large, oblong, rounded lobes, and the upper lip of two smaller rounded ones, the lower lip somewhat bearded within; sterile filament club-shaped, with a long and dense, bright yellow beard.

This plant is most closely related to *P. glaucus stenosepalus* A. Gray and *P. Whippleanus* A. Gray, but is distinguished by its thinner leaves, pubescent stem, rather less dense inflorescence, and its narrow and less deeply 2-lipped and lighter-colored corolla. From *P. Whippleanus* it differs also in the rather larger size of the plant and the bearded sterile filament. Type collected on shady slopes at the Lookout Mine, Sierra Co., New Mexico, May 2, 1905, *Metcalfe 1605*.

NEW MEXICO COLLEGE
OF AGRICULTURE AND MECHANIC ARTS,
AGRICULTURAL COLLEGE, NEW MEXICO.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1908)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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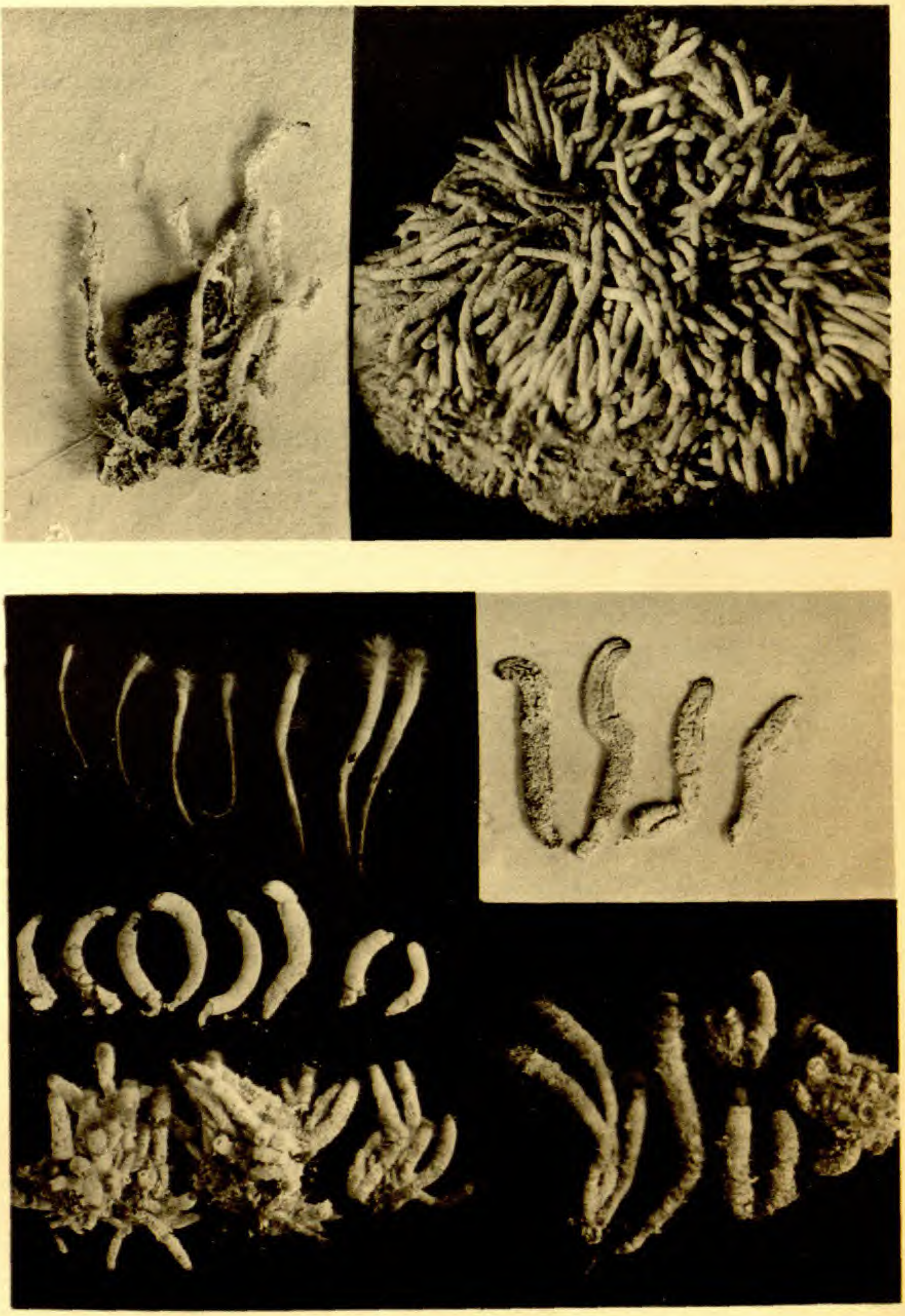
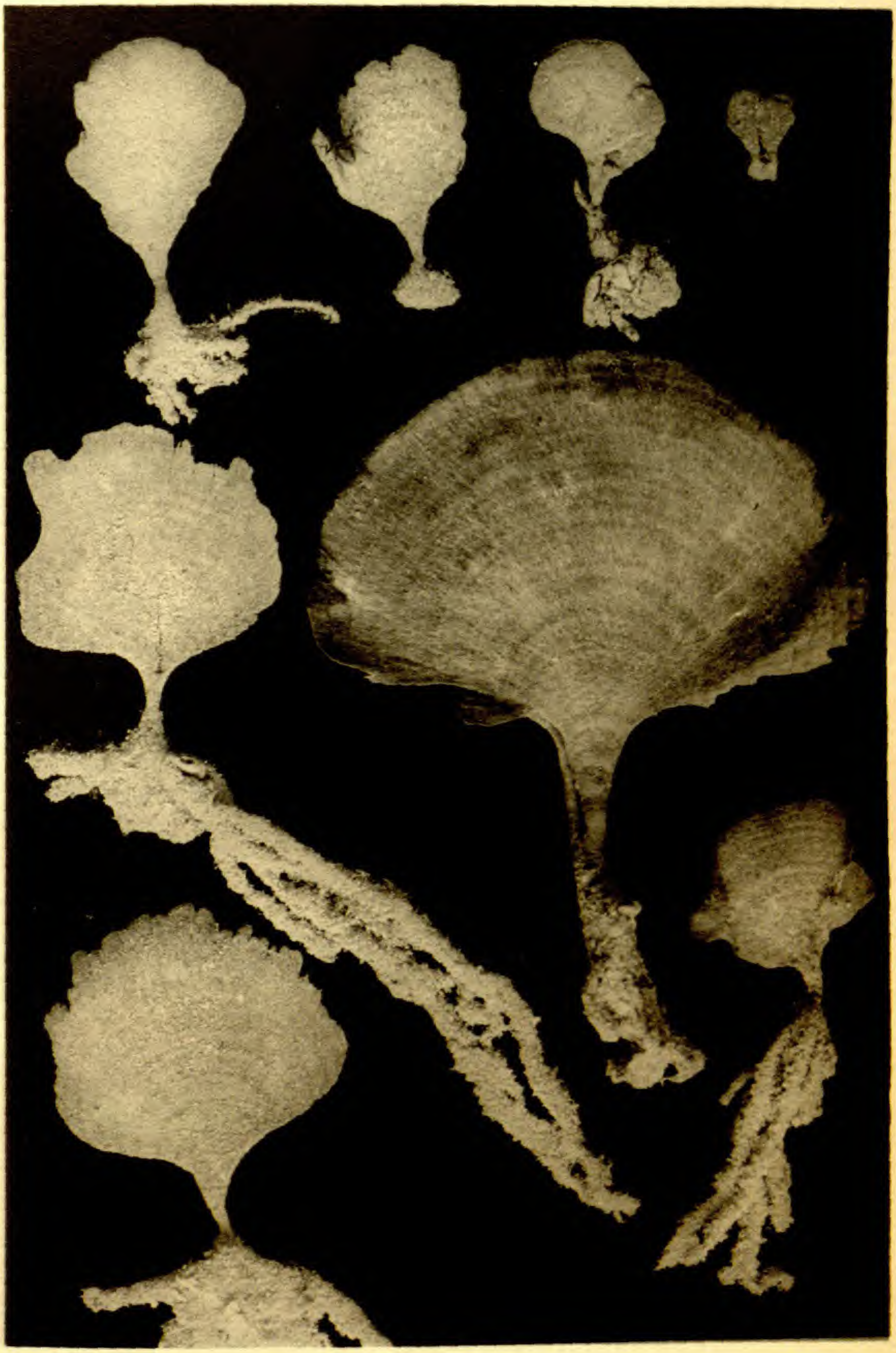


1. NEOMERIS DUMETOSA Lamour.
2. NEOMERIS ANNULATA Dickie
3. NEOMERIS STIPITATA M. A. Howe
4, 7. NEOMERIS VAN BOSSEAE M. A. Howe
5. NEOMERIS MUCOSA M. A. Howe
6. NEOMERIS COKERI M. A. Howe

COCKAYNE, BOSTON



UDOTEA CONGLUTINATA (Ell. & Soland.) Lamour.

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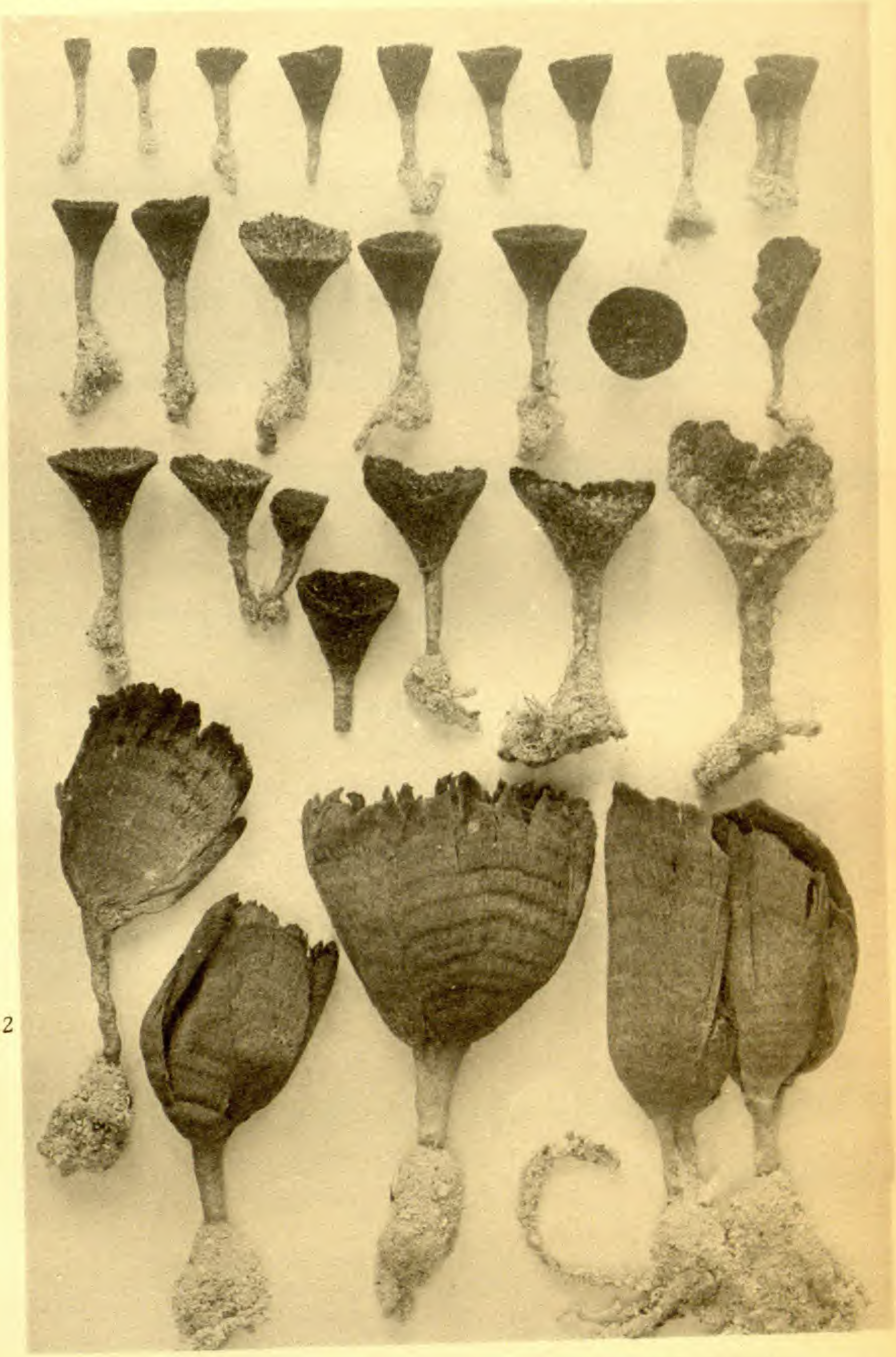

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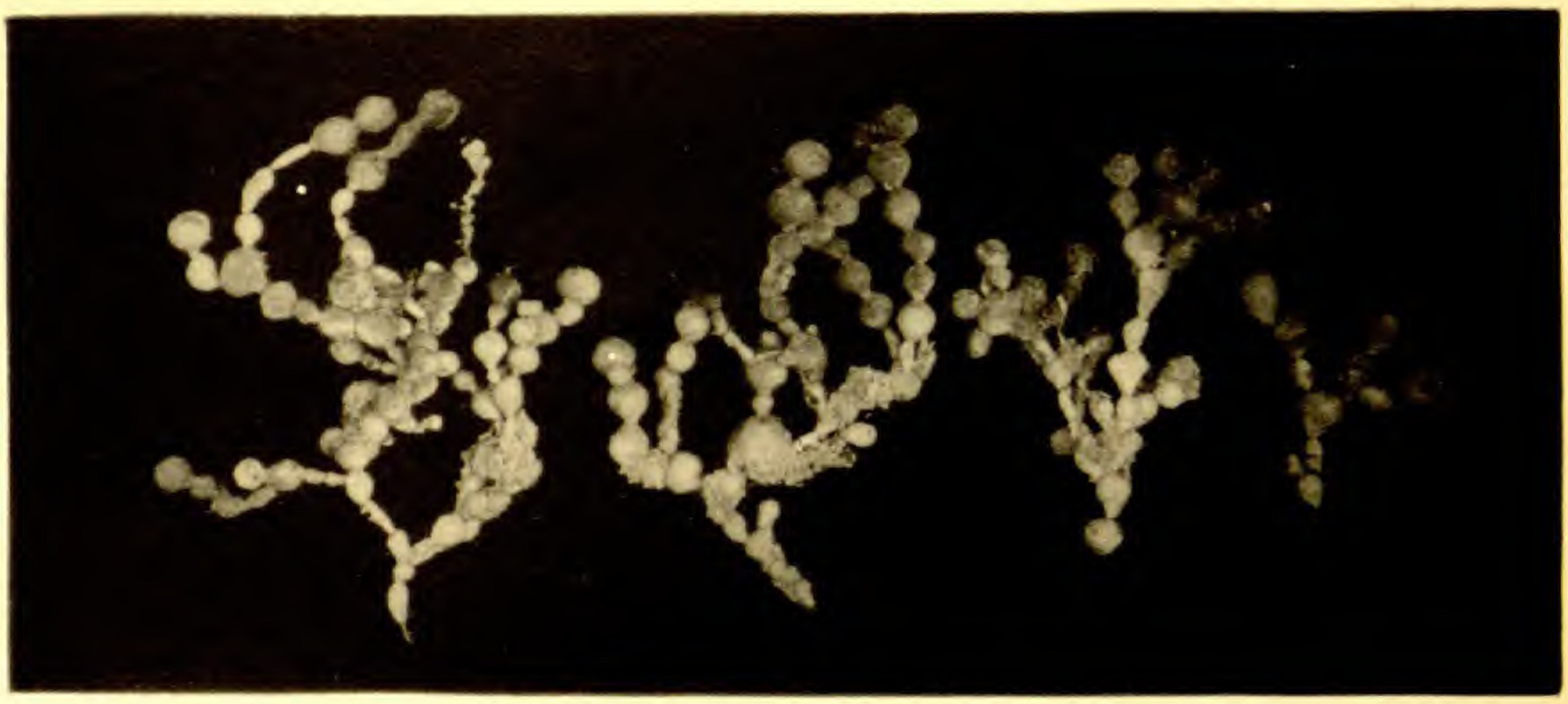

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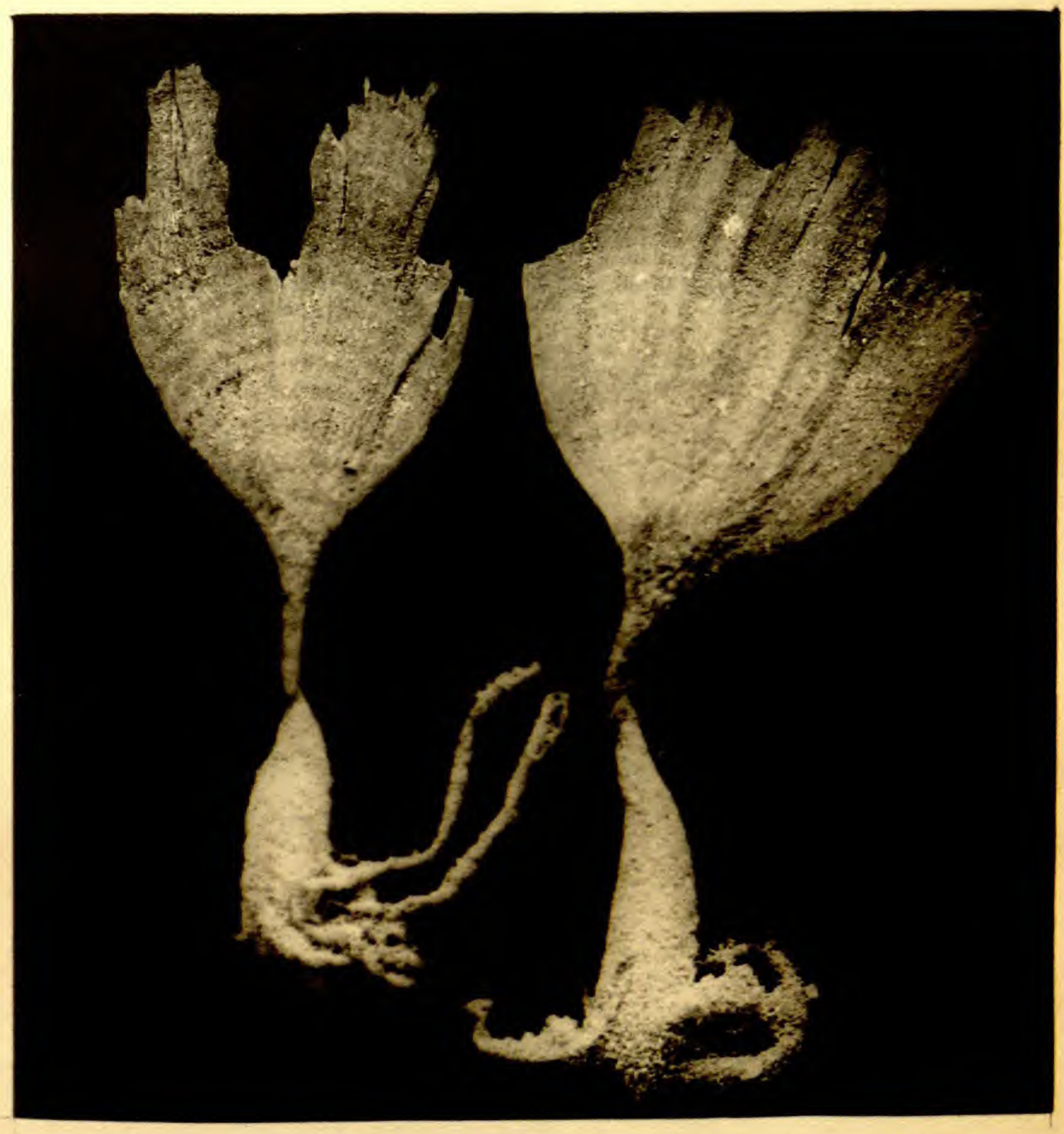
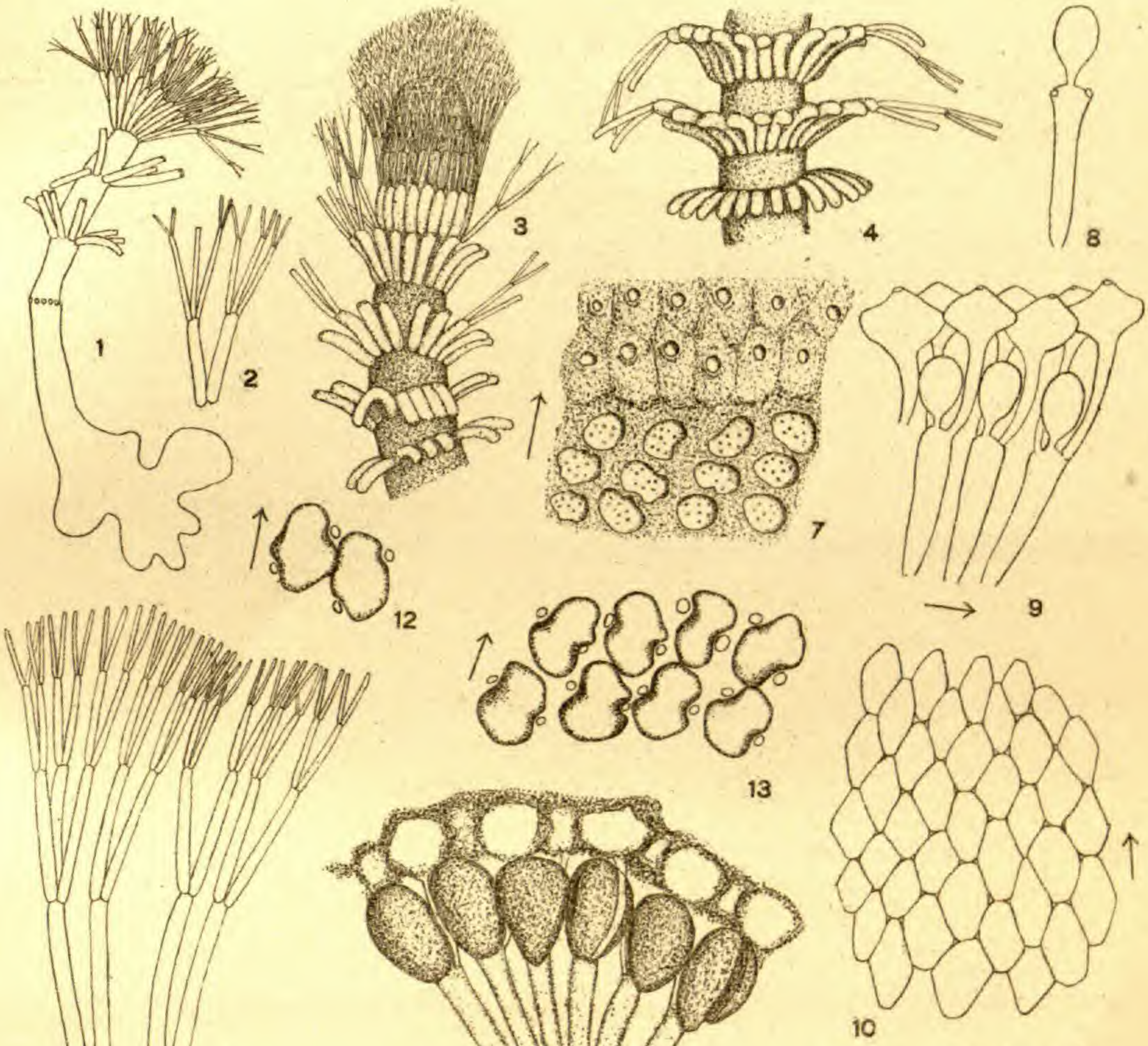


1. HALIMEDA LACRIMOSA M. A. Howe

2. UDOTEA SPINULOSA M. A. Howe

COCKAYNE, BOSTON



1-14. NEOMERIS MUCOSA M. A. Howe

15-16. NEOMERIS STIPITATA M. A. Howe

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20. NEOMERIS DUMETOSA Lamour.

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5-9. ACETABULUM POLYPHYSOIDES (Crouan) Kuntze

10. ACETABULUM POLYPHYSOIDES DELTOIDEUM M. A. Howe

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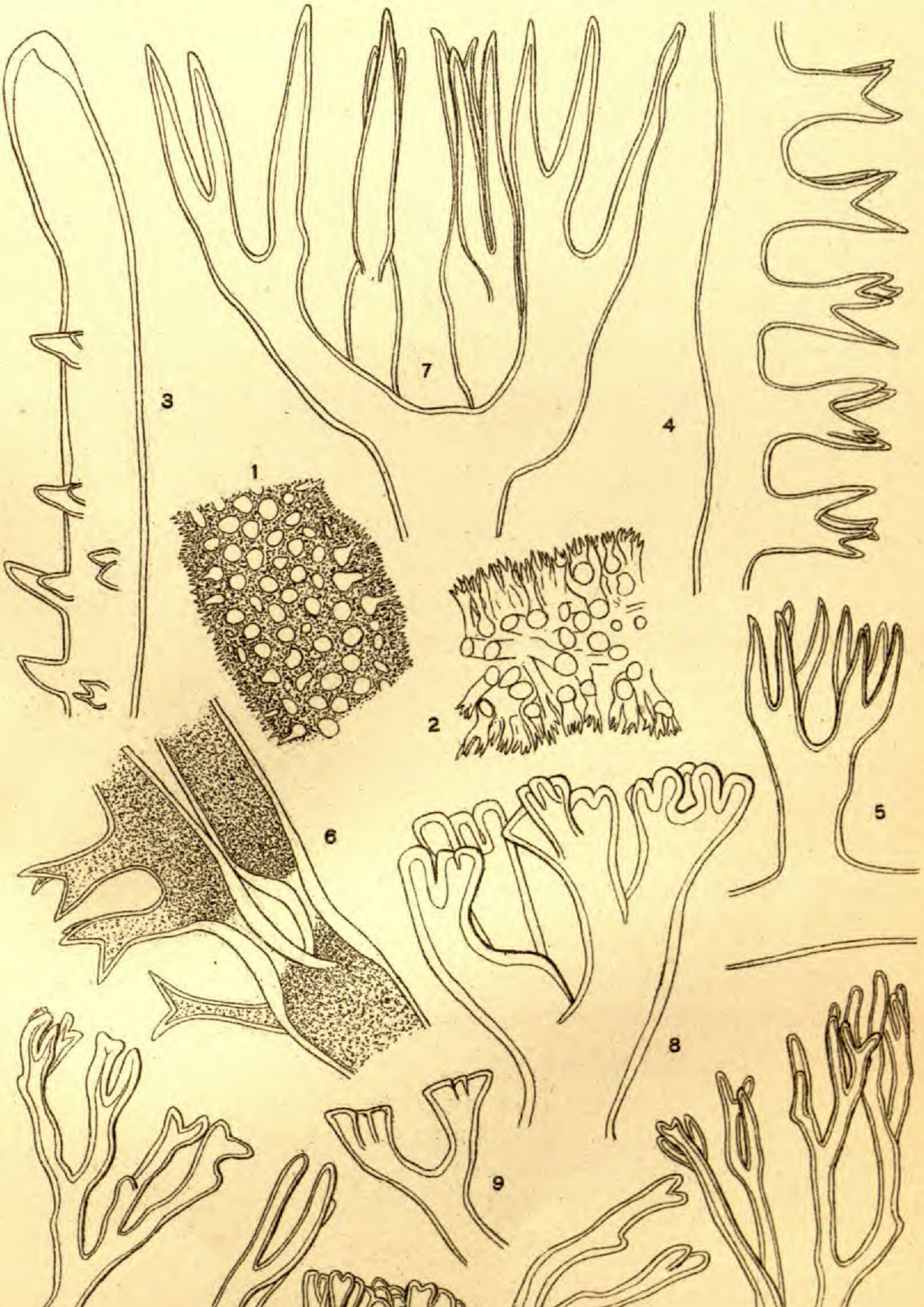

1-7. UDOTEA SPINULOSA M. A. Howe

8-10. UDOTEA CYATHIFORMIS Decaisne

11-13. UDOTEA CONGLUTINATA (Ell. & Soland.) Lamour.

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North American Flora

THIS work is designed to present descriptions of all plants growing independently of cultivation, in North America, here taken to include Greenland, Central America, the Republic of Panama, and the West Indies, except Trinidad, Tobago, and Curaçao and other islands off the north coast of Venezula, whose flora is essentially South American.

It will be published in parts at irregular intervals by the New York Botanical Garden through the aid of the income of the David Lydig Fund bequeathed by Charles P. Daly.

It is planned to issue parts as rapidly as they can be prepared, the extent of the work making it possible to commence publication at any number of points. The completed work will form a series of volumes with the following sequence:

Volume 1. Mycetozoa, Schizophyta, Diatomaceae.
Volume 2 to 10. Fungi.
Volumes 11 to 13. Algae.
Volumes 14 and 15. Bryophyta.
Volume 16. Pteridophyta and Gymnospermae.
Volumes 17 to 19. Monocotyledones.
Volumes 20 to 30. Dicotyledones.

The preparation of the work has been referred by the Scientific Directors of the Garden to a committee consisting of Dr. N. L. Britton, Dr. W. A. Murrill and Dr. J. H. Barnhart.

Professor George F. Atkinson, of Cornell University, Professors Charles R. Barnes and John M. Coulter, of the University of Chicago, Mr. Frederick V. Coville, of the United States Department of Agriculture, Professor Edward L. Greene, of the United States National Museum, Professor Byron D. Halsted, of Rutgers College, and Professor William Trelease, of the Missouri Botanical Garden, have consented to act as an advisory committee.

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BULLETIN

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TORREY BOTANICAL CLUB

MARCH, 1909

The study of winter buds with reference to their growth and leaf content *

Emmeline Moore

(with plates 9–11)

The growth of buds in winter has been the subject of much speculation and discussion by the botanist and by the casual observer. This speculation and discussion, stimulated by an occasional winter of unusual mildness, has given rise to various theories about the disturbance of that quiescent state, or winter rest-period, which has stamped itself so indelibly on the trees and shrubs of our temperate zones. Inquiry into these theories, especially those relating to the winter growth of buds, discloses the fact that there has been comparatively little investigation or careful observation to substantiate them. The scattered statements which have crept into literature are, as a rule, merely opinions or passing observations made in the course of investigation of other phenomena.

Askenasy (1877) found some evidence of the growth of buds in winter. He says that the so-called period of rest, extending from about the first of November to the beginning of February, is one of extremely slow growth, a growth which in November becomes almost *nil*. His investigations, however, cover the rest period of but one species of our trees, *Prunus Avium*, the wild cherry, and include the study of the flower buds alone.

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* Awarded the second prize by the Boston Society of Natural History in the Walker Prize Competition for 1908.

[The Bulletin for February, 1909 (36: 55–116. *pl. 1–8*) was issued 4 Mr 1909.]

From the investigations of Fischer (1891) and others, there is evidence that certain activities and various metabolic processes take place within the winter bud. Fischer claimed that to the external periodicity revealed in the phenomena of growth there is a corresponding internal periodicity in the processes of metabolism; that, in the buds and young shoots, movements and changes in the reserve material take place during the cool and cold seasons; and that these activities are dependent not only upon temperature but upon the inherent tendencies of the plant.

The results of Fischer's investigation would admirably supplement those of Askenasy had the latter considered a greater variety of plants. The study of flower buds of *Prunus Avium* alone can scarcely serve as a type for the growth of the leaf buds of all our trees and shrubs.

The problem of growth in the leaf bud during winter presents two important subjects for scientific research,—the question of growth, in so far as it relates to the enlargement of tissue through the addition of new cells or the stretching of cells already formed, and the question of leaf content dealing with the formation of additional leaf fundaments. These problems are considered in the present investigation.

METHODS

Material: As a basis for this study, observations and investigations have been made on the following twenty-two species, including seventeen different genera, of the common trees and shrubs of Wellesley, Massachusetts:

Fagus americana L. (American beech).
Fagus sylvatica L. (European beech).
Syringa vulgaris L. (lilac).
Ulmus americana L. (American elm).
Alnus incana Willd. (speckled alder).
Fraxinus americana L. (white ash).
Tilia vulgaris Hayne.
Tilia americana L. (basswood).
Acer platanoides L. (Norway maple).
Populus tremuloides Michx. (American aspen).
Betula populifolia Marsh. (American white birch).
Hicoria ovata Britton (shag-bark).

Hicoria microcarpa Britton (small-fruited hickory).
Salix fragilis L. (brittle willow).
Salix alba L. (white willow).
Aesculus Hippocastanum L. (horse-chestnut).
Quercus alba L. (white oak).
Quercus rubra L. (red oak).
Picea excelsa Link (Norway spruce).
Liriodendron Tulipifera L. (tulip-tree).
Rhododendron maximum L. (great laurel).
Philadelphus (mock orange).

DETERMINATION OF BUD CONTENT

For the study of leaf content, normal branches, upper and lower ones from various parts of the tree or shrub, were taken and studied during the months of November and December, 1905 and 1906. A long pruning shears was used to reach the upper branches. The number of nodes was counted and recorded for each season's growth, two and, where practicable, three years back. By this method a record of the number of leaves which were developed during those seasons was obtained. The terminal or upper axillary bud of each shoot, the nodes of which had been counted, was examined with a dissecting microscope, and the number of leaves found in the bud was noted.

FIELD OBSERVATIONS ON GROWTH

Observations on the growth of the bud were carried on during all of the winter and spring months. Ten normal buds of each genus were marked with a nurseryman's wooden label. During the latter half of November, 1905, and each month thereafter until the unfolding of the leaves in April or May, these buds were measured for the greatest length and the greatest diameter in each case. Measurements in length were made with a steel spacing dividers; measurements in diameter, with a micrometer screw caliper graduated to 0.01 mm. During the months of February, March, and April, measurements were made twice a month, once at the beginning and once at the close. Data resulting from these measurements, about 3000 in all, form the basis of the curves of growth as well as of the deductions on dormancy and growth in the gross study of buds.

MICROSCOPIC STUDY OF GROWTH

Collecting: Collections of material were made during the latter part of each month from November to April inclusive. Buds were cut from the high and low parts of each tree with the long pruning shears. The trees from which the buds were taken were situated in exposed and in sheltered places. In each case, however, the buds were cut from mature shrubs or trees and not from saplings or young growths.

Fixing: These methods are given in considerable detail because the varied character of the buds offered peculiar difficulties in fixing and cutting. In general, the bud scales were removed to the young leaves and the remainder of the bud was fixed entire. In the horse-chestnut the two outer whorls of leaves, and in the beech three lower leaves were also removed. Buds were placed directly in 20 per cent. alcohol and then passed successively through 40, 60, 80, 95 per cent. and absolute alcohol, remaining in each grade 24 hours. To insure perfect dehydration the absolute alcohol was changed once. The material was brought gradually into pure cedar oil by passing through the grades of alcohol and cedar oil, 33 and 66 per cent. cedar oil, 24 hours each. After remaining in cedar oil a few days, it was then carried through the grades of paraffin and cedar oil, 33 and 66 per cent. paraffin, to pure paraffin, melting point 54°, in which it was finally imbedded.

Staining: The buds were sectioned with a Minot-Zimmermann revolving microtome. In most cases they were cut 10 μ in thickness. The exceptions to this were the woody and hairy buds, the hickory, oak, basswood, birch, and alder. These buds were cut from 25 to 50 μ in thickness, depending upon the character of the bud. This greater thickness of the sections was not disadvantageous, since an outline study of the growing point, and not a cytological study, was desired. All sections were mounted serially. The usual method of staining with Delafield's hæmatoxylin was followed in all cases except one. The basswood sections are not well stained by this method because of the mucilaginous nature of the buds. The water used in the Delafield stain dissolves the mucilage which spreads over and obscures the tissue. A satisfactory stain was secured by using a solution of Bismarck brown in absolute alcohol. After the slides came from the xylol, they were stained horizontally two or three minutes and washed in absolute alcohol. They were then cleared and mounted in the usual manner.

GROSS STUDY OF BUDS

Leaf content: The observation that winter buds contain leaves is doubtless older than the science of botany. The final proposition to prove is, how many of the leaves which develop during the spring and summer actually exist in the bud at the beginning of winter. In a consideration of this question the number of leaves found in the terminal or upper axillary bud has been counted and compared with the number of nodes which developed in the same twig during the two or three preceding seasons. Such an enumeration, combined with a microscopical study of sections of buds fixed each month from November to May, 1905–6, and with field observations at the time of the unfolding of the leaves in the spring cannot fail to give results which must be regarded as conclusive.

Bailey (1898) says: "There are as many leaves packed away in the bud, as a rule, as there will be leaves on next year's shoot." He gives no citations of literature and presents no investigations on which to base this generalization. We are left in doubt whether an individual plant or different species of plants may show variation in this respect. All effort to find any published record more definite than this has been futile.

The whorls of leaves in the bud of *Acer platanoides* agree, as to number, with the number of nodes on the same twigs one, two, or three seasons back with the exception that, in some cases, the number of whorls is one more or one less than the number of nodes. Observations on a large number of primary branches together with the dissection of terminal buds show this variation in the number of nodes developed during different seasons. In fact, this tendency to variation is true of all trees and shrubs and is particularly noticeable in secondary branches. This discrepancy is easily explained by the fact that, practically under the same conditions, the number of nodes produced each season may vary slightly. Since the counts so nearly agree, it is, therefore, fair to assume that buds with four whorls of leaves will produce four nodes; those with three whorls will produce three nodes and so on. The number of nodes on the branches of each season is four or three. The number of leaves in the bud is six or four plus a pair of papillae in position for the fourth or third whorl of leaves.

A study of the microscopic sections of the bud during the winter and spring shows no organization of new leaves. At the time of the swelling of the buds in early April, new growths appear at the meristematic point (FIGURE 33, *s.f.*). Field studies during the period of the unfolding of the leaves show with perfect clearness that these new growths are the first pairs of scales of the future terminal bud, the bud of the next season. The new scales, admirably protected by the encircling bases of the petioles of leaves, show exceedingly slow growth in comparison with the normal leaves, and an unmistakable differentiation into bud coverings.

Bud dissection of *Aesculus Hippocastanum* shows that the full number of leaves exists in the bud at the beginning of winter. In addition two pairs of tiny scales appear as papillae in the meristematic point (FIGURE 36, *s.f.*). As they develop in the spring, the long, pointed character, indicative of scales, becomes prominent. The number of whorls of leaves in the bud of the main branches is generally four, sometimes five. This corresponds with the usual number of nodes developed in the branches during previous seasons. It is an interesting observation that the number of nodes is always less where the terminal bud is a flower bud.

Fagus americana and *Fagus sylvatica* have their leaves well developed in the bud and contain the full number for the season, five to seven on the primary shoots, three to four on the secondary ones. These leaves are, on the whole, farther advanced in regard to form and structure than those found on any other buds examined.

The number of leaves in the buds of *Fraxinus americana*, *Liriodendron Tulipifera*, and *Hicoria ovata* is more or less readily determined with the aid of the dissecting microscope, and agrees in each case with the usual number of nodes on the twigs of previous seasons — three or four whorls in *Fraxinus*, seven to nine leaves in *Liriodendron*, and five to seven leaves in *Hicoria*. A comparative study of the microscopic sections of buds during the winter months and the observations in the field during the unfolding of the buds gives undoubted evidence that here, too, the full number of leaves is packed away in the bud before the approach of winter.

Müller (1866–7) made an extensive study of *Fraxinus* from early spring to midsummer and found that the bud scales of the next season's terminal bud began a rapid development in April. The present study of *Fraxinus americana* confirms Müller's observations on this species, for, as will be seen by reference to FIGURES 34 and 35, no addition of leaves occurs during the winter months. The new additions, which take place after April 16, are the scales whose development has been traced by Müller.

Philadelphus enters upon the winter rest with the buds buried beneath the leaf scars. These buds were examined with difficulty, not only on account of their small size but because of the similarity between the outer coverings and the inner leaves. In the stained sections of the buds, these structures are differentiated and the leaves easily enumerated. Eight to ten whorls of true leaves are generally present and this is the usual number that unfolds. FIGURES 44 and 45 show median sections through a bud. The young whorls of leaves are closely appressed until the blades are quite well expanded. When the leaves are unfolded in May, there appear between the last two leaves two small, yellowish scale-like leaves which soon die away, evidently because the meristematic point itself ceases to function and thus terminates further growth at this point of the shoot.

There is little question that in the one conifer studied, *Picea excelsa*, the buds contain through the winter the complete number of rudimentary leaves. Küster (1899) says that in *Abies* and in *Pinus* the number of leaves in the bud is probably the same in the fall as during the time of unfolding. The present study would tend to confirm this view for *Picea*, since the earliest growth in the spring indicates a production of tiny scales at the growing point of the bud rather than the organization of more needle-like leaves.

The young leaves in the *Rhododendron* buds correspond frequently to the number of leaves and nodes present on shoots of the preceding season. The irregularity in branching renders the count difficult in growths of two successive seasons. The largest number of leaves counted in any bud is twelve; the largest number of nodes for previous years, fourteen. Because of the more or less whorled arrangement about the meristematic point, an exact enumeration of leaves and papillae is impossible from a study of serial sections. There remains, then, an element of doubt as to the number of leaves and leaf fundaments actually contained in these buds.

In buds of *Syringa vulgaris* the inner bud scales so gradually emerge into leaves that it is impossible to differentiate between them. In fact what appear to be *bona fide* scales in the bud develop into normal leaves as the buds unfold. These scars are crowded more or less into the ring of true scale scars which in part become obliterated by the growth of the stem. Any enumeration of nodes, therefore, in the shoot of the preceding season is untrustworthy as a criterion for the number of leaves contained in the winter bud. The microscopic sections are more satisfactory in that they admit of a detailed and minute study of the vegetative point. From these slides it is evident that the vegetative point exhibits a variation in ability to produce new leaves in addition to those already existing in the bud. It is believed, from a study of the slides, that buds, which early in the spring develop buds in the axils of the uppermost leaves, do not make new leaves at the apex of the growing point, but that buds in which these axillary growths are absent early in the growing season, continue to form new leaves (FIGURES 12 and 13). A probable explanation lies in the assumption that the energy of growth is directed to the upper axillary buds rather than to the meristematic point of the bud. These cells soon cease to function and die, thus terminating the growth of the stem. It appears, then, that the leaf content of the bud of *Syringa vulgaris* may receive additions in the spring. These new leaves are few, one or two pairs at the most. They never fully develop but shrivel away when the meristematic point ceases to function.

There is evidence that, in the leaf buds of *Salix fragilis* and *Salix alba*, the leaves are not all organized at the beginning of winter. The nodes on primary shoots vary from seven to thirty-six. The leaves found in any bud of these shoots do not exceed thirteen in number plus one or two papillae; moreover, the very nature of the growing end, with its continued production of closely appressed leaves, seems to establish the conclusion that the leaf content is not complete in *Salix* at the beginning of winter.

In the buds of *Populus tremuloides* the leaves, from five to nine in number, are very small but comparatively well formed. The number of nodes found on the growth of a given season varies

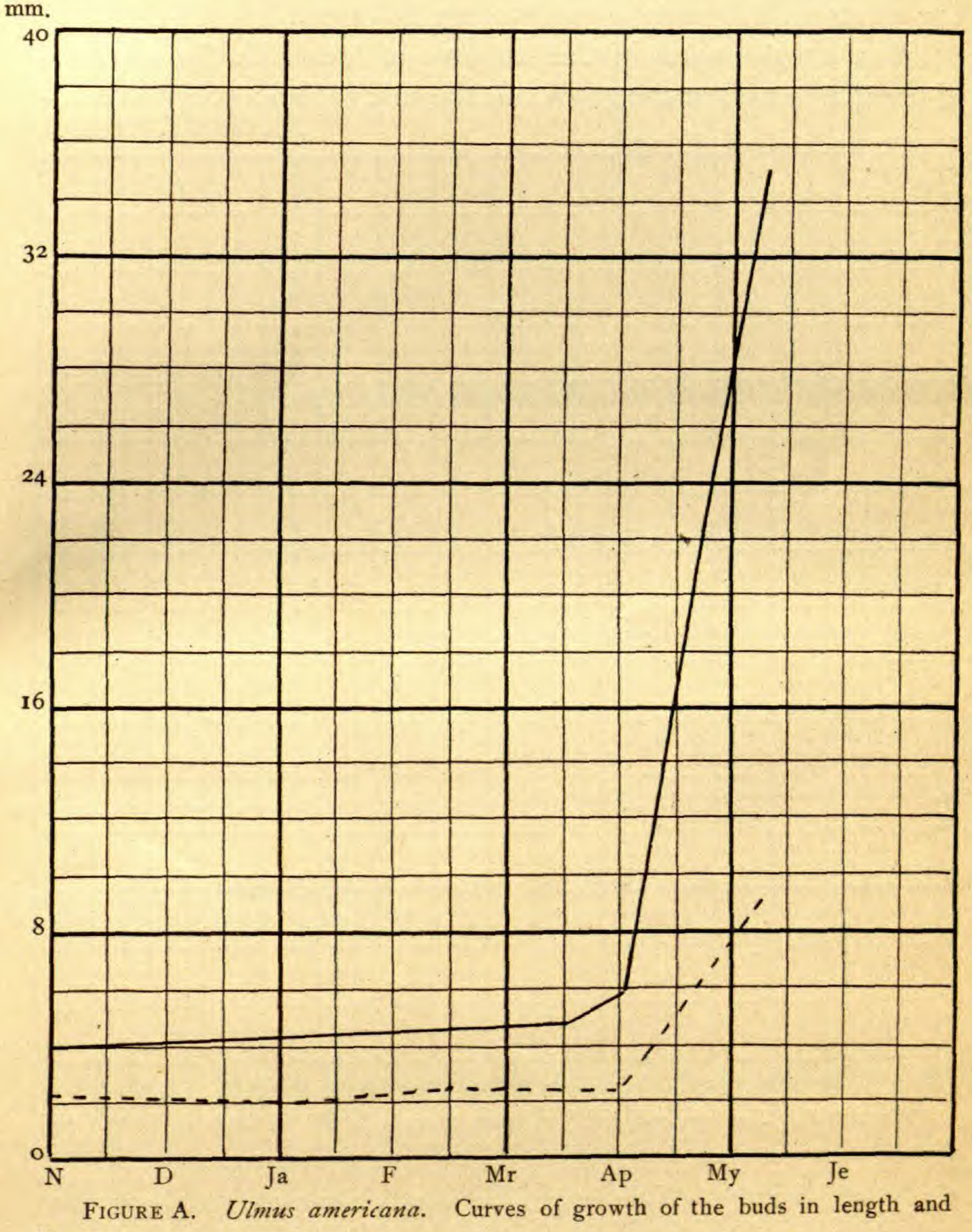

FIGURE A. *Ulmus americana*. Curves of growth of the buds in length and diameter.

from six to twelve. A growth of six nodes may follow one of six, ten, or twelve nodes and *vice versa*. This irregularity in the amount of growth occurs during different seasons or in the same season. However, the sudden growth of the leaves, as though pushed out *en masse*, indicates that there are no new additions. The organization of a terminal bud and axillary buds as soon as the leaves unfold tends to substantiate this view.

In a consideration of the number of leaves in the buds of *Quercus alba* neither the gross nor the microscopic study was entirely satisfactory. The leaves are not only exceedingly minute but they are densely covered with hairs which render sectioning difficult. Complete sections were too few to be of value in determining the actual number of leaves in the bud, but the unbroken vegetative points were more often secured and their study would indicate an approach, at least, to the full number of leaves. This

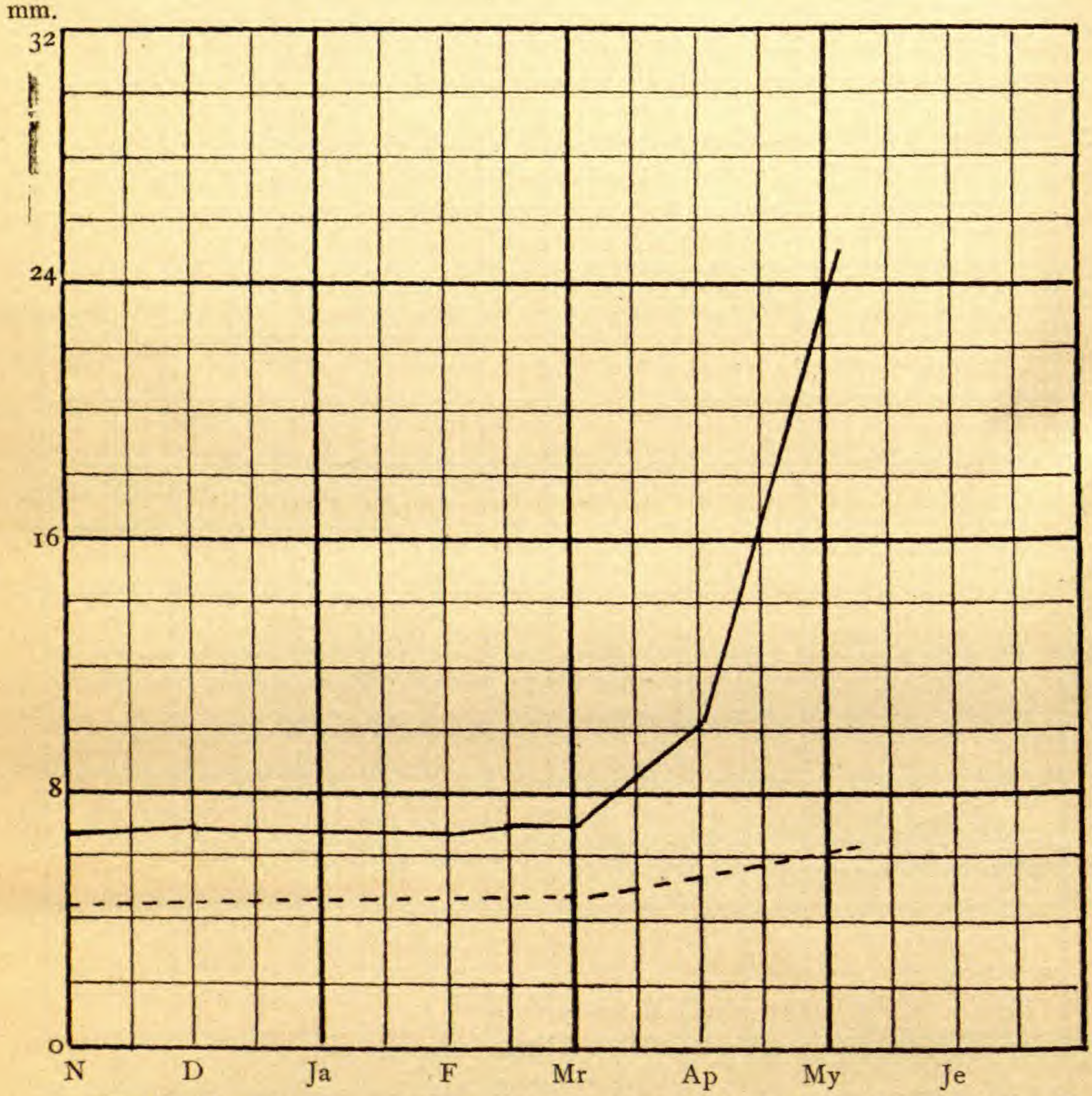

FIGURE B. *Syringa vulgaris*. Curves of growth of the buds in length and diameter.

is especially true of buds which show in section numerous scale-like growths around the meristematic point. These scale-like growths appear, in the unfolding bud, to be the stipules of the whorl of leaves at the distal end of the young stem (FIGURE 48). Since the whorl is not a true one but is produced by a shortening of the internodes in this part of the stem, the number of leaves at the beginning of winter for this species is still a matter of conjecture. Buds of *Quercus rubra* give stronger evidence of containing the complete number of leaves in that the leaves with the new terminal bud and the whorl of axillary buds are pushed out and developed simultaneously, as in *Populus*.

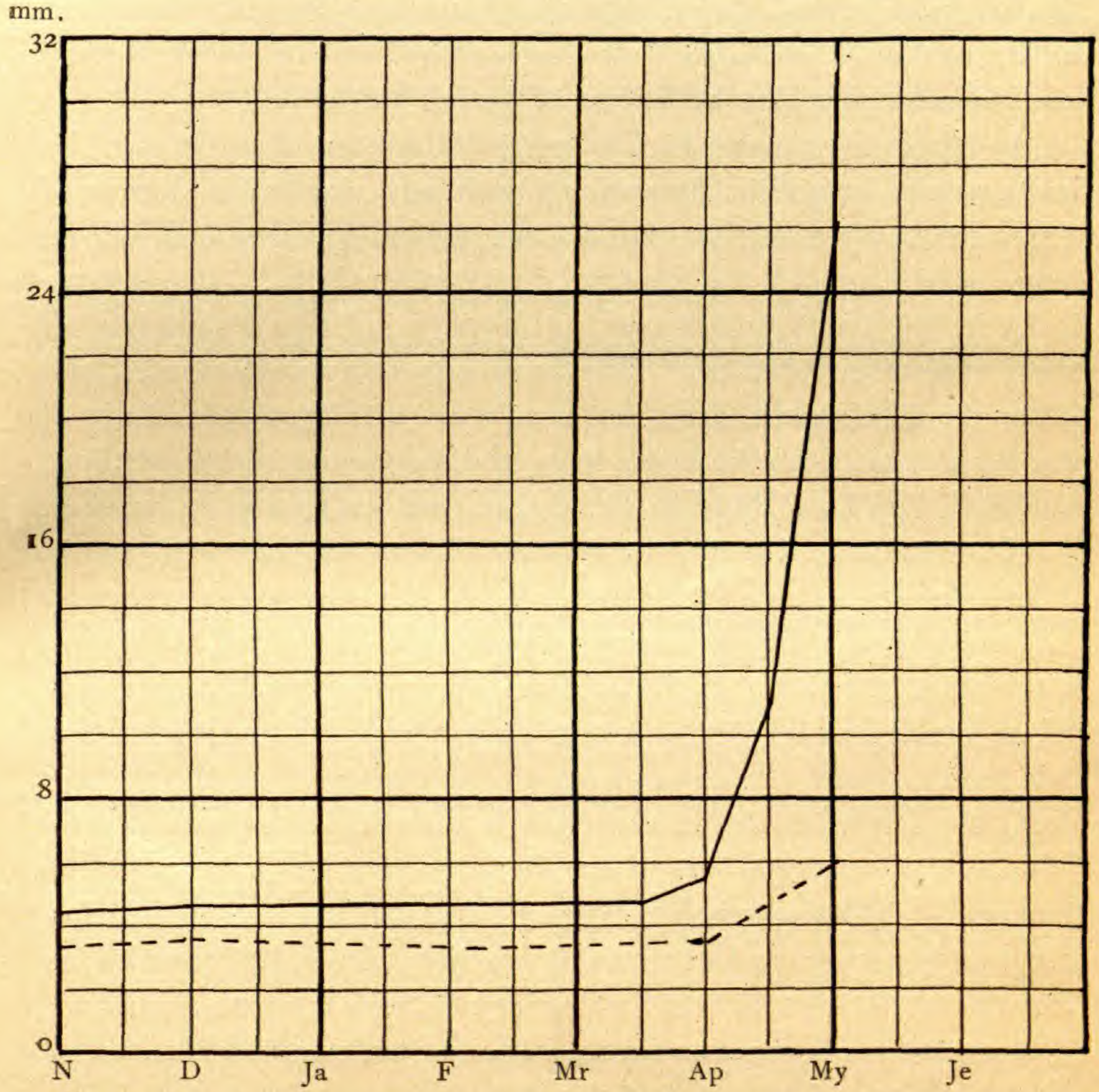

FIGURE C. *Quercus rubra.* Curves of growth of the buds in length and diameter.

From evidence accumulated from November, 1905, to May 22, 1906, it is probable that in *Betula populifolia* the full number of leaves, five to eight in terms of nodes, does not exist in the bud during the winter. Two well-formed leaves are readily distinguished, but the rest of the bud is a gelatinous mass from which only one or two leaf-like bodies can be extricated. When the bud unfolds, the two well-formed leaves expand at once but the rest of the bud undergoes an exceedingly slow development, during which period it is probable that new additions of leaves are made.

In *Ulmus americana*, in *Tilia vulgaris*, and in *Alnus incana*, the leaf content cannot be determined with any reasonable degree of accuracy beyond the fact that a large proportion if not all of the leaves which unfold are present during the winter. The irregularity in the number of leaves and nodes renders a comparison of these quantities valueless. The answer to this question, as in the other doubtful cases, must be sought in a microscopic study of the development of the buds from the beginning of the swelling period in April and May to the end of leaf expansion in summer.

To summarize briefly, the full number of leaves which unfold in the spring exists in the winter buds of *Acer platanoides*, *Aesculus Hippocastanum*, *Fagus americana*, *Fagus sylvatica*, *Fraxinus americana*, *Liriodendron Tulipifera*, *Hicoria ovata*, *Philadelphus*, *Picea excelsa*, and *Populus tremuloides*. In *Syringa vulgaris* the full number may or may not exist. In the last case, the number probably developed in the spring does not exceed one or two pairs of leaves, which soon die when the meristematic point ceases to function. Although the number of leaves in the bud approaches the number characteristic of this species there still remains an element of doubt in the following: *Rhododendron maximum*, *Quercus alba*, *Ulmus americana*, *Tilia vulgaris*, and *Alnus incana*. New additions of leaves probably take place in *Betula populifolia*, in *Salix fragilis*, and in *Salix alba*.

Measurements of buds : It is a striking coincidence that those winters during which observations on the size of the bud have been carried on have been winters of extraordinary mildness.

Askenasy (1877), whose investigations on the growth of the flower buds of cherry extend over a period of three years, says: "It is an important fact that greater warmth in winter exercises but little influence on the growth of cherry buds. However, when

Cornus mas and *Forsythia viridissima* bloom in early January, as they often do, it is possible that the temperature of the fall and winter months has a higher significance for these species than for cherry."

Küster (1899) holds that those organs in which growth is demonstrable during an unusually mild winter cannot fail to show some advance in a normally cold one.

Buds which were measured during each month of the winter 1905–6, show no appreciable increase in length or in diameter, although the winter was one of unusual mildness, a winter in which the mean temperature, 27° F. for the coldest month, was exceedingly high. The buds of the following species appeared absolutely dormant: *Fagus americana*, *Fagus sylvatica*, *Quercus alba*, *Quercus rubra*, *Tilia vulgaris*, *Tilia americana*, *Hicoria ovata*, *Hicoria microcarpa*, and *Fraxinus americana*. The flower buds of *Alnus incana*, *Ulmus americana*, *Betula populifolia*, *Populus tremuloides*, *Salix fragilis*, and *Salix alba* are more or less easily influenced by continuous high temperatures and consequently

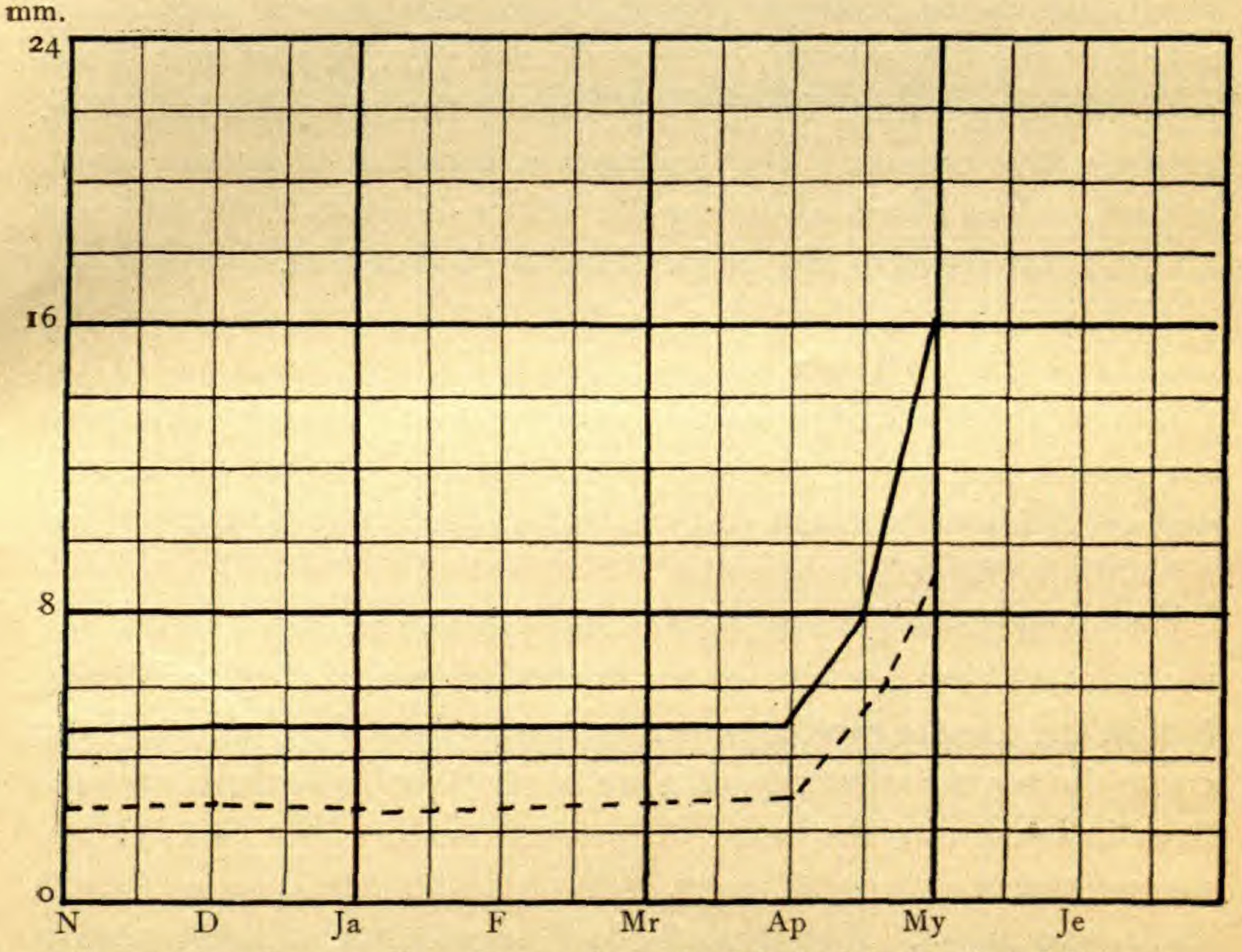

FIGURE D. *Quercus alba*. Curves of growth of the buds in length and diameter.

show a variable development. The flower buds of *Ulmus* and the catkins of *Alnus* were noticeably larger in January. In some cases the catkins of *Salix* and *Populus* had pushed aside their scaly coverings as early as December, but such precocious growth in these two genera is confined to the flower buds of saplings and of immature growths. Favorable situations and exposure to warm sunshine are apparently factors which influence such premature development.

Sendtner (1851) observed that different parts of a plant show a different attitude toward the varied influences and growth stimulations affecting them during the winter months.

According to Schimper (1903), it has been proved experimentally that the flower buds, or reproductive organs, possess a lower optimum temperature for growth than is the case with leaf buds, or vegetative organs. This principle is apparent in nature, since, in each species observed during the winter of 1905–6, the true leaf bud is in all respects less active than the flower bud.

Wiegand (1905) mentions the fact that flower buds do not increase in size until late spring. Similarly, the leaf buds of the trees and shrubs studied in this investigation show practically no increase in size during the winter rest-period. At least their normal condition of apparent rest is not disturbed in so far as their external appearance is concerned.

The curves of growth (figures *A–J*) indicate a slight alternating increase and decrease during the winter, a gradual increase during March and a more rapid advance in April. The fluctuations of the curve during the winter months are a result of difficulties encountered in measuring the buds. The outer scales often dry out and many either loosen or fall away. This is clearly the case in *Hicoria*, *Picea*, and *Alnus*. The quantity and consistency of scale varnish varies also. But in spite of these difficulties a gradual continuous growth, if present, could not fail to be observed and recorded in a series of measurements which are made at regular and frequent intervals during the winter and spring. The curves of growth are therefore of value in illustrating the time and rapidity of swelling, as well as the variations which are exhibited by the different genera and species.

The time at which the different plants under investigation

FIGURE E. *Hicoria ovata.* Curves of growth of the buds in length and diameter.

renew their growth in the spring varies considerably, as will be seen from the following curves. The curve of *Ulmus americana* illustrates a retardation in growth of about two weeks beyond that of *Syringa vulgaris* (FIGURES *A*, *B*). *Quercus rubra* and *Quercus alba* vary somewhat (FIGURES *C*, *D*). The buds of the two species of *Hicoria* differ not so much in time as in rapidity of development (FIGURES *E*, *F*). A greater delay in the swelling and unfolding of the buds occurs in *Tilia* and in *Betula* (FIGURES *G*, *H*). Buds of the two evergreens, *Rhododendron* and *Picea*, remain in a state of apparent rest until a later date than the buds of any other species that have been studied (FIGURES *I*, *J*).

Henslow (1901) remarks: "Buds are primarily the result of the lowering of temperature in autumn; for as soon as this rises above a certain degree they burst open and begin to grow." A comparison of the curve of temperature with the curves of growth indicates that temperature is not the only factor controlling the growth of buds. It will be seen that growth took place in March at a lower temperature than in the preceding winter months. Zero temperatures appear to have no effect on the size of the bud. Buds both with dry and with somewhat succulent scales were measured with the thermometer at 0° F. No difference in size could be detected as a result of these measurements. Wiegand (1905) records a similar observation for buds but finds a decided contraction in twigs due to the expulsion of air from the intercellular spaces.

As a rule, the first apparent evidence of growth in the bud is in the appearance, at the distal end, of small tufts lighter in color than the outer scales. These tufts were the elongating inner scales, which were soon followed by the leaves themselves. The increase in the diameter of the buds was proportionally much slower than the increase in length. A comparison of the field observations with the microscopic sections of the buds gives evidence of growth within the bud before it becomes visible externally. This was most clearly apparent in *Aesculus* (FIGURE 38).

Such observations regarding the period of rest and growth in buds may come to the eye of any careful and painstaking observer in the field. What takes place within the scales during this time is not so easily observed, yet one must admit that the unfolding of the leaf is only the last phase of a long-continued development whose stages of progress can be little known without a microscopic study of the internal structures and tissues.

MICROSCOPIC STUDY OF GROWTH

It is not the purpose of this investigation to trace the growth and development of leaves or leaf tissues from a purely embryological or cytological standpoint, but to consider changes in the size of cells already present, the addition of new cells or tissues, and the organization of new leaf fundaments.

A microscopic study of buds taken from the somewhat miscellaneous collection of trees and shrubs previously mentioned reveals a wide variability in the stage of development at which the leaf buds enter the winter rest. At one extreme stand *Fagus americana* and *Fagus sylvatica* with all of their leaves well formed and the future terminal and axillary buds present and in an advanced stage of development. At the other extreme stand *Betula*

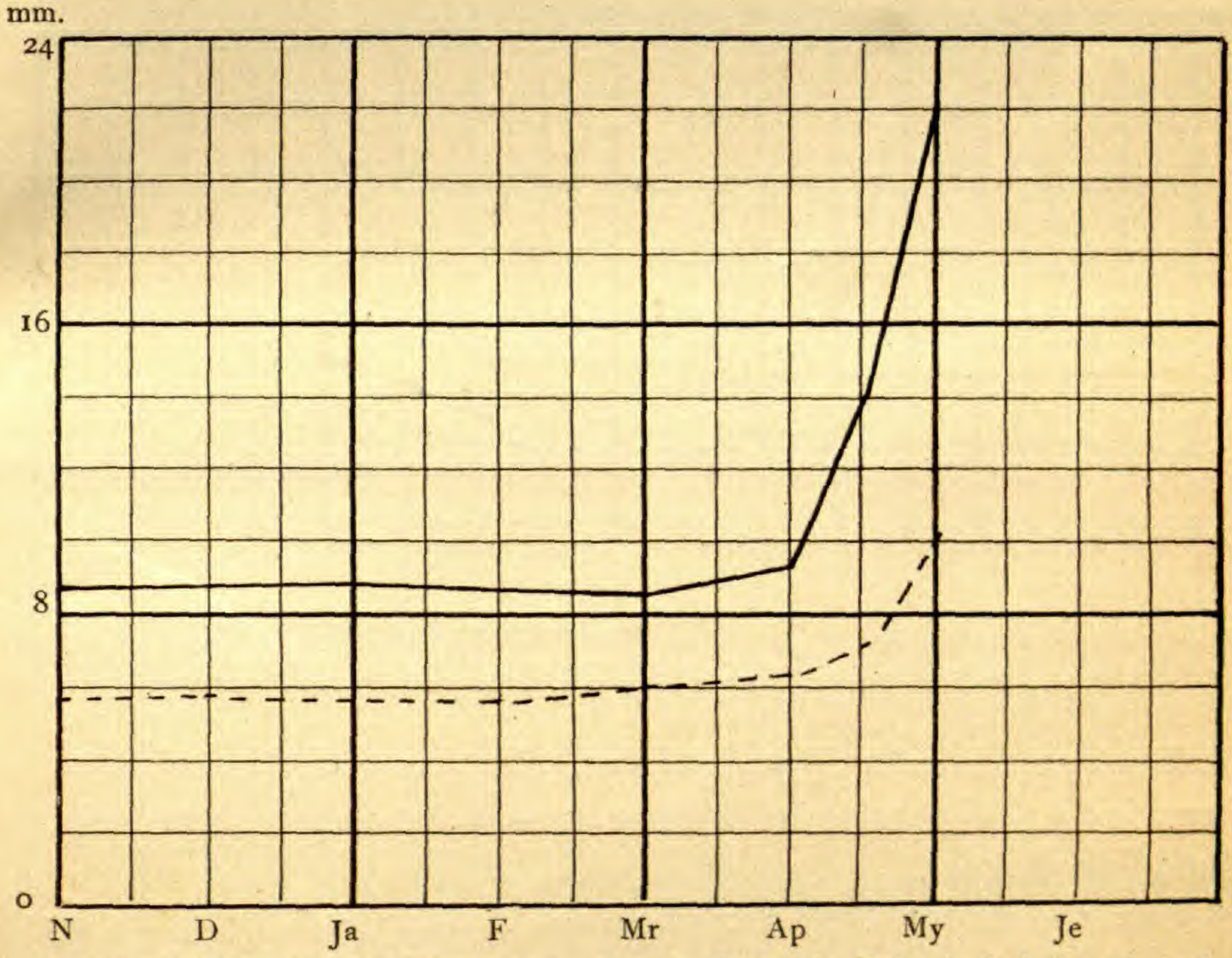

FIGURE F. *Hicoria microcarpa*. Curves of growth of the buds in length and diameter.

populifolia, *Salix fragilis*, and *Salix alba*, with an incomplete number of leaves and the axillary buds absent.

In *Fagus* neither the axis nor the axillary buds (FIGURE 15) show any change whatsoever until the April swelling which precedes the unfolding of the bud. Other cases in which the axillary buds are present in rudimentary form during the winter are *Fraxinus americana* (FIGURES 34 and 35), *Quercus alba* (FIGURES 46 and 47), *Ulmus americana* (FIGURES 17 and 18), *Alnus incana* (FIGURE 51), and *Syringa vulgaris* (FIGURE 8).

Mere areas of cells, which are rich in protoplasm and are stained more deeply than the surrounding tissue, occur in the leaf axils of *Liriodendron Tulipifera*, *Salix fragilis*, *Salix alba*, and *Acer platanoides*. No indications of axillary buds appear in the following: *Aesculus Hippocastanum*, *Picea excelsa*, *Rhododendron maximum*, *Tilia vulgaris*, *Populus tremuloides*, *Betula populifolia*, and *Philadelphus*.

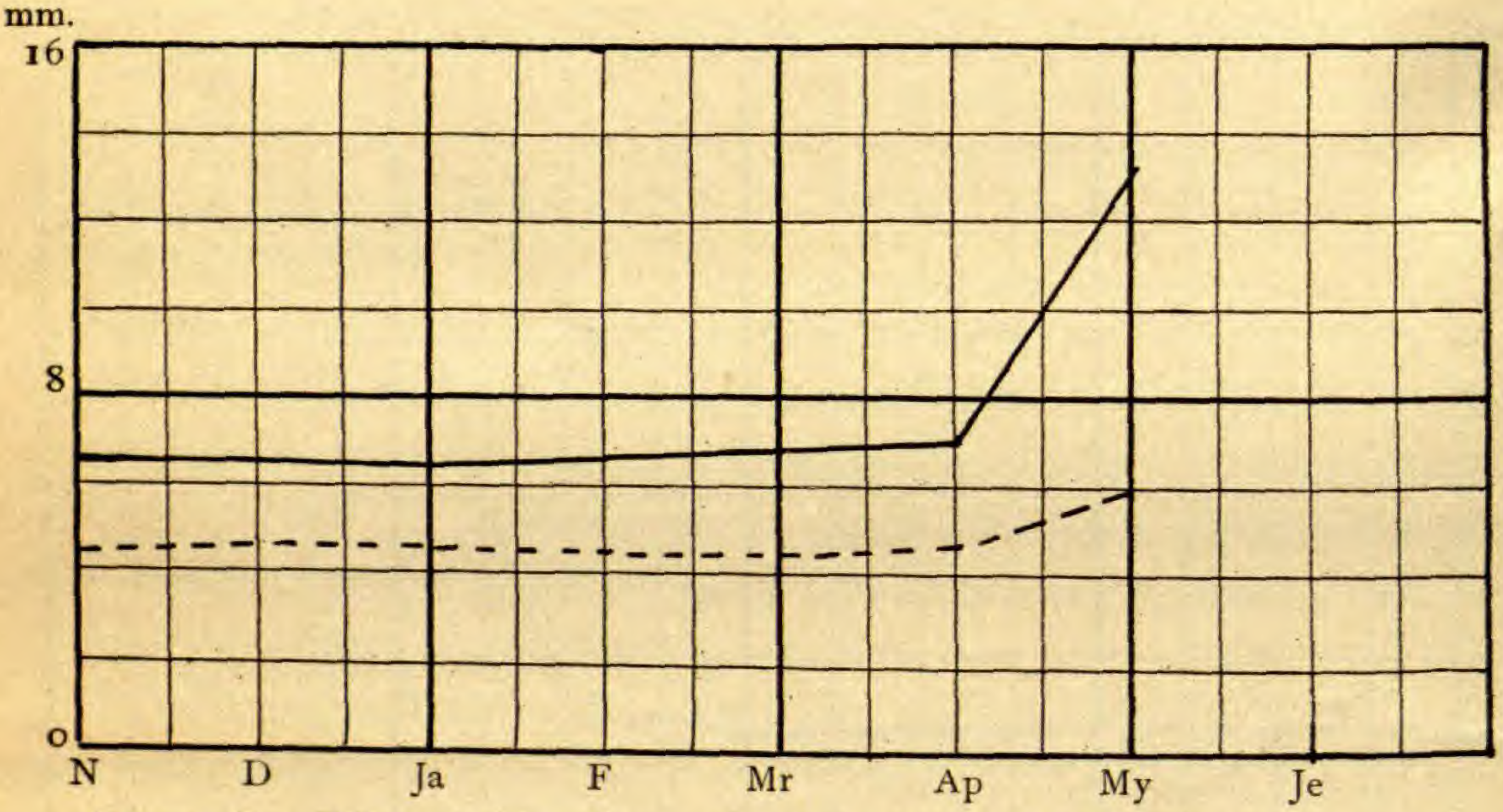

FIGURE G. *Tilia vulgaris*. Curves of growth of the buds in length and diameter.

In the flower bud, according to Coulter and Chamberlain (1903), the spore-mother-cell stage seems to be the usual halting place at the beginning of the rest period.

In an embryological study of *Ulmus americana*, Shattuck (1905) found the cells within microsporangia in the mother-cell stage in the early part of February and assumed that they passed the winter in this stage.

Miss Ferguson (1904) found in *Pinus* that the archesporial tissue was not differentiated into the spore-mother-cells until April, thus disproving Coulter and Chamberlain's general statement, as well as their special one, in regard to the gymnosperms.

Chamberlain (1898) says: "The flower buds of *Salix* pass the winter in the pollen-mother-cell stage." This general statement for *Salix* is questioned since flower buds of *Salix fragilis* gathered in November did not follow this rule. In this case the cells of the anther appear to be homogeneous and show no differentiation of tissues.

It follows from these different observations that both leaf buds and flower buds enter the winter in various stages of development. The exact point at which growth is suspended appears to be an inherited characteristic rather than one solely dependent upon climatic conditions.

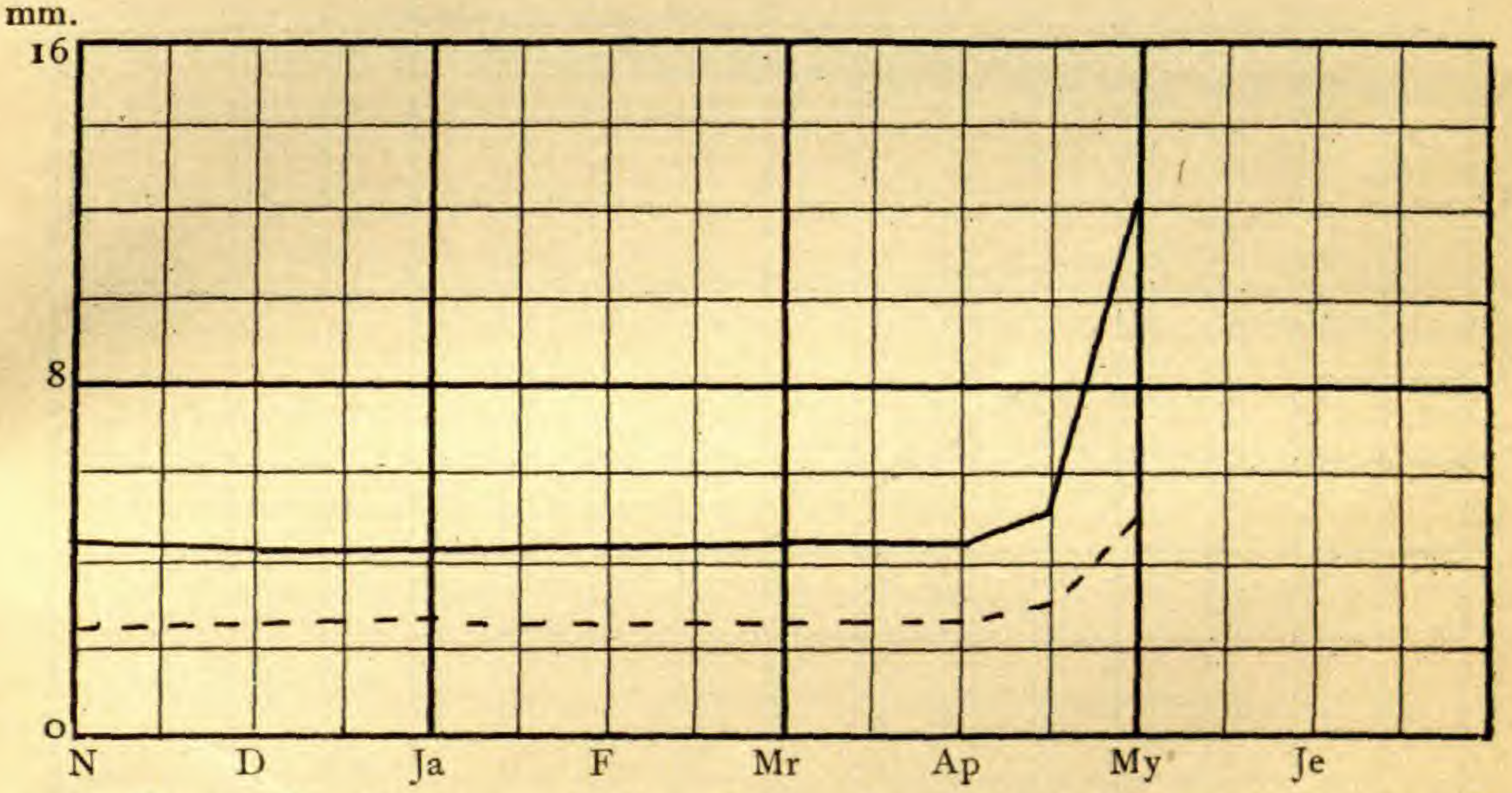

FIGURE H. *Betula populifolia.* Curves of growth of the buds in length and diameter.

We have seen that most buds, as a rule, do not increase appreciably in size during the winter months. The question that naturally arises is: Are these buds absolutely quiescent from November to February or are they undergoing changes which are not apparent externally?

Pfeffer (1903) claims that the influence of the continued cold of winter seems to have produced in the life of most plants in the colder zones a well marked period of rest. Strasburger (1903) says: "It is not in reality an absolute rest; for although the outwardly visible processes of development and growth stand still, the internal vital processes, although retarded, never altogether cease."

The investigations of Miyaké (1902) demonstrate that in evergreen leaves "starch is formed by photosynthesis in winter, though feebly, and its translocation occurs in the same season."

According to Fischer (1891), who has made many important observations on the metabolic processes which occur within the tree during winter, various activities and movements of the reserve material take place in the interior of the tree long before any externally visible changes become apparent. The starch which is stored in the pith of the young shoot moves toward the buds and accumulates in the embryonic leaves and flowers from which hitherto it has been absent. It is a reserve material and just suffices for the first stages of growth preceding the swelling of the buds.

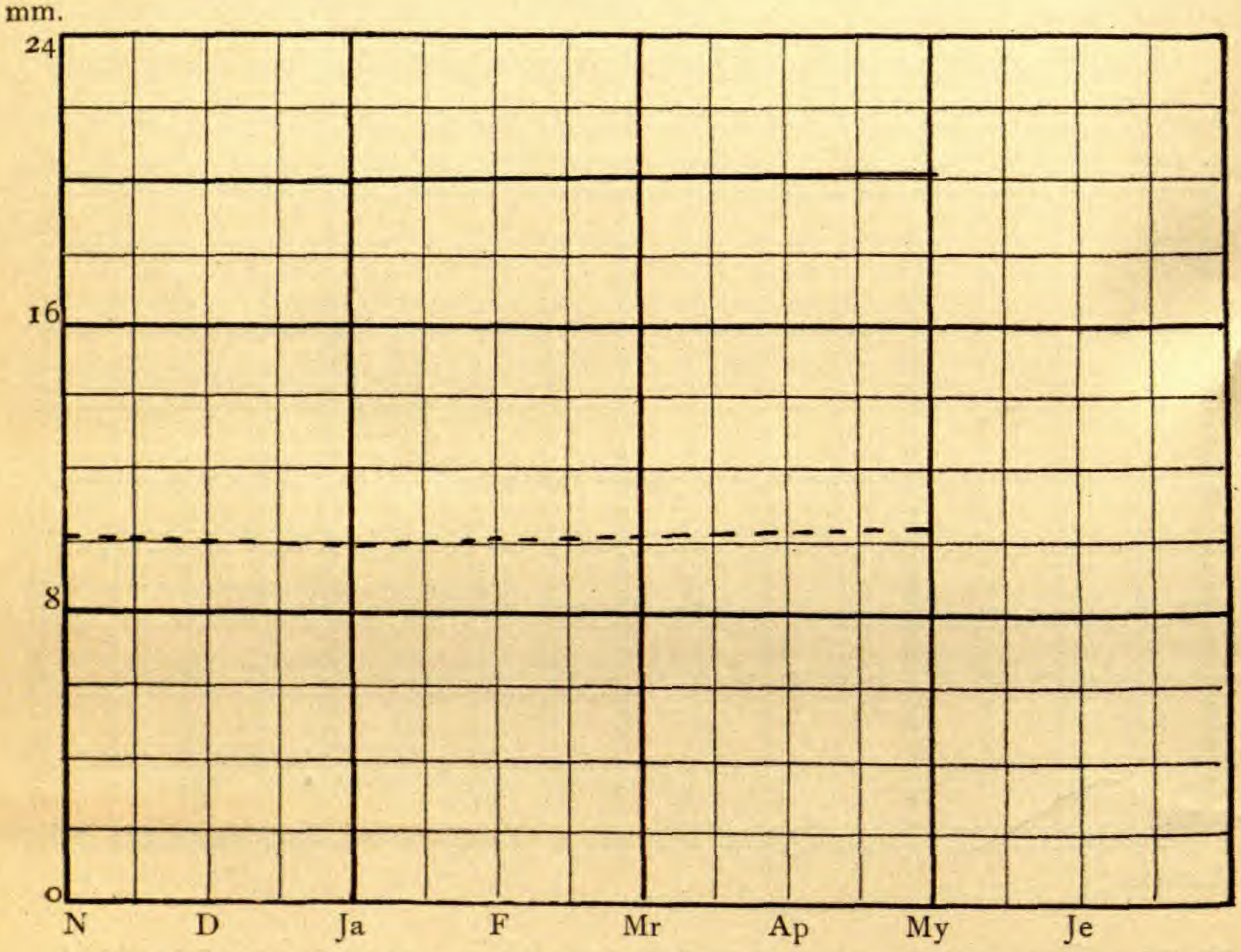

FIGURE I. *Rhododendron maximum.* Curves of growth of the buds in length and diameter.

Hartig (1861) observed that the duration of time during which this transportation of reserve food takes place is about the same for all trees, two months in all, but that the beginning of this activity varies in different trees. Activity begins about the middle of February in *Acer*, and about the middle of March in *Quercus*.

Baranetzky (1873) suggests that the power of bleeding, which is so frequently observed in plants, is a direct expression of the internal changes which are repeated every year in hibernating trees.

Halsted (1890) observed in February small quantities of starch in the pistil and in the filaments of stamens, organs which in early winter do not contain this reserve food.

It is possible that as a result of these metabolic processes growth is induced, although ever so slowly, and serves as a preparation for the sudden and rapid development of the young leaves and embryonic parts of the bud in the spring.

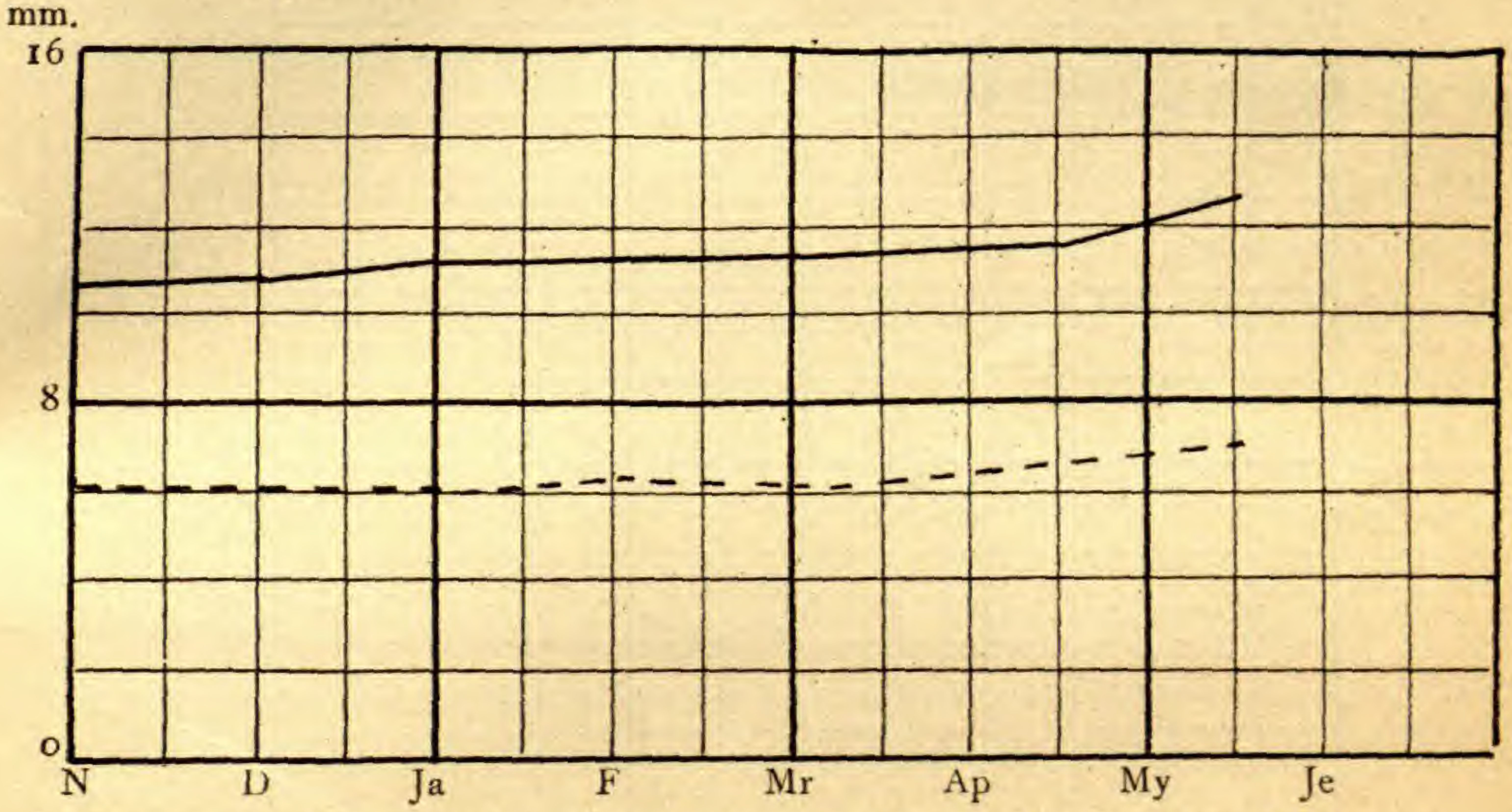

FIGURE J. *Picea excelsa.* Curves of growth of the buds in length and diameter.

There are many difficulties necessarily in the way of determining absolutely any increase due to the stretching of cells in the leaf or in the leaf fundaments of the bud. In comparing buds for the different months of the rest period, slight variations in size and in stage of development must be expected, but irregularities in this respect are minimized by a comparison of a large number of similar buds.

The median sections of buds and meristematic points illustrated in the present investigation were drawn after a comparative study of more than a thousand slides of serial sections representing over five hundred buds. It will be seen by reference to the plates that the leaf fundaments or lobes of homogeneous tissue, and the young leaves, which increase in size and in degree of development toward the periphery of the bud, are arranged in acropetal order around the meristematic point (FIGURES 1, 8, 30).

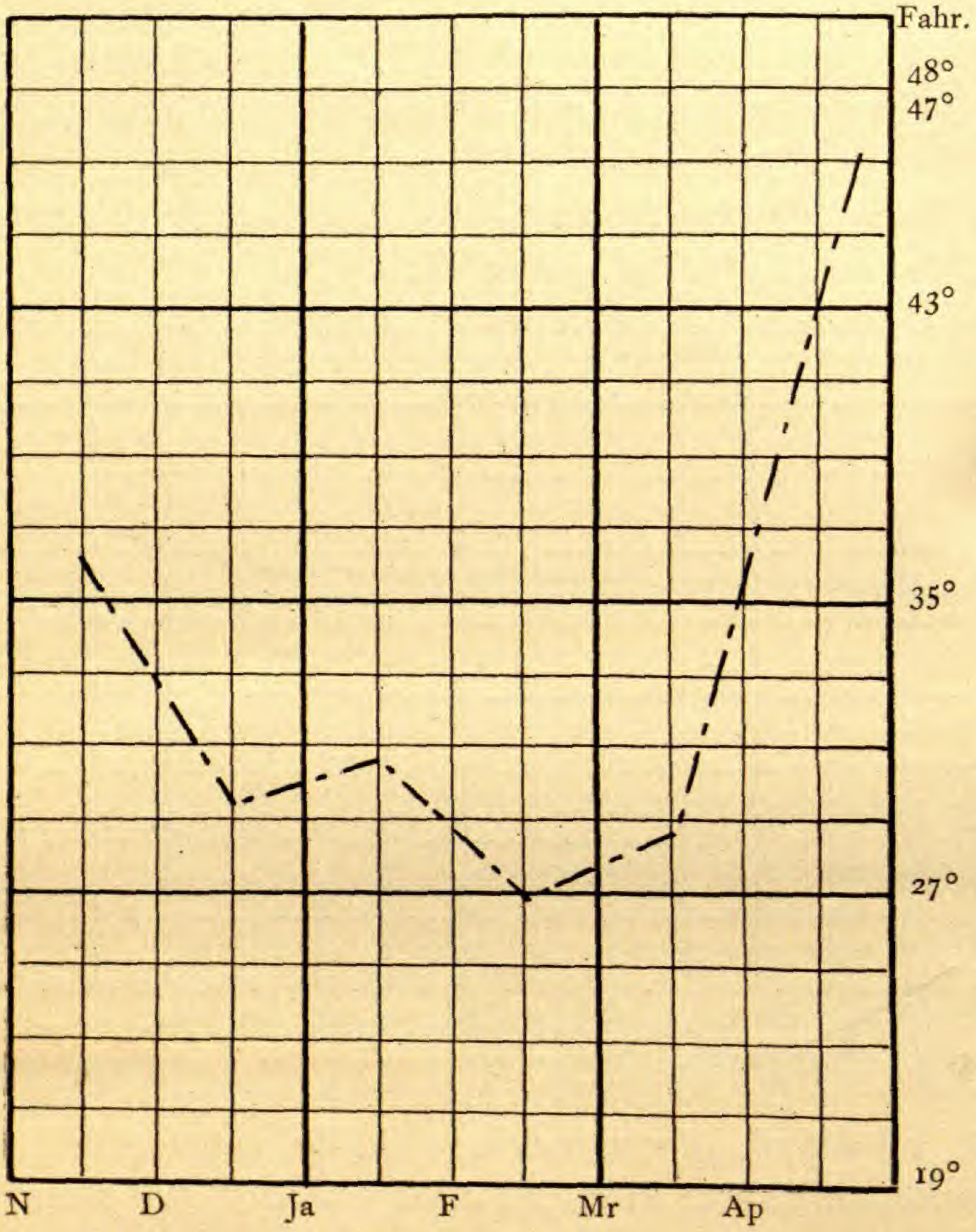

FIGURE K. Temperature curve.

In the species under investigation, growth of the leaf bud by addition of new tissue does not take place during November, December, or January. It seems apparent, however, that a stretching of cells occurs in many instances and manifests itself in the greater convexity of the meristematic point and its consequently crowded condition (FIGURES 3, 4, 9, 21, 22). This stretching in the apical part of the meristematic region causes no change in the size or in the external appearance of the buds under investigation, although it becomes a measurable factor in the leaf buds of *Sambucus* and of *Prunus*, species which more readily respond to the continuous high temperatures of an unusually mild winter.

Küster says that during the warm winter of 1899 leaf buds of *Acer platanoides* showed not only a stretching of the cells but also an addition of new tissue in the axils of the upper leaves. These results must be seriously questioned, for his drawings of free-hand sections do not give the accuracy of detail which the microtome sections reveal. A careful search through many series of sections proves conclusively that what Küster called new tissues are the basal parts of the petioles which partially encircle the young axis of the bud (FIGURES 31 and 32).

All cells in the tissues of the winter buds are exceedingly small and closely packed together. A pronounced stretching of the tissue occurs in the following species during February: the inner scale fundaments of *Aesculus Hippocastanum* increase in length (FIGURE 38); the rudimentary leaves of *Syringa vulgaris* appear larger (FIGURE 10); the bud of *Philadelphus*, which in its dormant state is buried beneath the leaf scar, protrudes as a tiny bud through the rift in the upper portion of the scar.

The mean temperature for the month of March was exceptionally low for that month (FIGURE K), yet there are many evidences that growth occurred. *Liriodendron* and *Acer* show minute cushions of tissue which later develop into axillary buds (FIGURES 5 and 32). In *Alnus* the cushions of tissue increase slightly in size (FIGURE 51). A change in the color of the *Salix* buds, a change from a dull red to a more living one, gives evidence that the life processes are more active; their interior structure also reveals growth by the enlargement of parts at the growing tip (FIGURE 23), and in the more deeply staining tissue at the leaf axils. Buds of *Fraxinus* show no additional tissue but a general stretching of all parts. These buds which show a gradual but unmistakable advance in interior structure through February and March undergo rapid and vigorous growth in April when the leaf blades become more or less expanded and free.

In leaf buds which develop more slowly, as in *Quercus*, *Hicoria*, *Fagus*, *Populus*, and *Tilia*, there is little evidence of growth or stretching in the meristematic points or other local areas from November to March inclusive. It seems probable that growth entirely, or almost entirely, ceases for a time. A cytological and a physiological study of these parts as they occur during the winter is required to verify this conclusion.

Geleznoff (1851), a Russian investigator who studied the leaf buds of *Quercus* and *Betula* in their winter condition, says: "All buds make some advance in growth of new tissues and organs from December to February even at continued temperatures of 0° and less." It is possible this report of the organization of new parts at such temperatures is the result of incorrect observations of unlike buds, for plant physiologists hold that the growth and the construction of new organs at temperatures below 0° is impossible (Davenport, 1897).

In late March and early April the buds of *Quercus*, *Hicoria*, and *Fagus* begin a general swelling which becomes noticeable in a lengthening of the internodes and a more crowded condition of the meristematic point. *Betula*, *Populus*, and *Tilia* remain dormant for a longer time. Sections of the last two species indicate changes by the 16th of April in the general length of scale or leaf fundaments, and irregularities in the outline of the meristematic surface (FIGURES 26 and 29). Aside from the stretching of cells, the outline of the buds of *Betula* remains the same, but in the region of the leaf axils the tissue becomes more deeply staining than heretofore. On April 16 the leaf buds of *Picea* and *Rhododendron* appear as in the preceding months of the rest period (FIGURES 40–43). Observations on *Picea* in early May reveal an alteration in the papilla-like leaves which from now on assume rapidly their needle-shaped character. No change, up to this time, is visible in the leaf buds of *Rhododendron*.

SUMMARY

In some species the full number of leaves that unfold in the spring exists at the beginning of winter. In other species, the majority of leaves are present at this time and additions occur at the time of unfolding. The terminal and axillary buds of the next summer and autumn are in many cases well organized at the approach of winter.

The leaf buds of all deciduous and evergreen trees and shrubs investigated enter upon a winter resting period, the duration of which varies in the different plants.

The greater warmth of an unusually mild winter exercises but little influence on the growth of leaf buds. Flower buds respond more quickly to the influence of continuous high temperatures.

Of the species under investigation, some leaf buds show no change either in length or in diameter until February or March; others not until April or May.

In some cases growth may take place in February and March at lower temperatures than prevail during the preceding winter months.

Organization of additional tissues does not take place within the leaf buds during the winter but becomes apparent in March or April. A stretching of cells occurs in the meristematic region of some species as early as December and January, and manifests itself by a greater convexity of the meristematic surface. This change is microscopic and produces no change in the external appearance of the buds.

The first apparent evidence of growth is a swelling of the closely compacted tissues. With continuous high temperatures rapid and vigorous growth follows.

The leaf buds of the two evergreens investigated, *Picea* and *Rhododendron*, exhibit the longest rest period.

For valuable aid and supervision in carrying on this investigation most grateful acknowledgment is given to Dr. Margaret C. Ferguson, of Wellesley College.

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Explanation of text figures and of plates 9-11

Figures *A–J* represent the curves of growth of the buds in length and in diameter. Figure *K* is the temperature curve. The continuous line indicates growth in length. The dotted line indicates growth in diameter. The dot and dash line shows the mean temperature. The numerals on the axis at the left of curves *A–J* represent the growth of the bud in millimeters. The numerals at the right of curve *K* indicate the mean temperatures, Fahrenheit. The bottom line represents the time during which measurements were made, the 25th of November, December, and January, the 10th and 25th of February, March, April, and May. As a rule, for each species, the measurements of ten buds are averaged for each curve. The curves end at the time of unfolding of the bud.

All figures in plates 9–11 were drawn with the aid of the Abbé camera lucida. A Zeiss microscope was used. All figures represent longitudinal sections. Figures 1 and 8 are magnified 10 times; all others are magnified 25 times. The abbreviations used in the explanation of plates are as follows:

Axis of incipient shoot, *a.*; axillary bud, *ax.b.*; base of petiole, *b.p.*; leaf, *l.*; leaf fundament, *l.f.*; petiole, *p.*; scaly covering, *s.c.*; scale fundament, *s.f.*; stipule, *st.*; terminal bud, *t.b.*; vegetative point, *v.p.*; vascular tissue, *v.t.*

PLATE 9

1–6. *Liriodendron Tulipifera*

1. Median longitudinal section of bud with two outer leaves removed. November.

2. Vegetative point during rest period. 29 D.

3, 4. Greater convexity of vegetative point and crowding of parts. 30 Ja, 28 F.

5. A general elongation of axis, of leaf, and of scale fundaments. 30 Mr.

6. Bud two weeks later than in preceding figure. Marked increase in size. 16 Ap.

7–14. *Syringa vulgaris*

7. Appearance of vegetative point during winter rest period. 25 N.

8. Median longitudinal section showing appearance of axis during winter. January.

9. Appearance of vegetative point in winter. 30 Ja.

10. Elongation of leaf fundaments. 28 F.

11. Stretching of parts and addition of upper axillary buds. 30 Mr.

12, 13. Two stages of vegetative point on April 16.

14. Axillary bud. 5 My.

15 and 16. *Fagus americana*

15. Typical structure of an axillary bud as found within the terminal bud during winter. November, March.

16. Same, showing increase in size. 16 Ap.

17–19. *Ulmus americana*

17. General appearance of vegetative point during winter. November.

18. Greater convexity of vegetative point. 30 Ja.

19. General growth of meristematic region. 16 Ap.

20–24. *Salix fragilis*

20. Winter condition of vegetative point. November, December.

21, 22. Greater convexity of vegetative point. 30 Ja, 28 F.

23. General stretching of meristematic region. 30 Mr.

24. Additional growth of new organs. 16 Ap.

25 and 26. *Tilia vulgaris*

25. Winter condition of vegetative point. February.

26. Greater breadth at vegetative point. March.

27. *Betula populifolia*

Appearance of apical part of bud in winter and spring. November, April.

28 and 29. *Populus tremuloides*

28. Winter condition of apical region. November, March.

29. General stretching and growth of meristematic region. 16 Ap.

PLATE 10.

30–33. *Acer platanoides*

30. Appearance during rest period. November, December.

31. General stretching of parts in meristematic region. January, February.

32. Appearance of scale fundament and upper axillary bud. 30 Mr.

33. General growth of parts and appearance of future terminal bud. 16 Ap.

34 and 35. *Fraxinus americana*

Appearances during rest period and early spring. November, March.

36–39. *Aesculus Hippocastanum*

36, 37. Appearances during rest period. November, January.
38. Elongation of scale fundaments. 28 F.
39. Broadening of apical region. 30 Mr.

PLATE II

40 and 41. *Picea excelsa*

General dormant condition during winter and early spring. November, March.

42 and 43. *Rhododendron maximum*

Dormant condition during winter and spring. November, 16 Ap.

44 and 45. *Philadelphus*

44. Median longitudinal section of bud, showing winter condition. November, January.

45. Median longitudinal section of bud, showing stretching of parts. February, March.

46–48. *Quercus alba*

46. Axillary bud within the terminal bud at beginning of rest period. November.
47. Winter condition of vegetative point. December, March.
48. General stretching of parts. 16 Ap.

49–51. *Alnus incana*

49, 50. Appearances during winter rest period. November, February.
51. General growth in apical part of meristematic region. 30 Mr.

The present treatment of monotypic genera of fungi *

C. L. SHEAR

In view of the approaching International Botanical Congress to be held in Brussels in 1910, at which it is proposed to provide rules for the nomenclature of the cellular cryptogams, and also in view of the impression which seems to prevail in some minds that the nomenclature of the fungi is in no great need of revision, it may not be inappropriate to call attention to one important phase of conditions as they now exist in mycological nomenclature, namely, the treatment of monotypic genera. Whatever views one may entertain in regard to the type method in general, as a basis of fixing genera and species, we do not anticipate there are many who would deny that genera originally based upon a single species should retain that species. In other words, one would rather expect a monotypic genus always to contain its monotype, however many other species might be added to it. The International Commission of Zoological Nomenclature has already adopted the type method of fixing genera. Their first rule is "a genus proposed with a single original species takes that species as type." In order to show the actual condition prevailing at present with reference to this particular phase of the question, the following cases are cited. These have been selected at random from the Pyrenomycetes and Fungi Imperfecti. Many more cases of the same kind could be found without difficulty.

Coelosphaeria Sacc. Myc. Ven. Spec. 115. 1873 was proposed as a substitute for *Nitschkia* Otth. 1869, which Saccardo regarded as a homonym of *Nitzschia* Hassall 1845. Only one species, *C. Fuckelii* (Nitsch.) Sacc., was included in the genus by Saccardo, *loc. cit.*, and this species happened to be the type of *Nitschkia*, the genus for which *Coelosphaeria* was substituted. Overlooking the fact that this same species was the type of *Cyathisphaeria* Dumort. 1822, note the use of the name *Coelosphaeria* by Ellis and Ever-

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* Read beford Section G of the American Association for the Advancement of Science at the Baltimore Meeting, December 31, 1908.

hart, N. A. Pyren. 246, 1890. They use the name *Nitschkia* in connection with its original type, thus depriving Saccàrdo's *Coelosphaeria* of its monotype. The genus is then "emended" by Ellis and Everhart and the name *Coelosphaeria* applied to another group of species.

Cryptosphaeria Grev. Scot. Crypt. Fl. **1**: *pl. 13.* 1823. This, according to the original publication cited, was monotypic, *C. Taxi* (Sow.) Grev. being the only species described or mentioned at that time, although the next year, in Fl. Edin. 359. 1824, the author included many other species. In the original description he says "Sporules always ? naked." In a footnote he says "they [the plants included in the genus] are always also characterized by having their spherules not enclosed in filiform tubes as in the true *Sphaeria*." Thus his description as well as his type excludes ascomycetous fungi. Now this monotype is found in Saccardo, Syll. Fung. **3**: 359 under *Diplodia* Fries 1834, to which genus it had been previously transferred by De Notaris, while *Cryptosphaeria* is cited by Saccardo as having been published at a later date than the original, Scot. Crypt. Fl. **4**: *pl. 201.* 1826, "*pro min. parte*," and is used to include fourteen species of pyrenomycetous fungi, only one of which was ever referred to the genus by Greville and that three years after the original publication of the genus.

Cylindrosporium Grev. Scot. Crypt. Fl. **1**: *pl. 27.* 1822. was based upon the single species *C. concentricum* Grev., which was described and illustrated in the place cited. Unger in 1833, Die Exantheme, 168, added two species to Greville's genus, but these were apparently not congeneric with Greville's species. Later, Berkeley and Broome examined Greville's type specimen and referred his species to the later genus *Gloeosporium* Desm. & Mont. Ann. Sci. Nat. Bot. III. **12**: 295. 1849, thus depriving Greville's genus of its monotype. *Cylindrosporium* was used for a time as a depository for miscellaneous species by Berkeley and others until Saccardo, Michelia **2**: 12, "emended" it and referred two species to it, one of his and one of Berkeley's. Later, in Syll. Fung. **3**: 737, he attributes the name to Unger "em. Sacc." Thus the monotype of Greville's genus has been transferred to a later genus and Greville's name used for another genus and attributed to a later author.

Isothea Fr. Summ. Veg. Scand. 421. 1849. A description of the genus is given and one species mentioned, *Sphaeria rhytismoides* Bab. with a citation of an illustration by Berkeley in Ann. & Mag. Nat. Hist. **6**: 361. 1841. This monotype is transferred by Saccardo to the more recent genus *Laestadia* Auers. 1869 as *L. rhytismoides* (Berk.) Sacc. Syll. Fung. **1**: 224, while *Isothea* is "emended" and restricted to a species, *I. Nyssae* B. & C. Grevillea **4**: 157. 1876, referred to it by Berkeley and Curtis many years later and entirely unknown to Fries and also unknown at present except for the original brief and imperfect description.

Naemaspora Willd. Fl. Berol. 414. 1787. This was published as a monotypic genus, being based on *Sphaeria bombarda* Batsch = *Bombardia fasciculata* Fr., which was later taken from *Naemaspora* and used as the monotype of *Bombardia* Fr. Summ. Veg. Scand. 1849. Authors have since attributed *Naemaspora* to various later writers, including Persoon, Ehrenberg, and Fries. Fries, Syst. Myc. 478, cites Ehrenberg; Lindau, in Engler and Prantl's Pflanzenfamilien, attributes the genus to Persoon; and Saccardo says "Pers. em." and spells the name *Naemospora.* All recent authors have applied the name to a group of Fungi Imperfecti having so far as known no particular relation to Willdenow's monotype.

Septaria Fr. Nov. Fl. Suec. **5**: 78. 1819. *S. Ulmi*, the monotype of Fries, now passes as *Phloeospora Ulmi* (Fr.) Wallr. The name was changed to *Septoria* by Fries because of a genus *Septaria* among animals (*cf.* Syst. Orb. Veg. 119. 1825). Saccardo cites Fr. Syst. Myc. **3**: 480. 1829 as the place of publication, where a description is given with mention of two species which had been added to the genus by Desmazières. In Summ. Veg. Scand. 426. 1849, Fries mentions the original monotype, *S. Ulmi*, first in a footnote as one of the type species.

Phloeospora Wallr. Fl. Crypt. Germ. **2**: 176. 1833 was based on two species, the first being *Septoria Ulmi* Fr. The monotype of *Septaria* having been taken from it and placed in the more recent genus *Phloeospora,* the name *Septoria* is applied to another group of species and "emend. Sacc." added, which was apparently regarded as sufficient explanation and justification of the act.

Sphaeropsis Lév. Dem. Voy. in Crim. **2**: 112. 1842 was based upon a single species, *S. conica* Lév. n. sp., the specimens being apparently old, the spores were thought to be free. Later, it was found that the type was an ascogenous form and the species was placed by Cesati and De Notaris in their new genus *Amphisphaeria*, Schem. Sfer. Ital. 49. 1863, becoming *A. conica* (Lév.) Ces. & DeNot., which name has been adopted by Saccardo, Syll. Fung. **1**: 719, while the name *Sphaeropsis* is applied to a great group of species of Fungi Imperfecti and the genus "emended."

It is perhaps unnecessary to cite further instances of this kind to illustrate the present practice of most mycologists. Saccardo has been referred to in connection with most of these cases, not because he furnishes the most notorious examples of this practice, but because his Sylloge Fungorum is a general work widely used and largely followed by mycologists at present. In many cases he simply followed the example of some preferred predecessor. Cases of the same sort can be found in Engler and Prantl's Pflanzenfamilien, Rabenhorst's Kryptogamen-flora and almost any general work on systematic mycology.

The present condition of mycological nomenclature, as indicated by the cases cited, has been brought about apparently in great part by several rather natural causes. One of the most important of these has been the want of accurate knowledge on the part of the earlier writers of the organisms with which they were dealing. With the poor microscopes available and the lack of time or inclination to use them, there is little wonder that important and essential microscopic characters of the smaller fungi were not recognized. Generic characters and descriptions were therefore generally based upon superficial examinations of specimens with the naked eye or a hasty and insufficient study with a magnifier or microscope. As a consequence, the descriptions given were usually very imperfect or erroneous. As the older mycologists seem to have tried to interpret genera by descriptions or concepts instead of appealing directly to the actual organism which the original author used, this may account in part, perhaps, for the neglect of types. All subsequent writers, as well as the author of a genus, appear to have felt perfectly free to take one or all the species from a genus at any time or to modify or amend its description according to their conception of it. This attitude towards the subject also appears to account in part at least for the practice of citing different authors for the same genus or different works of an author as the place of publication. Writers seem to have felt at perfect liberty to attribute a genus to the person whose idea of its limits most nearly accorded with theirs, without particular reference to its treatment or the species included in it by its original author. The place of publication cited for a genus seems either to have been selected upon the same basis or else chosen because it happened to be the most convenient or accessible work. Thus it happens that the ordinary citations for the publication of fungus genera do not, in the majority of cases perhaps, refer to the first or original description or author of the genus. Blind following of authority has also contributed its share towards bringing about the present deplorable condition.

Without adopting some plan of permanently fixing generic names to some particular species, it is difficult to understand how any degree of stability or uniformity can be attained in the use of names.

WASHINGTON, D. C.

New species of fungi

CHARLES HORTON PECK

Clitopilus Davisii

Pileus thin, convex, becoming nearly plane, glabrous, creamy white or buff, flesh white, odor and taste farinaceous; lamellae narrow, thin, close, adnate or slightly decurrent, white becoming flesh-colored; stem slender, equal or slightly tapering upward, solid or stuffed, subbulbous, white or whitish, shining, becoming brown or brownish with age, often with a white mycelium at the base; spores subglobose, angular, uninucleate, 8–10 μ broad.

Pileus 2–3 cm. broad; stem 4–7 cm. long, 2–6 mm. thick.

Gregarious; in dry, gravelly soil. Stow, Massachusetts. September. Simon Davis. The pileus is said to be umbonate in the fresh state, but in the dried specimens it is subumbilicate.

Pileus tenuis, convexus, deinde subplanus, glaber, flavus, carne albida, odore saporeque farinaceis; lamellae angustae, tenues, confertae, adnatae vel leviter decurrentes, albae, deinde incarnatae; stipes gracilis, aequalis vel sursum leviter attenuatus, solidus farctusve, subbulbosus, nitidus, albidus, in maturitate brunnescens, saepe basi mycelio albo; sporae subglobosae, angulares, uninucleatae, 8–10 μ latae.

Pileus 2–3 cm. latus; stipes 4–7 cm. longus, 2–6 mm. crassus.

Eccilia flavida

Pileus thin, convex, glabrous, umbilicate, pale yellow, obscurely striate when dry; lamellae thin, somewhat close, decurrent; stem slender, glabrous, hollow, colored like the pileus or a little paler, commonly with a white mycelium at the base; spores subglobose, angular, 8–12 μ × 6–8 μ.

Pileus 2–2.5 cm. broad; stem 2.5–3.5 cm. long, 1.5–2 mm. thick.

Stow, Massachusetts. September. George E. Morris. In the dried specimens the umbilicus has a whitish color and the lamellae are colored like the pileus.

Pileus tenuis, convexus, glaber, umbilicatus, flavidus, siccatus obscure striatus; lamellae tenues, subconfertae, decurrentes; stipes gracilis, glaber, fistulosus, in colore pileo similis, saepe basi mycelio albo; sporae subglobosae, angulares, 8–12 μ × 6–8 μ.

Pileus 2–2.5 cm. latus; stipes 2.5–3.5 cm. longus, 1.5–2 mm. crassus.

Boletus Morrisii

Pileus fleshy, convex, dry, glabrous, smoky brown with a yellow margin or yellow and red with brown spots, the margin surpassing the tubules, flesh pale yellow; tubules at first short, minute, bright yellow, then elongated, convex in mass, orange-brown, rounded behind and depressed about the stem or free, the mouths larger, subrotund; stem equal or slightly thickened toward the base, solid, punctate with minute reddish dots, yellowish externally, pale yellow within and sometimes streaked with reddish brown; spores oblong fusiform, 10–15 μ × 4–5 μ.

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

In sandy soil under scrub oaks. Ellis, Massachusetts. August. G. E. Morris. The species belongs to the section *Edules*, and is well marked by its dotted stem.

Pileus carneus, convexus, siccus, glaber, fumoso-brunneus, in margine lutescens, margine tubulos excedente, carne flavida; tubuli primo brevissimi, minuti, aurei, deinde elongati, convexi, circum stipitem depressi vel liberi, subrotundi, aurantiaco-brunnei; stipes aequalis vel leviter basi incrassatus, solidus, punctis minutis rufescentibus asperatus, extus lutescens, intus flavidus vel colore rufo-brunneo tinctus; sporae oblongo-fusiformes, 12–18 μ × 4–5 μ.

Pileus 2.5–8 cm. latus; stipes 5–8 cm. longus, 8–12 mm. crassus.

Herpotrichia rhodospiloides

Perithecia gregarious, globose, seated on or involved in an effused thin black tomentum, subglabrous and dull reddish brown or grayish at the apex, sometimes entirely black; ostiola obscurely lacerated; asci clavate or subcylindric, 60–100 μ long, 10–12 μ broad; spores crowded or subdistichous, oblong or subfusiform, straight or slightly curved, uniseptate with one or two nuclei in each cell, hyaline, becoming slightly colored with age, 16–20 μ × 6–8 μ.

On decorticated wood of cottonwood, *Populus deltoides* Marsh. Batesville, Arkansas. October. Elam Bartholomew.

The fungus forms thin somewhat interrupted black patches on the surface of the wood. The tomentum is composed of slender black flexuous filaments. The species is closely allied to *Herpotrichia rhodospila* (B. & C.) Sacc. but differs from it in the paler color of the apex of the perithecium and in having uniseptate spores. The subiculum also is tomentose, not crustaceous. The perithecia are sometimes entirely black and almost wholly glabrous.

Perithecia gregaria, globosa, tomento effuso atro insidentia, ad apicem subglabra rufo-brunneaque vel grisea, aliquando omnino atra, ostiolis obscure laceratis; asci clavati subcylindraceive, 60–100 μ longi, 10–12 μ lati; sporae confertae subdistichaeve, oblongae, subfusiformes, rectae vel subcurvatae, uniseptatae, hyalinae, in maturitate flavescentes, 16–20 μ longae, 6–8 μ latae; cellula quaque 1–2-septata.

Botrytis uredinicola

Tufts 1–2 mm. broad, hypophyllous, soft, snowy white; hyphae rather short, sparingly branched, septate, branches very short; spores globose, hyaline, 8–10 μ in diameter.

Parasitic on sori of some uredinous fungus inhabiting leaves of tall smooth panic grass, *Panicum virgatum* L. Stockton, Kansas. July. E. Bartholomew. Related to *Botrytis pilulifera* Sacc. but differing from it in its habitat and in its much smaller spores.

Caespites 1–2 mm. lati, hypophylli, molles, nivei; hyphae breviusculae, sparse ramosae, septatae, ramis brevissimis; sporae globosae, hyalinae, 8–10 μ latae.

Gyroceras divergens

Spots on the upper surface of the leaf grayish with a faint purplish tinge, on the lower surface purplish brown, more or less confluent; hyphae hypophyllous, the sterile creeping, branched, often short, hyaline or pallid, the fertile suberect, multiseptate, variable in length and diameter, 20–80 μ × 6–10 μ, forming brown tomentose patches, the cells 4–8 μ long, 6–10 μ broad, sometimes a few of them with a longitudinal septum.

On living leaves of sugarberry, *Celtis occidentalis* L. Batesville, Arkansas. October. E. Bartholomew.

This species differs from *Gyroceras Celtidis* (Biv.) M. & C., an inhabitant of *Celtis australis*, in the color of the spots and in its chains of spores, which are shorter, broader, and erect, not incurved or involute at the apex, and in sometimes having a few of the articulations longitudinally divided. In this character the species diverges from the typical character of the genus. The number of septa in a spore chain may vary from 3 to 15, but in *G. Celtidis* they may exceed 20. In our fungus the apical cells or spores are sometimes broader than the basal ones, thereby giving a subclavate shape to the whole chain. An occasional constriction is seen in some chains, which is suggestive of *Septonema*.

Maculae foliorum facie superiore griseae, facie inferiore purpureo-brunneae, saepe confluentes; hyphae hypophyllae, steriles repentes, ramosae, vulgo breves, hyalinae pallidaeve, fertiles suberectae, multiseptatae, 20–80 μ × 6–10 μ, areas tomentosas brunneas formantes, loculis 4–8 μ longis, 6–10 μ latis, paucis septo longitudinali aliquando divisis.

Cercospora brunnea

Tufts hypophyllous, minute, densely effused on angular, sometimes confluent brownish spots, which are 2–5 mm. broad; hyphae crowded, flexuous, sparsely septate, brown, 60–100 μ × 5–6 μ; spores cylindric or subclavate, often curved, 1–3-septate, subhyaline, 40–60 μ long, 5–6 μ broad.

On leaves of tall white lettuce, *Prenanthes altissima* L. Rogers, Arkansas. September. E. Bartholomew. This differs from *C. Prenanthis* E. &. K. in its brown hyphae and septate spores.

Caespites hypophylli, minuti, dense effusi, maculas angulares, saepe confluentes, brunnescentes, occupantes, 2–5 mm. latas; hyphae confertae, flexuosae, 1–3-septatae, brunneae, 60–100 μ × 5–6 μ; sporae cylindraceae vel subclavatae, saepe curvatae, subhyalinae, 40–60 μ longae, 5–6 μ latae.

Cercospora biformis

Spots brown, angular, limited by the veinlets of the leaf, sometimes confluent; hyphae hypophyllous, flexuous, septate, brown, 30–150 μ long, 4–6 μ thick; spores of two kinds, one nearly cylindric, hyaline, obtuse at each end, commonly 3- or 4-septate, 40–100 μ long, 4–6 μ broad, the other narrowed above into a long slender prolongation, hyaline, 6–12-septate, about 6 μ broad in the widest part, 3 μ in the narrowest part.

On living or languishing leaves of passion flower, *Passiflora incarnata* L. Batesville, Arkansas. October. E. Bartholomew.

This species differs from *Cercospora fuscovirens* Sacc., an inhabitant of the yellow passion flower, *Passiflora lutea* L., in producing yellow spots on the leaves and in the dimorphic character of the spores. From *Cercospora truncatella* Atk., which also inhabits leaves of *P. incarnata*, it may be separated by its angular spots with no brown margin, by its hypophyllous hyphae, and by the two-formed spores.

Maculae brunneae, angulares, folii venulis limitatae, aliquando confluentes; hyphae hypophyllae, flexuosae, septatae, 30–150 μ longae, 4–6 μ latae, brunneae; sporae biformes, una subcylindracea hyalina utrinque obtusa, vulgo 3–4-septata, 40–100 μ × 4–6 μ, altera in partem gracilem longam sursum extenuata, 6–12-septata, hyalina, 5–6 μ ad partem latissimam, 3–4 μ ad partem angustissimam crassa.

Fusarium juglandinum

Tufts minute, superficial, floccose, subconfluent or effused, whitish becoming slightly tinged with pink; hyphae short, slender, dense, hyaline; spores fusiform, curved, pointed at each end, 3–7-septate, commonly 4–6-septate, 30–60 μ long, 6–8 μ broad.

Dead shoots of black walnut, *Juglans nigra* L. Stockton, Kansas. July. E. Bartholomew. The species belongs to the subgenus *Fusisporium* as arranged in Saccardo's Sylloge, Vol. IV.

Caespites minuti, superficiales, floccosi, subconfluentes vel effusi, albidi, deinde colore rosaceo leviter tincti; hyphae breves, graciles, densae, hyalinae; sporae fusiformes, curvatae, utrinque acuminatae, 3–7-septatae, vulgo 4–6-septatae, 30–60 μ longae, 6–8 μ latae.

Fusarium Bartholomaei

Sporodochium compact, subglobose oblong or pulvinate, arranged in series, whitish, a long time covered by the elevated epidermis; sporophores slender, erect, straight, crowded, 40–60 μ long, 1–2 μ broad; spores slender, curved, 5–6-nucleate, continuous, hyaline, terminating at each end in a very thin bristle-like point, 15–25 μ long, 1–2 μ broad, the bristle-like point 10–12 μ long.

Lower surface of leaves of Indian grass, *Sorghastrum nutans* (L.) Nash. Stockton, Kansas. September. E. Bartholomew. The species belongs to the subgenus *Fusamen.* It is well marked by the bristle-pointed spores, and is peculiar in having its receptacles mostly arranged in lines and covered for a long time by the firm epidermis of the host plant.

Sporodochia compacta, subglobosa, oblonga pulvinatave, in series digesta, albida, epidermide elevata diu tecta; sporophori graciles, recti, conferti, 40–60 μ longi, 1–2 μ lati; sporae graciles, curvatae, 5–6-nucleatae, continuae, hyalinae, in setula tenuissima utrinque terminantes, 15–25 μ × 1–2 μ, setulae 10–12 μ longae.

GEOLOGICAL HALL,
ALBANY, NEW YORK.

Additions to the flora of Peninsular Florida

I. NATIVE SPECIES

John K. Small

The species enumerated below are for the most part additions to the hitherto known flora of the United States. They are all new to the mainland and only five of them were heretofore known as members of the flora of the United States from specimens collected on the Florida Keys.

With one or two exceptions, these additions were brought to notice by exploration carried on by the New York Botanical Garden, and the type specimens of the species here described for the first time are preserved in its herbarium.

Thysanella robusta sp. nov.

Plants mainly 6–9 dm. tall, often somewhat spreading, much stouter than those of *T. fimbriata:* leaves 3–6 cm. long, ascending; blades linear, acute, striate-nerved; ocreae imbricate on the lower part of the stem, mostly separated above, copiously fringed: racemes mainly 4–7 cm. long, 8–10 mm. thick, the ocrealae closely imbricate, each terminating in an elongate pale tip: calyx white, often becoming pink; the outer sepals entire or irregularly cleft, the inner ones becoming 3.5 mm. long: filaments about 4 mm. long: achenes fully 2 mm. long and fully 1.5 mm. wide, long-beaked.

A species hitherto confused with *Thysanella fimbriata.* It differs from that species by its much greater size, the larger sepals and achenes. Specimens collected at Braidentown, Florida, August 28, 1901 (*Tracy 7638*), may constitute the type.

Other recently collected specimens belonging to this species are: Jensen, March 25, 1897, *Curtiss 5837*. Dade County, November & December, 1903, *Eaton 776*.

Warea Carteri sp. nov.

Annual, glabrous, bright green: stems erect, 4–15 dm. tall, simple or widely branched above, mostly purple-tinged below, terete: leaves alternate; blades linear or sometimes cuneate, especially on the lower part of the stem, 1.5–3.5 cm. long, abruptly pointed or mucronate, often slightly veiny: racemes many-flowered, the rachis becoming 12–20 mm. long: pedicels becoming 9–12 mm. long: sepals 4.5–5.5 mm. long, nearly linear to somewhat spatulate: petals white or nearly so, 6–8 mm. long, the claws prominently sharp-toothed, the blades orbicular to reniform, undulate: stamens 7–8 mm. long, the anthers about ⅓ as long as the filaments: ovary-body about as long as the stipe: pod-bodies 5–6 mm. long, curved, terminating the stipe, which becomes 6–7 mm. long.

Named for Mr. J. J. Carter, of Pleasant Grove, Pennsylvania, who has been associated with the writer in the exploration of South Florida.

This, apparently the most common species of *Warea*, occurs in great abundance, especially in southern peninsular Florida. Specimens belonging here have hitherto been confused with *Warea cuneifolia* (Muhl.) Nutt. *Warea Carteri* differs from *W. cuneifolia* in its narrower sepals, white corolla, suborbicular or reniform petal-blades, longer-stipitate ovary, shorter pedicels, longer pod-body and shorter mature stipe. The type specimens were collected in pinelands between Cutler and Black Point, Florida, November, 1903 (*Small & Carter 831*). Other specimens belonging here are as follows:

Miami, November, 1878, *Garber 26*; October and November, 1903, *Small & Carter 511.* Indian River region, September, *Curtiss 171.*

Cracca corallicola sp. nov.

Perennial, densely pale-hairy all over, the branches, peduncles and petioles short-hirsute: stem erect, 4–19 dm. tall, densely branched, the branches decidedly zigzag, rather rigid: leaves numerous, 4–11 cm. long; leaflets 11–15, 9–31 mm. long, the blades linear to linear-oblong, mucronate, prominently ribbed, copiously pubescent: stipules quite persistent, 1–3 mm. long: racemes several-flowered, borne on short peduncles: pedicels stout, becoming 2–3.5 mm. long: calyx permanently hirsute; tube broadly campanulate; lobes subulate above the broader bases, the lower ones nearly as long as the tube: corolla pinkish or purplish; standard 7–11 mm. long; blades orbicular or obovate-orbiculate; wings 6–7 mm. long; keel shorter than the wing-petals: pods 3.5–4.5 cm. long, about 3 mm. wide, finely pubescent: seeds fully 3 mm. long.

This species differs from *Cracca cinerea* L. by its pubescence, the shape of the blades of the leaflets, the smaller corolla and the short calyx-lobes. The type specimens were collected in pinelands between Cocoanut Grove and Cutler, November, 1904 (*Small 2112*).

SWIETENIA MAHAGONI Jacq.

As a member of the flora of the United States, the mahogany has heretofore been confined to the Florida keys. Its range may now be extended to the mainland, where it was found growing on the Everglade Keys in the large hammock south of Miami in November, 1904 (*Small 2272*).

CAPERONIA CASTANAEFOLIA (L.) St. Hil.

This West Indian plant was discovered growing on Long Key (Everglades) in January, 1909 (*Small & Carter 2832*).

CHAMAESYCE BLODGETTII (Engelm.) Small

Hitherto this species has been known only from the lower Florida keys and the Bahamas. Several years ago it was discovered on the mainland, growing plentifully in open hammocks back of Black Point below the settlement of Cutler (*Small & Carter 823*).

COLUBRINA RECLINATA (L'Her.) Brongn.

The tree was found on the Everglade Keys, growing in hammocks southwest of the settlement of Perrine in November, 1904 (*Small 2249a*).

PASSIFLORA PALLENS Poepp.

Specimens matching C. Wright's Cuban specimens numbered 2599 were collected from plants growing on the edges of several hammocks in the homestead country southwest of Cutler. The species was first discovered in Florida near Camp Longview by Mr. P. Wilson and the writer (*no. 1740*) and later by the writer on the Caldwell and adjoining homesteads (*no. 2143, 2557 & 2559*). The plants are remarkable on account of their large stipules, and in this respect they resemble those of the South American *Passiflora stipulata* Aubl.

SOLANUM BLODGETTII Chapm.

Previous to the year 1904 this species was known only from Key West. During the past few years it has been collected both on the mainland of Florida and on the Bahamas. The following citations represent specimens from peninsular Florida. They are all from the Everglade Keys and vicinity.

Everglades near Camp Jackson, *Britton 237*. Hammocks, Long Key, *Small & Wilson 1678*. Everglades west of Camp Jackson, *Small & Wilson 1962*. Everglades between Homestead and Cross Key, *Small & Carter 2675*.

BOURRERIA VIRGATA (Sw.) G. Don

The shrub or small tree was recently discovered growing on an outlying Everglade Key situated about eight miles below the settlement of Cutler (*Small & Carter 2818*).

Goniostachyum citrosum sp. nov.

A straggling or reclining shrub with elongate and irregularly branched stems, the bark pale-gray or whitish, the branches strigillose: leaves opposite; blades lanceolate to elliptic-lanceolate, 2.5–6 cm. long, acuminate, shallowly serrate, pubescent on both sides, pale beneath, dark green above, narrowed to petiole-like bases: peduncles solitary in the axils, 5–16 mm. long, strigillose: spikes depressed, 4–6 mm. long; bracts ovate, acute or acuminate, the outer ones 4–5 mm. long: calyx about 1 mm. long; lobes broadly triangular, much shorter than the tube: corolla white, about 4.5 mm. long, minutely pubescent; tube swollen above the middle; limb about 3 mm. broad: nutlets 1.5 mm. long.

This species differs from *Goniostachyum graveolens* by its strigillose foliage, its sparingly and shallowly serrate acuminate leaf-blades and its short spikes. The type specimens were collected in the hammocks near the Silver Palm Schoolhouse southwest of Perrine, November, 1904 (*Small 2142*). Collected in 1906 in the same region (*Small & Carter 2680*).

This plant was first collected in Mexico many years ago; but these specimens were referred to *Lantana canescens* H. B. K., a species originally from northern South America. The species was discovered in Cuba the same year that it was first found in Florida. Its geographical distribution seems to be the same as that of *Alvaradoa amorphoides* Liebm., with which it is associated in the hammocks in Florida.

Phyla stoechadifolia (L.) comb. nov.

Verbena stoechadifolia L. Sp. Pl. 19. 1753.

Lippia stoechadifolia H. B. K. Nov. Sp. & Gen. Pl. **2**: 265. 1817.

Recent exploration on Long Key (Everglades) brought this verbenaceous plant to light as a member of the flora of the United States (*Small & Carter 2863*). On certain portions of the largest island of the group the plants grew in great abundance.

LANTANA OVATIFOLIA Britton

This species described from plants collected on the Bahamas is common in southern peninsular Florida. The collections cited below belong to this species:

Punta Rassa, *Hitchcock 268.*
Bull Key, opposite Lemon City, *Small & Carter 618.*
Ft. Lauderdale, *Small & Wilson 1747.*
Between Homestead and Camp Jackson, *Small & Wilson 1877.*
Beach opposite Miami, *Small 2101.*
Palm Beach, *Small 2134.*

GERARDIA DOMINGENSIS Spreng.

This West Indian *Gerardia* was found growing in great abundance in the low pinelands about Camp Longview and in the adjacent everglades during the spring of 1904 (*Small & Wilson 1570 & 2008*).

SPERMACOCE ASPERA Aubl.

Plants belonging to this species were found growing in abundance in hammocks between Cocoanut Grove and Cutler, Florida, by Mr. J. J. Carter and the writer in November 1903 (*no. 1207*).

DIODIA RIGIDA Cham. & Schlecht.

The pinelands between the settlement of Cutler and Black Point Creek contain many large areas of this tropical American plant. Luxuriant plants were collected there in November, 1906 (*Small & Carter 2706*).

PHORADENDRON RUBRUM (L.) Krug & Urban

The discovery of this species in peninsular Florida adds another parasitic plant to our flora. Flowering specimens were collected at Deep Lake .Florida, March 7, 1905, by Mr. A. A. Eaton (*no. 1310*).

Melanthera radiata sp. nov.

Stems several or many from a thick root, radially spreading, decumbent, 2–4 dm. long, simple or sparingly branched, sparingly appressed-pubescent: leaves opposite; blades ovate in outline, 1–4 cm. long, more or less distinctly hastate-lobed and irregularly toothed, rough-pubescent, short-petioled: heads long-peduncled: involucres not foliaceous; bracts ovate to oblong-ovate, not surpassing the disk, the outer ones 6–7 mm. long, ciliate and pubescent: bractlets 6–7 mm. long, ciliate at the tips: corollas 6.5–8 mm. long; tube sparingly pubescent above; lobes ovate, ciliate: achenes 2.5–3 mm. long, slightly broadened upward, very minutely papillose, with a prominent tip over each side: pappus-bristles deciduous, longer than the achene.

Melanthera radiata is most closely related to *M. aspera* (Jacq.) Steud. (*M. deltoidea* Michx.) from which, however, it differs conspicuously in habit, the several or many stems arising from a thick, woody root, spreading radially, and decumbent. The leaf-blades too are small and very short-petioled and with sharp teeth. The type specimens were collected in pinelands near the homestead trail near Camp Longview, Florida, May 13–16, 1904 (*Small & Wilson 1575*).

Some aspects of the mycorhiza problem*

BENJAMIN C. GRUENBERG

The roots or underground stems in many families of plants exhibit the constant presence of a symbiotic fungus. Mycorhiza has been described in liverworts and ferns as well as in over twenty families of flowering plants, including gymnosperms, monocotyledons, and dicotyledons. With very few exceptions, mycorhiza is not characteristic of the plants of a whole family, that is, in most families of plants examined, some species have the mycorhiza, and some have not. There are even species of plants in which the presence or absence of the root fungus seems to be determined by external conditions; symbiosis is facultative, so far at least as the phanerogam is concerned.

The identity of the fungus in the mycorhiza has been the subject of many investigations, but has not been definitely determined for more than a very few cases, and even in these not with satisfactory certainty. The chief difficulties in the way of identifying the mycorhiza fungus lies in the fact that the mycelium cannot be readily isolated and made to sporulate. The frequent finding of *Fusarium* forms in cultures of mycorhiza fungus leads to the suspicion of foreign contamination. The spores of *Penicillium* are common in the soil and various moulds frequently appear in cultures even after great pains have been taken to free specimens from adhering soil particles or other foreign matter. All groups of fungi, from bacteria and slime-moulds to Pyrenomycetes and agarics have been declared to form the mycorhiza in different plants by different observers. It is impossible to identify the fungus from the mycelium alone, although recent examinations of forest trees have shown the presence of characteristically colored mycelia which were believed to be connected with sporocarps in the vicinity.

As to the relationship between the fungus and the higher plant

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* Read before Section G of the American Association for the Advancement of Science at the Baltimore Meeting, December 31, 1908.

(commonly called the host although it is not commonly supposed that the relationship is a parasitic one) there have been offered many theories. In 1846 Reissek declared that the root fungus was a normal phenomenon in the life of the plant, like the production of flowers: it is not necessary to the existence of the plant but is produced under certain conditions, spontaneously. Schacht in 1852 and Irmisch in 1853 described the fungus in many orchid roots and rhizomes and concluded that the fungus was not parasitic, but offered no definite explanation of the constant presence of the fungus in the orchid.

In 1877 Pfeffer suggested that as root hairs were absent from the roots or rhizomes bearing fungi, the fungi perform the absorbing function of root-hairs. In 1882, Kamienski, studying *Monotropa*, concluded that the relation between this plant and its root fungus is a mutual symbiosis, and in 1885 Brunchorst ascribed a similar nutritive function to the symbiont of the Papilionaceae. In 1886 Müller inferred from the behavior of the roots of forest trees that the fungus serves to disintegrate the soil. Frank in 1888 thought that the root fungus is of special service to its symbiont in absorbing nitrogen compounds from the soil, or from the humus. It has since been definitely determined that the organisms in the root-tubercles of leguminous plants, as well as other fungi, have the ability to fix atmospheric nitrogen, and this capacity is of sufficient advantage to compensate for any carbohydrate the fungus may obtain from its partner.

There is probably no need to consider, nowadays, some of the earlier theories of spontaneous generation of autonomous organisms within the tissues of the seed plant; or the idea that the fungus-infested tissue is the result of degeneration or the gall of an insect. All the probabilities point to some nutritive relation between two autonomous organisms, including under the concept "nutritive" water and salt relations. However, there is no reason to assume that the mycorhiza has the same significance in all cases.

Our ordinary ideas of mutual symbiosis fail when we come to consider the case of plants entirely free from chlorophyl. The case of *Monotropa* was interpreted by Kamienski as follows: The *Monotropa* derives its organic nutrients from the humus through the intermediation of the fungus, which obtains from the

Monotropa a convenient substratum. Formally, this interpretation explains the relation well enough, but it is not certain that that is all there is to the matter. In several species of *Corallorhiza*, the coral-root orchid, chlorophyl is entirely absent, and the leaves are reduced to a few inconspicuous, sheathing scales. Nevertheless these plants contain large amounts of starch in the underground portions as well as some in the scape and in the floral organs.

We may account for the presence of starch in these plants in the same way as we account for it in the underground portions of a green plant, that is, we may say that it has been condensed from sugar. The real problem in the coral-roots is, how do they get their sugar? Many authors have described these plants and others without chlorophyl as having no stomata; this may have been due to faulty observation, or to *a priori* reasoning from the absence of chlorophyl, or to biased observation. The fact remains that in all species of *Corallorhiza* examined by the writer, stomata are well developed in all parts of the plant, including floral envelope and rhizome. On the latter, the stomata are frequently clogged with earth, but there is no doubt as to their presence. The absence of all absorbing organs has also been declared to be characteristic of these plants. But there is present on each internode of the rhizome a whorl of tiny papillae which are found to bear tufts of fine hairs that may well serve as root-hairs in the absorption of soil water. These trichomes are very delicate and easily destroyed in removing the rhizome from the adhering soil, but they may be easily found by washing the soil off in several changes of water.

Now, the plant having been provided with stomata and absorbing organs, it may be supposed that the organism is prepared to manufacture its carbohydrates in the orthodox fashion, since it has some chromoplasts in the parts above ground. But the area exposed to the light is very small, in comparison with the bulk of the subterranean portion, and the absorbing surface is also very small. Still these facts could not be taken in themselves to preclude the possibility of photosynthesis. A vigorous specimen of *Corallorhiza multiflora* growing in a pine grove was examined for starch by scraping off the skin at several points and treating with dilute solution of iodine in potassium iodide. The plant was covered over with a light-tight box and left this way for several days. On reexamining the subepidermal regions for starch, no difference in the apparent abundance of this substance could be observed. That the plant does not obtain its carbohydrate synthetically I feel convinced.

The only other direction from which it may come is the soil. The constituents of the humus that may yield carbohydrates, the means for their absorption, and the mechanism for their conversion into starch remain to be determined.

The question of the entry of the fungus into the rhizome is another open problem. The seeds of orchids are notoriously indifferent to all efforts to coax them into germination, and without seedlings free from the fungus it is hopeless to find the complete analysis of the relation between the symbionts. In many mycorhizas there have been found hyphal connections between the endotropic mycelium and external mycelia. But in very many cases absolutely no trace of such connection can be found. In *Corallorhiza* the mycelium of the cortical layers frequently sends hyphae singly or in bundles into the trichomes on the papillae, but it is not certain that these hyphae regularly reach the exterior. With the exception of the trichomes, the epidermal cells are uniformly free from hyphae. It has been supposed that the fungus gains entrance through the stomata of the rhizome; it would be necessary to find seedlings free from the fungus, and stomata through which the hyphae could be seen to pass. I have searched for both and have found neither.

If the orchid is absolutely dependent upon the fungus for its nutrition, how may the seedling develop without the fungus? The embryo of the orchid seed is undifferentiated, and the nutrients stored within the seed could not carry the plant along very far. But the ripened seeds are ordinarily free from fungus; at any rate fungal threads are not present in every seed, and it has been impossible to grow from the seeds any fungus that at all resembles the fungus of the mycorhiza. Moreover, the scape, through which any connection between the mycorhiza and the seed would have to pass, is generally quite free from mycelial threads.

The mycorhiza problem is not only of great interest theoretcally, but may have important practical bearings upon the transplanting of trees, reforestation problems, tuberization, nitrification of the soil etc.

DEWITT CLINTON HIGH SCHOOL,
NEW YORK CITY.

INDEX TO AMERICAN BOTANICAL LITERATURE
(1908)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions their kindness will be appreciated.

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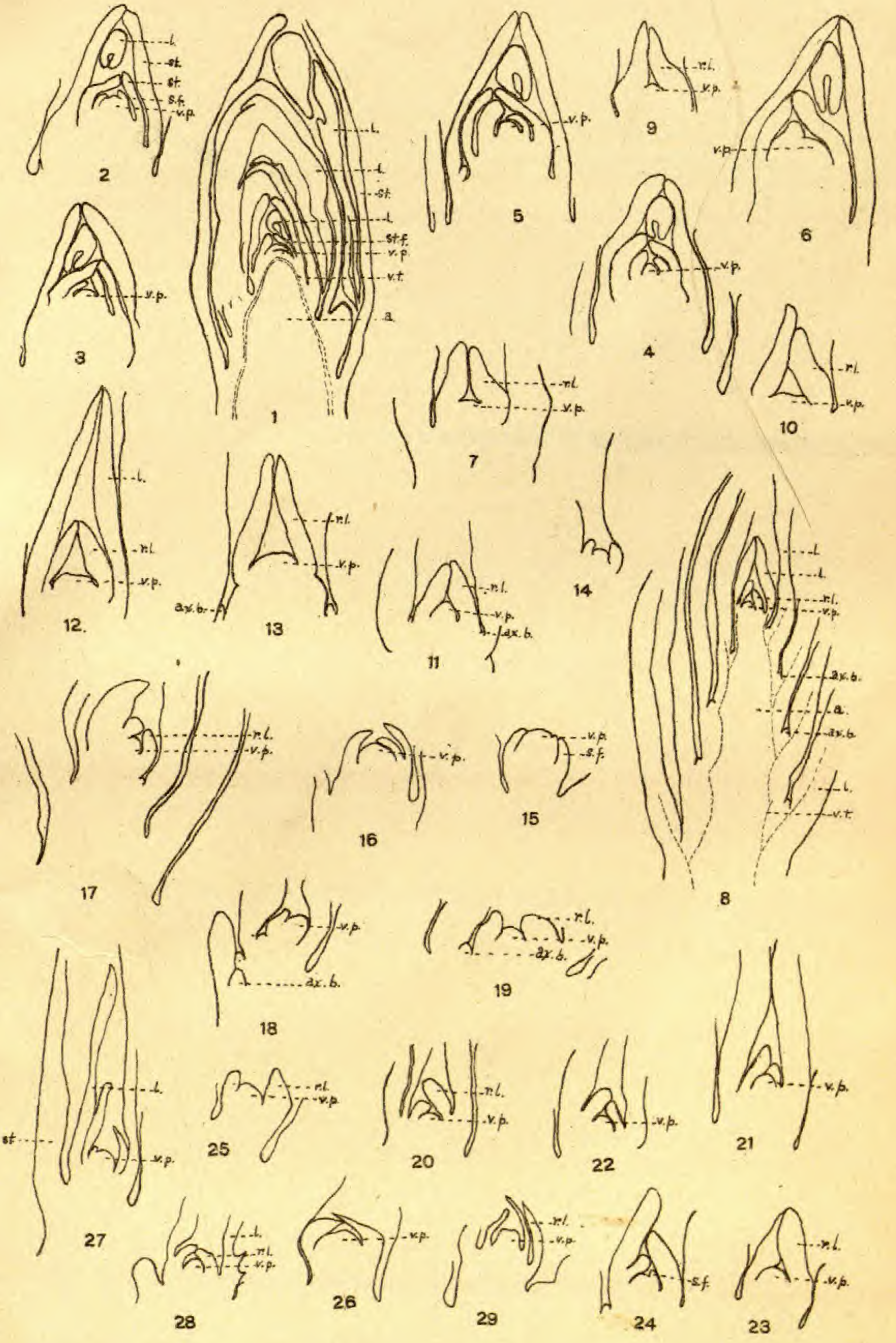

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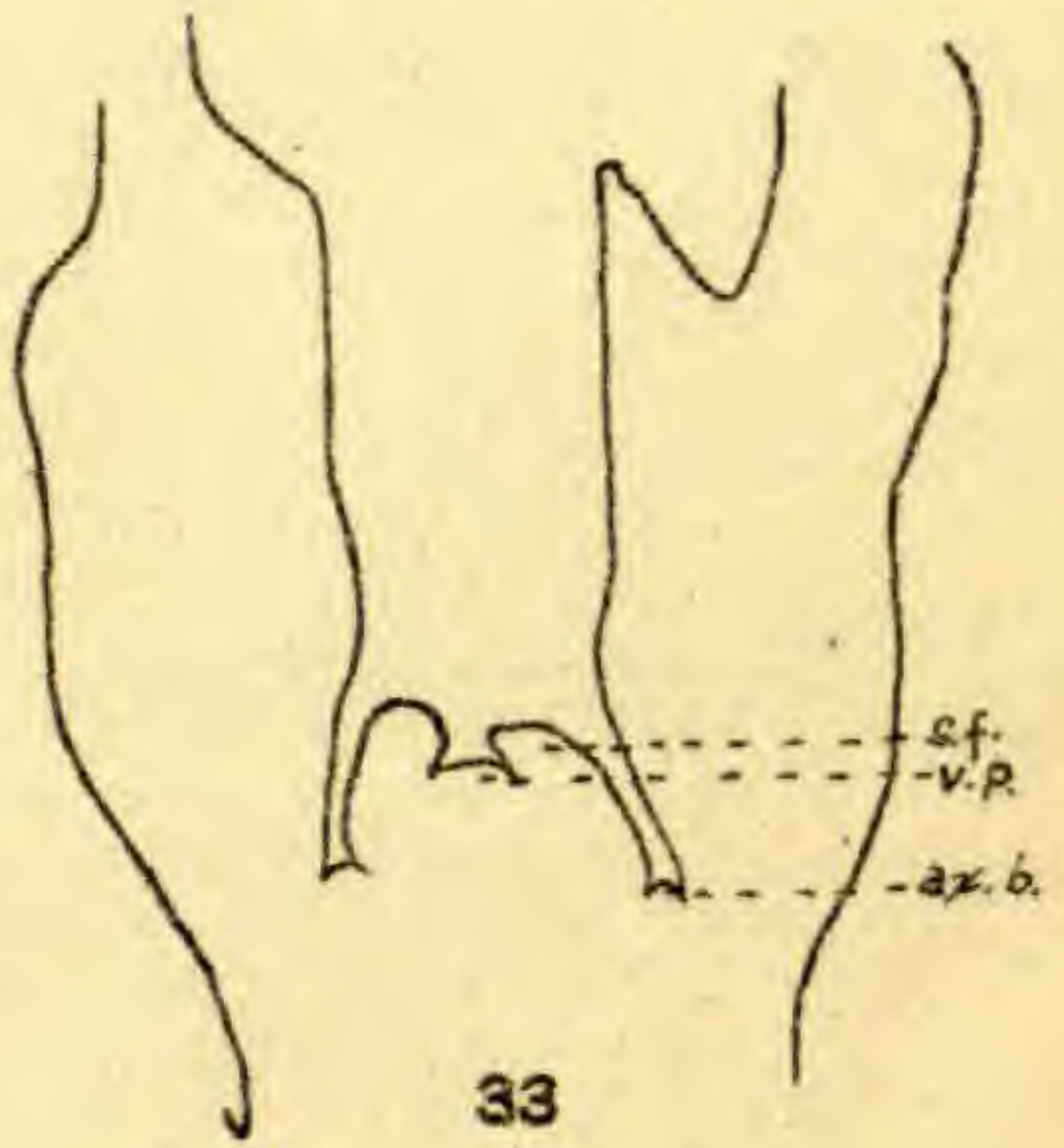

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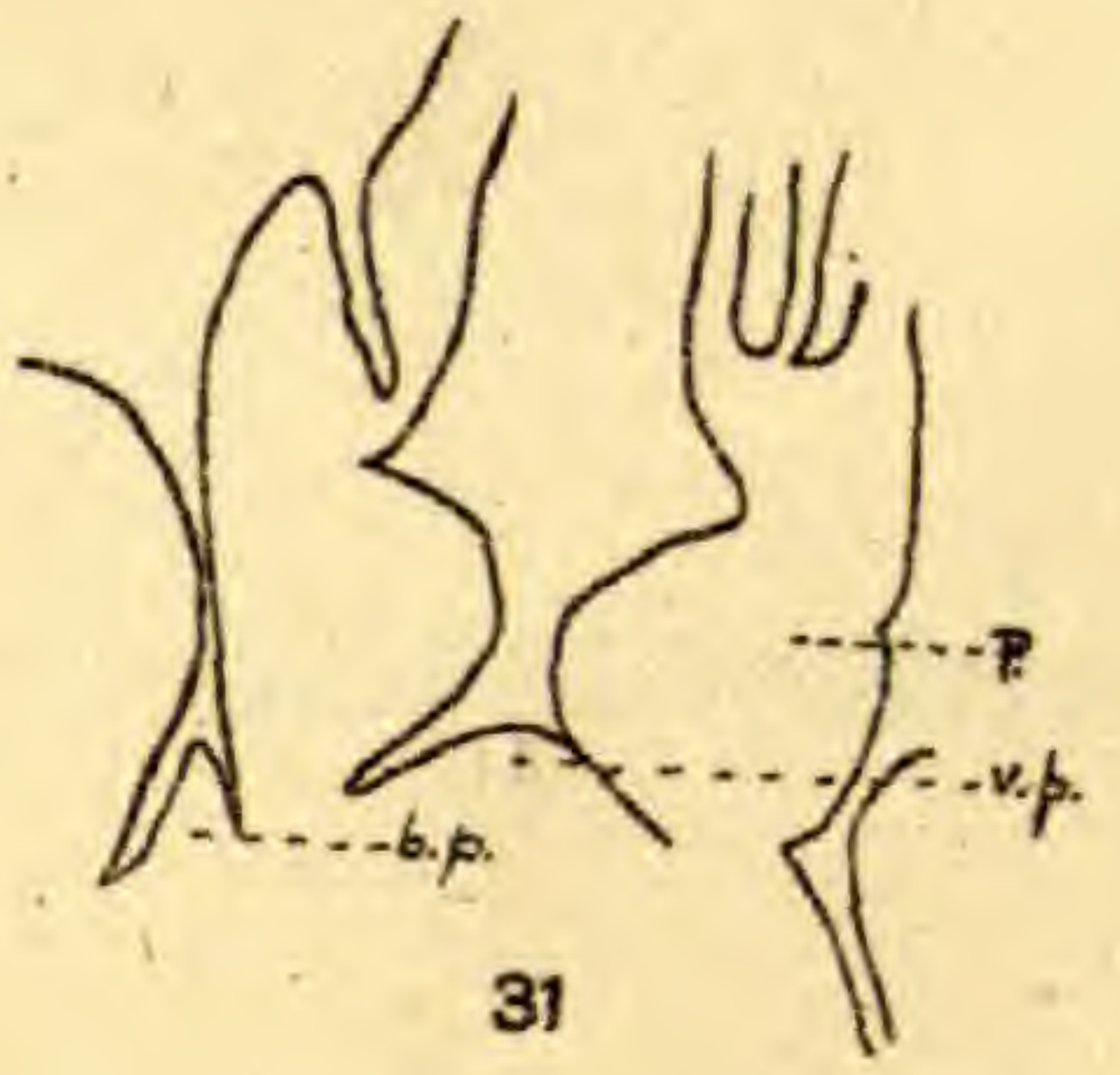

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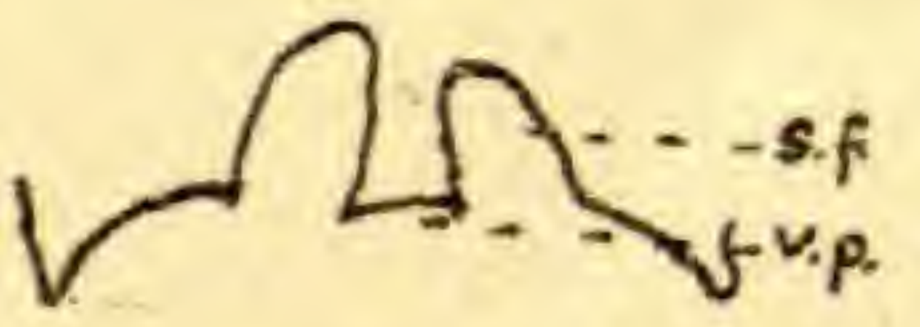

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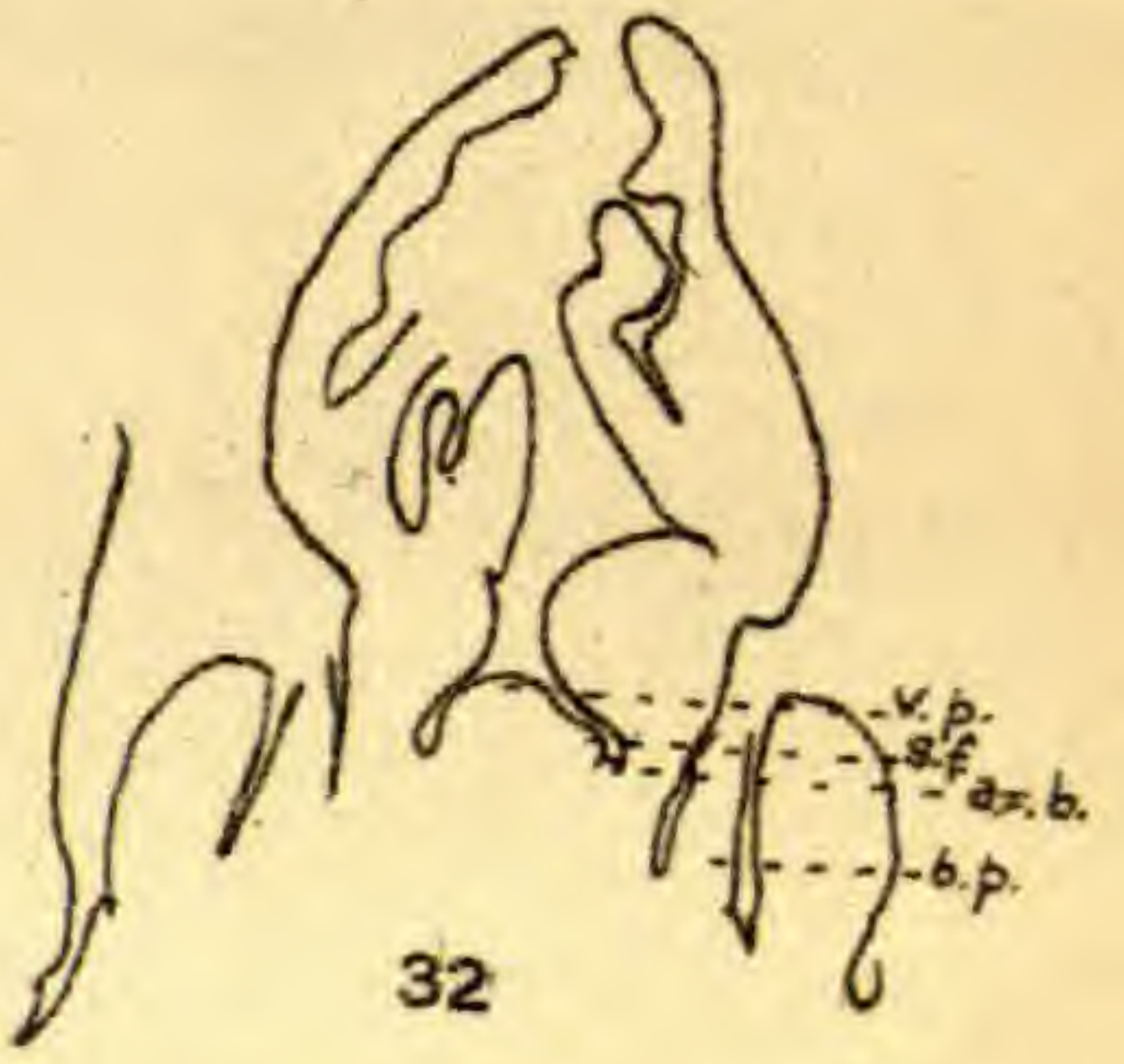

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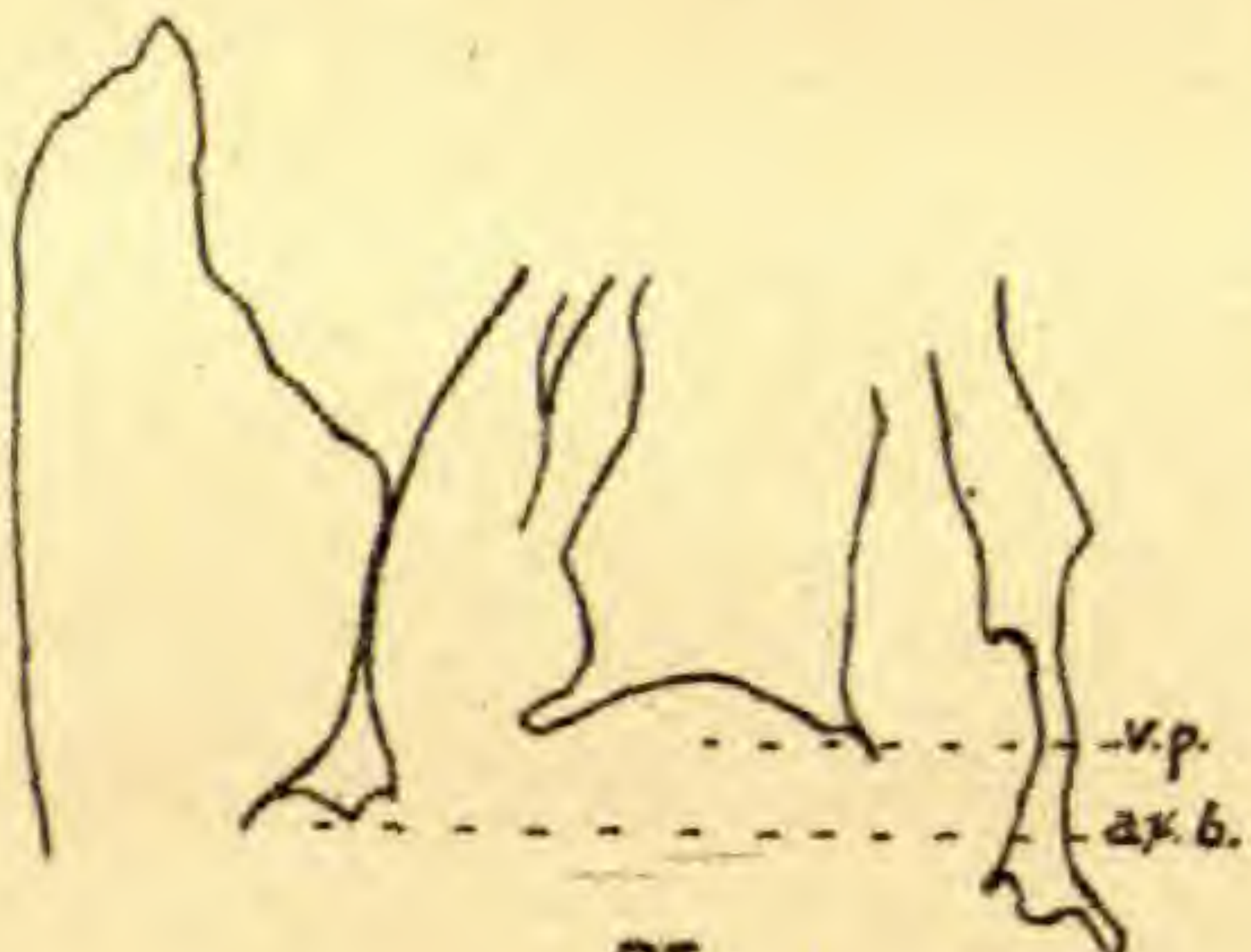

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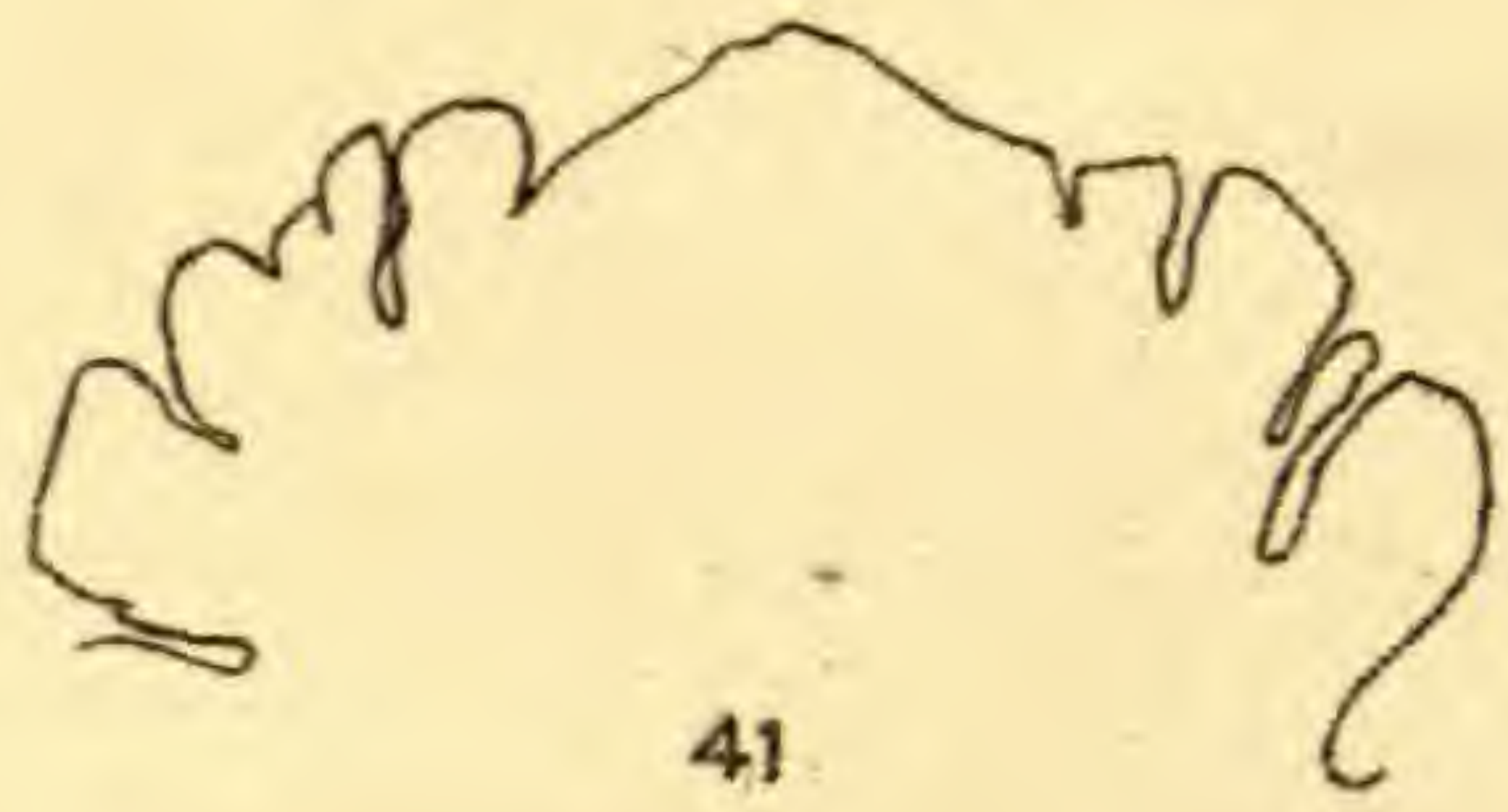

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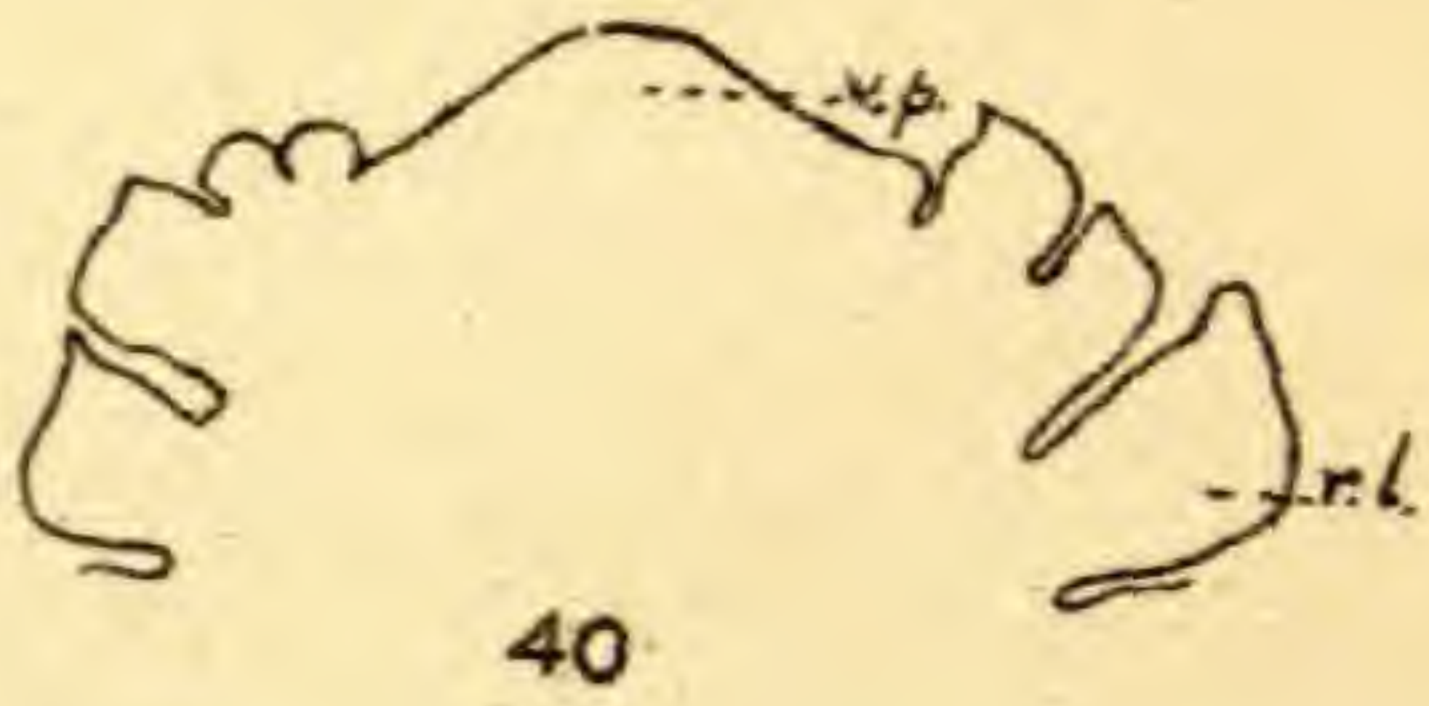

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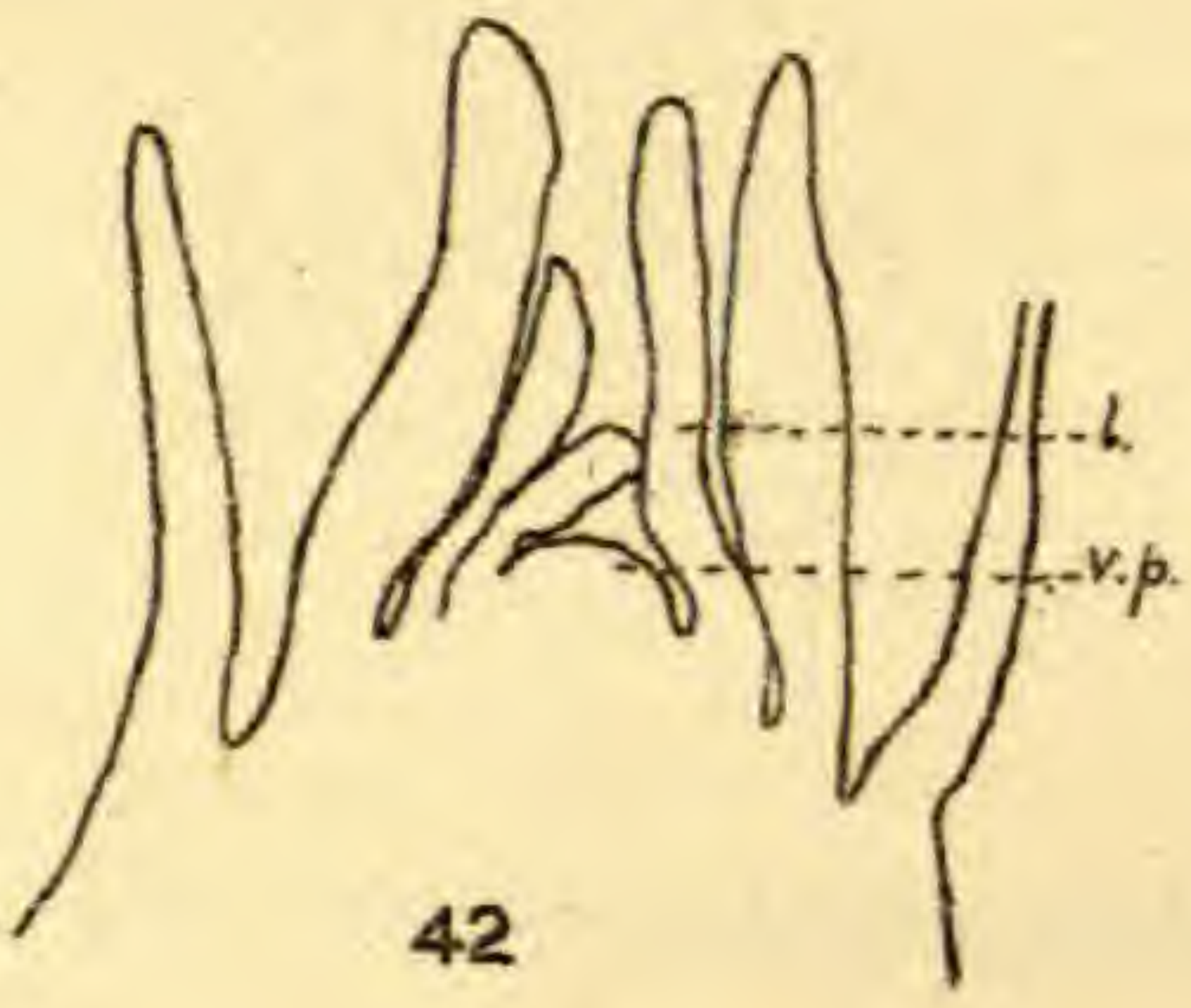

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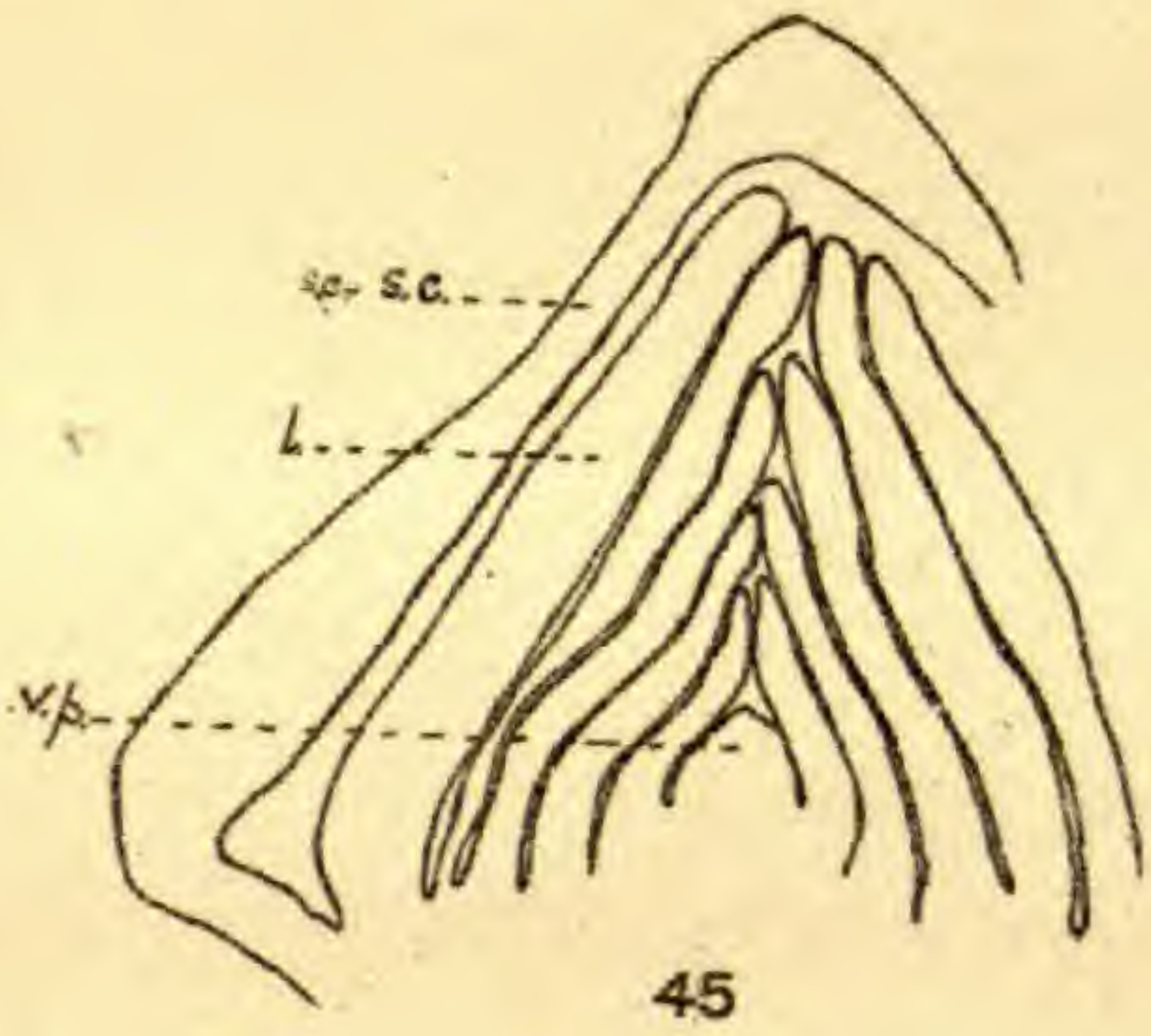

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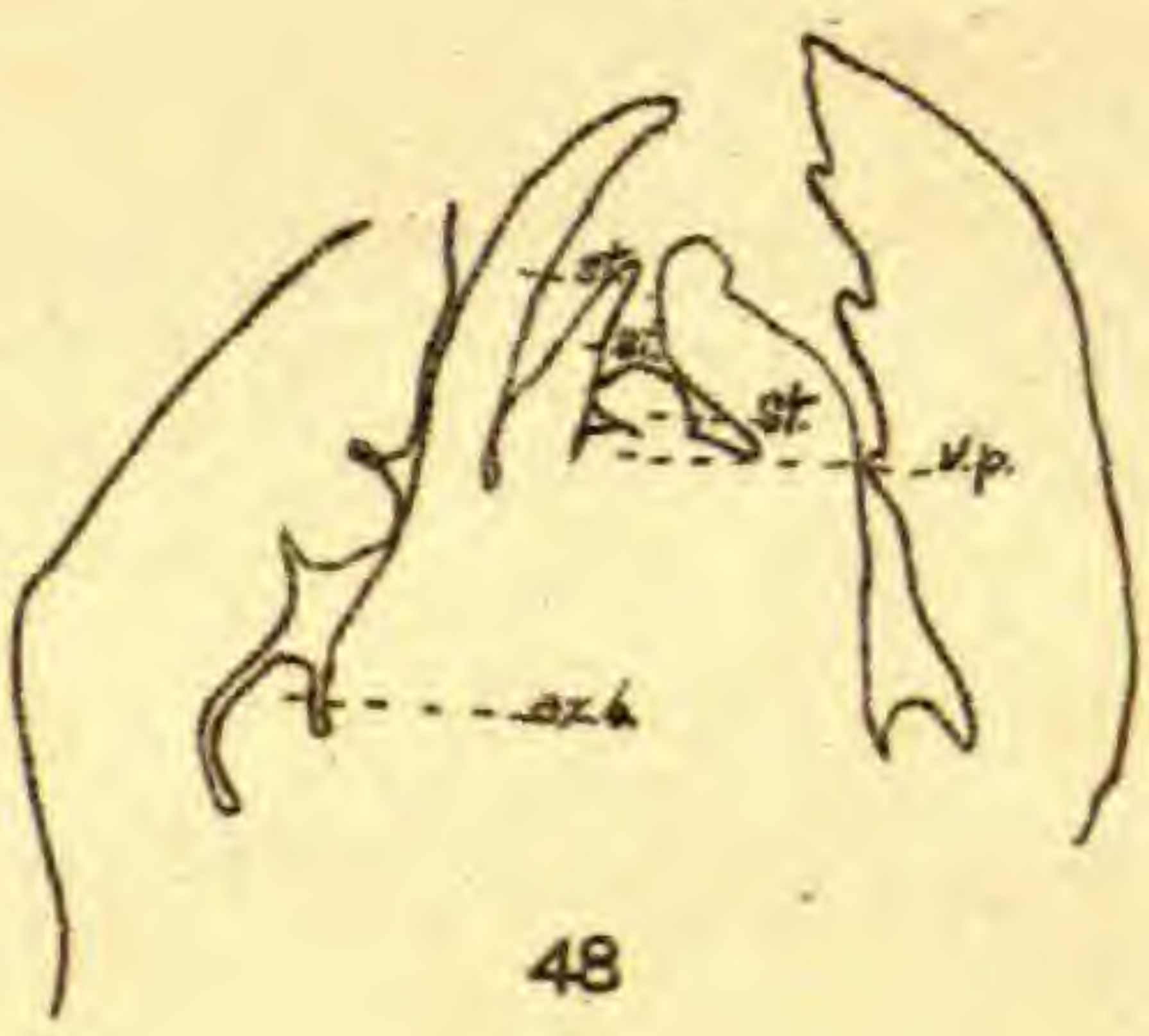

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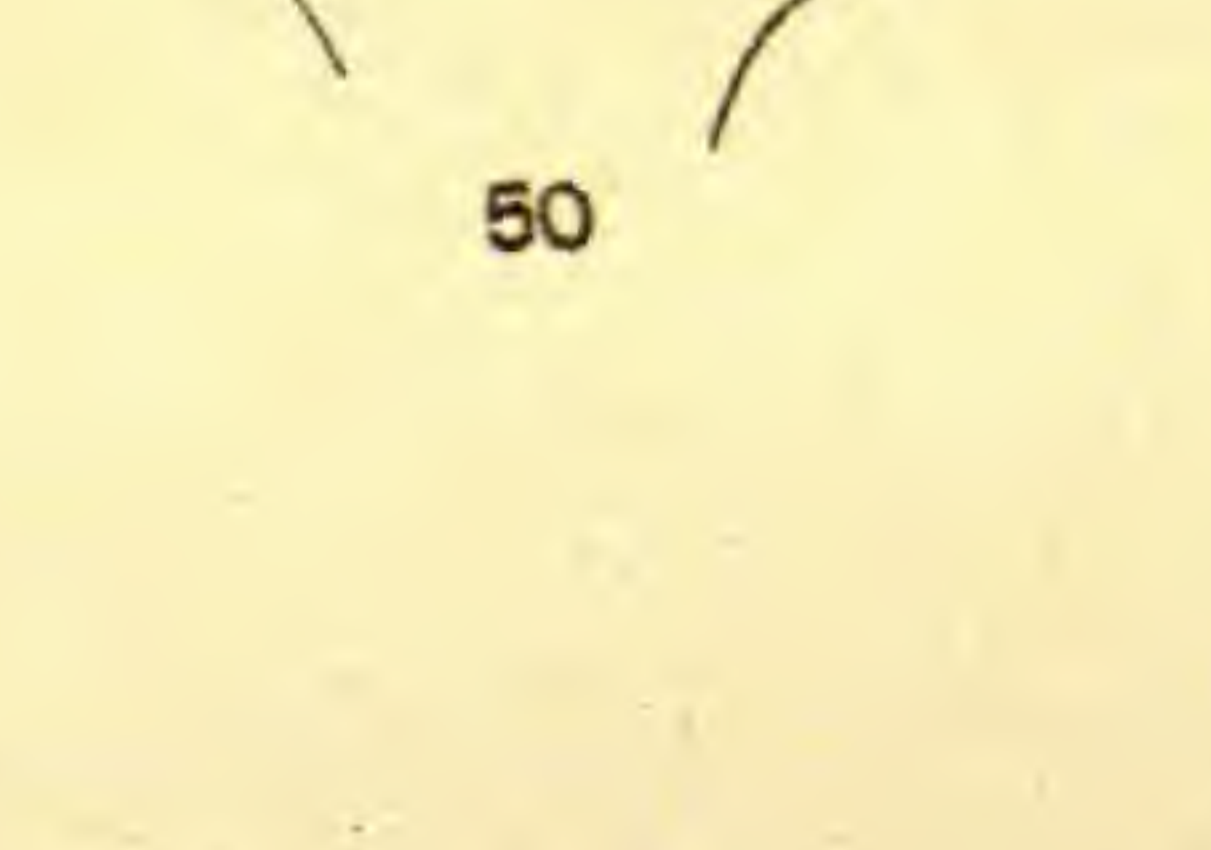

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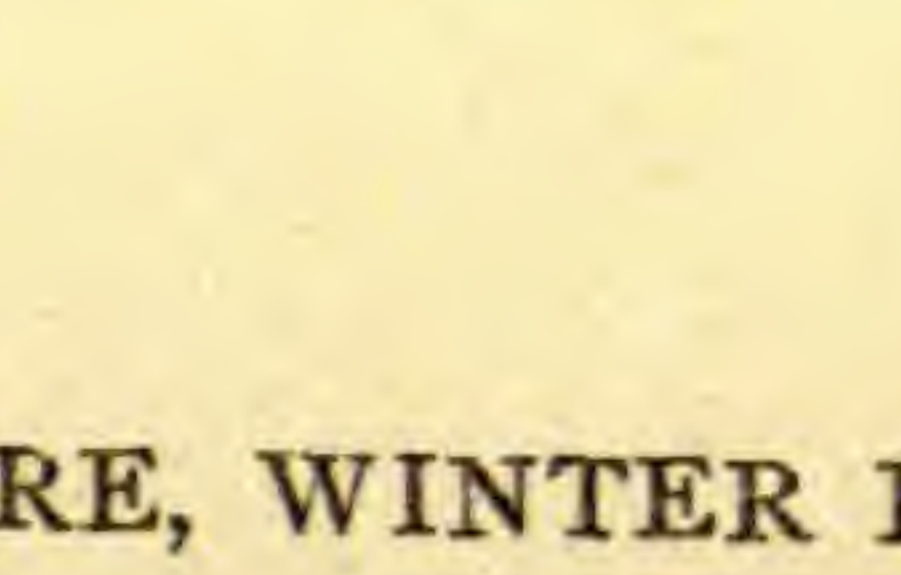

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Volume 16. Pteridophyta and Gymnospermae.
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The preparation of the work has been referred by the Scientific Directors of the Garden to a committee consisting of Dr. N. L. Britton, Dr. W. A. Murrill and Dr. J. H. Barnhart.

Professor George F. Atkinson, of Cornell University, Professors Charles R. Barnes and John M. Coulter, of the University of Chicago, Mr. Frederick V. Coville, of the United States Department of Agriculture, Professor Edward L. Greene, of the United States National Museum, Professor Byron D. Halsted, of Rutgers College, and Professor William Trelease, of the Missouri Botanical Garden, have consented to act as an advisory committee.

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

APRIL, 1909

Sex in dioecious plants

CHESTER ARTHUR DARLING

(WITH PLATES 12–14)

Probably no other question has received such universal attention among biologists as that of heredity, and perhaps no avenue of approach in solving this question promises at present greater results than that of the determination of sex. It has been generally believed until within the last few years that sex was largely determined by surrounding conditions, such as food, heat, light, or other external factors. This belief was strengthened by such work as that of Prantl ('81) on the ferns. When prothallia were cultivated with abundant nutriment only archegonia developed, whereas antheridia were formed on those poorly nourished. It should be noted however, that the prothallia with which he worked were not strictly dioecious, but had a "tendency to dioeciousness."

Similar experiments were performed upon other groups of plants, as well as upon animals, with the same general results. There can be little doubt that environmental factors do influence either directly or indirectly the development of sexual organs in plants where both tendencies exist. But recent and more careful experiments have shown that in strictly dioecious forms such factors do not determine, at least in the life history of the individual, which sex shall develop.

Strasburger ('00) working with plants and Cuenot ('99) with animals, have carefully reviewed the evidence and in their own experiments have shown that in dioecious forms sex is not determined by environmental factors but is inherent in the germ cells.

[The BULLETIN for March, 1909 (36: 117–176. *pl. 9–11*) was issued 27 Mr 1909.]

In view of this belief regarding the determination of sex, attention has been directed in the past few years to the study of these cells. Probably no single work has done more to throw light upon this interesting question than the carefully conducted investigations on the dioecious mosses by the Marchals ('06). In experiments with *Barbula unguiculata* Hedw., *Bryum argenteum* L., and *Ceratodon purpureus* Brid., they have shown that two kinds of spores exist in every capsule in equal numbers, half of the spores giving rise to male gametophytes and half to female gametophytes. They selected mosses which may regenerate secondary protonemata from fragments of the leaf, stem, or rhizoid of the gametophyte, and in every case the sex character of the parent plant was faithfully transmitted to the regenerated portions. By subjecting the protonemata to varied conditions of growth, they were unable in any case to alter the sex of the individual. These careful experiments seem to confirm their conclusion that the gametophytes in these cases contained the characters of but one sex.

In a later paper ('07) they report the results obtained in researches on the sporophyte. By regenerating parts of the seta or of the walls of the capsule they obtained protonemata which were always bisexual in character, instead of being unisexual as in the case of those produced from the spores or from parts of the gametophyte plant. It is significant that in a great majority of cases these protonemata showed only male characters, a much smaller number showed the sex characters of both male and female, and a very few showed only those of the female. By further experiment with secondary and tertiary protonemata obtained from these apparent male and apparent female forms, they found in every case that both sex characters were really present, but that one set was latent.

Since the gametophyte generation has but half as many chromosomes as the sporophyte generation, they conclude that the unisexual character of the spores is due to two series of chromosomes which are separated at the time of the reduction division, or when the spores are formed, so that half the spores contain the series which can develop one sex, and half the series which can produce the other. At the time of fecundation these two series are again united, making the tissue of the sporophyte bisexual in character.

These experiments seemed to them to indicate that the protonemata which are produced by the spores or by the tissue of the gametophyte are unisexual. However, either one of two interpretations may be given to the results: (1) The protonemata which are apparently unisexual contain the characters of both sexes, but one set has become latent to the extent that it does not become active by artificially varying the conditions of growth. (2) The characters of but one sex are really present. This latter interpretation is the one given by the Marchals.

A similar case in the Bryophyta, that of *Marchantia polymorpha*, has been worked out, although with much less certainty. It is reported by Blakeslee ('06) that the sporophyte produces two kinds of spores in the same sporangium, one giving rise to male thalli, the other to female. The gametophytes appear to be unisexual, as shown by the work of Noll, in which he cultivated plants of both sexes by means of the gemmae for over thirty generations but was unable to change the sex character of the thalli by growing them under varied conditions.

Blakeslee ('06) finds a similar condition existing in *Mucor Mucedo*. He states that two kinds of spores are produced in a single sporangium, the one giving rise to unisexual male mycelium, the other to unisexual female. He finds that the zygospores are bisexual. Although neither in *Marchantia* nor in *Mucor* were the proportions of the two kinds of spores obtained, yet as far as the observations go they seem to indicate that the same general phenomenon obtains as was found by the Marchals in the dioecious mosses.

I have been unable to find any account of work done on the Pteridophyta that would indicate the occurrence of two kinds of spores in the same sporangium. Prantl ('81) and Duval-Jouve ('63) working on the ferns and equisetums, respectively, both state that there is a tendency to dioeciousness but that occasionally both sex organs may be found on a single prothallium; Strasburger ('00) also believes that dioeciousness has not been fully established in the ferns. Wherever dioeciousness occurs in the Pteridophyta, it is apparently associated with heterospory, and it must follow that in these cases the separation of the two tendencies occurs previous to spore formation. The difference then in the dioeciousness of the Bryophyta and Pteridophyta would seem to be merely one of time as to the separation or dominancy of one tendency, in the former appearing with the production of the spores, in the latter before spore formation.

Owing to the parasitism of the female gametophyte, the Spermatophyta do not lend themselves so readily to experimentation. However, the unique and careful work of Correns ('07) on *Bryonia* indicates that two kinds of microspores are formed in dioecious flowering plants; one through fertilization causes a staminate sporophyte to develop, the other a pistillate.

In this work Correns pollinated the pistillate flowers of the dioecious *Bryonia dioica* with pollen from the monoecious *Bryonia alba*; the offspring were in the main dioecious, a few staminate flowers appearing on the same plant with the pistillate but soon dying. This showed that dioeciousness dominated monoeciousness, though not completely. Furthermore, the offspring were pistillate, no staminate plants being developed; this showed that the pistillate character of the dioecious plant dominated the staminate character of the monoecious plant. Correns concludes, therefore, that all egg cells of *Bryonia dioica* bear the same tendency, and that this tendency is to develop pistillate plants.

He next pollinated the pistillate flowers of *Bryonia dioica* with pollen from the staminate flowers of the same species, and obtained in the offspring twenty-one staminate and twenty-one pistillate. Since he used flowers from the same pistillate plant as in his first crossing, the staminate character must have been introduced by the pollen spores; and since half of the offspring were staminate, and the egg contained the pistillate tendency, it would follow that there is a difference in the pollen spores.

In the third place he pollinated the pistillate flowers of *Bryonia alba* with pollen from *Bryonia dioica* and obtained all dioecious offspring, thirty-eight staminate and thirty-eight pistillate; this further showed that dioeciousness was dominant. He concludes from this and the preceding experiment that the pollen spores of *Bryonia dioica* are of two kinds or otherwise all plants would have been pistillate as in his first experiment. These results were so unexpected, he says, that he tried them over and over with different individual plants but always with the same results. These noteworthy investigations on dioecious flowering plants, he believes, warrant the following conclusions: (1) The egg has a sex tendency which is female. (2) In each microsporangium two kinds of pollen spores are formed in equal number; half having the tendency to develop staminate individuals and half to develop pistillate individuals. (3) The staminate tendency dominates the pistillate tendency.

Noll ('07) in his work on the dioecious *Cannabis* has been led practically to the same conclusions as those of Correns, and independently of the latter's results. It has been known for some time from the observations of Heyer, Haberlandt, and Strasburger that in a state of nature the distribution of staminate and pistillate plants in the dioecious forms is nearly equal. Heyer found, after observations on several thousand individuals, that in *Mercurialis annua* the proportion was 106 staminate to 100 pistillate; in the same species Strasburger found the ratio to be 103.8 staminate to 100 pistillate, and in *Melandrium album* he found 100 staminate to 128.16 pistillate. In *Cannabis*, Heyer found from 40,000 plants the proportion to be 100 to 114.93; Haberlandt in Austria in the same species found 100 staminate to 120.4 pistillate; and Fisch in Erlangen found from 66,000 plants 100 staminate to 154.24 pistillate. To determine the cause of this ratio, Noll first gathered seeds from various individual plants of *Cannabis* which had been pollinated by natural agencies. On growing these seeds he found that the percentage of staminate and pistillate offspring derived from the seeds of a single plant varied materially from the normal ratio. In some extreme cases only 10 per cent. were pistillate, while in other extreme cases 90 per cent. were pistillate; it should be stated that in general there was no such extreme variation. From this evidence he concludes that the egg does not determine the ratio, otherwise there would not be such extremes of variation.

In the second place he crossed individual pistillate plants with the pollen from a single anther, with the result that the ratio of the offspring showed a very close approximation to the normal. From a plant crossed with pollen from a single anther there were obtained 100 staminate and 117.3 pistillate, while from a plant crossed with the pollen from a single inflorescence there resulted 100 staminate and 121.6 pistillate. Noll was led to believe from these experiments that the ratio of staminate and pistillate plants in the offspring is determined by the pollen spore and not by the egg. Although the conclusions seem hardly warranted from the data, yet they are in harmony with the results obtained by others.

It is the belief of the Marchals, of Correns, and of Noll, that this separation of the tendencies occurs in the formation of the spores. Although dioeciousness, as the term is usually applied, refers to the gametophyte in the Bryophyta and to the sporophyte in the Spermatophyta, yet it is very probable that the separation of the two tendencies is fundamentally the same in both groups; for in both groups two kinds of spores are produced in the same sporangium or microsporangium in equal number.

From the experiments thus far carried on in plants it would seem that possible assistance in the solution of the problem of the determination of sex in dioecious forms may be had in the study of spore formation. Much attention has been given in recent years to the study of the spores in plants and to the germ cells in animals; so that at present their general morphology is well understood. It may be regarded, at least as a working hypothesis, enforced by the classical work of Boveri on the dispermic sea-urchin egg, that each chromosome or group of chromosomes bears a definite relation to the development of particular parts of the organism. With this as a basis, the works of McClung, Stevens, Montgomery, Wilson, and others on the spermatogenesis of insects are particularly significant. It has been found in nearly one hundred species that there are two kinds of spermatozoa produced in equal number, differing in the character of the chromosome complex. In these cases there are two methods of formation of the chromosomes; most of them are formed by the segmentation of the spireme thread, but the so-called "accessory" or "idiochromosomes" (Wilson, '09*a*) arise generally at least from a chromatin nucleolus. The difference in the two kinds of spermatozoa formed is due to the distribution of these idiochromosomes. Regarding the determination of sex these facts are of special interest, since the fertilization of the egg with one kind of spermatozoa always produces a male individual, while fertilization with the other kind produces a female. The natural inference is that it is the idiochromosomes which have to do with the determination of sex.

Wilson ('09*a*) in his comparative review of the types of sexual differences of the chromosome groups, divides the known cases into five classes as follows:

1. "Both sexes with the same number of chromosomes, a pair of equal idiochromosomes present in both. No visible difference between the two classes of spermatozoa or between the male and female somatic groups."

2. "Both sexes and both classes of spermatozoa with the same number of chromosomes; the male with a pair of unequal idiochromosomes, half the spermatozoa receiving the large one and half the small one."

3. "The female chromosome group with one more chromosome than the male. The male with an unpaired idiochromosome and an odd spermatogonial number, half the spermatozoa receiving the idiochromosome and half being without it."

4. Female group (by inference only) with two more chromosomes than the male. In the male a pair of unequal idiochromosomes, half the spermatozoa receiving both these idiochromosomes, and hence two more than the other half."

5. "Female group with three more chromosomes than the male. Half the spermatozoa receiving three more chromosomes than the other half."

Wilson ('06) has been able to show very clearly a progressive series from forms in which there is a visible difference in number or in size of the idiochromosomes to those in which there is no visible difference in either number or size, as for example those included in his first class. He regards this class "as very important as a sort of connecting link to forms, perhaps the more usual, in which there is no visible difference."

It is generally believed that in plants the chromosomes are formed by the segmentation of the spireme thread. The careful work of Allen ('05) on *Lilium*, together with the works of others on the same genus, seems to leave no doubt that in these forms all of the chromosomes are formed in this manner. In the work of Gregoire ('04) on *Trillium*, in that of Martins-Mano ('04) on *Solanum* and *Phaseolus*, and in fact in all of the literature examined, I have found no case where any of the chromosomes are reported to be formed in any other manner. A possible exception is that of *Spirogyra* ; but because of the very small size of the chromosomes there has arisen among the workers on this genus a difference in interpretation of the observations which leaves the case at present in a very uncertain position.

It is important to note that all of the work done on the formation of the chromosomes in the plant cells has been done on hermaphrodite forms.

OBSERVATIONS ON THE POLLEN SPORE FORMATION IN *Acer Negundo*

It was my purpose in taking up this study to determine if there is a behavior of the chromosomes in dioecious plants analogous to that found in the spermatogenesis of insects, and apparently having to do with the determination of sex. After examining the anthers of several of the dioecious Angiospermae, I found in *Acer Negundo* L., a maple reported to be strictly dioecious, a nucleus with comparatively few chromosomes. Another feature which makes this plant especially favorable for study, is the successive stages of development found in each loculus of the anther, the youngest stages being at the base, the oldest at the top.

The mother cells in the early stages are differentiated from the surrounding tapetal cells in possessing a greater amount of chromatin-staining material in the form of a single, spherical nucleolus. A small amount of linin is visible with a few nodes or denser portions, but these do not take chromatin stain (FIG. 1).

The first visible change of the cell during the early growth period, is a slight increase in size of the nucleus and the appearance of a small bud-like process on the nucleolus (FIG. 2). This chromatin-staining mass gradually comes from the nucleolus in the form of a spherical body; at first it seems to be attached by a thread but soon becomes free and migrates to the nuclear wall, where it becomes connected with the linin and soon diffuses out upon it to build up the spireme thread (FIGS. 3–6). Soon after the first body is given off another one appears and behaves in the same manner as the first (FIGS. 5, 6). From the fact that these bodies gradually lose their chromatin-staining capacity and the reticulum at the same time becomes more apparent, there can be little doubt but that these are masses of chromatin which go to make up the spireme thread.

As growth continues more of these bodies come from the nucleolus, often two at a time; the exact number, however, could not be determined because those coming off first lose their identity before the later ones appear. It seems certain that these bodies are coming from the nucleolus rather than going into it, for in the same section the nuclei at the bottom of the anther, which contains the youngest stages, have bud-like processes just appearing, while farther up they are merely attached, and in the uppermost parts they have migrated to the wall of the nucleus. This very marked progressiveness in development in the same anther is of prime importance in considering the successive stages.

These chromatin bodies differ somewhat in size; and as they continue to appear the denser portions of the linin take the chromatin stain more deeply, and soon these nodes begin to disappear and the thread becomes more or less continuous (FIG. 10). Owing to the size of the thread at this stage, I could not determine whether it was split or not; it appears somewhat jagged or irregular in places, often bead-like, as frequently noted by other observers at this stage (FIGS. 10, 11).

The chromatin bodies usually cease to come off from the nucleolus at about the time when the spireme thread is well formed and takes the chromatin stain deeply. Synapsis now follows very quickly and the thread always appears to be associated with the nucleolus (FIG. 12). After this stage the thread unfolds and there appear thickenings upon it; often two threads may be seen to be parallel and sometimes united for a part of their length. The thickening thus formed becomes more condensed and finally the thread segments; successive stages show that this is the method of formation of at least some of the chromosomes (FIGS. 15–18). The details in the formation of the chromosomes could not be determined with accuracy; however, it appears from the study of many preparations in this stage, that many if not all are formed by the approximation and fusion of two threads. Eight chromosomes are formed by the segmentation of the spireme thread (FIGS. 16–20). There can be no doubt about the number thus formed; for in scores of uncut nuclei only eight could be detected during these successive stages.

Just previous to the formation of the synaptic knot, a large body appears coming from the nucleolus (FIGS. 10–12); at first it does not stain deeply with chromatin stains, but gradually it acquires the same staining capacity as the spireme thread. This body does not become freed for some time, at least not until the chromosomes derived from the thread are well formed, nor does it appear at any time to be associated with the thread in any way. During the first stages after synapsis this large chromatin body, which may be called a chromosome, shows very clearly a splitting (FIG. 13); this splitting is more or less visible until after this chromosome is freed. Occasionally, but not often, small chromatin bodies are given off from the nucleolus at this stage, similar to those given off before synapsis and these also function as those which served to build up the spireme thread (FIG. 14). They certainly do not behave like the bivalent chromosome which remains attached for so long a time to the nucleolus.

While the eight chromosomes formed from the spireme are becoming clearly defined, the one on the nucleolus gradually comes farther out and in addition one or two others make their appearance in a similar manner (FIG. 20). Each one of the chromosomes thus formed from the nucleolus shows very clearly the bivalent character; as they become freed, however, they appear more and more condensed so the splitting cannot be seen. There seems to be some variation in the number of chromosomes which appear at any one time upon the nucleolus, sometimes two or even four may be seen; but in every case no two seemed to be freed at the same time nor do two ever arise in succession from the same place. In all five chromosomes are thus derived. To illustrate the many successive stages found in the same loculus of an anther, it may be noted that FIGURES 15, 16, 20, 21, 22, are drawings from the same anther, while FIGURES 17, 18, 19, were taken from another single anther in the same stage of development.

Soon after the fifth chromosome makes its appearance on the nucleolus, the nuclear wall breaks down and the chromosomes become arranged in the equatorial plate; in the numerous nuclei examined in this stage, hardly two polar views showed the same arrangement of the chromosomes. There is also to be seen a slight difference in size of the chromosomes but the difference is not sufficient to enable one to identify any particular individual with certainty. During the interval from the collapse of the nuclear wall to the arrangement of the chromosomes in metaphase, the chromosomes have become more condensed (FIGS. 22, 23). At this metaphase stage one or more bodies are found in the cytoplasm, which are undoubtedly remains of the nucleolus, and which finally disappear. It is very evident that these are not chromosomes located at some distance from the others, for in subsequent stages where counts can be made only thirteen chromosomes exist; and in side view these bodies have no connection with the spindle.

Particular attention was given to the first nuclear division to determine if there is any unequal distribution of the number or in the size of the chromosomes analogous to what has been found in the spermatogenesis of insects; but all observations indicate that each chromosome splits into equal halves and each half moves to opposite poles of the spindle. Polar views of the nuclei in anaphase stages of the first division (FIGS. 24 *a* and *b*), and in metaphase of the second division (FIG. 33), both show the same number, thirteen; numerous counts were made of these stages so there can be no doubt about the equal distribution. Side views of the spindle during the metaphase and anaphase stages also show, as nearly as could be determined, that each chromosome splits into equal halves; the only irregularity noticed was that some of the chromosomes in some nuclei divide before others, but in late anaphase all seem to be in about the same plane.

As the chromosomes are gathered at the poles, they are so massed that their individuality cannot be determined; very soon, however, the nuclear membrane is formed and as it increases in size chromatin masses become readily distinguishable (FIG. 25). In each daughter nucleus there is found one large chromatin mass and a few smaller ones varying somewhat in size. Many observations seem to indicate that these smaller chromatin masses pass into one large mass in one of the daughter nuclei, while in the other daughter nucleus they unite so as to form two chromatin masses of unequal size (FIGS. 25, 26, 28). As a consequence, the two daughter nuclei present a different appearance at this stage in their reconstruction by one containing one large and one small chromatin-staining mass, while the other contains but one large one. This seems to be a very general phenomenon. In a very few cases, however, two bodies were seen in each daughter nucleus (FIG. 27). Many successive stages were observed in the same loculus of an anther (FIGS. 25–30 were taken from the same loculus) so there can be little doubt about the general order and succession of these changes.

As a general rule the secondary chromatin body to be found in the one nucleus ultimately fuses or coalesces with the larger one so that each daughter nucleus simulates a resting condition (FIG. 29). At this stage the nuclei appear very similar to the nucleus of the mother cell, possessing the small non-staining bodies about the nuclear wall. Occasionally the secondary chromatin mass found in the one nucleus does not fuse with the larger one ; this lack of fusion is probably due to the shortness of time which intervenes between the first and second divisions.

Owing to the rapidity of development and to the small size of the nuclei, the formation of the chromosomes for the second division could not be followed with the detail obtained for the first. No spireme was noticed during these stages, but in many cases the spherical chromatin masses were clearly seen coming from the nucleolus, as observed in the formation of the thread for the first division. It should be noted in cases where the secondary chromatin mass has not fused with the larger one, — as sometimes occurred in the reconstruction of one of the daughter nuclei after the first division, — that this secondary mass as well as the large one gave off spherical bodies which served to build up the spireme thread (FIG. 31). In later stages many nuclei were found that showed the bivalent chromosomes coming from the nucleolus (FIGS. 30–32), clearly indicating the same general phenomenon as occurred in the formation of the chromosomes for the first division. The number of chromosomes formed in this manner could not be determined with accuracy, but there is no reason to believe that there is a difference in behavior from the first division, where eight were formed by the segmentation of the spireme and five from the nucleolus.

In the polar view of the metaphase stage of the second division (FIG. 33), thirteen chromosomes are to be seen in each plate. Owing to the small size, the division of the chromosomes could not be accurately determined, but in side views there appeared no irregularity in the figure which might indicate an unequal distribution; it seems probable that each chromosome divides so that each of the four daughter nuclei receives the same number.

As the nuclear membrane begins to be formed for each daughter nucleus, several masses of chromatin are visible in each; and as fusion of these masses continues it is found that the two daughter nuclei derived from one of the nuclei contain one more chromatin mass than do the other two (FIGS. 34, 35). No cell walls are formed until after the second division is completed; this enables one to identify with certainty the two nuclei derived from the same mother nucleus. Although a less number of nuclei was observed in this stage than in the reconstruction of the daughter nuclei after the first division, this phenomenon of the extra chromatin mass appears to be even more constant in the reconstruction after the second divsion.

As to the significance of this difference in the behavior of the chromatin in the two sets of daughter nuclei, we can only conjecture. The fact that it commonly occurs in the first division and that the two daughter nuclei hand on these respective characters to the nuclei derived from them, leads us to suspect that this difference in behavior of the chromatin is in some way connected with an essential difference in its character.

Ultimately the second chromatin body fuses with the larger one, so that in the complete resting stage all four nuclei have the same appearance (FIG. 36), resembling the resting stage of the mother-cell nucleus. The four pollen spores are formed by the simultaneous division of the cytoplasm into four parts, each containing a nucleus.

SUMMARY OF OBSERVATIONS

A. All of the chromatin is contained in the single spherical nucleolus in the resting stage. The nucleolus may not be entirely chromatin, since at the time of division fragments of it are thrown out into the cytoplasm, where they gradually disappear.

B. The spireme is built up by the chromatin coming out of the nucleolus in the form of several spherical bodies, which may vary somewhat in size; these become attached to the linin and diffuse out upon it. Usually all of these bodies appear before synapsis.

C. Eight chromosomes are formed by the segementation of the spireme thread.

D. Five bivalent chromosomes come out of the nucleolus after synapsis and after the spireme has become segmented into the other eight.

E. There is no unequal distribution of the chromosomes in the first division, and probably none in the second; so that each pollen spore contains thirteen chromosomes.

F. In the reconstruction of the daughter nuclei after the first division, each nucleus contains one large chromatin mass and several smaller ones which lose their staining capacity as their chromatin passes into the large mass. A secondary chromatin mass appears in one of the two daughter nuclei; this may or may not fuse with the larger mass.

G. In the formation of the chromosomes for the second division, as nearly as can be determined, the same phenomena occur as in the first division; where two chromatin masses occur in one of the daughter nuclei of the first division, the smaller mass, as well as the large one, gives off chromatin in spherical bodies to build up the chromosomes.

H. In the reconstruction of the daughter nuclei after the second division, the two derived from one nucleus contain each one more chromatin mass than the two derived from the other. This difference in behavior of the chromatin in both the first and second division seems to indicate a difference in the nature of the chromatic substance in half of the nuclei. In the resting stage, all nuclei have the same appearance, each with a single, spherical nucleolus and several non-staining bodies around the nuclear wall.

GENERAL CONCLUSIONS

The storage of the chromatin in the nucleolus and its later behavior in building up the thread, as noted in *Acer Negundo*, does not appear to be a phenomenon newly observed. Wager ('04) in his work on the root-tip of *Phaseolus*, believes that the nucleolus in the species studied contains nearly all of the chromatin; and that it is transferred previous to division into the spireme thread, which then segments into chromosomes. He reviews the literature upon the subject and comes to the general conclusion that in some species the chromatin is contained in the nucleolus and in some apparently not; where it is thus contained the chromatin seems to be transferred by the thread becoming attached to the nucleolus. Cardiff ('06) figures a bud-like process attached to the nucleolus of *Acer platanoides* and thinks that it illustrates the manner of transfer of the chromatin from the nucleolus to the spireme thread. I have observed in the pollen mother cells of *Zea Mays* these bud-like processes which I believe to function in the same way. As to the manner in which the chromatin is transferred to the thread, I find, however, no case in plants, which has been thoroughly investigated, that corresponds to the condition reported in this paper, although this method of transference may not be uncommon.

Cytologists are practically unanimous in the belief that the chromosomes in plants are formed by the segmentation of the spireme thread. The only process analogous to the formation of the five chromosomes which come out of the nucleolus in *Acer Negundo* is that found in the formation of the idiochromosomes in insects. It might be urged that the case is not analogous, because in *Acer Negundo* all of the chromatin is contained in the nucleolus and that these five chromosomes are merely delayed in their formation; nevertheless the significant fact remains that the formation of these five is different from that of the other eight in that they come from the nucleolus already formed. It is to be noted, moreover, in insects that sometime during the life history of these idiochromosomes they are contained in a chromatin nucleolus, and in many cases they are at some period associated with the true nucleolus or plasmosome. So far as the observations go, this case of *Acer Negundo* seems to correspond in a general way to those insects which Wilson includes in Class I, where the two kinds of spermatozoa contain idiochromosomes of the same number and of the same size. The evidence at present is far too meager to warrant any definite conclusion as to the nature of the five chromosomes, which are somewhat suggestive of idiochromosomes in the manner of their formation.

The common occurrence of the difference in behavior of the chromatin in the two nuclei attracted my attention from the first and led me to examine the phenomenon with a view to determine if there was an essential difference in the character of the chromatin. I suspected at first that it might be due to an extra chromosome, but further study showed that each nucleus contained the same number. It is not impossible, however, that there may be two series of chromosomes that are inherently different in character and which are, therefore, handled differently in the reconstruction of the nuclei. On the other hand, I find Wager ('04) states that in the vegetative cells of *Phaseolus* the nucleoli originate by the fusion of the chromosomes, first into a number of small nucleolar masses and then by further fusion into the large nucleoli found in the mature cell. Some of his figures seem to indicate that the fusion of these bodies does not take place at the same time in each daughter nucleus; and from an examination of figures of other works this feature does not appear to be uncommon. In view of these facts, it is impossible to judge how much weight should be attached to this behavior of the chromatin in the spore formation of this dioecious species; but the fact that it occurs so regularly in the great majority of cases during the early stages of reconstruction, leads one to believe that it may not be without significance. Considering the experimental work of Correns, it is very tempting to conclude that this may have something to do with the determination of the two kinds of pollen spores; however, we can hardly be justified in drawing any conclusion.

Coming now to the consideration of dioeciousness, the facts point very strongly to the conclusion that in the dioecious mosses, and probably in the dioecious Bryophyta generally, there is a dominancy and a separation of the tendencies in the formation of the spores. Evidently there is no such separation in the spore formation of hermaphrodite mosses; each spore must possess both tendencies. One of the tendencies, however, must dominate the other at some time during the germination of the spore previous to the formation of the sex organs. It does not seem inconceivable that this dominancy may take place in the vegetative cell, possibly due to external factors or conditions; this seems to be evidenced by the work of Prantl, Klebs, and others on various groups. Marchals' work clearly shows that fertilization brings both tendencies together, making the sporophyte tissue bisexual in character. By means of the protonemata regenerated from this tissue they find that one tendency may be dominant and the other latent or recessive throughout the development of the gametophyte; or in other cases they find that both tendencies may be potent so that both sex organs develop.

In the Pteridophyta the tendency to dioeciousness, as noted by Prantl and Duval-Jouve in the ferns and equisetums, may be accounted for on the grounds that a complete dominancy of the two tendencies does not take place at the time of spore formation, but this dominancy arises at a later period depending directly or indirectly on external conditions. In the heterosporous Pteridophyta the dominancy of one tendency occurs at some time previous to the formation of the spores, so that the two kinds are found in different sporangia. The essential difference, therefore, between the dioeciousness of the Bryophyta and of the Pteridophyta is that in the former there is a dominancy and separation of the tendencies in the formation of the spores, and in the latter there is no such dominancy and separation attending spore formation. In the isosporous ferns this dominancy occurs after the formation of the spores and in the heterosporous forms before. This interpretation seems to be in accord with the work of Morgan ('09) on the phylloxerans; he finds that there are two kinds of eggs produced, a large female-producing egg and a smaller male-producing one. These eggs develop parthenogenetically, each forming but one polar body. Both eggs previous to the formation of the polar body contain the somatic number of chromosomes, twelve; after the formation of this body, the female-producing one contains twelve, the male-producing ten. Since the size of these two kinds is evidently determined at another time than at the reduction division, it may be cited as further evidence that a dominancy may occur other than at the time of spore formation.

The monoecious and hermaphrodite Spermatophyta present a somewhat different condition. It seems very evident that the sporophyte tissue is bisexual in character, but that one tendency may dominate the other. Observations show that the willows, which are usually dioecious, may occasionally develop both sex organs. Another case is that of *Melandrium*, as reported by Strasburger ('00); when the pistillate flowers are attacked by *Ustilago*, the primordia of the stamens, which otherwise do not develop, produce the mother-cell stage in the anther. Kerner shows that all stages may be found from those forms in which both functional stamens and pistils are produced, to those where only stamens or pistils develop. In fact all kinds of combinations and stages from strictly hermaphrodite forms to strictly dioecious ones exist. All of these facts might be interpreted as pointing to the conclusion that both tendencies do exist in the sporophyte but that one may be more or less dominant. If these tendencies should be of sufficient potency, then a hermaphrodite sporophyte would result; if the potency of the two varied, then one or the other of the tendencies would appear in proportion to their potency.

Considering the case of dioecious Spermatophyta, the only evidence at hand seems to indicate that there are two kinds of pollen spores, and that the sporophyte resulting from one kind will be staminate and from the other pistillate. As to the sex tendency of the megaspore there is little evidence; Correns' work seems to indicate that it contains the tendency to develop pistillate individuals. However, the evidence at present is not sufficient to warrant any conclusion as to whether there is a dominancy or a separation of the tendencies in the formation of the megaspore.

In conclusion I may briefly state the current hypotheses regarding the determination of sex. I use the term "tendency" in the sense of "power to develop," as I have in the preceding discussions.

Correns ('07) believes that the female organism contains only the female tendency and that it is recessive to the male; while the male contains both tendencies, the male dominant and the female latent.

Punnett and Bateson's ('08) hypothesis is practically the reverse of that of Correns. They believe that the male contains only the male tendency and that it is recessive to the female; while the female contains both tendencies, the female dominant and the male recessive or latent.

Wilson ('09 *b*) accounts for the determination of sex on a cytological basis. He concludes that the female tendency is the result of one or more X-elements which are not found in the male; this X-element may be represented by an idiochromosome. He believes that the male contains the determining factors, and so in a general way agrees with Correns.

Castle ('09) explains sex determination as dependent upon the presence of a factor or factors which are inherited in accordance with Mendel's law. Femaleness is due to the presence of this factor or factors and maleness to its absence. The differential factor is transmitted in two ways: (1) The differential factor is doubly represented in the female, which is homozygous, *i. e.*, gives rise to similar gametes. The male, characterized by but one differential factor, is heterozygous, *i. e.*, gives rise to two gametes, one possessing and the other lacking the differential factor. Sex determination therefore rests with the male parent, for when fertilization is effected by the male gamete possessing the differential factor males result. The female is homozygous dominant, not, as Correns supposed, recessive; while the male is heterozygous dominant, pure recessives being unknown. (2) The differential factor appears in but one of the gametes, *i. e.*, the egg. Therefore sex must be determined by the female (egg) since the male does not carry the differential factor. The female is heterozygous dominant and the male is homozygous recessive; homozygous dominants are unknown.

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Explanation of plates 12–14

All figures were made by means of a camera lucida with Spencer 1.5 mm. objective and Leitz compens. ocular 12. The original drawings were reduced one third; all figures are magnified 3,000 diameters.

PLATE 12

1. Mother cell in early growth period with single, spherical nucleolus and non-staining bodies on linin.

2. Mother cell showing chromatin body just appearing on the nucleolus.

3. The nucleus slightly larger, the chromatin body farther out from nucleolus.

4. The chromatin body nearly free, attached by a thread.

5. Chromatin body free, a second appearing.

6. The first chromatin body attached to the linin and beginning to lose its chromatin. The second nearly free.

7. Several chromatin bodies diffusing out on the linin, others appearing. The thread becoming more apparent.

8. A later stage showing two bodies appearing at a time.

9. The thread well formed, the last bodies becoming free from the nucleolus.

10. The thread is formed; a chromosome which stains very lightly appears coming from the nucleolus.

11. The thread begins to knot up toward one side of nucleus.

12. The contraction phase with the thread in a knot at one side of nucleus, associated with the nucleolus. The chromosome upon the nucleolus takes the chromatin stain more deeply.

13. The thread unfolding; the chromosome on the nucleolus shows its bivalent character. The cytoplasm begins to pull away from the cell wall.

14. A little later stage, in which a chromatin body is coming from the nucleolus like those in 3; this is not a very common phenomenon.

15. The threads begin to become parallel and a thickening appears preparatory to the formation of the first chromosome from the thread.

PLATE 13

16–19. Successive stages of formation of the eight chromosomes from the thread. The chromosome remains attached to the nucleolus but still shows its bivalent character.

20. The eight chromosomes from the thread are well formed. One chromosome nearly freed from the nucleolus, three others appearing in succession.

21. One chromosome entirely freed from the nucleolus, a second merely attached by a thread, a third and fourth just appearing.

22. Three chromosomes freed from the nucleolus, the other two apparent at opposite ends of the nucleolus. Cytoplasm well drawn away from the cell wall.

23. Polar view of the thirteen chromosomes in metaphase, showing some difference n size of the chromosomes.

24, *a* and *b*. Polar views of a single nucleus in anaphase, in which each chromosome has split and each half is moving toward opposite poles.

25. Early stage of reconstruction of the daughter nuclei, showing the one large chromatin mass in each, together with several smaller ones which vary in size and staining capacity. The smaller masses seem to pour their chromatin into large ones. Remains of nucleolus may be seen in cytoplasm.

26. A later stage of reconstruction showing nearly all of the chromatin lodged in one large mass in one cell and in one large and one small in the other.

PLATE 14

27. An uncommon stage, in which there are two chromatin bodies in each daughter nucleus. In one nucleus they appear to be of more equal size than in the other; the large mass in one appears somewhat irregular due to the fusion of the smaller masses.

28. A very common stage, in which one nucleus has the one chromatin body, the other the large and small one.

29. All of the chromatin has fused into one large mass in each nucleus. The small non-staining bodies appear around the wall of the nucleus.

30. Early stages preparatory to the second division. The bivalent chromosomes just appearing on the nucleolus.

31. Later stage showing in one of the nuclei the secondary chromatin mass giving up its chromatin in small spherical bodies to form the other chromosomes.

32. A stage just previous to the breaking down of the nuclear wall; the bivalent chromosomes clearly visible, coming from the nucleolus.

33. Polar views of the metaphase of the second division showing thirteen chromosomes in each plate.

34. Early stage in reconstruction of the daughter nuclei; the ones opposite each other are derived from the same nucleus; the two derived from one show three chromatin bodies each, the other two show but two each.

35. A later stage in reconstruction, in which the bodies are all fused into one chromatin nucleolus in two of the nuclei; while in the other two fusion is taking place in one and not in the other.

36. The resting nuclei after the second division; each nucleus contains the single spherical nucleolus with the small non-staining bodies about the nuclear wall.

Notes on North American Hypocreales — II. Nectria Peziza*

FRED J. SEAVER

(WITH PLATE 15)

Sphaeria Peziza was described by Tode in 1791, and while there is probably no type specimen in existence, the illustrations and descriptions by Tode seem, from our observations, quite definitive of the species. While many species of the present and closely related genera cannot be distinguished except by a close microscopic study of the spore-characters, thus rendering illustrations of gross characters, only, valueless, this is not true of the one here treated. Having observed and studied this species for the past five years in the field, covering an extensive range of locality, we find that there are few members of the genus, if any, which are more easily recognized on external characters. Add to this, on microscopic examination, the broadly-elliptical, septate, non-constricted spores with a distinct oil-drop in each cell, and the species would seem to be very well marked.

This is probably one of the most common and widely distributed species of non-stromatic *Nectria*, and, as is usually the case with species which are common and subject to more or less variation, has been much studied, greatly misunderstood, and many times redescribed. The perithecia in this species are large, compared with those of other species of the genus, ranging from one third to one half millimeter in diameter and nearly globose, especially when moist, with the ostiolum only slightly prominent. The color is from pale to deep orange, becoming deeper on drying, but often fading with age to very pale yellowish or whitish. The plants are usually widely scattered but occasionally crowded, giving somewhat the appearance of a stromatic form, but no true stroma is present. The perithecia produce no well-developed hairs but are often clothed with a growth of mycelial threads, which character seems to vary with conditions. Specimens col-

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* Notes on North American Hypocreales — I, appeared in Mycologia **1**: 19–22. *pl. 2.* 1909.

lected in good condition are nearly smooth but become more or less roughened with age. The variation is not great but is sufficient to have led to some confusion. The perithecia at maturity, especially when dry, almost invariably collapse from the top, becoming cup-shaped and in this condition very much resemble a *Peziza*, which fact has doubtless suggested the specific name. This latter character has been the cause of considerable confusion.

Most of the American specimens examined by Mr. Ellis have been referred by him to *Nectria vulpina* (Cooke) Ellis & Everh., while most of the foreign specimens examined by the writer have been referred by various authors to *Nectria Peziza* (Tode) Fries, but notwithstanding this fact close study of American and foreign material fails to reveal any difference. *Nectria vulpina* (Cooke) Ellis & Everh. was based on material collected at Newfield, New Jersey, and was first described by Mr. Cooke as a *Peziza*, a mistake which is likely to be made on account of the close resemblance of these plants to some of the cup-fungi. The species was later transferred to the genus *Dialonectria* by Mr. Cooke and still later to the genus *Nectria* by Saccardo, and still retained as a distinct species, although there was no reliable character by which it could be distinguished from the commonly recognized species *Nectria Peziza* (Tode) Fries. A specimen in the Ellis collection which is evidently cotype material of *Nectria vulpina* (Cooke) Ellis & Everh. has been closely studied with the hope of discovering some character by which it might be distinguished from *Nectria Peziza* (Tode) Fries, but except for a very slight variation in the size of the spores this is a typical specimen of the latter species, as are the other specimens in the same collection referred to this name.

Nectria betulina, which was described from American material, seems to be a form of the present species which occurs in cracks and crevices of bark, and, the perithecia becoming crowded, presents the appearance of a stromatic form. The perithecia and spores are typical of *Nectria Peziza* (Tode) Fries and I am unable to separate it from that species. *Nectria rimincola* Cooke is a similar form. I give below a complete synonymy and description of *Nectria Peziza* (Tode) Fries, based on our own study :

NECTRIA PEZIZA (Tode) Fries, Summa Veg. Scand. 388. 1849

Sphaeria Peziza Tode, Fungi Meckl. **2**: 46. 1791.
? *Peziza hydrophora* Bull. Hist. Champ. 243. 1809.
Peziza Dasyscypha vulpina Cooke, Hedwigia **14**: 82. 1875.
Nectria rimincola Cooke, Grevillea **11**: 108. 1883.
* *Nectria lasioderma* Ellis, Am. Nat. **17**: 194. 1883.
Dialonectria vulpina Cooke, Grevillea **12**: 83. 1884.
Nectria Umbellulariae Plow. & Hark. Bull. Calif. Acad. Sci. **1**: 26. 1884.
Nectria vulpina Ellis & Everh. N. Am. Pyrenom. 103. 1887.
Nectria betulina Rehm, Ann. Myc. **3**: 519. 1905.

Perithecia superficial, scattered, gregarious or occasionally crowded, globose or subglobose, usually collapsing from the top and becoming pezizoid, at first clothed with a scant covering of delicate, white, mycelial threads (no true hairs) which disappear with age, leaving the perithecia smooth or in very old specimens slightly rough and furfuraceous, 250–500 μ in diameter (mostly about 300 μ), varying in color from pale to deep orange, color darker in dried specimens, weathered specimens fading to pale yellow; ostiolum minute, in young specimens just visible and in older forms depressed and inconspicuous; asci cylindrical or clavate, 8-spored, 50–75 μ × 5–8 μ; spores broadly elliptical, obliquely 1-seriate or becoming crowded and partially 2-seriate, thick-walled, 1-septate, not constricted, with 1 large, conspicuous oil-drop in each cell, 10–14 μ × 4–6 μ (mostly 10 × 5 μ); paraphyses short, branched, not conspicuous. [PLATE 15.]

On decaying decorticated wood, more rarely on bark, fungi, and old hemp cloth.

TYPE LOCALITY: Mecklenburg, Germany.

DISTRIBUTION: New York to Ontario, North Dakota, California, and Louisiana.

ILLUSTRATIONS: Tode, Fungi Meckl. **2**: *pl. 15. f. 122;* Bulliard, Herb. France, *pl. 410. f. 2;* Currey, Trans. Linn. Soc. **22**: *pl. 57. f. 44;* Berkeley, Outl. Brit. Fung. *pl. 24. f. 6;* Greville, Crypt. Fl. **4**: *pl. 186. f. 2.*

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* The type of this species in the Ellis collection is so scant that scarcely a perithecium in good condition could be found, and it is impossible to make a thorough study of gross characters. The spores are typical of the above species.

EXSICCATI: Ravenel, Fungi Am. Exsicc. *644;* Ellis, N. Am. Fungi *774;* Wilson & Seaver, Ascom. and Lower Fungi 16. Other specimens examined: California, *Harkness;* Iowa, *Arthur, Seaver;* Louisiana, *Langlois*; Maine, *Harvey;* New York, *Atkinson, Brown, Seaver;* North Dakota, *Seaver* (various collections); New Jersey, *Ellis* (various collections); Ohio, *Hawkins, Morgan;* Ontario, *Dearness, Macoun.*

Explanation of plate 15

1. Cluster of plants, natural size.
2. Several plants, × 50.
3. Diagram section of plant, × 50.
4. Cluster of asci, × 1200.
5. One spore, × 2500.

The embryo-sac of Pandanus

DOUGLAS HOUGHTON CAMPBELL

(WITH PLATES 16 AND 17)

Among the interesting problems which are engaging the attention of botanists at the present time is the study of certain anomalies in the structure of the embryo-sac of the angiosperms, to which, of late, attention has been called. The stereotyped character of the embryo-sac structures was long taken for granted; but it is becoming more and more evident that the departures from the type are more numerous and more marked than has generally been supposed. Further discoveries in this direction are therefore naturally of interest.

As the Pandanaceae are considered to be among the lowest of the Monocotyledons, it was thought that they might show some deviations from the ordinary type of embryo-sac and a special effort was made to obtain material during a visit to the East Indies made in 1906. While in Java in the spring of 1906, I had an opportunity of collecting material of several species of *Pandanus*, and an examination of this made it evident that the embryo-sac in this genus differs very markedly from that known in any other plant. A preliminary note * was published giving the most important facts. The present paper treats in detail the development of the embryo-sac up to what is probably the stage of fertilization, but unfortunately none of the material was old enough to show the fertilization and the early stages of endosperm formation or the development of the embryo. The results, however, seemed important enough to warrant publication and are set forth at length in the following pages.

The most marked departure from the typical embryo-sac that has yet been observed is that of *Peperomia*, in which the writer first demonstrated that there were normally sixteen nuclei instead of the eight characteristic of the typical embryo-sac.† Through

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* CAMPBELL, D. H. The embryo-sac of *Pandanus*. Preliminary note. Ann. Bot. **22**: 330. 1908.

† CAMPBELL, D. H. The embryo-sac of *Peperomia*. Ann. Bot. **15**: 103–118. *pl. 6.* 1901.

the work of Johnson * and Brown † other species have been investigated which agree in their essential structures with *P. pellucida*, the species in which the original discovery was made. A sixteen-nucleate stage was found by Schnegg ‡ to occur sometimes in *Gunnera*, and Ernst § has recently shown that this is regularly the case in *G. macrophylla*. In the latter, however, the embryo-sac in its mature condition resembles more nearly that of the typical angiosperms than does that of *Peperomia*. In a preliminary announcement Stephens ‖ has stated that in several genera of the South African family Penaeaceae the embryo-sac regularly contains sixteen nuclei, but the details have not yet been published. Certain Araceae also show certain marked deviations from the usual type, but these are not constant and their meaning is still obscure.¶ Shattuck ** reports in *Ulmus americana* a condition intermediate between *Peperomia* and the typical angiosperms. More or less marked deviations from the type have also been observed in *Juglans* †† and certain Liliaceae, but these are less striking than in *Peperomia* and *Gunnera*. In a number of plants representing widely separated families peculiarities in the antipodal cells have been observed, which, in some cases at least, point to an increase in the vegetative tissues of the gametophyte. There is often a greater or less enlargement of the antipodal cells which may be accompanied by an increase in their number. This usually follows after

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* JOHNSON, D. S. On the endosperm and embryo of *Peperomia pellucida*. Bot. Gaz. **30**: 1–11. *pl. 1*. 1900.

——. On the development of certain Piperaceae. Bot. Gaz. **34**: 321–340. *pl. 9, 10*. 1902.

† BROWN, W. H. The nature of the embryo-sac of *Peperomia*. Bot. Gaz. **46**: 445–460. *pl. 31–33*. 1908.

‡ SCHNEGG, H. Beiträge zur Kenntniss der Gattung *Gunnera*. Flora **90**: 161–208. 1902.

§ ERNST, A. Zur Phylogenie des Embryosackes der Angiospermen. Ber. Deuts. Bot. Gesells. **26a**: 419–438. *pl. 7*. 1908.

‖ STEPHENS, E. L. A preliminary note on the embryo-sac of certain Penaeaceae. Ann. Bot. **22**: 329. 1908.

¶ CAMPBELL, D. H. Studies on the Araceae. The embryo-sac and the embryo of *Aglaonema* and *Spathicarpa*. Ann. Bot. **17**: 665–687. *pl. 30–32*. 1903.

——. Studies on Araceae, III. Ann. Bot. **19**: 329–349. *pl. 14–17*. 1905.

** SHATTUCK, C. H. A morphological study of *Ulmus americana*. Bot. Gaz. **40**: 209–223. 1905.

†† NAWASCHIN, S. Ein neues Beispiel der Chalazogamie. Bot. Centralbl. **63**: 353–357. 1895.

fertilization, *e. g.*, *Sparganium* and several Araceae, or this increase in number may take place before fertilization, as in certain grasses.* Many Ranunculacae are also characterized by a large development of the antipodal cells, which may become multi-nucleate, but according to Mottier † the nuclear division is amitotic and is presumably a secondary condition. The increase in the number of antipodals in the Compositae and some other sympetalous forms is considered by Coulter ‡ to be a secondary condition associated or involved in the formation of a haustorial organ.

In *Pandanus* there is an increased number of nuclei, *i. e.*, 14 instead of 8, and to judge from the most advanced stages that were met with, there is a failure to develop the definite structures of the typical embryo-sac. It is possible an examination of older material may show a development of further embryo-sac structures before fertilization takes place.

The Pandanaceae, comprising the genera *Pandanus* and *Freycinetia*, are confined entirely to the old world, being especially abundant in the Malayan region, where they constitute a very striking feature of the flora. One species of each genus extends to the Hawaiian Islands. The Pandanaceae are usually considered to be among the lowest of the monocotyledons, and the present work was undertaken to see whether the embryo-sac structures showed any deviations from the ordinary angiospermous type which might be interpreted as of primitive nature. The results, as we shall see, indicate that the embryo-sac in *Pandanus*, at least, normally differs very much from that of the typical angiosperms, and that the differences indicate a less specialized condition, approximating the very generalized type of *Peperomia*.

The material upon which the following account is based was collected in Buitenzorg during my stay at the botanic gardens there from March to June, 1906. The collection of Pandanaceae in the Buitenzorg Gardens is without much question the richest in the world, and while there I collected all of the suitable material there

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* CANNON, W. A. A morphological study of the flower and embryo of the wild oat, *Avena fatua* L. Proc. Calif. Acad. III. **1**: 329–364. *pl. 49–53*. 1900.

† MOTTIER, D. M. Contributions to the embryology of the Ranunculaceae. Bot. Gaz. **20**: 241–248, 296–304. *pl. 17–20*. 1895.

‡ COULTER, J. M., & CHAMBERLAIN, C. J. Morphology of angiosperms, page 102. 1903.

was available. I must here express my deep appreciation of the great help afforded me by Professor Treub and the Director of the Garden, Mr. H. J. Wigmann, who gave me every assistance in procuring specimens. *Pandanus* offers special difficulties in securing material, as most of the species do not flower freely, and even under the extraordinarily favorable conditions at Buitenzorg only a small number of species flowered during my three months' stay.

Many of the specimens growing in the garden at Buitenzorg are still unnamed, as the limits of the species are still very poorly understood, and the large genus *Pandanus* seems to be very much in need of a thorough revision. Three of the species collected, however, were named, two of them being comparatively small species: *P. Artocarpus* Griff., and *P. affinis* Kurz. The other was the large, wide-spread species *P. odoratissimus* L. f., which extends as far as the Hawaiian Islands. The material was fixed in several ways: one per cent. chromic acid, weak Flemming's solution, and acetic alcohol. All of the methods proved satisfactory. The younger flowers offer no difficulties in the way of fixation, but in the later stages the outer part of the carpels becomes hard and this must be cut away so as to expose the softer tissues surrounding the ovule. Owing to the small number of inflorescences that were available, it was impossible to obtain any of the stages subsequent to fertilization, but it is hoped that material may be procured which will supplement the account of the earlier stages which is given here.

All of the Pandanaceae are dioecious. The pistillate flowers in *Pandanus* are in dense heads, which in the smaller species are borne several together at the end of a short branch, each head being subtended by a conspicuous bract. In the larger species, where the head of fruit may be as big as a large pineapple, the heads are solitary and enveloped in a large number of bracts. The Pandanaceae have been placed close to the Sparganiaceae, and the heads of flowers, as well as the spiky fruit look very much indeed like those of *Sparganium*. In the smaller species; *e. g.*, *P. Artocarpus* (FIG. 1) the flower consists of a single carpel, which, in form as well as in the position of the ovule, resembles that of *Sparganium simplex*, but the conspicuous scale-like bracts that surround the carpel in *Sparganium* are absent. In the large species like *P.*

odoratissimus several carpels are more or less completely coherent, and may be compared to the compound pistils of *Sparganium eurycarpum* or *S. Greenii.* Each carpel contains a solitary anatropous ovule attached to one side of the ovarian cavity very near its base. The placenta and the base of the funiculus bear thickly placed glandular hairs. These are probably concerned with the conduction of the pollen-tube to the micropyle.

The ovule presents no notable peculiarities in its form. There are two integuments, of which the inner one in the younger ovules projects somewhat beyond the outer one, which is not very strongly developed but finally reaches the level of the inner integument. On the inner side of the ovule the outer integument is completely adherent to the funiculus (FIG. 2). The embryo-sac is separated from the apex of the nucellus by several layers of cells.

The nucellus is more or less pointed at the top, and there is a very sharply defined epidermis consisting of a single layer of cells except at the apex of the nucellus, where periclinal divisions occur, so that there may be three or four layers of cells in this region. This formation of periclinal walls, combined with an elongation of the cells, produces the more or less prominent beak which is usually present. FIGURE 3 shows a median longitudinal section of one of the youngest ovules that was found. This was from *P. affinis*, which differs slightly from the other species examined in the form of the embryo-sac mother-cell, as well as in the greater thickness of the epidermis at the apex of the nucellus. As the older stages of this species were not available, it is impossible to say how they would compare with the corresponding stages in the other two species that were studied.

The embryo-sac mother-cell at this stage is undivided, but it is easily recognized by its dense contents and its very conspicuous nucleus. In section it appears almost triangular in form with a pointed base and broad apex. Between it and the epidermis is a group of cells, probably tapetal or "parietal" cells, and, to judge from the form and position of the group, they arise from the division of a single cell which presumably is a sister-cell of the embryo-sac mother-cell.

DEVELOPMENT OF THE EMBRYO-SAC IN PANDANUS ARTOCARPUS

The earliest stages of the embryo-sac found in *P. Artocarpus* (FIGS. 4–6) were somewhat more advanced than that described for *P. affinis*. The mother-cell is more nearly cylindrical and the base is truncate and sometimes almost as broad as the apex, and in such cases it forms the lowermost of a single series of cells, or at least such is the appearance in a longitudinal section. (See FIG. 6.) More frequently the upper end of the mother-cell is broader and two series of parietal cells appear in longitudinal sections. These two series probably arise from a median division of the tapetal or "parietal" cell, and by subsequent periclinal divisions give rise to about three layers of cells between the mother-cell and the epidermal layer at the apex of the nucellus. The sporogenous cell divides by transverse division into two cells, of which the lower is the larger and becomes the embryo-sac. The upper cell, *x*, divides again into two by a vertical wall and these two small cells persist with little change for a long time, but finally disintegrate and are visible only as two small, darkly stained, shrunken bodies lying above the apex of the embryo-sac. In these early stages *Pandanus* conforms closely to the ordinary angiosperms, except for the vertical division in the upper sporogenous cell, and differs from *Peperomia* and *Gunnera* in the formation of three cells which may be interpreted as megaspores, instead of having the sporogenous cell develop directly into the embryo-sac without preliminary division.

Unfortunately no nuclear divisions were found, although these were carefully looked for, and this was true also for the later stages in the development of the sac. This was perhaps due to the fact that the material was all collected at about the same time of the day. The collectors brought the material in usually at about eight o'clock in the morning, and apparently the nuclear divisions occur at some other period of the day.

It is probable, as in other forms that have been critically studied, that the first reduction division occurs when the spore mother-cell first divides.

The youngest stage met with in *P. Artocarpus* is shown in FIGURE 6. The young embryo-sac is easily recognizable, the cytoplasm being noticeably more densely granular than that of the adjoining cells of the nucellus, and the nucleus is somewhat larger. The nucleolus in this case lay in the cytoplasm near the nucleus, but this was doubtless the result of the nucleus having been sectioned and the nucleolus accidentally displaced in mounting the section. At this stage the embryo-sac had enlarged very little, being only slightly broader than the sister-cell above it, which in this instance was rather larger than usual, although there is a good deal of difference in different cases in this particular. FIGURE 4 shows a slightly more advanced stage. The upper sporogenous cell is smaller and the nucleus less conspicuous than usual. The appearance of the transverse division in the upper cell is probably due to a shrinkage of the protoplasm, and this probably also accounts for the very small and poorly defined nucleus. The cytoplasm of the young embryo-sac is vacuolate, and the conspicuous nucleus with its single nucleolus occupies the center of the cell. A slightly older stage is shown in FIGURE 5. The vacuoles have become more numerous but less definite and the nucleus is noticeably larger. The sister-cell has divided longitudinally instead of transversely as is the case in most angiosperms. While this longitudinal division is rather unusual, it has been observed in a number of other forms, both in monocotyledons and dicotyledons.*

The young embryo-sac rapidly increases in size and the nucleus divides, one of the daughter nuclei moving to the upper end of the sac, the other to the chalazal end. The two nuclei are quite similar in appearance (FIG. 8), and the cytoplasm still occupies the whole cavity of the sac, although there are numerous large vacuoles. The large vacuoles in the center of the sac finally unite, and by the time the second mitosis is complete (FIG. 9) a single large vacuole occupies the greater part of the sac and the cytoplasm is mainly confined to the ends of the sac, there being only a thin layer lining the lateral walls.

Up to this point *Pandanus* agrees exactly with the typical angiosperms, but the subsequent history of the embryo-sac is decidedly different. The two nuclei at the micropylar end of the sac undergo no further division, and in the oldest stages that were found, two nuclei only, unchanged except for an increase in size,

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* COULTER, J. M., & CHAMBERLAIN, C. J. Morphology of angiosperms, pages 75, 76. 1903.

were invariably present. The history of the chalazal nuclei is different. FIGURE 10 shows a stage with four chalazal nuclei, of which three appear in the section shown. The cytoplasm has increased noticeably in amount, and this becomes still more marked in the later stages. Owing to the failure to secure division stages, the sequence of nuclear divisions by which the number of the chalazal nuclei is increased cannot be determined. Several cases, one of which is shown in FIGURE 11, show six chalazal nuclei, but whether there is any rule as to which of the four nuclei of the preceding stage divide and which remain undivided must for the present remain in doubt, and the same is true of the subsequent division by which the number of chalazal nuclei increases to eight and finally to twelve. There seem to be regularly twelve chalazal nuclei in the older stages, although it is possible that in some cases there may be only ten.

There is more or less variation in the form of the lower end of the embryo-sac. It is sometimes pointed (FIGS. 9, 12), or it may be broad and rounded. Not infrequently one or more of the cells of the nucellus push up into it, so that the lower end of the sac is divided into short, sac-like extensions (FIG. 11, *a*).

In the most advanced stages that were secured, the embryo-sac had increased materially in size. At the micropylar end, which is narrower than the chalazal end, there are two nuclei, while at the chalazal end there are twelve nuclei embedded in a large mass of densely granular cytoplasm containing several conspicuous vacuoles (FIGS. 14–16). A similar but smaller mass of cytoplasmic material occupies the micropylar end, and the large central vacuole is bounded laterally by a rather thick layer of cytoplasm, which, however, contains no nuclei. In most cases observed there was no apparent differentiation of the micropylar cytoplasm, but in a very few instances, the most conspicuous of which is shown in FIGURE 14, there was a slight indication of what looked like the separation of an egg-cell and synergid, but this was very vague, and the limits of the egg, if such it was, were very poorly defined. At this stage, the two cells lying above the embryo-sac are still visible, but are evidently disintegrating.

Corresponding to the enlargement of the embryo-sac is a marked increase in the size of the nuclei, which at the same time show a distinct reticulum, while in the younger sac the contents of the nucleus appear more compact and uniformly granular. The nucleolus also increases much in size and becomes very conspicuous. In *P. Artocarpus* the increase in size is more marked in the chalazal nuclei than in the micropylar ones, which are noticeably smaller. In the most advanced stages the arrangement of the nuclei is very similar to that in *Peperomia hispidula* described by Johnson, except that there are fourteen instead of twelve chalazal nuclei in the latter, and these ultimately fuse into one enormous endosperm nucleus. No indications of any nuclear fusions were met with in any of the embryo-sacs of *Pandanus*, and the final history of these large chalazal nuclei must for the present remain undecided.

Pandanus odoratissimus was also examined for comparison with *P. Artocarpus*, from which it was found to differ only in some minor particulars. This species has very large fruits with the carpels united into groups, forming more or less complete compound pistils, but the union of the carpels is a very loose one. The upper part of the carpels soon becomes very hard and woody, but the base remains succulent for some time and is easily sectioned. The inflorescences from which the preparations were made were about 6 centimeters in diameter, and it was supposed that these carpels had already been fertilized. It was therefore hoped that the later stages of the sac would be obtained, but examination showed that in spite of the large size of the carpels, which were nearly 2 centimeters in length, the ovules were little further advanced and not noticeably larger than those in the apparently much younger and smaller flowers of *P. Artocarpus*. An examination of the stigma showed the presence of pollen-spores, some of which were still ungerminated, while others had emitted the pollen-tubes. None of the ovules that were examined, however, showed the presence of the pollen-tube, and the question must still remain open whether the sac undergoes any further changes before the actual fertilization occurs. In *P. odoratissimus* the two micropylar nuclei are quite as large as those of the chalazal region (FIG. 21), and the largest sac found in this species was slightly larger than that of apparently the same age in *P. Artocarpus*. In *P. odoratissimus* a few nuclei were seen which contained two nucleoli, and one of these nuclei looked as if it possibly might have been the result of the fusion of two.

Owing to the similarity in the appearance of the nuclei of the nucellus-cells adjacent to the young embryo-sac and those of the sac itself, the former may sometimes be mistaken for those belonging to the embryo-sac, but in the later stages the much greater size of the embryo-sac nuclei makes it very easy to recognize them. However, a structure is occasionally met with that is at present not quite clear. There is sometimes found a small cell (FIGS. 13, 15, *y*) apparently cut off from the side of the embryo-sac, recalling the small cells of similar appearance cut off from the sac in *Peperomia*. The contents of these cells are densely granular like those of the embryo-sac, but the nuclei are usually small, and I am inclined to believe at present that these cells really belong to the nucellus and have pushed into the cavity of the embryo-sac somewhat in the same fashion as those already mentioned as sometimes pushing up from below. The occasional occurrence of a small nucleus apparently free in the cytoplasm of the sac, and differing in appearance from the other nuclei, suggests that possibly the wall of this intruding cell may have become resorbed, discharging the nucleus into the embryo-sac. These points cannot be settled, however, until the history of the nuclear division is known.

All of the cells surrounding the embryo-sac differ more or less from the outer nucellar tissue, having more watery contents and sometimes rather larger nuclei. They are probably concerned to some degree with the nutrition of the embryo-sac, and sometimes this central mass of tissue suggests a mass of sporogenous cells; and it is not impossible that it really may represent a mass of sporogenous tissue of which only one cell gives rise to the spores.

Various attempts have been made to explain, as modifications of the ordinary angiospermous embryo-sac, the peculiar conditions found in *Peperomia* and the other forms with a double number of nuclei. Johnson and Brown both believe that the embryo-sac in *Peperomia* represents four megaspores and not a single one; and Coulter * in a recent paper maintains that the embryo-sac

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* COULTER, J. M. Relation of megaspores to embryo-sacs in angiosperms. Bot. Gaz. 45: 361–366. 1908.

mother-cell in all cases where there is no previous division is to be regarded not as a single megaspore, but as an aggregate of four. He thinks that the nature of the reduction division which precedes the formation of the embryo-sac necessarily involves the production of four megaspores, or at least of four nuclei which represent them. It undoubtedly is true that so far as we know at present the reduction division cannot be omitted where fertilization is to occur, but as Brown has pointed out, it does not follow that the presence of the heterotypic division in a cell in the nucellus is alone sufficient ground for holding that such a cell is necessarily a megaspore mother-cell, inasmuch as the reduction division may occur at various points in the life history of a plant. He further points out the well-known fact that all stages of reduction in the sporogenous tissue may be traced from the ferns, where a single archesporeal cell gives rise to a mass of tapetal cells and sporogenous tissue, to such angiosperms as *Lilium*, where the sporogenous cell at once forms a single megaspore. He says, "It does not seem reasonable to suppose that the division of the mother-cell into four megaspores may not also be left out and the mother-cell function directly as a megaspore. In this case the heterotypic division might be pushed forward and take place in the embryo-sac." The fact that the embryo-sac is actually, if not theoretically, part of the sporophytic structure, and the extensive reduction of the sporogenous tissue in the cells of the angiosperms in general make it somewhat rash to assume that the limits between sporophyte and gametophyte are as sharply drawn as they are in the pteridophytes.

Brown bases his opinion that the four nuclei in the young embryo-sac of *Peperomia* represent separate megaspores, upon the fact that in the two first nuclear divisions in *P. Sintenisii* transverse cell walls are formed, and in *P. pellucida* cell plates accompany the two first nuclear divisions. In the third division which results in the eight-nucleate stage, cell plates are wanting. But, as in the last division, by which the sixteen-nucleate stage arises, cell plates are formed, and, in the case of certain of the nuclei, cell walls also, this seems rather inadequate grounds for assuming that the embryo-sac represents four spores instead of a single one.

While the single megaspore in *Peperomia* and other similar forms cannot probably be considered a primitive condition, this does not imply that the embryo-sac structures themselves may not be primitive in character. It is a significant fact that in the great majority of angiosperms the structures of the embryo-sac are not in the least affected by the number of divisions in the sporogenous tissue that precede the formation of the embyro-sac. The great variability in this respect shown by plants of near affinity, as in the often cited case of the Liliaceae, indicates that this is a matter of secondary importance. It certainly seems hardly likely that a structure made up of four megaspores should behave exactly like one derived from the germination of a single spore, and the generally accepted view that in such cases as *Peperomia* and *Lilium* the embryo-sac is a single megaspore formed without previous division from the mother-cell can hardly be admitted to have been disproved by these recent speculations. If we admit Coulter's views as to the compound nature of the embryo-sac of *Lilium*, we have still to explain why in *Peperomia*, where the course of development up to the beginning of the division of the embryo-sac is precisely the same as that of *Lilium*, there should later be such an extraordinary departure from the usual angiospermous type. And if the sixteen-nucleate embryo-sac of *Peperomia* is derived from the eight-nucleate one of a form like *Heckeria*, it remains to be explained why there are sixteen nuclei instead of eight, and why the subsequent history is so different. In the Liliaceae, where there is an entirely analogous condition of things, the structure of the mature embryo-sac is not in the least influenced by the fact that in some cases there is a division of the mother-cell and in other cases the division is suppressed, and it is hard to see why, in the case of *Peperomia*, the development of the embryo-sac directly without preliminary division should result in such remarkably different structures, unless we admit that the sixteen-nucleate stage is an earlier type of embryo-sac which has persisted in a few existing genera like *Peperomia* and *Gunnera*.

In *Gunnera macrophylla*, Ernst found the early development of the embryo-sac to be very much like that of *Peperomia*, but there was later developed a definite egg-apparatus of the normal type and a group of conspicuous antipodal cells. In *G. Hamiltonii*, according to Schnegg, these structures are much less evident. Ernst believes that the single sporogenous cell in *Peperomia* and *Gunnera* is less primitive than the four cells found in so many angiosperms, but he does not believe that this suppression of the divisions is in any way associated with the peculiar characters of the embryo-sac itself. He thinks that the sixteen-nucleate embryo-sac should be recognized as an independent type not in any way derived from the ordinary eight-nucleate sac, and this we believe will really prove to be the case. Whether the ordinary eight-nucleate type has been derived from this sixteen-nucleate form may be questioned; but the condition in *Gunnera macrophylla*, which is almost intermediate in character between *Peperomia* and the ordinary angiospermous type, makes this not at all improbable. I believe we are justified in assuming that the condition in *Gunnera macrophylla* really does represent a condition nearly intermediate between the very primitive condition found in *Peperomia* and the familar eight-nucleate sac of the typical angiosperms. The recent announcement of still another sixteen-nucleate sac in the Penaeaceae may be referred to again in this connection.

The peculiar embryo-sac of *Pandanus* cannot be explained on the theory of reduction from the typical eight-nucleate form. The embryo-sac in this case is one of three sporogenous cells, and even if we admit that it is composed of two megaspores, in one of these the nuclei are twelve in number instead of eight, while the other has only two. Of the forms hitherto described, *Peperomia hispidula* most nearly resembles *Pandanus* in the arrangement of the nuclei in the embryo-sac.

SUMMARY OF RESULTS

1. The pistillate flower of *Pandanus* may consist of a single carpel, or of several loosely united carpels. Each carpel bears a single anatropous ovule.

2. The primary sporogenous cell is separated from the epidermis of the nucellus by several layers of parietal or tapetal cells, which are presumably derived from the division of a single tapetal cell.

3. The primary sporogenous cell divides transversely into two cells, of which the lower, and larger one, gives rise at once to the embryo-sac; the upper cell divides by an anticlinal wall again into two equal cells.

4. The first division in the embryo-sac results in two similar nuclei which occupy the poles of the sac.

5. The micropylar nucleus divides but once; usually no trace of a differentiation into egg-cell and synergid can be seen, but occasionally there seems to be a suggestion of such differentiation.

6. The primary chalazal nucleus divides repeatedly until twelve nuclei are formed; but the order of these nuclear divisions could not be determined, and the twelve resulting nuclei look very much alike.

7. The nuclei increase in size as the sac grows, but in no cases were there seen any indications of nuclear fusions. In the most advanced stages that were secured, all of the fourteen nuclei were quite separate.

8. In *P. Artocarpus* the two micropylar nuclei are somewhat smaller than the chalazal nuclei; in *P. odoratissimus* they are equal in size; otherwise the two species agree closely in the structure of the embryo-sac.

CONCLUSION

Until the fertilization stages can be examined, it will not be possible to state positively that the fourteen-nucleate stage really represents the condition of the sac at the time of fertilization, and the further history must be left for future investigation. Whether these investigations will reveal in the post-fertilization stages conditions approximating those in *Sparganium*, which in its floral structure resembles *Pandanus*, remains to be seen. *Sparganium* in the early development of the embryo-sac follows the usual course of development, and it is not until later that there occurs the extraordinary development of the antipodal cells. To judge from the conditions of the sac in the oldest stages that were met with, *Pandanus* differs very much from the typical angiosperms, and has its nearest analogue in *Peperomia hispidula*. The increased number of nuclei is evidently perfectly normal, and can hardly have been derived from the ordinary eight-nucleate type, nor can it be explained as a case of fusion of four megaspores, since only one of the megaspore divisions is suppressed. Probably the two micropylar nuclei represent a primitive egg-apparatus consisting of the egg and a single synergid, but what relation, if any, the twelve chalazal nuclei bear to the antipodal and polar nuclei of the ordinary embryo-sac it is useless to conjecture until the further history is known. For the present the embryo-sac of *Pandanus* must be assumed to represent a new type with its nearest analogue in *Peperomia*, from which it differs in its marked polarity in its early stages, and the apparent absence of any nuclear fusions, as well as in the fact that there are only fourteen instead of sixteen free nuclei. It probably represents a less specialized and more ancient type of sac than the typical eight-nucleate one.

The recent work of Porsch on the embryo-sac has not been seen by the writer, and so it will not be possible to discuss here the views of that writer as to the homologies of the parts of the embryo-sac. From the references to his work by other investigators, it seems that he regards the egg-apparatus and antipodal cells of the ordinary embryo-sac as representing two archegonia. The condition of things in *Pandanus* would certainly lend no support to such a view. The accumulating discoveries of plants in which the double, or approximately double number of nuclei is normally present in the embryo-sac, makes it more and more likely that, as Ernst maintains, this really is a distinct type of sac not derived from the eight-nucleate one, but an independent and presumably more primitive type. It is to be expected that further researches will add to the number of these sixteen-nucleate sacs and may throw more light upon the characteristic eight-nucleate sac which distinguishes the great majority of angiosperms.

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Explanation of plates 16 and 17

PLATE 16

FIG. 3 refers to *Pandanus affinis* Kurz, the others all refer to *P. Artocarpus* Griff. Except Figs. 1, 2, the drawings were all made with a Leitz $\frac{1}{16}$ oil immersion, oc. 1. The drawings are reduced about one fourth in the reproduction.

FIG. 1. A single pistillate flower of *Pandanus Artocarpus*, × 4½; *o*, the ovule.

FIG. 2. Section of a young ovule, × about 40; *m*, the embryo-sac.

FIG. 3. Longitudinal section of the nucellus of a very young ovule of *P. affinis*; the sporogenous cell is still undivided; the nuclei of the parietal cells are shown.

FIG. 4. Young embryo-sac, *m*, and the sister-cell, *x*.

FIG. 5. Upper part of the nucellus showing the young embryo-sac, *m*, the sister-cells, *x*, and the parietal cells lying above.

FIG. 6. A somewhat younger stage than the last; only a single row of parietal cells.

FIG. 7. A somewhat older stage; the embryo-sac contains two nuclei, only one of which shows in the section.

FIG. 8. Embryo-sac with two nuclei; only one of the sister-cells, *x*, shows in the section.

FIG. 9. Embryo-sac with four nuclei; only one of the micropylar nuclei is seen in the figure.

FIG. 10. Embryo-sac with two micropylar and four chalazal nuclei.

PLATE 17

FIGS. 17–21 refer to *Pandanus odoratissimus* L., the others to *P. Artocarpus;* all figures drawn with Leitz $\frac{1}{16}$ oil-immersion, oc. 1. Reduced one fourth in reproduction.

FIG. 11. Embryo-sac having six chalazal nuclei, four of which are shown in *a*; one of the nucellar cells has pushed up into the base of the embyro-sac; *b*, the micropylar end of the same sac, showing the two cells, *x*, above the sac.

FIG. 12. *a*. Micropylar end of an embryo-sac with eight chalazal nuclei; the remains of the two sterile "megaspores" are seen above the sac. *b*. Chalazal end of the same.

FIG. 13. Transverse section of the chalazal region of an embryo-sac with 8 chalazal nuclei. The small cell, *y*, probably belongs to the nucellus.

FIG. 14. Upper end of an embryo-sac in which there was an apparent slight differentiation into a synergid (?), *s*, and an egg-cell (?), *o*; one of the chalazal nuclei is seen.

FIG. 15. Chalazal end of the same sac; there were probably 12 chalazal nuclei; the small cell, *y*, probably belongs to the nucellus.

FIG. 16. Chalazal end of one of the largest sacs that was found — 12 chalazal nuclei were present.

FIG. 17. Apex of the nucellus of a young ovule of *P. odoratissimus;* the embryo-sac had four nuclei.

FIG. 18. Micropylar end of the sac shown in Fig. 17; one of the two nuclei is shown.

FIG. 19. Mature (?) embryo-sac showing one of the two micropylar nuclei, and three of the twelve chalazal ones.

FIG. 20. Transverse section showing six of the twelve chalazal nuclei.

FIG. 21. The two micropylar nuclei from the same sac.

The power of growth exhibited by ostrich ferns

GEORGE E. STONE

The power of growth exerted by plants is frequently so great that the work accomplished in some cases seems almost incredible. It is the purpose of this paper to give the results of some observations made by the writer relating to the power of growth in plants.

The writer has had for many years a number of ostrich ferns (*Onoclea Struthiopteris* Hoffm.) growing about his residence, where he has had an opportunity to observe them daily. These ferns have received the best of care and many of them have attained a very large size. Previous to planting them the beds in which they are growing were dug out to a depth of a few feet and filled with soil most suitable for their luxuriant development. Some of these beds are located close to the house, which has a border of tar concrete varying from 2½ to 5 feet in width. The ferns growing close to this border spread profusely and as the beds are rather limited in size the ferns frequently push their rhizomes under the concrete and the young frond stalks force themselves up through it. The concrete is composed of tar and coarse gravel mixed and rolled in the usual way, and has been laid for a number of years. It is from 2½ to 3 inches thick and exceptionally hard, and a heavy stroke from a sledge-hammer makes little or no impression upon it.

The rupturing of the concrete by the young frond shoots occurs almost yearly. Sometimes the concrete is ruptured where it joins the underpinning of the house, and again the ferns come up through the middle of the concrete. This occurs in the spring, when growth is active and when the fronds are unfolding. While those fronds which push themselves up through the concrete are necessarily more backward in unfolding than those not obstructed in their growth, it requires only a week or ten days, as a rule, for them to rupture the concrete, after which time they unfold quite rapidly. In one case, however, it required two years for a certain group of fronds to break through the concrete.

The ease with which this is accomplished and the relative freedom of the fronds from scars and injuries is remarkable when one takes into consideration the solidity of the concrete and the enormous power necessary for rupturing it.

Being interested in this phenomenon, we endeavored to ascertain approximately the power required to accomplish this rupturing; therefore we excavated a portion of the soil under the concrete and arranged a lever in such a manner that force could be applied in practically the same way as was done by the ferns; that is, a round piece of wood was placed on the end of the lever of the same dimensions as the undeveloped cluster of fern fronds. The fulcrum of the lever was 1 foot from the point of contact with the concrete, and weights were placed on the other end of the lever at different distances, as the case required. Our object in this test was to ascertain how long it would take to rupture the concrete and to determine the amount of weight necessary to do this. It was not intended to apply force enough to cause a rupturing of the concrete immediately, or even in a few hours, but to determine how much weight it would require to do this in ten to fifteen days; in other words, the same length of time as was usually required by the ferns to accomplish this. In this way we could obtain some idea of the force exerted by the fern fronds in breaking through the concrete.

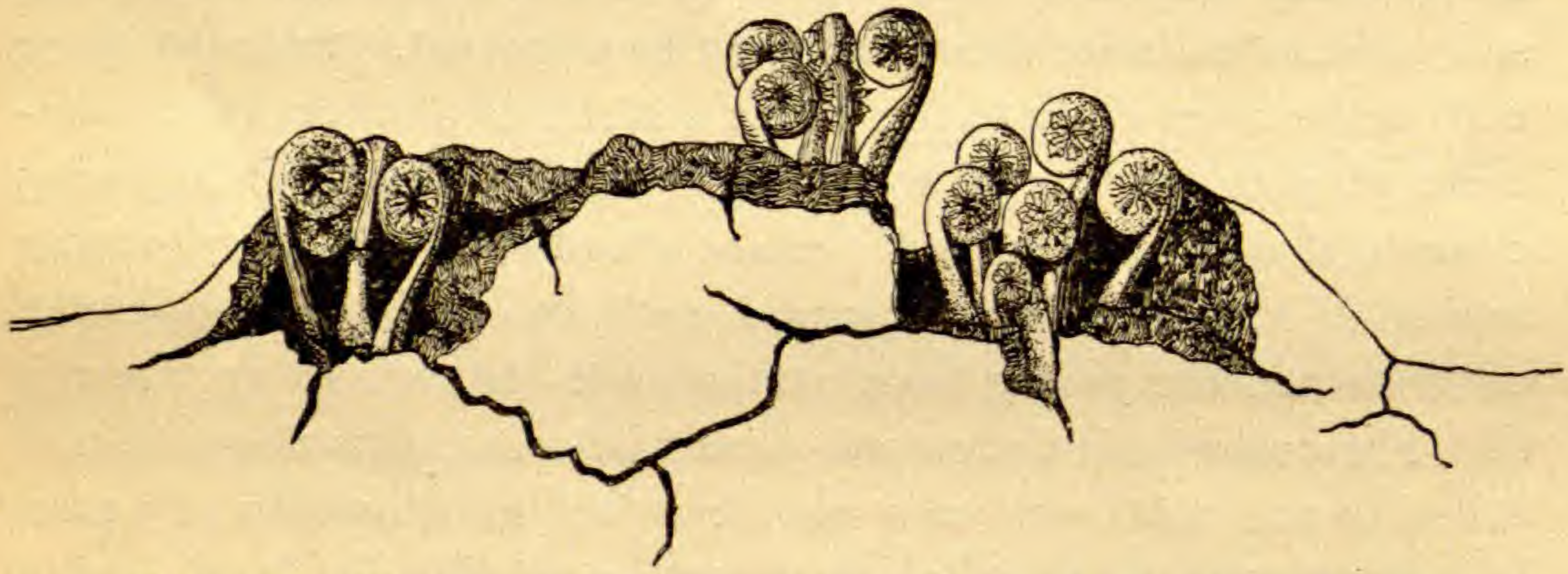

FIGURE 1. The rupturing of concrete by the young fronds of ostrich ferns (*Onoclea Struthiopteris* Hoffm.).

In one test, which we will designate no. 1, where the pressure exerted on the under surface of the concrete was equal to 699 pounds, rupturing occurred in a few hours. In another instance (test no. 2), where a weight of 264 pounds was applied, it required ten days to break through, and in still another (test no. 3) it required thirteen days for a weight of 189 pounds to produce the same effect on the concrete as that caused by the ferns. A few other tests were tried, but those given are typical of the results obtained.

In test no. 1, where a weight of 699 pounds was used and the concrete was ruptured in a few hours, the pressure applied exceeded that exerted by the ferns, and this is probably also true of test no. 2, in which a weight of 264 pounds was used, although in some instances this might not exceed the work done by the ferns. The force applied in test no. 3 was very similar, as regards length of time required and the manner of breaking through, to that actually accomplished by the ferns. This test, therefore, represents a fairly good duplication of what actually took place, and represents, at least in our estimation, the amount of force required to accomplish the same results shown by the ferns. If we take into consideration the average cross-section area of the frond shoots, which equals in one instance 39.15 square millimeters, we have, since there were six of these, 234 square millimeters as the total cross-section area of the frond shoots. In this test we found that the weight required was 189 pounds, or about 84,672 grams. This factor divided by the total area of the frond sections, or 234, equals 361 grams to each square millimeter of cross-section surface, or about 35 atmospheres. From the results of the various tests we are led to believe that this calculation is not an overestimate of the work actually accomplished by these ferns. Employing the same data for test no. 2, we would obtain a pressure of 49 atmospheres, which in our estimation, is somewhat in excess of the pressure actually exerted by the ferns. It should be pointed out, however, that tar concrete is much modified by temperature; at the same time the temperature was much higher at the time of the lever experiments than when the rupturing was done by the ferns, which occurred in April and May, while the experiments with the lever were done in May and June. The ferns were observed very closely during the time they were rupturing the concrete. This substance was so hard that after it had been pushed up it was impossible to make any impression upon the ragged edges except by the use of tools. The fern fronds, when pushed through the concrete, were practically unscarred in all cases and were normal in shape. The work was accomplished by a slow and constantly increasing pressure exerted on the under surface of the concrete.

There are many instances on record showing the great power exerted by plants when growth is restricted. It is well known that such restriction acts as a marked stimulus to the osmotic properties of the cells. Pfeffer* and others have measured the power of growth in various plant organisms, and in one instance Pfeffer records a longitudinal pressure equal to 24 atmospheres in the roots of *Zea Mays*, when encased in plaster of Paris. The writer has observed many instances where considerable power has been exerted by plants in overcoming difficulties. He has occasionally observed mushrooms breaking through tar concrete walks near dwellings, in which instance much power was exerted by these most delicately constructed plants. Cases are on record where flagstones have been dislocated by mushrooms which grew under them. We observed also in one instance a large dwelling house with one corner elevated a few inches above the others by the presence of elm roots under the foundation, and the dislocation of sidewalks, curbings, etc., by tree roots is a matter of common observation.

There are innumerable instances seen in mountainous regions where the roots of trees growing among ledges and boulders have moved large masses of rock. The writer has had under observation for many years a black birch tree, one of whose roots is continually elevating a large boulder. This particular tree has been growing in this situation for many years and one of the roots has entered a fissure in the boulder. This crack or fissure is at an angle of about 15 degrees, and where the root passes between the two halves of this boulder its vertical diameter is 4 or 5 inches, while its lateral diameter is 18 or 20 inches or more. Careful measurements of the dimensions of this boulder, together with specific gravity determinations, would indicate that the weight is

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* "Druck und Arbeitsleistung durch wachsende Pflanzen," 1893.

about 18 tons, which is annually being lifted higher and higher by the root situated between the two halves.

The experiments made some years ago by Clark, at the Massachusetts Agricultural College, in harnessing a squash, showed that it was capable of growing and developing under a weight of 5,000 pounds, but from data obtained in this experiment it would appear that there were not more than two or three atmospheres developed in the cells, and hence not remarkable from the point of view of pressure exerted by the cells. The average pressure exerted by ordinary growing cells is from one to three atmospheres, but by resorting to stimulation this pressure may be enormously increased and may even exceed one hundred atmospheres, as in the case of moulds growing in concentrated solutions.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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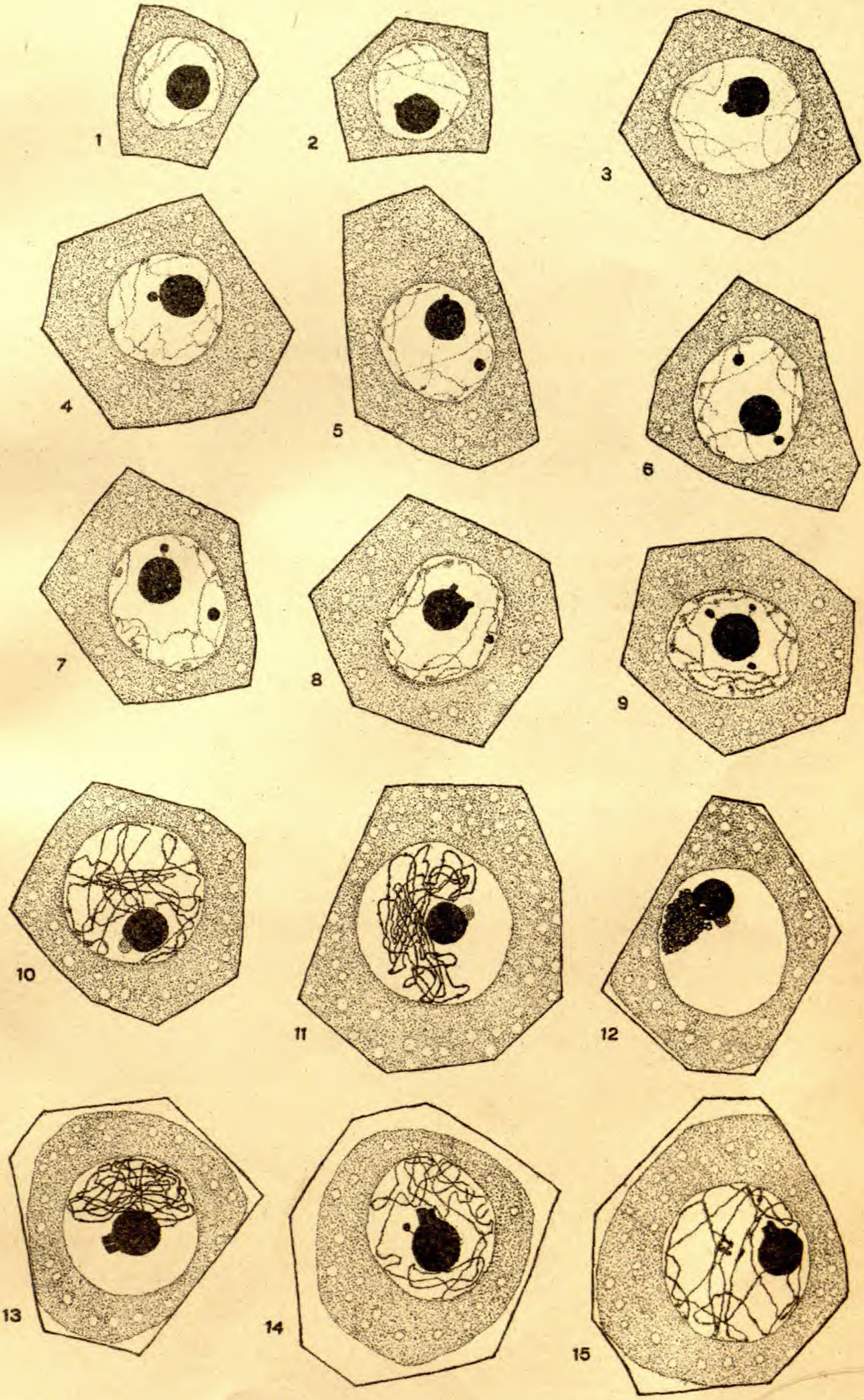

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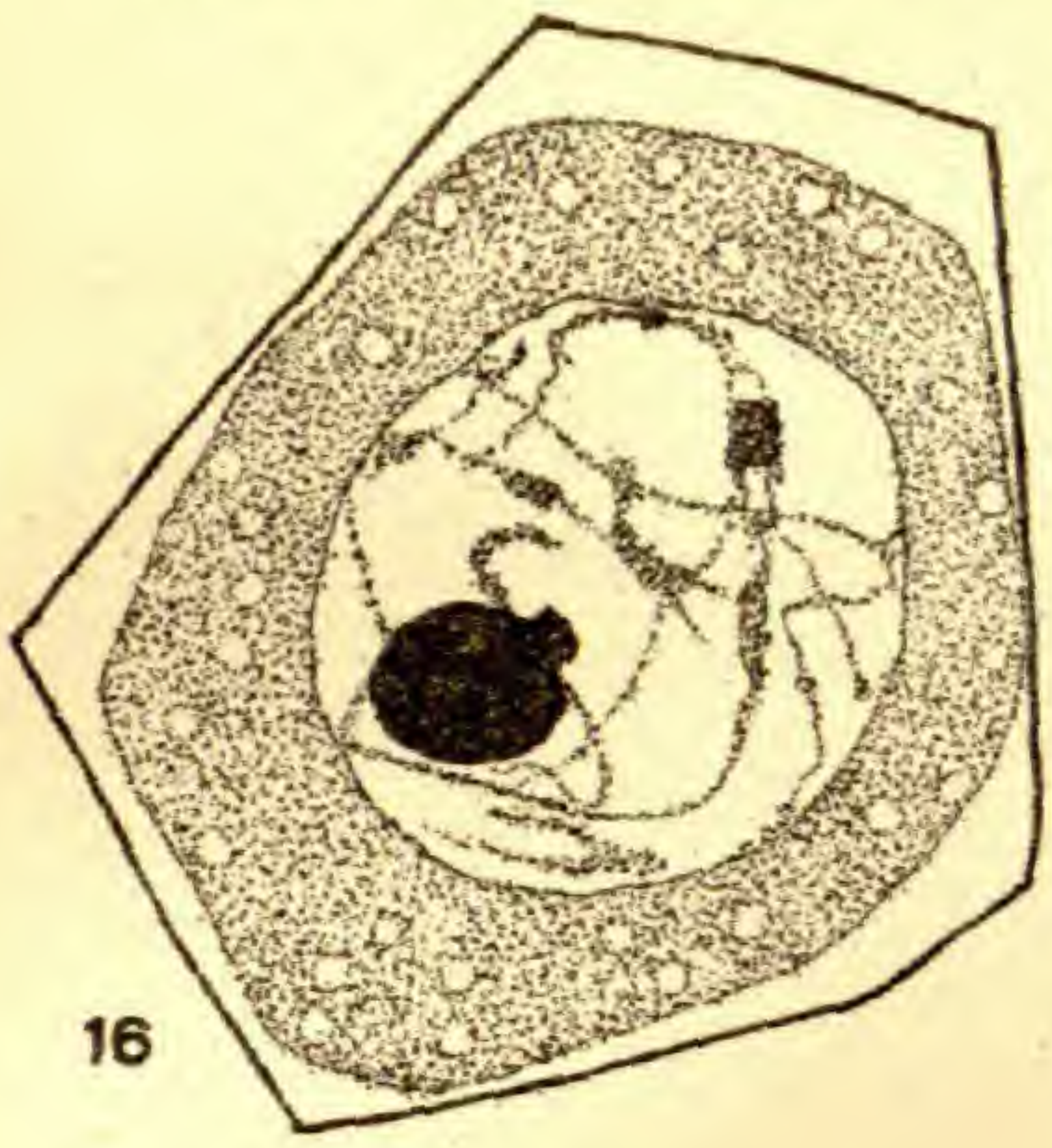
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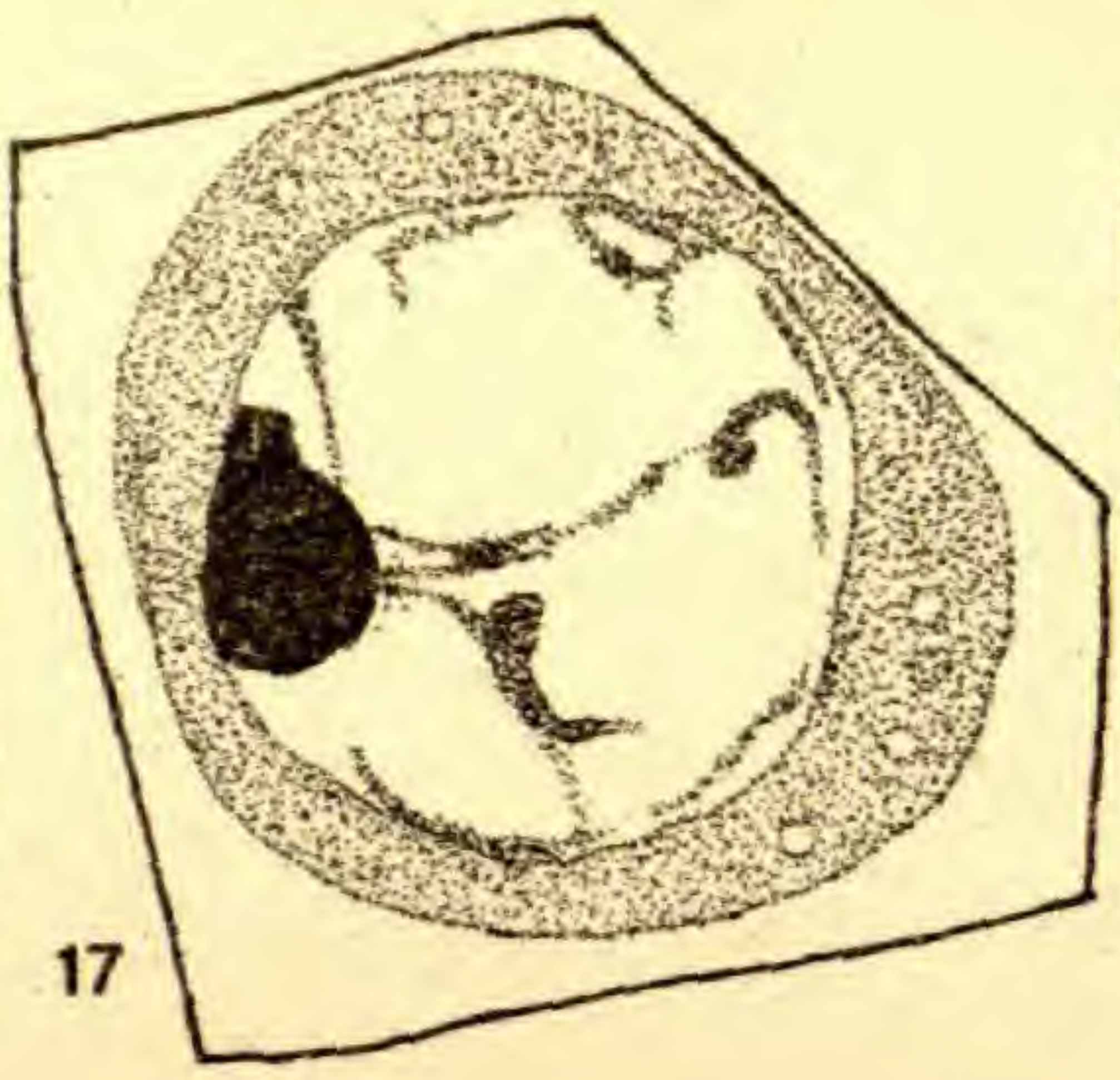
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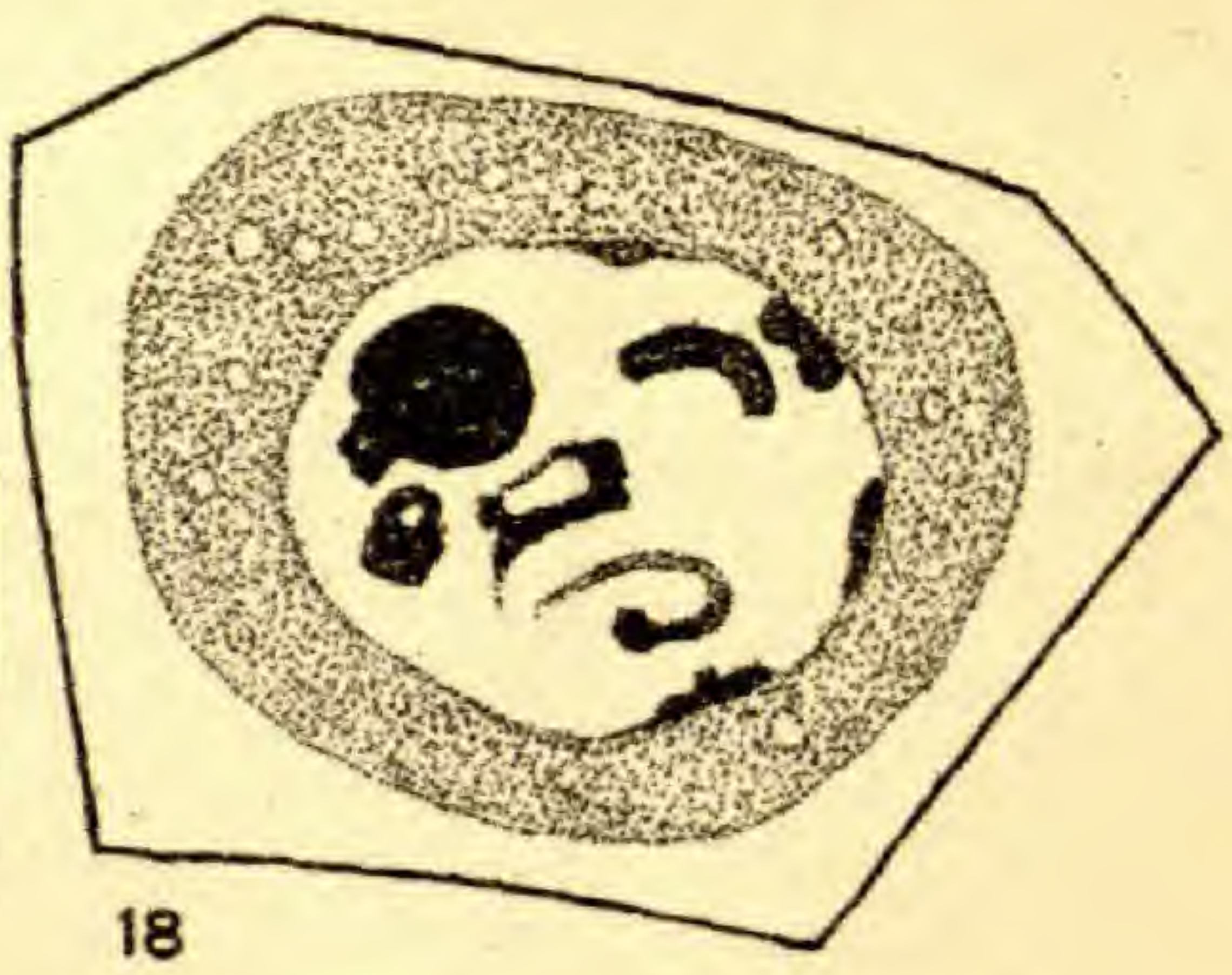
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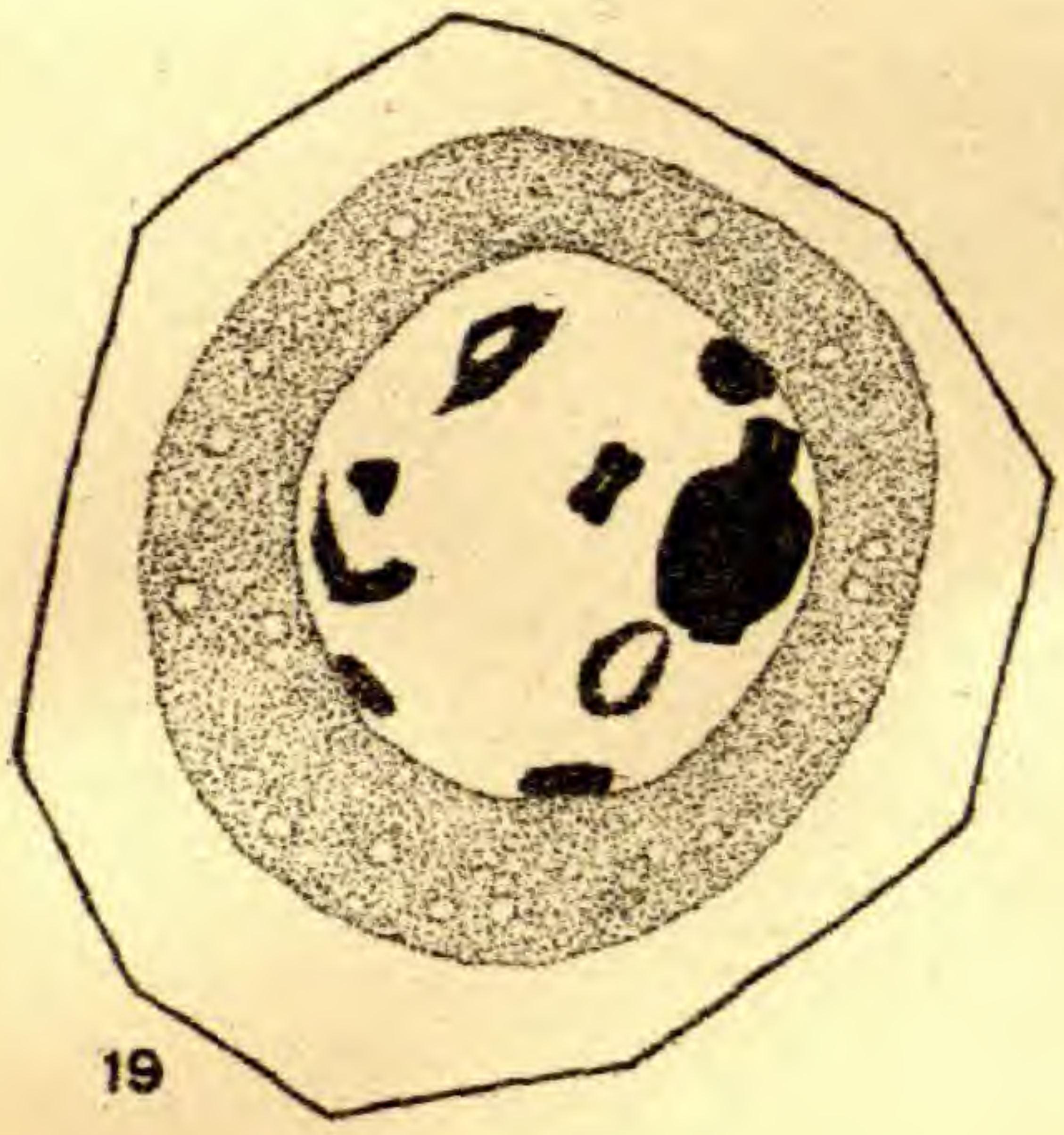
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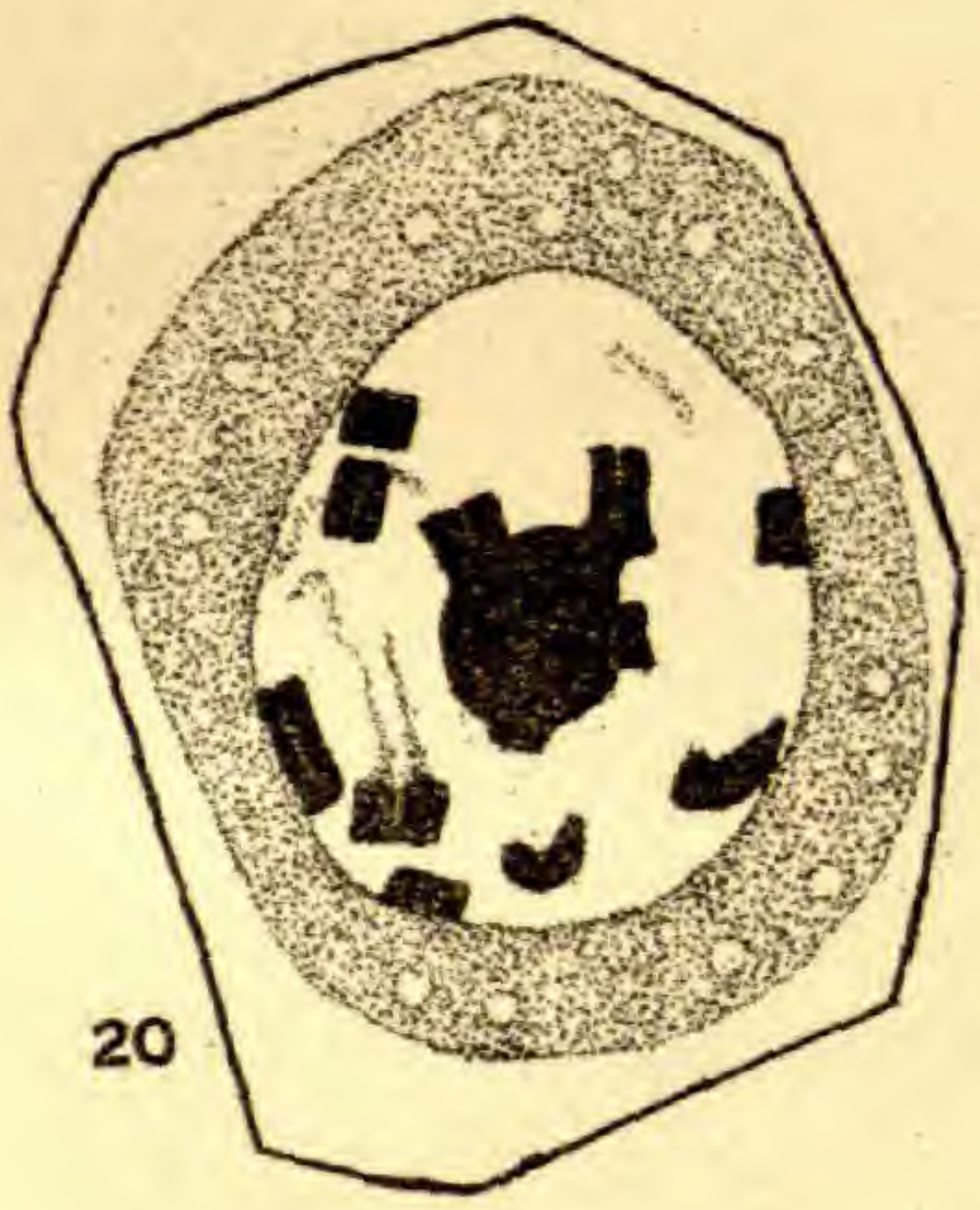
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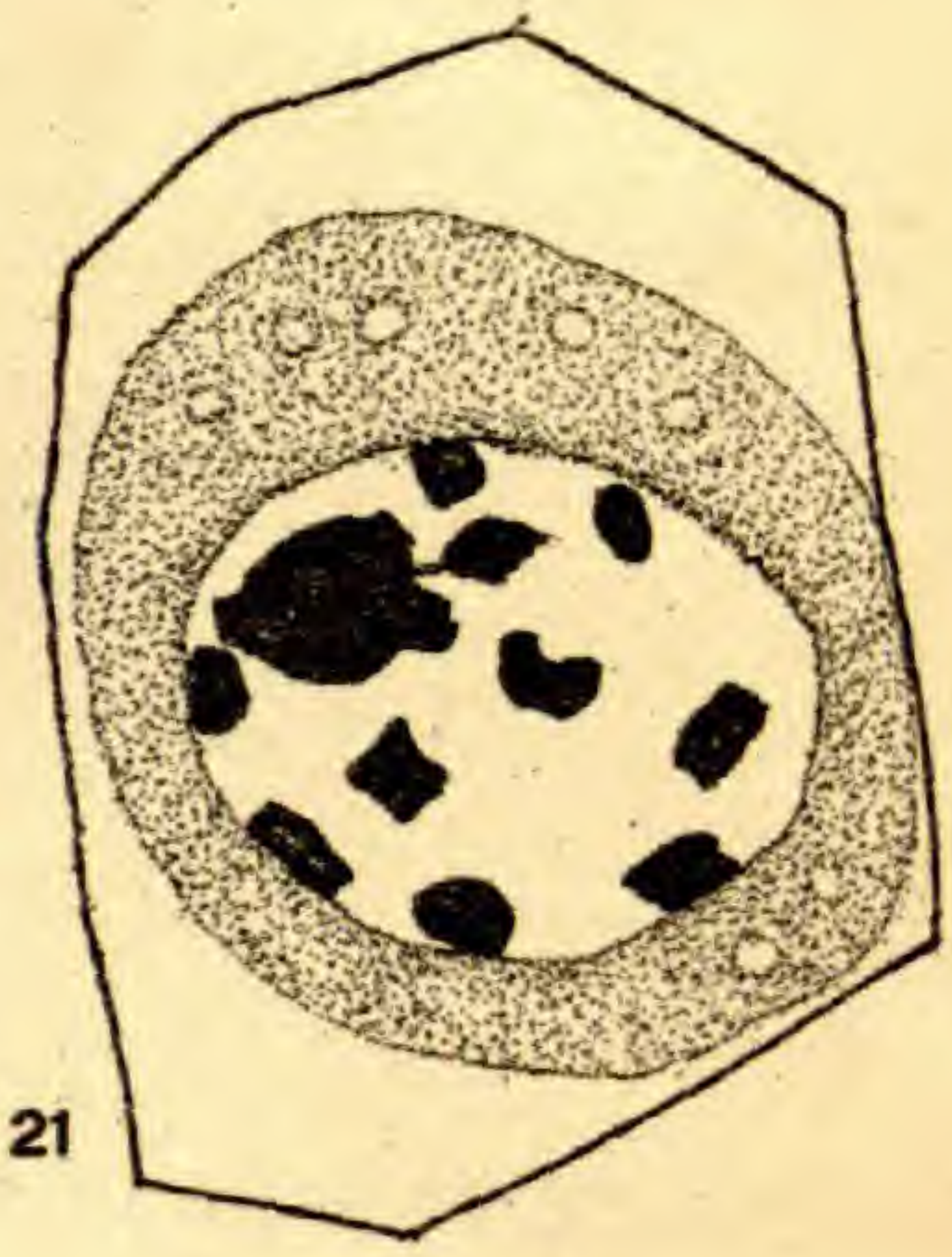
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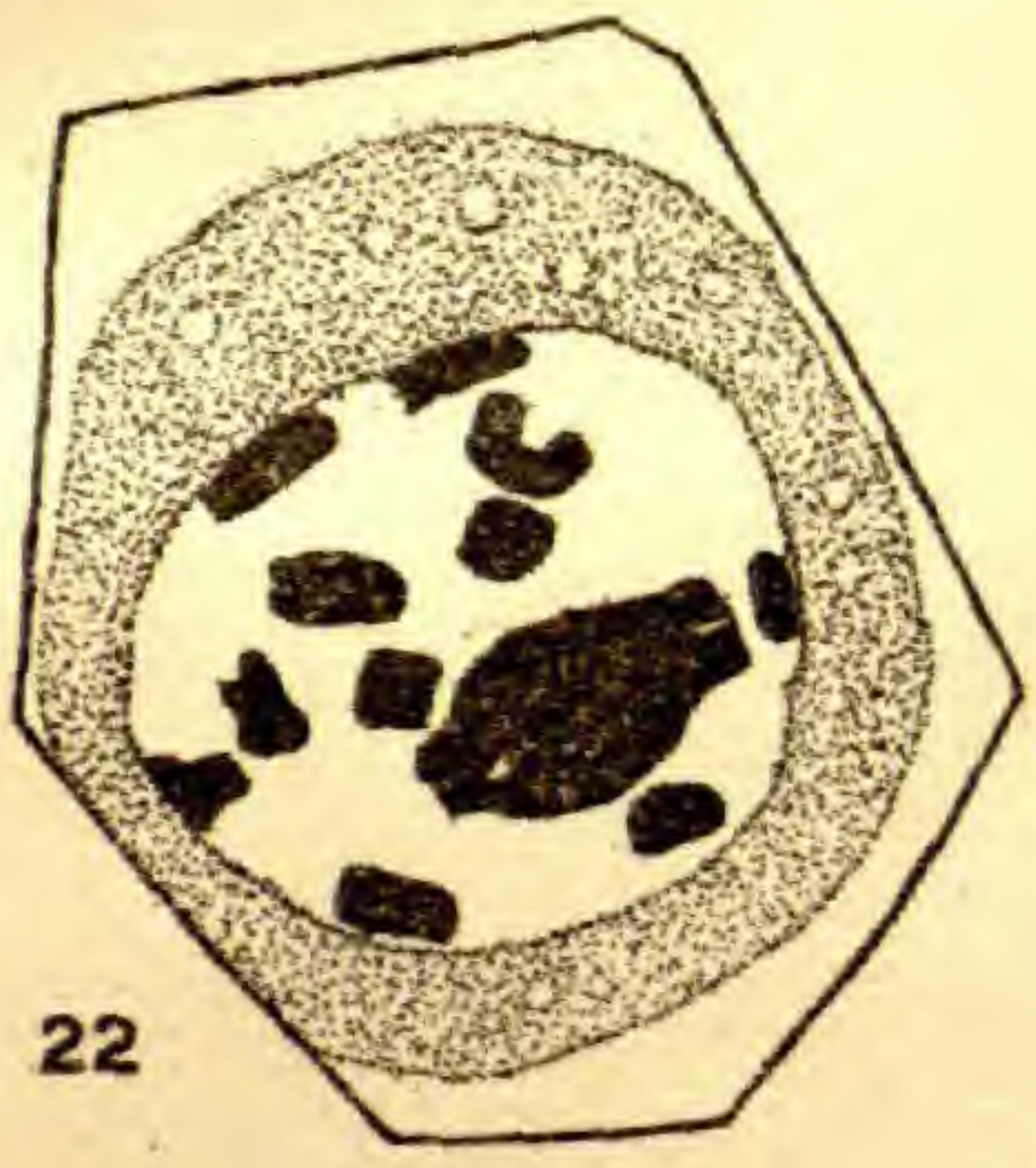
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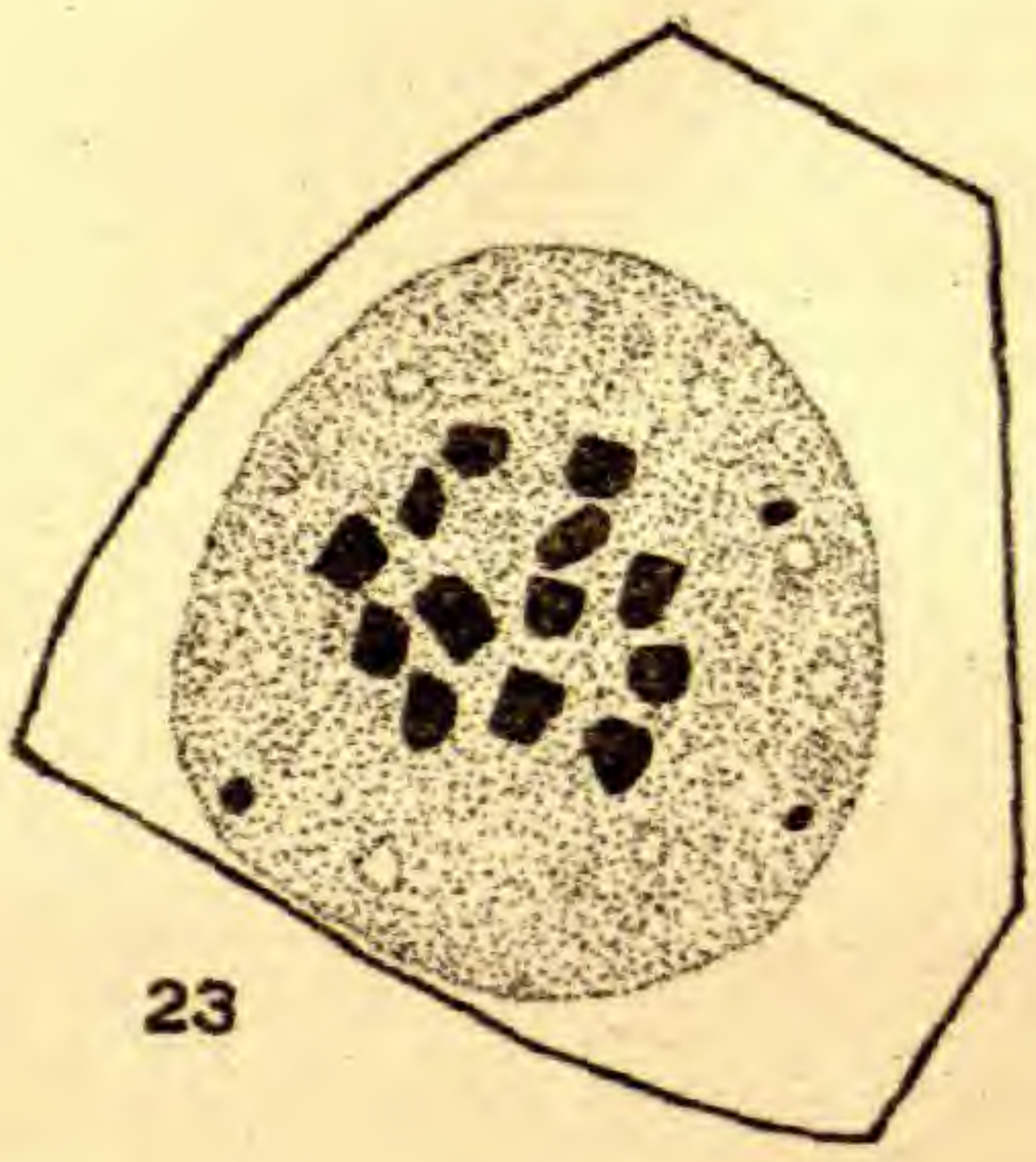
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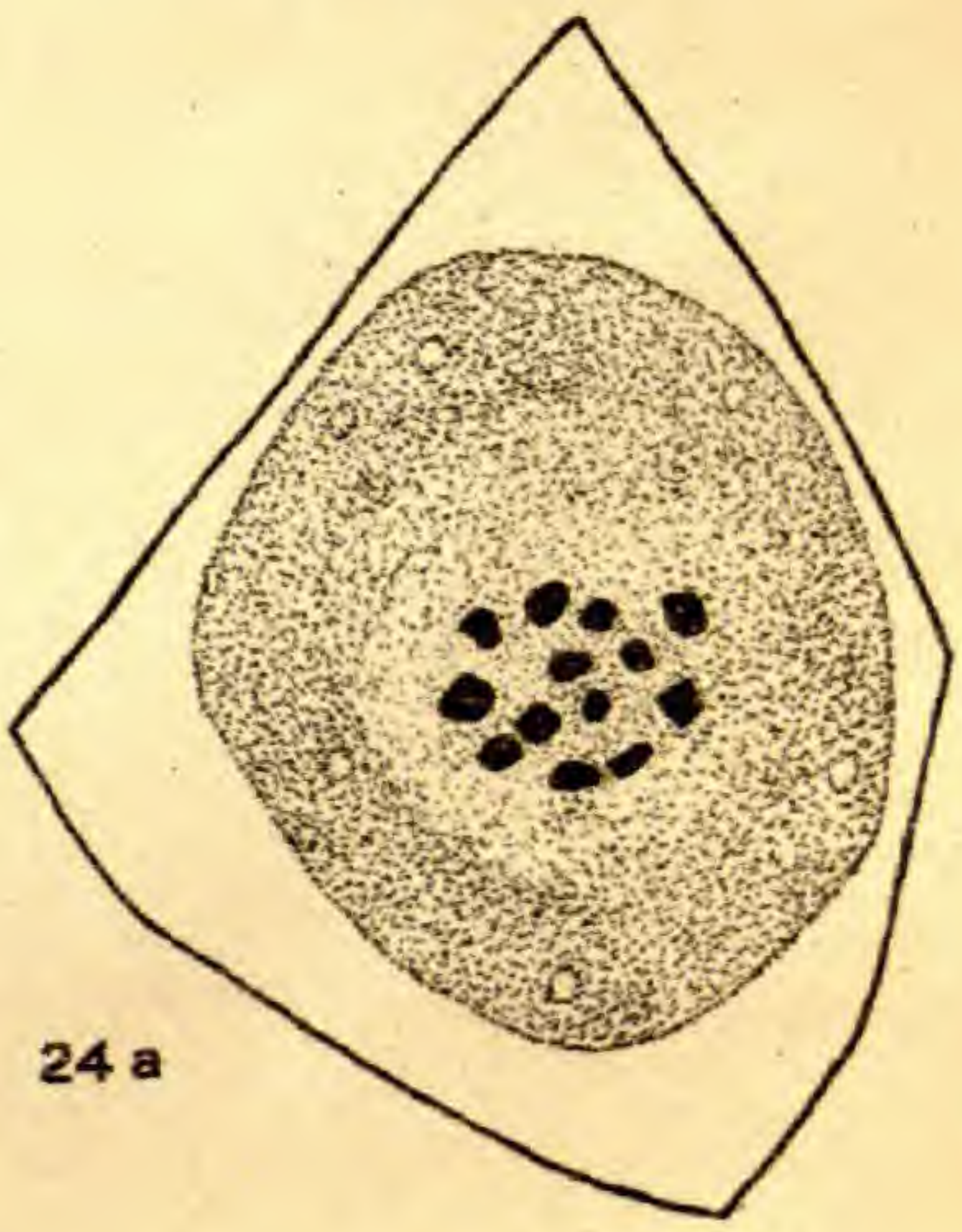
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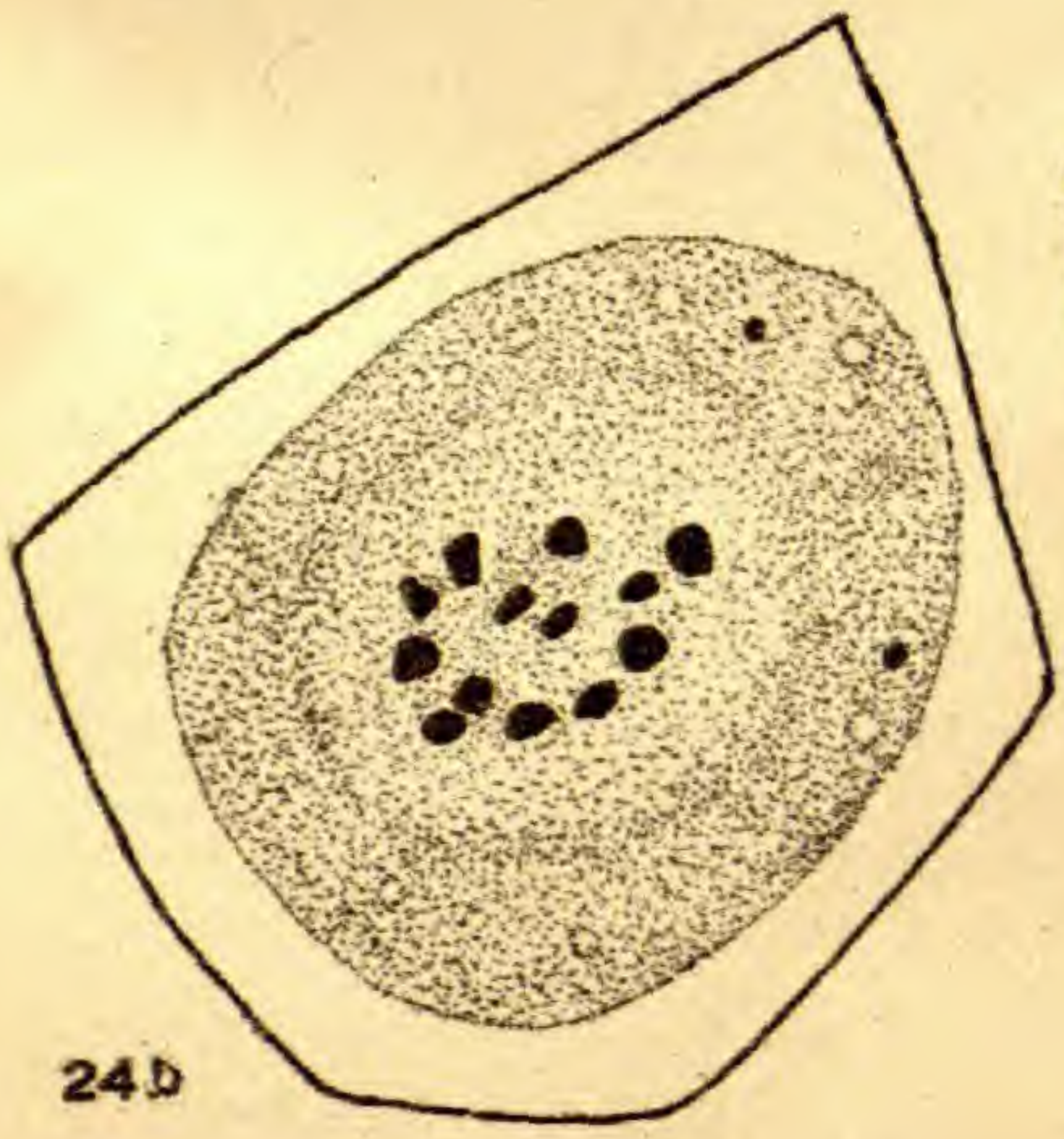
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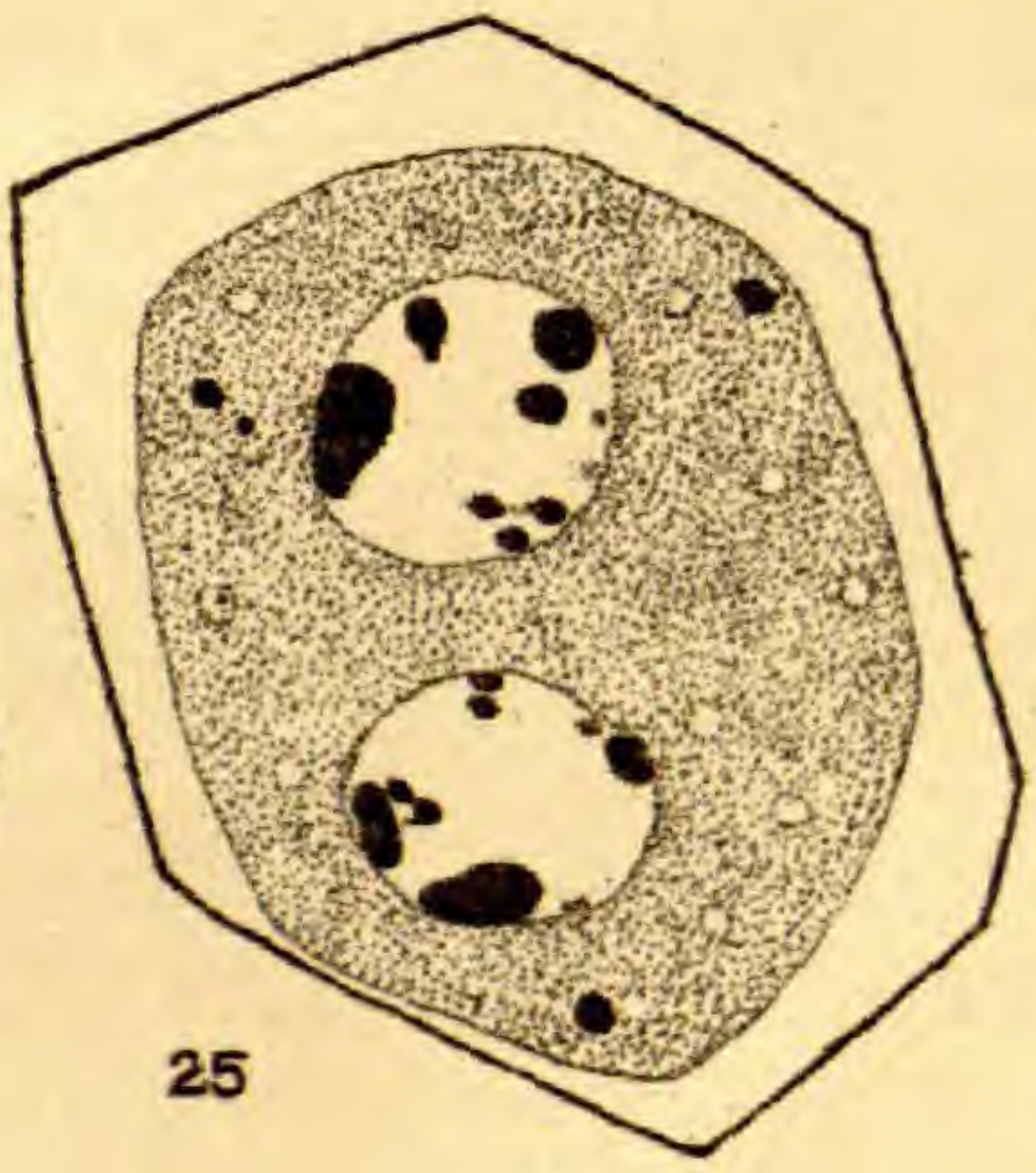
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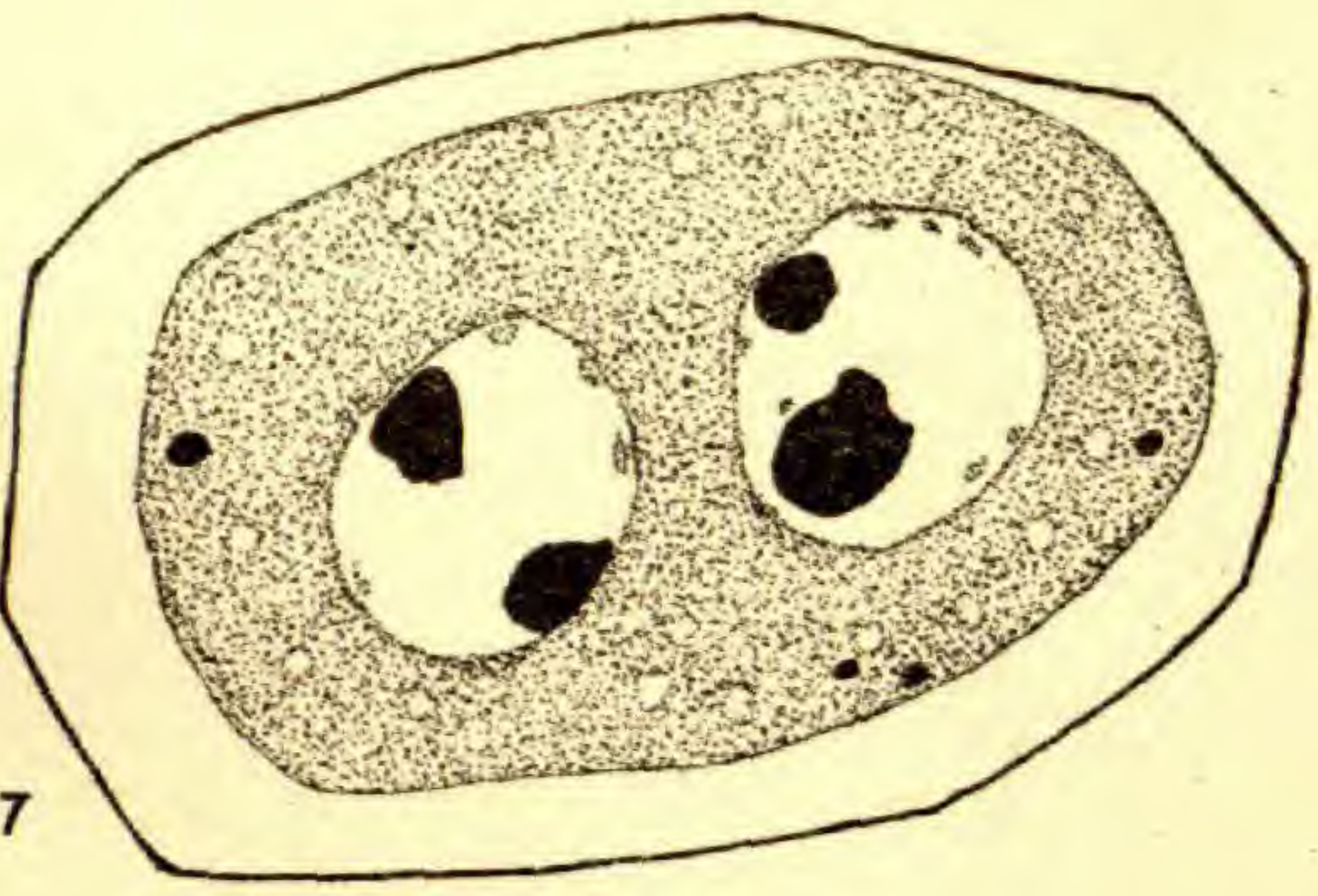

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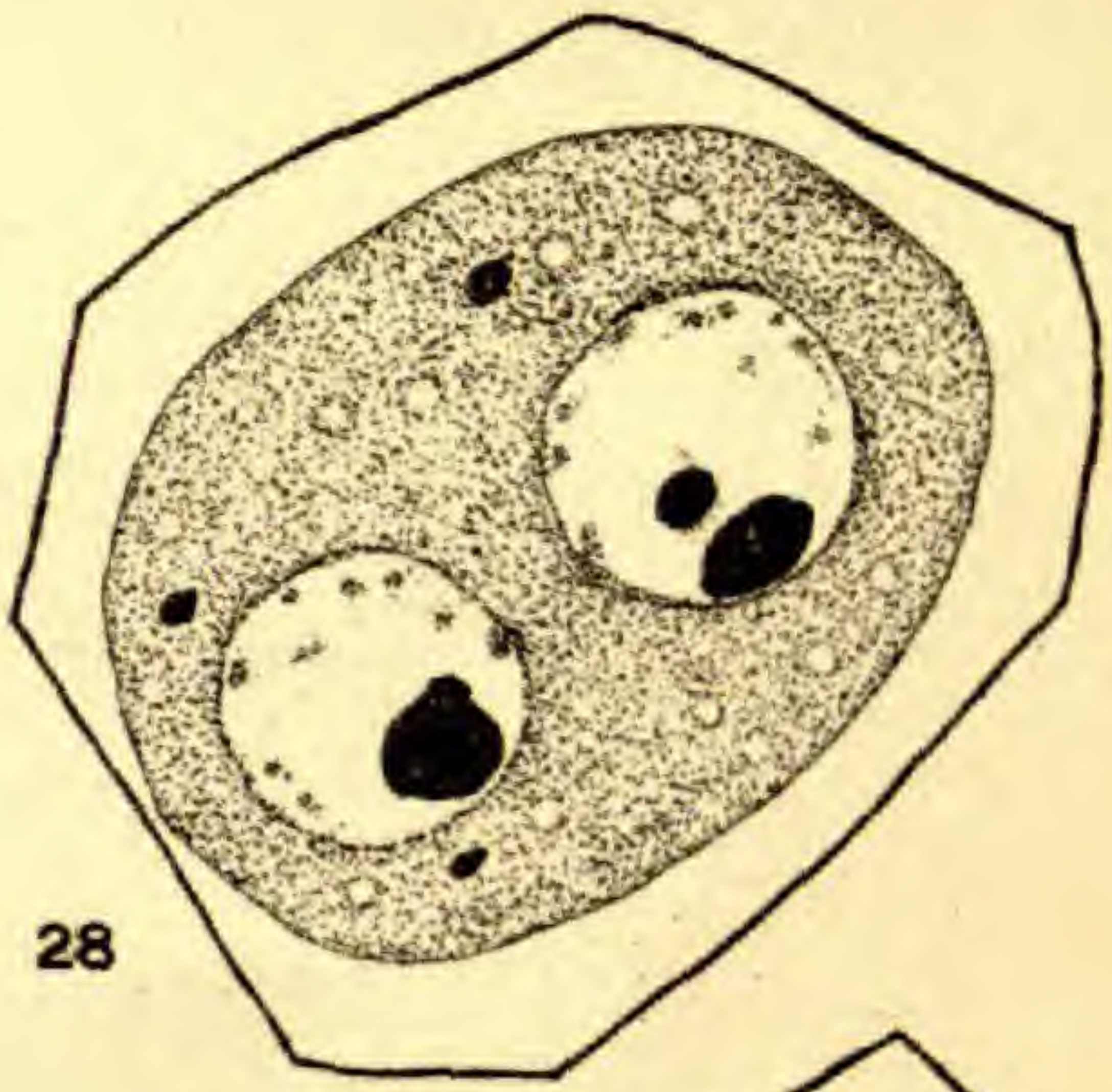

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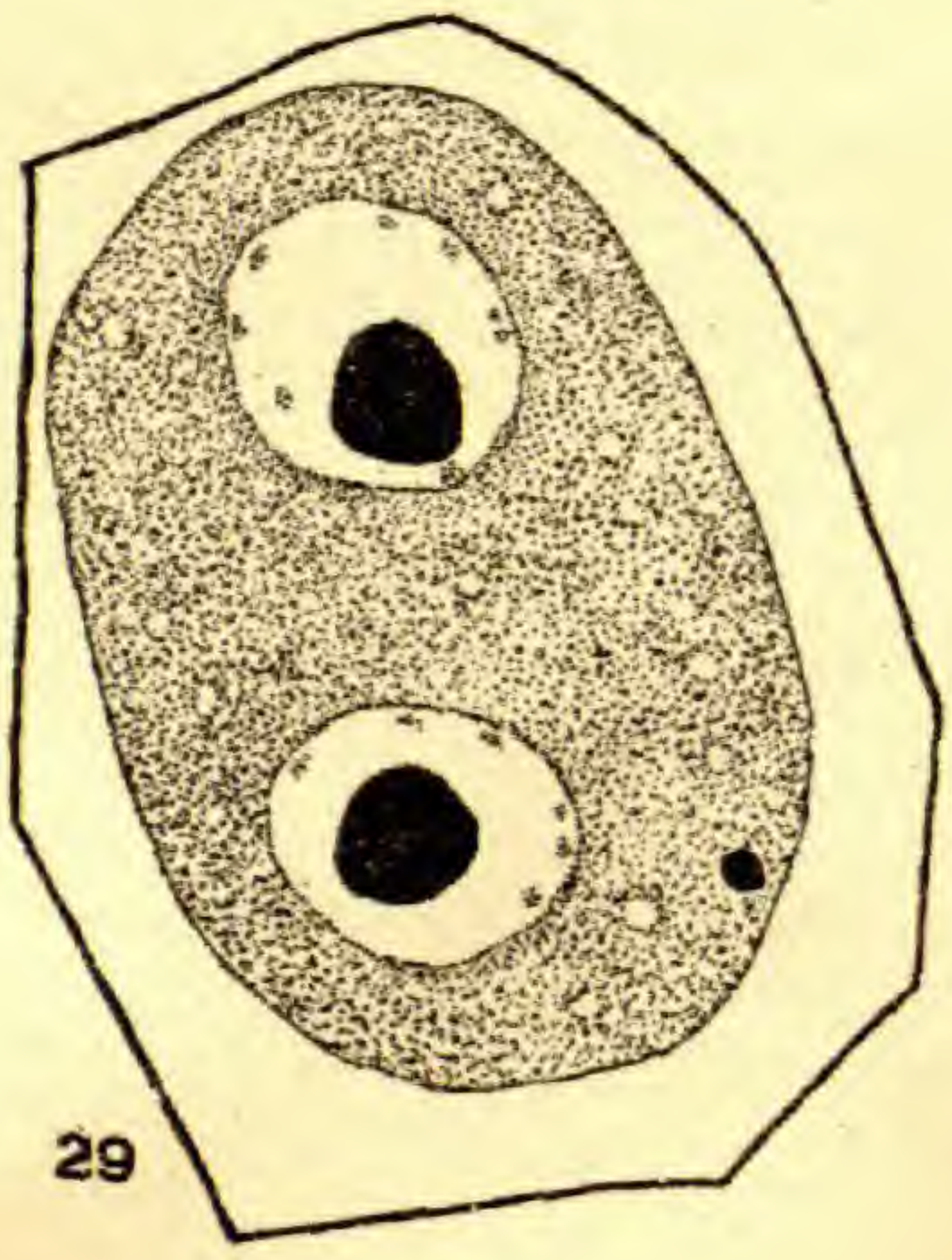

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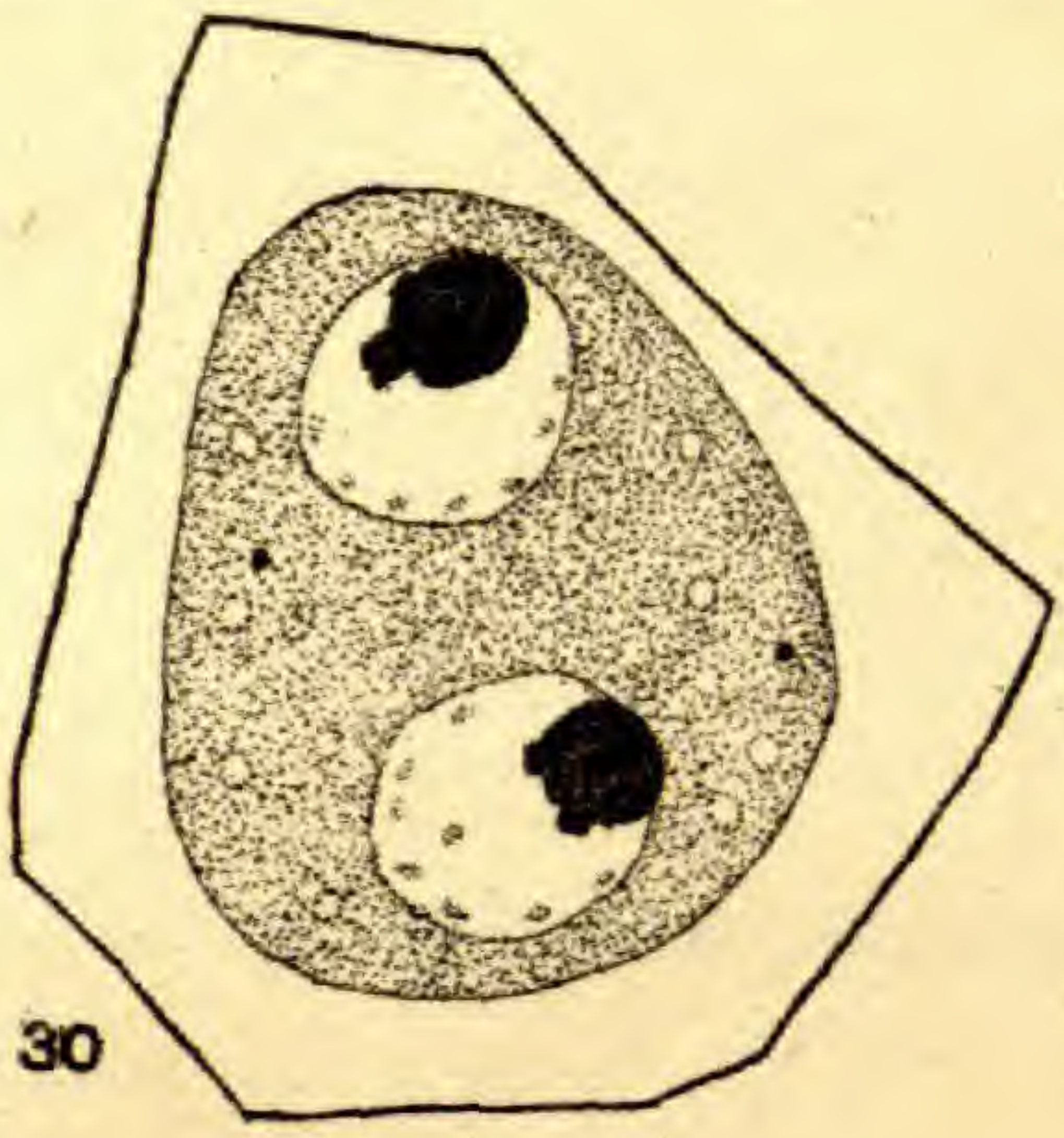

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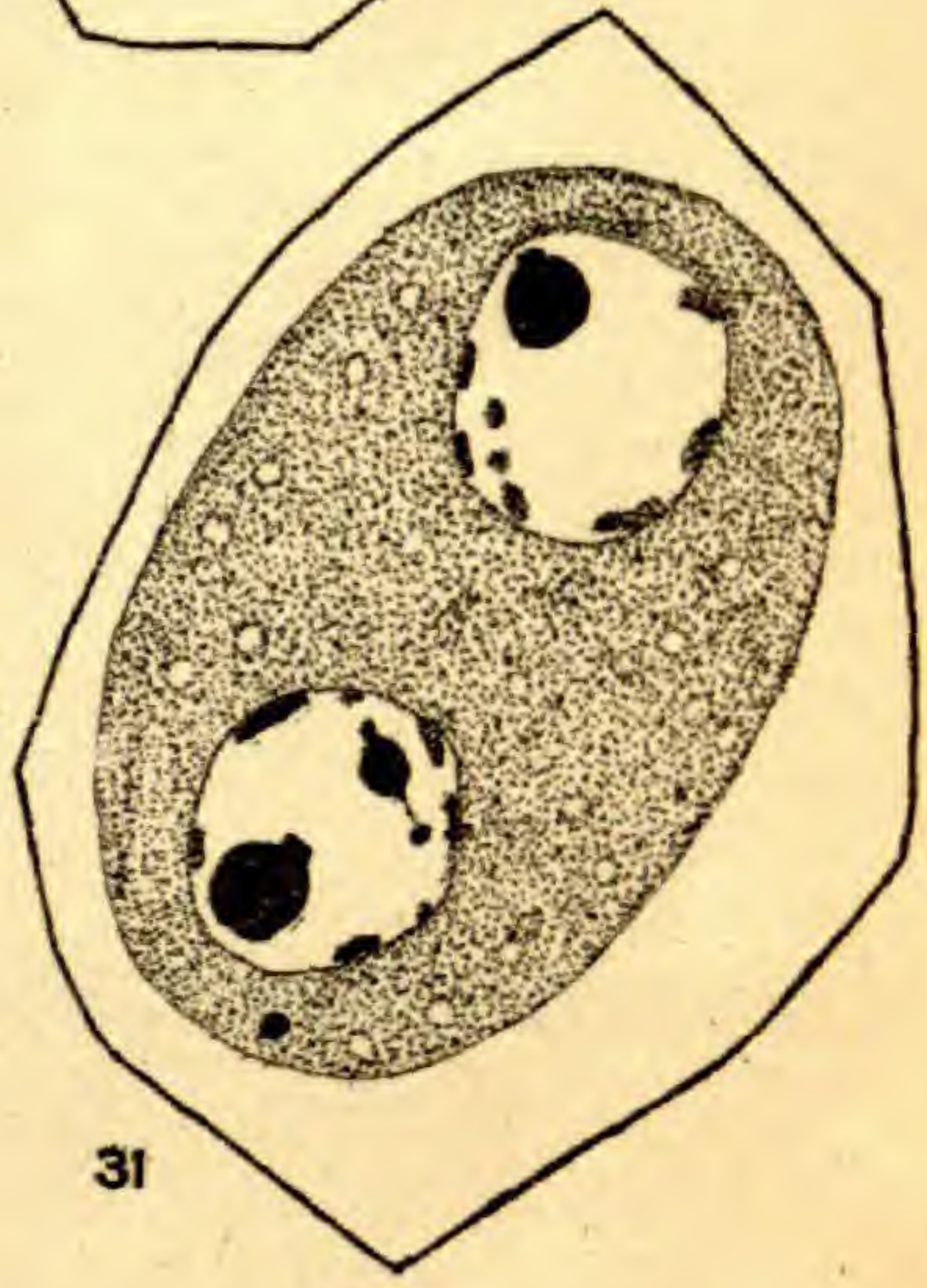

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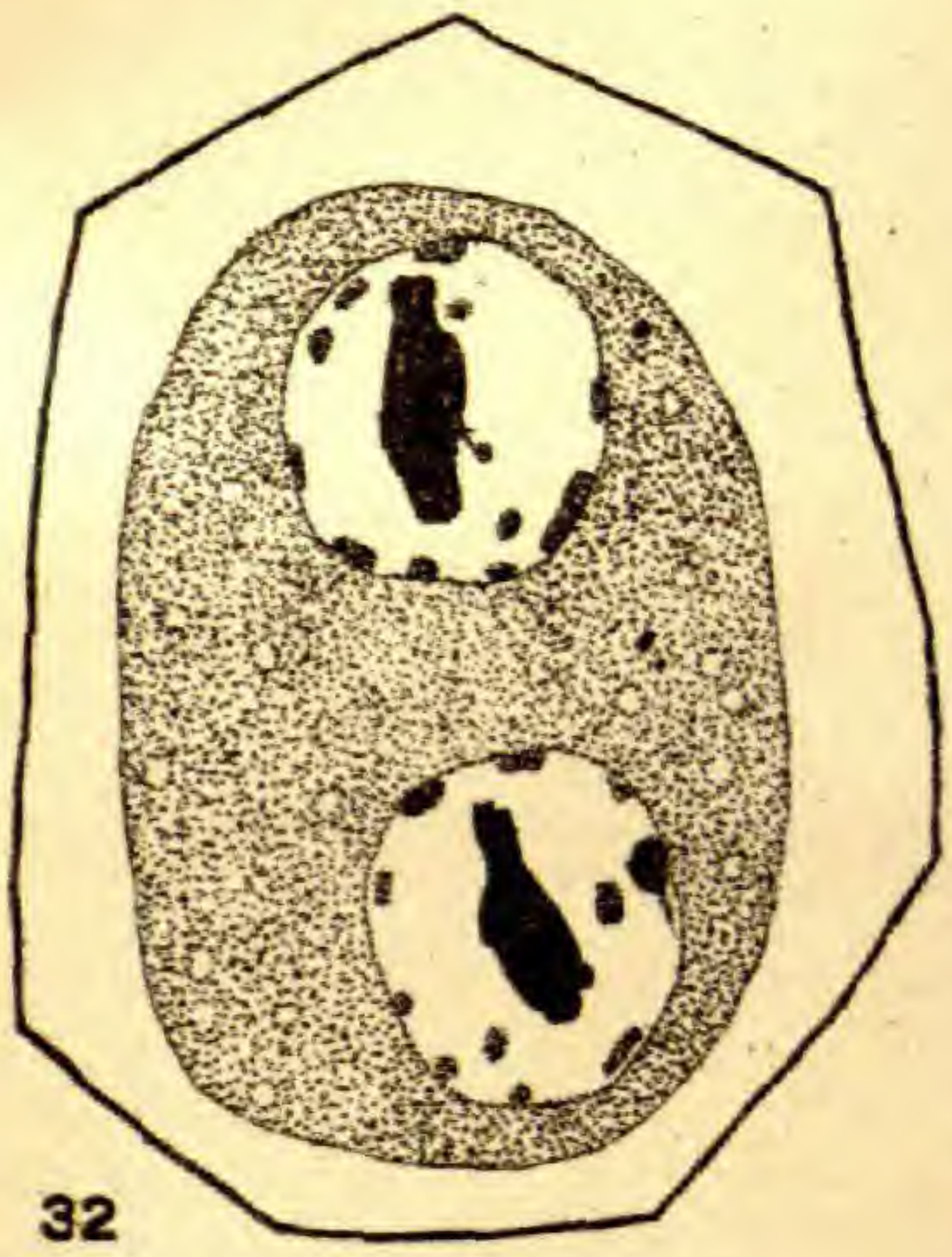

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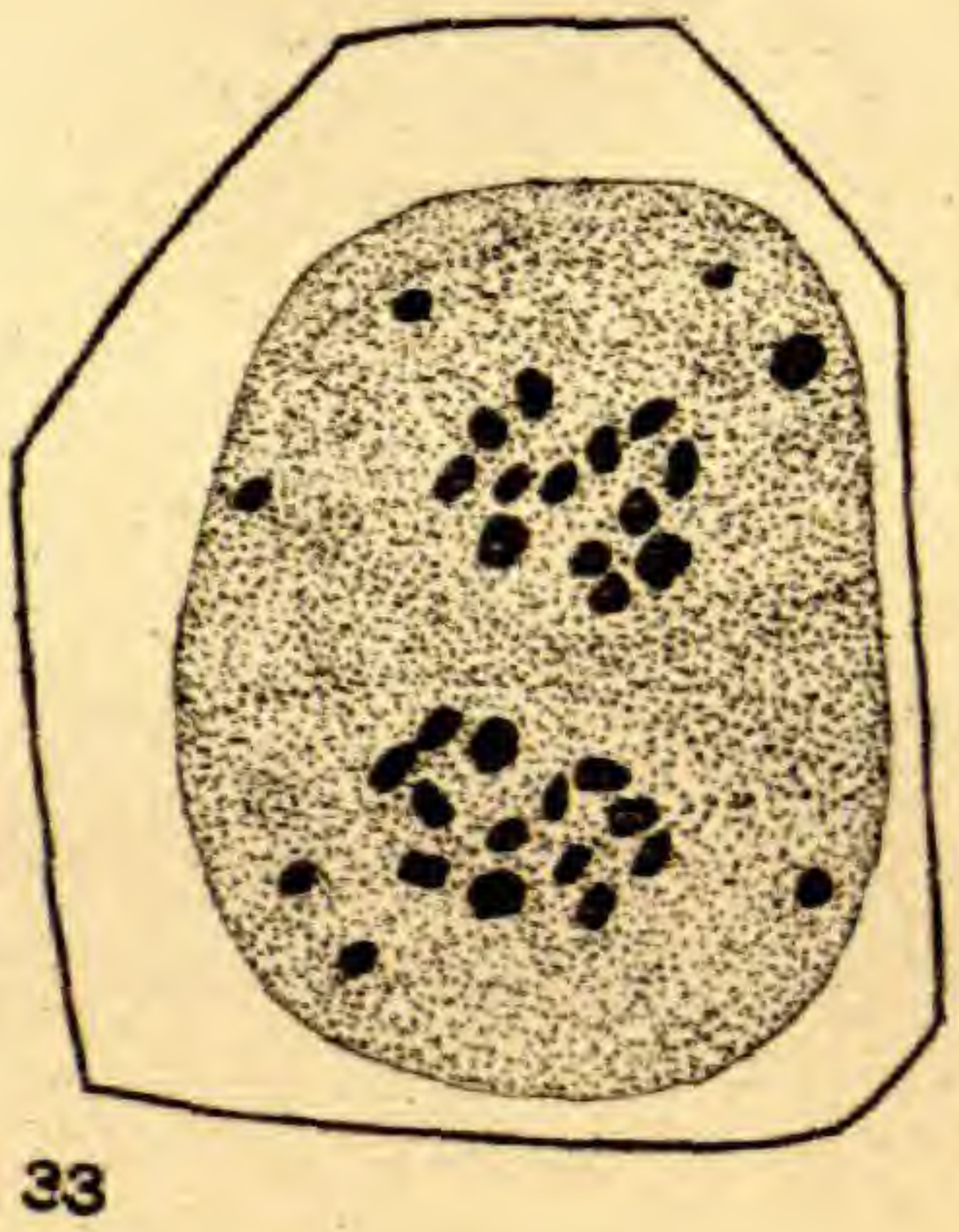

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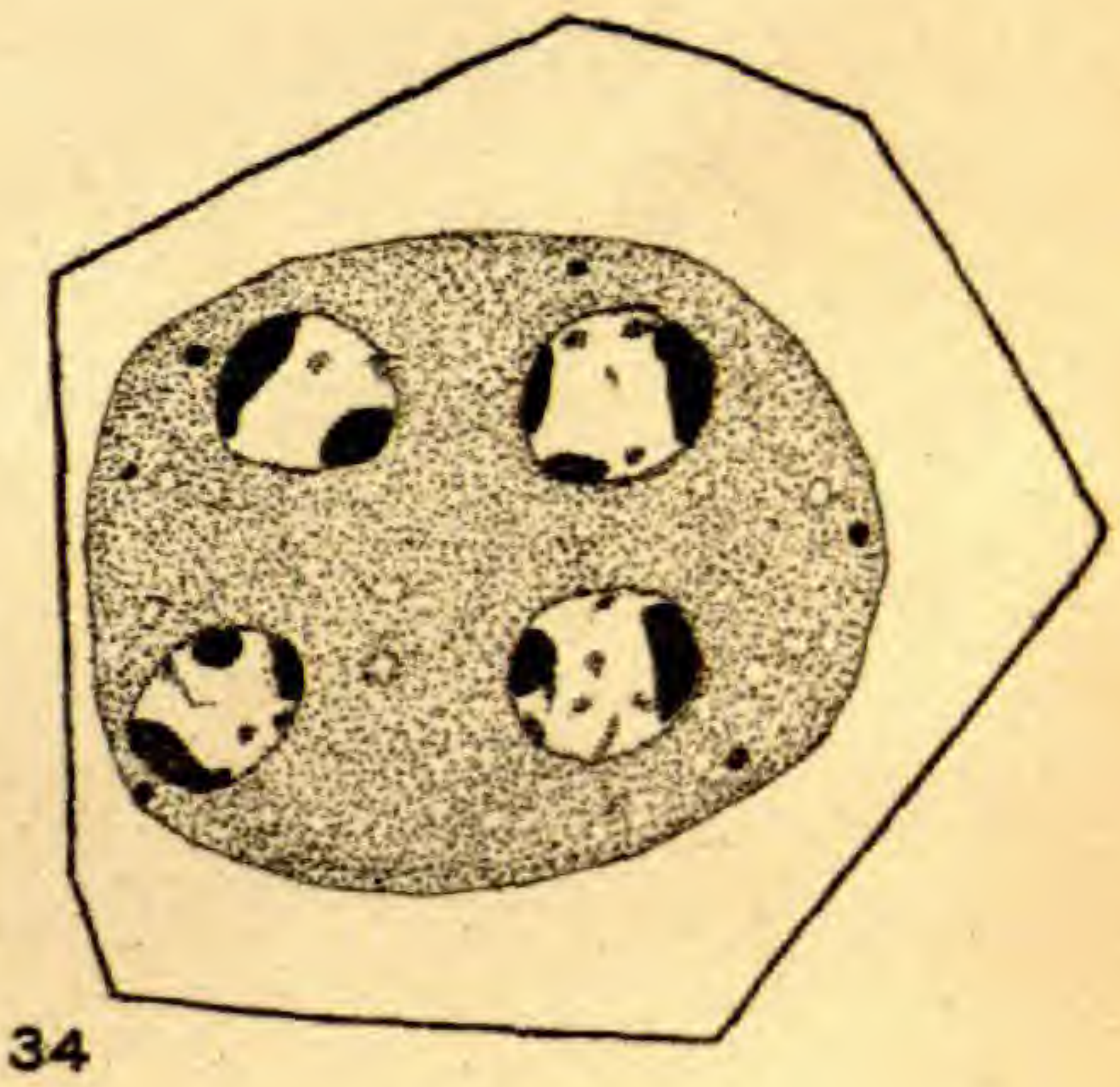

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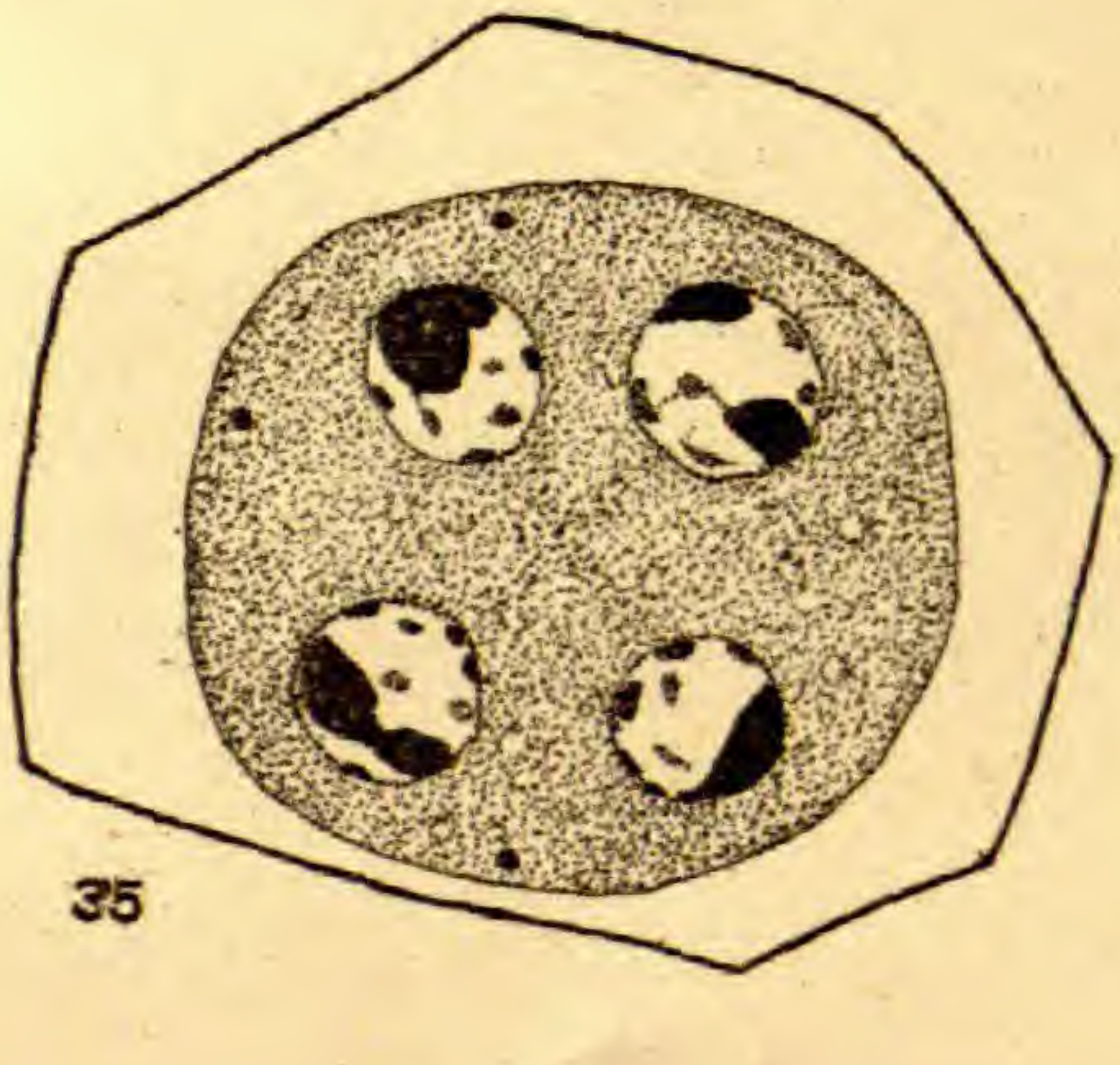

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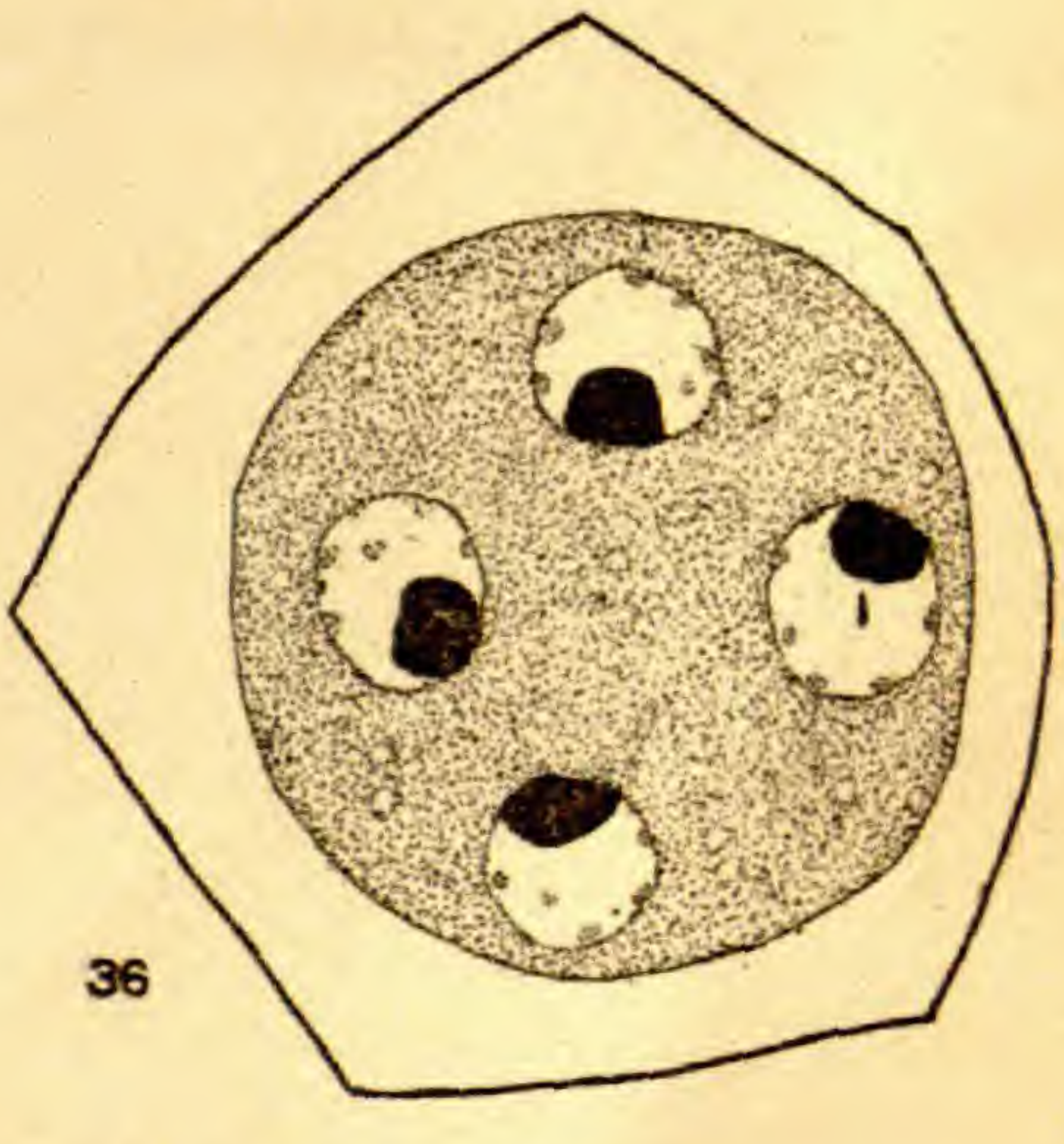

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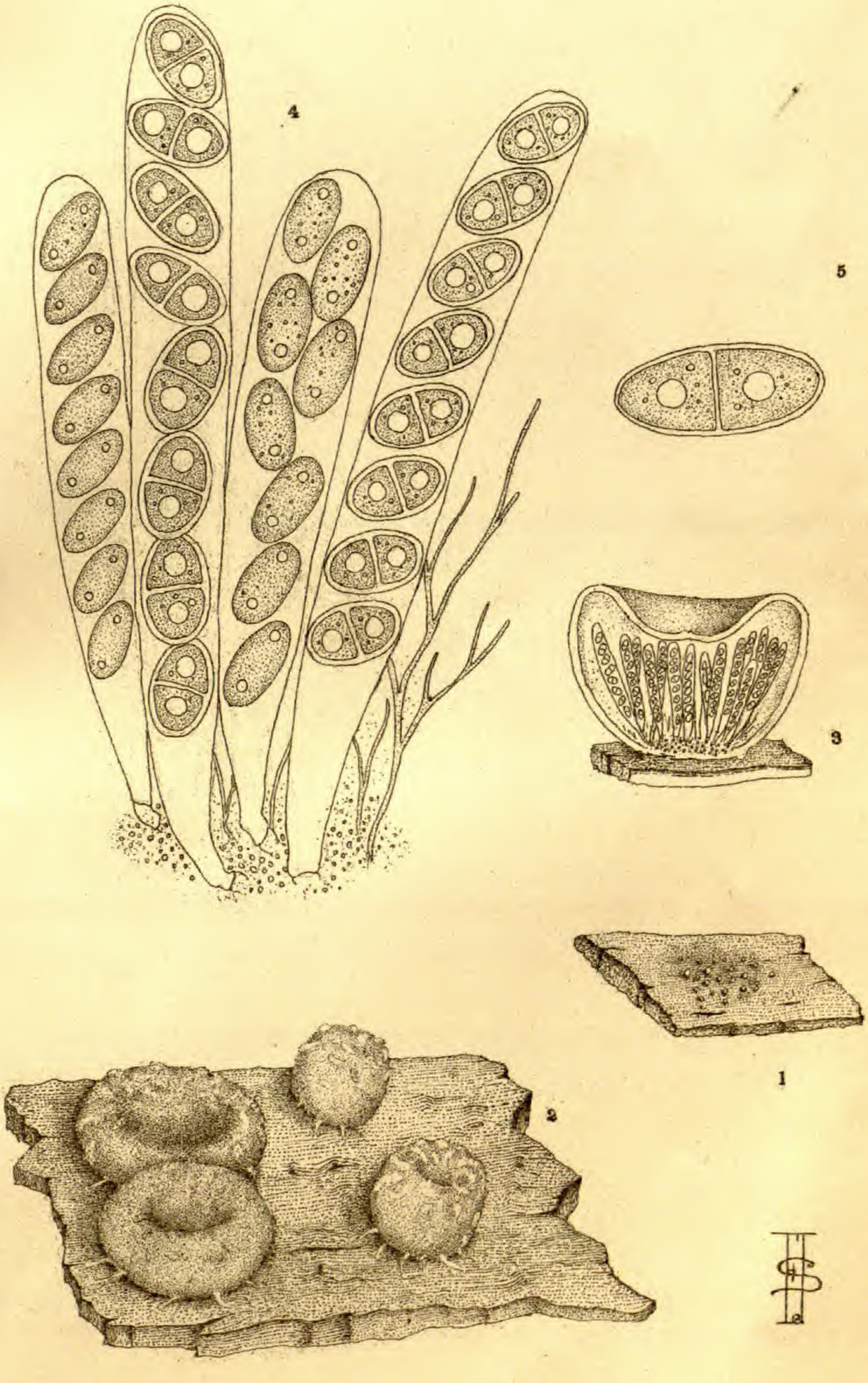

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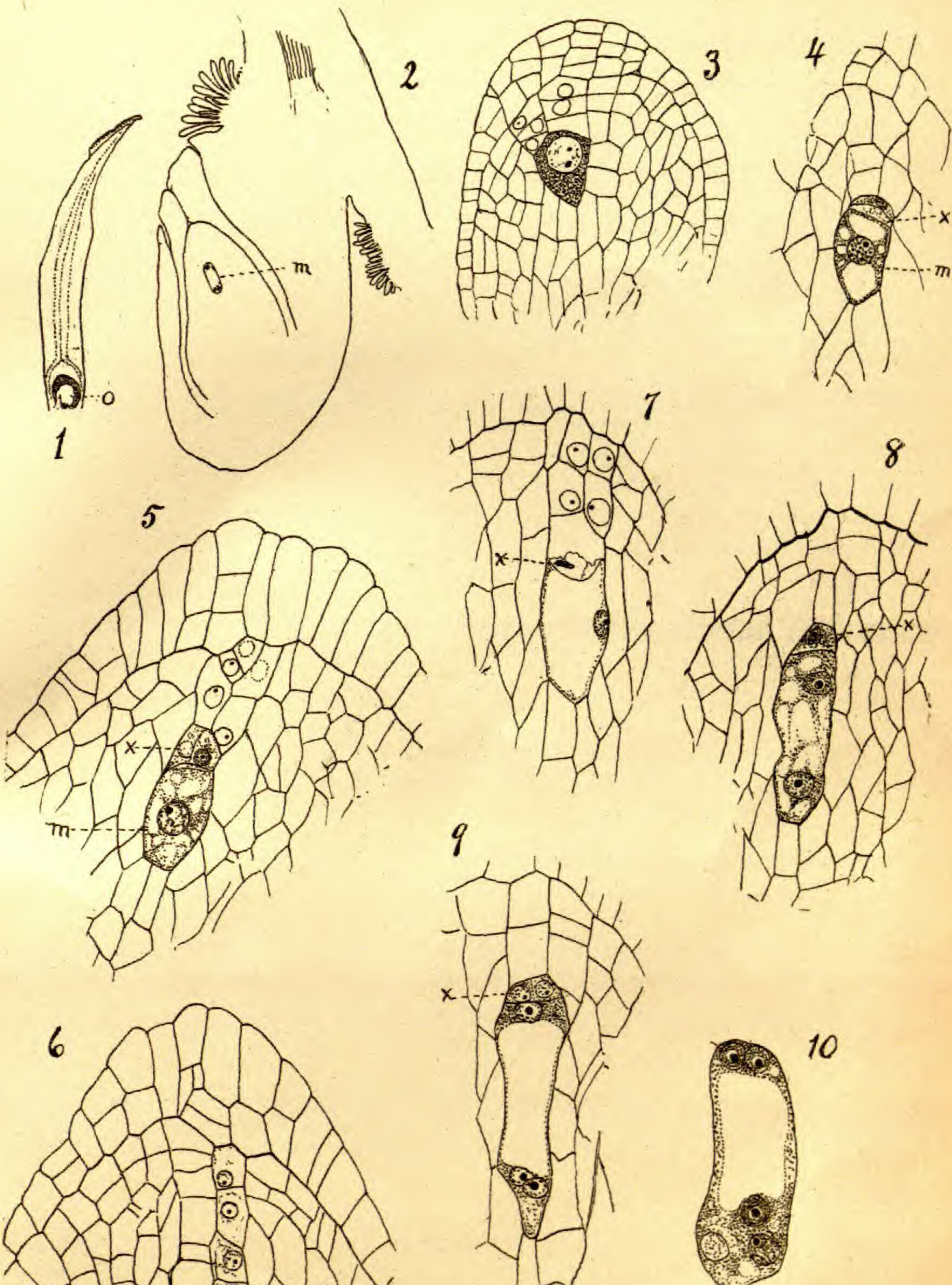

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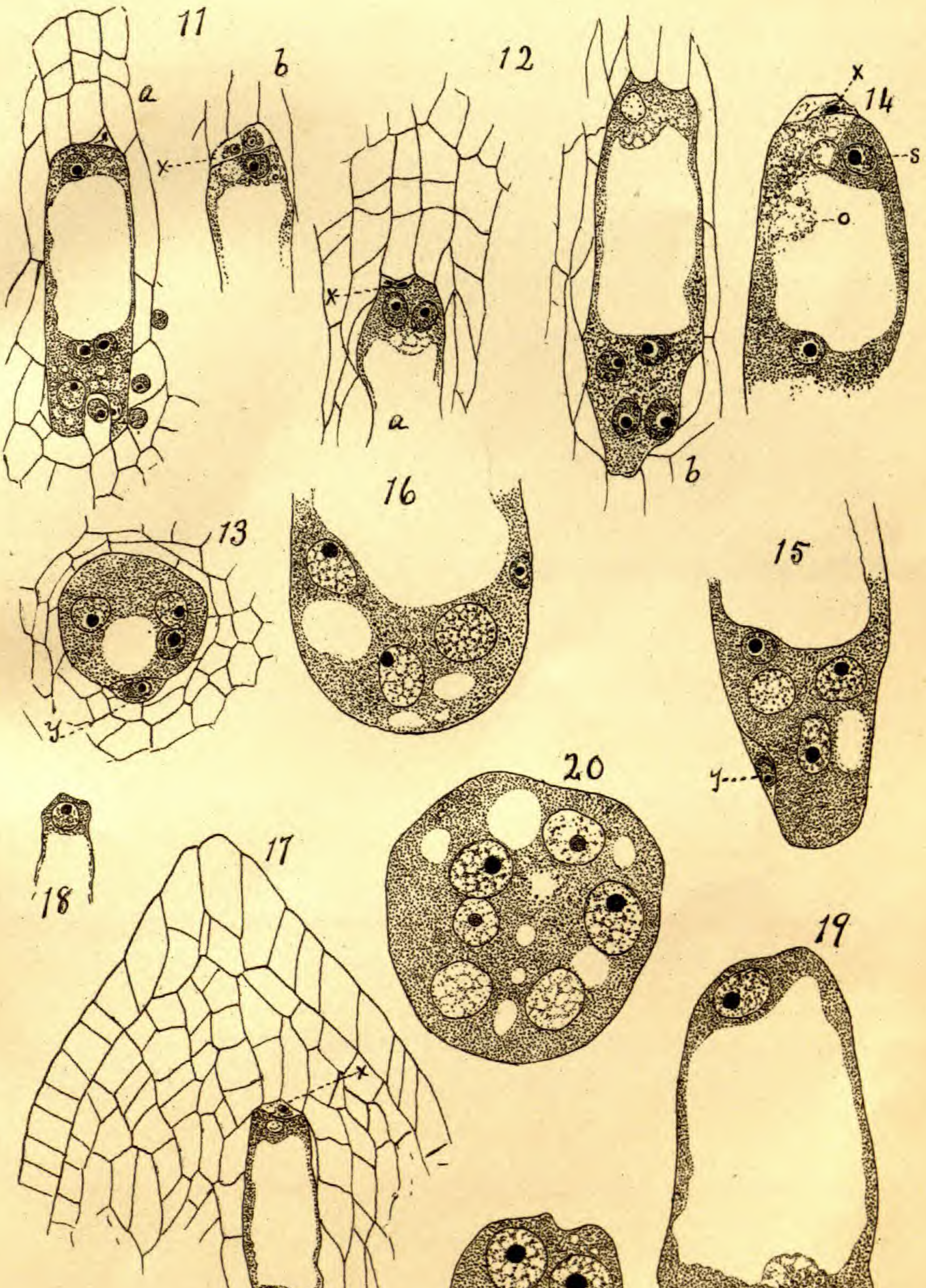

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

MAY, 1909

Nitrogen assimilation of Sterigmatocystis nigra and the effect of chemical stimulation[*]

Marion E. Latham

Inasmuch as the question of the relation of unstimulated and stimulated crops of *Sterigmatocystis nigra* to their carbohydrate supply had been several times investigated by Professor Richards and his students, it was decided to look into the effect of chemical stimulation upon the nitrogen consumption. Upon examination, it was found that this led largely to a study of the question of nitrogen fixation by the fungus under varying conditions, with the results given below. It will be remembered that Richards[†] determined the optimum stimulation for various salts; that Watterson[‡] worked over the effect of such stimulation on the CO_2 given off; that Richards[§] also determined the effect of irritation on the relative sugar consumption; and the present writer[||] worked along the same line and also considered the amount of oxalic acid excreted. This present paper is offered as a contribution to our knowledge of the nitrogen metabolism of *Sterigmatocystis nigra*. It has been carried out in the Botanical Laboratories

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[*] The investigations here reported upon have been aided by a grant made to H. M. Richards from the Esther Herrman Fund of the New York Academy of Sciences.

[†] Richards, H. M. Die Beeinflussung des Wachsthums einiger Pilze durch chemische Reize. Jahrb. Wiss. Bot. **30**: 665. 1897.

[‡] Watterson, A. The effect of chemical irritation on the respiration of fungi. Bull. Torrey Club **31**: 291. 1904.

[§] Richards, H. M. The effect of chemical irritation on the economic coefficient of sugar. Bull. Torrey Club **26**: 463. 1899.

[||] Latham, M. E. Stimulation of *Sterigmatocystis* by chloroform. Bull. Torrey Club **32**: 337. 1905.

[The BULLETIN for April, 1909 (**36**: 177–234. *pl. 12–17*) was issued 4 My 1909.]

of Barnard College with the aid and advice of Professor Richards, to whom the writer is pleased once more to be able to acknowledge indebtedness and gratitude. A grant from the Esther Herrman Fund supplied some of the special apparatus used in prosecuting the work.

In 1895 Puriewitsch * published the results of an investigation on the nitrogen-fixing power of *Aspergillus niger* (*Sterigmatocystis*) and *Penicillium glaucum*, concluding that both organisms are able to bring uncombined nitrogen into chemical union, the amount so combined being in direct proportion to sugar supply and bearing no definite relation to the dry weight of the fungal felt. This work has been brought to question by various commentators † because of the small amount of nitrogen determined in analyses and the large chance of error inherent in the Kjeldahl method. Puriewitsch ‡ in his cultures used phosphoric acid in minute quantity to inhibit the growth of any nitrogen-fixing bacteria, not being sure, it seems, of his stock of the fungus. It has been indicated by the results that follow that the presence of this phosphoric acid will account for the small amount of nitrogen combined by the fungus, since the mycelium was stimulated by the acid and the ability to fix atmospheric nitrogen at the same time diminished.

Saida § has recorded a gain in total nitrogen in compound when working with *Aspergillus*; Winogradsky || had none. Berthelot ¶ had written in 1893 that he found a fixation of nitrogen by *Aspergillus niger*, *Alternaria tenuis*, and *Gymnoascus*; but of these only the *Alternaria* culture was pure and there the gain reached as high as 98 per cent. of the original nitrogen content. Brefeld ** investigated the action of *Ustilago*, which he found did not assimilate free

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* Puriewitsch, K. Ueber die Stickstoffassimilation bei den Schimmelpilzen. Ber. Deuts. Bot. Gesells. **13**: 342. 1895.

† Lafar, F. Handbuch der Technischen Mykologie **3**: 1–69. 1904–1906.

Czapek, F. Biochemie der Pflanzen **2**: 125. 1905.

Jost, L. Plant Physiology, 235. 1907. [English translation.]

‡ Puriewitsch, K. *Loc. cit.*

§ Saida, K. Ueber die Assimilation freien Stickstoffs durch Schimmelpilze. Ber. Deuts. Bot. Gesells. **19**: 107. 1901.

|| See Lafar, F. Handbuch der Technischen Mykologie **3**: 11.

¶ Berthelot, M. Recherches nouvelles sur les microrganismes fixateurs de l'azote. Comptes Rendus **116**: 842. 1893.

** Brefeld, O. Versuche über die Stickstoffaufnahme bei den Pflanzen. Centralb. für Bakt. II. **8**: 24. 1902.

nitrogen and, furthermore, had no part in aiding the action of the host. In the case of *Phoma*, Saida [*] confirms Puriewitsch's conclusions with regard to the proportion between the amount of nitrogen brought into combination and the sugar at hand; and moreover, he records that when the fungus is growing on a solution poor in nitrogen compounds, then the CO_2 evolved becomes greater, that is, a greater expenditure of energy is indicated. Ternetz [†] found a gain in combined nitrogen due to the activity of a fungus isolated from the roots of *Oxycoccus*.

This summary of the work done on the relation of fungi to nitrogen-fixing is intended to touch the main points only. The literature may be had in detail from the works of Czapek [‡] and Lafar [§] and we are therefore content with this brief citation. The same question with bacteria has, of course, been more widely worked over, but with it we have made no attempt to deal.

In our former work, gaseous chloroform was the reagent used as a stimulant, but in this case we had recourse to zinc sulphate in solution, a stimulant with which Richards [||] had earlier worked. This was both because the difficulties in manipulation with the gas added to those of Kjeldahl analysis would probably have taken more time than we could hope to give to the work, and also because zinc sulphate has been more often used as a stimulant and its action is better known. The principle in each case is the same so that results would be similar. Aside from the difference in stimulant, the same methods were used as previously, the same superior reagents and insoluble glass, and the same care in preparation. A careful plate culture was prepared with the nutrient media in the gelatine to test the purity of the *Sterigmatocystis*. This showed no trace of bacteria whatever, so it was concluded that the spores were bacteria-free or at worst so little contaminated as to be highly satisfactory for our work. The growing cultures were kept under sealed bell-jars in order to exclude influences other than the one under observation, since we had found that the fungus is very sen-

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[*] Saida, K. *Loc. cit.*

[†] Ternetz, C. Assimilation des atmosphärischen Stickstoffs durch einen torfbewohnenden Pilz. Ber. Deuts. Bot. Gesells. 22: 267. 1904.

[‡] Czapek, F. *Loc. cit.*

[§] Lafar, F. *Loc. cit.*

[||] Richards, H. M. *Loc. cit.*

sitive to traces of gases in the atmosphere. The recipe of the culture solution is this:

1.00 gm. NH_4NO_3	5.00 gm. sugar
0.50 " KH_2PO_4	100 c.c. water
0.25 " $MgSO_4$	trace of iron

The solution was made up in bulk in carefully cleaned and sterilized "non-sol" glass, boiled, cooled, and a suitable quantity taken at once for determining the nitrogen content. The rest was sown with spores, and zinc sulphate added in measured quantities where desired. The cultures were then allowed to grow for five or six days to reach a proper state, when they were reaped, the substratum analyzed at once for nitrogen, and the felts washed and dried preparatory to their analyses. In making all measurements, accurate pipettes and burettes were used, and for weighing the dry felt, a good Becker balance. To ascertain the nitrogen present the Gunning-Jodlbauer modification of the Kjeldahl process was followed. Two felts were cultivated at each stimulation and two determinations of nitrogen were made on each solution and on each felt. The procedure was to analyze the solution as provided to the fungus and again immediately after the crop was reaped, any difference being attributed to the action of the fungus. Then the dried felt was analyzed and the results obtained here added to the others and thus the full amount of nitrogen present in chemical union was determined. The most marked change is visible in the fluid substratum, because *Sterigmatocystis*, like nitrogen-fixing bacteria, may under favorable conditions excrete as a waste product some of the nitrogen compounds which it has formed from gaseous atmospheric nitrogen. The amount to be found in the make-up of the fungus itself being, as we find, relatively the same under all circumstances.

From six series grown after methods had been mastered, it was seen that (1) *Sterigmatocystis* grown normally does fix free nitrogen which is found to be in combination if nitrogen compounds be supplied in favorable quantity; (2) the amount of nitrogen so combined decreases if the culture be subjected to stimulation, both absolutely and relatively, *i. e.*, both in absolute quantity and in amount per gram of dry weight of crop produced, the diminution being shown most markedly by the decrease in combined nitrogen in the substratum, where the amount of nitrogen fixed may become negative, that is to say, from which nitrogen may be used in metabolism ; (3) the amount of nitrogen entering into the composition of the felt remains relatively the same in normal and stimulated growths ; (4) the optimal stimulation from a carbohydrate point of view is not marked in nitrogen fixation where there is a gradual decrease in the amount caused to combine. These six series are wholly consistent within themselves.

TABLE I

Series.	Stimulation in terms of normal $ZnSO_4$ solution	Net dry weight Mg.	A Nitrogen furnished each culture Mg.	B Total nitrogen in each culture solution after growth Mg.	B—A Nitrogen fixed in each culture solution Mg.	Mg. of nitrogen fixed in solution per gram of felt	C Nitrogen in felt Mg.	Mg. of nitrogen per gram of dry felt	B + C Total nitrogen in felt and solution Mg.	B + C — A Total nitrogen fixed Mg.	Total nitrogen fixed in Mg. per gm. of dry felt
1	0.0000	200.2	115.4	175.8	60.4	301.5	11.1	55.5	186.9	71.5	357.2
	.0005	740.8		116.3	0.9	1.2	45.8	61.8	162.1	46.7	63.04
	.00075	722.6		112.2	—3.2	—4.5	69.3	63.5	181.5	66.1	91.47
	.001	767.5		112.6	—5.6	—7.4	44.9	58.5	157.5	42.1	54.85
2	0.0000	302.8	117.7	311.3	193.6	639.4	11.5	38.0	322.8	205.1	677.3
	.0003	740.5		118.4	.7	1.0	45.1	61.0	163.5	45.8	61.85
	.0005	705.5		144.7	27.0	38.3	44.2	62.6	189.1	71.4	101.20
	.0007	630.0		130.7	13.0	20.6	40.0	63.5	170.7	53.0	84.14
3	0.0000	185.0	141.6	132.8	—8.8	—47.6	10.4	56.1	143.2	1.6	8.65
	.0003	751.0		158.5	16.9	22.5	43.0	57.2	201.5	59.9	79.76
	.0005	705.0		150.0	8.4	11.9	43.8	62.2	193.8	52.2	74.04
	.0007	698.9		148.5	6.9	9.9	43.7	62.5	192.2	50.6	72.40
4	0.0000	270.0	155.1	185.2	30.1	111.5	14.9	55.4	200.1	45.0	166.8
	.0003	763.3		139.4	—15.7	—20.6	45.3	59.4	184.7	29.6	38.78
	.0005	773.0		146.9	— 8.2	—10.6	45.0	58.2	191.9	36.8	47.61
	.0007	772.4		129.4	—25.7	—33.3	40.3	52.1	169.7	14.6	18.90
5	0.0000	420.9	156.3	173.9	17.6	41.8	20.4	48.4	194.3	38.0	90.28
	.0005	728.9		146.8	— 9.5	—13.0	44.1	60.4	190.9	34.6	47.46
	.001	685.2		147.0	— 9.4	—13.7	35.0	51.1	182.0	25.7	37.51
	.0015	662.5		120.2	—36.1	—54.5	40.0	60.3	160.2	3.9	5.89
6	0.0000	316.5	160.3	115.4	—44.9	—141.9	11.6	36.6	127.0	—33.3	—105.2
	.0003	769.7		79.8	—80.5	—104.6	46.5	60.3	126.3	—34.0	—44.17
	.0005	853.7		65.8	—94.5	—110.7	52.0	60.3	117.8	—42.5	—49.78
	.0007	765.5		72.9	—87.4	—116.8	47.3	61.8	120.2	—40.1	—52.38

It may be seen by reference to Table I that with the control crops, those under normal conditions and without stimulation, there was found an increase of nitrogen over that of the initial amount of nitrate that varied from 205.1 milligrams to 1.6 mg.; the amount supplied varying at the same time from 115.4 mg. to 156.3 mg. When the supply passed beyond the optimum point, when in this case 160.3 mg. were given the fungus at the outset, nitrogen was consumed. This would seem to indicate that the critical point with regard to nitrogen supply is slightly below 160.3 mg. in 50 c.c. of solution, although no attempt was made to determine the critical point with accuracy. It is known in the case of other nitrogen-fixing organisms that with an increasing nitrogen supply, the ability to utilize free nitrogen becomes less and less. At the point where it ceases, nitrogen must, of course, be consumed in the growth of the fungus. It will be noted how great is the difference between the amount of nitrogen fixed by the series just below the one in question and those with a much less amount supplied in the culture fluid. As the curve of nitrogen supply rises the curve of nitrogen-fixing ability falls, until the two cross at a point at which nitrogen consumption will begin. It may very well be that along such lines lies the inability of *Azotobacter* to fix nitrogen, ascribed by Beijerinck * to unexplained internal causes.

The average of the normals of all six series is 54.7 mg. or 199 mg. per gram of dry weight of the fungus felt; excluding from the average the series in which nitrogen was consumed, that is, series 6, the average becomes 72.2 mg. of nitrogen fixed, which is equivalent to 260.1 mg. per gram weight of dry crop. This union of atmospheric nitrogen diminishes with stimulation, being fairly constant around the point of optimal stimulation —.0005N $ZnSO_4$ — but finally disappearing. With a .0005N solution of $ZnSO_4$, the amount of nitrogen brought into combination varies from 34.6 mg. to 71.4 mg., the average being 48.3 mg. and this is 66.6 mg. per gram of dry felt produced. The effect of chemical stimulation upon nitrogen assimilation is therefore obvious at a glance if we compare normal and stimulated results, 72 mg. or 260.1 mg. per gram of dry felt in the unstimulated as against 33.2 mg. or 66.6 mg. per gram of dry substance in the stimulated. And again to compare the highest figures obtained at each point, a total gain of 174.2 per cent. of nitrogen over the amount supplied the normal

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* Beijerinck, W. Centralb. für Bakt. II. 7 : 561. 1901.

crop *versus* 60.6 per cent. gain in the crop grown at the optimal stimulation.

As was said before, commentators in their reviews have made objection to the work on nitrogen combination by fungi on the ground that the amounts determined by the analysis were too small to be due positively to anything but experimental error. Now Puriewitsch's largest analysis gave 18.2 mg. of nitrogen with 9.8 mg. supplied at first, making a gain in fixed nitrogen of 8.4 mg. Saida's largest gain was 1.7742 mg. of nitrogen for *Aspergillus* and 10.536 mg. with a culture of *Phoma* which was

TABLE II

AVERAGES OF FIVE SERIES, SERIES 6 BEING OMITTED

Stimulation in terms of normal $ZnSO_4$ solution	B — A Total nitrogen fixed in each culture solution Mg.	Mg. of nitrogen fixed in each solution per gram of felt	C Nitrogen in felt Mg.	Mg. of nitrogen per gm. of dry felt	B + C Total nitrogen in felt and solution Mg.	B + C — A Total nitrogen fixed Mg.	Total nitrogen fixed in Mg. per gram of dry felt
.0000	58.6	209.3	13.7	50.7	209.5	72.2	260.1
.0003	.6	1.0	44.5	59.2	183.2	45.1	60.2
.0005	3.7	5.6	44.6	61.0	185.6	48.3	66.7
.0007	— 2.2	— 1.8	48.3	60.4	178.5	46.1	66.7
.0010	— 7.5	—10.5	39.9	54.8	169.8	33.9	46.2
.0015	—36.1	—54.5	40.0	60.3	160.2	3.9	5.9

TABLE III

GRAND AVERAGES OF ALL SERIES

Stimulation in terms of normal $ZnSO_4$ solution	B — A Total nitrogen fixed in each culture solution Mg.	Mg. of nitrogen fixed in each solution per gram of felt	C Nitrogen in felt Mg.	Mg. of nitrogen per gm. of dry felt	B + C Total nitrogen in felt and solution Mg.	B + C — A Total nitrogen fixed Mg.	Total nitrogen fixed in Mg. per gram of dry felt
0.0000	41.3	150.8	13.3	48.3	195.7	54.7	199.2
.0003	—19.7	—25.4	45.0	59.5	169.0	25.3	34.1
.0005	—12.7	—13.8	45.8	60.9	174.3	33.2	47.3
.0007	—19.3	— 24.8	48.1	60.7	166.9	28.8	42.9
.0010	— 7.5	— 10.5	39.9	54.8	169.8	33.9	46.2
.0015	—36.1	—54.5	40.0	60.3	160.2	3.9	5.9

grown on a decoction of beet sugar, sugar, and some nitrogen source; while the gain for *Mucor* was 2.0699 mg. Ternetz in work with the "*Oxycoccus*-Pilz" found a gain of 3.2994 mg. of nitrogen. These are the more recent researches on the subject. In 1893, Berthelot wrote that in working with *Aspergillus* he had determined a gain of 26 per cent. in a certain culture, the crop giving an absolute gain of 7 mg. The figures we have been able to obtain have shown as high as 205 mg. in one instance, the lowest amount being 1.6 mg., but the total average is 72.2 mg. for five control cultures and 48.3 mg. for cultures at the optimal stimulation. These numbers in nitrogen analysis are not open to the objection made by the critics cited above, and by others. They are indeed rather large for nitrogen determinations. Of course they include all the nitrogen in the culture, both that excreted into the nutrient solution, and that entering into the make-up of the vegetative body as well as the original supply. The largest amount gained in solution was 193.6 mg. over and above the 117.7 mg. supplied.

Proofs of accuracy in the operations may be adduced from the facts that examinations of different specimens of a felt made at times at some interval from one another gave results which varied by only a small fraction of a milligram; and examinations of the reagents at different times were fortunate in the same respect. Again, the different results constantly obtained with normal and stimulated crops, all at the same time consistent within themselves, would seem to give further indication of some success in manipulation. So that on the whole, it is hoped that this work will be considered as having measurably confirmed the results of the earlier workers with normal cultures; and also as having brought forward some data of value, namely, that while stimulated crops behave more economically with regard to their carbohydrate consumption, and while the amount of nitrogen entering into the composition of the fungal felt is relatively the same as for a normal growth, yet with regard to their nitrogen relation these stimulated cultures are less thrifty than normal ones, which, unless the nitrogen supplied them be in too great quantity, are able to use gaseous nitrogen and to bring it into chemical combination even in excess of actual need.

To explain the reason for the activity of the organism along these lines, there are these suggestions: one, that the fixation of free nitrogen and its excretion in combined form may be a function connected with fructification, since stimulated felts do not produce spores; another, which is more theoretical and yet more probable, is that the stimulated crop, driven to its most rapid metabolic activity by the stimulant, is forced to consume its carbohydrate more economically and therefore finds less energy to use in effecting the combination of the relatively inert and difficultly combinable nitrogen and so must use the more readily assimilable compound nitrogen; or again, it may be that since by the presence of the stimulant, the fungus can consume carbohydrate more thoroughly and with less waste, therefore it finds, in what would be a normal amount under ordinary circumstances, a more than necessary amount under the favoring influence of the stimulant, which would of course be then potentially a too great supply and the result would be over-feeding in this direction and therefore there would be a tendency to lessened activity in expending energy for nitrogen combination. This last hypothesis is in accord with Moore's * conclusions on the activity of the root-tubercle bacteria in fixing nitrogen when well supplied with nitrogen compounds, but not in accord with the results of those who find that the fixation of nitrogen is directly proportional to the amount of sugar at hand.

If, however, the absolute numerical results be questioned, there can surely be no doubt of the fact that stimulation serves to decrease the amount of nitrogen to be found in the nutrient substratum, while it has little or no effect upon the relative amount combined in the fungal felt. And lastly, if even these results be questioned on the ground that the *Sterigmatocystis* was not pure but mixed with a nitrogen-combining bacterium — which we consider to have been refuted by the evidence of the plate culture before mentioned — there remains still the fact that in the body of the fungus hyphae in which the normal and stimulated fungi vary so widely in appearance, the relative nitrogen content of the chemical composition remains the same.

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* Moore, G. T. Soil inoculation for legumes. U. S. Dept. Agr. Bur. Pl. Ind. Bull. 71. 1905.

The conclusions, summarized, are given below:

1. The work of Puriewitsch and others who found fixation of free nitrogen by *Sterigmatocystis nigra* (*Aspergillus niger*) is confirmed.

2. The fixation of free nitrogen is lessened and finally inhibited by the presence of zinc sulphate in minute quantities.

3. The relative amount of nitrogen entering into the substance of the fungal felt remains the same for stimulated and unstimulated cultures, the differences of behavior toward nitrogen appearing in the fluid substratum.

BOTANICAL LABORATORIES, BARNARD COLLEGE,
COLUMBIA UNIVERSITY.
FEBRUARY, 1909.

Contributions to the Mesozoic flora of the Atlantic coastal plain — III. New Jersey*

EDWARD W. BERRY

(WITH PLATES 18 AND 18*a*)

The present brief contribution includes additions and corrections to our knowledge of the fossil flora of the Raritan formation of New Jersey and embraces certain results obtained during a monographic revision of this flora for the Geological Survey of that state which it is desirable to publish in advance of the completed work for the purpose of intelligent citation in connection with the investigation of similar floras from the southern coastal plain.

It is now nearly twenty years since Professor J. S. Newberry, through failing health, was compelled to stop work upon the Raritan flora. In this interval there has been no published addition to our knowledge of this flora except Dr. Arthur Hollick's admirable work in preparing Professor Newberry's manuscript for publication.

Much new material has been collected by the writer and others, all of which has been passed in review and the ranges of many of the species have been greatly extended. It is not my purpose, however, to give any extended discussion or lists of species at the present time, but simply to indicate certain taxonomic changes made necessary by the progress of our knowledge of certain forms or by our present ideas of their specific segregation. Synonymy is omitted wherever possible, as is any lengthy discussion of the species mentioned.

DICKSONIA GROENLANDICA Heer, Fl. Foss. Arct. **6**^{2}: 23. *pl. 35. f. 8, 9.* 1882; **7**: 2. *pl. 48. f. 1–3.* 1883

Dicksonia borealis Heer, *op. cit.* **6**^{2}: 23. *pl. 44. f. 2.* 1882. Not Heer, 1878, a distinct Jurassic type.

Anemia stricta Newb. Fl. Amboy Clays 38. *pl. 3. f. 1, 2.* 1896.

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* Published by permission of the New Jersey Geological Survey.

Both of Heer's types which are here united with Newberry's species are small fragments of ultimate pinnae, which their author confesses are very similar, a fact well brought out by a comparison of the figured specimens. The material from Woodbridge, N. J., is more ample, and, as may be seen lower down on the frond, the pinnules become toothed and finally pinnatifid, a feature not shown in the scant material from Greenland. There is slight reason, however, for doubting their identity, Newberry himself having pointed out that *Dicksonia borealis* of Heer was probably identical with his Amboy Clay species.

Although common at Woodbridge, this species has not been found elsewhere in the coastal plain except for a single specimen which the writer discovered recently in the Tuscaloosa formation of Alabama. It is present at both the Atane and the Patoot horizons in Greenland.

OCCURRENCE: Woodbridge.

COLLECTIONS: New York Botanical Garden.

Asplenium raritanense sp. nov.

Frond and pinnae unknown. Pinnules small, 1.33 cm. long by 10 mm. in greatest breadth, ovate, with narrow somewhat straight-sided base, palmately divided into one terminal and two pairs of lateral, rounded, not deeply parted lobes; margin entire at base and in sinuses, sharply toothed on the lobes. Venation flabellate; about seven veins entering the base of the pinnule, these soon forking dichotomously, the ultimate divisions terminating in the marginal teeth. [PLATE 18, FIGURE 1.]

This species, which is quite unlike anything heretofore known from the Raritan formation, is unfortunately based on the single tiny pinnule figured. The general form and habit remain unknown. It is markedly distinct from any described fossil species known to the writer, although showing some points of resemblance to various arctic species referred to this genus by Professor Heer. Since the chances of more representative material being found are remote, it has seemed best to describe it under the above name.

OCCURRENCE: Hylton Pits.

COLLECTIONS: Johns Hopkins University.

Podozamites Knowltoni nom. nov.

Podozamites angustifolius (Eichw.) Schimper, Pal. Végét. **2**: 160. 1872. — Lesq. Cret. & Tert. Fl. 28. 1884; Fl. Dakota Group 27. *pl. 1. f. 4.* 1892. — Newb. Fl. Amboy Clays 44. *pl. 13. f. 1, 3, 4* (not *f. 2*). 1896. Not Schenk, 1868.

Zamites angustifolius Eichwald, Lethaea rossica **2**: 39. *pl. 2. f. 7.* 1860.

In 1872 Schimper referred the *Zamites angustifolius* of Eichwald to the genus *Podozamites*, overlooking the fact that Schenk, four years earlier, had described and named a *Podozamites angustifolius*. The natural impulse would be to dedicate this to Eichwald but Eichwald has already had a species of *Podozamites* named for him, in consequence of which the above name is proposed in honor of Dr. F. H. Knowlton, of the U. S. National Museum. This species has a wide range both geological and geographical. It is common in the Jurassic of high latitudes in Russia, Siberia, Bornholm, and Spitzbergen, and in the Upper Cretaceous indistinguishable remains are widely distributed in America. The abundant Raritan remains are long-lanceolate, 5–15 cm. in length by 0.6–1.2 cm. in width, the base narrowed to a short petiole, the summit long-pointed and the venation fine. They are similar to the leaflets of *Podozamites lanceolatus* but are usually longer, narrower, and more flexuous in outline.

OCCURRENCE: Woodbridge.

COLLECTIONS: New York Botanical Garden.

Pinus raritanensis Berry

Pinus sp. Newb. Fl. Amboy Clays 47. *pl. 9. f. 5, 6, 7, 8 (?), 17, 18 (?).* 1896.

It seems very desirable that at least the leaves which are included under Newberry's *Pinus* sp. should have a specific name, since pine leaves of this type in fascicles of three occur to the southward in the coastal plain and a definite name is therefore a necessity for purposes of intelligent citation. Whether the poorly preserved cones and winged seeds which occur in the same beds are referable to the same species, it is impossible to determine, and since in the overlying Magothy formation there are two types of leaves of *Pinus* as well as quite different seeds I have placed a query after Newberry's figures of cones and seeds in the above citation. *Pinus* seems to be confined to the upper part of the Raritan, although leaves, cones, and seeds are common in much older deposits elsewhere, going back as far as the Jurassic. Leaves are recorded from the Kome, Kootanie, Trinity, and Lakota formations; the Albian of Europe is remarkable for the large number of *Pinus*-like cones which it contains and Heer has recorded five species from the Atane beds.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Smilax raritanensis sp. nov.

Paliurus ovalis Newb. Fl. Amboy Clays 107. *pl. 23. f. 8, 9* 1896. Not Dawson, 1886.

Leaves of small size, ovate-elliptical, with entire margins, obtusely pointed apex and slightly cuneate base, 3.5–4 cm. long by 1.5–2 cm. wide. Primaries three, of medium size, diverging at acute angles from the extreme base, the laterals regularly curving upward and joining the midvein at the summit. Secondaries not visible except one or two transverse internal ones, and a few curved camptodrome external ones.

This species was identified by Professor Newberry with *Paliurus ovalis* Dawson,* which it somewhat resembles, and this latter species has been reported by Lesquereux † from the Dakota group and by Hollick ‡ from Marthas Vineyard. These occurrences may represent Dawson's species but the Raritan leaves are obviously different, being relatively shorter and broader and of an altogether different aspect.

Professor Newberry remarks of the difficulty of correlating these and other fossil species with the modern species of *Paliurus*, which usually has serrate or crenate leaves, and, while no new material has been obtained, it seems desirable to place these leaves in the genus *Smilax*, which contains many very similar modern leaves. Lesquereux describes two species of *Smilax* from the Dakota group, both of which are much larger-leaved and differ in other respects from the Raritan species.

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* Dawson, Trans. Roy. Soc. Can. 3^4: 14. *pl. 4. f. 4, 8.* 1886.

† Lesquereux, Fl. Dakota Group 166. *pl. 35. f. 7.* 1892.

‡ Hollick, Mon. U. S. Geol. Surv. 50: 91. *pl. 34. f. 14.* 1907.

OCCURRENCE: Locality unknown.

COLLECTIONS: New York Botanical Garden.

MYRICA HOLLICKI Ward, Amer. Jour. Sci. **45**: 437. 1893

Myrica grandifolia Hollick, Trans. N. Y. Acad. Sci. **12**: 5. *pl. 3. f. 1.* 1892. Not Schimper, 1872.

Leaves of large size, 18–22 cm. in length by 4–6 cm. in width, broadly lanceolate, widest near the middle and tapering equally to the acuminate apex and the cuneate base. Margins entire for a short distance above the base, elsewhere sharply serrate. Petiole long and stout. Midrib also stout. Secondaries slender, very numerous, being not more than 2–3 mm. apart, branching from the midrib at angles of 45° or slightly more, subdividing and inosculating near the margin and sending branches into the marginal teeth. [PLATE 18, FIGURE 2.]

The type of this exceedingly handsome species is a single incomplete specimen collected at Tottenville, Staten Island, sixteen or more years ago and now preserved in the museum of the Staten Island Association of Arts and Sciences. A single specimen was collected from the Lower Raritan at Milltown. It is a larger, slightly broader leaf with slightly less prominent teeth but is obviously identical with the type.

OCCURRENCE: Milltown.

COLLECTIONS: U. S. National Museum.

Quercus raritanensis nom. nov.

Quercus Johnstrupi Newb. Fl. Amboy Clays 69. *pl. 19. f. 7.* 1896. Not Heer.

Leaves ovate, subcoriaceous, apparently about 8–9 cm. in length by 4.5 cm. in width, pointed above. Margin with coarse pointed teeth, separated by rounded sinuses.

The New Jersey occurrence of this species is based on the single obscure fragment of the terminal half of a leaf figured by Professor Newberry and identified with *Quercus Johnstrupi* Heer, a Greenland species. The New Jersey form is obviously not the same as Heer's, which has pointed instead of rounded sinuses and is a smaller, more *Myrica*-like leaf, with the marginal teeth dentate rather than serrate.

The present species considerably resembles an undescribed *Quercus* from the Cretaceous of North and South Carolina but this resemblance cannot be construed as a proof of identity because of the incompleteness of the New Jersey material, consequently the present form is here renamed in allusion to the locality from which it was collected.

OCCURRENCE: Sayreville.

COLLECTIONS: N. Y. Botanical Garden.

Populus orbicularis (Newb.) comb. nov.

Phyllites orbicularis Newb. Fl. Amboy Clays 130. *pl. 24. f. 7, 8.* 1896.

Leaves orbicular, very slightly emarginate and slightly decurrent from the rounded base to the apparently short petiole, length about 5 cm. and breadth usually two or three millimeters less than 5 cm. Margin entire. Midrib moderately stout. Secondaries camptodrome, relatively coarse, about 6 pairs, subopposite, branching from the midrib at a wide angle, less curved than in the preceding, and inclined to be somewhat flexuous.

Newberry calls attention to the resemblance of this species to *Populus hyperborea* Heer, but is quite positive that it is not related to *Populus*. The writer does not share this opinion. Unless we are prepared to discard *Populus* for *Phyllites* in a large number of cases this species should surely be referred to the former genus. It is a remarkable coincidence, referred to in the present connection only because of its general interest, that the type of Sternberg's genus *Phyllites* was very likely a true *Populus* and that *Phyllites* as a form genus for undeterminable leaves will probably have to be dropped eventually in favor of some other name.

The present species is based upon scanty but perfect material confined to the Sayreville horizon.

OCCURRENCE: Sayreville.

COLLECTIONS: N. Y. Botanical Garden.

Salix raritanensis nom. nov.

Salix membranacea Newb. Later Ext. Floras 19. 1868; Fl. Amboy Clays 66. *pl. 29. f. 12.* 1896. Not Thuill, 1799.

Leaves broadly lanceolate, often unsymmetrical, large, petiolate, length about 13 cm. and breadth at the widest part, which is toward the base, about 3 cm. Base rounded and obtuse. Apex narrowed and acute. Texture smooth and thin. Midrib slender, somewhat curved. Secondaries remote, branching from the midrib at an angle of 45° and curving upward in parallel courses, camptodrome.

This is another species of *Salix* which it is difficult to define with precision. If the emphasis is laid upon the large size, thin texture, and rounded base, we have characters which are easily recognized and which can be made constant by elimination. It is apparently common in the Lower Raritan and has been reported by Hollick (*loc. cit.*) from Marthas Vineyard, the latter horizon probably of Magothy age. I have queried the small leaf figured by Hollick from Kreischerville, Staten Island, as it seems to be of a different consistency although it may be only a small leaf of this species. The latter author has tentatively included *Salix mattewanensis* Berry, which comes from the Magothy formation at Cliffwood, N. J., under this species. This is, in the writer's judgment, perfectly distinct and represents a much smaller, less elongated leaf, of a different consistency and venation.

Unfortunately, the original name *Salix membranacea* is preoccupied, so that it becomes necessary to propose a new name.

OCCURRENCE: Sayreville, Woodbridge, Milltown.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Salix pseudo-Hayei nom. nov.

Salix sp. Newb. Fl. Amboy Clays 68. *pl. 42. f. 6–8.* 1896.

Leaves small, relatively short and broad, ovate-lanceolate, uniformly about 3 cm. in length by 1.1–1.4 cm. in greatest breadth, which is about half way between the apex and base. Apex acuminate. Base rounded. Margin entire. Petiole short. Midrib slender and slightly curved. Secondaries fine, obscured in some specimens, five or six pairs, alternate, camptodrome, branching from the midrib at an angle of about 45° and curving upward.

This species is not uncommon in the Raritan, although Professor Newberry fails to mention the exact localities from which he collected it. Later material has come from the Lower Raritan at Milltown. It has been compared with the Dakota group species, *Salix Hayei* Lesq., and with the arctic Tertiary *Salix Raeana* Heer, both of which it resembles in general appearance. The Dakota group leaf, however, is coriaceous, with a coarse venation, blunt apex, and more narrow pointed base and is seen to be quite different from the Raritan species when careful comparisons are made.

OCCURRENCE: Milltown.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Salix Lesquereuxii nom. nov.

Salix proteaefolia Lesq. Amer. Jour. Sci. **46**: 94. 1868. — Newb. Fl. Amboy Clays 66. *pl. 18. f. 3, 4.* 1896. Not *Salix proteaefolia* Forbes, 1829.

Salix proteaefolia longifolia Lesq. Fl. Dakota Group 50. *pl. 64. f. 9.* 1892.

Proteoides daphnogenoides Newb. *p. p.*, Fl. Amboy Clays 72. *pl. 32. f. 11* (not *f. 13, 14*). 1896.

Dewalquea grönlandica Newb. *p. p.*, *op. cit.* 129. *pl. 41. f. 12* (not *f. 2, 3*).

Leaves ovate-lanceolate, somewhat more acuminate above than below, variable in size, ranging from 6 to 12 cm. in length and from 1.1 to 2.2 cm. in greatest width, which is usually slightly below the middle. Petiole stout, much longer than in *Salix flexuosa*, ranging up to 1.2 cm. in length. Midrib stout below, tapering above. Secondaries numerous, sometimes as many as twenty pairs; they branch from the midrib at angles of about 45° and are parallel and camptodrome.

Unfortunately, the name given this species was used for another by Forbes in 1829 so that it becomes necessary to rename it, and no name can be more appropriate than that of its distinguished describer, Leo Lesquereux, to whom it is here dedicated.

This is an exceedingly variable species, as might be expected in a *Salix*, and Lesquereux established several varieties, of which at least one, *i. e.*, *linearifolia*, is referable to *Salix flexuosa* Newb. Some of Lesquereux's forms are distinguishable with difficulty from the latter and this is especially shown in the leaves which he figures on plate 1 of his Cretaceous and Tertiary Flora. They are, however, larger and somewhat more robust, of a thicker texture and broadest near the base, from which they taper upward to an exceedingly acuminate tip. In general, *Salix Lesquereuxii* is a relatively much broader, more ovate form with more numerous and better seen secondaries and a longer petiole. It is a characteristic Cenomanian species in both the east and the west and has even been reported from the Cretaceous of Argentina by Kurtz. It is abundant in the Raritan formation both in the lower and upper beds.

OCCURRENCE: Sayreville, Woodbridge, South Amboy.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Ficus ovatifolia nom. nov.

Ficus ovata Newb. Fl. Amboy Clays *70. pl. 24. f. 1–3.* 1896. Not Don, 1802–03.

Leaves ovate 8–13 cm. in length by 4–7 cm. in breadth, petiolate. Apex extended, acute. Base rounded or somewhat descending. Margins entire. Principal veins three, from the base, the midrib being the stoutest and slightly flexuous. The lateral veins diverge at an angle of about 45° and curve upward, traversing somewhat more than the basal half of the leaf and connecting with branches from the lowest pair of camptodrome secondaries, of which there are several alternating pairs, which branch from the midrib at a wider angle. The laterals give off on the outside 8–10 camptodrome veins. Quadrangular areoles formed by nearly straight transverse nervilles fill all of the intervening space.

This species is very close to the same author's *Ficus Woolsoni*, which is a much less elongated, comparatively broader leaf, often with a cordate base in consequence.

The very appropriate name *ovata* is preoccupied, so that it becomes necessary to rename the Raritan species. It occurs also in the Bladen formation of North Carolina.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Garden.

Magnolia Hollicki nom. nov.

Magnolia auriculata Hollick, Bull. Torrey Club **21**: 61. *pl. 179. f. 6, 7.* 1894.—Newb. Fl. Amboy Clays 75. *pl. 58. f. 1–9, 11* (not *f. 10*). 1896. Not *M. auriculata* Lamarck, 1783.

Leaves orbicular-ovate, 4–10 cm. in length by 2–5.5 cm. in width, petiolate. Apex acute, slightly extended in one or two specimens. Base rounded occasionally, usually pronouncedly auriculate. Petiole and midrib stout. Secondaries few, 6 or 7 pairs, subopposite, camptodrome. Texture smooth and subcoriaceous.

This magnificent species is abundant and well preserved at the Woodbridge locality and Marthas Vineyard and in the Magothy formation of Maryland. Professor Newberry was somewhat uncertain as to its relationship with *Magnolia* and compared it with *Aristolochia*, *Polygonum*, and *Toxylon*. The latter is the only genus which is at all suggestive and it furnishes no instances of auriculate bases, while this character of a base prevails in more than one modern species of *Magnolia*. The outline, consistency, and venation are all in accord in pointing to *Magnolia* as the proper generic reference.

Unfortunately, the specific name *auriculata* had been previously used by both Lamarck and Desvaux in 1783 and 1789, so that the fossil species may well be renamed in honor of Dr. Hollick, who has done so much in the elucidation of the Cretaceous floras in the vicinity of New York.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Garden.

MAGNOLIA BOULAYANA Lesq.

Magnolia Boulayana Lesq. Fl. Dakota Group 202. *pl. 60. f. 2.* 1892.

Magnolia glaucoides Hollick, Bull. Torrey Club **21**: 60. *pl. 175. f. 1, 7.* 1894. — Newb. Fl. Amboy Clays 74. *pl. 57. f. 1–4.* 1896.

Leaves narrowly elliptical, usually uniform in size and shape, 8.5–13 cm. in length and 3.5–4.5 cm. in breadth. Apex usually bluntly rounded, sometimes acute. Base similar to the apex. Petiole moderately stout, 3–4 cm. in length. Midrib moderately stout. Secondaries slender, often obsolete, about 11 pairs, equidistant, parallel, camptodrome, branching from the midrib at an angle of about 40°. Tertiaries, when seen, transverse. Texture coriaceous.

This species was described originally from the Dakota group of Kansas. Professor Newberry described the Raritan remains, which are abundant at the Woodbridge locality, as a new species and it has been kept distinct by Hollick, who recognized however, its practical identity with the Dakota group plant. There can be no question but that they belong to the same species, which is also recorded from Marthas Vineyard and Long Island and from the Woodbine formation of Texas and the Tuscaloosa formation of Alabama.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Garden.

LAUROPHYLLUM NERVILLOSUM Hollick, Mon. U. S. Geol. Surv. **50**: 82. *pl. 27. f. 6, 7.* 1907

Proteoides daphnogenoides Hollick, Ann. N. Y. Acad. Sci. **11**: 420. *pl. 36. f. 1, 3.* 1898.

Leaves of comparatively large size, oblong-lanceolate, about 15 cm. in length by about 2.6 cm. in greatest breadth, which is about midway between the apex and base. Apex acuminate. Base pointed, narrowly cuneate. Midrib short. Secondaries thin, close, parallel, branching from the midrib at angles not exceeding and usually somewhat less than 45°, ascending, nearly straight or somewhat flexuous, branching and inosculating near the margin where they merge in the tertiary venation, connected by transverse nervilles.

This species was described originally from the terminal moraine at Tottenville, Staten Island, and undoubtedly represents transported Raritan materials. Three specimens are contained in the Milltown collection and the writer has also collected it from somewhat higher horizons south of New Jersey. It is somewhat like *Laurophyllum lanceolatum* Newberry but has a markedly different venation and a less lanceolate outline. It is also quite close to *Laurophyllum elegans* Hollick, which is, however, a more slender lanceolate leaf, with narrowly produced apex and base and a somewhat coarser venation, with less close and more curved camptodrome secondaries.

OCCURRENCE: Milltown.

COLLECTIONS: U. S. National Museum.

LAUROPHYLLUM ELEGANS Hollick, Mon. U. S. Geol. Surv. **50**: 81. *pl. 27. f. 1–5.* 1907

Laurus plutonia Hollick, Trans. N. Y. Acad. Sci. **11**: 99. *pl. 3. f. 3, 4.* 1892; **12**: 236. *pl. 6. f. 1.* 1893.

Proteoides daphnogenoides Hollick, Ann. N. Y. Acad. Sci. **11**: 420. *pl. 36. f. 2.* 1898.

Leaves elongate-lanceolate, somewhat flexuous, about 12–13 cm. in length by about 2 cm. in greatest width, which is about midway between the apex and the base; from this point they narrow gradually apically into an attenuated, acuminate, usually curved tip, and basally into a long, narrowly cuneate base. Midrib stout, stouter than in *Laurophyllum nervillosum* Hollick. Secondaries numerous, usually less close and somewhat coarser than in the latter species, branching from the midrib at an acute angle below, which becomes more open above the base of the leaf; they are usually more curved than in *L. nervillosum* and more distinctly camptodrome. Tertiaries transverse throughout.

These leaves were recorded originally by Hollick as *Laurus plutonia* Heer and were later compared with *Laurus angusta* Heer, which latter species they resemble more than they do the former. In outline they are not unlike *Laurophyllum angustifolium* Newb., from Woodbridge, N. J., but differ decidedly in venation. They are also similar but quite distinct from *Laurophyllum nervillosum* Hollick, and *Laurophyllum reticulatum* Lesq. of the Dakota group.

The specimens outside of those recorded in the present contribution from New Jersey and those which are as yet unpublished from the region south of New Jersey, are from transported materials associated with the terminal moraine from which numerous specimens have been collected. Those from Tottenville, Staten Island, are undoubtedly of Raritan age, while those from Glen Cove may have been originally from the Magothy formation, although they are probably Raritan.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

PHASEOLITES MANHASSETTENSIS Hollick, Bull. N. Y. Botanical Garden **3**: 414. *pl. 78. f. 1, 2.* 1904

Leaves ovate-falcate, markedly unsymmetrical, 6–7.5 cm. in length by 2.4–2.8 cm. in greatest breadth, which is below the middle of the leaf. Margins entire. Apex acute. Base cuneate. Petiole short and stout. Midrib stout and curved. Secondaries fine, about 9 pairs, often obsolete, diverging from the midrib at an acute angle. [PLATE 18, FIGURE 3.]

This species was described from Manhasset Neck, Long Island, a locality which should probably be included within the Raritan formation. The species is scarcely distinguishable from *Phaseolites elegans*, described by the same author from Brooklyn, and both are very close to the Dakota group *Phaseolites formus* Lesq., in fact, it is scarcely conceivable that these extremely limited variations are not all of a single species. However, they should be allowed to stand until more abundant and complete material is at hand for comparison. Another comparison which is suggested is with *Hymenaea dakotana* Lesq.

The Milltown leaf, of which two specimens have been found, is more suggestive of *Phaseolites elegans* in general appearance than it is of the species with which it is identified. This is due to its more slender apical portion. On the other hand, it shows the very full convex base on one side, and the more acutely branching secondaries which are considered specific characters of *Phaseolites manhassettensis*.

OCCURRENCE: Milltown.

COLLECTIONS: U. S. National Museum.

Leguminosites raritanensis sp. nov.

Leaflets large, 7.5 cm. by 5.1 cm., almost a perfect ellipse in outline, slightly emarginate at the apex. Midrib thin and straight. Secondaries numerous, nearly straight, ascending at an angle of about 45°, camptodrome, of delicate calibre and scarcely discernible. [PLATE 18, FIGURE 4.]

This species is based upon a single individual and seems properly referable to this genus. In outline it suggests some of the forms which have been referred to *Populus* but its venation is quite different. It resembles also some of the specimens referred to *Liriodendropsis*, which is simply another way of emphasizing the fact that it is a leguminous leaflet of unknown generic affinities.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

Caesalpinia raritanensis sp. nov.

Elliptical leaflets about 3 cm. long and 2.2 cm. broad, with markedly emarginate apex. Midrib missing. Secondaries branching at a wide angle, almost 90°, and but slightly curved, anastomosing by broad evenly rounded loops about two thirds of the distance to the margin.

This is possibly only an extraordinarily large leaflet of *Caesalpinia Cookiana* Hollick, somewhat more elongated in outline and strictly congeneric with that species. It is, unfortunately, based upon a single imperfect specimen.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

Citrophyllum gen. nov.

Fossil spermatophytes with elliptical to ovate or ovate-lanceolate, coriaceous leaves, with entire or slightly undulate margins and stout conspicuously alate petioles. Secondary venation fine, more or less immersed, regular, camptodrome. Embracing leaves of the same general character as those of the modern genus *Citrus* and very similar to them.

Citrophyllum aligerum (Lesq.) comb. nov.

Ficus aligera Lesq. Fl. Dakota Group 84. *pl. 10. f. 3–6.* 1892.—Berry, Rep. State Geologist [N. J.] for 1905, 139. 1906; Bull. Torrey Club **33**: 172. 1906.

Leaves small, elliptical to ovate or ovate-lanceolate, coriaceous, varying from 2.5 to 6 cm. in length by 1.8–3.2 cm. in breadth. Margin entire, occasionally slightly undulate. Apex rounded or obtusely acuminate. Base rounded, subtruncate or cuneate. Petiole stout, 0.7–2 cm. in length, conspicuously alate. The petiolar wings may be oblong-lanceolate or obovate; together they are from 2.5 to 5 mm. in width, averaging about 3.5 mm. Midrib stout. Secondaries fine, more or less obscured by the coriaceous leaf-substance, about 9 alternate pairs, branching from the midrib at angles of from 45 to 50°, parallel, camptodrome. [PLATE 18a, FIGURES 1–8.]

These curious leaves were described by Lesquereux from the Dakota group as a species of *Ficus* and compared with *Ficus bumelioides* Ettings. and *Ficus Mudgei* Lesq., neither of which has alate petioles, while the first has an emarginate apex. Subsequently, the same leaves were found in the Magothy formation of New Jersey and only recently a single small leaf was found in the Upper Raritan beds of South Amboy. They exhibit considerable variability in outline, but all have exactly the same aspect and conspicuous alate petioles. They appear to be related to the leaves of the modern genus *Citrus.* The latter have exactly the same texture and venation, the same variability in outline and marginal undulations, the same stout midrib and conspicuously alate petioles. In examining a suite of specimens of the latter and comparing them with the fossils the conclusion seems to be irresistible that they are related and the writer has consequently referred the fossils to a new genus with a name that emphasizes this relationship to the modern genus. All of the fossil specimens that are at all complete are figured on PLATE 18a and two modern leaves are introduced for comparison. Possible arguments against the present view may be based on the theory that the modern alate petioles are derived from ancestors with compound leaves, in fact some modern species still have trifoliolate leaves and if this were true of the fossils as well it would require considerable rapidity of evolution in this genus previous to the Mid-Cretaceous. The modern leaves absciss from the top of the petiole and would be unlikely to occur as fossils with the petiole attached, neither can any indication of such an abscission line be made out in the fossils. This is the most difficult argument to combat. However, modern leaves are sometimes shed in their entirety and we are justified in predicating the occasional fall of leaves before maturity when the abscission layer of cells has not yet become weakened. The agency might be violent winds, the passage of large animals like some of the Cretaceous dinosaurs, or weakened conditions due to insect or fungus diseases.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

Ilex amboyensis nom. nov.

Ilex? ovata Newb. Fl. Amboy Clays 98. *pl. 18. f. 2.* 1896. Not Goepp. 1852.

Leaves small, broadly lanceolate, about 4 cm. in length by 2 cm. in breadth. Apex obtuse. Base narrowed and apparently acute. Margin beset with small and large subacute teeth. Midrib moderately stout and curved. Only a few secondaries are visible; these branch from the midrib at angles of about 45° and with but slight curving run directly to the marginal teeth.

This species was based on the single specimen figured by Professor Newberry (*loc. cit.*) and no additional specimens have come to light. Professor Newberry's name was a preoccupied one and the present name is given in allusion to the general locality.

OCCURRENCE: Sayreville.

COLLECTIONS: N. Y. Botanical Garden.

Pterospermites obovatus (Newb.) comb. nov.

Protophyllum obovatum Newb. Fl. Amboy Clays 128. *pl. 38. f. 4.* 1896.

Leaf elliptical, about 12 cm. in length by 7.5 cm. in greatest breadth, which is near the middle. Margin entire. Midrib stout. Secondaries about 10 pairs, subopposite to alternate, comparatively slender and somewhat flexuous, camptodrome. Apex apparently rounded. Base contracted and then prominently auriculate, the three or four secondaries involved radiating from the base of the midrib.

This species is based upon a single specimen from Woodbridge, which Professor Newberry suggested may be related to the modern species of *Coccoloba*.

Very little can be said in favor of the reference of this leaf to Lesquereux's genus *Protophyllum*, all of the species of which differ from it in outline and marginal characters. Professor Newberry places great reliance upon the character of the base, but in the Raritan specimen this is decidedly auriculate and not subpeltate and the veins in this part of the leaf are radiate and not more or less parallel. Finally, the venation is distinctly camptodrome and not craspedodrome as it is in Lesquereux's definition of the genus and in all the other species which have subsequently been referred to it. For these reasons it is here placed in the genus *Pterospermites*, which seems to be a more natural arrangement. It may be compared with *Pterospermites auriculatus* Heer * of the Atane beds of Greenland which, while somewhat different in outline, is a leaf of the same general facies and is undoubtedly congeneric.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Garden.

EUCALYPTUS ANGUSTA Velen.

Eucalyptus angusta Velen. Fl. Böhm. Kreidef. 4: 3. *pl. 3. f. 2–12.* 1885; Květena českého cenomanu 21. *pl. 6. f. 1.* 1889.—Sap. Fl. Foss. Portugal 207. *pl. 36. f. 12.* 1894.

"Blätter lineal, schmal lineallanzettlich, in der Mitte oder in der unteren Hälfte am breitesten, ganzrandig, vorne in eine sehr lange Spitze vorgezogen und mit einem harten Dorn beendet. Der Primärnerv gerade, ziemlich stark, zur Spitze hin verdünnt. Die Secundärnerven zahlreich, unter spitzen Winkeln entspringend, am Rande durch einen Saumnerv untereinander verbunden. Der Blattstiel gerade, etwa 1 cm. lang, stark." Velenovsky, 1885.

The foregoing is Velenovsky's description of this interesting species, which is exceeding common at a number of localities in

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* Heer, Fl. Foss. Arct. 6^2: 95. *pl. 27. f. 4.* 1882.

the Perucer-schichten of Bohemia (Cenomanian), where the author subsequently found fruit-bearing twigs which he described and figured in 1889 and which, it would seem, conclusively establish the botanical relations of these leaves.

Subsequently, Saporta (*loc. cit.*) recorded this species from the Albian beds of Portugal; the latter material is, however, rather incomplete and open to question. Recent collections in our own coastal plain show that this species was present in considerable abundance on this side of the Atlantic at the same time that it flourished in Europe. It has been collected from the upper Raritan at South Amboy, where it is common, from the Bladen formation of South Carolina, and from the Upper Cretaceous of Georgia, and may be somewhat more fully characterized as follows:

Leaves alternate or scattered, mostly elongated, linear-lanceolate, often falcate, 4.5–15 cm. in length by 5–13.5 mm. in width, with an attenuated acute tip and a narrowly cuneate base declining to the short and stout petiole. Midrib moderately stout below, becoming attenuated above. Secondaries very numerous, fine, and close, about 1 mm. apart, parallel, rather straight; they branch from the midrib at acute angles of about 30° or slightly less and run with but slight curvature to join the well-marked but fine marginal hem, which shows in all the American material and in most of the illustrations of the foreign material. [PLATE 18, FIGURE 5.]

In all respects this is one of the most characteristically *Eucalyptus*-like species of the many which have been so identified; and its totality of characters combined with the presence of attached fruits in the Bohemian material, which are not unlike some of those of modern forms, renders the identification very satisfactory.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

Andromeda Cookii nom. nov.

Andromeda flexuosa Newb. Fl. Amboy Clays 121. *pl. 34. f. 1–5.* 1896. Not Moon, 1849.

Leaves coriaceous, variable in size, lanceolate, 6–12 cm. in length by 1.5–3 cm. in width, with an acuminate apex and a somewhat cuneate base. Midrib stout and flexuous. Secondaries strong, somewhat flexuous, branching from the midrib at an acute angle and arching upward in long curves, camptodrome. Tertiaries mostly simple, transverse, forming oblong areoles.

This species is of the same general character as the other Raritan species of *Andromeda*, with which it is strictly congeneric. It is a common form in the Lower Raritan, although most of the specimens are imperfect. Elsewhere it is recorded from Glen Cove, Long Island, but the material from the latter locality is not very conclusive. The name given to this species by Newberry was unfortunately preoccupied and the name here used is given in honor of the late George H. Cook, whose work on the Raritan and allied formations has furnished the basis for all subsequent studies.

OCCURRENCE: Sayreville, Woodbridge, Milltown.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Myrsine Gaudini (Lesq.) comb. nov.

Myrsinites? Gaudini Lesq. Fl. Dakota Group 115. *pl. 52. f. 4.* 1892.

Myrsine elongata Hollick, Bull. Torrey Club **21**: 54. *pl. 177. f. 2.* 1894. — Newb. Fl. Amboy Clays 122. *pl. 22. f. 1–3.* 1896.

Leaves oblanceolate or elongate-obovate, 5.5–7 cm. in length by 1.9–2.5 cm. in greatest width. Margin entire. Apex obtusely rounded. Base somewhat elongated, narrowly cuneate. Petiole present, stout. Midrib stout below, rapidly diminishing in calibre. Secondaries numerous, 8–10 pairs, alternate, branching from the midrib at angles of from 40° to 45°, camptodrome. When tertiary venation is distinctly preserved, the venation is more typical than when only the secondaries are partially visible.

This species is well distributed in the Raritan and has been recorded also from Long Island and Staten Island. The identification of *Myrsinites? Gaudini* Lesq. with the eastern forms with which it is obviously identical extends the range eastward from Kansas to Long Island. It may be readily distinguished from the other Raritan species by its relatively narrow elongated form. It is also present in undescribed collections of the writer from North Carolina and Alabama.

OCCURRENCE: South Amboy, Milltown.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Diospyros amboyensis nom. nov.

Phyllites ellipticus Newb. Fl. Amboy Clays 130. *pl. 24. f. 9.* 1896.

Leaves elliptical, large, 8 cm. long by 4–6 cm. broad. Margin undulate. Apex rounded, almost retuse. Base broadly rounded, thus differing from the wedge-shaped base of *D. primaeva.* Midrib strong, although not so strong as in the latter species. Secondaries numerous, 8–10 pairs, regular, leaving the midrib at an angle of about 45°, camptodrome. Tertiary venation of large polygonal meshes finer in calibre than in *D. primaeva.*

Unfortunately, no specimens other than Newberry's original type have been found and it is possible that it was an aberrant leaf of the common *Diospyros primaeva,* some undoubted leaves of which suggest it in their sum of characters. One of the leaves which Heer identifies from the Atane schists of Greenland as *Populus hyperborea,** while the apex is partially destroyed and the tertiaries are not shown, is very similar to the species under discussion. This similarity does not extend, however, to the other leaves identified as this species. Newberry's specific name having already been used for a species of *Diospyros,* it becomes necessary to rename the Raritan plant.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Gerden.

Acerates amboyensis Berry

Acerates sp. Hollick in Newb. Fl. Amboy Clays 124. *pl. 32. f. 17; pl. 41. f. 4, 5.* 1896.

Leaves narrow and elongated, somewhat falcate, lanceolate or linear-lanceolate, 5–7.5 cm. in length by 5–8 mm. in breadth, gradually narrowed above and cuneate below. Margin entire, somewhat undulate. Petiole apparently wanting. Texture thick. Secondaries numerous, rather angular, branching from the midrib at acute angles, camptodrome.

There is no reason why this species should not have a specific name, if only for purposes of intelligent citation. It is, however, perfectly distinct from the other members of the Raritan flora and is easily recognized. It is confined to the Upper Raritan in New Jersey but occurs in the Bladen formation of North Carolina. Several species of *Acerates* are described by Heer from the Greenland Cretaceous.

OCCURRENCE: South Amboy.

COLLECTIONS: N. Y. Botanical Garden.

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* Heer, Fl. Foss. Arct. 3^2: *pl. 29. f. 6.* 1874.

Explanation of plates 18 and 18a

PLATE 18

FIG. 1. *Asplenium raritanense* sp. nov., Hylton Pits, N. J.
FIG. 2. *Myrica Hollicki* Ward, Milltown, N. J.
FIG. 3. *Phaseolites manhassettensis* Hollick, Milltown, N. J.
FIG. 4. *Leguminosites raritanensis* sp. nov., South Amboy, N. J.
FIG. 5. *Eucalyptus angusta* Velen., South Amboy, N. J.

PLATE 18a

FIG. 1. *Citrophyllum aligerum* (Lesq.) Berry, South Amboy, N. J.
FIGS. 2–5. *Citrophyllum aligerum* (Lesq.) Berry, Cloud Co., Kansas.
FIGS. 6–8. *Citrophyllum aligerum* (Lesq.) Berry, Cliffwood Brick Company, N. J.
FIG. 9. *Citrus vulgaris* Risso, Florida.
FIG. 10. *Citrus Limonum* Risso, St. Croix.

Some unsolved problems of the prairies

HENRY ALLAN GLEASON

Of the territory now known as Illinois, probably two thirds was originally occupied by the various plant associations constituting the type of vegetation known as prairie.* Poorly developed in southern Illinois, and extending but a short distance east into Indiana or north into Wisconsin, they swept to the west across Iowa, and in Nebraska united with the main portion of the prairie province, which extends northward from Texas on the south into the British possessions. This eastern extension has been appropriately named by Pound and Clements the eastern arm of the province, and its position is shown with considerable accuracy in their paper † on "The vegetation regions of the prairie province." The Illinois prairies alone are referred to in this paper.

Unfortunately for the ecologist, the prairies of Illinois were converted into cornfields long before the development of ecology and phytogeography in America, thus forever prohibiting the *satisfactory* investigation of some questions of the most absorbing interest and also of considerable importance in aiding a clear

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*Following the stimulating and valuable example of Harper (Ann. N. Y. Acad. Sci. **17**: 25. 1906) concerning the meaning of the terms "swamp" and "branch," the use and restriction of the term "prairie" may be discussed. According to the Century Dictionary, the word is derived through the French from the Latin *pratarium* or meadow-land, and was first applied by the early French explorers to the broad expanses of grassland of Illinois, Iowa, and neighboring states. The English language, developed in a forested country, had no regular word for grassland except meadow, the meaning of which was restricted by local conditions to cultivated land or to the small strips of grassland along ponds or streams. When the word prairie was adopted from the French into the English, it was still limited to the grassland of the region mentioned above; it was and is a local term, and should be kept so. Other similar grass-covered lands in different parts of the hemisphere have received analogous names which have become more or less established in the language. Such are pampas in southern South America, llanos in northern South America, and savannas in the southeastern United States. The term prairie should be applied to none of these, nor to any other areas of grassland except those of the limited territory of the Middle West, covered by the prairie province.

† Bot. Gaz. **25**: 381–394. *pl. 21.* 1898.

understanding of American ecology and phytogeography in general. The thoroughness with which original conditions have been destroyed over central and northern Illinois is surprising to the botanists of the more densely populated, but sparsely settled East. In most of the counties of this part of the state there is absolutely no virgin prairie or forest, and in other cases the prairies are limited to narrow strips along railroads or small streams. In one case they are modified either by civilization or by burning and in the other they are not typical of the original upland prairies. Cook County, in which is located Chicago with its two million inhabitants, is mainly outside of the prairie province, but contains ten times as much unused land as do Champaign, MacLean, or Livingston counties, located in the "corn belt." On the other hand, Cook County offers poor facilities for field work in comparison with the vicinity of New York City.

The opportunity for study is, however, not entirely lost, but the investigation is made more difficult, and every succeeding season lessens the possibility of work along this line. In this paper there are merely indicated some of the particular questions that still await satisfactory solution, in the hope of awakening interest, and, if possible, stimulating research along this line. The questions are by no means entirely unanswered; every ecologist has a general idea in regard to them, but the detailed information is for the most part lacking. Our information may be drawn from a number of sources, some of which may be enumerated:

1. Books of travel and description, of which many are extant, though they are unfortunately more picturesque than scientific in their method of treatment. These begin with the published works of the early French explorers, Marquette and Hennepin, and extend to the middle of the last century. They are particularly numerous between 1810 and 1850, when the prairie country was being most rapidly settled.

2. A fairly good knowledge of the prairie flora, which we owe to Bebb, Mead, Vasey, Hall, and Brendel, of a past generation, and which may still be supplemented by direct observation along roadsides and railroads.

3. Several areas of considerable extent on which prairies are still preserved, but under abnormal conditions, such as the swampy

prairies in the Chicago area, described by Cowles,* and the sand prairies along the Illinois River,† and in other parts of northwestern Illinois.‡

4. Comparisons with the still existing prairies farther west, as described by ecologists from Iowa, South Dakota,§ and Nebraska.||

By carefully combining observations taken from as many standpoints as possible we should still be able to reconstruct for ourselves, so to speak, the prairies of the state and to solve many of the ecological questions which they call up.

Some of the questions that have occurred to me are these:

1. What were the conditions, climatic or of other nature, at the close of the glacial epoch, which led to the invasion of prairie plants from the west rather than forest plants from the southeast? Certain climatic conditions are more favorable to the growth of prairie than of forest, notably a low winter rainfall, and it is noteworthy that this type of rainfall is quite well developed in northern Illinois, and thence west, but not in Indiana, or in southern Illinois. Transeau's interesting map,¶ comparing rainfall and evaporation, is also pertinent here. Prairie plants complete their cycle of development more rapidly than forest trees, and might enter the territory sooner on that account. But if trees had migrated to the north and west ever since the glacial period at a rate equal to their present movement, the present state of Illinois would undoubtedly, by this time, have been covered entirely with forest. If the American botanists will use more geological evidence in their work, and if it can be used here as successfully as by the German phytogeographers, Schulz for example, considerable light will be thrown on this important point. The actual cause of the

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* Bot. Gaz. **31**: 73–108; 145–182. *f. 1–35.* 1901.

† Gleason, Bull. Ill. State Lab. Nat. Hist. **7**: 149–194. *pl. 8–23.* 1907.

‡ A more detailed paper on other inland sand areas of the state is now in preparation.

§ Harvey, Floral succession in the prairie-grass formation of southeastern South Dakota. Bot. Gaz. **46**: 81–108; 277–298. *f. 1–4.* 1908.

|| Pound and Clements, *loc. cit.*

———. The phytogeography of Nebraska. Lincoln, 1900.

Thornber, The prairie-grass formation in region I. Bot. Surv. Nebr. **5**: 29–143. 1901.

¶ Forest centers of eastern America. Amer. Nat. **39**: 875–889. *f. 1–6.* 1905.

treelessness of the prairies, which has been so widely discussed by geologists and by a few botanists also, is not to be found in any of the present conditions, but in the accumulated effects of centuries of arid climate in the southwest, from which direction the plants of our prairies immigrated.*

2. The flora of the prairies of the Wisconsin glaciation in the northern part of Illinois is very different from that of the Illinoisian glaciation at the south, estimated to be eight times as old. Does this flora at the south indicate the survival of a pre-Wisconsin interglacial flora, which persisted during the Wisconsin period, or an invasion of prairie species from a different direction or at a different time, or merely an adaptation to different conditions of soil, temperature, or rainfall, or something else? So far as I know, no one has attempted to account for this peculiar feature of the Illinois flora. Personally, it seems that it must in some way be related to, or caused by, pre-Wisconsin conditions, although what those conditions were I have no idea. Certainly, an understanding of this question would aid in answering the first one also.

3. The aquatic plants surrounding the sloughs and ponds of the prairie were generally of broad distribution, or at least in no wise typical of the prairie province. The latter class of plants was usually semi-xerophytic, and occurred in the uplands. What is the significance of this? Does it throw any light upon the order of entrance of plants, and of western plants in particular, into this area?

4. The occurrence of scattered colonies of prairie species beyond the eastern limits of the province may indicate a former more extensive range of the prairie. A notable example of this is the colony on Cedar Point, near Sandusky, Ohio,† probably two hundred miles east of their normal limits. Will it be possible by careful search for such relict colonies in other places to determine what was the maximum extension of the prairie? This would aid in giving a good idea of the rate of invasion of the forest.

5. The isolated occurrence of the western plants on Cedar

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* Cf. Harvey, *loc. cit.*, 84.

† Jennings, An ecological classification of the vegetation of Cedar Point. Ohio Nat. **8**: 291–340. *f. 1–22.* 1908.

See also Bonser, Ecological study of Big Spring prairie, Wyandot County, Ohio. Ohio Acad. Sci. Special Paper 7. 1903.

Point may be compared with the presence of *Cristatella Jamesii* and *Lesquerella argentea* on the sand dunes along the Illinois and Mississippi rivers, many miles from the nearest reported station in Nebraska or Dakota, or of *Opuntia fragilis* in northwestern Illinois. A number of insects found there have also a similar distribution, as shown by Mr. C. A. Hart. Neither of the plants has any means of dispersal adequate to bridge over this gap, and we can only assume that at one time they had a distribution more nearly continuous. What have been the causes which have restricted them to these widely separated stations? Is it possible that there was a post-glacial period with so little rainfall that their distribution was continuous over the whole desert-like intervening territory? And if so, what other Neo-Sonoran plants also reached into Illinois at that time? Did we ever have *Echinocereus viridiflorus*, *Cactus missouriensis*, *Cucurbita foetidissima*, *Yucca glauca*, or other plants of similar habits in this state?

The preceding questions have been phytogeographical in nature rather than ecological and have to do mainly with the historical development of the prairies. Following are some that relate more directly to ecology:

6. What was the structure of the original prairie associations? The remnants of the prairie flora still existing along our railroad tracks give only a faint idea of the normal structure of the prairie vegetation. The older botanists neglected this matter almost entirely, although it was open to direct observation. So far as I know, but one botanist, C. W. Short, discusses the subject, in an article published in 1845. He mentions particularly the aggregation of individuals of one species and contradicts the idea given by popular, more impressionistic writers. "The flora of the prairies, the theme of so much admiration to those who view them with an ordinary eye, does not, when closely examined by the botanist, present that deep interest and attraction which he has been led to expect. Its leading feature is rather the unbounded profusion with which a few species occur in certain localities than the mixed variety of different species occurring everywhere." Probably the time has passed when this question could have been satisfactorily answered.

7. Within every complex of related plant associations there

are one or more definite orders of succession, leading from pioneer to climax associations. The steps in the succession follow each other in a regular series and constitute what may be called a normal succession. The normal succession for prairie associations has not yet been fully investigated. Cowles has described a portion of it in the pond-swamp-prairie series in the Chicago area,* and I have discussed some of the successions on prairie-covered dunes,† but this by no means exhausts the subject.

8. It is a matter of common knowledge that in this region the forest is everywhere pushing out upon the prairie. This matter has been investigated by but few, and we are still ignorant, if we may depend upon the published accounts of direct local observation, of the factors which tend to retard or accelerate the advance of the forest, or of the nature of the tension zone between the two associations, or of those particular species which may be called the pioneers in the forest advance.§ It may be said at this point that the forest undoubtedly invaded the prairie along two distinct lines, a hydrophytic to mesophytic advance longitudinally along the water courses, probably led by cottonwood, elm, maple, and ash, culminating in the climax flood-plain forest, and a xerophytic lateral advance along the bluffs, led by oak and hickory. Likewise we do not know what species, normally of the forest, migrated independently into the prairie and there, constituting the derived element of the prairie flora, possibly aided in resisting the encroachments of the forest. Neither do we know why the forest in central and southern Illinois invaded along the river courses, while in northern Illinois it advanced also along the morainic hills, nor what was the effect of prairie fires in checking the spread of the forest. Each of the points is still open to direct observation, to some extent at least; and by a careful study of the habitats of various forest species along country roadsides, at the margins of woods, along small streams, and in woodland pastures, we should still be able to get some idea of the structure of the original forest margin, and with it of the pioneer species in the forest advance.

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* *Loc. cit.* 155, 156.

† *Loc. cit.* 158–171.

§ Harvey (*loc. cit.*) gives a good general summary of this subject.

For lack of a better name this type of succession may be called abnormal, to distinguish it from the normal type mentioned before.* The abnormal succession here is between Upper Austral prairies and Upper Austral forest. The prairie came in contact also with the transition zone forests at the north, and between them there is still another type of succession to be studied, even more abnormal in nature, and possibly entirely different in operation. Our Illinois prairies also approached the Lower Austral zone in southern Illinois, but there was apparently no transition between them.

These questions are by no means the only ones still awaiting investigation in the Illinois prairies. Others equally important will present themselves at once to every ecologist. Local conditions will produce local questions whose solution may throw much light on the broader problems of the prairies as a whole. Those that I have given refer entirely to the phytogeographical and associational sides of ecology. I have not touched upon any of the numerous and varied questions of individual or physiological ecology, such as light relation, water requirements, transpiration, individual or specific relations to the environment, and the like; nor have I mentioned any questions concerning the taxonomic side of the flora, which should still yield many interesting species to the modern systematist.

UNIVERSITY OF ILLINOIS,
URBANA, ILLINOIS.

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* An excellent discussion of these two general types of succession has been given by Transeau in his "The bogs and bog flora of the Huron River valley," Bot. Gaz. **40**: 351–375, 418–448. 1905; **41**: 17–42. *f. 1–16.* 1906. See especially **41**: 38.

Notes on the embryo-sac of Passiflora adenophylla

MELVILLE THURSTON COOK

(WITH PLATE 19)

While in Cuba, about two and a half years ago, the writer had occasion to make a study of the characters of the embryo-sacs and embryos of a number of tropical plants. While pursuing this work attention was called to *Passiflora adenophylla* Mast.* which was growing luxuriantly in the botanical garden of the Agricultural Experiment Station at Santiago de las Vegas. Unfortunately, a sufficient amount of material for a complete study was not secured before leaving the island. However, the facts brought out by the study were so interesting that it has been considered advisable to present them at this time.

The early stages in the formation of the embryo-sac were not observed. The four-nucleate stage (FIG. 1) did not vary from the usual form. It was about twice as long as broad and the two nuclei at the micropylar end were somewhat larger than the two at the antipodal end. In the eight-nucleate stage (FIG. 2) the sac had elongated to about three times the length of the four-nucleate sac and the antipodal half was considerably narrower than the other half. The egg was considerably larger than the two synergids, the antipodals were well defined and the two polar nuclei unite near the egg (FIGS. 2 and 4).

The pollen-tube is very prominent (FIGS. 3, 6, and 7) and the two sperm-nuclei are clearly visible after their escape into the sac (FIG. 3). Double fertilization was very evident (FIGS. 4 and 5) and was observed in a great many preparations. In fact the writer has never examined plants in which double fertilization was so conspicuous.

However, the most interesting feature of this study was the peculiar behavior of the pollen-tube, which, as previously stated, was very prominent. In the majority of cases it does not discharge its nuclei but continues its growth within the sac, eventually

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* Determined by Dr. J. N. Rose, of the National Museum, Washington, D. C., where a specimen has been deposited. It is a native of Brazil.

filling it (FIGS. 6, 7, and 8) and becoming very much twisted and tangled in the process. The growth of the tube seems to be so vigorous that its entrance into the embryo-sac usually results in the complete absorption of the egg-apparatus (FIGS. 6 and 7) and eventually of the entire contents of the sac. In those cases in which the tube does not burst, the egg-apparatus begins to disintegrate immediately upon the entrance of the tube (FIGS. 6 and 7). The sac then enlarges and the tube makes a vigorous growth, enlarging in both diameter and length and eventually filling the sac with a very much tangled mass (FIG. 8), which apparently draws its nourishment from the nucellus. It stains very deeply with haematoxylin. In the material from which this study was made, this condition was the rule and not the exception. It appears that the parasitic nature of the pollen-tube in these cases has developed in excess of the usual manner and that instead of performing the function usually performed by this organ, it really prevents the formation of the embryo.

In some instances the pollen-tube acted in the usual manner (FIGS. 3 and 4) and several cases were observed in which the egg had the appearance of having been fertilized (FIG. 4). A satisfactory study of the embryo was impossible because of the lack of material.

A number of sacs were observed in which a non-cellular endosperm had been formed (FIG. 9). In no case was the endosperm and an abnormal pollen-tube observed in the same sac.

DELAWARE AGRICULTURAL EXPERIMENT STATION,
NEWARK, DELAWARE.

Explanation of plate 19

FIG. 1. Four-nucleate embryo-sac.

FIG. 2. Eight-nucleate embryo-sac.

FIG. 3. Micropylar end of the sac, showing the egg, the pollen-tube and two sperm-nuclei.

FIG. 4. Micropylar end of the sac, showing the fertilized egg, the two polar nuclei in the act of uniting, and one sperm-nucleus.

FIG. 5. Union of the two polar nuclei and one sperm-nucleus.

FIG. 6. Micropylar end of the embryo-sac, showing the entrance of the pollen-tube without rupturing, and the egg-apparatus in early stage of disintegration.

FIG. 7. Micropylar end of the embryo-sac, showing later stage in the growth of the tube and the further disintegration of the egg-apparatus.

FIG. 8. Later stage in the development of the embryo-sac, showing it almost entirely filled by the excessive growth of the pollen-tube.

FIG. 9. The endosperm.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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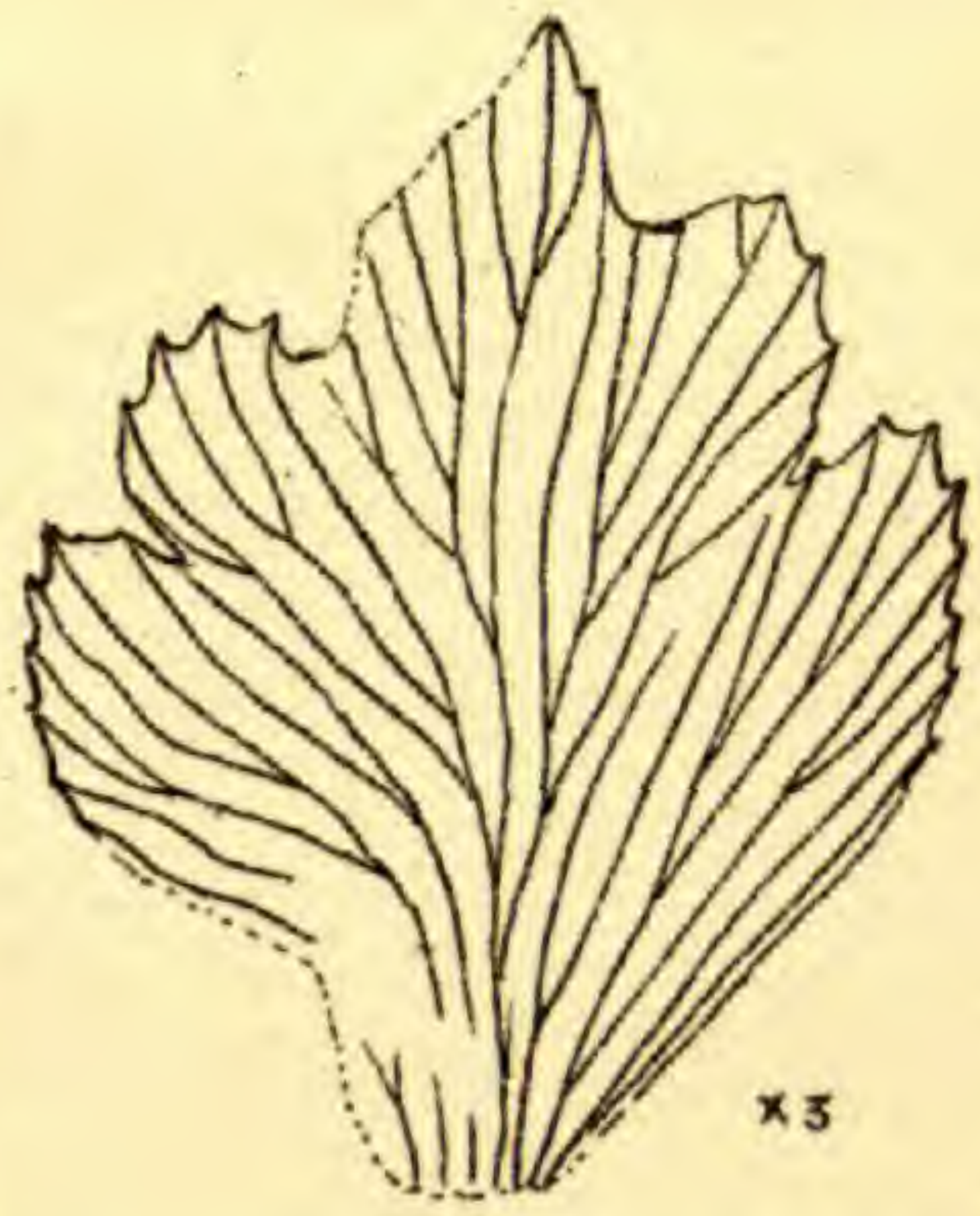

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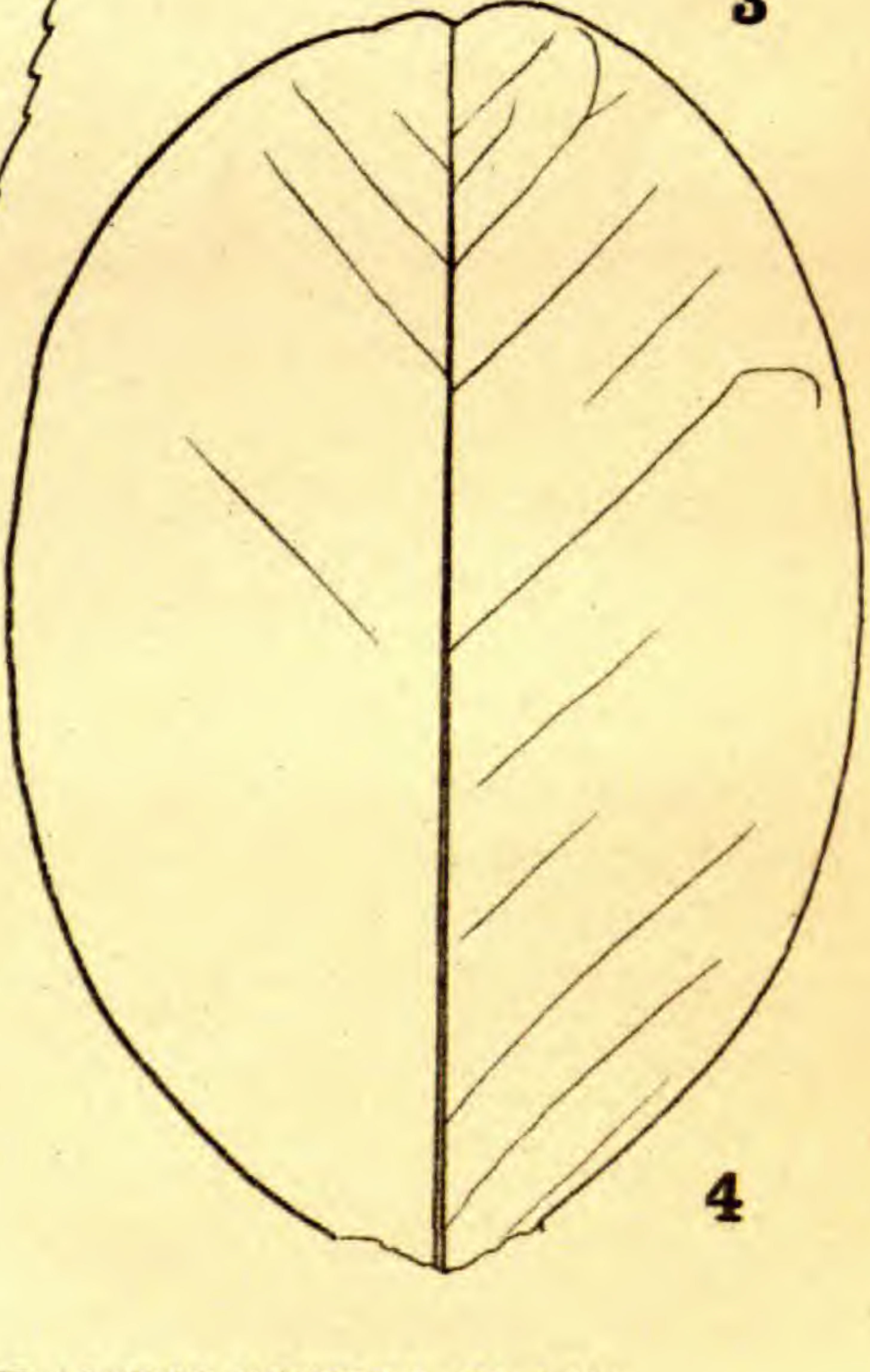

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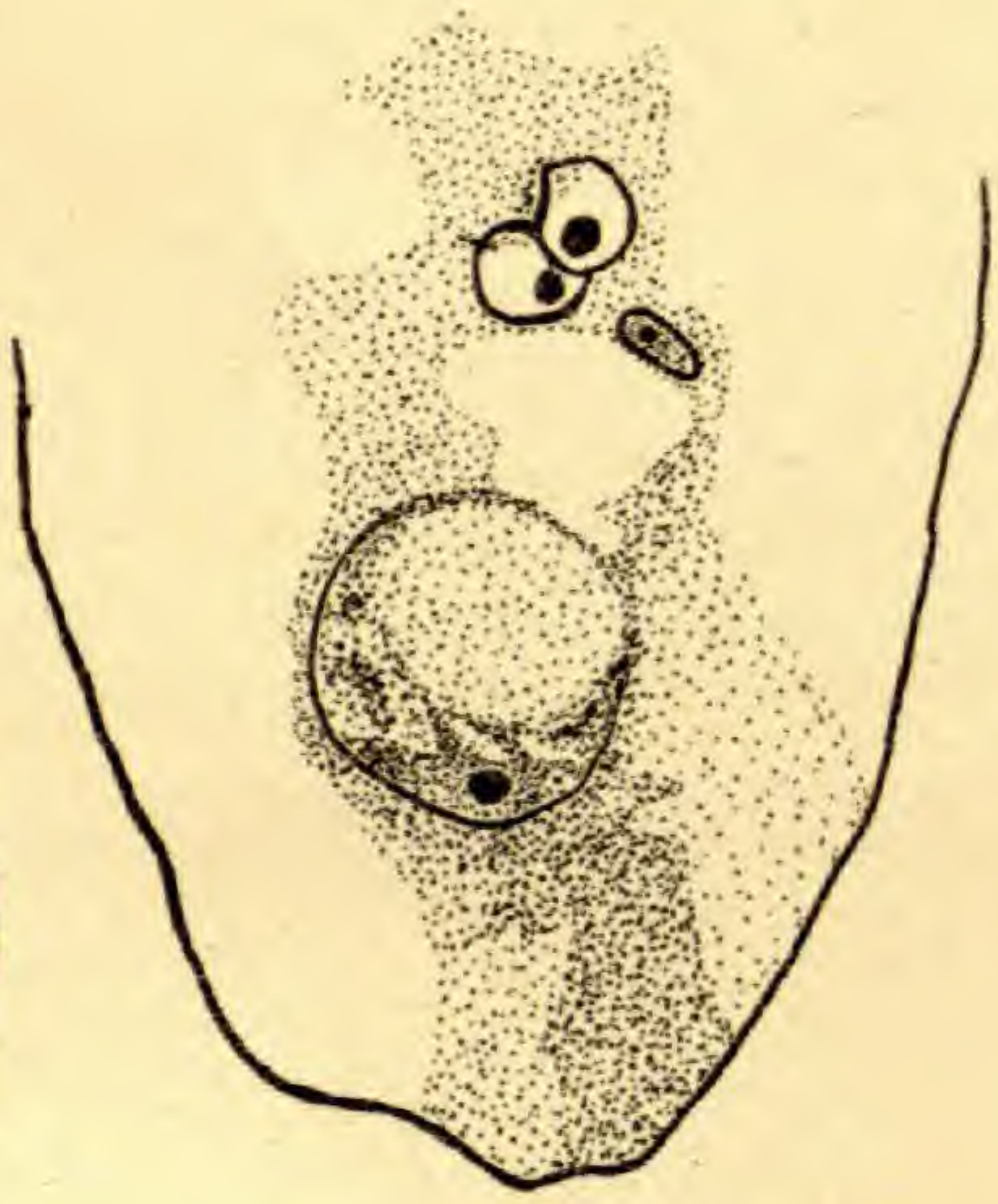

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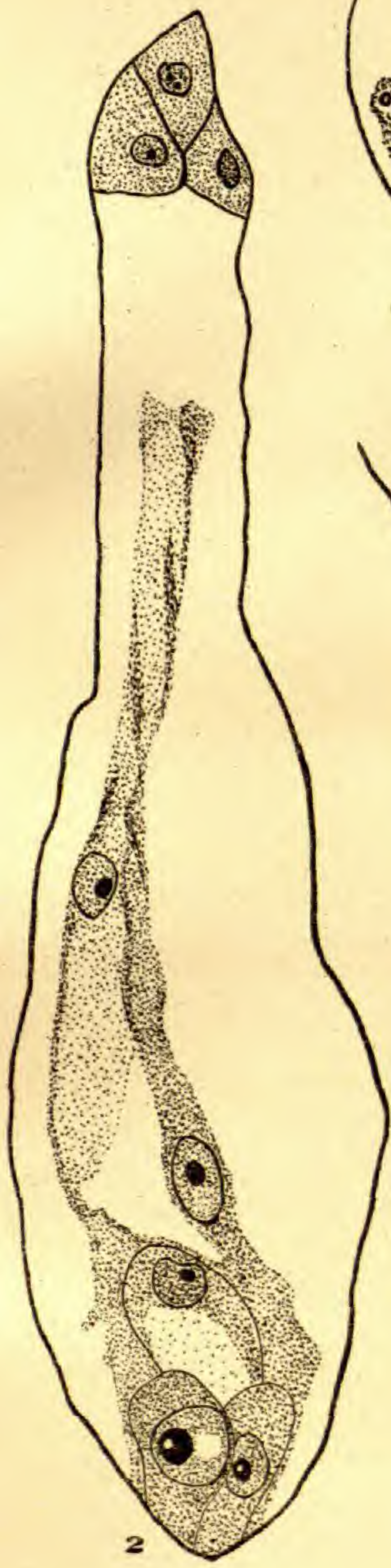

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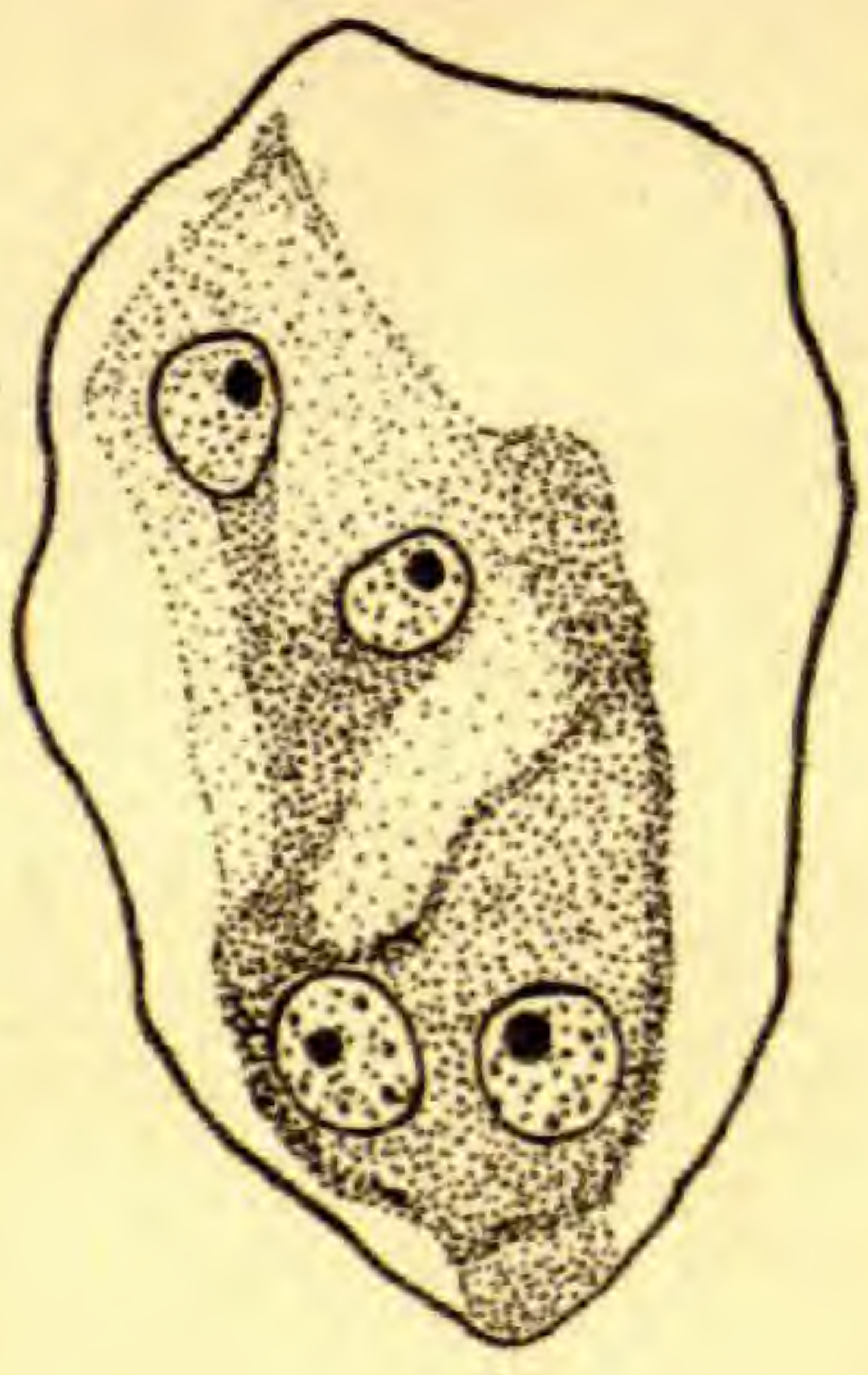

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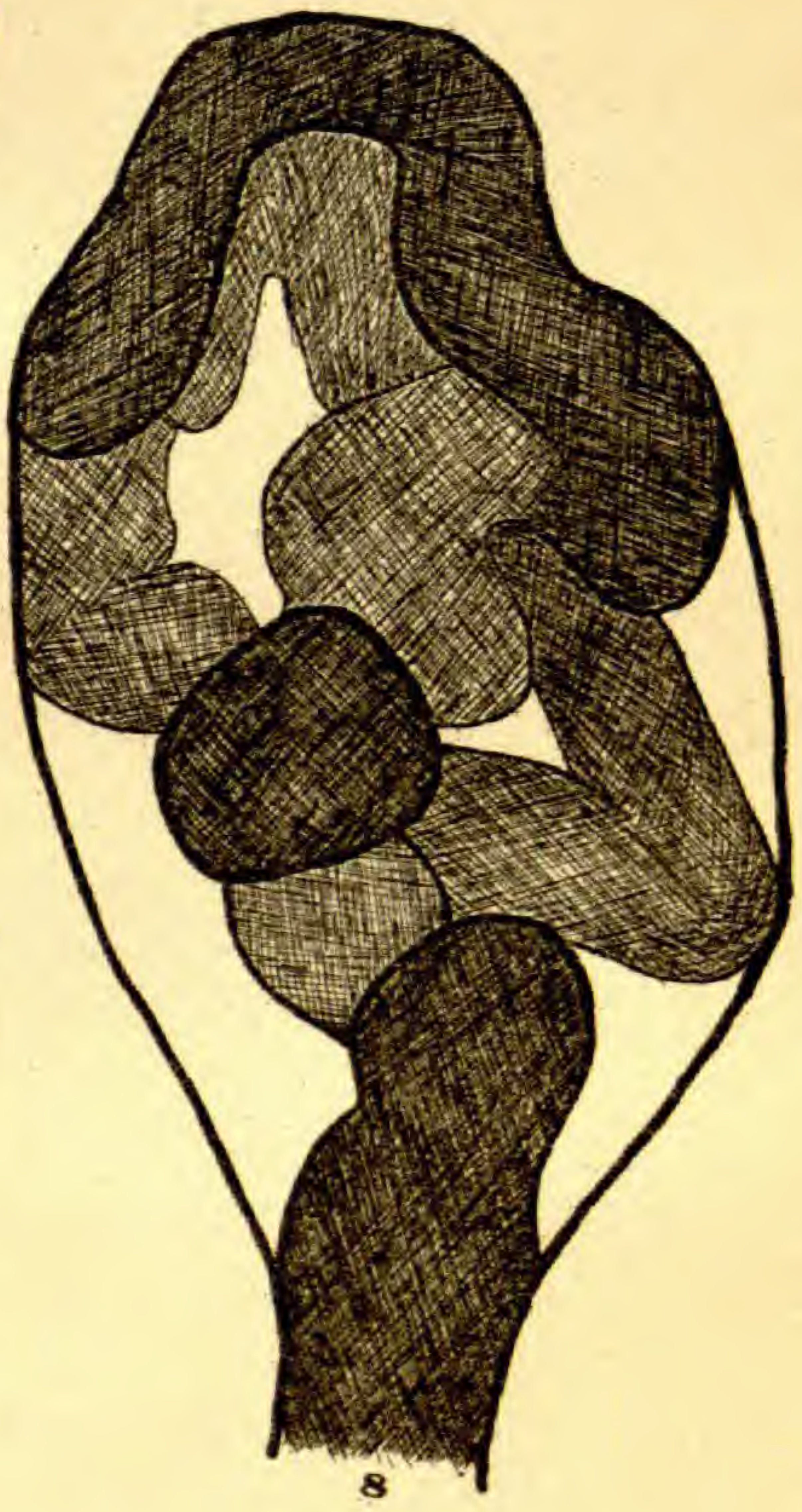

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Osmotic theories, with special reference to van't Hoff's law

J. B. DANDENO

Osmotic action is a phenomenon referred to in nearly all text-books on physics, in many works on physical chemistry, and in practically all books which deal with physiological phenomena, whether relating to plant or animal. In these same text-books, whether relating to physics, chemistry, or biology, one will look in vain for a satisfactory explanation of osmotic processes. In fact a variety of definitions will be found, some relating to diffusion merely, some relating to osmosis and diffusion in a general way, some relating to osmosis particularly, but all more or less vague; and, when relating to pressure produced by osmotic action, sometimes confusing and contradictory. Of course, osmotic activities in themselves are physical phenomena purely; but as they bear so important a part in relation to physiological operations, they are dealt with frequently in works on biology. But it is to the physical chemist, perhaps, to whom we must look for more light with respect to the operations underlying osmotic processes.

It is not intended here to go into a history of the subject, yet, in order to understand the question in its relationships, it is necessary to give a few points of a historical nature.

The phenomenon of osmosis, first observed in relation to organisms, crept into the text-books and other books on physics, and was dealt with there in connection with diffusion and dialysis rather than as osmosis merely. In such books we have to read through such terms as colloid and crystalloid before we come to osmosis. As a matter of fact, however, colloid and crystalloid

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have nothing to do with the subject, for* "The law of osmotic pressure holds for all substances no matter what the nature." However, we have to know something of the meaning of these terms before we can interpret the statements and definitions given in the text-books on physics. The following statement † gives a common idea with regard to osmosis: "When liquids or gases force their way through porous septa and mix the diffusion is called osmose." Now this would actually not be osmosis at all unless the septum is porous only to such an extent as will permit, yet hinder to some extent, the passage of the liquid. According to the definition given above, the process is diffusion merely. But since the term "force their way through," is used, we have to conclude that it is not mere diffusion. The definition includes, therefore, something of a contradiction. In the following quotation is given another view of the osmotic action: ‡ "In case of two liquids separated by a porous septum, the liquid which wets the septum the better, passes through the more rapidly." This is intended to imply that the attraction which the septum has for the liquid is the factor including osmose, but this is not true in many cases, as for example in the case of the pig's bladder and thistle-tube experiment. For example, when a little caustic potash has been added to the sugar solution which is placed on one side of the septum, and pure water on the other, the sugar solution, aided by the alkali, wets the membrane more quickly than pure water, yet the water passes through the membrane more readily, and the movement is inward. In fact, the sugar solution does not pass through at all, at least not for a considerable time. Referring to the subject of osmosis, Anthony & Brackett § say "An explanation of these facts follows if we suppose that diffusion of a liquid through a continuous membrane can occur only when the liquid is capable of temporarily uniting with the membrane and forming part of it." From this it appears that the membrane itself is the active agent in the process, and that osmotic pressure is due to the attraction and perhaps chemical action of the membrane.

Enough has been said about the general view of osmotic ac-

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*Ostwald, Outlines of general chemistry, 128. 1895.

† Gage & Fessenden, Text-book on physics, 43. 1887.

‡ Appleton, Chemical philosophy, 132. 1897 [ed. 4].

§ Text-book of physics, 106. 1888 [ed. 4].

tion to show that we need more definite statements with regard to the subject. We need to remodel our ideas — if the quotations above can be taken as representative of them — because there is no subject more fundamental, more universal in plant and animal functions, than osmosis. And it is in this connection that we need something more definite than we have. The physiologist is confronted with osmotic phenomena at every turn, and he looks in vain for explanations which will satisfy the conditions he meets. Some theories meet with one condition, but not another.

We regard to osmotic pressure, it should be said that no definite measurements were made of it until Pfeffer * developed an apparatus based in its mechanism on the plant cell, but made of inorganic material, and capable of measuring the pressure set up by osmotic forces. Pfeffer's work was epoch-making in this respect, and practically all development made on osmotic measurements, both theoretical and experimental, has been based on Pfeffer's researches. The apparatus which Pfeffer prepared has been known as the "Pfeffer cell." This cell is composed of a porous earthenware cup like a battery jar, in the walls and bottom of which is a precipitate of copper ferrocyanide. This jar, when plugged and connected with a manometer, can be used to measure the pressure produced by osmotic action of certain given substances. This cell, though easily described, is extremely difficult to make, and in very few laboratories, so far as the writer can learn, has the Pfeffer cell been made to work successfully. Comparatively recently, however, the Pfeffer cell has been improved to a high degree by Morse and colleagues † at Johns Hopkins University, and used with great success on osmotic pressure investigations. The improvement to the Pfeffer cell has been mainly in the matter of extracting the air from the porous jar, and placing the membrane. This is done by means of an electric current which forces the liquid into the wall of the jar. The insertion of the stopper plug is a difficult operation also; in fact, where high pressures are to be recorded, the whole operation is one which requires the greatest care in every detail, and one which taxes the patience of the operator to the utmost. Morse and Frazer succeeded in preparing a

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* Osmotische Untersuchungen. 1877.

† Am. Chem. Jour., vols. 26, 28, 34, and others.

cell which sustained a pressure of 31 atmospheres, certainly an enormous pressure. Until the electrical method of arranging the cell was developed, a pressure of no such magnitude had ever been obtained.

Recently there has been prepared a good work on osmotic action and its bearing upon plants, by B. E. Livingston.* While this work covers the ground rather thoroughly, it does not refer to Morse's work, and it holds too strictly to van't Hoff's theory of osmotic pressure. However, Livingston's book is by far the most comprehensive and readable on the subject in the English language to-day.

With regard to the subject of osmotic *pressure*, four names stand out prominently, Pfeffer, Morse, van't Hoff, and de Vries — Pfeffer as the originator of the Pfeffer cell, Morse for the development of the cell for high pressure, van't Hoff for an expression of a theory of osmotic pressure, comparing the solute to a gas, and de Vries for recorded results of relative osmotic pressures in plants. It is mainly in regard to *osmotic pressure* and the theories advanced to explain it, that the present discussion is offered. The theory of van't Hoff is the one most generally accepted at the present time, and the only other one that has been offered is now considered rather old and insufficient The chief objections to both theories are that they do not *explain*, and that, in several cases, they leave much to be desired in regard to several phases of osmotic phenomena. Van't Hoff's theory, when put into simple English, is as follows: "Dissolved substances exert the same pressure in the form of osmotic pressure as they would exert were they gasified, at the same temperature, without change of volume," and this idea has been widely accepted. The main reason for its general acceptance is that it seems to harmonize with certain other well-known physical laws; but van't Hoff himself does not appear to have had any experimental knowledge of the actual pressure which osmotic substances do exert. His law, as well as Ostwald's conclusions with regard to the magnitude of osmotic pressure, was based on Pfeffer's researches, and Pfeffer himself was not able to measure osmotic pressure when such pressure reached a point as high as five or six atmospheres. Pfeffer's work in this regard has

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*Livingston, "The rôle of diffusion and osmotic pressure in plants." 1903.

been, in fact, the basis for all modern conceptions of osmotic pressure. His figures have entered into text after text, in both physics and chemistry. The work is now regarded as a classic, and van't Hoff's law gives it an emphasis which will carry it on through time, for many years yet. Now, van't Hoff's law does not explain the *cause* of osmotic pressure, it merely states it, and leaves the explanation to be inferred.

Let us point out some of the most serious objections to van't Hoff's law as it relates to osmotic pressure. It bases its argument, from the experimental side, on Pfeffer's researches and conclusions. These show several weaknesses which seriously affect van't Hoff's theory as well as Pfeffer's own figures. Pfeffer states that the osmotic pressure of cane sugar, when a gram molecular weight is dissolved in a liter volume, is 22.4 atmospheres and this is what it should be theoretically according to van't Hoff's theory. Sugar is not an electrolyte, hence no account is to be taken of dissociation. In looking into Pfeffer's work * to examine minutely the methods, this statement is found: "The same pressure (that is, 22.4 atmos.) must be exerted by a solution of 342 grams of cane sugar in 1 liter of water." Now, he surely could not have meant this as stated, because it is not in accord with some of his own statements, and is certainly not in accord with van't Hoff's law, or any ordinary interpretation of it. Moreover, further on is given, on pp. 146, 147 of Pfeffer's Plant Physiology, one statement referring to solution concentration; "1 gram in 100 c.cm. *of water*," and this refers to a column heading on the preceding page, "Osmotic pressure of 1 gram in 100 c.c. *of solution*." From this it appears as though he regarded the two statements, "dissolved in a liter of water," and "dissolved to a liter of solution" as the same thing. In the phrase "342 grams of cane sugar in one liter of water," we have a concentration quite different from that made by dissolving 342 grams to one liter of solution. The latter is that to which van't Hoff's theory directly applies. Theoretically, 342 grams to 1 liter volume gives 22.4 atmospheres pressure. Now, it may be said that Pfeffer made a mere typographical error, when he said "in 1 liter of water." Of course, neither Pfeffer, van't Hoff, nor Ostwald had ever actually developed a pressure of 22.4 atmospheres. Pfeffer used weaker solutions, and

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* Osmotische Untersuchungen, 1877, and Physiology of plants, 1900.

from these he *calculated* what the pressure would be for stronger solutions. Supposing we assume that Pfeffer meant to say "342 grams in 1 liter solution" (and this is the only statement tenable if we are to harmonize it with van't Hoff's theory), we are led to an important conflict with Morse's actual experiment which shows that a solution containing 342 grams of cane sugar per liter (of solution), gives over 31 atmospheres pressure. We then arrive at this paradox — *theoretically*, the pressure should be 22.4 atmospheres; *actually*, it is over 31 atmospheres. This pressure of 31 atmospheres was actually obtained. In fact the pressure was more than this, but the apparatus (osmometer) burst at this enormous pressure, and the pressure may therefore be considered more. They conclude that a pressure of at least 32 atmospheres would result from a volume-normal-solution of cane sugar (342 grams per liter of solution).

The actual difference in volume between a solution made by dissolving 342 grams of cane sugar in one liter of solution, and that made by dissolving 342 grams of it in one liter of water is about 214.4 c.c. In the first case the volume is 1000 c.c. and in the latter the volume is 1214.4 c.c.

The following experiment shows also that the gas-pressure theory is not tenable. Pour a few c.c. of chloroform into a test-tube, then drop into this a crystal of iodine. The chloroform turns red from the dissolved iodine. Now pour very gently on top of this a few c.c. of water, and on top of the water a few c.c. of xylol to which has been previously added a crystal of iodine. The xylol dissolves the iodine and so we have one red liquid on top, and one on the bottom of the water. The water remains clear for days, weeks, and months, showing that none of the iodine passes from either the xylol or the chloroform to the water. According to the gas theory, it should do so. But if we carefully suspend by a wire, a crystal of potassic iodide in the water, then, after a short time, the iodine coloration is seen in the water. Some of the iodine has left one or other, or both neighboring liquids. The explanation of this is that the KI solution *attracts* the molecules of iodine from the other solutions. They are attracted *to* not forced *from*.* Morse gives the following expression which applies to

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* Am. Chem. Jour. 34: 91. 1905.

this: "The determining factor in osmotic pressure is the numerical ratio existing between the molecules of the dissolved substance and of the solvent, rather than the number of molecules of the dissolved substance which are contained in a unit volume of the solution." If we place in a tube the three liquids as above, but instead of pure water we substitute a water solution of iodine with potassic iodide, in a day or two the brownish solution in the center becomes colorless towards both top and bottom, while the chloroform and the xylol have turned reddish, showing that the iodine has passed into these liquids. Now if the dissolved iodine acted as a gas, we should have the water solution becoming lighter-colored, but uniformly so, and not light-colored at each end. When the iodine left the water to pass into the chloroform, other molecules of iodine would replace them from behind, if they were *driven* into the chloroform by "gas-pressure." Several other experiments with the liquids, also with turpentine, xylene, ether, and carbon disulphide have been made with colored substances in solution; and the conclusion reached from observation of these is that the pressure which we call osmotic pressure is due to *attraction*.

The Traube * pellicle affords a further illustration of the case in point. When the lump of $CuCl_2$ is dropped into the solution of potassium ferrocyanide a membrane is formed about the lump. Inside of this membrane is $CuCl_2$ solution, and outside is the ferrocyanide solution. The water is taken in through the membrane and into the $CuCl_2$ solution, thus increasing the volume. The membrane bursts and is immediately repaired. The process is continued with another rupture, and so on. Now, the point of rupture is always at, or near, the top of the sack of $CuCl_2$ solution. The solution of copper chloride is much more dilute at the top, yet, if the theory of "bombardment of molecules" were sound, it should rupture obviously where the molecules are most numerous, which is at the bottom. It can easily be seen that the solution is more dense at the bottom by the deep blue color, and it would naturally be so because of the very slow diffusion of the solute upwards. As has been said, the sack should rupture at the bottom, assuming the "gas-pressure" theory. The reason the sack ruptures at the top — an explanation not necessary, how-

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* Described in Pfeffer, Physiology of plants 1: 106. 1900 [trans. by Ewart].

ever, to this discussion — is that the membrane is weaker at the top, owing to the fact that the copper chloride is less dense there, and the consequently less rapid chemical action; and also to the fact that the membrane is not so old at, or near, the top. The phenomena which may be observed in the formation of the Traube pellicle present a strong argument against the "gas-pressure" theory.

Take a glass jar and place in it a bright, well-cleaned piece of zinc, or bright iron, then fill with distilled water, and cover tightly with a bladder parchment as for an osmometer. Now immerse the whole jar in a strong solution of copper sulphate. After a time the zinc (or iron) becomes coated over with a dark brown substance which proves to be copper, or copper oxide. If a similar experiment be made, but without the zinc strip, there is no copper sulphate found in the closed jar, even after a few hours. Now the only reasonable conclusion as to how the copper molecules, or ions, reached the zinc, is that they were *attracted* there by the zinc and not *driven* from behind.

The matter of interpretation, or explanation of the gas-theory as accounting for osmotic pressure, shows perhaps as forcibly as the experiment mentioned, that the theory of gas-pressure is wholly inadequate to the situation. Two or three illustrations of the conclusions reached by those basing their explanations on the "gas-pressure" theory may be given to demonstrate what such theory leads to. Take, for example, the explanation often given of osmotic pressure. Livingston * states it thus: "The following explanation of osmotic pressure has been given by various authors. The quotation is from Davenport [Experimental Morphology]: 'Upon the side containing the greater number of molecules of salt [solute], fewer water [solvent] molecules will in a given time strike the membrane than upon the other side; and since the number passing through is proportional to the number striking, relatively fewer molecules of water will consequently pass out, and so there will be a resultant flow of water to that side; and if the mass of water is confined, it will exert great pressure.' This explanation is untenable for several reasons. . . . Into this matter it is unnecessary to go farther than to add that osmotic pressure can be demonstrated as readily in solutions occupying less volume than the original solvent as in those occupying more. It is obvious

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* The rôle of diffusion and osmotic pressure in plants.

that in the former case there must be a greater number of solvent particles per unit volume than in the pure solvent. Hence if the above explanation can be retained, there should be no osmotic pressure developed in such solution; indeed, it should appear on the side of the pure solvent."

Livingston gives in the book already named a more detailed argument than that quoted above to show the fallacy of the theory offered as explanation of osmotic pressure.

Now Livingston himself offers a theory which is objectionable perhaps to the same degree as that which he so thoroughly refutes. He says, p. 26, the pressure is "due to the bombardment of the walls by the solute particles," and, p. 31, "If there were available a membrane permeable to the solute but impermeable to the solvent, this diffusion tension of the solvent might be directly measured. It would be an osmotic pressure similar to that occasioned by the solute molecules, but of much greater magnitude and in the opposite direction." From this it appears as though both solute and solvent exerted osmotic pressure, and this is due to the "bombardment of the walls." But he says, p. 28, "Osmotic pressure is independent of the solvent and dependent only upon the number of particles of solute." Now the bombardment of the walls *outward* does not account for an *inflow* of water; in fact, it would, if anything, oppose the inflow. But he speaks of an osmotic pressure of the pure solvent. Now if this be so, the inflow would be due to this pressure and not to the bombardment of the walls in the opposite direction. He says, p. 30, "Water molecules pass . . . in both directions" and also "particles of solute hinder the escape of the solvent molecules." Yet, if the solute molecules were *bombarding outward*, there would be a greater tendency for a free course without hindrance for solvent molecules *outward*. From the above, the gist of the idea is that the pressure is due to the bombardment of the walls by the solute, and that water is forced in owing to the bombardment from within, because "The pressure produced by the solvent on one side of the membrane is practically equalled by that on the other side." Yet the crucial point is to account for the inflow of water, and it is not easy to see how water enters when there is no force exerted except a bombardment in the *opposite direction*.

One other illustration of a conclusion arrived at from the gas-pressure theory may be given. The statement has been made that if a solution strong osmotically were placed in a very thin glass flask (such as that used by physicists to demonstrate atmospheric pressure by exhausting the air and causing the flask to collapse), the flask would immediately explode because of the "bombardment of the molecules in solution." The experiment is the best proof of the fallacy of this notion. There is no osmotic pressure whatever in such a case and no explosion either. All these theories fall to the ground when examined closely. Now, it is not the intention here to show the insufficiency of these theories merely. The chief object in writing this discussion is to present a clear and reasonable theory, to explain *osmotic action* and particularly *osmotic pressure;* a theory is valuable only so long as it explains.

The theory proposed here postulates two things: (1) That a membrane can be less permeable to one liquid than to another. (2) That the molecules of all substances which are soluble in a certain solvent have an attraction for the molecules of the solvent and the molecules of the solvent for the substance in solution. In regard to the former of these two postulates, it may be said it is entirely comprehensible that a membrane may permit one body to pass through a pore more readily than another, because of the relative size or shape of pore and molecule, and because of friction offered by the membrane to the passage of the molecule. The second postulate above mentioned refers to a condition so common in nature that it scarcely needs a word of comment. All molecules are probably endowed by nature with this attractive force, but it must not be forgotten that this force operates only at very minute distances. To be more explicit, let us take an example. Choosing the common osmometer having a sugar solution within and water without the pig's bladder membrane; suppose the sugar molecule to be too large to pass through the pores of the bladder, and that these pores are large enough to permit the water molecules to pass with little or no opposition, the molecules of sugar attract the molecules of water and both tend to move toward each other. The sugar molecules are prevented from moving through the membrane, but the water is not, hence there is an *inflow* of water, due to attraction. This attraction, then, is the *force* which underlies osmotic pressure. The operation tends to show that osmotic pressure is, however, regulated by the character of the membrane, and this character depends upon two things; the size of the pores, and the actual relative attraction which the membrane has for the solvent and for the substance in solution. Osmotic processes are not different from diffusion. The membrane simply *shows this diffusion.*

Now, the actual amount of pressure developed by a substance in solution will obviously depend upon the number of molecules (or ions) in a given volume of the solution, hence any other conditions, such as freezing point or boiling point, which have to do with molecular activities, will not likely be very different from osmotic phenomena. And in this connection, it is easy to realize that such attraction as that postulated for osmotic pressure might very probably be different in one substance from that in another. From this it is easy to account for the high pressure of potassium nitrate as compared with sugar, in equimolecular solutions, *without assuming the dissociation theory.* In this case, there is no necessity for assuming ionization. The cause of the high pressure in one case as compared with that in another, is due to the specific attraction of the molecule of the potassium nitrate, and not to the assumption that there are two bodies or ions of K and NO_3, instead of one KNO_3 body. If we assume the dissociation theory to account for the relatively high pressure of such substances as are called electrolytes, we must ascribe as much attractive force to each ion as to the whole molecule, which is a more unreasonable assumption than to ascribe to one molecule of a different kind a greater attractive force than to that of another. In the former case, we have to say, not that "The whole is greater than its part," but that each part is equal to the whole, which, if not unreasonable, is hovering near it. Jost * alludes to "each free ion having the same osmotic value as the entire molecule." To prove this incorrect, is, of course, not easy, but the burden of proof must rest on those who advance that theory. The dissociation theory itself is without much support, and in physiological problems it gives no light. There are so many physiological operations at variance with it that we need not assume the theory

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* Plant physiology, 16. 1907 [Eng. trans.].

of ionization at all. In fact, Jost admits this in the following quotation: "However, botanical investigations on the amount of osmotic pressure are entirely independent of this physical theory." The absorption of soil water by plants is a function which cannot be explained on the gas-pressure theory, but is capable of reasonable explanation on the theory of attraction.

With regard to solutions of two or more substances, the statement is generally made that osmotic pressure is the sum of the individual pressures; quoting from Livingston, p. 29, "The total osmotic pressure of a dilute solution of mixed solutes is the sum of the partial osmotic pressures of the component solutes." But, in some cases, this is not true. If we measure the osmotic pressure of a dilute NaCl solution, and then add some $CaCl_2$ to this solution, there is no increase in osmotic pressure. This has been borne out by Osterhout * in his experiments on plasmolysis which he performed upon certain algae. He applied a NaCl solution to the alga, and brought about plasmolysis. He then added some $CaCl_2$ to a similar solution of NaCl and applied this mixed solution to a similar alga. In this case, the plasmolysis did not occur, although the solution was stronger osmotically. In the matter of determining the osmotic pressure of mixed solutions, very little has so far been done. What has been done, however, seems to show that no one can predict *a priori* just what the sum total pressure of mixed solutions will be. As far as plasmolytic operations have been used to demonstrate relative osmotic pressure, it may be inferred that the specific characters of the substances in solution are the determining factors; and that these may differ with different plants. If, however, we assume the theory proposed here — that of specific attraction — these phenomena are easily explained. In mixed solutions, the various molecules of solutes quite probably exert an attraction upon one another, as well as upon the solvent; and, to some extent at least, it may be supposed that whatever attraction a substance might have when alone in solution, would be modified by the presence of molecules of other solutes. Hence, it is not difficult to account for the modified osmotic pressure of such mixed solutions.

In plant and animal functions, it is mixed solutions mainly

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* Bot. Gaz. 46: 54. 1908.

with which we are concerned. The "gas-pressure" theory affords no explanation, while the theory of attraction gives a foundation for reasonable explanations of all such phenomena. Root absorption, as a function of plants, is one which, as far as the text-books are concerned, is explained by the statement that the force causing absorption is osmotic pressure. To apply van't Hoff's "gas-pressure" theory with a view to an explanation of the process is next to impossible, for the osmotic pressure is *within* the cell of the plant, and it is not easy to see how such pressure acting *outward* could cause an *inflow* of water. It should also be considered that we have to account for, not only the inflow of water, but also the inflow of substances in solution. The theory of attraction is quite applicable to these activities, and it furnishes a reasonable explanation from the fact that a disturbance of the content of soil water, by the addition of another solute, may render what the soil contained previously to this addition more (or less) available to the plant; because in the theory here advanced, it is assumed that solutes have an attraction for one another as well as for the solvent. When a solution is saturated, this attraction is practically satisfied; or more explicitly, it is counteracted by the attraction of one molecule for another of its kind in the process of crystallization.

With regard to the relatively high osmotic pressure said to be produced in plant cells, it may be said that the method is founded entirely upon van't Hoff's theory and Pfeffer's calculations; and as employed to estimate such pressure, it is open to serious objection. The method of finding the osmotic pressure in a given cell is to use a solution of known osmotic strength (?), and if this *just* induces plasmolysis, the cell sap of the plant is said to be of equal osmotic pressure. But it has been shown by Osterhout, previously cited, that distilled water may, under certain conditions, bring about plasmolysis; also that the addition of $CaCl_2$ to a solution of NaCl which has produced plasmolysis, will actually restore turgor, although the external solution is now stronger osmotically. Moreover, it is not yet known experimentally just what is the magnitude of the osmotic pressure of most of the solutions which have been used in plasmolysis, hence the conclusions are open to objection.

A word about ionization. The attraction theory does not assume ionization, though not inconsistent with it. Physiological investigation gives no support to the theory of dissociation, and osmotic pressure need not assume it. The strongest argument in favor of dissociation is the electrical conductivity, but the very current brought to bear upon the solution may actually *induce* the condition which, by the ionization theory it is assumed exists there *before* the electrodes are applied. It is not intended here to go into any discussion of the theory of dissociation further than to state that osmosis, or osmotic pressure, does not furnish any data for such theory. Osmosis and osmotic action can be explained fully without the assumption of dissociation or ionization. And these statements are made with full knowledge of the fact that the relatively high pressure of such substances as KNO_3 was taken as one basis for the assumption of dissociation.

The theory of surface tension to account for osmotic pressure has been advanced, but, from the physiological side, it can receive no support. Surface tension is something which depends upon the attraction of the molecules of the solvent for one another, and that only in the most minute distances; and is developed only in a few layers of molecules on the extreme surface. It cannot account for osmotic pressure or other osmotic phenomena.

More recently other theories, more or less directly connected with the attraction theory, have been advanced in opposition to van't Hoff's gas-pressure theory.

Perhaps the most important of these is the discussion offered by Kahlenberg * in which he opposes vigorously the gas-pressure theory. So far, we agree with him thoroughly, but the main point of difference between Kahlenberg's argument and that offered in this discussion lies in the fact that Kahlenberg ascribes to the membrane a large portion of that factor which the attraction theory ascribes to the molecules of solute and solvent.

Some of his experiments, notably that employing the three substances — chloroform, water, and ether — and which he calls a "typical case of osmosis," can scarcely be considered osmosis at all, for it is only a mixing of three liquids possessing varying degrees of solubility for one another. Water in this case would

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* Trans. Wisconsin Acad. 15: 209. 1904.

be called the membrane. We cannot follow him so far as this, for in speaking of the membrane, he says, "The substance must be soluble in the membrane." In some of his experiments the membrane was dissolved to some extent by the liquid in contact, but so far as it was soluble, the condition was not "typical osmosis." Solubility of the membrane is not necessary. For instance, if we use parchment paper (butter paper) and two liquids, (1) water, (2) sugar solution, these arranged for an osmometer will give about one third of an atmosphere pressure without extra support. There is no solubility whatever of the membrane in either liquid.

On the other hand, we agree with Kahlenberg in the following (*loc. cit.* 271): "To speak of osmotic pressure of any isolated solution . . . is nonsense." . . . And further, to assume that solutes are polymerized or dissociated in dilute solutions because the osmotic pressures developed by the latter in given cases happen to deviate from values computed from the gas laws is evidently equally unjustifiable practice." We do not differ materially from him with respect to the moving force causing osmotic pressure, excepting in the name he employs; namely, chemical affinity. We think this term not happily chosen because the affinity is purely a *physical* one, and not chemical. There is no chemical change whatever. If there be chemical action involved in the operation thus far, it is not osmosis. From the above statement, it must not be assumed that we undervalue the influence of the membrane as a part of the operation. The membrane is absolutely essential. It is a *sine qua non*, but it is merely a screen between the two liquids.

The gas-pressure theory has also been attacked from another point of view, quoting from Nature **72**: 541: "Batelli and Stefanini have brought forward, however, a number of facts which, if subsequently verified, are likely to prove insuperable objections to its [the van't Hoff law's] validity. . . . It is contended that osmotic pressure is essentially a capillary phenomenon." To what extent this may hold good will depend upon how far the idea of capillarity is carried, and if it is used in its broadest sense, the capillary idea is not far removed from that offered in this discussion —that of *attraction*.

A summary of the salient points of this discussion, and of the experiments involved, presents the following: The chief arguments against the gas-pressure theory are: (1) Morse's experiments with sugar solutions show an osmotic pressure of about 32 atmospheres in a gram-molecular weight per liter solution, when it should, by van't Hoff's law, be only 22.4 or thereabouts. (2) The writer's own experiments with colored solutions of various kinds and with different solvents, also his physiological experiments concerned with absorption and with cell sap. (3) Osterhout's experiments on plasmolysis. (4) Many operations connected with living plants, *e. g.*, the formation of ice (in freezing weather) in the intercellular spaces, the formation of calcium oxalate crystals outside the living cells, and others. (5) The growth of the Traube pellicle. (6) Kahlenberg's experiments and discussions.

The Attraction Theory here proposed is not only in harmony with all the phenomena presented as argument against the gas-pressure theory, but it affords a reasonable explanation in each and every case. This theory is not claimed to be entirely new, for it was used, in part here and there, many years ago, but was never applied generally enough, hence it was not surprising to find van't Hoff's law superseding. But van't Hoff's law shows so many weak points that it cannot be accepted as explanatory of osmotic pressure.

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Some noteworthy Hepaticae from the state of Washington

LOIS CLARK

(WITH PLATE 20)

Although Washington is the smallest of the three Pacific Coast states, it has an area of over sixty-nine thousand square miles and presents a great variety of climatic and physiographic conditions. The Cascade Mountains divide the state into eastern and western Washington. In eastern Washington the climate is hot and dry in the eastern and southern portions, cool and moist in the western and northern, especially along the eastern slopes of the mountains. In western Washington the climate is cool and moist throughout, and the whole region abounds in shaded water courses and extensive forests. The state, therefore, throughout the greater part of its extent, is exceedingly favorable for the growth of a rich hepatic vegetation.

Taking the state as a whole, there is only one small area, the university campus at Seattle, where the Hepaticae have been at all thoroughly collected. Other regions which have received some attention are Paradise Valley on Mount Ranier, Queets River valley and Elwha River valley in the Olympic Mountains, and Stevens Pass in the Cascade Mountains. Elsewhere in western Washington very little has been done, and in eastern Washington the Hepaticae have been still more neglected. In spite of the work to be accomplished before our knowledge of the hepatic flora approaches completion, the writer, from collections already made, has been able to identify 101 species from the state, a number which compares favorably with the 86 species known from California and the 117 species known from British Columbia. The most important of the collections studied were made by Professor O. D. Allen, Mr. A. S. Foster, and Professor T. C. Frye.

Scarcely anything has been published on the Hepaticae of Washington. Underwood's list of 1891 * enumerates 16 species,

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* A preliminary list of Pacific Coast Hepaticae. Zoe 1 : 361–367. 1891.

and Roell's list of 1893,* 23 species, no fewer than 19 being additions to Underwood's list. Howe has since reported three more species, Stephani two, and C. Müller, of Freiburg, two, so that 42 species in all have been definitely reported from the state. As noted above, this number has been considerably more than doubled by recent investigations.

The present paper makes no attempt to give a complete account of the species known from the state. It simply calls attention to nine species which are of more than passing interest. These include one species new to science and a new variety of a recently published *Scapania.* Of the remaining species noted four are new to North America and three to the United States, although previously reported from the Canadian provinces.

ASTERELLA LINDENBERGIANA (Corda) Lindb.

Fimbriaria Lindenbergiana Corda; Nees von Esenbeck, Naturg. Europ. Leberm. **4**: 283. 1838.

Fimbriaria Bonjeanii DeNot. Mem. Accad. Torino II. **1**: 335. *f. e.* 1839.

Asterella Bonjeanii Trevis. Rend. Ist. Lomb. Sc. II. **7**: 777. 1874.

Hypenantron Bonjeanii Trevis. Mem. Ist. Lomb. III. **4**: 440. 1877.

Asterella Lindenbergiana Lindb. Musc. Scand. 1. 1879.

Hypenantron Lindenbergianum O. Kuntze, Rev. Gen. **1**: 89. 1891.

On wet soil. Queets River valley and Elwha River valley, Olympic Mountains, at an altitude of 4500 feet, *Frye* (*63*, *71*). New to North America, but widely distributed in Europe although nowhere abundant.

A. Lindenbergiana is one of the larger species of the genus. As Howe † clearly shows, it agrees in this respect and also in general habit with *A. californica* (Hampe) Underw., which is still known from California only. The two species agree also in developing their inflorescences either on the main thallus or on

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* Nordamerikanische Laubmoose, Torfmoose, und Lebermoose. Hedwigia **32**: 181–203; 260–309; 334–402. *pl. 9–10.* 1893.

† Mem. Torrey Club **7**: 50. 1899.

its principal divisions, instead of on short ventral branches. *A. Lindenbergiana* may be at once distinguished by its monoicous inflorescence, by its violet-red pseudoperianth, by its dark purple spores, and by its red elaters. In *A. californica* the inflorescence is dioicous, the pseudoperianth is white, and the spores and elaters are yellow. The remaining species of the Pacific Coast, although all monoicous, are considerably smaller than *A. Lindenbergiana*, and in two of them, *A. violacea* (Aust.) Underw. and *A. Bolanderi* (Aust.) Underw., the inflorescences both male and female are borne on short ventral branches. In *A. violacea* the pseudoperianth is usually violet, but the spores and elaters are yellow, becoming brownish with age; in *A. Bolanderi* the pseudoperianth is white and the spores and elaters are yellowish brown. Three other species, *A. fragrans* (Schleich.) Trevis., *A. gracilis* (Web. f.) Underw., and *A. Palmeri* (Aust.) Underw., remain to be considered, all of which agree with *A. Lindenbergiana* in the position of the inflorescences but differ in their white pseudoperianths. *A. fragrans* is further distinguished by the numerous white appendages of the ventral scales, which project far beyond the margin in the apical region; *A. pilosa*, by the yellow spores and elaters; and *A. Palmeri*, by the opaque and dark brown spores and yellow elaters.

PALLAVICINIA BLYTTII (Moerck) Lindb.*

Jungermannia Blyttii Moerck; Hornemann, Fl. Dan. **12**: 6. *pl. 2004.* 1830.

Blyttia Mörkii Nees; G. L. & N. Syn. Hep. 474. 1846.

Moerckia Blyttii Brockmann, Arch. Ver. Freunde Naturg. Mecklenburgs **17**: 190. 1863.

Pallavicinia Blyttii Lindb. Not. Sallsk. F. et Fl. Fenn **9**: 17. 1868.

Calycularia Blyttii Steph. Mem. Herb. Boissier **16**: 6. 1900.

On wet rocks. Near Hume's Glacier, Queets River valley, Olympic Mountains, at an altitude of 5000 feet, *Frye* (*56*). Paradise Valley, Mount Ranier, 5000 feet, *Flett.* New to North America, but widely distributed in Europe in subalpine localities.

The present species bears a strong resemblance to *P. Flotowiana* (Nees) Lindb., which is now known from several widely scat-

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*Only a few of the synonyms are here given.

tered stations in North America. It agrees with it also in the structure of the thallus, the thickened median portion of which is usually composed throughout of parenchymatous tissue. In this respect both species differ markedly from *P. Lyellii* (Hook.) S. F. Gray and its immediate allies, in which the thallus is characterized by a median strand of narrow elongated cells, forming a very conspicuous feature of the plant. *P. Blyttii* is a little more robust than *P. Flotowiana* and may be easily distinguished by its golden-yellow rhizoids, by its bluntly lobed archegonial scales, and by the ridges of its spores, which are beset with short and truncate spines. In *P. Flotowiana* the rhizoids are white, the archegonial scales are sharply cleft, and the ridges on the spores are smooth along their margins.

NARDIA BREIDLERI (Limpr.) Lindb.

Alicularia Breidleri Limpr. Jahresb. Schlesisch. Gesells. für vaterl. Cultur **47**: 311. 1880.

Nardia Breidleri Lindb. Medd. Soc. F. et Fl. Fenn. **6**: 252. 1880.

On wet soil. Mount Ranier, at an altitude of 6300 feet, *Allen*. An arctic and alpine species new to North America but widely distributed in Europe and known also from Siberia.

Nardia Breidleri grows in flat, depressed mats close to the snow line and is greenish brown in color. It is much smaller than our other species of the genus and looks at first sight more like a *Cephalozia*. It even agrees with *Cephalozia* in the occasional presence of postical branches, although the branching is typically lateral, as in the other species of *Nardia*. The leaves in *N. Breidleri* are either orbicular or a little broader than long and are also more or less concave. They are often bifid one fourth to one third, with obtuse sinus and rounded lobes, but are sometimes only emarginate at the apex. The leaf-cells, mostly 10–16 μ in diameter, have a smooth cuticle and thin walls destitute of trigones. The underleaves are minute and subulate, although sometimes vaguely bifid. Apparently the closest ally of the species is *N. Geoscyphus* (DeNot.) Lindb., which also may be recorded from Washington. It is considerably larger than *N. Breidleri*, the leaves are much more variable, being sometimes undivided and sometimes variously bifid, and the leaf-cells, which measure 20–30 μ

in diameter, have distinct trigones. It is also paroicous in its inflorescence while *N. Breidleri* is dioicous. In both species the perigynium bears a rudimentary sac at the base, differing in this respect from all our other species of the genus.

Jungermannia Allenii sp. nov.

Brownish green or reddish, growing in tufts: stems 1.5–3 cm. long, 0.15–0.25 mm. in diameter, ascending or suberect, sparingly branched, the branches arising close to the postical end of the line of attachment of the leaves; rhizoids few or wanting, not pigmented: leaves distant to subimbricated, obliquely inserted, somewhat concave, slightly decurrent, oval to subrotund, 1–1.5 mm. long, 0.8–1.35 mm. wide, undivided or slightly emarginate, entire, bordered by a row of more deeply pigmented cells; median leaf-cells from 20–30 μ in diameter, trigones large and distinct, cuticle striolate: underleaves sometimes minute and fugacious, sometimes large and persistent, mostly 20–40 μ in length and bearing numerous hyaline papillae, the large ones occasionally attaining a length of 1 mm., sometimes undivided, sometimes variously bilobed or bifid: inflorescence dioicous. [PLATE 20, FIGURES 1–11.]

On rocks, more or less submerged. Paradise Valley, Mount Ranier, *Allen*, *Flett*. Professor Allen's specimen, which may be considered the type of the species, is deposited in the herbarium of A. W. Evans, at New Haven, Connecticut.

The specimens examined are all sterile with the exception of a single plant bearing a very immature female inflorescence. On the basis of this plant the species is assumed to be dioicous. Unfortunately in the absence of mature floral organs, the generic position cannot be definitely determined. The reddish pigmentation, which is sometimes very marked, points perhaps to *Nardia* or *Jamesoniella*, but it seems wisest to retain the species in *Jungermannia*, at least for the present. In habit and in size it somewhat resembles *J. cordifolia* Hook., which is not uncommon in Washington, although it has not before been recorded from the state. In this species, however, the pigmentation is never reddish, the leaf-cells are wholly destitute of trigones, and there are no underleaves. In *Nardia compressa* (Hook.) S. F. Gray, with which the new species may also be compared, the two rows of plane or slightly concave leaves are laterally appressed to each other, the cuticle is smooth, and the underleaves are uniformly minute and triangular. The large underleaves in *J. Allenii* are by no means frequent, many stems failing to show them altogether, yet they constitute a striking feature of the species.

JUNGERMANNIA RIPARIA Tayl.

Jungermannia riparia Tayl. Ann. & Mag. Nat. Hist. **12**: 88. 1843.
Aplozia riparia Dumort. Hep. Europ. 63. 1874.

On rocks. Foothills of Mount Ranier, *Allen.* New to the United States but widely distributed in Europe and already reported from British Columbia.

The closest allies of *J. riparia* are *J. cordifolia*, *J. atrovirens* Schleich., and *J. pumila* With. In some respects it is intermediate between the first two and agrees with them in its dioicous inflorescence. It is considerably smaller than *J. cordifolia* and shows a more prostrate habit, producing an abundance of rhizoids and flagella. Its leaf-cells are also distinct in developing trigones, those of *J. cordifolia* having walls of uniform thickness. When compared with *J. atrovirens*, *J. riparia* is seen to be considerably larger and less deeply pigmented, but the two species are apparently connected by intermediate forms. *J. pumila* can be at once distinguished by its paroicous inflorescence.

HYGROBIELLA LAXIFOLIA (Hook.) Spruce

Jungermannia laxifolia Hook. Brit. Jung. *pl. 59*. 1816.
Gymnocolea laxifolia Dumort. Recueil d'Obs. Jung. 17. 1835.
Cephalozia laxifolia Lindb. Musc. Scand. 3. 1879.
Hygrobiella laxifolia Spruce, On Cephalozia 73. 1882.
Cephalozia Notarisiana Massal. Accad. Sc. Med. Nat. Ferrara 201. 1903.

On wet rocks. Paradise Valley, Mount Ranier, *Frye.* New to the United States, but widely distributed in Europe and already reported in North America from Greenland and Labrador.

Although a small species, *H. laxifolia* exhibits a number of very distinct features. The plants grow in tufts, and the ascending or erect stems develop few or no rhizoids. The branching is lateral, some of the branches being similar to the stem and some flagelliform. The transversely inserted leaves are distinctly complicate and equally bifid for about one third their length with acute divisions. The underleaves are large and similar to the leaves in the majority of cases, but they are sometimes undivided and sometimes show unequal segments. The leaf-cells are characterized by being more or less elongated, measuring from 40–70 μ in length and from 20–30 μ in width; they have thin walls but more or less distinct trigones. The lateral branches, large underleaves, and elongated leaf-cells should at once separate it from the genus *Cephalozia*, to which some authors have referred it, and there is little probability of confusing it with any other northern genus.

DIPLOPHYLLEIA OBTUSIFOLIA (Hook.) Trevis.

Jungermannia obtusifolia Hook. Brit. Jung. *pl. 26.* 1816.

Diplophyllum obtusifolium Dumort. Recueil d'Obs. Jung. 16. 1835.

Diplophylleia obtusifolia Trevis. Mem. Ist. Lomb. III. **4**: 420. 1877.

On wet rocks. Seattle, *Piper*. New to the United States but previously reported from British Columbia. Widely distributed in Europe.

The present species bears a strong resemblance to the dioicous *D. taxifolia* (Wahl.) Trevis., agreeing with it in its rounded leaf-lobes, and it is possible that the two plants have been more or less confused. It is, however, somewhat smaller, and is especially remarkable for its paroicous inflorescence, the antheridia in all other known species being borne on special branches. In the eastern United States, specimens of the recently described *D. apiculata* Evans used to be referred to *D. obtusifolia*, and it is by no means impossible that the true *D. obtusifolia* may yet be detected east of the Mississippi. *D. apiculata* may at once be distinguished by its sharp-pointed leaf-lobes and autoicous inflorescence. In *D. albicans* (L.) Trevis., which is apparently the most abundant species in Washington, the plants are considerably larger, the inflorescence is dioicous, and the leaf-lobes are marked by median bands of elongated cells, simulating nerves in appearance.

SCAPANIA INTERMEDIA (Husnot) Pearson

Scapania nemorosa, var. *intermedia* Husnot, Hep. Gall. 22. *pl. 3. f. 23.* 1875.

Scapania intermedia Pearson, Hep. British Isles 227. *pl. 91.* 1900.

On damp rocks. Near Hume's Glacier, Queets River valley, Olympic Mountains, at an altitude of 5000 feet, *Frye* (*78*). New to North America but previously known in Europe from France and England. The determination of the Washington specimens was kindly confirmed by Dr. Karl Müller, of Freiburg in Breisgau, Germany, one of the highest authorities on the genus *Scapania*.

According to Dr. Müller* *S. intermedia* is a species of somewhat doubtful validity, occupying a position between *S. umbrosa* (Schrad.) Dumort. and *S. dentata* Dumort. and apparently connected with the latter species by transitional forms. It may be distinguished from *S. umbrosa* by the rounded postical lobes of its leaves and from *S. dentata* by its smaller size, smaller leaf-cells, and rougher cuticle. *S. intermedia* is also closely related to *S. Evansii* Bryhn, a North American species which is still imperfectly known. In *S. Evansii*, however, the leaves are less imbricated, and their lobes are less coarsely dentate.

Scapania paludosa papillosa C. Müll. Frib. var. nov.

Reddish brown or almost black: cuticle of the leaves verruculose on both surfaces, the verruculae circular to elliptical in outline, measuring 4–10 μ in length and about 4 μ in width in middle of lobe but becoming smaller toward the margin, densely crowded, some of the larger cells showing as many as 25 on each surface: in other respects agreeing with the type. [PLATE 20, FIGURES 12–17.]

On wet rocks. Near Hume's Glacier, Queets River valley, Olympic Mountains, *Frye* (*88*). A portion of the type is preserved in the herbarium of A. W. Evans, at New Haven, Connecticut.

In the typical forms of *S. paludosa* C. Müll. Frib., the cuticle is smooth or nearly so, and it was at first thought that the roughened cuticle in the Washington specimens would justify separating them as a distinct species. Unfortunately they are completely sterile and, upon submitting them to Dr. Müller for his opinion, it was suggested that the wisest course would be to describe them provisionally as a new variety, reserving final judgment until more complete material should be available. They agree with characteristic *S. paludosa* in showing strongly decurrent leaf-lobes, with blunt apices and a short more or less arched keel. The decurrent

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* Nova Acta Acad. Caes. Leop.-Carol. 83: 117. 1905.

portions of the lobes are especially distinct in the new variety and form a more or less continuous line along the postical aspect of the stem. They agree in this respect with the variety *vogesiaca* C. Müll. Frib., a golden-green form with exceedingly minute verruculae, known only from the Vosges Mountains in Alsace-Lorraine. The typical form of the species, which is also green, has been collected in several localities in New England, where it seems to prefer the edges of small pools in bogs at rather high altitudes. The Washington specimens mark a wide extension of the known range of the species in North America, and it is also widely distributed in Europe.

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Explanation of plate 20

1–11. *Jungermannia Allenii* L. Clark

1. Part of stem, postical view, × 15. 2. Part of stem, antical view, × 15. 3. Part of stem with two branches, postical view, × 15. 4. Leaf, × 15. 5, 6. Underleaves, × 140. 7. Cells from margin of leaf, × 240. 8. Underleaf, × 240. 9, 10. Underleaves, showing papillae, × 140. 11. Cells from middle of leaf, × 240. The figures were drawn from the type specimen.

12–17. *Scapania paludosa papillosa* C. Müll. Frib.

12. Part of stem, antical view, × 15. 13. Part of stem, postical view, × 15. 14. Leaf, antical view, × 34. 15. Leaf, postical view, × 34. 16. Cells from margin of leaf, × 240. 17. Cells from middle of lobe, showing papillae, × 240. The figures were all drawn from the type specimen.

Preliminary notes on the genus Usnea, as represented in New England

R. Heber Howe, Jr.

(with plates 21–23)

There is probably no small genus of Lichenes that seems more puzzling to the student than the genus *Usnea*, nor one over which lichenologists are more uncertain or have more often disagreed. We have only to follow the literature from Linnæus to Tuckerman to see how the status of the species has been continually rearranged, though the genus, so far as I can ascertain, has been monographed but once, in 1799.*

A long study of the plants of this genus in the field, with the assembling of a large collection of specimens, and a comparison of over two thousand examples in other herbaria, has led me to believe that the members of the genus are often determined by a most superficial examination, and that one of the best criteria of Tuckerman's Genera Lichenum (p. 13) — *papillate* or *epapillate* thallus — is left out of the equation in the majority of cases where it could have been applied. I have found numerous instances where examples with a *glabrous* thallus have been placed under *barbata*,† and distinctly *papillate* species labelled both *trichodea* and *longissima*. Superficial comparison is used so generally for the determination of lichens that one specimen, wrongly determined, may be the highway for many more.

The general infertility of the filamentous forms, the wide variety of color, which is greatly affected by age, both during growth and in herbaria, have also helped to lead to the common dilemma.

That in some ways the genus would be more easily understood if revised,‡ there seems little doubt, though the less we tamper with the only American standard to which we can cling, the bet-

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* Schrader, H. A. Jour. für Bot. 1 : 42–85, including *Alectoria*.

† See conclusion of paper.

‡ See Zahlbruckner in Engler & Prantl, Nat. Pflanzenfam.

ter — at least while field studies of distribution and of environmental effects are so sorely needed — a much better classification seeming now, with our present knowledge, improbable. Progress is not always indicated by frequent revision or by a multiplicity of names, a factor which I think to-day we are only too prone to forget.

It is true that so many different subspecies and forms of *Usnea barbata* have been described and are recognized that the concept of the typical form has been practically obliterated; but is this necessary? *Barbata* no doubt now stands for a generic, rather than a specific concept in most students' minds. The diagnosis, as given by Tuckerman, is so brief and indefinite that specimens are rarely referred to it, but are placed under one of the forms, which have enlarged the limits of the species to include many untypical specimens.

This state of affairs is not easily remedied. The anterior pagination of *Lichen barbatus* over *L. floridus* in Linnaeus' original description * makes it impossible for us to adopt the perhaps more logical *Lichen floridus* for the type form on which to build,† unless we abandon *L. barbatus*. That intergradation also exists between all forms now classed under *Usnea barbata*, no one can doubt, and I am left, therefore, for the present as Tuckerman probably was, to accept the classification of his Synopsis of 1882, based mainly on Fries, as the only feasible one, and to let my field and laboratory studies elucidate wherever and whenever they can.

The only change that in late years has been made is to raise *florida*, *ceratina*, *dasypoga*, and *plicata* to full species, which, it is true, rids us of the disallowed and absurd quadrinomials, and leaves our taxonomy of the present *barbata* group as follows; *barbata* in this case, perhaps, should have been used to designate a papillate section:

Usnea florida (L.) Web.
Usnea ceratina Ach.
Usnea dasypoga (Ach.) Fr.
Usnea plicata (L.) Web.

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* Sp. Pl. 1155, 1156. 1753.

† It was recognized as such by Fries, Lich. Eur. 19. 1831. "Typus speciei est forma *florida*, optime fertilis & fruticulosa."

This raising was done by Herre in a most wholesale fashion; *hirta* and *rubiginea* being included, and though a follower of Zahlbruckner, he raises *plicata* to specific rank, which the latter in Engler & Prantl does not do. All this too, without a reason, except the admission that "the species [are] not always well defined and apparently intergrading." Such revisions only serve to burden, as a rule, the synonymy, and for the present, at least, I am unwilling to abandon Tuckerman, though I believe with further study a more lucid and correct classification can be adopted; and I believe that Herre's, based I suppose on that of Hoffmann, though now seeming somewhat warranted, will prove inadequate, and is not allowable according to the methods now followed in nomenclature.

I have used the life zones in outlining the range of the various species, though no doubt plants adhere less closely to such areas than do the animals, being dependent so largely on substrata and conditions of moisture. But to a surprising degree, a nice relationship is shown by this genus.

The following purely artificial key to the genus as represented in New England may be of some aid in determining the species of this difficult group:

Key

Thallus papillate

1. Terete.
    - A. Erect; apothecia abundant, terminal.
        - Rigid; apothecia middling-sized .... *U. barbata florida*.
        - Subcrustose, strigose, short-branched; apothecia large ... [*strigosa*].*
    - B. Erect, rarely subpendulous; apothecia wanting (or very rare).
        - Rigid, generally hirsute, sorediate .... [*hirta*].
        - Rusty red .... [*rubiginea*].
    - C. Subpendulous (maximum length, 30 cm.); apothecia rare or wanting, sessile on main filaments or subterminal.
        - Rigid, coarse; fibrils rectangularly arranged .... *U. barbata*.
    - D. Pendulous (average length, 60 cm.); apothecia (rare or very uncommon as represented in this region).
        - Rigid, coarse; fibrils, if present, rectangularly arranged .. *U. barbata ceratina*.
        - Pliant, slender (except at very base); fibrils rectangularly arranged .... *U. barbata dasypoga*.
        - Pliant, slender; lateral fibrils wanting .... *U. barbata plicata*.

Thallus epapillate

- E. Lax, slender (average length 30 cm.); fibrils capillaceous; apothecia not common .... *U. trichodea*.

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* [] indicates contingent forms for which a name is a burden.

F. Lax, slender, scurfy (maximum length 2 m.); fibrils rectangularly arranged; apothecia wanting............*U. longissima.*

2. Compressed.
   Pitted, lax, slender (average length 60 cm.); fibrils capillaceous; apothecia rare..*U. cavernosa.*
3. Angular.
   Rigid, coarse (maximum length 1 m.); fibrils rectangularly arranged; apothecia rare or wanting..........................*U. angulata.*

Family: USNEEI

Genus: USNEA (Dill.) Ach.

USNEA BARBATA (L.) Fr.

This typical form must always include a great variety of individually* developed examples, though never includes *slender* filamentous plants of a pendular length exceeding 25 cm. In all save habit of growth and absence of apothecia (the latter a purely artificial line), it has every characteristic of the following subspecies *florida;* and from undoubted sterile examples of the latter, no line can be drawn. *U. barbata* is not uncommonly hirsute, and sorediate, when it is recognized as the variety *hirta*, along with seemingly sterile examples of the next. It is sometimes dichroic, when it is termed the variety *rubiginea*, though this condition is more common of so-called sterile *florida.*† Plate 21 accompanying this paper illustrates a unique phase which I have been able exactly to duplicate but twice,‡ and shows a curiously naked intermediate condition between *barbata* and *ceratina* (though much nearer the latter), which, if *barbata* is dispensed with, falls naturally under sterile *ceratina*, with fruited plants of which it was in one case growing.

The distribution of the typical form is coextensive with that of *florida*, which is suggestive, except that it is this generally infertile form that is largely restricted to the drier situations throughout New England, exclusive of the upper Canadian zone, where it is certainly only rarely represented. Typical examples are restricted to the Upper Austral zone, being apparently intermediary between *ceratina* of the middle Atlantic states and sterile *florida* of the Transition zone.

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*Nylander, Syn. Meth. Lich. 267. 1858–60; "erectus aut pendulus," and "e pluribus constat formis."

† These plants in herbaria have always been difficult of determination, as pressing often makes what was an erect plant *in situ*, appear pendulous.

‡ From South Canterbury, Conn., Plymouth, N. H., and St. Martinsville, La.

USNEA BARBATA FLORIDA (L.) Fr.

This is a distinct and easily recognized subspecies, the tufted thallus rarely if ever attaining a development of over 12 cm. The apothecia reach a diameter of 25 mm.* Infertile conditions are not uncommon, and are abundant if we do not recognize *barbata*, and if we hold that *hirta* and *rubiginea* are merely contingent phases. In the so-called variety *hirta*, with the failure to develop apothecia, due presumably to lack of sufficient moisture, the plant often becomes hirsute (and now blackening with age), and is more or less sprinkled with soredia, the distal portions of the filaments often becoming confluently crusted, or sorediate. But this sorediate condition is not absolutely confined to *florida*, but is present occasionally in all forms,† and the difficulty of recognizing it by a name is at once apparent. No doubt if some of our foliose lichens were not so constant morphologically, the sorediate subspecies now recognized would appear as absurd as in the present instance. The stress of the original separation of this form, it has been said, was laid, as the name would imply, on the hirsute ‡ character, the sorediate condition being of secondary importance.

Rubiginea, plainly, it appears to me, is a case of dichromatism, and in other branches of science, ornithology, for example, dichroic conditions are not invariably named, *i. e.*, *Megascops* [*Otus*] *asio* (L.). Later it will be seen that filamentous forms are occasionally also dichroic, though the fertile *florida* is rarely affected.§ By way of explanation, the dichromatism seems perhaps to be due to some sort of dye that attacks mainly the infertile forms — possibly following up the cortex, and sometimes staining the cottony portions of the medulla outside the indurated cord. This explanation is suggested by the fact that the proximal portions are generally first colored, though this is not always true. The color on the other hand may be due to a morphological change as a result of age,

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* Mexican specimen.

† Schaerer, 1839, says of *ceratina* "glabra vel verrucoso-pulverulenta."

‡ See first supposed reference, before Linnaeus' description: Tragus, H., "Muscus arborum villosus incanus," etc.; Schaerer, 1839, defines "verrucoso-pulverulenta, fibrillosa et efibrillosa"; Linnaeus' original description reads: "Lichen filamentosus ramosissimus erectus, tuberculis farinaceis sparsis." *Hirtus* would then seem probably used in the sense of rough.

§ Michaux, A., Flora Boreali-Americana 2: 332. 1819: "minus hirta, rubigineo-rubens; scutellis concoloribus." Sorediate specimens are frequently dichroic.

bringing about a new selective scattering, which seems the most likely solution, as old herbarium specimens become in time rust-red. This dichroic condition is at best very difficult of explanation. My friend Mr. Edward Mallinckrodt, of the Mallinckrodt Chemical Works, writes me in reply to a request of mine to investigate this coloration:

"The color is no doubt due to some change of an organic dye contained in the plant, not to any mineral substances and hence the difficulty in analyzing it, as we are easily able to handle mineral substances but not organic. You are no doubt aware that a good deal has been written upon the subject of red leaves without any consensus of opinion as to the cause, if I am properly informed. If I were sure that at the end of a month or so work on the lichen would lead to definite results, I might take it up although all of our men are pretty busy and outside problems are hardly in order, but as a matter of fact unless your lichen is an exception it contains a number of plant substances, which are pretty closely related and difficult to identify. Even if we got these out we would still be unable to put our finger on this one and say that its behavior in a test-tube accounts for the color change in the plant. The whole trouble is that with organic compounds nature works such extremely obscure changes that the chemist in the laboratory can hardly follow them. Analysis, therefore, is extremely difficult in this case, while comparatively easy in the case of mineral or inorganic products."*

Usnea barbata florida occurs on living deciduous trees, more rarely on conifers (degenerate on other substrata), throughout New England, save, in a broad sense, in the upper Canadian zone. It attains its greatest luxuriance in swamps, or in shaded and moist situations. In such places almost every plant found will be heavily fruited, whereas in drier localities only a few plants comparatively will bear apothecia, giving us proof that the remaining plants are sterile examples of *florida*, and should not be classed under a separate species, or even subspecies.

USNEA BARBATA FLORIDA (L.) Fr., f. STRIGOSA Ach.

This form, not recognized in Tuckerman's Synopsis of 1882, but included in the one of 1848, is a contingent form of *florida*,

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* See Nylander, *loc. cit.* 265: "Color rubiginosus interdum obviens vix nisi maceratione ortus, nec typicus (inde quoque in *Usnea florida* oritur var. rubiginea Mich., ut animadvertit Eschweiler).

and, so far as I can ascertain, has an approximately coextensive range; from obtainable data, however, it seems to be somewhat littoral, though I have examined specimens from the interior of North America. One from Fayette, Ohio, is dichroic. Some have supposed that *strigosa* represents an aged condition of *florida*, but I do not think that this can be proved. I have observed in the field fresh normal specimens of *florida* in three years grow old and blacken, becoming somewhat ligneous, brittle, and abraded, losing in this way their fibrils and assuming an estrigose appearance, but the short rami, the ample and therefore necessarily crowded apothecia are conditions that certainly in the second instance (short rami) cannot be brought about by age, and are characteristic of certain plants which can be referred only to Acharius' *strigosa*, a form of *florida* which may or may not be worthy of recognition — a form, I believe, that represents only an unusually luxuriant condition, brought about by abundant moisture, such as the littoral examples of the Atlantic seaboard, which are affected by fog, and particularly those seen from Mexico (Hidalgo, over 7,000 feet) and other regions of excessive moisture and luxuriant growth.

USNEA BARBATA CERATINA (Ach.) Schaer.

With the filamentous forms the difficulty of determination is increased threefold,* for immediately a greater similarity seems evident. If we remember, however, that so far we have considered only *papillate* forms, our work is greatly simplified. It is the present subspecies that I feel sure has caused the greatest perplexity in the determination of New England Usneas, for if we accept Schaerer's later diagnosis literally † (see *pl. 1*, Enum. Crit. Lich. 1850), I have seen but three examples of a truly filamentous *Usnea* from these states bearing large or even middling-sized apothecia. There are distributed in herbaria under this subspecies a great many specimens distinctly referable to *barbata* (sterile *florida*), and more often to the following subspecies *dasypoga*. Throwing out the question of "apotheciis magnis," which of course

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* The great luxuriance of Pacific coast specimens, due evidently to abundant moisture, if used for comparison, is very misleading.

† Enum. Crit. Lich. Eur. 3. 1850. See also Nylander, Syn. Meth. Lich. 269, "Thallus aut erectus aut pendulus."

only represents a state, the comparative, yet supposedly diagnostic terms, "lax," or "rather lax," are so indefinite as applied to the filamentous forms of this genus that they are really meaningless. In *Alectoria,* * the contrast is sufficient, and eliminates the personal equation.

It is interesting to note that in Tuckerman's Synopsis of 1848 (p. 8) he not only includes the contingent form *strigosa* which he later dropped, but does not include *ceratina* which he later included. It must be remembered that the former work referred to "New England and other Northern States," the region now under consideration, while the work of 1882 considered the lichens of all North America. If *ceratina* occurs in New England, then the statement of Tuckerman (1882), *i. e.*, "apothecia middling to large, rarer in extreme (mountain) forms, which pass into *c*" (= *dasypoga*), must be made at least to read, "rarer in Transition zone where it passes into *c*" (= *dasypoga*) above the Austral zone, and even then it seems we must leave the separation of *ceratina* from the following subspecies to practically the presence or absence of ample apothecia, which would again only emphasize the distinguishing of forms on fertile or sterile states. *Ceratina* no doubt is a rare subspecies in New England, as Tuckerman himself plainly indicates; and of the Tuckerman *Usnea* material that I have examined to date, not a single example has been found and in all the New England material I have examined, but a few examples can be placed here. Willey included it in his New Bedford list, but how typically or commonly represented we do not know, as no annotations are given. I have seen but three fruited specimens from New England, all collected by Miss Cummings at Plymouth, N. H., and all lacking lateral fibrils. Shaerer defined it as "fibrillosa vel efibrillosa," but if we are logical in our taxonomy it would seem that we must either propose a name for this naked condition of *ceratina,* or drop *plicata* as a variety of *dasypoga* (see Engler & Prantl), or recognize naked conditions of both coarse *ceratina* and slender *dasypoga,* under one species *plicata,* which seems distinctly inadvisable.

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* Between *A. chalybeiformis* and *A. implexa.*

USNEA BARBATA DASYPOGA Fr.

This subspecies is the pendulous (long on the Pacific coast), filamentous form that reaches 35 or 40 cm. in length. It is the occasional coarseness of the proximal portions of this lichen that has led it to be determined as *ceratina* by many individuals. *U. barbata dasypoga* is common in the high altitudes of the Cana-

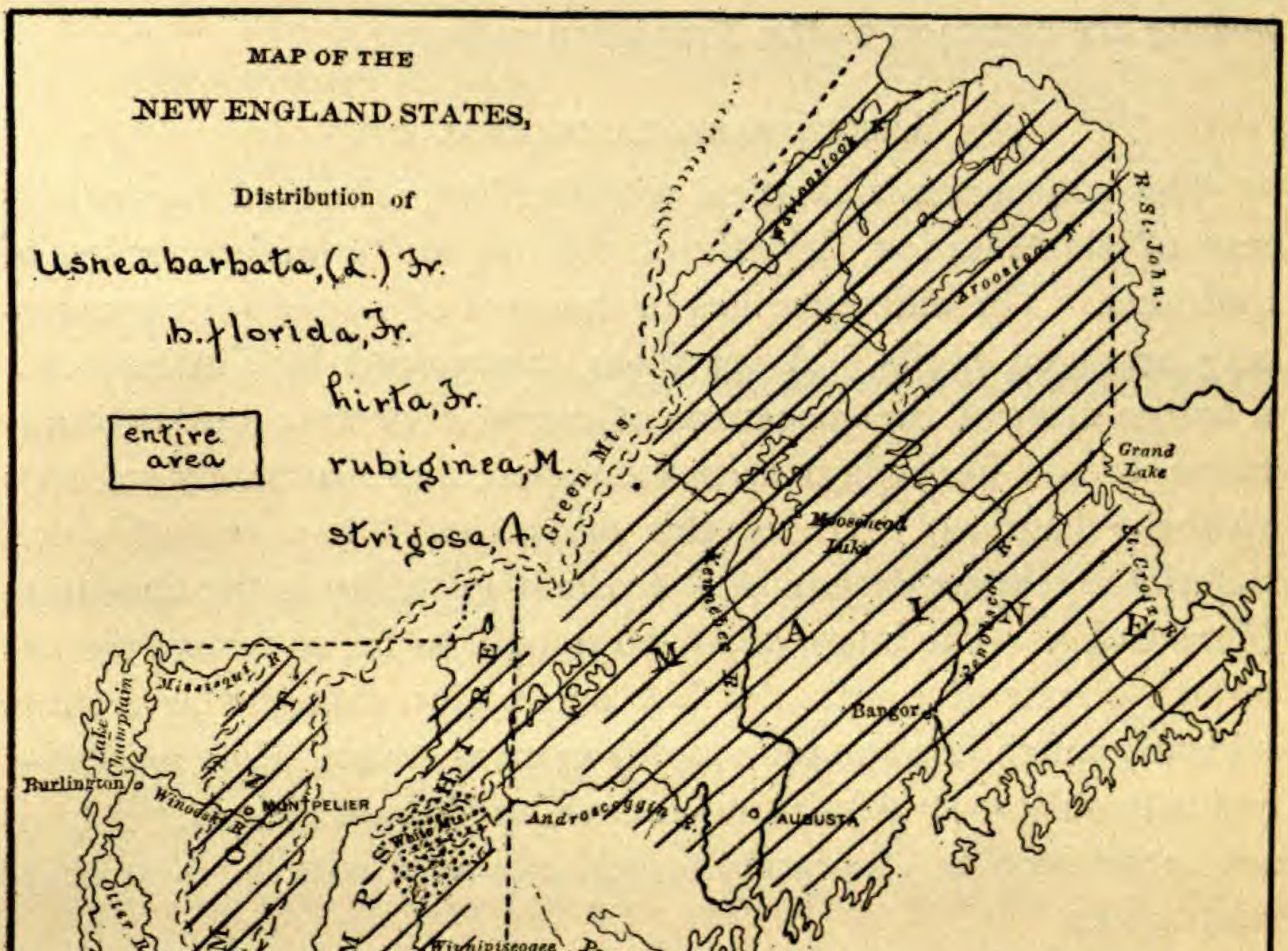

FIGURE A. Map showing distribution of subspecies and forms of *Usnea barbata* in New England.

dian zone, and occurs also in northern Maine, its range being quite similar to that of *U. longissima.* On what grounds Willey included it in his New Bedford list, we cannot tell, as the entry is again without annotation.* There are, however almost Hudsonian "islands" within his area where it could occur, with such species as *Certhia familiaris americana* (Bonap.) and *Parus* [*Penthestes*] *hudsonicus* Forst. Transitional forms between this and the typical *barbata* are common to the Transition regions.

USNEA BARBATA PLICATA Fr.

This subspecies is identical with the last, in regard to slenderness of filamentation, length of thallus, color and scarcity of apothecia. The difference lies in the *lack* of numerous rectangularly arranged fibrils. A specimen determined by Tuckerman † is unlike most of the specimens of recent collection and determination in the herbaria I have examined, and absolutely accords with the diagnosis. Under this subspecies I have found much material of expert determination which in reality is the epapillate *U. trichodea.* The range of *plicata* is held to be, so far as I can ascertain, coextensive with the last subspecies, though this form is evidently much less common and is more northern, being exhibited typically only from Alaska, northern Canada, and Siberia. I have not as yet seen an absolutely typical example from the New England states.

USNEA BARBATA ARTICULATA Ach.

This subspecies does not occur in this region, as Tuckerman implies, or else it is generally overlooked by collectors.

USNEA ANGULATA Ach.

This species in the majority of cases is well marked and easily distinguished. The angular, generally epapillate thallus sometimes attains a length of over one meter. Occasionally a specimen shows but little angulation, being nodulose instead, and approaches *barbata* or one of its subspecies (see specimen in Sull. Moss. Chapt.

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* I have since examined the Willey herbarium and find neither subspecies represented by typical specimens.

† In the Taylor Herbarium, Bost. Soc. of Nat. Hist., from British North America; one fibril figured in our PLATE 22.

Herb., *Mrs. L. A. Carter*, Aug. 6, '01, Lake Winnepesaukee, N. H.*). This condition is mentioned by Tuckerman.

U. angulata seems to have a range somewhat coextensive with the following species, *U. trichodea*, though limited more closely to the Austral zone. In fact, it is only poorly developed, as I have observed it, in the Canadian coniferous "islands," where

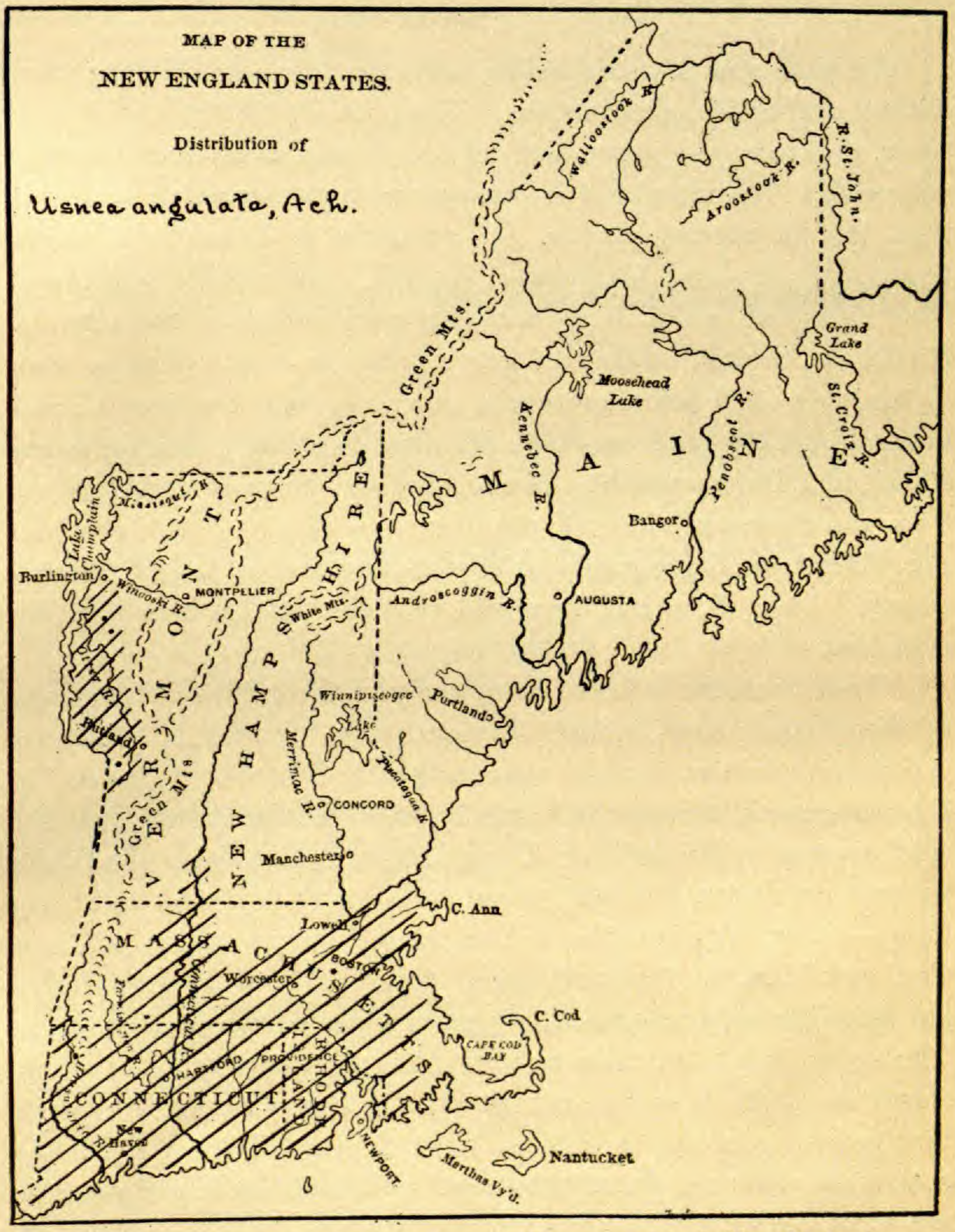

FIGURE B. Map showing distribution of *Usnea angulata* in New England.

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* This even suggests *U. cavernosa* Tuck.

trichodea thrives. I have seen no specimens from Marthas Vineyard, but find it commonly, and well represented from Connecticut. Its presence in the Transition zone needs careful establishment. I have examined specimens from Bristol and Monkton, Vt., and one labelled White Mts.; Oakes Collection, in the herbarium of the U. S. National Museum.

USNEA TRICHODEA Ach.

We have now left to consider only the true, *epapillate* species, distinct and easily recognizable. The present, though variable in color, due to age, is *green*, and only in young plants does it appear yellowish. In maturity it is often an even darker shade of green than that of normal *florida*. *U. trichodea* is throughout, a distinctly slender and filamentous species, somewhat suggesting *cavernosa* (with which it is not often confounded) in character of fibrillation, though rarely attaining a pendular length of more than 25 cm. It often bears apothecia, especially near the coast (Cumberland and Hancock counties, Me., and Plymouth, Bristol, Barnstable, and Dukes counties, Mass.), and this helps to distinguish it from the commonly infertile *dasypoga* and *plicata*, which problem the difference of geographical distribution makes largely unnecessary. Though, as has been said, with the latter it is continually confused.

Usnea trichodea is found commonly in the cold cedar swamps of the Austral zone, in fact it appears that its range is somewhat coextensive in the former zone with the Canadian "islands" of *Chamaecyparis thyoides* (L.) B.S.P., and in the latter with the cold swamp "islands" of *Larix*, *Picea*, and *Abies*. In these swamps *trichodea*, however, grows also on various accompanying trees — *Acer*, for example. The unique faunal region of Cape Cod and Marthas Vineyard, where Canadian and Austral faunas are bewilderingly associated, supports this species in abundance. The upper Transition zone or perhaps rarely lower Canadian zone seems to limit its range, except on the coast, where it extends northward certainly as far as Nova Scotia. I have found no specimens collected above 1400 feet. This species is undoubtedly the most common of the filamentous forms.

USNEA LONGISSIMA Ach.

In color this species suggests the last rather than *dasypoga* and *plicata*, though it fades to a yellowish in herbaria much more quickly than does *trichodea*. It is the most pendulous species and a length of nearly four meters has been attributed to it.* Though

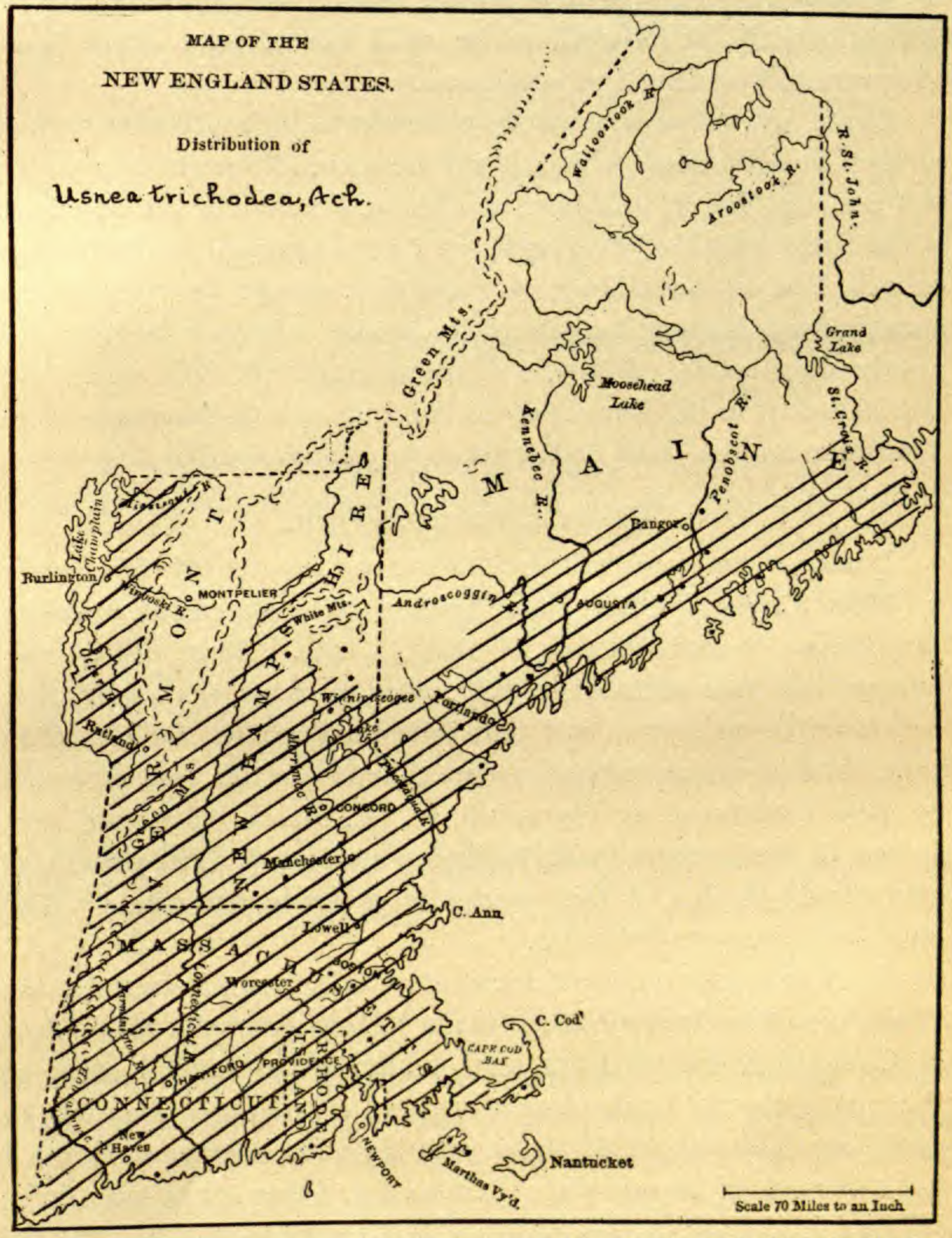

FIGURE C. Map showing the distribution of *Usnea trichodea* in New England.

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*See Herre, A. W. C. T. Proc. Wash. Acad. Sci. 7: 345. 1906. This length is never attained, so far as I know, in New England, 3 m. being the maximum recorded.

never bambusaceous or papillate, it is nearly always *scurfy*, the main filaments of the thallus often appearing white, so thickly clothed are they in a furfuraceous crust. This feature is so characteristic and common that it may almost be used as a safe diagnostic character. The fibrillation suggests *angulata*, though the fibrils are of more varying length, of a more slender nature, and are more thickly beset.* Apothecia, so far as I know, have never been observed in New England specimens.

Usnea longissima is a species common to high altitudes, typical of the Canadian zone, which, it will be seen, allows its occurrence in Vermont, New Hampshire, and Maine (excluding the sea-coast in the latter south of Portland). I have examined no specimens collected below an altitude of 1200 feet, except from the Maine coast, where latitude equals altitude and where it is rare and poorly developed. Willey, a contemporary of Tuckerman, did not include it in his New Bedford list, but, of late, specimens from Transition regions have been erroneously determined as *longissima*.

USNEA CAVERNOSA Tuck.

I cannot find any reference to the occurrence of this species in New England other than Tuckerman's statement, "White Mountains," in his Synopsis of 1882 (p. 43). From this we can judge it is a rare member of the genus, perhaps the rarest, that occurs in these states, and that it is confined to the Canadian zone. I have examined but one specimen from this area, collected by Miss Cummings at Plymouth, N. H., March, 1891, and preserved in her herbarium at Wellesley College.† The pitted and compressed thallus of this species is perfectly diagnostic. The fibrillation suggests *trichodea*.

In closing this paper it seems decidedly preposterous for me to question the determinations made in this genus by Miss Clara E. Cummings, and yet I am certain after a most careful study of the genus that if Tuckerman's diagnostic criteria of *papillate* or *epapillate* thallus is valid (along with his other distinctions), and I have found it to be unerring, then no. 83, *Usnea longissima* Ach.,

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* This is especially true of tropical and other regions of large rainfall, where it becomes *shaggy*.

† Another specimen (no. *1148* in author's herb.) has lately been received from Dr. Manton Copeland from Brunswick, Maine.

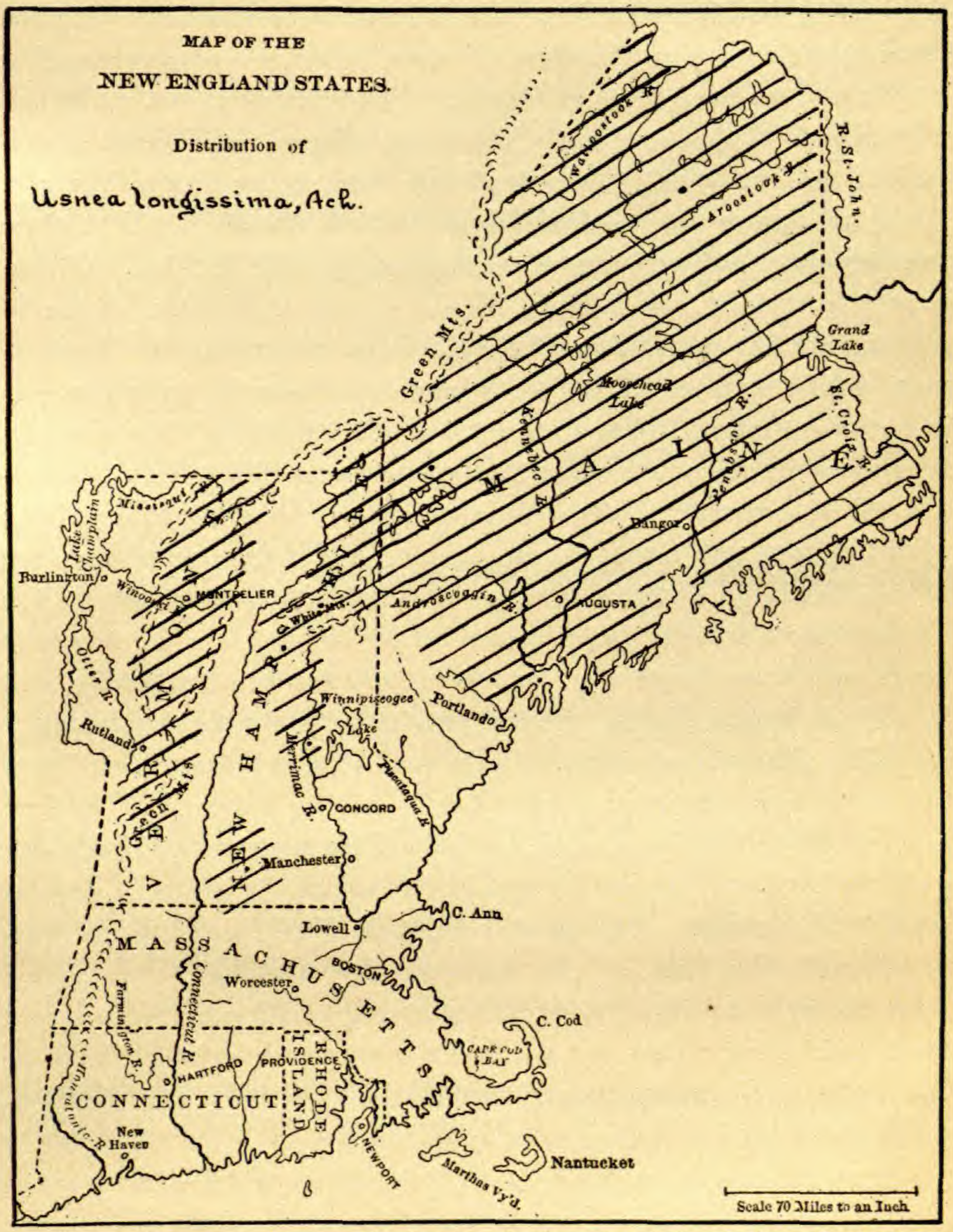

FIGURE D. Map showing distribution of *Usnea longissima* in New England.

in my set of Lichenes Boreali-Americani, second edition, collected at North Woodstock, N. H., August, 1892, by Miss Cummings, must be referred to *Usnea barbata dasypoga* Fr. The specimen distributed in my set is distinctly *papillate*, *not* scurfy in any portion, and not at all characteristically fibrilled. All other nos. 83 of this exsiccati that I have examined contain typical specimens of *longissima*, which would probably prove in this case that an error in distributing had been made, which is little to be wondered at, considering the enormous pressure of work Miss Cummings struggled with in endeavoring to help others. One specimen, no. 52 of the "Decades," is also correct. With no. 269 of the former distribution, and no. 5 of "Decades" the case is, however, different. These specimens are labelled *Usnea barbata plicata* (L.) Fr.; they are, however, distinctly *epapillate* and untypically fibrilled. Moreover, the locality, Wellesley, Mass., is not within the range of *plicata*, so far as I have observed it or according to Tuckerman, whereas it is a region where *trichodea* is common. It is curious that no. 160 of the "Boreali-Americani" distribution is not only labelled *trichodea*, but contains excellent fruited specimens from Brewster, Mass. This mistake of Miss Cummings only goes to prove the undue stress laid on the presence or absence of apothecia and the difficulty of determining specimens from Tuckerman's meager descriptions in his Synopsis. *U. trichodea* bears apothecia frequently, true *plicata* never or very rarely, and is without lateral fibrils. These two statements are explanatory of Miss Cummings' error. The including of *longissima* from Waltham and *dasypoga* from Natick, in the Flora of Middlesex County, Mass. (1888, p. 166), by Miss Cummings would certainly point to the fact that she believed both species to occur in the region of Wellesley. Feeling as I do, that Miss Cummings, or perhaps one of her aids, in this instance was mistaken, I am sure I have no right, at least, to let the matter go without mention, as I have said before "that one specimen wrongly determined may be the highway for many more," and this is especially true of specimens distributed in well-known exsiccati.

It is my hope to publish within a year or two a manual of North American Usneas, but before this can be done I have yet to examine a great many more specimens from outlying localities not represented in the herbaria I have so far seen, as well as to go over the literature with renewed care. The appended records are taken from all the published New England lists of which I have knowledge, and serve to show how sadly this side of the work has been neglected, and how much is left to be accomplished in the study of distribution. I have examined many of the specimens on which the annotations in these lists were made, as many erroneous records have crept in through a misunderstanding of the genus. Let me here enter a plea for more complete data appended to specimens, and a more common publication of authentic local lists, in order that a better study of lichen distribution can be worked out, which I feel sure would help in the labor of taxonomy and broaden our whole knowledge of lichens.

For kind assistance and permission to examine various herbaria I am endebted to Dr. G. M. Allen, Mr. J. A. Cushman, Mr. C. W. Johnson of the Boston Society of Natural History, Dr. N. L. Britton, Dr. M. A. Howe, Dr. J. H. Barnhart, and Mr. R. S. Williams of the New York Botanical Garden, Miss Mary F. Miller of Washington, D. C., Prof. Bruce Fink of Miami University, Dr. Lincoln W. Riddle of Wellesley College, Mr. Fred. LeRoy Sargent of Cambridge, Mr. W. D. Jackson, Bridgewater State Normal School, Mr. Mintin A. Chrysler of the University of Maine, Prof. W. Whitman Bailey and J. Franklin Collins of Brown University, Dr. Manton Copeland of Bowdoin College, Mr. A. H. Norton, of the Portland Society of Natural History, Prof. G. E. Stone of the Massachusetts Agricultural College, Mr. A. S. Goodale of Amherst College, Miss M. A. Day of the Gray Herbarium, Mr. J. S. Galbraith and Prof. S. F. Clarke of Williams College, Mr. Witmer Stone of the Academy of Natural Sciences, Philadelphia, Dr. Alexander W. Evans of the Sheffield Scientific School, New Haven, Conn., Mr. C. C. Plitt of Baltimore, Md., Dr. J. N. Rose of the U. S. National Museum, Washington, D. C., and many others.

Published New England records for the species of *Usnea:*

MAINE. — Harvey, 1894: *florida, hirta, "serotina," dasypoga, plicata:* Orono, *Harvey;* Cumberland, *Blake.*

Harvey, 1894: *longissima:* Greenfield.

Eckfeldt, Wilson, & Cummings (in Rand & Redfield), 1894: *barbata, florida, hirta, rubiginea, ceratina, dasypoga, plicata, trichodea:* Mt. Desert.

Harvey, 1896: *plicata, longissima:* Jackman.

Harvey & Knight, 1897: *plicata, longissima:* Jackman.

NEW HAMPSHIRE. — Howe, 1906: *ceratina* (?): Mt. Monadnock.

Howe, 1908: *florida, hirta, rubiginea, strigosa, dasypoga* (?), *angulata, longissima:* Mt. Monadnock region.

VERMONT. — Frost, 1871 : *barbata, florida, strigosa, rubiginea, hirta, dasypoga:* Brattleboro.

MASSACHUSETTS. — Hitchcock, 1833 : *florida, plicata.*

Hitchcock, 1833 : *strigosa:* Plainfield.

Tuckerman & Frost, 1875 : *barbata, florida, hirta, rubiginea, ceratina, dasypoga:* Amherst.

Sprague, 1880 : *florida, hirta, rubiginea, trichodea.*

Waltham Botanical Club, 1883 : *barbata, florida, strigosa, hirta, longissima:* Waltham.

Cobb, 1887 : *barbata, florida, hirta, rubiginea, ceratina, dasypoga, angulata, trichodea, longissima:* Amherst.

Cummings, 1888 : *florida, hirta, dasypoga, angulata, trichodea longissima:* Middlesex Co.

Willey, 1892 : *barbata, florida, hirta, rubiginea, ceratina, dasypoga, trichodea:* New Bedford.

Howe, 1906 : *rubiginea, ceratina* (?), *strigosa:* Middlesex Co.

Howe, 1903 : *hirta:* Mt. Watatic.

CONNECTICUT. — Hall, 1877 : *barbata, florida, rubiginea, dasypoga,* (*angulata, Prof. Eaton*)*:* New Haven.

THOREAU MUSEUM OF NATURAL HISTORY,
CONCORD, MASSACHUSETTS.

Explanation of plates 21-23

PLATE 21

Usnea barbata ceratina collected at South Canterbury, Conn., by Mrs. S. B. Hadley. Very slightly reduced.

PLATE 22

Papillate species

1. *Usnea barbata florida* Fr.

2. *Usnea barbata florida*, f. *strigosa* Ach. Notice short branching and large apothecia.

3. *Usnea barbata florida*, f. *hirta* Fr. Notice hirsute condition and sorediate terminal fibrils.

4. *Usnea barbata ceratina* Schaer. Notice coarse character and frequent presence of apothecia.

5. *Usnea barbata dasypoga* Fr. Notice similarity of fibrillization to that of *U. longissima* Ach. in lower specimen.

6. *Usnea barbata plicata* Fr. Notice almost entire lack of small fibrils (see text).

All slightly reduced in size.

PLATE 23

Epapillate species

1. *Usnea cavernosa* Tuck. Notice similarity of fibrillization to that of *U. trichodea* Ach.

2. *Usnea longissima* Ach. Notice delicateness of main fibril as compared with *U. b. dasypoga* Fr.

3. *Usnea trichodea* Ach. Notice similarity in fibrillization to that of the upper specimen of *U. b. dasypoga* Fr.

4. *Usnea angulata* Ach. Notice similarity of fibrillization to that of *U. b. florida* Fr., intermediate between *U. longissima* Ach. and *U. b. dasypoga* Fr.

New species of fungi

CHARLES HORTON PECK

Amanita bivolvata

Pileus fleshy, convex or nearly plane, at first viscid, striate on the margin, white, brownish in the center, flesh white; lamellae close, unequal, free, white; stem equal, solid, flocculose, annulate, white, the annulus narrow, often disappearing with age, the volva large, thick, soft, spongy, lobed on the outer margin and having an elevated entire inner margin surrounding the stem; spores subglobose or broadly elliptic, 10–12 μ × 8–10 μ.

Pileus 7–10 cm. broad; stem 13–15 cm. long, 1.6–2.5 cm. thick.

Under oak trees. Claremont, California. January. C. F. Baker.

A large fine white species remarkable for its deep white volva of a soft spongy texture and with a double margin surrounding the base of the stem, the exterior margin of two or three lobes, the interior thin and entire.

Pileus carnosus, convexus subplanusve, primus viscidus, margine striatus, albus, in centro brunnescens, carne alba; lamellae confertae, inaequales, liberae, albae; stipes aequalis, solidus, flocculosus, annulatus, albus, annulo angusto in maturitate saepe evanescente, volva magna, crassa, mollis, spongiosa, margine exteriore lobata, interiore integra; sporae subglobosae vel ellipsoideae, 10–12 μ × 8–10 μ.

Pileus 7–10 cm. latus; stipes 13–15 cm. longus, 1.6–2.5 cm. crassus.

Amanita calyptratoides

Pileus fleshy, convex, then nearly plane, striate on the margin, covered in the center by a large irregular adhering fragment of the white universal veil or by small fragments formed by the breaking up of the veil, grayish brown or lead-colored or sometimes ochraceous or cream-colored, flesh white, taste mild; lamellae moderately close, unequal, sinuate, adnexed, white; stem nearly equal, hollow, striate at the top, white, the slight evanescent annulus soon disappearing or becoming inconspicuous; spores often uninucleate, broadly elliptic, 10–12 μ × 6–8 μ, usually with an oblique apiculus at one end.

Pileus 4–8 cm. broad; stem 8–12 cm. long, 8–16 mm. thick.

Under oak trees. Claremont, California. January. C. F. Baker.

This species is allied to *Amanita calyptrata* Peck, from which it is distinguished by its smaller size, darker color with no greenish tints, and by its slight evanescent annulus. Its habitat also is under or near oak trees, while that species occurs under or near fir trees.

Pileus carneus, convexus, demum subplanus, margine striatus, in centro veli universalis candidi fragmento magno aut fragmentis parvis adhaerentibus tectus, ochraceus, cremeus, griseo-brunneus vel plumbeus, carne alba, sapore miti; lamellae subconfertae, inaequales, sinuatae, adnexae, albae; stipes subaequalis, cavus, albus, ad apicem striatus, annulo levi mox evanescente vel inconspicuo; sporae saepe uninucleatae, late ellipsoideae, 10–12 μ × 6–8 μ, vulgo basi apiculatae.

Pileus 4–8 cm. latus; stipes 8–12 cm. longus, 8–16 cm. crassus.

Amanita ocreata

Pileus fleshy, convex or nearly plane, glabrous, even on the margin, white, flesh white; lamellae close, unequal, broadly sinuate, white; stem equal, solid, glabrous or slightly fibrillose below the annulus, minutely floccose above, white, the annulus thin, membranaceous, the volva white, soft, deep with an entire free margin; spores subglobose or elliptic, 10–12 μ × 8–10 μ.

Pileus 4–6 cm. broad; stem 8–10 cm. long, 1–2 cm. thick.

Under oak trees. Claremont, California. January. C. F. Baker.

Pileus carnosus, convexus vel subplanus, glaber, margine levis, candidus, carne alba; lamellae confertae, inaequales, late sinuatae, albae; stipes aequalis, solidus, glaber vel leviter fibrillosus infra annulum, supra minute floccosus, candidus, annulo tenui, membranaceo; volva mollis, candida, margine integro, libero; sporae subglobosae vel ellipsoideae, 10–12 μ × 8–10 μ.

Pileus 4–6 cm. latus; stipes 8–10 cm. longus, 1–2 cm. crassus.

Armillaria subannulata

Pileus thick, fleshy, convex or broadly convex, subviscid, fibrillose, alutaceous, darker in the center where it is adorned with reddish brown fibrils, margin even, flesh white, odor and taste farinaceous; lamellae close, adnexed, white, sometimes becoming brown on the edges; stem equal, solid, subradicating, reddish brown, white at the top, veil thick, soft, white, evanescent; spores elliptic, 10–12 $\mu \times$ 8–9 μ.

Pileus 10–11 cm. broad; stem 9–15 cm. long, 2–3 cm. thick.

Common. Among fallen leaves under oak trees. Claremont, California. January. C. F. Baker.

A large species well marked by its fibrillose pileus, stout stem, evanescent annulus, and farinaceous taste and odor.

Pileus carnosus, convexus vel late convexus, subviscidus, fibrillosus, alutaceus, in centro obscurior ubi fibrillis rufobrunneis ornatus, margine levi, carne alba, odore saporeque farinaceis; lamellae confertae, adnexae, albae, aliquando acie brunnescentes; stipes aequalis, solidus, subradicans, rufobrunneus, ad apicem albus, velo crasso, molli, albo, evanescente; sporae ellipsoideae, 10–12 $\mu \times$ 8–9 μ.

Pileus 10–11 cm. latus; stipes 9–15 cm. longus, 2–3 cm. crassus.

Clitocybe microspora

Pileus thin, broadly convex or slightly depressed in the center, dry, often eccentric, glabrous or finely and obscurely fibrillose when old, on the margin sometimes irregular or lobed, white or cream-colored, flesh white, odor and taste farinaceous; lamellae thin, close, narrow, unequal, decurrent, white; stem equal, subcartilaginous, hollow, colored like the pileus; spores minute, globose or broadly elliptic, 3–4 μ long.

Pileus 2.5–6 cm. broad; stem 2.5–3 cm. long, 6–8 mm. thick.

Claremont, California. January. C. F. Baker.

Related to *Clitocybe eccentrica* Peck, from which it is separated by its larger size, pileus never umbilicate, lamellae less crowded, stem hollow, and spores smaller.

Pileus tenuis, late convexus seu centro leviter depressus, siccus, saepe eccentricus, glaber vel in maturitate obscure fibrillosus, in margine aliquando irregularis lobatusve, albus vel cremeus, carne alba, sapore et odore farinaceis; lamellae tenues, confertae, angustae, inaequales, decurrentes, albae; stipes aequalis, subcartilagineus, cavus, albus; sporae globosae vel late ellipsoideae, 3–4 μ longae.

Clitocybe sphaerospora

Pileus fleshy, nearly plane, centrally depressed when old, glabrous, opaque, brick-red, darker in the center, flesh tough, white, no distinct taste or odor; lamellae subdistant, narrowed toward each end, decurrent, white, interspaces somewhat venose;

stem equal, slightly radicating, solid, white; spores globose, 10–12 μ broad.

Pileus 5.5–7 cm. broad; stem 5–6.5 cm. long, 1.5–2 cm. thick.

Under oaks. Claremont, California. January. C. F. Baker.

A species belonging to section *Disciformes*, tribe 2, and well marked by its reddish pileus, solid stem, and large globose spores.

Pileus carneus, subplanus, in maturitate centro depressus, glaber, lateritius, centro obscurior, carne lenta, alba; lamellae subdistantes, utrinque angustatae, decurrentes, albae, interstitiis subvenosis; stipes aequalis, subradicans, solidus, albus; sporae globosae, 10–12 μ latae.

Pileus 5.5–7 cm. latus; stipes 5–6.5 cm. longus, 1.5 cm. crassus.

Leptonia flavobrunnea

Pileus thin, fragile, convex, umbilicate or centrally depressed, decurved on the margin, sometimes becoming nearly plane, minutely tomentose in the center, subhygrophanous, dark brown or reddish brown when young and moist, yellowish brown when dry, taste slightly farinaceous; lamellae adnate or subdecurrent, somewhat close, pale lemon-yellow becoming reddish ochre or pinkish, sometimes transversely venose; stem slender, fragile, flexuous, terete or compressed, stuffed or hollow, glabrous, fibrous, pallid or lemon-yellow, becoming brownish yellow, often curved and white at the base; spores subglobose, angular, uninucleate, obliquely apiculate at one end, 8 μ.

Pileus 10–25 mm. broad; stem 5–7.5 cm. long, 2–3 mm. thick.

Gregarious. In swamps under deciduous trees. Stow, Massachusetts. August. S. Davis & G. E. Morris.

Pileus convexus, tenuis, fragilis, umbilicatus vel centro depressus, margine decurvus, quondam subplanus, centro minute tomentosus, subhygrophanus, rufo-brunneus juveno et humido, flavo-brunneus sicco, sapore leviter farinaceo; lamellae adnatae seu subdecurrentes, subconfertae, citrinae, demum roseolae, aliquando transverse venosae; stipes gracilis, fragilis, flexuosus, teres compressusve, farctus cavusve, glaber, fibrosus, pallidus citrinusve, deinde brunneo-luteus, saepe basi curvus et albus; sporae subglobosae, angulares, uninucleatae, oblique apiculatae, 8 μ.

Inocybe Bakeri

Pileus fleshy, broadly convex, becoming nearly plane, dry, densely fibrillose, yellowish or tan-colored, flesh white; lamellae close, adnexed, subventricose, pale brown, ferruginous brown when mature; stem nearly equal, solid, slender, glabrous, mealy at the top, becoming striate, more or less radicating, white; spores ferruginous-brown, 12–14 $\mu \times$ 6–7 μ; cystidia 40–50 μ long.

Pileus 2.5–5.5 cm. broad; stem 5–8 cm. long, 5–6 mm. thick.

Under oak trees. Claremont, California. January. C. F. Baker.

Related to *I. sambucina* Fr. but separated by its smaller size, larger, and more slender stem, and the absence of any strong odor. Belongs to the tribe *Velutini*.

Pileus carneus, late convexus, demum subplanus, siccus, dense fibrillosus, cremoreus vel subalutaceus, carne alba; lamellae confertae, adnexae, subventricosae, pallido-brunneae, deinde ferrugineo-brunneae; stipes subaequalis, solidus, gracilis, glaber, ad apicem albo-farinosus, demum striatus, subradicans, albus; sporae ferrugineo-brunneae, 12–14 $\mu \times$ 6–7 μ; cystidia 40–50 μ longa.

Pileus 2.5–5.5 cm. latus; stipes 5–8 cm. longus, 5–6 mm. crassus.

Inocybe bulbosa

Pileus fleshy, nearly plane, subumbonate, dry, radiately fibrillose, slightly rimose, tan-colored or ochraceous; lamellae thin, close, broadly sinuate, pale buff, becoming brownish ochraceous; stem straight, glabrous, solid, bulbous at the base, cream-colored; spores oblong, even, 10–18 $\mu \times$ 6–7 μ; cystidia subcylindric, 60–80 $\mu \times$ 15–20 μ.

Pileus 3–4.5 cm. broad; stem 5–7 cm. long, 7–9 mm. thick, the bulb 15–17 mm. in diameter.

Under oak trees. Solitary. Claremont, California. February. C. F. Baker.

This species belongs to the section *Rimosae* and is related to *I. rimosa* (Bull.) Fr., but it is a larger species with a more expanded and less distinctly rimose pileus, more strongly bulbous stem, and larger cystidia.

Pileus carneus, subplanus, subumbonatus, siccus, fibrillosus, leviter rimosus, alutaceus ochraceusve; lamellae tenues, confertae, late sinuatae, luteolae, demum brunneo-ochraceae; stipes rectus, solidus, glaber, basi bulbosus, pallidus; sporae leves, oblongae, 10–18 $\mu \times$ 6–7 μ; cystidia subcylindracea, 60–80 $\mu \times$ 15–20 μ.

Pileus 3–4.5 cm. latus; stipes 5–7 cm. longus, 7–9 mm. crassus, bulbus 15–17 mm. latus.

Flammula praecox

Pileus fleshy, convex, becoming nearly plane, glabrous, moist or hygrophanous, brown or reddish brown, paler when old and dry, sometimes with a dull greenish tint, margin at first involute, flesh pallid; lamellae rather close, adnate or sometimes slightly rounded behind, pale ochraceous becoming brownish ochraceous, whitish and minutely crenulate or eroded on the edge; stem equal or slightly tapering upward, becoming hollow with age, silky-fibrillose, slightly floccose or furfuraceous at the top when young by the pure white slight and evanescent veil, pallid, with a soft white tomentum at the base; spores subochraceous, ellipsoid, 7–8 μ × 4–5 μ.

Pileus 2–3 cm. broad; stem 2–4 cm. long, 4–6 mm. thick.

Gregarious or cespitose. On decaying wood, bark, or branches of deciduous trees, commonly basswood, *Tilia americana* L., or even on dead herbaceous stems. Rockville, Indiana. February and March. G. T. Howell.

Remarkable for its early appearance. It apparently belongs to the tribe *Sapinei* but the color of the young lamellae is uncertain.

Pileus carneus, convexus, demum subplanus, glaber, hygrophanus, brunneus, deinde pallido-brunneus vel rufo-brunneus, aliquando viride tinctus, primo margine involuto, carne pallida; lamellae subconfertae adnatae, aliquando adnexae, pallido-ochraceae, demum brunneo-ochraceae, acie albidae, crenulatae vel erosae; stipes aequalis vel sursum leviter attenuatus, demum fistulosus, sericeo-fibrillosus, in juventate ad apicem leviter floccosus vel furfuraceus velo candido evanescente, pallidus, basi tomento molli candido; sporae subochraceae, ellipsoidae, 7–8 μ × 4–5 μ.

Pileus 2–3 cm. latus; stipes 2–4 cm. longus, 4–6 mm. crassus.

Naucoria vinicolor

Pileus broadly convex or centrally depressed, glabrous, dry, wine-colored, flesh reddish; lamellae subdistant, broad, adnexed, wine-colored; stem equal, hollow, fibrillose, subbulbous, colored like the pileus; spores elliptic, obtuse at each end, smooth, 8–9 μ × 5–6 μ.

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

Growing from decaying wood or other vegetable matter in open ground. Claremont, California. January. C. F. Baker.

A peculiar species but well marked by its vinous red color. The base of the stem is often covered by a white tomentum. It belongs to the section *Gymnotae*.

Pileus late convexus vel in centro depressus, glaber, siccus, vinicolor, carne rufescente; lamellae subdistantes, latae, adnexae, vinicolores; stipes aequalis, fistulosus, fibrillosus, subbulbosus, concolor; sporae ellipsoideae, utrinque obtusatae, leves, 8–9 μ × 5–6 μ.

Pileus 2–3 cm. latus; stipes 3–5 cm. longus, 3–4 mm. crassus.

Agaricus bivelatus

Pileus fleshy, thin, broadly convex, radiately fibrillose and floccose, cream-colored slightly tinged with pink, smoky brown in the center; lamellae thin, close, free, pink then seal-brown; stem equal or slightly bulbous, glabrous, shining, white-floccose at the top, stuffed or hollow, cream-colored, with a narrow double annulus which at length disappears; spores subglobose, 5–6 μ × 4–5 μ.

Pileus 4–5 cm. broad; stem 3.5–6 cm. long, 8–11 mm. thick.

Under oaks. Claremont, California. January. C. F. Baker.

A distinct species well marked by its double veil, the outer or lower layer being thin and separable from the upper thicker layer.

Pileus carneus, tenuis, late convexus, radiatim fibrillosus, floccosus, cremeus incarnato leviter tinctus, in centro fumoso-brunneus; lamellae tenues, confertae, liberae, incarnatae demum atrobrunneae; stipes aequalis vel leviter bulbosus, glaber, nitidus, farctus vel fistulosus, cremeus, ad apicem floccis albis, annulo duplici angusto, demum evanescente; sporae subglobosae, 5–6 μ × 4–5 μ.

Pileus 4–5 cm. latus; stipes 3.5–6 cm. longus, 8–11 mm. crassus.

Agaricus subnitens

Pileus fleshy, broadly convex or slightly depressed in the center, densely fibrillose, shining on the margin, cream- or tan-colored, flesh white; lamellae thin, close, free, pink becoming dark brown; stem equal or slightly thickened below, stuffed or hollow, white and fibrillose above, cream-colored and shining below with a finally deciduous brown but white-margined annulus; spores elliptic, purplish brown, 6–8 μ × 4–5 μ.

Pileus 4.5–9.5 cm. broad; stem 8.5–13 cm. long, 1–1.5 cm. thick.

Under oaks. Claremont, California. January. C. F. Baker.

Remarkable for its large annulus, which eventually disappears.

Pileus carneus, late convexus vel in centro leviter depressus, dense fibrillosus, margine nitidus, cremeus alutaceusve; lamellae tenues, confertae, liberae, incarnatae demum atro-brunneae; stipes aequalis vel leviter infra incrassatus, farctus fistulosusve, supra albus et fibrillosus, infra cremeus et nitidus, annulo crasso, brunneo, margine albo, demum deciduo; sporae ellipsoideae, purpureo-brunneae, 6–8 × 4–5 μ.

Pileus 4.5–9.5 cm. latus; stipes 8.5–13 cm. longus, 1–1.5 mm. crassus.

Hypholoma campanulatum

Pileus thin, campanulate, dry, somewhat shining, glabrous, sometimes slightly appendiculate with fragments of the white veil, ochraceous; lamellae thin, close, nearly free, pale brown becoming dark brown, whitish on the edge; stem long, equal, glabrous, hollow, white or cream-colored with a soft white tomentum at the base; spores blackish brown, elliptic oblong, 8–10 μ × 4–5 μ.

Pileus 3–4 cm. broad; stem 8–13 cm. long, 4–7 mm. thick.

Open ground among shrubs, grass, and weeds. Claremont, California. January. C. F. Baker.

Pileus tenuis, campanulatus, siccus, subnitidus, glaber, aliquando albi veli fragmentis leviter appendiculatus, ochraceus; lamellae tenues, confertae, subliberae, pallido-brunneae, demum atro-brunneae, in acie albidae; stipes longus, aequalis, glaber, fistulosus, albus cremeusve, basi tomento molli albo; sporae oblongae ellipsoideaeve, atro-brunneae, 8–10 μ × 4–5 μ.

Pileus 3–4 cm. latus; stipes 8–13 cm. longus, 4–7 mm. crassus.

Phyllosticta innumerabilis

Spots large, suborbicular, sometimes occupying more than half the leaf, brown, yellowish on the circumference; perithecia hypophyllous, minute, 80–100 μ broad, densely gregarious, very numerous, membranous, orbicular, amber-colored; spores oblong or cylindric, hyaline, 6–8 μ × 1.5–2 μ, sporophores 10–20 μ × 1–1.2 μ.

On living leaves of *Amelanchier*. Fort Niobrara, Nebraska. September. Rev. J. M. Bates.

Maculae magnae, suborbiculares, aliquando folii partem magnam occupantes, brunneae, in margine flavidae; perithecia hypophylla, minuta, 80–100 μ lata, dense gregaria, numerosissima, membranacea, orbicularia, mellea; sporae oblongae vel cylindraceae, hyalinae, 6–8 μ × 1.5–2 μ, sporophoribus 10–20 μ × 1–1.2 μ suffultae.

Phoma platysperma

Perithecia minute, about 0.5 mm. broad, numerous, covered by the epidermis, erumpent, black; spores subglobose or broadly ellipsoid, 10–12 μ × 8–10 μ.

On bark of black willow, *Salix nigra* Marsh. River Forest, Chicago, Illinois. March. E. T. & S. A. Harper.

Perithecia minuta, 0.5 mm. lata, numerosa, epidermide tecta, erumpentia, nigra; sporae subglobosae aut late ellipsoideae, 10–12 μ × 8–10 μ.

Sphaeropsis simillima

Perithecia minute, 0.25–0.33 mm. broad, densely gregarious, rarely 2–4 united in a tuft, erumpent, black; spores elliptic or oblong, obtuse, 20–25 μ × 10–12 μ.

On bark of silver maple, *Acer saccharinum* L. River Forest, Illinois. April. E. T. & S. A. Harper.

The perithecia, being occasionally slightly tufted, show an intimate relationship with the genus *Haplosporella*, but as the simple perithecia are much more numerous than the tufted, the species is here placed in the genus *Sphaeropsis*. The specific name is suggested by the great similarity between this species and *Sphaeropsis fertilis* Peck.

Perithecia minuta, 0.25–0.33 mm. lata, dense gregaria, rare caespitosa, erumpentia, atra; sporae ellipsoideae vel oblongae, obtusae, 20–25 μ × 10–12 μ.

Dothiorella Celastri

Perithecia cespitose, 2–20 in a cluster, commonly crowded, erumpent, black, whitish within, unequal, subcoriaceous, subastomous; tufts 0.5–1 mm. broad; spores broadly elliptic or subglobose, hyaline or subhyaline, 5–8 μ × 4–5 μ.

On dead stems of bitter-sweet, *Celastrus scandens* L. Riverside, Illinois. March. E. T. & S. A. Harper.

In some specimens there appears to be a slight stroma or a few hyphae on which the perithecia are seated. The perithecia are unequal in size and shape.

Perithecia caespitosa, vulgo conferta, erumpentia, inaequalia, subcoriacea, subastomata, atra, intus albida; caespites 0.5–1 mm. lati; sporae late ellipsoideae vel subglobosae, hyalinae subhyalinaeve, 5–8 μ × 4–5 μ.

Diplodina fusispora

Perithecia 0.5–1 mm. broad, densely gregarious, sometimes slightly cespitose, irregular or subglobose, erumpent, black; spores short-fusiform, acute at each end, hyaline, at first simple, then uniseptate, 16–20 μ × 4–5 μ.

On branches of silver maple, *Acer saccharinum* L. River Forest, Illinois. April. E. T. & S. A. Harper.

Perithecia 0.5–1 mm. lata, dense gregaria, aliquando leviter caespitosa, irregularia vel subglobosa, erumpentia, atra; sporae breve fusiformes, utrinque acutae, hyalinae, primo simplices, deinde uniseptatae, 16–20 μ × 4–5 μ.

Myxosporium acerinum

Pustules minute, covered by the epidermis, scattered, grayish; spores oozing out and forming minute whitish dots or masses of unequal size, very large, oblong, often narrowed toward one end, granular within, hyaline, 24–40 μ × 8–12 μ.

On bark of silver maple, *Acer saccharinum* L. River Forest, Illinois. April. E. T. & S. A. Harper.

Acervuli minuti, in cortice nidulantes, sparsi, grisei; sporae exudantes et massas minutas inaequales albidas formantes, maximae, oblongae, saepe infra attenuatae, intus granulares, hyalinae, 24–40 μ × 8–12 μ.

Stagonospora linearis

Perithecia pulvinate or hemispheric, 1–1.5 mm. broad, even or rugulose, erumpent, firm, black, whitish within, often yellowish at the base, seriately arranged; spores straight or slightly curved, subcylindric, subclavate or subfusoid, obtuse at each end, triseptate, hyaline, 40–60 μ × 5–6 μ, supported on slender branching sporophores.

On dead branches of hickory. River Forest, Illinois. January. E. T. & S. A. Harper.

Apparently well marked by the long spores and branched sporophores. The perithecia in the specimens seen are astomous.

Perithecia pulvinata hemisphaericave, 1–1.5 mm. lata, levia rugulosave, erumpentia, firma, atra, intus albida, basi flavescentia, seriatim disposita; sporae rectae vel leviter curvae, utrinque obtusae, triseptatae, subcylindraceae, subclavatae, vel subfusiformes, hyalinae, 40–60 μ × 5–6 μ, sporophoribus gracilibus ramosis suffultae.

Bovistella floridensis

Peridium subglobose, 6–20 mm. broad, flaccid, cortex minutely granular or subpulverulent, brown, soon drying and often forming squamules about the apex, then disappearing and revealing the glabrous whitish inner peridium which opens by a definite circular mouth; sterile base present but compact and scanty; capillitium of long, slender, branching and intertwined subhyaline threads about equal to the spores in diameter, grayish when freed from the spores and viewed with the naked eye, glebe brown when mature; spores globose, rough, 4–5 μ, pedicel 10–20 μ.

On the college campus, DeFuniak Springs, Florida. G. Clyde Fisher.

Peridium subglobosum, 6–20 mm. latum, flaccidum, cortice minute granulari pulverulentove, brunneo, in siccitate squamulas minutas circum apicem formante, demum evanescente; peridium interius glabrum, albidum, ore rotundo dehiscens, basi sterili parvo; capillitium filamentis longis, gracilibus, ramosis, intricatis, subhyalinis compositum; sporae globosae, asperulae, pedicellatae, 4–5 μ latae; pedicellae 10–20 μ longae.

GEOLOGICAL HALL,
ALBANY, NEW YORK

A new fungus of the swamp cedar

Howard J. Banker

(with plate 24)

During the past year Mr. W. H. Ballou has discovered a new and interesting fungus which appears to be very destructive to the swamp cedar, *Chamaecyparis thyoides* (L.) B.S.P., of the New Jersey coast. The fungus is parasitic on the cedar and as yet appears to be confined to that species. Its destructive effects on the forest are described and well illustrated in an article in the Scientific American for December 19, 1908.

Mr. Ballou's observations of the work of this fungus have been confined to the region about Forked River, Ocean County, New Jersey, where it seems to have fully established its work of destruction. It is desirable that observations be made as soon as possible throughout the range of this cedar that the origin and progress of the disease may be determined. The plant is likely to escape notice without diligent search. The sporophores are borne high on the tree close to or in the canopy, and from their position, size, coloring, and their tendency to fall away from the deadened wood, they are not readily detected.

I take pleasure in dedicating the species to the discoverer whose persistent work on the swamp cedar has led to the detection of this destructive fungus.

Steccherinum Ballouii sp. nov.

Plant parasitic, perennial, pileate; pileus campanulate to subdimidiate, more or less imbricate, sessile, decurrent on a vertical substratum to pendent from a horizontal substratum, easily separable, 1–4 cm. long, 1–5 cm. wide, often confluent laterally to 10 cm.; surface sulcate-zonate, radiately subrugose, somewhat scrobiculate, sometimes velutinous on younger and more protected parts, often licheniferous on the older parts, dark olive-brown when fresh, drying to gray-brown on older parts, becoming light seal-brown on younger portions toward margin; margin obtuse, somewhat lobed, seal-brown extending around quite to the hymenial side; substance thin, 1–2 mm., of two layers, the upper harder, somewhat brittle, dark brown, the lower softer, light brown; hyphae of upper portion subrigid, thick-walled, dark-colored, more or less interwoven, having numerous globular guttulate bodies massed among the hyphae, single hypha 3–4 μ wide; hyphae of lower portion thin-walled, subhyaline, more or less parallel, without globular bodies, but with numerous granules scattered among them, single hypha 3–4 μ wide; hymenium colliculose, subfarinaceous under a lens, golden yellow when fresh, fading in drying to a light buff or pale cream-colored; teeth various, coarse, subterete to difform, confluent, papilloid to elongate, usually obtuse, tips sometimes brownish, 1–5 mm. long, 0.5–1 mm. wide, irregularly distributed; spores hyaline, broadly elliptical to subglobose, 7–7.2 μ by 5.5–6.5 μ wide; taste mild, slightly bitter, suggesting old hickory nuts; odor slight, resembling the substratum. [PLATE 24.]

On living *Chamaecyparis thyoides* (L.) B.S.P. at Forked River, Ocean County, New Jersey, *W. H. Ballou*, April 6, 1908. Type specimen in the writer's herbarium.

The plant belongs to the family Hydnaceae, which possesses but few parasitic forms. The only other species positively known to be strictly parasitic is *Echinodontium tinctorium* Ell. & Ev., which also attacks species of the Pinaceae on the Pacific coast. The two fungi possess some strikingly similar characteristics, but it is doubtful if they are congeneric. Both approach the tough woody Polyporaceae more closely than any other of the Hydnaceae and would be readily mistaken for members of that family on casual observation. The present plant suggests especially the genus *Coriolus* and except for Hydnaceous hymenial surface would appear to have closer affinities with this genus than with any of those now included in the Hydnaceae. This statement, however, may be made of two or three other species heretofore referred to the genus *Steccherinum*. It seems best, therefore, to refer this new species for the present to this latter genus.

There has long been a doubt in the writer's mind whether the families of the Agaricales, especially the Thelephoraceae, Hydnaceae, and Polyporaceae, are not distinguished by a very artificial characteristic in the form of the hymenial surface. The natural lines of cleavage appear in many instances to be at right angles to the present system and to be determined by histological rather than morphological characters.

DE PAUW UNIVERSITY,
GREENCASTLE, INDIANA.

Explanation of plate 24

The figure shows one of the plants pendent from a horizontal branch. The base of the branch is to the left. The part of the pileus toward the observer is slightly out of focus in order to bring the teeth of the opposite under side sharply into view. Magnified 1.4+. The photograph was made by one of my pupils, Paul Collins.

INDEX TO AMERICAN BOTANICAL LITERATURE
(1908)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions their kindness will be appreciated.

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B[ean], W. J. *Rhus Toxicodendron.* Kew Bull. Misc. Inf. **1908**: 455, 456. D 1908.

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Includes 4 new species in *Sabal*, *Thrinax*, and *Coccothrinax* (2).

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Native in New Mexico.

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Includes new species in *Paspalum*, *Nassella* (2), *Calamagrostis*, *Eragrostis*, *Melica*, *Poa*, and *Festuca*, from Bolivia.

Harms, H. *Araliaceae*. [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42**: 237, 238. 29 D 1908.

Includes *Pentapanax Ulei* sp. nov.

Harms, H. *Leguminosae*. [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42**: 202–217. 29 D 1908.

Includes 30 new species in *Calliandra* (8), *Mimosa* (7), *Bauhinia*, *Cassia* (3), *Swartzia*, *Sweetia*, *Zornia* (3), *Dalbergia*, *Machaerium*, *Platymiscium*, *Camptosema*, *Galactia*, and *Phaseolus*.

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Includes new species in *Coriolopsis* (4), *Cerrenella*, *Inonotus* (3), *Fomes*, *Pyropolyporus* (10), *Amauroderma* (3), *Ganoderma* (11), *Lenzites* (2), and *Gloeophyllum*.

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Includes *Stenolobium arequipense* sp. nov.

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A new species from Guatemala.

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371–375. 2 My 1908; 426–436. 30 My 1908; 483–514. 1 Jl 1908; 561–608. 31 Jl 1908; 661–696. 31 Au 1908; 745–776. 30 S 1908; 837–866. 31 O 1908.

Includes new American species in *Chiloscyphus* (4), *Zoopsis*, *Cephalozia* (6), *Alobiella*, *Odontoschisma* (10), *Adelanthus* (2), *Marsupidium*, *Calypogeia* (6), *Mastigobryum* (16), and *Saccogyna* (2).

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Urban, I. *Loasaceae*. [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42**: 231, 232. 29 D 1908.

Includes *Loasa Gilgiana* sp. nov.

Urban, I. Plantae novae andinae imprimis Weberauerianae — IV (Schluss). Bot. Jahrb. **42**: 177. 29 D 1908.

Includes *Stenolobium arequipense* sp. nov. from Peru. (Sprague.)

Ulbrich, E. *Malvaceae*. [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42**: 225–229. 29 D 1908.

Includes 5 new species in *Sida* (2), and *Pavonia* (3).

Ule, E. Beiträge zur Flora von Bahia — I. Bot. Jahrb. **42**: 191–238. *pl. 1* + *f. 1*. 29 D 1908.

Includes 10 separate papers indexed under their respective authors as follows, Ule (6), Harms (2), Ulbrich, and Urban.

Ule, E. *Bromeliaceae*. [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42**: 191–199. *f. 1*. 29 D 1908.

Includes new species in *Sincoraea* gen. nov., *Cryptanthopsis* gen. nov., *Bromelia*, *Nidularium*, *Hohenbergia* (2), *Aechmea*, *Dyckia*, and *Encholirion* (2).

Ule, E. *Capparidaceae*. [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42**: 201, 202. 29 D 1908.

Includes a new genus and three new species.

Ule, E. *Euphorbiaceae*. [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42**: 217–225. 29 D 1908.

Includes 4 new species in *Argyrothamnia*, *Plukenetia*, *Pera*, *Jatropha* (3), *Manihot* (2), *Sebastiania* (2), *Stillingia*, and *Euphorbia* (3).

Ule, E. *Loranthaceae*. [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42**: 199–201. *pl. 1*. 29 D 1908.

Includes new species, *Struthanthus sincorensis*, *S. tenuicaulis*, and *Phoradendron Caesalpiniae*.

Ule, E. *Melastomataceae.* [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42** : 232–236. 29 D 1908.

Includes 7 new species in *Chaetostoma*, *Microlicia* (2), *Pterolepis*, *Itatiaia*, gen. nov., *Fritzschia*, and *Marcetia*.

Ule, E. *Violaceae.* [In Ule, Beiträge zur Flora von Bahia — I.] Bot. Jahrb. **42** : 230, 231. 29 D 1908.

Includes 2 new species, *Hybanthus procumbens* and *H. arenarius*.

Thornber, J. J. The viability of seeds. Plant World **11** : 158, 159. Jl 1908.

Theissen, F. Fragmenta bra ilica. Ann. Myc. **6** : 531–535. 31 D 1908.

Includes *Phyllachora Goeppertiae* sp. nov.

Vries, H. de. Über die Zwillingsbastarde von *Oenothera nanella.* Ber. Deuts. Bot. Gesells. **26a** : 667–676. 19 D 1908.

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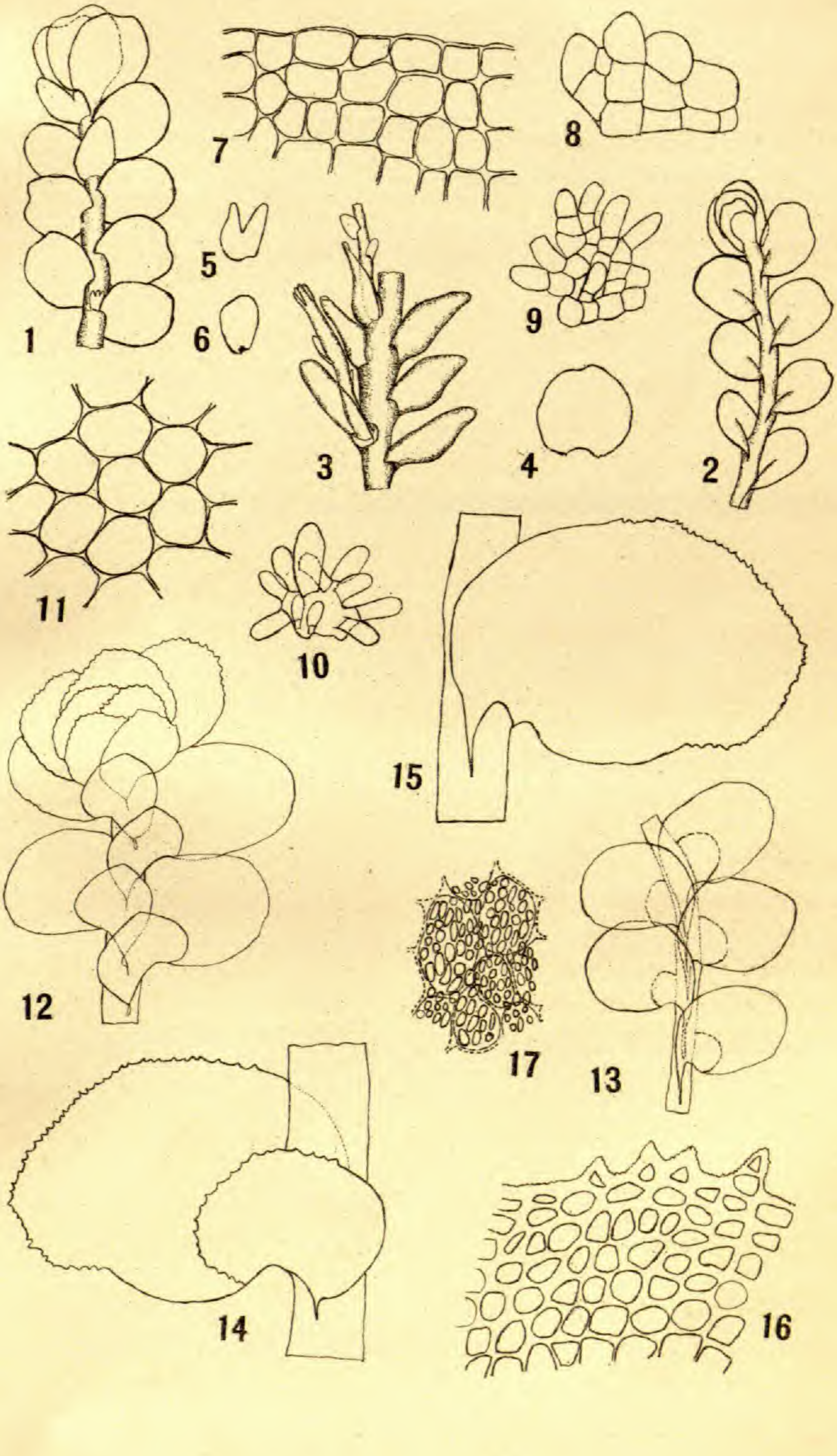
Wolff, H. *Eryngium Buchtienii* Wolff nov. spec. Repert. Nov. Spec. **6** : 24. 1 N 1908.

Native of Bolivia.



1-11. JUNGERMANNIA ALLENII L. Clark

12-17. SCAPANIA PALUDOSA PAPILLOSA K. Müll. Frib.

USNEA BARBATA CERATINA Schaer.

1. USNEA BARBATA FLORIDA Fr.
2. USNEA BARBATA FLORIDA STRIGOSA Ach.
3. USNEA BARBATA FLORIDA HIRTA Fr.
4. USNEA BARBATA CERATINA Schaer.
5. USNEA BARBATA DASYPOGA Fr.
6. USNEA BARBATA PLICATA Fr.

1. USNEA CAVERNOSA Tuck.
2. USNEA LONGISSIMA Ach.
3. USNEA TRICHODEA Ach.
4. USNEA ANGULATA Ach.

STECCHERINUM BALLOUII Banker

North American Flora

THIS work is designed to present descriptions of all plants growing independently of cultivation, in North America, here taken to include Greenland, Central America, the Republic of Panama, and the West Indies, except Trinidad, Tobago, and Curaçao and other islands off the north coast of Venezula, whose flora is essentially South American.

It will be published in parts at irregular intervals by the New York Botanical Garden through the aid of the income of the David Lydig Fund bequeathed by Charles P. Daly.

It is planned to issue parts as rapidly as they can be prepared, the extent of the work making it possible to commence publication at any number of points. The completed work will form a series of volumes with the following sequence:

Volume 1. Mycetozoa, Schizophyta, Diatomaceae.
Volume 2 to 10. Fungi.
Volumes 11 to 13. Algae.
Volumes 14 and 15. Bryophyta.
Volume 16. Pteridophyta and Gymnospermae.
Volumes 17 to 19. Monocotyledones.
Volumes 20 to 30. Dicotyledones.

The preparation of the work has been referred by the Scientific Directors of the Garden to a committee consisting of Dr. N. L. Britton, Dr. W. A. Murrill and Dr. J. H. Barnhart.

Professor George F. Atkinson, of Cornell University, Professors Charles R. Barnes and John M. Coulter, of the University of Chicago, Mr. Frederick V. Coville, of the United States Department of Agriculture, Professor Edward L. Greene, of the United States National Museum, Professor Byron D. Halsted, of Rutgers College, and Professor William Trelease, of the Missouri Botanical Garden, have consented to act as an advisory committee.

Vol. 7, Part 1, Ustilaginales, including Ustilaginaceae and Tilletiaceae, by G. P. Clinton, was issued Oct. 4, 1906. Vol. 7, Part 2, Coleosporiaceae, Uredinaceae, and Aecidiaceae (pars), of the Uredinales, by J. C. Arthur, was issued March 6, 1907. Vol. 9, Parts 1 and 2, Polyporaceae, by W. A. Murrill, were issued Dec. 19, 1907, and March 12, 1908. Vol. 22, Part 1, including Podostemonaceae by George V. Nash, Crassulaceae by N. L. Britton and J. N. Rose, and Penthoraceae and Parnassiaceae by P. A. Rydberg, was issued May 22, 1905. Vol. 22, Part 2, including Saxifragaceae and Hydrangeaceae by J. K. Small and P. A. Rydberg, Cunoniaceae, Iteaceae, and Hamamelidaceae by N. L. Britton, Pterostemonaceae by J. K. Small, Altingiaceae by Percy Wilson, and Phyllonomaceae by H. H. Rusby, was issued Dec. 18, 1905. Vol. 22, Part 3, Grossulariaceae by F. V. Coville and N. L. Britton, Platanaceae by H. A. Gleason, Crossosomataceae by J. K. Small, Connaraceae by N. L. Britton, Calycanthaceae by C. L. Pollard, and Rosaceae (pars) by P. A. Rydberg, was issued June 12, 1908. Vol. 22, Part 4, Rosaceae (pars) by P. A. Rydberg, was ssued Nov. 20, 1908. Vol. 25, Part 1, including Geraniaceae by L. T. Hanks and J. K. Small, Oxalidaceae and Linaceae by J. K. Small, and Erythroxylaceae by N. L. Britton, was issued Aug. 24, 1907.

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

JULY, 1909

The mildews of the cereals *

GEORGE M. REED

In a recent paper[22] I have given a complete summary of the work that has been done on the physiological specialization of the Erysiphaceae. Since that paper was completed Salmon[29] has published some results with the hop mildew [*Sphaerotheca Humuli* (DC.) Burr.]. Salmon obtained ascospores from the hop and sowed them on the same plant, and also on *Potentilla reptans* and *Spiraea Ulmaria*, but infection occurred only on the hop. The conidia produced on the hop failed also to infect *Spiraea Ulmaria* although conidia similarly produced infected the hop.

Thus far one or more species of five genera of the Erysiphaceae have been tested with reference to their physiological specialization, namely, *Erysiphe*, *Microsphaera*, *Phyllactinia*, *Sphaerotheca*, and *Uncinula*. As yet no species of *Podosphaera* has been tested. The work with *Sphaerotheca*, *Microsphaera*, *Phyllactinia*, and *Uncinula* has been very limited, relatively few tests having been made with species of these genera. Practically all of the work of importance has been done with two species of *Erysiphe*, viz., *E. Cichoracearum* and *E. Graminis*.

Although from the morphological standpoint the same species of mildew, *Erysiphe Graminis*, attacks all grasses reported as hosts of the mildew, yet physiological differences have been found to exist between the mildews on the various grasses. Marchal[18] first pointed out the existence of *formes spéciales* in the grass mildew. He states that the mildew on each of the cereals (barley, oats,

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* Contributions from the Department of Botany of the University of Missouri — No. 17.

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rye, and wheat) belongs to a separate specialized form. The mildew on wheat (*Triticum vulgare*) infected wheat and also *T. Spelta*, *T. polonicum*, and *T. turgidum*, but not *T. dicoccum*, *T. durum*, *T. monococcum*, barley, oats, or rye. The mildew on barley (*Hordeum vulgare*) infected barley and also *H. hexastichon*, *H. jubatum*, *H. murinum*, *H. nudum*, and *H. trifurcatum*, but not *H. bulbosum*, *H. maritimum*, *H. secalinum*, oats, rye, or wheat. The mildew on rye (*Secale cereale*) infected rye and *S. anatolicum*, but not the other cereals. The mildew on oats (*Avena sativa*) infected oats and also *A. fatua*, *A. orientalis*, and *Arrhenatherum elatius*, but not the other cereals.

Salmon has also done considerable work with the grass mildew, and while in general his results agree with those of Marchal, yet there are some interesting minor differences. For example, Salmon[24] was unable to infect *Arrhenatherum elatius* with the oat mildew. In the case of the barley mildew, Salmon[25] found that conidia from barley infected *Hordeum bulbosum*, *H. deficiens*, *H. distichon*, *H. hexastichon*, *H. intermedium*, *H. maritimum*, *H. vulgare*, and *H. Zeocriton*, but not *H. jubatum*, *H. murinum*, *H. secalinum*, or *H. silvaticum*.

My previous results[21] with the mildew on *Secale cereale* agree with those of Marchal. I was not able to infect barley, oats, wheat, and twelve other grasses, all of which have been reported as hosts of *Erysiphe Graminis*, while rye was readily infected with conidia from the same host.

During the past year I have carried out further extensive experiments with the mildews of barley, rye, and wheat. While at the University of Wisconsin, I had, as described in an earlier paper,[21] cultures of the rye and barley mildews growing in the botanical greenhouse. Through the kindness of Professor R. A. Harper, cultures of these mildews were forwarded to me at Columbia, Missouri. The wheat mildew was first found in the fall of 1907, at Columbia, on wheat plants brought into the greenhouse from the field for experimental work. In a few days after these plants were brought in, the mildew was observed to be present. The fungus spread very rapidly and cultures have been kept growing ever since.

I am indebted to a number of people for furnishing me with the seed of the various cereals and grasses used in the following tests. The U. S. Department of Agriculture, at Washington, D. C., sent seed of *Triticum dicoccum* (Black Winter Emmer and White Emmer), *T. durum* (var. Kubanka), *T. polonicum*, *T. Spelta*, *Hordeum distichon*, *H. nudum*, *H. vulgare*, and *H. Zeocriton*. Vilmorin-Andrieux & Company furnished seed of *Hordeum trifurcatum*, *Triticum monococcum*, and *T. turgidum*. From the California Agricultural Experiment Station I received seed of *Hordeum distichon*, *H. tetrastichon*, *Triticum dicoccum* (Black Emmer), *T. durum* (varieties Black Don, Chilean, and Kubanka), and *T. Spelta*. Haage & Schmidt, Erfurt, Germany, furnished seed of a number of plants, among others *Hordeum trifurcatum*, *Triticum monococcum*, and *T. turgidum*. Professor Trelease, of the Missouri Botanical Garden, sent me seed of *Triticum durum affine*, *T. compactum creticum*, and *T. monococcum*. Professor C. A. Zavitz, of the Ontario Agricultural College, sent seed of *Triticum dicoccum* (Red Emmer, Russian Emmer, Common Emmer, and Black Winter Emmer), and *T. durum* (Medeah Spring Wheat, Soretina Spring Wheat, and Wild Goose Spring Wheat). I am especially indebted to Professor Doctor Fr. Bubák, Director of the Botanical Garden at Tábor, Bohemia, for seed of *Triticum Freycenetii*, *T. monococcum* (varieties *Hornemannii* and *vulgare*), *T. Spelta*, *T. Thaoudar*, *T. Tumonia*, *T. turgidum*, *Secale dalmaticum*, *S. montanum*, *S. cereale* × *Triticum vulgare*, *Hordeum maritimum*, and *H. Steudelii* × *H. trifurcatum*.

According to Hackel[15] there are only three distinct species of *Triticum* in cultivation. Hackel classifies the cultivated wheats as follows:

Triticum
- *monococcum* L., Einkorn.
- *sativum*
  - *dicoccum* Schrank, Emmer.
  - *Spelta* Hackel, Spelt.
  - *tenax*
    - *vulgare* Hackel, Wheat.
    - *compactum* Hackel, Club Wheat.
    - *turgidum* Hackel, Poulard Wheat.
    - *durum* Hackel, Durum Wheat.
- *polonicum* L. Polish Wheat.

Hackel classifies the commonly cultivated barleys as follows: *Hordeum sativum distichon* Hackel, including several varieties, as *erectum*, *nutans*, *Zeocriton*, *macrolepis*, *deficiens*, and *nudum*; *H.*

sativum hexastichon Hackel; and *H. sativum vulgare* Hackel, including *H. coeleste*, *H. intermedium*, *H. Kaufmanni*, and *H. trifurcatum*.

TABLE I.—RESULTS WITH *Avena sativa* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
38c	1908 Jan. 2	*Hordeum distichon*	8	3	3	1908 Jan. 11	—	—
77b	Feb. 10	" "	9	3	2	Feb. 17	—	—
79c	" 10	" "	9	2	3	" 17	—	—
80c	" 10	" "	9	3	3	" 17	—	—
86c	" 22	" "	9	5	6	" 29	—	—
13a	1907 Dec. 24	*Hordeum vulgare*	8	3	3	1907 Dec. 30	—	—
21b	" 31	" "	10	2	3	1908 Jan. 7	—	—
23b	" 31	" "	10	4	2	" 7	—	—
24b	" 31	" "	10	3	3	" 7	—	—
25c	" 31	" "	10	3	4	" 7	—	—
36b	1908 Jan. 2	" "	8	3	1	" 11	—	—
44b	" 18	" "	14	3	3	" 24	—[1]	—
45b	" 18	" "	14	3	2	" 24	—[1]	—
65c	Feb. 3	" "	10	3	2	Feb. 10	—	—
66c	" 3	" "	10	3	3	" 10	—	—
67a	" 3	" "	10	2	3	" 10	—	—
147a	Oct. 31	" "	9	3	1	Nov. 7	—	—
147c	" 31	" "	9	2	1	" 7	—	—
98b	Mar. 3	*Hordeum Zeocriton*	7	2	2	Mar. 10	—	—
99b	" 3	" "	7	3	4	" 10	—	—
100b	" 3	" "	7	2	4	" 10	—	—
101a	" 3	" "	7	2	4	" 10	—	—
58a	Feb. 1	*Triticum durum*	8	3	3	Feb. 10	—	—
93b	" 22	*Triticum polonicum*	9	5	6	" 29	—	—
94c	Mar. 3	*Triticum Spelta*	7	3	5	Mar. 10	—	—
95c	" 3	" "	7	4	2	" 10	—	—
16c	1907 Dec. 25	*Triticum vulgare*	9	3	5	1907 Dec. 30	—	—
18a	" 25	" "	9	2	4	" 30	—	—
26b	" 31	" "	10	4	2	1908 Jan. 7	—	—
27b	" 31	" "	10	3	3	" 7	—	—
32a	1908 Jan. 2	" "	8	3	5	" 11	—	—
42a	" 17	" "	13	3	4	" 24	—	—
62a	Feb. 3	" "	10	3	3	Feb. 10	—	—
76a	" 10	" "	9	3	2	" 17	—	—
90a	" 22	" "	9	5	6	" 29	—	—
92c	" 22	" "	9	4	4	" 29	—	—

---

[1] Discolored areas were visible on the inoculated leaves, indicating the beginning of infection. No well-developed mycelium producing conidia appeared, however These were the only plants in which any evidence of infection was obtained.

TABLE II.— RESULTS WITH *Hordeum bulbosum* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. p'ants	Controls
	1908					1908		
132b	Oct. 21	*Hordeum vulgare*	8	4	2	Oct. 30	—	—
133b	" 21	" "	8	4	1	" 30	—	—
137b	" 31	" "	9	1	0	Nov. 7	—	...
138c	" 31	" "	18	3[1]	1	" 7	—	—
151a	Nov. 10	" "	19	1[2]	1	" 19	—	—
153b	" 10	" "	19	2[1]	0	" 19	—	...
163c	" 16	" "	13	1	0	" 26	—	...
164a	" 16	" "	13	2	1	" 26	+[3]	—
176c	" 27	" "	13	1[2]	1	Dec. 5	—	—
178b	" 27	" "	13	2[2]	2	" 5	—	—
179c	" 27	" "	13	1	0	" 5	—	...
181a	" 27	" "	24	2[2]	2	" 5	—	—

[1] The second leaf inoculated.

[2] Two leaves inoculated.

[3] A few small tufts of conidia appeared on one inoculated leaf.

In the tables given herewith, I have deemed it best to follow the older classification of Linnaeus, as the various cultivated varieties of wheat and barley are commonly referred to in this way. I have, however, indicated the position of the forms tested in Hackel's classification.

The plants used in the experiments were grown in two and one-half inch flower pots. In each pot some of the plants were inoculated, while the remaining ones were kept as controls. Generally the spores were sown on the first green leaf. After the plants were inoculated, the pots were placed under a tall bell-jar, usually three pots being placed under the same jar. The bell-jars were slightly raised at the base to allow a free circulation of air. The pots were placed in a saucer, and water, when needed, was poured into the latter.

The plants were inoculated by transferring with a scalpel conidia from an infected plant and spreading them over the surface of the leaf of the plant that was to be inoculated. In order to be sure of plenty of conidia, I found it advantageous to place infected plants under a bell-jar for a day or two before inoculation. In this way the conidia were formed in abundance and remained upon the leaves instead of being scattered by currents of air. Thus I

TABLE III. — RESULTS WITH *Hordeum distichon* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
5b	1907 Dec. 16	*Hordeum distichon*	9	3	4	1907 Dec. 23	+++	—
78b	1908 Feb. 10	" "	9	3	4	1908 Feb. 17	+++	—
79b	" 10	" "	9	4	2	" 17	+++	—
80a	" 10	" "	9	4	1	" 17	+++	—
86a	" 22	" "	9	5	6	" 29	+++	—
88a	" 22	" "	9	4	2	" 29	+++	—
85b	" 21	*Hordeum nudum*	8	5	5	" 29	+++	—
1a	1907 Dec. 9	*Hordeum vulgare*	8	3	3	1907 Dec. 16	+++	—
3a	" 9	" "	8	3	2	" 16	+++	—
4c	" 9	" "	8	2	3	" 16	+++	—
8c	" 16	" "	9	3	2	" 23	+++	—
9c	" 16	" "	9	1	1	" 23	+++	—
12a	" 24	" "	8	4	4	" 30	+++	—
15c	" 25	" "	9	3	2	" 30	+++	—
34b	1908 Jan. 2	" "	8	2	2	1908 Jan. 11	+++	—
35b	" 2	" "	8	2	3	" 11	+++	—
36c	" 2	" "	8	2	2	" 11	+++	—
44c	" 18	" "	14	3[2]	1	" 24	+++	—
45a	" 18	" "	14	2[2]	3	" 24	+++	—
46c	" 18	" "	14	4[2]	4	" 24	+++	—
64b	Feb. 3	" "	10	1	2	Feb. 10	+++	—
65b	" 3	" "	10	2	2	" 10	+++	—
67c	" 3	" "	10	3	3	" 10	+++	—
133a	Oct. 21	" "	8	2	1	Oct. 30	+++	—
6c	1907 Dec. 16	*Hordeum Zeocriton*	9	3	3	1907 Dec. 23	+++	—
17b	" 25	*Triticum vulgare*	9	2	3	" 30	—	—
33a	1908 Jan. 2	" "	8	3	2	1908 Jan. 11	—	—

[1] *Hordeum sativum distichon* Hackel.

[2] The second leaf of each plant inoculated.

TABLE IV.—RESULTS WITH *Hordeum jubatum* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
133c	1908 Oct. 21	*Hordeum vulgare*	8	8	4	1908 Oct. 30	—	—
135c	" 23	" "	10	3	3	" 31	—	—
163a	Nov. 16	" "	13	3	1	Nov. 26	—	—
175b	" 27	" "	13	1	0	Dec. 5	—	...
180a	" 27	" "	13	1	1	" 5	—	—
181b	" 27	" "	24	1[1]	1	" 5	—	—

[1] Two leaves of the plant inoculated.

was always sure of a large quantity of good, viable conidia. In most experiments plants of the same species as that from which the mildew was obtained were inoculated. If the mildew developed upon these plants, it was considered sufficient evidence that the conidia were entirely viable.

TABLE V. — RESULTS WITH *Hordeum maritimum* With.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
120b	1908 July 28	*Hordeum vulgare*	4	2	1	1908 Aug. 5	—	—
121c	“ 28	“ “	4	3	1	“ 5	—	—
130c	Oct. 19	“ “	6	5	2	Oct. 26	—	—
131c	“ 19	“ “	6	5	3	“ 26	—	—
137c	“ 31	“ “	9	4	3	Nov. 7	—	—
138b	“ 31	“ “	9	3	1	“ 7	—	—
152c	Nov. 10	“ “	7	7	2	“ 19	—	—
153a	“ 10	“ “	7	8	2	“ 19	—	—
173a	“ 20	“ “	6	8	6	“ 26	—	—
174c	“ 20	“ “	6	7	3	“ 26	—	—
176b	“ 27	“ “	13	3[1]	5	Dec. 5	—	—
177c	“ 27	“ “	13	3[1]	3	“ 5	—	—

[1] Two leaves of each plant inoculated.

TABLE VI.— RESULTS WITH *Hordeum nodosum* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
112c	1908 July 10	*Hordeum vulgare*	20	2	0	1908 July 18	+++	. . .
116b	“ 18	“ “	28	3[2]	0	“ 28	++	. . .
132c	Oct. 21	“ “	8	7	10	Oct. 30	+++	—
135b	“ 23	“ “	10	7	8	“ 31	+++	—
151c	Nov. 10	“ “	19	3	1	Nov. 19	—[3]	—
152a	“ 10	“ “	19	2[4]	4	“ 19	—[3]	—
163b	“ 16	“ “	13	6	5	“ 26	+++	—
164c	“ 16	“ “	13	10	6	“ 26	+++	—
175a	“ 27	“ “	13	5	3	Dec. 5	++	—
177b	“ 27	“ “	13	4	6	“ 5	+++	—
178c	“ 27	“ “	13	4	6	“ 5	+++	—
179b	“ 27	“ “	13	5	2	“ 5	+++	—
181c	“ 27	“ “	24	6[4]	6	“ 5	—	—

[1] *Hordeum pratense* Huds.= *H. secalinum* Schreb.

[2] The first leaf of one plant and the second and third leaves of the other two plants were inoculated. Infection occurred on the first leaf of the one plant.

[3] The tips of the inoculated leaves had withered and turned yellow.

[4] Two leaves inoculated.

TABLE VII.—RESULTS WITH *Hordeum nudum* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
5a	1907 Dec. 16	*Hordeum distichon*	9	2	2	1907 Dec. 23	+++	—
38a	1908 Jan. 2	" "	8	2	2	1908 Jan. 11	+++	+[2]
78a	Feb. 10	" "	9	3	1	Feb. 17	+++	—
80b	" 10	" "	9	3	3	" 17	+++	—
86b	" 22	" "	9	3	3	" 29	+++	—
87b	" 22	" "	9	1	3	" 29	+++	—
7a	1907 Dec. 16	*Hordeum nudum*	9	2	1	1907 Dec. 23	+++	—
85a	1908 Feb. 21	" "	8	4	2	1908 Feb. 29	+++	—
1b	1907 Dec. 9	*Hordeum vulgare*	8	3	4	1907 Dec. 16	+++	—
2c	" 9	" "	8	3	3	" 16	+++	—
4a	" 9	" "	8	2	3	" 16	+++	—
8b	" 16	" "	9	2	2	" 23	+++	—
9a	" 16	" "	9	2	1	" 23	+++	--
35c	1908 Jan. 2	" "	8	3	2	1908 Jan. 11	+++	+[2]
37c	" 2	" "	8	4	3	" 11	+++	—
45c	" 18	" "	14	3	3	" 24	+++	—
48c	" 18	" "	14	1	2	" 24	+++	—
67b	Feb. 3	" "	10	1	2	Feb. 10	+++	—
68a	" 3	" "	10	1	0	" 10	+++	.....
61b	" 1	*Triticum polonicum*	7	1	1	" 10	—	—
43c	Jan. 17	*Triticum vulgare*	13	2	3	Jan. 24	—	+[2]

[1] Hackel considers this a variety of *Hordeum sativum distichon.*

[2] A small patch of mycelium bearing conidia on one leaf of a control.

TABLE VIII.—RESULTS WITH *Hordeum Steudelii* ♀ × *H. trifurcatum* ♂

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
120a	1908 July 28	*Hordeum vulgare*	4	3	1	1908 Aug. 5	+++	—
121b	" 28	" "	4	3	2	" 5	+++	—
131b	Oct. 19	" "	6	3	3	Oct. 26	+++	—
172b	Nov. 20	" "	6	2	1	Nov. 26	+++	—
173c	" 20	" "	6	2	3	" 26	+++	—
174b	" 20	" "	6	3	3	" 26	+++	—
177a	" 27	" "	6	4	3	Dec. 5	+++	—
179a	" 27	" "	6	3	2	" 5	+++	—
180c	" 27	" "	6	3	1	" 5	+++	—

TABLE IX.— RESULTS WITH *Hordeum tetrastichon* L.[1]

Number of experiment	Date	Source of conidia	Age of plants ys)	No. of plants inoculated	No of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
130b	Oct. 19	*Hordeum vulgare*	6	3	2	Oct. 26	+++	—
172a	Nov. 20	" "	6	3	2	Nov. 26	+++	—
173b	" 20	" "	6	3	6	" 26	+++	—
174a	" 20	" "	6	2	1	" 26	+++	—
175c	" 27	" "	6	3	4	Dec. 5	+++	—
178a	" 27	" "	6	5	4	" 5	+++	—
180b	" 27	" "	6	7	2	" 5	+++	—

[1] Variety *trifurcatum* Schl. used.

TABLE X. — RESULTS WITH *Hordeum trifurcatum* Jacq.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
115a	July 14	*Hordeum vulgare*	4	4	2	July 22	+++	—
115b	" 14	" "	4	3	3	" 22	+++	—
119b	" 23	" "	6	3	1	" 29	+++	—
151b	Nov. 10	" "	7	1	0	Nov. 19	+++	....
164b	" 16	" "	13	2[2]	1	" 26	+++	—

[1] Considered by Hackel to be a form of *Hordeum sativum vulgare*.

[2] Two leaves of each plant inoculated.

The infection, if it occurred, was observed in three to five days after inoculation. A number of observations were made, but only the final one is recorded.

In the accompanying tables I have brought together the results of the tests. I have indicated a full, vigorous growth of mildew by three plus signs, a good infection by two plus signs, a slight infection by one plus sign, and no infection by the minus sign.

For the purpose of direct comparison, I have brought together in TABLE XXVIII all of the results given with these twenty-seven different grasses. I have also included my[21] own previous results with the grass mildew and also the results obtained by Marchal[18] and Salmon[24, 25, 27].

Marchal does not give the data upon which his conclusions are based. It is impossible to tell whether he sowed spores from

TABLE XI.—RESULTS WITH *Hordeum vulgare* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
5c	1907 Dec. 16	*Hordeum distichon*	9	3	2	1907 Dec. 23	+++	—
38b	1908 Jan. 2	" "	9	3	4	1908 Jan. 11	+++	—
77a	Feb. 10	" "	9	4	4	Feb. 17	+++	—
192a	Nov. 30	*Hordeum nodosum*	9	1	2	Dec. 5	+++	—
7c	1907 Dec. 16	*Hordeum nudum*	9	4	3	1907 Dec. 23	+++	+[2]
1c	" 9	*Hordeum vulgare*	8	4	4	" 16	+++	—
2b	" 9	" "	8	3	3	" 16	+++	—
3b	" 9	" "	8	2	2	" 16	+++	—
9d	" 16	" "	9	4	3	" 23	+++	—
10a	" 24	" "	10	2	4	" 30	+++	—
11b	" 24	" "	10	4	2	" 30	+++	—
12b	" 24	" "	10	3	3	" 30	+++	—
13c	" 24	" "	10	4	4	" 30	+++	—
14b	" 25	" "	9	4	3	" 30	+++	—
14c	" 25	" "	9	3	3	" 30	+++	—
15a	" 25	" "	11	3	2	" 30	+++	—
20b	" 31	" "	10	3	3	1908 Jan. 7	+++	—
22c	" 31	" "	10	3	2	" 7	+++	—
24c	" 31	" "	10	2	3	" 7	+++	—
25b	" 31	" "	10	3	2	" 7	+++	—
37b	1908 Jan. 2	" "	8	2	3	" 11	+++	+[2]
44a	" 18	" "	14	2	3	" 24	+++	—
46b	" 18	" "	14	1	1	" 24	+++	—
47b	" 18	" "	14	1	2	" 24	+++	—
64a	Feb. 3	" "	10	2	3	Feb. 10	+++	—
66a	" 3	" "	10	2	1	" 10	+++	—
111c	July 10	" "	7	5	5	July 18	+++	—
112a	" 10	" "	7	2	5	" 18	+++	—
115c	" 14	" "	4	4	3	" 22	+++	—
116a	" 18	" "	8	2[3]	2	" 28	+++	—
119a	" 23	" "	6	4	3	" 29	+++	—
120c	" 28	" "	4	4	2	Aug. 5	+++	—
121a	" 28	" "	4	5	3	" 5	+++	—
130a	Oct. 19	" "	6	3	3	Oct. 26	+++	+[2]
131a	" 19	" "	6	4	2	" 26	+++	—
132a	" 21	" "	8	3	1	" 30	+++	—
135a	" 23	" "	4	3	6	" 31	+++	—
137a	" 31	" "	9	2	1	Nov. 7	+++	—
138a	" 31	" "	9	3	1	" 7	+++	—
147b	" 31	" "	9	2	2	" 7	+++	—
152b	Nov. 10	" "	7	5	3	" 19	+++	—
153c	" 10	" "	7	4	3	" 19	+++	—
172c	" 20	" "	6	4	2	" 26	+++	—
176a	" 27	" "	6	6	7	Dec. 5	+++	—
6b	1907 Dec. 16	*Hordeum Zeocriton*	9	3	3	1907 Dec. 23	+++	—
98c	1908 Mar. 3	" "	7	3	2	1908 Mar. 10	+++	—

TABLE XI.—RESULTS WITH *Hordeum vulgare* L.[1]—*Continued*

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
99c	Mar. 3	*Hordeum Zeocriton*	7	2	1	Mar. 10	+++	—
100c	" 3	" "	7	2	1	" 10	+++	—
101c	" 3	" "	7	3	3	" 10	+++	—
39c	Jan. 17	*Triticum dicoccum*	13	3	2	Jan. 24	—	—
40c	" 17	" "	13	2	3	" 24	—	—
59b	Feb. 1	*Triticum durum*	8	2	3	Feb. 10	—	—
60a	" 1	*Triticum polonicum*	8	2	2	" 10	—	—
94a	Mar. 3	*Triticum Spelta*	7	1	1	Mar. 10	—	—
	1907					1907		
16b	Dec. 25	*Triticum vulgare*	11	2	2	Dec. 30	—	—
18c	" 25	" "	11	4	4	" 30	—	—
19c	" 25	" "	9	2	3	" 30	—	—
						1908		
27a	" 31	" "	10	3	3	Jan. 7	—	—
28a	" 31	" "	10	4	3	" 7	—	—
29c	" 31	" "	6	3	4	" 7	—	—
	1908							
30c	Jan. 2	" "	8	4	2	" 11	—	—
32b	" 2	" "	8	3	2	" 11	—	—
33b	" 2	" "	8	3	2	" 11	—	—
41c	" 17	" "	13	2	3	" 24	—	—
63c	Feb. 3	" "	10	1	1	Feb. 10	—	—
75a	" 10	" "	9	4	3	" 17	—	+[2]
96c	Mar. 3	" "	7	2	4	Mar. 10	—	—

[1] *Hordeum sativum vulgare* Hackel.

[2] A small infected area appeared on one control.

[3] The second green leaf of each plant inoculated.

each of the cereals on the various grasses. Consequently I have merely indicated whether his results are negative or positive. I have indicated his results simply on the basis of his seven *formes spéciales.*

In this table the first figure indicates the number of tests, the second figure the number of plants or leaves inoculated, and the third figure the number that became infected.

It is plain, from a consideration of TABLE I, and also the general summary, that the oat (*Avena sativa*) is immune to the barley, rye, and wheat mildews. In no case did complete infection follow where conidia were used from any of these three cereals. If, however, conidia are taken from *A. sativa* and sown upon the same plant, full infection follows, as shown by both Marchal's and Salmon's results.

TABLE XII.— RESULTS WITH *Hordeum Zeocriton* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
77c	1908 Feb. 10	*Hordeum distichon*	9	4	3	1908 Feb. 17	+++	—
79a	" 10	" "	9	4	2	" 17	+++	—
87a	" 22	" "	9	3	2	" 29	+++	—
88c	" 22	" "	9	5	3	" 29	+++	—
7b	1907 Dec. 16	*Hordeum nudum*	9	3	5	1907 Dec. 23	+++	—
85c	1908 Feb. 21	" "	8	4	5	1908 Feb. 29	+++	—
2a	1907 Dec. 9	*Hordeum vulgare*	8	2	4	1907 Dec. 16	+++	—
3c	" 9	" "	8	4	4	" 16	+++	—
4b	" 9	" "	8	2	4	" 16	+++	—
8a	" 16	" "	9	3	3	" 23	+++	+[2]
9b	" 16	" "	9	2	2	" 23	+++	—
20c	" 31	" "	10	3	2	1908 Jan. 7	+++	—
21a	" 31	" "	10	3	2	" 7	+++	—
22a	" 31	" "	10	2	2	" 7	+++	—
23a	" 31	" "	10	2	2	" 7	+++	—
24a	" 31	" "	10	2	2	" 7	+++	—
25a	" 31	" "	10	3	3	" 7	+++	—
47a	1908 Jan. 18	" "	14	3	3	" 24	+++	+[2]
48b	" 18	" "	14	2[3]	3	" 24	+++	—
65a	Feb. 3	" "	10	2	1	Feb. 10	+++	—
68b	" 3	" "	10	1	1	" 10	+++	—
68c	" 3	" "	10	1	2	" 10	+++	—
6a	1907 Dec. 16	*Hordeum Zeocriton*	9	3	2	1907 Dec. 23	+++	—
42b	1908 Jan. 17	*Triticum vulgare*	13	3[3]	3	1908 Jan. 24	—	—

[1] Considered by Hackel to be a form of *Hordeum sativum distichon*.

[2] A small infected area on two of the control plants.

[3] The second green leaf of each plant inoculated.

It is to be noted that in two of my experiments (44*b* and 45*b*, TABLE I), the leaves inoculated with barley mildew showed marked discolored areas. These areas were observed closely from time to time. There was strong evidence of an incipient infection, but the fungus failed to reach a full development. It is interesting in this connection to recall some of Salmon's[28] experiments. Salmon has studied the stages of development reached by the mildew from wheat when sown on barley, a plant which the wheat mildew cannot fully infect. He has found that the conidia germinate and form tubes which develop haustoria. There was, however, no marked development of the mycelium.

TABLE XIII. — RESULTS WITH *Secale cereale* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
78c	1908 Feb. 10	*Hordeum distichon*	9	3	1	1908 Feb. 17	—	—
87c	Feb. 22	" "	9	2	3	" 29	—	—
88b	" 22	" "	9	2	3	" 29	—	—
13b	1907 Dec. 24	*Hordeum vulgare*	8	3	1	1907 Dec. 30	—	—
21c	" 31	" "	10	2	1	1908 Jan. 7	—	—
23c	" 31	" "	10	3	3	" 7	—	—
34c	1908 Jan. 2	" "	8	2	2	" 11	—	—
35a	" 2	" "	8	3	1	" 11	—	—
46a	" 18	" "	14	1	2	" 24	—	—
48a	" 18	" "	14	2	2	" 24	—	—
66b	Feb. 3	" "	10	1	1	Feb. 10	—	—
136a	Oct. 23	*Secale cereale*	4	2	1	Oct. 31	+++	—
158c	Nov. 10	" "	7	4	1	Nov. 19	+++	—
159a	" 10	" "	7	1	0	" 19	+++	...
170c	" 20	" "	17	2[1]	2	" 26	+++	—
171c	" 20	" "	6	3	1	" 26	+++	—
187c	" 27	" "	6	1	0	Dec. 5	+++	...
83a	Feb. 21	*Triticum durum*	8	3	2	Feb. 29	—	—
17a	1907 Dec. 25	*Triticum vulgare*	9	3	2	1907 Dec. 30	—	—
19a	" 25	" "	9	2	3	" 30	—	—
26c	" 31	" "	10	3	1	1908 Jan. 7	—	—
28b	" 31	" "	10	2	1	" 7	—	—
29a	" 31	" "	10	3	2	" 7	—	—
31a	1908 Jan. 2	" "	8	2	2	Jan. 11	—	—
41b	" 17	" "	13	2	1	" 24	—	—
76b	Feb. 10	" "	9	2	1	Feb. 17	—	—
91c	" 22	" "	9	3	2	" 29	—	—

[1] The first leaf of one plant and the second leaf of the other inoculated.

TABLE XIV. — RESULTS WITH *Secale dalmaticum* Vis.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. Plants	Controls
158b	1908 Nov. 10	*Secale cereale*	7	1	0	1908 Nov. 19	—	....
171b	" 20	" "	17	1[1]	0	" 26	—	....
186a	" 27	" "	24	1[2]	0	Dec. 5	—	....

[1] The first and second leaves inoculated.

[2] The second and third leaves inoculated.

TABLE XV. — RESULTS WITH *Secale montanum* Guss.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
146c	1908 Oct. 31	*Secale cereale*	12	1	0	1908 Nov. 7	—	.....
159b	Nov. 10	" "	22	1[1]	1	" 19	—	—
170a	" 20	" "	17	2[2]	1	" 26	—	—
186b	" 27	" "	13	1[2]	0	Dec. 5	+++	.....
187a	" 27	" "	24	2[2]	2	" 5	—	—
199a	Dec. 14	" "	23	3	0	" 23	—	.....
199b	" 14	" "	30	1	0	" 23	+++	.....
199c	" 14	" "	23	1	0	" 23	+++	.....

[1] The first and third leaves inoculated.

[2] Two leaves of each plant inoculated.

Out of the eleven species of *Hordeum* tested with the barley mildew, seven (*Hordeum distichon*, *H. nudum*, *H. Steudelii* × *H. trifurcatum*, *H. tetrastichon*, *H. trifurcatum*, *H. vulgare*, and *H. Zeocriton*) proved perfectly susceptible. Infection occurred on every plant that was inoculated.

One species (*Hordeum nodosum*) gave a very large percentage of infection, fifty-one plants out of the sixty-four inoculated becoming infected. According to the Index Kewensis, this species is the same as *Hordeum secalinum* Schreb. Salmon[25] claims that *H. secalinum* is entirely immune to the barley mildew. I am uncertain whether Salmon was working with *H. secalinum* Schreb. or whether he had some other species of *Hordeum* listed under this specific name. It is clear from my results that young plants of *Hordeum nodosum* are quite susceptible to the barley mildew. Older plants, however, appear to be immune, for in every case where the second green leaf was inoculated, no infection occurred.

When plants of *Hordeum bulbosum* were inoculated with conidia from barley, only one leaf out of the twenty-four inoculated became infected. It is interesting to note that Salmon secured only one positive result out of fourteen inoculated plants, and Marchal reported the results with this plant as negative, when conidia from barley were used. This species evidently is practically immune to the barley mildew.

In my experiments I was unable to infect *Hordeum jubatum* with the barley mildew. This result is in harmony with the work of Salmon. Marchal, however, states that *H. jubatum* can be infected with conidia from the barley.

My results with *Hordeum maritimum* agree with Marchal's. I was unable to obtain any infection if conidia from barley were

TABLE XVI. — RESULTS WITH *Secale cereale* L. × *Triticum vulgare* Vill.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
127d	1908 Oct. 19	*Secale cereale*	6	1	1[2]	1908 Oct. 26	—	—
136b	" 23	" "	4	1	0	" 31	—	.....
146a	" 31	" "	12	1[3]	0	Nov. 7	+[4]	.....
146b	" 31	" "	12	1[3]	0	" 7	+[4]	.....
158a	Nov. 10	" "	7	1	0	" 19	+[4]	.....
162d	" 12	" "	9	1	1[2]	" 21	++[5]	—
170b	" 20	" "	6	1	0	" 26	—	.....
171a	" 20	" "	17	2[6]	1	" 26	++	—
186c	" 27	" "	13	2	0	Dec. 5	++[7]	.....
187b	" 27	" "	13	1[8]	0	" 5	++[9]	.....
196b	Dec. 14	" "	30	2[10]	0	" 23	—	.....
197b	" 14	" "	30	2	0	" 23	++[11]	.....
198b	" 14	" "	30	2	0	" 23	—	.....
122c	July 28	*Triticum vulgare*	4	2	1	Aug. 5	—	—
126a	" 28	" "	4	2	1	" 5	—	—
127c	Oct. 19	" "	6	1	1	Oct. 26	—	—
145c	" 31	" "	18	1[12]	1	Nov. 7	—	—
162c	Nov. 12	" "	9	1	1	" 21	—	—
168b	" 20	" "	6	2	0	" 26	+[13]	.....
185b	" 26	" "	12	1[8]	0	Dec. 5	—	.....
196a	Dec. 14	" "	30	2	0	" 23	—	.....
197a	" 14	" "	30	2	0	" 23	—	.....
198a	" 14	" "	30	2	0	" 23	—	.....

[1] The seed for these experiments was obtained from Professor Bubák, Director of the Botanical Garden, Tábor, Bohemia.

[2] The control plant was inoculated with conidia from wheat but no infection occurred. (See exp. 127c and 162c.)

[3] The second leaf inoculated.

[4] Slight discolored areas appeared on the inoculated parts.

[5] A good infection, conidia being produced.

[6] Two leaves inoculated.

[7] A good infection of one leaf, and the lower leaf sheaths of one plant.

[8] Three leaves inoculated.

[9] A fair infection of one leaf.

[10] The second leaf of one plant and the fourth leaf of the other inoculated.

[11] A good infection of one leaf.

[12] The second and third leaves inoculated.

[13] A small infected area appeared on one leaf.

TABLE XVII. — RESULTS WITH *Triticum compactum* Host[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
105b	June 24	*Triticum vulgare*	4	2	1	June 30	+++	—
106c	" 24	" "	4	2	0	" 30	+++	....
107b	" 24	" "	4	2	2	" 30	+++	—
108b	July 7	" "	6	1	1	July 14	+++	—
109c	" 7	" "	6	4	2	" 14	+++	—
110a	" 7	" "	6	4	3	" 14	+++	—
118a	" 22	" "	5	2	2	" 29	+++	—
139a	Oct. 31	" "	7	5	3	Nov. 7	+++	—
144a	" 31	" "	7	10	4	" 7	+++	—

[1] *Triticum sativum compactum* Hackel. The variety *creticum* was used in all the tests.

sown on seedlings of this plant. Altogether twelve tests were made, fifty-eight plants being inoculated. Salmon, however, states that three plants out of twelve inoculated became infected. The species shows a marked resistance to the barley mildew, even though it may not be entirely immune.

When rye (*Secale cereale*) was inoculated with the barley or wheat mildew, no infection occurred. This was clearly shown through the large number of tests made. If, however, rye plants were inoculated with rye mildew, full and complete infection took place. Furthermore, the mildew on rye was capable, according to Marchal, of infecting *Secale anatolicum*. I have found that three plants of *S. montanum* out of twelve inoculated became infected. In these successful infections there was a very vigorous growth of mildew. In the three attempts made with *Secale dalmaticum* no infection occurred.

Conidia from wheat (*Triticum vulgare*) failed to infect any of the other cereals. Conidia from this same host, however, produced full and complete infection upon all of the eleven species of *Triticum* tested. Every plant of *Triticum compactum*, *T. durum* (six varieties), *T. Freycenetii*, *T. polonicum*, *T. Spelta*, *T. Thaoudar*, *T. Tumonia*, *T. turgidum*, and *T. vulgare* which were inoculated with conidia from wheat, became infected.

Fifty-seven leaves of *Triticum monococcum* were inoculated and forty-seven of these became infected. In most cases a good, vigorous growth of mildew was present.

TABLE XVIII. — RESULTS WITH *Triticum dicoccum* Schrank[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
34a[2]	1908 Jan. 2	*Hordeum vulgare*	8	4	4	1908 Jan. 11	—	—
111b[2]	July 10	" "	7	3	2	July 18	—	—
99a[2]	Mar. 3	*Hordeum Zeocriton*	7	2	1	Mar. 10	—	—
39a[2]	Jan. 17	*Triticum dicoccum*	13	2	3	Jan. 24	+++	—
40b[2]	" 17	" "	13	3	4	" 24	+++	—
60c[2]	Feb. 1	*Triticum polonicum*	8	2	1	Feb. 10	+++	—
74c[2]	" 10	" "	9	3	3	" 17	+++	—
93c[2]	" 22	" "	9	2	2	" 29	+++	—
56b[2]	" 1	*Triticum Spelta*	8	1	3	" 10	+++	—
69a[2]	" 10	" "	9	3	3	" 17	+++	—
70a[2]	" 10	" "	9	3	2	" 17	+++	—
94b[2]	Mar. 3	" "	7	3	1	Mar. 10	+++	—
95a[2]	" 3	" "	7	3	4	" 10	+++	—
30a[2]	Jan. 2	*Triticum vulgare*	8	4	3	Jan. 11	+++	—
31b[2]	" 2	" "	8	2	3	" 11	+++	—
43a[2]	" 17	" "	13	4	4	" 24	+++	—
50c[2]	" 24	" "	10	4	2	" 30	+++	—
55a[2]	" 24	" "	10	3	2	" 30	+++	—
62b[2]	Feb. 3	" "	10	2	0	Feb. 10	+++	....
89c[2]	" 22	" "	9	3	2	" 29	+++	—
91b[2]	" 22	" "	9	3	3	" 29	+++	—
96b[2]	Mar. 3	" "	7	3	1	Mar. 10	+++	—
97a[2]	" 3	" "	7	3	2	" 10	+++	—
149c[2]	Nov. 2	" "	9	4	2	Nov. 7	+++	—
150b[2]	" 2	" "	9	5	3	" 7	+++	—
184a[2]	" 27	" "	6	8	8	Dec. 5	+++	—
193c[2]	Dec. 14	" "	24	2[3]	2	" 20	+++	+[4]
156a[5]	Nov. 10	" "	7	4	4	Nov. 19	+++	—
157b[5]	" 10	" "	7	4	3	" 19	+++	—
166b[5]	" 20	" "	6	9	9	" 26	+++	—
169b[5]	" 20	" "	6	6	1	" 26	+++	—
182c[5]	" 27	" "	6	9	7	Dec. 5	+++	—
193b[5]	Dec. 14	" "	24	3[3]	2	" 20	+	—
155c[6]	Nov. 10	" "	7	5	4	Nov. 19	—	—
161b[6]	" 12	" "	9	5	4	" 21	—	—
165b[6]	" 20	" "	6	8	3	" 26	—	—
167c[6]	" 20	" "	6	7	4	" 26	—	—
182a[6]	" 27	" "	6	8	6	Dec. 5	—	—
183b[6]	" 27	" "	6	4	2	" 5	++	—
184c[6]	" 27	" "	6	7	7	" 5	—	
154b[7]	" 10	" "	7	5[8]	3	Nov. 19	+	-
155b[7]	" 10	" "	7	4	7	" 19	—	—
166c[7]	" 20	" "	6	4	7	" 26	—	—
169a[7]	" 20	" "	6	5	6	" 26	—	—
183c[7]	" 27	" "	6	8	4	Dec. 5	—	—
193a[7]	Dec. 14	" "	24	2[3]	2	" 20	—	—
64c[9]	Feb. 3	*Hordeum vulgare*	10	4	8	Feb. 10	—	—
71c[9]	" 10	*Triticum dicoccum*	9	3	2	" 17	+[10]	—
72a[9]	" 10	" "	9	3	2	" 17	—	—
83c[9]	" 21	*Triticum durum*	8	4	6	" 29	—	—
84c[9]	" 21	" "	8	3	3	" 29	—	—
56a[9]	" 1	*Triticum Spelta*	8	3	6	" 10	—	—

TABLE XVIII. — RESULTS WITH *Triticum dicoccum* Schrank.[1]—*Continued*

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
57b[9]	1908 Feb. 1	*Triticum Spelta*	8	4	5	1908 Feb. 10	—	—
69c[9]	" 10	" "	9	2	3	" 17	+[10]	—
95b[9]	Mar. 3	" "	7	3	3	Mar. 10	—	—
49b[9]	Jan. 24	*Triticum vulgare*	10	4	2	Jan. 30	—	—
50b[9]	" 24	" "	10	3	2	" 30	—	—
54a[9]	" 24	" "	10	3	3	" 30	—	—
89b[9]	Feb. 22	" "	9	4	4	Feb. 29	—	—
90b[9]	" 22	" "	9	3	3	" 29	—	—
96a[9]	Mar. 3	" "	7	3	3	Mar. 10	—	—
97b[9]	" 3	" "	7	3	3	" 10	—	—
103c[9]	May 16	" "	10	2	1	May 24	++[11]	—
104c[9]	" 30	" "	6	2	3	June 10	—	—
108c[9]	July 7	" "	4	3	2	July 14	—	—
143a[9]	Oct. 31	" "	7	5	9	Nov. 7	—	—
165a[9]	Nov. 20	" "	6	5	5	" 26	—	—
185c[9]	" 27	" "	13	2[12]	1	Dec. 5	—	—

[1] *Triticum sativum dicoccum* Hackel.

[2] Black Winter Emmer.

[3] Two leaves of each plant inoculated.

[4] A slight infection of one control plant.

[5] Red Emmer.

[6] Common Emmer.

[7] Russian Emmer.

[8] One seedling had a different appearance from the others and was well infected with the mildew. Evidently the seedling was not a plant of Russian Emmer.

[9] White Emmer.

[10] Slight discolored areas were present on one of the inoculated leaves.

[11] A good infection of one leaf of one plant, the mildew appearing on the leaf-sheath and the lower portion of the blade.

[12] The second leaf and sheath of each plant inoculated.

Five varieties of Emmer (*Triticum dicoccum*) were tested with the wheat mildew. As seen from the table, two varieties (Black Emmer and Red Emmer) were entirely susceptible to the mildew. Every plant inoculated became infected, and the growth of the fungus was as vigorous as ever appeared upon wheat. The other three varieties (White Emmer, Common Emmer, and Russian Emmer) proved quite resistant to the mildew. Out of forty-four leaves of Common Emmer inoculated, four showed infection. Out of sixty-seven leaves of White Emmer inoculated, three became infected; and none of the twenty-seven plants of Russian Emmer

TABLE XIX. — RESULTS WITH *Triticum durum* Desf.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
111a[2]	July 10	*Hordeum vulgare*	7	3	5	July 18	—	—
58b[2]	Feb. 1	*Triticum durum*	8	1	0	Feb. 10	+++	....
84a[2]	" 21	" "	8	3	2	" 29	+++	—
73b[2]	" 10	*Triticum polonicum*	9	2	1	" 17	+++	—
74a[2]	" 10	" "	9	2	1	" 17	+++	—
93a[2]	" 22	" "	9	1	1	" 29	+++	—
70b[2]	" 10	*Triticum Spelta*	9	3	1	" 17	+++	—
51b[2]	Jan. 24	*Triticum vulgare*	10	2	2	Jan. 30	+++	—
52a[2]	" 24	" "	10	1	1	" 30	+++	—
53a[2]	" 24	" "	10	3	1	" 30	+++	—
63a[2]	Feb. 3	" "	10	1	1	Feb. 10	+++	—
91a[2]	" 22	" "	9	2	3	" 29	+++	—
139b[3]	Oct. 31	" "	7	5	4	Nov. 7	+++	—
140a[3]	" 31	" "	7	4	5	" 7	+++	—
140b[4]	" 31	" "	7	3	2	" 7	+++	—
142b[4]	" 31	" "	7	3	4	" 7	+++	—
140c[5]	" 31	" "	7	4	2	" 7	+++	—
144b[5]	" 31	" "	7	5	1	" 7	+++	—
141a[6]	" 31	" "	7	2	3	" 7	+++	—
149b[6]	Nov. 2	" "	9	1	0	" 7	+++	....
141c[7]	Oct. 31	" "	7	2	2	" 7	+++	—
149a[7]	Nov. 2	" "	9	2	1	" 7	+++	—
144c[8]	Oct. 31	" "	7	4	3	" 7	+++	—
150c[8]	Nov. 2	" "	9	3	3	" 7	+++	—
156c[9]	" 10	" "	7	3	4	" 19	+++	—
161c[9]	" 12	" "	9	3	2	" 21	+++	—

[1] *Triticum sativum durum* Hackel.

[2] Var. Kubanka.

[3] Var. Black Don.

[4] Var. Medeah.

[5] Var. Chilean.

[6] Var. *affine*.

[7] Var. Wild Goose.

[8] Var. Velvet Don.

[9] Var. Soretina Spring Wheat

TABLE XX. — RESULTS WITH *Triticum Freycenetii* Hort.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
122b	July 28	*Triticum vulgare*	4	6	4	Aug. 5	++	—
123a	" 28	" "	4	6	2	" 5	++	—
128a	Oct. 19	" "	6	3	3	Oct. 26	+++	—
129c	" 19	" "	6	5	2	" 26	+++	—
166a	Nov. 20	" "	6	5	1	Nov. 26	+++	—
167b	" 20	" "	6	3	2	" 26	+++	—
182b	" 27	" "	6	2	3	Dec. 5	++	—
184b	" 27	" "	6	4	4	" 5	+++	—

TABLE XXI. — RESULTS WITH *Triticum monococcum* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
114c[1]	1908 July 14	*Triticum compactum*	4	2	1	1908 July 22	++	—
102b[2]	May 16	*Triticum vulgare*	10	1	0	May 24	—	....
104b[2]	" 30	" "	24	1[3]	0	June 10	– –	....
105c[2]	June 24	" "	4	1	0	" 30	+	....
106b[2]	" 24	" "	4	2	1	" 30	++	—
107c[2]	" 24	" "	4	1	0	" 30	+++	....
108a[2]	July 7	" "	7	1	1	July 14	—	—
109a[2]	" 7	" "	7	2	1	" 14	—	—
110b[2]	" 7	" "	7	2	1	" 14	+++	—
117c[1]	" 22	" "	5	3	2	" 29	+++	—
118b[1]	" 22	" "	5	3	1	" 29	+++	—
123c[4]	" 28	" "	4	2	1	Aug. 5	+++	—
129b[4]	Oct. 19	" "	6	4	1	Oct. 26	++	—
143c[4]	" 31	" "	7	5	4	Nov. 7	+++	—
150a[4]	Nov. 2	" "	9	2	1	" 7	+++	—
156b[4]	" 10	" "	7	3	4	" 19	—	—
162b[4]	" 12	" "	9	3	2	" 21	++	—
125c[5]	July 28	" "	4	3	3	Aug. 5	+++	—
128b[5]	Oct. 19	" "	6	3	4	Oct. 26	++[6]	—
142c[5]	" 31	" "	7	3	2	Nov. 7	++	—
145b[5]	" 31	" "	7	3	3	" 7	+++	—
157c[5]	Nov. 10	" "	7	3	1	" 19	+++	—
160b[5]	" 12	" "	9	4	1	" 20	++	—

[1] Seed obtained from Vilmorin-Andrieux Co., of Paris.

[2] Seed obtained from Dr. Wm. Trelease.

[3] Two leaves inoculated.

[4] Variety *Hornemanni.*

[5] Variety *vulgare.* Varieties *Hornemanni* and *vulgare* were obtained from the Botanical Garden at Tábor, Bohemia.

[6] A very good infection of one leaf.

became infected. There is, therefore, a marked difference in susceptibility of these five varieties. It is to be noted here, that Marchal obtained negative results when he sowed conidia from wheat on *Triticum dicoccum.* His results may be due to the fact that he was working with an immune variety. It is apparent from my results that some varieties are quite susceptible, while others are almost or entirely immune.

My results show two other interesting differences from those of Marchal. In my work, six different varieties of *Triticum durum* were tested. In every case full infection followed. Marchal, on the other hand, states that this species is immune to the wheat

TABLE XXII.— RESULTS WITH *Triticum polonicum* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
71a	Feb. 10	*Triticum dicoccum*	9	2	1	Feb. 17	+++	—
59c	" 1	*Triticum durum*	8	3	2	" 10	+++	—
73c	" 10	*Triticum polonicum*	9	1	1	" 17	+++	—
57a	" 1	*Triticum Spelta*	8	3	1	" 10	+++	—
51a	Jan. 24	*Triticum vulgare*	10	3	2	Jan. 30	+++	—
52c	" 24	" "	10	3	2	" 30	+++	—
53b	" 24	" "	10	3	1	" 30	+++	—
62c	Feb. 3	" "	10	2	0	Feb. 10	+++	..
75b	" 10	" "	9	1	0	" 17	+++	..
92a	" 22	" "	9	3	3	" 29	+++	—
168c	Nov. 20	" "	6	3	4	Nov. 26	+++	—
169c	" 20	" "	6	3	2	" 26	+++	—

TABLE XXIII. — RESULTS WITH *Triticum Spelta* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
72c	Feb. 10	*Triticum dicoccum*	9	2	2	Feb. 17	+++	—
59a	" 1	*Triticum durum*	8	4	6	" 10	+++	—
83b	" 21	" "	8	3	3	" 29	+++	—
84b	" 21	" "	8	4	4	" 29	+++	—
61c	" 1	*Triticum polonicum*	8	2	4	" 10	+++	—
74b	" 10	" "	9	3	1	" 17	+++	—
56c	" 1	*Triticum Spelta*	8	4	7	" 10	+++	—
69b	" 10	" "	9	3	3	" 17	+++	—
49c	Jan. 24	*Triticum vulgare*	10	3	2	Jan. 30	+++	—
54c	" 24	" "	10	3	3	" 30	+++	—
55b	" 24	" "	10	3	3	" 30	+++	—
89a	Feb. 22	" "	9	6	3	Feb. 29	+++	—
102c	May 16	" "	10	4[2]	3	May 24	+++	—
103b	" 16	" "	10	2[2]	2	" 24	+++	—
110c	July 7	" "	4	3	2	July 14	+++	—
134c	Oct. 21	" "	8	6	3	Oct. 30	+++	—
139c	" 31	" "	7	3	5	Nov. 7	+++	—
142a	" 31	" "	7	5	5	" 7	+++	—

[1] *Triticum sativum Spelta* Hackel.

[2] Two leaves of each plant inoculated.

mildew. The other case is with reference to *Triticum monococcum*, which Marchal claims gave negative results. As already stated, forty-seven out of fifty-seven leaves inoculated became infected in the tests which I made.

It is evident from this review that the mildew on each of the

TABLE XXIV.—RESULTS WITH *Triticum Thaoudar* Boiss.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
125a	1908 July 28	*Triticum vulgare*	4	4	4	1908 Aug 5	+++	—
127b	Oct. 19	" "	6	4	2	Oct. 26	+++	—
145a	" 31	" "	7	4	2	Nov. 7	+++	—
148a	Nov. 2	" "	9	6	2	" 7	+++	—
154a	" 10	" "	7	2	1	" 19	+++	—
160a	" 12	" "	9	4	2	" 20	+++	—

TABLE XXV.—RESULTS WITH *Triticum Tumonia* Schrad.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
124b	1908 July 28	*Triticum vulgare*	4	3	2	1908 Aug. 5	+++	—
134a	Oct. 21	" "	8	1	0	Oct. 30	+++	....
155a	Nov. 10	" "	7	2	0	Nov. 19	+++	....
161a	" 12	" "	9	3	1	" 21	+++	—

TABLE XXVI.—RESULTS WITH *Triticum turgidum* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
113a	1908 July 14	*Triticum vulgare*	4	4	2	1908 July 21	+++	—
114b	" 14	" "	4	2	1	" 21	+++	—
117b	" 22	" "	5	1	0	" 29	+++	...
124c	" 28	" "	4	2	2	Aug. 5	+++	—
126b	" 28	" "	4	3	2	" 5	+++	—
134b	Oct. 21	" "	8	2[2]	1	Oct. 30	+++	—
165c	Nov. 20	" "	6	3	2	Nov. 26	+++	—
167a	" 20	" "	6	3	2	" 26	+++	—
168a	" 20	" "	6	3	3	" 26	+++	—

[1] *Triticum sativum turgidum* Hackel.

[2] Two leaves of each plant inoculated.

four cereals is restricted to the species of each genus. The mildew on oats occurs on species of *Avena* only; the barley mildew on species of *Hordeum* only; the rye mildew on species of *Secale* only; and the wheat mildew on species of *Triticum* only.

TABLE XXVII. — RESULTS WITH *Triticum vulgare* Vill.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
10b	1907 Dec. 24	*Hordeum vulgare*	10	3	3	1907 Dec. 30	—	—
10c	" 24	" "	10	3	3	" 30	—	—
11a	" 24	" "	10	5	4	" 30	—	—
11c	" 24	" "	10	2	4	" 30	—	—
12c	" 24	" "	10	2	2	" 30	—	—
14a	" 25	" "	11	4	5	" 30	—	—
15b	" 25	" "	11	3	4	" 30	—	—
20a	" 31	" "	10	4	4	1908 Jan. 7	—	—
22b	" 31	" "	10	2	2	" 7	—	—
36a	1908 Jan. 2	" "	8	3	3	" 11	—	+[2]
37a	" 2	" "	8	3	3	" 11	—	—
47c	" 18	" "	14	2	3	" 24	—	—
112b	July 10	" "	7	6	6	July 18	—	—
98a	Mar. 3	*Hordeum Zeocriton*	7	3	2	Mar. 10	—	—
100a	" 3	" "	7	2	1	" 10	—	—
101b	" 3	" "	7	3	3	" 10	—	—
114a	July 14	*Triticum compactum*	4	3	3	July 22	+++	—
39b	Jan. 17	*Triticum dicoccum*	13	3	4	Jan. 24	+++	—
40a	" 17	" "	13	3	3	" 24	+++	—
71b	Feb. 10	" "	9	3	3	Feb. 17	+++	—
72b	" 10	" "	9	2	2	" 17	+++	—
58c	" 1	*Triticum durum*	8	2	3	" 10	+++	—
60b	" 1	*Triticum polonicum*	8	2	2	" 10	+++	—
61a	" 1	" "	8	2	1	" 10	+++	—
73a	" 10	" "	9	3	1	" 17	+++	—
57c	" 1	*Triticum Spelta*	8	1	1	" 10	+++	—
70c	" 10	" "	9	2	2	" 17	+++	—
16a	1907 Dec. 25	*Triticum vulgare*	11	3	3	1907 Dec. 30	+++	—
17c	" 25	" "	11	2	6	" 30	+++	—
18b	" 25	" "	11	3	5	" 30	+++	—
19b	" 25	" "	9	3	4	" 30	+++	—
26a	" 31	" "	10	2	2	1908 Jan. 7	+++	—
27c	" 31	" "	10	2	3	" 7	+++	—
28c	" 31	" "	10	1	1	" 7	+++	—
29b	" 31	" "	10	3	3	" 7	+++	—
30b	1908 Jan. 2	" "	8	3	2	" 11	+++	—
31c	" 2	" "	8	2	2	" 11	+++	—
32c	" 2	" "	8	3	2	" 11	+++	—
33c	" 2	" "	8	3	3	" 11	+++	—
41a	" 17	" "	13	2	2	" 24	+++	—
42c	" 17	" "	13	3	3	" 24	+++	—
43b	" 17	" "	13	3	3	" 24	+++	—
49a	" 24	" "	10	3	2	" 30	+++	—
50a	" 24	" "	10	3	1	" 30	+++	—
51c	" 24	" "	10	3	2	" 30	+++	—
52b	" 24	" "	10	2	3	" 30	+++	—
53c	" 24	" "	10	3	2	" 30	+++	—

TABLE XXVII. — RESULTS WITH *Triticum vulgare* Vill.[1]—*Continued.*

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
54b	Jan. 24	*Triticum vulgare*	10	3	2	Jan. 30	+++	—
55c	“ 24	“ “	10	3	1	“ 30	+++	—
63b	Feb. 3	“ “	10	2	1	Feb. 10	+++	—
75c	“ 10	“ “	9	2	3	“ 17	+++	—
76c	“ 10	“ “	9	4	2	“ 17	+++	—
90c	“ 22	“ “	11	3	3	“ 29	+++	—
92b	“ 22	“ “	11	4	4	“ 29	+++	—
97c	Mar. 3	“ “	7	3	3	Mar. 10	+++	—
102a	May 16	“ “	10	2[3]	2	May 24	+++	—
103a	“ 16	“ “	10	2[3]	1	“ 24	+++	—
104a	“ 30	“ “	6	2	2	June 10	+++	—
105a	June 24	“ “	4	3	3	“ 30	+++	—
106a	“ 24	“ “	4	4	3	“ 30	+++	—
107a	“ 24	“ “	4	2	2	“ 30	+++	—
109a	July 7	“ “	4	3	2	July 14	+++	—
113b	“ 14	“ “	4	3	4	“ 22	+++	—
117b	“ 22	“ “	5	1	0	“ 29	+++	....
118c	“ 22	“ “	5	3	2	“ 29	+++	—
122a	“ 28	“ “	4	3	2	Aug. 5	+++	—
123b	“ 28	“ “	4	3	2	“ 5	+++	—
124a	“ 28	“ “	4	3	5	“ 5	+++	—
125b	“ 28	“ “	4	2	3	“ 5	+++	—
126c	“ 28	“ “	4	2	3	“ 5	+++	—
127a	Oct. 19	“ “	6	2	2	Oct. 26	+++	—
128c	“ 19	“ “	6	2	2	“ 26	+++	—
129a	“ 19	“ “	6	3	1	“ 26	+++	—
141b	“ 31	“ “	7	3	3	Nov. 7	+++	—
143b	“ 31	“ “	7	4	3	“ 7	+++	—
148b	Nov. 2	“ “	9	3	6	“ 7	+++	—
154c	“ 10	“ “	7	2	1	“ 19	+++	—
157a	“ 10	“ “	7	2	2	“ 19	+++	—
160c	“ 12	“ “	9	6	3	“ 20	+++	—
162a	“ 12	“ “	9	2	2	“ 21	+++	—
183a	“ 27	“ “	6	5	3	Dec. 5	+++	—
185a	“ 27	“ “	6	4	1	“ 5	+++	—

[1] *Triticum sativum vulgare* Hackel.

[2] Two small infected areas appeared on one leaf of a control.

[3] Two leaves of each plant inoculated.

So far as tested, all species of *Avena* are susceptible to the oat mildew. All species of *Triticum* are likewise susceptible to the wheat mildew. We find, however, that certain varieties of *Triticum dicoccum* are practically immune to the wheat mildew. Other varieties of this same species are entirely susceptible. Some species of *Hordeum* are immune to the barley mildew, and the same seems to be true of certain species of *Secale* with reference to the rye mildew.

TABLE XXVIII. — GENERAL SUMMARY OF RESULTS WITH THE MILDEWS OF THE CEREALS

Host plant	Conidia from *Avena sativa*		Conidia from *Hordeum vulgare*			Conidia from *Secale cereale*		Conidia from *Triticum vulgare*		
	Marchal	Salmon	Marchal	Salmon	Reed	Marchal	Reed	Marchal	Salmon	Reed
Agropyron repens	—	......	—	......	......	—	......	—	3, 8, 0	......
Alopecurus pratensis	......	1, 4, 0	......	......	......	......	......	......	......	......
Arrhenatherum elatius	+	1, 3, 0	......	......	......	......	......	......	......	......
Avena brevis	......	2, 5, 5	......	......	......	......	......	......	......	......
" *fatua*	+	......	......	......	......	......	......	......	......	......
" *nuda*	......	1, 3, 3	......	......	......	......	......	......	......	......
" *orientalis*	+	4, 4, 4	......	......	......	......	......	......	......	......
" *sativa*	+	8, 23, 23	—	1, 3, 0	22[1], 62, 0	—	16, 49, 0	—	3, 11, 0	14[2], 48, 0
" *sterilis*	......	2, 3, 3	......	......	......	......	......	......	......	......
" *strigosa*	......	2, 4, 4	......	......	......	......	......	......	......	......
Bromus mollis	......	......	......	......	......	......	5, 12, 0	......	......	......
Dactylis glomerata	......	2, 9, 0	......	......	......	......	8, 16, 0	......	......	......
Festuca elatior	......	......	......	......	......	......	8, 21, 0	......	......	......
" " *arundinacea*	......	1, 4, 0	......	......	......	......	......	......	......	......
" " *pratensis*	......	1, 4, 0	......	......	......	......	......	......	......	......
" *heterophylla*	......	1, 4, 0	......	......	......	......	8, 42, 0	......	......	......
Glyceria fluitans	......	......	......	......	......	......	5, 19, 0	......	......	......
Hordeum bulbosum	......	......	—	5, 14, 1	12, 24, 1	......	......	......	......	......
" *decipiens*	......	......	......	5, 15, 15	......	......	......	......	......	......
" *distichon*	......	......	......	5, 15, 15	25[3], 73, 73	......	......	......	......	2, 5, 0
" *hexastichon*	......	......	+	4, 12, 12	......	......	......	......	......	......
" *intermedium*	......	......	......	1, 3, 3	......	......	......	......	......	......
" *jubatum*	......	......	+	8, 25, 0	6, 17, 0	......	8, 32, 0	......	......	......
" *maritimum*	......	......	—	3, 12, 3	12, 58, 0	......	......	......	......	......
" *murinum*	......	......	+	5, 16, 0	......	......	......	......	......	......
" *nodosum*[4]	......	......	......	......	13, 64, 51	......	......	......	......	......
" *nudum*	......	......	+	......	19[5], 45, 45	......	......	......	......	2[6], 3, 0
" *secalinum*[4]	......	......	—	3, 9, 0	......	......	......	......	......	......
" *silvaticum*	......	......	......	4, 12, 0	......	......	......	......	+[7]	......
" *Steudelii × trifurcatum*	......	......	......	......	9, 26, 26	......	......	......	......	......
" *tetrastichon*	......	......	......	......	7, 26, 26	......	......	......	......	......
" *trifurcatum*	......	......	+	......	5, 13, 13	......	......	......	......	......
" *vulgare*	—	1, 6, 0	+	24, 70, 70	49[8], 150, 150	—	15, 45, 0	—	3, 12, 0	18[9], 47, 0

TABLE XXVIII.—General summary of results with the mildews of the cereals.—*Continued*

Host-plant	Conidia from *Avena sativa*		Conidia from *Hordeum vulgare*			Conidia from *Secale cereale*		Conidia from *Triticum vulgare*		
	Marchal	Salmon	Marchal	Salmon	Reed	Marchal	Reed	Marchal	Salmon	Reed
Hordeum Zeocriton	......	......	......	3, 9, 9	23^{10}, 63, 63	......	......	......	......	1, 3, 0
Lolium italicum	......	1, 3, 0	......	......	......	......	......	......	......	......
“ *perenne*	......	......	......	......	......	......	9, 39, 0	......	......	......
Phleum pratense	......	1, 4, 0	......	......	......	......	9, 52, 0	......	......	......
Poa annua	......	2, 9, 0	......	......	......	......	......	......	......	......
“ *compressa*	......	......	......	......	......	......	5, 16, 0	......	......	......
“ *nemoralis*	......	......	......	......	......	......	9, 40, 0	......	......	......
“ *pratensis*	......	......	......	......	......	......	12, 75, 0	......	......	......
“ *trivialis*	......	......	......	......	......	......	6, 35, 0	......	......	......
Secale anatolicum	......	......	......	......	......	+	......	......	......	......
“ *cereale*	—	2, 6, 0	—	1, 3, 0	11^{11}, 24, 0	+	58, 138, 131	—	2, 8, 0	10^{12}, 25, 0
“ *dalmaticum*	......	......	......	......	......	......	3, 3, 0	......	......	......
“ *montanum*	......	......	......	......	......	......	8, 12, 3	......	......	......
“ *cereale* × *Triticum vulgare*	......	......	......	......	......	......	13, 18, 9	......	......	10, 16, 1
Trisetum pratense	......	1, 4, 0	......	......	......	......	......	......	......	......
Triticum compactum	......	......	......	......	......	......	......	......	......	9, 32, 32
“ *dicoccum*[13]	......	......	......	......	3^{14}, 9, 0	......	......	......	......	24^{15}, 75, 75
“ *dicoccum*[16]	......	......	......	......	......	......	......	......	......	6, 35, 35
“ *dicoccum*[17]	......	......	......	......	......	......	......	......	......	7, 44, 4
“ *dicoccum*[18]	......	......	......	......	......	......	......	......	......	6, 27, 0^{19}
“ *dicoccum*[20]	......	......	......	......	1, 4, 0	......	......	......	......	21^{21}, 67, 3^{22}
“ *durum*	......	......	......	......	1, 3, 0	......	......	—	......	25^{23}, 65, 65
“ *Freycenetii*	......	......	......	......	......	......	......	......	......	8, 34, 34
“ *monococcum*	......	......	......	......	......	......	......	—	......	23^{24}, 57, 47
“ *polonicum*	......	......	......	......	......	......	......	+	......	12^{25}, 30, 30
“ *Spelta*	......	......	......	......	......	......	......	+	2, 6, 6	18^{26}, 63, 63
“ *Thaoudar*	......	......	......	......	......	......	......	......	......	6, 24, 24
“ *Tumonia*	......	......	......	......	......	......	......	......	......	4, 9, 9
“ *turgidum*	......	......	......	......	......	......	......	+	......	9, 23, 23
“ *vulgare*	—	2, 12, 0	—	1, 3, 0	16^{27}, 50, 0	—	24, 66, 0	+	5, 19, 19	66^{28}, 178, 178

[1] Includes five tests, sixteen plants inoculated with conidia from *Hordeum distichon*, and four tests, nine plants inoculated with conidia from *H. Zeocriton*.

[2] Includes one test, three plants inoculated with conidia from *Triticum durum;* one test, five plants inoculated with conidia from *T. polonicum;* and two tests, seven plants inoculated with conidia from *T. Spelta*.

[3] Includes six tests, twenty-three plants inoculated with conidia from *Hordeum distichon;* one test, five plants inoculated with conidia from *H. nudum;* and one test, three plants inoculated with conidia from *H. Zeocriton*.

[4] In the Index Kewensis, *Hordeum nodosum* L. is given as a synonym for *Hordeum secalinum* Schreb. I am uncertain, however, whether Salmon's work was with the same species as the one I tested.

[5] Includes six tests, fourteen plants inoculated with conidia from *Hordeum distichon;* and two tests, six plants inoculated with conidia from *H. nudum*.

[6] Includes one test, one plant inoculated with conidia from *Triticum polonicum*.

[7] Young leaves, when inoculated, became infected.

[8] Includes three tests, ten plants inoculated with conidia from *Hordeum distichon;* one test, one plant inoculated with conidia from *H. nodosum;* one test, four plants inoculated with conidia from *H. nudum;* and five tests, thirteen plants inoculated with conidia from *H. Zeocriton*.

[9] Includes two tests, five plants inoculated with conidia from *Triticum dicoccum;* one test, two plants inoculated with conidia from *T. durum;* one test, two plants inoculated with conidia from *T. polonicum;* and one test, one plant inoculated with conidia from *T. Spelta*.

[10] Includes four tests, sixteen plants inoculated with conidia from *Hordeum distichon;* two tests, seven plants inoculated with conidia from *H. nudum;* and one test, three plants inoculated with conidia from *H. Zeocriton*.

[11] Includes three tests, seven plants inoculated with conidia from *Hordeum distichon*.

[12] Includes one test, three plants inoculated with conidia from *Triticum durum*.

[13] Black Winter Emmer. It may be noted here that Marchal obtained negative results with the wheat mildew on *Triticum dicoccum*. He does not state what variety was used.

[14] Includes one test, two plants inoculated with conidia from *Hordeum Zeocriton*.

[15] Includes two tests, five plants inoculated with conidia from *Triticum dicoccum;* three tests, seven plants inoculated with conidia from *T. polonicum;* and five tests, thirteen plants inoculated with conidia from *T. Spelta*.

[16] Red Emmer.

[17] Common Emmer.

[18] Russian Emmer.

[19] As noted in Table XVIII, exp. 154*b*, one of the plants was plainly not a seedling of the Russian Emmer. This seedling, as already noted, became well infected.

[20] White Emmer.

[21] Includes two tests, six plants inoculated with conidia from *Triticum dicoccum;* two tests, seven plants inoculated with conidia from *T. durum;* and four tests, twelve plants inoculated with conidia from *T. Spelta*.

[22] Discolored areas were observed on inoculated leaves of two plants.

[23] Six different varieties were used. The figures include two tests, four plants inoculated with conidia from *Triticum durum;* three tests, five plants inoculated with conidia from *T. polonicum;* and one test, three plants inoculated with conidia from *T. Spelta*.

[24] Three varieties were used. The results include one test, two plants inoculated with conidia from *Triticum compactum.*

[25] Includes one test, two plants inoculated with conidia from *Triticum dicoccum;* one test, three plants inoculated with conidia from *T. durum;* one test, one plant inoculated with conidia from *T. polonicum;* and one test, three plants inoculated with conidia from *T. Spelta.*

[26] Includes one test, two plants inoculated with conidia from *Triticum dicoccum;* three tests, eleven plants inoculated with conidia from *T. durum;* two tests, five plants inoculated with conidia from *T. polonicum;* and two tests, seven plants inoculated with conidia from *T. Spelta.*

[27] Includes three tests, eight plants inoculated with conidia from *Hordeum Zeocriton.*

[28] Includes one test, three plants inoculated with conidia from *Triticum compactum;* four tests, eleven plants inoculated with conidia from *T. dicoccum;* one test, two plants inoculated with conidia from *T. durum;* three tests, seven plants inoculated with conidia from *T. polonicum;* and two tests, three plants inoculated with conidia from *T. Spelta.*

To these general statements there are two possible exceptions. Marchal states that the oat mildew will infect *Arrhenatherum elatius.* Salmon, however, obtained a negative result with the oat mildew on this grass. The evidence is not conclusive either way. The other exception is that, according to Salmon, conidia from wheat can infect *Hordeum silvaticum.* This species, however, is given in the Index Kewensis as *Elymus europaeus.* Furthermore, only young plants of this grass could be infected with the wheat mildew.

It would seem then that under normal conditions there are well-defined forms of *Erysiphe Graminis* occurring respectively on the species of each of the four cereals.

Especially interesting are the results with the hybrid between rye (*Secale cereale*) and wheat (*Triticum vulgare*). Professor Bubák, from whom I obtained the seed, informs me that the seed came originally from hybrids obtained by Rimpau in Germany.

So far as I can determine, a hybrid between rye and wheat has been obtained by three different workers. Wilson,[30] in 1875, placed rye pollen on the stigma of the wheat flower and thus secured a number of seeds. These seeds gave rise to plants the appearance of whose culm and head was intermediate between rye and wheat. The awns were midway in length between the short, blunt awns of the wheat, and the long, needle-like awns of the rye. The thickness of the culm and the slight villosity below the head were also rye characters. The hybrids were entirely sterile. The anthers did not open; in fact, the pollen was imperfectly developed.

Carman *[10, 11, 12] has also obtained a hybrid between wheat and rye. In 1882 he placed pollen from rye on the stigma of a white club-wheat. From the seed obtained he was able to grow plants for several generations. In the first year there were eight plants, which yielded good grains. The next year the seed from these eight plants was sown and grew to strong, healthy plants, producing, however, a medley of wheat plants. Some had naked heads, others had long awns of various types, all, however, closely related to wheat. The ninth plant obtained in the first year resembled rye and produced apparently worthless grains. However, when these grains were planted, they gave rise to plants which had a strong resemblance to the parent rye. The plants were much taller than the original wheat plant. In the character of the head there was a close resemblance to wheat.

In 1888 Rimpau[23] attempted to cross wheat and rye. He took the pollen from the rye and placed it on the stigma of the wheat flower. He obtained one seed, which gave rise to a plant that had long and narrow awns; the haulms were 30 cm. longer than those of the wheat plants, differing especially in the length and narrowness of the ears from the mother parent. The grains secured from these plants were sown in 1890. One plant produced brown, short, sterile heads similar in form to the square-head wheat; two plants had white, fertile heads, similar to the square-head wheat; the other resembled in character the hybrids of the previous year, having very long, narrow, brown, wheat-like heads, which, however, had the more open flower characteristic of the rye.

As already stated, the seed which I used in my experiments came from this original cross by Rimpau. As seen from TABLE XVI, thirteen tests were made, eighteen plants being inoculated with conidia from the rye. Of these plants, nine showed evidences of infection. Six plants had a fairly good growth of mildew, conidia being produced. On the other three, however, only well-marked discolored areas appeared. In no case did I obtain the vigorous growth of mildew characteristic of this fungus on the rye plant.

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* A good account of Carman's work is given by Barnard.[2]

Sixteen plants of the hybrid were inoculated with conidia from wheat in ten different tests. Of these plants, only one showed any evidence of infection. In experiment 168b, a small patch of mildew with conidia appeared.

In experiments 127c and 127d, different leaves of the same plant were inoculated, one with the rye mildew, the other with the wheat mildew. No infection occurred on either leaf. The same method was followed in experiments 162c and 162d. The leaf inoculated with conidia from rye showed a good growth of mildew, but the leaf inoculated with conidia from wheat gave no evidence whatever of infection.

It is apparent from my previous work that the wheat is entirely immune to the rye mildew. Twenty-four tests were made, in which sixty-six plants were inoculated with rye mildew, not one showing any evidence of infection. In contrast, every one of the one hundred and seventy-eight plants inoculated with wheat mildew, in sixty-six tests, became fully infected. The same thing holds true in the case of rye. Twenty-five rye plants, in ten tests, were inoculated with conidia from the wheat, but not one plant showed any evidence of infection. On the other hand, in a total of one hundred and thirty-eight plants inoculated with rye mildew, in fifty-eight tests, one hundred and thirty-one plants became infected.

The experiments with the rye-wheat hybrid clearly indicate that this hybrid is resistant to both the rye and the wheat mildew. It has, however, proved much more resistant to wheat mildew than to the rye, for only one infection occurred with this mildew. It would be interesting to know the entire history of the hybrid seed experimented with. I do not know to what generation the plants I worked with belonged, nor do I know whether they more closely resemble rye plants or wheat plants. I am growing the plants to maturity in order to determine the latter point.

In this connection it is interesting to mention an experiment by Eriksson[13] on some of Rimpau's rye-wheat hybrids. Eriksson found a form of *Puccinia dispersa* Eriks. & Henn. growing abundantly upon rye-wheat hybrids obtained from Rimpau. He states that the hybrid plants seemed to be more like the wheat than the rye. It is well known that there are two distinct forms of *Puccinia* *dispersa*, the form *Secalis* on rye, and the form *Tritici* on wheat. Eriksson sowed uredospores from the infected hybrid upon three rye plants and also upon three wheat plants of the same age. Eleven days later a rich growth of the rust appeared upon the inoculated areas of the wheat plants. No infection occurred on the rye, although the plants were kept several days longer. It is apparent, then, that this hybrid had a well-marked resistance to the form *Secalis* of *Puccinia dispersa*, and was entirely susceptible to the form *Tritici*.

Some interesting questions are raised by the results obtained with the White Emmer, Russian Emmer, and Common Emmer, and also with the rye-wheat hybrid. These three Emmers are mildew-resistant varieties of *Triticum dicoccum*, two other varieties of this species (Black Winter Emmer and Red Emmer) proving quite susceptible to wheat mildew. The rye-wheat hybrid is the offspring of two parents, both of which are extremely susceptible to a particular mildew and also perfectly resistant to the form specialized on the other plant. The offspring inherits the resistance of both plants, and consequently cannot be fully infected by the fungus specialized on either the rye or the wheat. As has already been stated, the resistance of the hybrid to the wheat mildew is much more marked than is its resistance to the rye mildew.

Considerable interest has recently been manifested in breeding plants resistant to fungus-diseases. In general, two methods have been followed.* The seed of certain individual plants, which had proved able to withstand the attacks of the particular disease, is collected and used as a starting point for securing a disease-resistant variety. The other method has been to cross varieties that have been found to be resistant, with susceptible varieties, in order to combine in one type the resistant characters of the one with the productivity, adaptability for market, etc., of the other.

The first method has been followed by Blinn[5] in developing cantaloups resistant to a blight caused by *Macrosporium cucumerinum* Ellis & Everhart; by Bolley[6] in securing flax resistant to flax wilt (*Fusarium Lini* Bolley); by Bain and Essary[1] in

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* For a more complete account of these methods, see a paper by the writer in the Second Annual Report of the State Board of Horticulture of Missouri, 284–286. 1909.

securing red clover resistant to *Colletotrichum Trifolii* Bain; by Jones[17] and others in securing potatoes resistant to late blight (*Phytophthora infestans* de Bary); and by Orton[19] in securing cowpeas resistant to the wilt fungus [*Neocosmospora vasinfecta* (Atk.) E. F. Smith].

A great deal has been done toward securing rust-resistant varieties of wheat and other cereals. For this purpose Carleton[8] has introduced into this country a number of foreign wheats, especially Russian varieties. The common bread wheats, varieties of *Triticum vulgare*, in general are quite susceptible to attacks of rust. On the other hand, many durum wheats, varieties of *Triticum durum*, are relatively immune, the variety Iumillo being almost perfectly resistant. During the season of 1904,[9] the loss of common wheats in large areas of North Dakota, South Dakota, and Minnesota amounted to 50–60 per. cent. of the crop. In the case of the durum wheats, the loss was 10 per cent. or less, generally 3–5 per cent.

Einkorn (*Triticum monococcum*) is also very rust-resistant. Some varieties of Emmer (*Triticum dicoccum*) are resistant, while others are susceptible. The Spelts (*Triticum Spelta*) are quite susceptible to rust attacks.

The second method, that of crossing susceptible and resistant varieties, has also been followed. The wilt disease already mentioned is extremely destructive to watermelons; the citron, however, is resistant. Orton[20] has obtained a hybrid between the watermelon and the citron which is resistant to the wilt. Unfortunately, however, the melons produced on the hybrid vines were not edible. The hybrid was again crossed with the watermelon and plants obtained, one-fourth citron and three-fourths watermelon, very resistant to wilt and also producing good, edible melons.

Attempts have been made to cross resistant varieties of cereals with non-resistant with a fair degree of success. Especially interesting are the results obtained recently by Biffen.[3, 4] He has attempted to show that Mendel's laws of inheritance apply to the transmission of disease-resistant qualities. In 1902 Rivet wheat (*Triticum turgidum*) and Red King (*Triticum vulgare*) were crossed. The former is relatively immune to the attacks of the yellow rust (*Puccinia Glumarum*), while the latter is very susceptible. The hybrids from this cross all rusted very badly, like the parent Red King. However, 300 grains were secured, from which 260 plants were raised in 1903. The season was very favorable for rust. The plants were examined at the height of the rust attack. Sixty-four were found practically immune and one hundred and ninety-five rusted, most of them badly. The ratio of 64 to 195 is nearly 1 to 3. Taken in connection with the fact that the first generation was badly rusted, Biffen concluded that susceptibility and immunity are Mendelian characters, susceptibility being dominant. The results for the third generation confirm this view. An examination of four plots which contained both rusted and non-rusted plants, showed 149 rusted plants and 48 free from rust, a ratio of 3.1 to 1.

Biffen has also crossed American Club Wheat (*Triticum compactum*) and Michigan Bronze (*T. vulgare*). The former is relatively immune, while the latter is a susceptible variety. The hybrids of the first generation were badly rusted. The seed of these hybrids was planted and the following results were obtained:

Plant	5a	yielded	56	rust-free	individuals	and	147	rusted	individuals.
"	5b	"	45	" "	"	"	153	"	"
"	5c	"	47	" "	"	"	142	"	"
"	5d	"	36	" "	"	"	154	"	"
"	5e	"	44	" "	"	"	164	"	"
			228				760		

Plants 5f, 5g, 5h, and 5j, gave 295 rust-free plants and 849 rusted. The whole series gave 523 immune and 1,609 rusted, a ratio of 1 to 3.07.

It was observed that the severity of the rust varied on the different plants. From fifty heads of badly rusted plants, .8 gm. of seed was obtained; from fifty heads of moderately rusted plants 64 gm. of seed; and from fifty heads of immune plants, 145 gm. of seed were harvested.

Biffen tested also the inheritance of immunity to the attacks of *Erysiphe Graminis*. *Hordeum spontaneum* Koch and *H. hexasticho-furcatum* K.H. were crossed, the former being the immune parent. The hybrid was attacked by mildew as badly as the susceptible parent. In the next generation 56 plants were badly mildewed, 16 slightly attacked, and 7 entirely free. At the same time, the parent *H. spontaneum* was very slightly mildewed, while the other parent was badly attacked.

Biffen concluded that liability to disease is the dominant character, the hybrids of the first generation being quite susceptible to the attacks of the fungus. In the second generation a portion of the hybrids proved practically immune; the remaining ones still proved susceptible to the disease. It is interesting to note that Orton, in his work with the watermelon wilt, found that the hybrid of the first generation was immune.

It must be remembered, of course, that the immunity which plants enjoy against a given fungus is relative, not absolute. Barley plants can be infected with the wheat mildew, if subjected to abnormal treatment. Salmon[26] has mechanically injured barley leaves, subjected them to anaesthetics, alcohol, or water heated to about 50° C., and inoculated them with conidia from wheat. Infection occurred on such treated leaves. Miss Gibson[14] has sown the spores of several rusts on hosts which they are not known to infect. She found that in nearly every case germ tubes were pushed out which passed through the stomata into the mesophyl of the leaf. The parasite may even attain a considerable development in a plant which it finally cannot fully infect.

Plants resistant to a particular fungus in one region may be quite susceptible to the same fungus if transferred to another locality. Butler[7] states that Farrer's hybrids, resistant to rust in Australia, show a marked liability to rust in India. Einkorn in general has been found extremely resistant to rust attacks. Howard,[16] however, reports that in India this same wheat succumbed to the attack of *Puccinia Graminis*, due, probably, to the hot season. The plants remained immune until the hot weather, although surrounded by other wheats infected with rust.

The above-mentioned facts indicate that the external conditions of the plant play a prominent part in determining whether it is immune or susceptible to a given fungus-disease. While immunity or susceptibility to disease may be transmitted from parent to offspring, the influence of external factors must also be taken into consideration.

The study of disease-resistant plants affords an extremely interesting field for investigation. As yet we do not know what immunity is. We are unable to state why Common Emmer is free from the attacks of mildew while the Black Winter Emmer is susceptible, nor do we know to what extent immunity or susceptibility to a given disease can be transmitted from parent to offspring. The influence of external conditions, the factors of a plant's environment, is yet to be worked out. Further investigations with these resistant varieties and their hybrids should throw considerable light on this question.

I desire to express my appreciation of Professor R. A. Harper's and also Professor C. Stuart Gager's kindness in reading the manuscript of this paper and for many valuable suggestions.

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On the characters and relationships of the Platanaceae*

ROBERT F. GRIGGS

(WITH PLATE 25)

Recent writers under the leadership of Niedenzu (1) in the Engler and Prantl Pflanzenfamilien have agreed in placing the Platanaceae in the Rosales between the Saxifragaceae and the Rosaceae. But as to the characters of the family, which of course form the basis of all deductions concerning its relationships, there is no agreement. This is very strikingly brought to notice by comparison of two leading floras recently published almost simultaneously. Robinson and Fernald in Gray's New Manual (2) state that the flowers are "destitute of calyx and corolla" while Gleason, (3) describing the Platanaceae in the North American Flora, attributes both calyx and corolla to the flowers.

Neither of these authors is to be held accountable for the statements in his description, for both are undoubtedly compilations from older authorities. Indeed, Robinson and Fernald's description is copied verbatim from Gray's fifth (4) and sixth editions published as long ago as 1867. But since the appearance of the Pflanzenfamilien in 1891, which figured and diagrammed the flowers as having both petals and sepals, almost all writers have credited the flowers with them and have described them, sometimes in considerable detail. Of these descriptions that of Sargent (5) will serve as an example. "Calyx of the staminate flower divided into 3–6 minute scale-like sepals slightly united at the base, about half as long as the 3–6 cuneiform sulcate, scarious pointed petals; stamens as many as the divisions of the calyx, opposite them, . . . ; calyx of the pistillate flower divided into 3–6, usually 4 rounded sepals much shorter than the acute petals; stamens scale-like, elongated-obovate, pilose at the apex; ovaries as many as the divisions of the calyx, superior. . . ." And in his Silva (6) he gives figures and floral diagrams showing these parts.

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* Contributions from the Botanical Laboratory of the Ohio State University, No. XLVII.

In view of these contradictory statements it seemed desirable to undertake a study of the genus for the purpose of ascertaining the facts and of discussing its relationships. When the matter was first taken up in 1905, it was the intention to work out the whole life history of our common sycamore, *Platanus occidentalis* L. With this end in view frequent collections were made from October to August and serial sections cut after the usual methods. This intention was frustrated by a severe frost at anthesis, which so injured the flowers that only a small portion of them ripened seed. The effects of this injury were entirely internal, however, for the heads all developed alike so that it was not possible to discriminate between the good and the bad until the sections were made — too late to replace the material the same season, and other work has prevented my doing so in succeeding years. The gaps in the life history are so great on this account that it has seemed advisable to publish only the observations on the morphology of the flower, which perhaps bears more directly on the relationships of the group. I here desire to express my thanks to my colleague, Professor John H. Schaffner, for much advice and criticism.

The head consists of a cluster of flowers so much shortened that the individual pedicels are hard to distinguish. At first sight, even under a microscope, the staminate head in section looks like a single receptacle the whole surface of which is indiscriminately covered with stamens much after the fashion of a staminate cone of *Pinus*, a similarity which is heightened by the resemblance of the stamens of the two, because of the enlarged leaf-like blade of the connective (FIG. 2). Closer scrutiny of a median section (FIG. 1), however, shows narrow furrows slightly deeper than the general surface of the head, which separate the stamens into groups of one or two (as seen in the section). These furrows are the intervals between the greatly shortened and crowded pedicels which cover the head. This is made more evident by the examination of a tangential section (FIG. 4). Each peduncle, which bears three or four stamens, is surrounded by a circular scale (*sc*, FIGS. 1, 2, 4), which tapers upward into a fringe of hairs. This is so minute and insignificant that it might easily be overlooked in the abundant hair of the head; it has no vascular supply and is only two cells in thickness; it develops early and before flowering time its cells are dead, leaving it simply a hairy fringe. Beyond these scales the staminate flowers are entirely naked until long after the stamens are completely formed. When growth is resumed after the winter, however, the receptacle, which has remained flat up to that time, begins to swell and forms bulging protuberances between the filaments (FIG. 2, *O*). In cross-section (FIG. 3) these are seen to be alternate with the stamens. They are the structures which have been called vestigial carpels.

Sections of the carpellate head (FIGS. 5–7) show an exactly similar condition. The shortened closely crowded peduncles are surrounded by vestigial sheathing bracts. The folded carpels, usually 6–9 in number, are located rather indiscriminately over the upper surface of the receptacle but with their inner open sides facing the center (FIG. 6). Beside these the only other floral parts present are three or four hairy staminodes (*s*, FIGS. 5–7), which fold over the carpels and protect them until just before anthesis. While the homology of the outgrowths from the receptacle of the staminate flower to carpels is somewhat uncertain because of their rudimentary condition, there is little doubt that these appendages of the carpellate flower are homologous with stamens. They develop before the carpels, have a strong vascular supply, and are even sometimes quadrilateral.

Such being the condition of the flowers, one turns with wonder to the accounts of those authors who give not only descriptions but figures of the petals and sepals. As has been said the account in the Pflanzenfamilien is the source of all the later descriptions. But this is itself a compilation from the work of Schoenland (7), from which its figures are copied. Schoenland describes the perianth very circumstantially and in considerable detail. According to him, I translate (p. 310): "The flowers are perigynous; they possess always two regular, alternating, characteristically different circles of involucral leaves each part of which may however show considerable variation. I have no hesitation therefore in designating the outer as calyx and the inner as corolla. . . . These circles are 3–6-parted (perhaps also to 8-parted). The numerical relations may vary in one and the same inflorescence. In the staminate flowers the 4-parted condition is most frequent." He figures a tetramerous pistillate flower with sepals, petals, staminodes, and carpels in regular circles, the parts of which alternate with each other. In this figure the divisions of the corolla are about half as long as the carpels — so large that they could scarcely be overlooked on examination even with a hand lens. He supplies diagrams also, showing trimerous, tetramerous, and hexamerous flowers with the parts equidistant in regular circles.

Only a few stages, however, are favorable for study. He says (p. 309): "The best time for the study of the completely developed flower is when the anthers have just begun to shed their pollen. Before this period the investigation is enormously difficult; afterwards the staminate flowers dry up and become unfavorable for investigation; likewise the pistillate flowers shed a part of their organs very quickly after anthesis. In fruit a strong growth of hair very similar to the pappus of the Compositae develops around the carpels, so that it is no wonder that even eminent botanists have stated that the perigynium of the Platanaceae is reduced to hair-like scales between the separate flowers, which represent the floral parts." But even at this favorable period he was able to find no constancy in the regular cycles he figures. On this point he says (p. 311): "In the case cited above where the different organs of the flower occur in like number the confirmation of the diagrams, empirically obtained, was more or less easy. But on account of the crowding of the flowers all possible cases of displacement, suppression, and stunting of the organs are brought about, so that in many flowers one can determine absolutely nothing with certainty regarding the spacial relations of the parts."

Schoenland did his work only a few years after the appearance of Eichler's Blütendiagramen, when the influence of Eichler's school was at its height. This school had already pushed the method of studying flowers by means of the comparison of floral diagrams to great extremes. Their method had proved so useful that it was supposed that the flowers of all plants must be referable in some way or other to such regular schemes. Under the influence of this school Schoenland seems to have labored principally to verify a diagram representing the cycles which he supposed ought to be present. In this deductive method of reasoning he was prevented from checking his results by the facts because of his supposition of a deciduous perianth and of modifications due to pressure, factors which though potent in many cases cannot be invoked to explain the flowers of *Platanus*.

Moreover, because of the hairiness and the early lignification of the inflorescence the sycamore is an exceedingly difficult object to handle even by the best methods of modern technique, which had not been invented at the time of Schoenland's work. He himself recognized very clearly the insufficiency of his methods, concerning which he says (p. 313): "A complete isolation of the individual young flowers is possible and was accomplished by me in different ways; but the advantages obtained thereby are very doubtful, since, because of the density of the inflorescence, parts of the preparations are easily torn off, which naturally introduces numerous errors.

"I have preferred therefore for the most part to cut thin sections from heads hardened in alcohol, and to observe them in glycerine by reflected and transmitted light. The thick pubescence of the bud-scales and of the sepals is extremely disturbing, so that for the most part one can determine in this way nothing certain regarding the sepals or the petals which they cover, especially since there occur, irregularly distributed between the individual flowers, rather long hairs which are entirely distinct from the pappus-like hairs of the fruit. In the staminate or apparently perfect flowers this method is of no service, since here the thick pubescence of the anthers or staminodes makes every observation impossible. In these I was limited to longitudinal sections of the flowers, and although I am aware that one can use results which are obtained in such a way only very cautiously, on account of the impossibility of orienting the sections satisfactorily, yet I believe that I have reached correct conclusions from them, since they are in perfect accord with the facts otherwise determined." We must admire the perseverance of a man who was willing to attempt scientific work under such difficulties but we cannot give much weight to his results.

It is apparently safe to assume that the inflorescence of *Platanus* has attained its present very compact condition by the shortening of the pedicels of the individual flowers. To what extent this shortening has involved loss of floral parts is a matter of conjecture. Such shortening might be expected to favor the development of perigyny but the flowers are clearly hypogynous (FIGS. 1, 2, 5) and have no perigynous disc as Schoenland maintains. The presence of staminodes and of rudimentary carpels seems to indicate clearly that the flowers were originally perfect. The homology of the scale encircling the pedicel is somewhat doubtful. It may be the vestige of the calyx. But its form suggests strongly the sheathing base of a foliage leaf. If it is to be compared with a leaf it would represent a vestigial bract surrounding the pedicel as the bases of the leaves surround the buds in their axils. But it is so much reduced that it is not possible in my judgment to determine with certainty what it represents.

Whether this represents a bract or a calyx, it is clear that *Platanus* is apetalous and that it should be removed from the Rosales and placed among the Apetalae. In this group the place of the Platanales is probably to be found next the Urticales. This position they originally held on account of their obvious resemblances to some of the Urticales. There seem to be in this case no characters of the life history which are more significant than those general similarities that every observer recognizes, namely: the tendency toward the aggregation of the flowers into spherical heads by the shortening of the pedicels, which has been carried to its culmination in *Platanus* and such genera of the Urticales as *Artocarpus* and *Toxylon*, and the development of sheathing stipules completely encircling the stem and covering the bud as in *Artocarpus* and *Ficus*. Between these genera and *Platanus* there is of course a gap so wide as to be of ordinal rank, and yet these similarities may indicate the approximate place of the Platanales among the orders of the Apetalae and save it from complete isolation.

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Explanation of plate 25

The figures are camera drawings of microtome sections. *c*, carpel; *o*, outgrowth from receptacle of staminate flower = vestigial carpel; *s*, staminode; *sc*, encircling scale; *st*, stamen.

FIG. 1. Portion of a median section of a staminate head, showing one flower with parts of two others at the sides, × 65. October 3.

FIG. 2. Longitudinal section of a staminate flower, showing outgrowths from the receptacle, which are doubtfully homologized with carpels, × 25. April 25.

FIG. 3. Cross section through the filaments of a flower of the same age as fig. 2, × 65.

FIG. 4. Tangential section through the pedicels of a staminate inflorescence of same age as figs. 2 and 3, × 65.

FIG. 5. Longitudinal section of a group of carpellate flowers, × 25. January 15.

FIG. 6. Tangential section of a carpellate head, × 65. April 18.

FIG. 7. Similar section at the level of the encircling scale, × 65. April 18.

Notes on Rosaceae — II

PER AXEL RYDBERG

SCHIZONOTUS

In Harms' list of Genera Conservanda, adopted by the Vienna Botanical Congress, the name *Sorbaria* A. Br. of 1864 is given among those which should be retained, and it is preferred to the older *Basilima* Raf. 1836 [should have been 1838] and the still older *Schizonotus* Lindl. of 1829. Usually the publication of the last-named genus is accredited to Wallich's Catalogue.* This catalogue, however, was not published in the sense the word "published" is usually taken, for it was merely a duplicated collector's list. Besides, *Schizonotus* is there merely a *nomen nudum, i. e.*, being accompanied neither by a description nor by a synonym cited. In Lindley's Introduction to the Natural System of 1830, *Schizonotus* is really published, as Lindley points out the characteristic fruit of *Spiraea sorbifolia* and proposes the name *Schizonotus* on page 81, and on page 83 enumerates *Schizonotus* as a genus recognized by him. The combination *Schizonotus sorbifolius* was not actually published until eleven years later in the second edition of Steudel's Nomenclator.

Is there any good reason for preserving *Sorbaria* instead of either of the two older names? If there had been a rule providing that when a subgenus, or section of a genus, is raised to generic rank, then the subgeneric or sectional name should be retained, *Sorbaria* A. Br. would have had a standing, for as a name of a section of *Spiraea* it dates from 1825. Such a rule has been advocated to some extent in this country, but the Vienna Rules do not provide for anything like it. *Sorbaria* apparently was selected purely arbitrarily, perhaps because it had been adopted by Focke in Die Natürlichen Pflanzenfamilien. If *Sorbaria* had been a generally accepted genus, there might have been also some reason for its retention, but this is not the case. Scarcely any one has used

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*No. 703. 1829.

it from its publication until it was used in the Pflanzenfamilien. If the choice had been only between *Sorbaria* and *Basilima* there might have been another reason why the former should be preferred; the latter was proposed by the erratic Rafinesque, who did things only by halves. But *Schizonotus* was proposed by Lindley, one of England's most prominent botanists. Perhaps the fact that Rafinesque applied the name *Schizonotus* to a different genus had something to do with it; but Rafinesque never intended to name a new genus *Schizonotus*, when he used it as generic name for *Spiraea discolor* Pursh. He simply thought that he was using it in the same sense as Lindley. It was simply a matter of wrong identification.

CHAMAEBATIARIA

This genus has been supposed to be monotypic. There exists, however, a second species, although it seems to be very rare and of a rather restricted distribution. *C. Millefolium* resembles the genus *Chamaebatia* in general habit and has often been mistaken for it, but this likeness is still greater in *Chamaebatiaria glutinosa*. Even to a trained botanist, who knows both, it would be hard, without flowers or fruit, to distinguish the latter from *Chamaebatia foliolosa*. The oldest specimen known of *C. glutinosa*, viz., its type, was sent to Dr. John Torrey, who wrote the following remarks on the sheet: "Given to me by Dr. Bolander, in San Francisco, Sept., 1872. The only specimen he had ever seen. We both supposed it might be a n. sp. of *Chamaebatia*, but it proves to be a *Spiraea*, nearly allied to my *S. Millefolium*. 4–5 feet high."

Besides the type, only the following specimens have been seen by the writer:

CALIFORNIA: 1855, *Newberry*.

NEVADA: *Ward;* 1885, *Mrs. Clements*.

PORTERANTHUS

This genus was first published under the name of *Gillenia* Moench in 1802. There is, however, an older *Gillena* Adans.* named for the same person and properly published, as it was based on *Volkameria* P. Br.† and *Tinus* L.‡

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* Fam. Pl. 2: 166. 1763.

† Hist. Jam. 214. 1756.

‡ Syst. 1010. 1759. [Ed. 10.]

LINDLEYELLA

This genus has been known as *Lindleya* H.B.K. (1823). But the name *Lindleya* had been used twice before, viz., in 1821–2 by Kunth* and by Nees.† The former is supposed to be a synonym of *Casearia* Jacq. and the latter of *Laplacea* H.B.K.,‡ published the same year. Which of the two was first published can scarcely be decided, and *Lindleya* Nees may replace *Laplacea* H.B.K. Following the rule, "Once a synonym, always a synonym," the writer was forced to propose a new name.

That the genus contains more than one species is evident. If anyone compares the illustrations cited in the North American Flora under *L. mespiloides* with those in the Botanical Register and the Fleurs des Serres, cited under *L. Schiedeana*, he will see that they can scarcely represent the same plant. *L. mespiloides* has been described as a very variable plant, perhaps partly on account of these very unlike illustrations. There are perhaps more than two species included, but the author has no evidence that proves the existence of more than two. All the specimens found in the herbaria of the New York Botanical Garden, Harvard University, and the United States National Museum, except one, agree fairly well with the original illustration in Humboldt, Bonpland & Kunth's Nova Genera et Species. The only exception is Schiede's plant and this agrees fairly well with the illustrations in the Botanical Register and in the Fleurs des Serres.

VAUQUELINIA

When the author began the revision of this genus, he had two species at hand, which had been named *V. corymbosa*, but the first glance at the original illustration of the latter showed him that neither of the two could belong to it. One of these was referred to *V. corymbosa* by Torrey in the Botany of the Mexican Boundary Survey. This error was corrected by Watson, who renamed the plant *V. Torreyi*. The plant had been collected earlier, however, during Emory's Reconnoissance and had been described by Torrey as *Spiraea californica*. For this reason the

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* Malv. 10. 1822.

† Flora 4: 299. 1821.

‡ H.B.K. Nov. Gen. et Sp. 5: 207. 1821.

name was changed to *V. californica* by Sargent, although the plant is not found within the state of California. *Spiraea californica* differs, however, somewhat from *Vauquelinia corymbosa* of the Mexican Boundary Survey, having broader and less tomentose leaves. Whether the two forms represent two distinct species or not is hard to tell, as the author has seen but one specimen resembling the type of the former, and both this specimen and the type are but fragmentary.

The other plant, named *V. corymbosa*, is a shrub from Chihuahua and best represented by Pringle's *no. 5*. This is characterized by its narrow leaves and has therefore received the name *V. angustifolia*. It is represented by the following specimens:

MEXICO: Santa Eulalia Mountains, state of Chihuahua, 27 May, 1885, *C. G. Pringle 5* (flowers); 14 Aug., 1885, *Pringle 369* (fruit); 1885, *E. Wilkinson* (flowers).

As stated before, neither of these could be referred to *V. corymbosa* Correa. Neither could they be referred to *V. Karwinskyi* Maxim. Of the latter I had seen no specimen, but Maximowicz's description was ample enough to determine this fact. The author therefore made a key and drew the description of the four species as well as he could from the herbarium material of two of them and the descriptions of the two others. While the monograph was in press some material was received from Washington, and in this material were found specimens of the two missing species. There was, however, only little to be added or modified in the descriptions. *V. corymbosa* is represented by the following specimens:

MEXICO: Ixmiquilpan, Hidalgo, Aug., 1905, *C. A. Purpus 1384*.

V. Karwinskyi by the following:

MEXICO: Alvarey, San Luis Potosi, May 19–22, 1905, *E. Palmer 594;* perhaps also, San Lorenzo Cañon, six miles southeast of Saltillo, Coahuila, April 16, 1905, *E. Palmer 538*.

SERICOTHECA

According to the Vienna Rules and Harms' list, *Holodiscus* Maxim. should be retained in preference to *Schizonotus* Raf. If there were any regard to priority, such a provision would be unnecessary, for *Schizonotus* Raf. (1838) is a homonym of the older

Schizonotus Lindl. (1830). But why should not *Sericotheca* Raf. (1838) be considered? It was just as well published as was *Schizonotus*, and was published by the same author. It is another illustration of how poorly digested and how incomplete Harms' list is. The present writer would perhaps be willing to subscribe to a list of *nomina conservanda*, provided that a good reason in each case could be given; but a list which arbitrarily retains or rejects genera published under similar conditions by Hill or Adanson, as shown by Druce in his introduction to his List of British Plants, has no standing with the present writer.

The genus *Sericotheca* is a very perplexing one, and it is very hard to draw lines between the species. Otto Kuntze reduced the whole genus to one species. Every one must admit that by so doing he went too far. The genus can be divided into two types; one with the teeth of the leaves rounded or rounded-ovate, ending in a short mucro, and achenes straight on the back; the other with the teeth lanceolate or triangular-ovate, ending in a long mucro, and the achenes more or less curved on the back. The two species would then be *S. discolor* and *S. argentea*. This would be the ultra-conservative view. Both species, especially the former, would, however, show such a diversity of forms that a number of varieties would have to be admitted. If S. *discolor* is compared with *S. microphylla* or *S. glabrescens*, few botanists would regard them as the same species. It is only when the other members of the genus are known and considered, that some would regard them as varieties of one species. C. K. Schneider, who can very well be credited to the conservative school, has been forced to admit four species. He made the statement that he could not see any difference between *Holodiscus microphyllus* and *H. dumosus* but I think this was due to the fact that he followed S. Watson in his interpretation of *H. dumosus*. Watson's idea of *H. dumosus* was an aggregate of those species which have a narrow and rather simple inflorescence, *i. e.*, *Sericotheca concolor*, *S. microphylla*, and *S. glabrescens*. *S. Boursieri* and *S. saxicola* would also have been included, had they been known to Watson. Now, the fact is that the original *Spiraea dumosa* Nutt. cannot be distinguished specifically from *Holodiscus australis* Heller. The latter Schneider admits as a good species. It is true that *Spiraea* *dumosa* Nutt. and *Holodiscus australis* Heller are not exactly alike. The former represents the extreme hairy form with more than usually double-toothed leaves and the latter the more glabrate extreme with simpler teeth.

It was with some reluctance that the writer proposed his new species *S. franciscana*, not because the type is not amply distinct from *S. discolor*, but because there are forms that connect the two. The former is characterized by its thick, dark green leaves, densely short-hairy, almost velvety above; the latter by its thin leaves, glabrous or almost so above. The following specimens are to be referred to *S. franciscana*:

CALIFORNIA: Monterey, on the Mexican Boundary Survey, 1850, *C. C. Parry;* Southern Upper California, *Fitch 2* and *3;* Sonoma (Whipple's Exploration), *Bigelow 4;* Pilarcitos, Sept., 1867, *N. J. Davis 48;* San Leandro, June, 1888, *Underwood* (type); Albion Ridge, Mendocino County, June, 1903, *J. McMurphy 266;* Crystal Spring Lake, June, 1903, *Elmer 4274;* [no locality], *Thomas Bridges 100(a);* 1868–'9, *Kellogg & Harford 201;* Crystal Spring Lake, Sept. 2, 1902, *Baker 1552;* Ukiah, Mendocino County, July 11, 1902, *Heller;* Duncan's Mills, July 18, 1882, *M. E. Jones 3579;* Santa Lucia Mountains, June, 1898, *R. A. Plaskett 161;* Mendocino, June, 1898, *H. E. Brown 805;* Coast Hills, San Luis Obispo County, May, 1885, *Mrs. Summers 95.*

S. pachydisca Rydb. of Mexico is intermediate between *S. discolor* and *S. dumosa* in leaf-form, but differs from both in the much more developed disk in the mouth of the hypanthium. This may be the same as *Schizonotus argenteus intermedius* O. Kuntze, but Kuntze's description is too incomplete.

It is strange that *Spiraea Boursieri* Carr. has not been recognized, notwithstanding the excellent figure published in the Revue Horticole.* The few specimens in existence in our herbaria have been included in *S. dumosa*, as interpreted by S. Watson, perhaps on account of its small and simple inflorescence. *S. Boursieri* differs, however, from *S. microphylla* and *S. concolor* in the shape of the leaves and the much larger flowers. It has the largest flowers of all the United States species known. To it may be referred:

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* 1859: *f. 108.*

CALIFORNIA: Yosemite Valley, 1872, *J. Torrey; Thomas Bridges 100.*

NEVADA: Clear Creek Cañon, Ormsby County, Aug. 6, 1902, *Baker 1431.*

To *S. concolor* are referred, besides the type:

CALIFORNIA: Long Meadow, Tulare County, June 7–14, 1888, *Edward Palmer 187;* Mt. San Antonio, July, 1901, *Le Roy Abrams 1917;* Coyote Creek, July 30, 1904, *Culbertson* [Baker's distribution no.] *4332.*

NEVADA: Western Nevada, 1865, *Stretch;* Pine Forest Mountains, July, 1901, *Griffiths & Morris 196.*

To *S. Schaffneri* are referred the following:

MEXICO: San Luis Potosi, 1879, *Schaffner 451; Parry & Palmer 223.*

ARIZONA: Bill Williams Mountains, June, 1883, *H. H. Rusby 588.*

S. obovata is closely related to *S. glabrescens*, but differs in the larger leaves, which are densely villous-pubescent above. It resembles also *S. dumosa* but its leaves are decidedly glandular-atomiferous. The following specimens are referred to it:

CALIFORNIA: Woods on Truckee River, July 17, 1886, *Sonne* (type); Bear Valley, Calaveras County, Aug. 23, 1892, *Geo. Hansen 234.*

Spiraea fissa Lindl. has been improperly understood. By the courtesy of the Director of the Kew Gardens, the New York Botanical Garden has received a fine tracing of the type and also some fragments. Kuntze's type of *Schizonotus argenteus alpestris* is now in the herbarium of the N. Y. Botanical Garden and there is also a duplicate of *Holodiscus argenteus bifrons* Focke. The former is merely a reduced form and the latter a rather luxuriant one of *S. fissa.* Neither deserves even a varietal rank. Kuntze recognized also a var. *fissus*, based on *Spiraea fissa* Lindl. Although he placed the two varieties in different divisions of the key, they can not be separated. The key is not workable, and as he cites no specimens, some of his varieties will remain unknown. The var. *alpestris* is the only one represented in his herbarium.

S. velutina is a closely related species, which has been confused with it and with *S. argentea.* It has the habit of *S. fissa,* but has more hairy leaves and fruit like that of *S. argentea.* It may be *Schizonotus argenteus mexicanus* O. Kuntze, but it is scarcely *Spiraea mexicana* Schiede. I refer to it the following specimens:

MEXICO: Sierra de San Filipe, Oaxaca, Sept. 25, 1894, *Charles L. Smith 821;* 1894, *E. W. Nelson 1085;* 1894, *Pringle 5734.*

FILIPENDULA

As represented in North America, this genus could very well be divided into 4 genera, viz.:

1. ULMARIA Hill, with *F. Ulmaria* and *F. denudata.*
2. FILIPENDULA Adans., with *F. Filipendula.*
3. THECANISIA Raf., with *F. rubra.*
4. [Unnamed], with *F. kamtschatica* and *F. occidentalis.*

Several of the Asiatic species, however, combine the characters of two or more of these genera and the generic lines disappear altogether. It was therefore deemed advisable to keep them as a single genus.

HORKELIA

Three species of this genus had been published since my Monograph of the North American Potentilleae.* These are: *H. glandulosa* Eastwood, *H. Wilderae* Parish, and *H. Rydbergii* Elmer. All of these are known from the type localities only. Six were proposed as new in the North American Flora, viz.: *H. truncata, H. Brownii, H. tenuisecta, H. integrifolia, H. pulchra,* and *H. hispidula.* Of these *H. truncata* and *H. tenuisecta* were partly known to the writer when his monograph was prepared, but were there included in other species. Two sheets of the former were included in *H. platycalyx* which it resembles in floral structure. These specimens were:

LOWER CALIFORNIA: Guadalupe Mountains, 1883, *C. R. Orcutt 840* (labeled *Horkelia californica paucifoliata* Wats.).

They were not very good specimens and therefore not so critically studied. Better specimens have been seen since. The best of these is in the herbarium of the University of California. Although the specimen was from a cultivated plant, it was designated as the type.

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* Mem. Dep. Bot. Columbia Univ. **2**: 1898.

H. tenuisecta was better known, but the author mistook it for *H. tenella* (*H. fusca tenella* S. Wats.). A reexamination of the type of the latter proved it to belong to a species which the writer thought undescribed. *H. tenuisecta* is therefore the same as *H. tenella*, in greater part, of the writer's monograph. To it belong the following specimens:

WASHINGTON: Falcon Valley, July 28, 1882, *Suksdorf 2492* (type), and 1896, *60;* Ice Cave, Trout Lake, Aug. 5, 1894, *F. E. Lloyd.*

To the true *H. tenella* belong the following:

CALIFORNIA: San Joaquin River, Fresno Co., 1891, *Coville & Funston 1836;* Hogg Ranch, Yosemite National Park, 1902, *Hall & Babcock 3378;* Morgan, Tehama Co., 1903, *4392;* Cannell Meadows, Tulare Co., 1904, *5117.*

Horkelia hispidula is related to *H. sericata* but lacks the silvery pubescence characteristic of that species. In habit it resembles *H. Micheneri* also and may easily be mistaken for it, if the floral characters are overlooked, the sepals and bractlets being very different. *H. hispidula* is known only from the type locality.

H. Brownii is related to *H. tenella* and *H. parviflora*. It differs from the former in the dense pubescence and from the latter in the deeply divided leaflets and the open inflorescence. To it is to be referred the following specimen, besides the type:

CALIFORNIA: Mt. Shasta, 1892, *E. Palmer 2448a.*

H. integrifolia is related to *H. tridentata* but differs in the entire leaflets and the appressed pubescence of the stem and the petioles. It is known only from the type locality.

H. pulchra is related to *H. congesta* but the leaflets are 13–17 instead of about 9 and they are deeply cleft into lanceolate divisions. It also is known only from the type station.

One change of name was necessary. *H. bernardina* Rydb. was substituted for *H. Parryi* Rydb., there being an older *H. Parryi* Greene. *H. Parryi* Rydb. was based on *H. Bolanderi Parryi* S. Wats. It may be that Dr. Greene had the latter in mind, when he proposed the new species, but there is no evidence that he did, for he cited no synonym, nor in any other way referred to Watson's variety. The types of both *H. Bolanderi Parryi* S. Wats. and *H. Parryi* Greene were collected by Parry in southern California, but at different localities and in different years.

HORKELIELLA

The writer thought it advisable to raise the subgenus *Horkeliella* of *Horkelia* to generic rank. Even if the characters separating it from *Horkelia* and *Ivesia* are not very prominent ones, the writer's opinion is that the arrangement here adopted will make the treatment of the tribe much clearer. To the two species included in the subgenus is to be added a third one, *Horkelia Congdonis.*

IVESIA

The writer restored this genus in the North American Flora, after having included it in *Horkelia* in his Monograph of the North American Potentilleae. In the latter publication he reduced it, simply because one species, *I. argyrocoma*, has more or less dilated filaments. The species is in every other respect as good a species of *Ivesia* as any of the *I. unguiculata* group. The type species of the genus, *I. Gordonii*, has but 5 stamens and a more scape-like stem, but the structure of the flower and the general habit are otherwise practically the same. In *I. pygmaea*, *I. Shockleyi*, *I. setosa*, and *S. Baileyi*, the hypanthium is much flatter than usual in the genus; it has a distinct thickening or disk in the throat, and the filaments are short, inclined towards the center of the flower, thus approaching the structure of the flowers of the genus *Comarella.* These species (except sometimes the last one) have leaves with spinulose-tipped teeth or lobes, and only 5 stamens. It is not advisable to remove these species from *Ivesia*, however, for at least the first two have otherwise the habit of *I. Gordonii* and other 5-stamened species of the *I. lycopodioides* group; and another species, *I. chaetophora* Rydb., has the same habit and the same spinulose-tipped teeth or divisions, but a more campanulated hypanthium, no thickened disk, and 10 stamens.

The species of the *I. eremica* group approach the genus *Potentilla* in the almost clawless petals and the less developed hypanthium, but otherwise they are typical Ivesias.

The following species were proposed as new: *I. Tweedyi*, *I. megalopetala*, and *I. setosa.*

The first one was included in *Horkelia utahensis* in my Monograph; the other two were there treated as varieties of *H. Gordonii* and *H. Baileyi*, respectively.

To *I. Tweedyi* belong, besides the type, the following specimens:

WASHINGTON: Cascade Mountains, 1882, *T. S. Brandegee.*

I. callida (Hall) Rydb. was transferred from *Potentilla*, and placed in the *I. eremica* group, although not so closely related to the other members.

PURPUSIA

P. saxosa is still unknown except from the type locality. Other specimens have been referred to this species, as for instance, *Heller 8297*, but this belongs to *Potentilla acuminata* Hall; some others belong to *Potentilla saxosa* Lemmon. *Ivesia Baileyi* may also be mistaken for it. The few pistils on a stalked receptacle and the absence of bractlets distinguish it at a glance from all three.

COMARELLA AND STELLARIOPSIS

These two genera were treated as in my monograph.

NEW YORK BOTANICAL GARDEN.

What is Convallaria odorata Mill.?

G. Claridge Druce

In the Annals of Scottish Nat. Hist. 226. 1906, I suggested that the plant described by Miller in the Gardener's Dictionary Ed. 8, no. 3, 1768, is the *Convallaria Polygonatum* L. Mr. James Britten, however, dogmatically asserted that Miller's specimen representing this species in the National Herbarium at South Kensington is a form of *Polygonatum multiflorum*. As there was doubt about the identity, I unfortunately chose *P. Sigillum* (Lepech.) to represent *Convallaria Polygonatum*, since British botanists have not accepted *Polygonatum Polygonatum*, the more logical combination.

The evidence, however, apart from the herbarium specimen, about the identity, of which more anon, in favor of Miller's plant being *C. Polygonatum* L. is very strong.

Gerarde (Herball 758. 1597) first records it as British and he calls it Sweete smelling Salomon's Seale: the Polygonatum 1 [*sic*] Clusii. That sort of Salomon's Seale with broad leaves groweth in certaine woods in Yorkshire called Clapdale woods. Johnson (Gerarde Emac. 904. 1633) corrects the reference to Polygonatum 2 Clusii and replaces the poor figure by an unmistakable plate of *C. Polygonatum* L. Ray (Syn. 1690) calls it the 'Sweet Smelling Solomon's Seal' and he does so also in his Historia (1: 665. 1688), where he says "flores . . . verum majores et odore (qui in vulgari nullus est)." Linnaeus (Sp. Pl. 451. 1762) under *C. Polygonatum* quotes Bauhin (Pinax 303) for *Polygonatum latifolium, flore majore odoro.* Hudson (Flora Anglica 146. 1762) gives the same reference and adds "Sweet Lily-Convally or Solomon's Seal." So that in Britain till the time of Miller the Sweet-Smelling Solomon's Seal was the name given to the plant with larger flowers, and angular stem—the *C. Polygonatum* L. Therefore the presumptive evidence of Miller's *C. odorata* being identical was very strong. His description in the Dictionary confirms this — *C. odorata*, Broad-leaved Solomon's Seal with a larger sweet flower.

Recently I have examined Miller's authentic specimen in the National Herbarium and to my great surprise find that Mr. Britten has made a serious error in naming it *P. multiflorum.* The specimen, which has the angular stems, the large flowers and glabrous filaments, is unmistakably *Convallaria Polygonatum* L., *Polygonatum officinale* All.

To those who follow the Vienna Rules, which claim priority for the earliest specific name except when it involves the duplication of a name, the name I first suggested has priority, *i. e.*, *Polygonatum odoratum* (Miller) Druce.

An attempt has been made to supersede *Polygonatum* Adans. by *Salomonia* Heister ex Fabric. Enum. Pl. Hort. Helmstad., Ed. 2. 38. 1763; indeed this is given in large type in the third Supplement to the Index Kewensis 158, but there is no need for this since *Polygonatum* dates not from Adanson 1763 (Fam. des Plantes) but from Hill 1756 (British Herbal).

OXFORD, ENGLAND.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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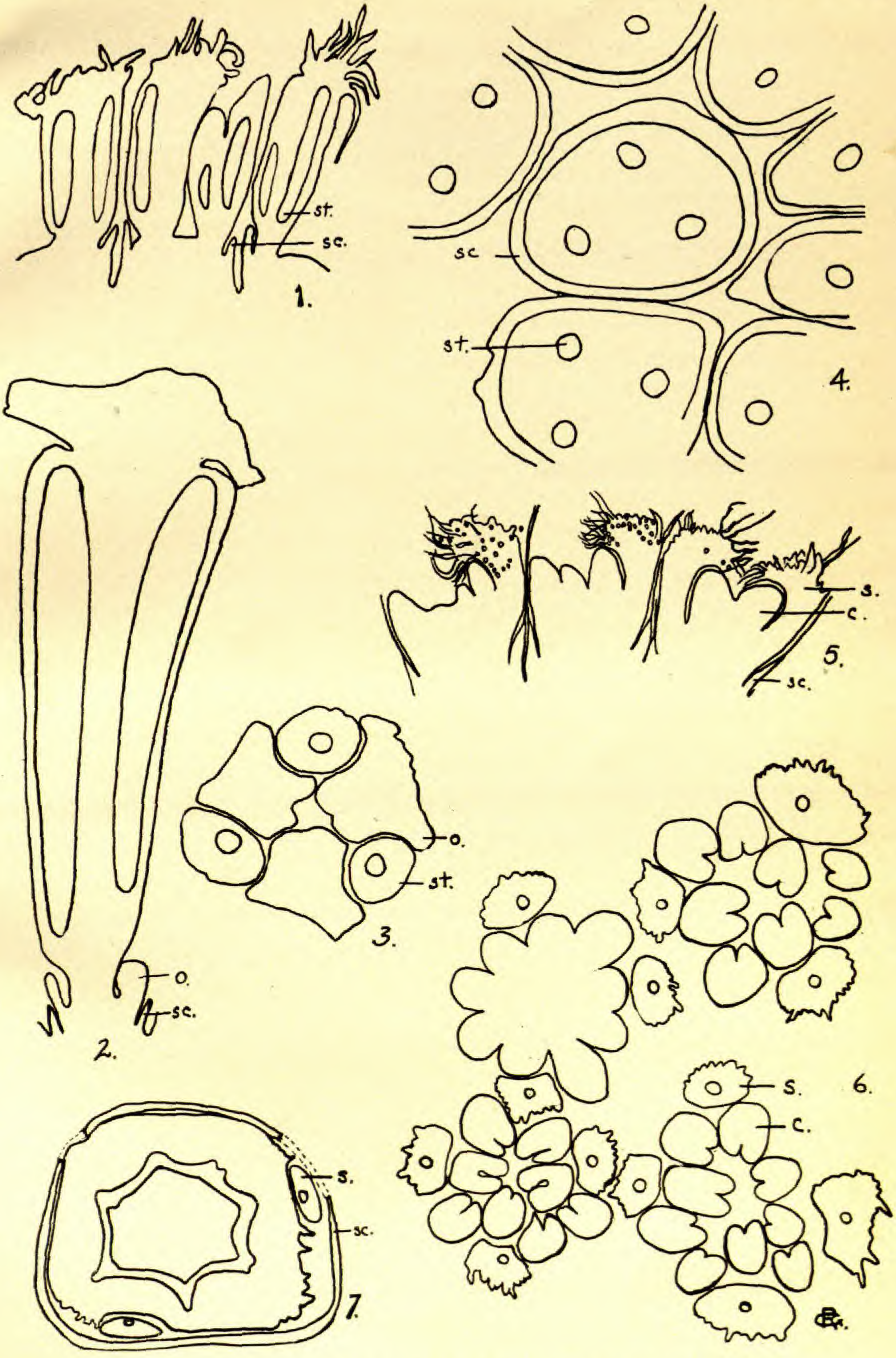

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

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THE TORREY BOTANICAL CLUB

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Vol. 36 No 8

BULLETIN

OF THE

TORREY BOTANICAL CLUB

AUGUST, 1909

The western American birches

BERTRAM T. BUTLER

The present paper aims to define and characterize the birches of western North America, about which very little has heretofore been written and which have been in more or less confusion as to their identification. After several seasons' work in the field and with the collections in the herbarium of the New York Botanical Garden and those of the College of Pharmacy, Columbia University, I have concluded that the birches of the West are mostly distinct from those of the East, only a few of the eastern species reaching the regions west of the Great Plains. The idea maintained by many writers of regarding the western forms as varieties or even as hybrids of eastern species has no scientific basis, the majority of the confusing varieties and hybrids having been proposed rather as a conjecture based upon a few superficial characters, and without proper study of living material or understanding of habitat and distribution.

While several of the species as described below show considerable variation, it seems more practical to group about a leading type all forms that cannot be clearly characterized than to give them varietal rank. Forms sufficiently distinct to warrant recognition have been regarded as species.

The illustrations are from drawings by the author and give in each instance the typical leaf-form, actual size, outline of the fruiting ament, actual size, and outline of the fruiting bractlet enlarged four diameters. Western forms have been given in cases where the type is from the East or the Middle West.

[The BULLETIN for July, 1909 (**36** : 353–420. *pl. 25*) was issued 14 Au 1909.]

The following key recognizes seventeen species. About these types as characterized may be grouped all the western forms known to me at the present time.

Key to the western American birches

- Bark separable into layers or sheets, the very thin outer layer peeling into small shreds; trees.
  - Bark chalky white or silvery gray.
    - Leaves broadly ovate, apex acute, base mostly subcordate, teeth spreading; twigs glabrous or slightly puberulent; bark silvery gray, often dark; middle lobe of bractlet acute, slightly longer than the rounded lateral ones. 15. *B. subcordata.*
    - Leaves narrowly ovate, apex long-acute or acuminate, base rounded or cuneate, teeth directed toward apex; twigs pubescent; bark chalky white; middle lobe of bractlet narrow, rounded, about twice as long as the acute or obtuse lateral ones. 14. *B. papyrifera.*
  - Bark yellowish or reddish-brown, often very dark.
    - Twigs very glandular; middle lobe of bractlet triangular, acute, much longer than the obliquely ovate or rhombic, spreading, lateral ones.
      - Leaves ovate, very thin, dark green, apex acute, finely and irregularly doubly serrate with slender long-pointed teeth. 16. *B. occidentalis.*
      - Leaves deltoid or ovate, thick, bronze-green, apex long-acuminate, coarsely serrate. 13. *B. alaskana.*
    - Twigs not or but slightly glandular, middle lobe of bractlet rounded, equaling or but slightly longer than the rounded ascending lateral ones.
      - Leaves broadly ovate, apex acute, base cuneate. 10. *B. kenaica.*
- Bark not separable into layers, outer bark not peeling into shreds; trees and shrubs.
  - Twigs and branchlets glandular-resiniferous, not hairy.
    - Samara wings broader than the nutlet.
      - Lateral lobes of bractlets spreading, obliquely ovate, auricled at the base; trees.
        - Leaves very thin; fruiting ament narrowly cylindrical, elongated, less than 1 cm. thick; lateral lobes of bractlet obtuse or rounded, claw much shorter than middle lobe. 12. *B. Piperi.*
        - Leaves thick; fruiting ament broadly cylindrical, stout, 1 cm. or more thick; lateral lobes of bractlet mostly acute, claw as long as middle lobe. 11. *B. utahensis.*
      - Lateral lobes of bractlets ascending, obliquely rhombic, not auricled at the base; shrubs or trees.
        - Shrubs or small shrub-like trees; bark shining, dark red-brown, smooth; leaves broadly ovate,

less than 4 cm. long except on young vigorous shoots, coarsely and irregularly serrate, thin, dark green, apex obtuse or acute, base mostly rounded; twigs densely glandular-resiniferous. 9. *B. fontinalis.*

Trees, often very large, never shrub-like; bark dull ashy gray or dull brown, flaked with gray, roughened; leaves ovate, somewhat lobed, 4–7 cm. long (or more on vigorous shoots), finely serrate, thick, dull bronze-green, apex acute, never obtuse or rounded, base mostly truncate; twigs but slightly glandular-resiniferous. 17. *B. montanensis.*

Samara wings not broader than the nutlet; shrubs.

Leaves crenate-serrate, obovate to orbicular, very resinous, less than 3 cm. long, apex rounded, base mostly cuneate, never cordate. 1. *B. glandulosa.*

Leaves irregularly serrate, broadly ovate or oval, slightly or not resinous, more than 3 cm. long, apex acute with cordate base, or apex obtuse with cuneate base. 3. *B. Hornei.*

Twigs and branchlets more or less hairy or pubescent, not or sparingly glandular-resiniferous, often glabrous; shrubs or shrub-like trees.

Samara wings broader than the nutlet.

Leaves oval or rhombic-ovate.

Leaves narrowly oval or rhombic-ovate, 6 cm. long or less, sharply serrate or dentate, apex acute, base cuneate; twigs finely pubescent, not glandular; middle lobe of bractlet triangular, obtuse, lateral lobes rounded, obliquely rhombic; fruiting ament 2–4 cm. long. 8. *B. Sandbergi.*

Leaves broadly oval, less than 4 cm. long, acute at both ends, serrate or crenate-serrate; twigs pubescent and sparingly glandular; middle lobe of bractlet rounded, as broad as or broader than the ascending rounded lateral ones; fruiting ament less than 2 cm. long. 4. *B. Elrodiana.*

Leaves obovate.

Leaves obovate, apex rounded, base cuneate; twigs puberulent, with long coarse scattered hairs, sparingly glandular; middle lobe of bractlet acute or obtuse, narrower than the spreading, obliquely rhombic, acute lateral ones; fruiting ament 2–3 cm. long. 5. *B. obovata.*

Samara wings not broader than the nutlet.

Leaves finely crenate or crenate-serrate.

Leaves oval, acute at both ends, less than 3 cm. long; twigs glabrous, puberulent at first, slightly glandular; fruiting ament less than 2 cm. long. 7. *B. crenata.*

Leaves obovate, apex rounded, base cuneate; twigs pubescent, not or slightly glandular; fruiting ament 3–4 cm. long, slender. 6. *B. Hallii.*
Leaves coarsely serrate.
Leaves obovate, apex acute or obtuse, base cuneate; twigs glandular-resiniferous, with long coarse scattered hairs; fruiting ament 1–2 cm. long. 2. *B. glandulifera.*

1. BETULA GLANDULOSA Michx. Fl. Bor.-Am. 2: 180. 1803

A low shrub 1–2 m. high or procumbent at high elevations; twigs and branchlets coarse, reddish brown to gray, densely glandular-resiniferous but not hairy or pubescent; leaf-blades 1–2.5 cm. long, broadly obovate to orbicular, often wider than long, with rounded apex and mostly cuneate base, finely crenate or crenate-serrate, reticulated, with the veins often impressed above, glabrous, often thickly dotted with minute resinous glands; petioles reddish, 2–10 mm. long; fruiting aments 1–2 cm. long, 4–5 mm. thick, cylindrical; bractlet 4–6 mm. long, finely ciliate and puberulent, about equally 3-lobed, lateral lobes ascending, rounded, nearly as long as the rounded middle lobe; samara nearly orbicular, about 2 mm. broad, the wings very narrow. [FIGURE 1.]

This species is readily distinguished by its densely glandular-resiniferous twigs and branchlets and the small rounded crenate or crenate-serrate leaves. It ranges from California to Alaska and eastward throughout the Rocky Mountains, across the continent to the north. The eastern forms differ slightly from those of the west.

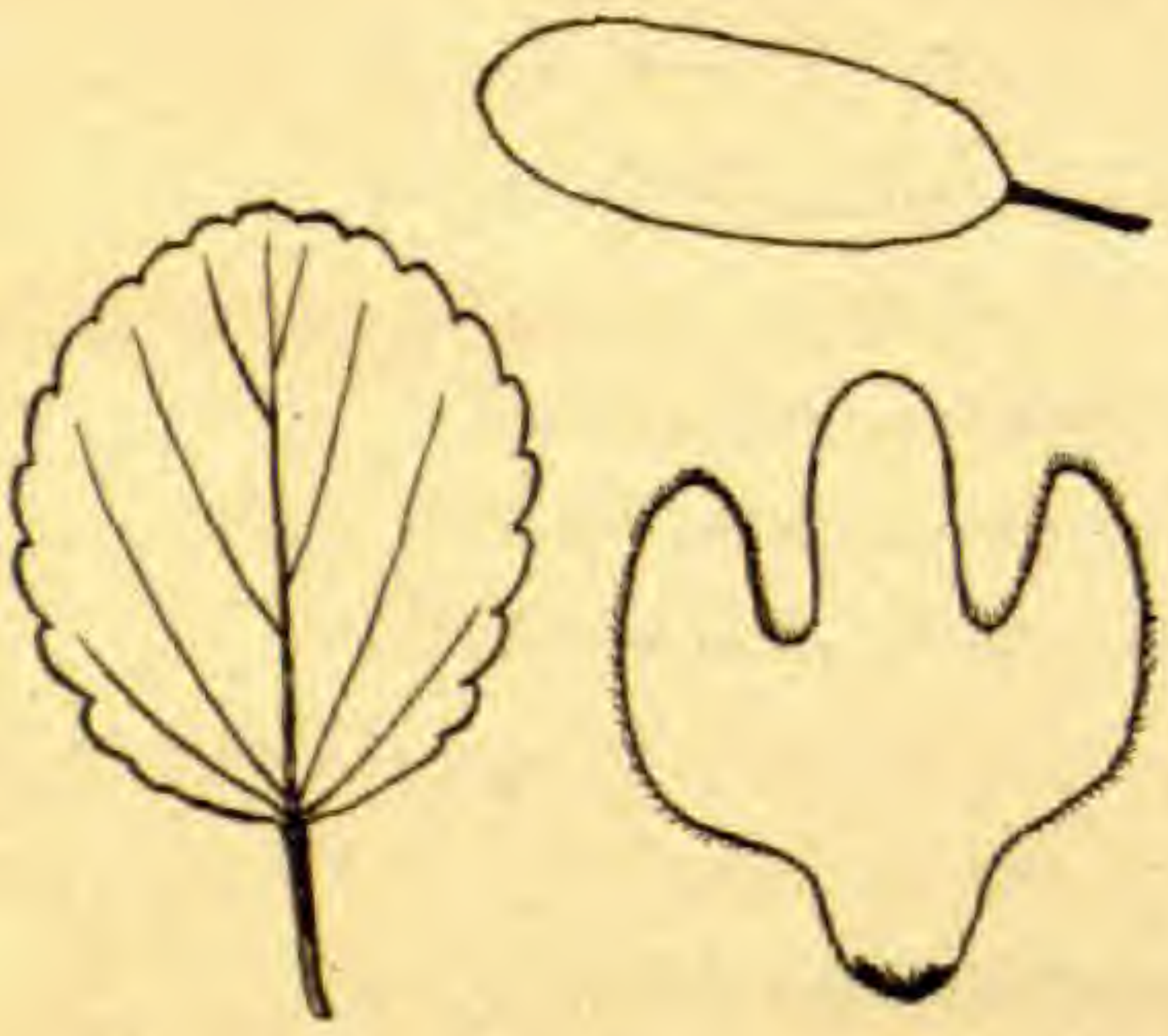

FIGURE 1. *Betula glandulosa* Michx. From *F. E. & E. S. Clements 315*, Ruxton Park, Colorado.

FIGURE 2. *Betula glandulifera* (Regel) Butler. From *B. T. Butler 305*, Rost Lake, Montana.

2. **Betula glandulifera** (Regel) sp. nov.

Betula pumila glandulifera Regel, Bull. Soc. Nat. Moscou **38**: 410. 1865.

A low shrub 1–2 m. high; branchlets very slender, reddish brown, shining, slightly glandular-resiniferous with long coarse scattered hairs, never pubescent, becoming smooth and gray; leaf-blades 2–5 cm. long, 1–3.5 cm. wide, obovate to suborbicular, with mostly acute, sometimes obtuse or rounded apex and cuneate base, often ovate on young shoots, smooth, thick, shining, dark green, serrate to crenate-serrate, often doubly serrate, with broadly triangular teeth 2–5 mm. broad at the base, strongly reticulated, hairy on basal margin and along veins beneath when young, sometimes pubescent on young shoots, thickly covered beneath with minute resin-dots; petioles 3–8 mm. long; fruiting aments 1.5–2 cm. long, 3–5 mm. thick, erect, cylindrical; bractlets puberulent, lobes about equal in width, the middle obtuse or truncate, longer than the ascending or slightly spreading rounded lateral ones; samara wings much narrower than the oval or ovate nutlet. [FIGURE 2.]

This species is distinguished by the coarse hairs upon the slightly resinous branchlets and the obovate, coarsely toothed leaves, which are strongly resin-dotted beneath. It is more closely related to several other forms than to *Betula pumila*, an eastern species not reaching the Rocky Mountain region, of which it has been considered a variety. It ranges from Oregon and British Columbia eastward to Michigan and Western Ontario. The specimens from the Middle West have bractlets with somewhat narrower lobes.

3. **Betula Hornei** sp. nov.

A shrub 1–2 m. high, glabrous; twigs and branchlets dark purplish-brown, glandular-resiniferous; older stems with thin gray easily removed coating; leaf-blades up to 4 cm. long and nearly or quite as wide, thick, dark bronze-green, yellowish below, broadly rhombic or ovate, with acute or obtuse apex and cordate or subcuneate base, sometimes lobed, irregularly crenate-serrate, often doubly serrate, with mostly coarse teeth, strongly reticulated, with 4 or 5 pairs of veins impressed above and conspicuous below, resin-dotted; petioles purple-tinged, 10–15 mm. long, glabrous; fruiting aments about 15 mm. long, 8–10 mm. thick, oval, glabrous, the stalk about 10 mm. long; bractlets about 5 mm. long and 4 mm. wide, lobes about equal in width, the middle lobe obtuse, the lateral obliquely ovate or rhombic, acute above, ascending, glabrous; samara about 3 mm. wide and as long; nutlet obovate with cuneate base, wing narrower than nutlet. [FIGURE 3.]

Type collected by W. T. Horne at Karluk, Alaska, in August, 1902, and reported as rare. Gorman's *no. 1195*, collected at White River, Yukon Territory, near timber line, is probably the same.

This is closely related to *Betula glandulosa* and *B. fontinalis*, differing from both in its fruit and leaves and from the latter also in habit of growth. Type in the herbarium of the N. Y. Botanical Garden.

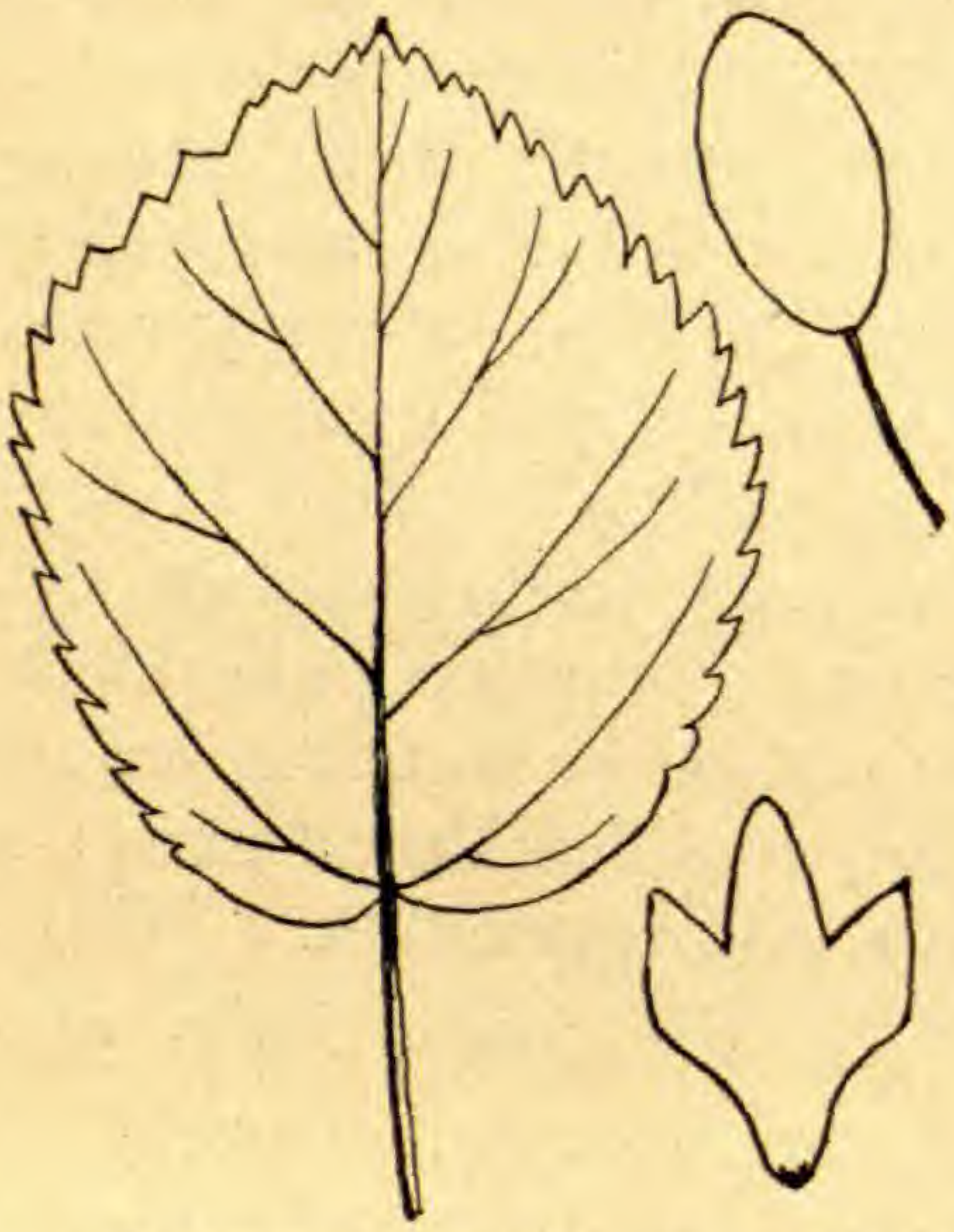

FIGURE 3. *Betula Hornei* Butler. From type, *W. T. Horne*, Karluk, Alaska.

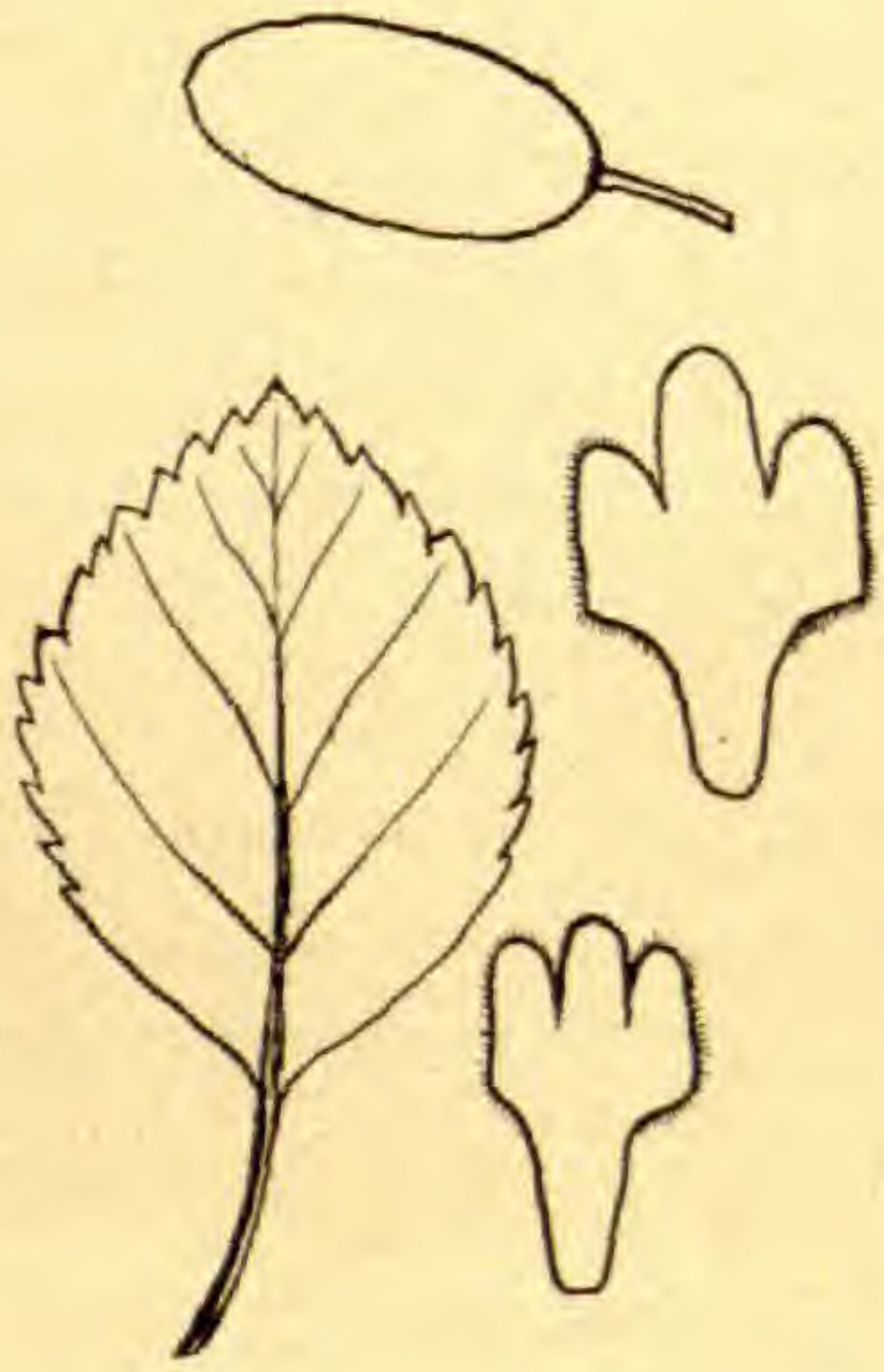

FIGURE 4. *Betula Elrodiana* Butler. From type, *B. T. Butler 309*, near Rost Lake, Montana.

4. **Betula Elrodiana** sp. nov.

A low shrub; stems glabrous, shining, red-brown or dull gray; twigs and branchlets slender, red-brown or gray, pubescent, sparingly glandular-resiniferous, becoming glabrous; leaf-blades 1–3 cm. long, 1–2 cm. wide, oval or rhombic, rarely ovate or obovate, often suborbicular, with acute, sometimes obtuse apex, and rounded, obtuse, or cuneate, and entire base, crenate-serrate with ovate teeth 1–4 mm. wide at the base, shining dark-green above, reticulated, dull green beneath, glabrous except for a few hairs on the basal margin and along the venation above and beneath, venation not conspicuous, 3–5 pairs of veins; petioles pubescent, pale brown or green, 5–10 mm. long; fruiting ament 10–15 mm. long, 6–8 mm. thick, cylindrical or oval on a slender stalk 3–8 mm. long; bractlet puberulent and ciliate, 3–5 mm. long, about 3 mm. wide, claw long, cuneate, lobes rounded, about equal in width, the middle usually but a little longer than the ascending lateral ones; samara 3–4 mm. wide, the wings much wider than the narrowly oval nutlet. [FIGURE 4.]

Type, *B. T. Butler 309*, from a swamp near Rost Lake, Montana, — in herbarium of the N. Y. Botanical Garden.

This has been determined as *Betula pumila*, from which it differs in having less pubescent, more or less glandular branchlets; nearly glabrous, never pubescent, oval leaves; bractlets differing in size and form; and in the broadly winged samaras. It is abundant in the type locality, forming small clumps about the swampy borders of small ponds and lakes in the eastern Flathead Valley.

It is with pleasure that the name of Dr. Morton J. Elrod, well known in connection with the natural history of the Flathead region of Montana, is given to this distinct species.

5. **Betula obovata** sp. nov.

A rather coarse shrub with rough dull gray bark and very small inconspicuous lenticels; branchlets slender, puberulent, but not hairy excepting a few scattered long hairs occasionally on young shoots, sparingly glandular-resiniferous, red-brown, becoming gray; leaf-blades 2–4 cm. long, 1.5–3.5 cm. wide, thick, firm, dark, shining and reticulated above, paler and dull green beneath, obovate, serrate or crenate-serrate with irregular teeth 1–4 mm. wide, apex rounded, base cuneate, venation coarse and conspicuous, veins 5 or 6 pairs, surface pubescent beneath especially along midrib and veins, often with longer scattered hairs on basal margin and along midrib, minute resin-dots beneath; petioles reddish brown, pubescent or with coarse hairs, 5–10 mm. long; fruiting ament cylindrical or oval, obtuse at each end, 2–2.5 cm. long, 6–8 mm. thick, stalk 6–8 mm. long; bractlets puberulent, ciliate, 3–5 mm. long, 2–3 mm. wide, middle lobe long-ovate or triangular, obtuse or subacute, lateral lobes obliquely rhombic or ovate, acute or subacute; samara 3–5 mm. wide, wing as broad as or mostly broader than the oval or obovate nutlet. [FIGURE 5.]

Type, *B. T. Butler 317*, valley of the Jocko River, Ravalli, Montana, — in herbarium of the N. Y. Botanical Garden.

This species is distinguished by its dark, shining, obovate, coarsely serrate leaves, rounded at the apex, and the broad-winged samaras. The fruit resembles that of *Betula fontinalis*, while the leaves and branchlets resemble those of *B. glandulifera*. The latter has leaves mostly acute at the apex and the branchlets are more resinous and more hairy. In *B. obovata* the branchlets are mostly glabrous with occasionally a very few coarse hairs.

6. BETULA HALLII Howell, Fl. N. W. America **1**: 614. 1902

A shrub 1–3.5 m. high with ashy gray branchlets; twigs finely pubescent to velvety-pubescent, sparingly glandular-resiniferous; leaf-blades about 4 cm. long and 2.5 cm. wide, obovate, with rounded apex and cuneate base, crenate to crenate-serrate with fine teeth, green and glabrous on both sides, with very numerous minute resin-dots beneath; petioles short, sometimes with a few scattered hairs; fruiting aments about 4 cm. long and 5–6 mm. thick, very slender; bractlets about 4 mm. long and 3 mm. wide, glabrous, the lobes narrow, obtuse or truncate, usually of about equal length and width; samara 1–2 mm. wide, wing narrower than the oval or obovate nutlet. [FIGURE 6.]

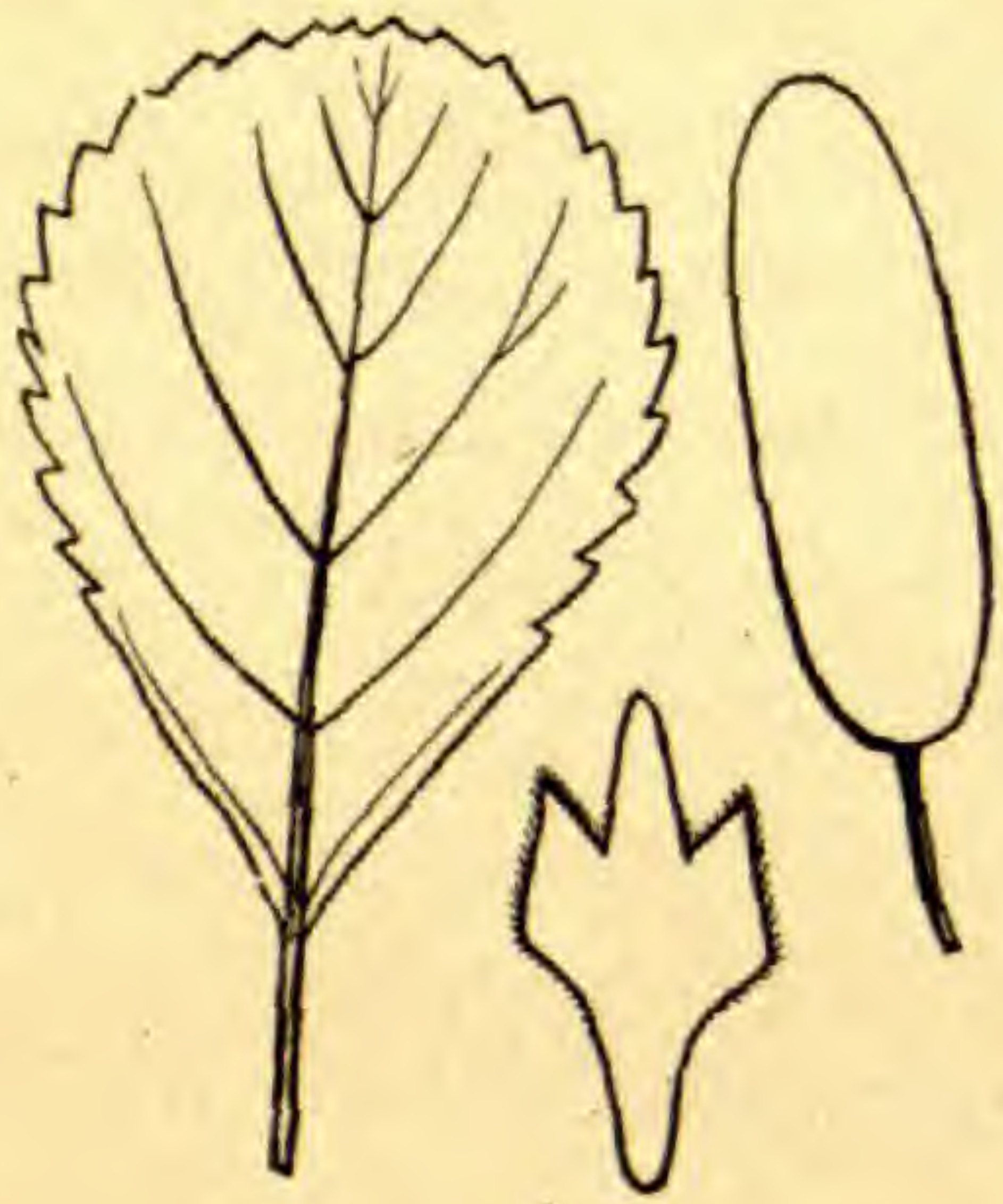

FIGURE 5. *Betula obovata* Butler. From type, *B. T. Butler 317*, Ravalli, Montana.

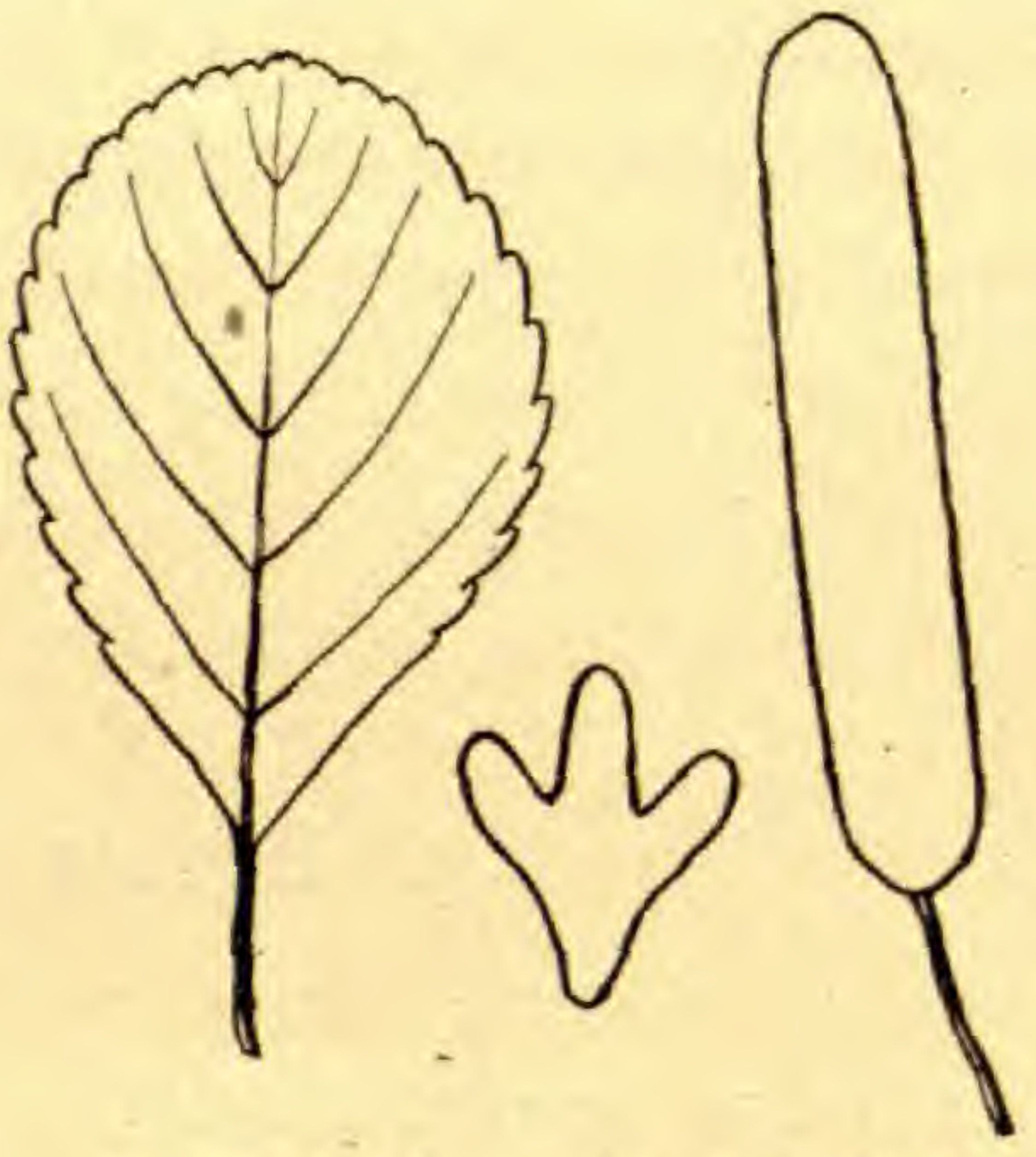

FIGURE 6. *Betula Hallii* Howell. From *E. Hall 469*, Lake Labish, Oregon.

The above description is based on Elihu Hall's *469* from Lake Labish, Marion Co., Oregon. Howell cites the above locality but gives no herbarium number. One would infer that the above number of Hall's would be at least a cotype. Howell describes the leaves as finely serrate but in all specimens I have examined they are more nearly crenate. H. Winkler in Das Pflanzenreich, 4^{61}: 72. 1904, gives the above number as *Betula pumila setarioides* Winkler.

It is distinguished by the long slender fruiting aments; glabrous, mostly finely crenate leaves; and pubescent, glandular-resiniferous branchlets. The samaras are like those of *Betula pumila* and *B. glandulifera* in being narrow-winged but the elongated fruiting aments and finely crenate glabrous leaves at once distinguish it from these species. It ranges from Oregon northward to Alaska and Yukon Territory.

7. **Betula crenata** Rydb. Ms., sp. nov.

A shrub 2.5–4.5 m. high, with dark brown or nearly black bark, branches only sparingly glandular-resiniferous, puberulent or glabrous and reddish at first; leaf-blades 1–3 cm. long, 8–20 mm. wide, slightly pubescent at first, resinous, glabrous when older, oval or elliptical, acute at both ends, crenate or crenate-serrate with very small teeth, shining dark green and reticulate-veined above, with 4 or 5 pairs of very delicate and inconspicuous veins, yellowish green beneath with minute resin-dots; petioles 5–10 mm. long; fruiting aments 12–18 mm. long, about 6 mm. thick, cylindrical; bractlets glabrous, about 4 mm. long and 3 mm. wide, middle lobe short-oblong or elliptic, obtuse or rounded at the apex, lateral lobes ascending, obliquely ovate or rhombic, obtuse; samara about 2 mm. wide, wings as wide as or narrower than the nutlet. [FIGURE 7.]

FIGURE 7. *Betula crenata* Rydb. From type, *D. T. MacDougal 665*, near Rost Lake, Montana.

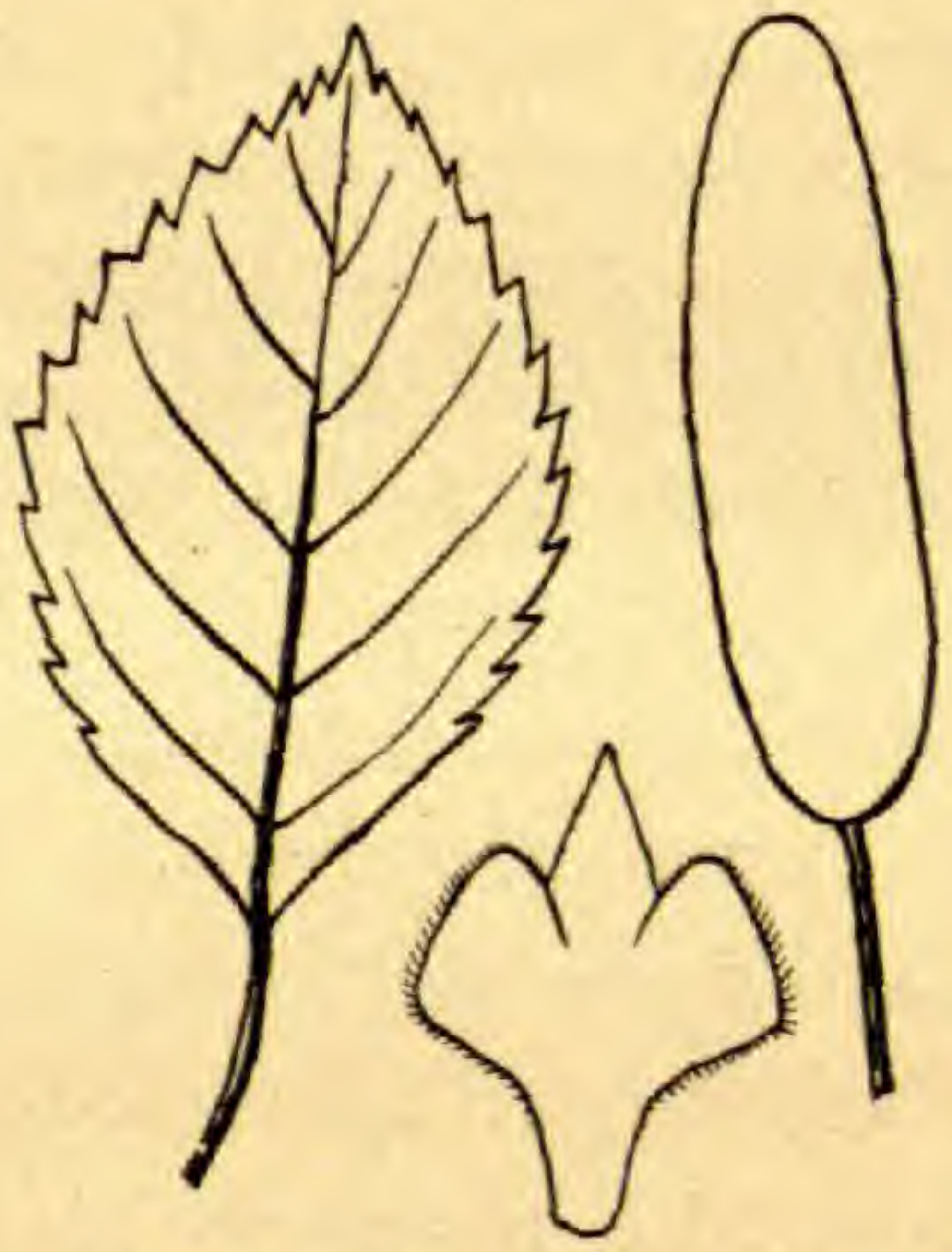

FIGURE 8. *Betula Sandbergi* Britton. From *B. T. Butler 365*, near Rost Lake Montana.

The species is distinguished by the glabrous oval or elliptical finely crenate leaves and the narrow-winged samara. It resembles *Betula Elrodiana* in size and outline of the leaf but the coarse serrate teeth of the latter readily separate the two. The type is D. T. MacDougal's *665*, collected near Rost Lake, Montana, and is apparently rare.

8. BETULA SANDBERGI Britton, Bull. Torrey Club **31**: 166. 1904

A shrub or shrub-like tree with dark reddish-brown bark, not separable into layers; lenticels not conspicuous; branchlets finely pubescent but not glandular-resiniferous, coarse, greenish, becoming gray and red-brown, covered with a bluish bloom; leaf-blades up to 6 cm. long in the type specimen, 3–4 cm. in the Rocky Mountain form and 12–22 mm. wide, thick, firm, dull bronze-green above, paler and sparsely hairy beneath, slightly resinous, rhombic-ovate or oval, acute at both ends, margins somewhat thickened, coarsely and irregularly serrate or dentate, veins 4 or 5 pairs; fruiting aments 2–3 cm. long, slender-stalked; bractlets about 4 mm. long, nearly as wide, pubescent, middle lobe mostly triangular, obtuse or acute, longer than the ascending, rounded, lateral ones; samara 3–5 mm. wide, wings broader than the more or less puberulent nutlet. [FIGURE 8.]

This small tree-like birch is readily distinguished by its coarse thick rhombic leaves and pubescent, often glabrous, but not glandular-resiniferous branchlets. It frequents swampy places and resembles *Betula fontinalis* in habit and growth but is readily distinguished from that species by the leaves and branchlets. The leaves are larger and more coarsely toothed than those of *B. Elrodiana*, the bractlets and fruiting aments are quite different, and the latter remains a low shrub, not assuming a tree-like form.

The type locality is Hennepin Co., Minnesota. It has been found in Saskatchewan and in Montana, being apparently rare.

9. BETULA FONTINALIS Sarg. Bot. Gaz. **31**: 239. 1901

Shrub-like, forming clumps similar to those of some of the willows and reaching from four to eight meters in height, often assuming tree-like proportions; bark smooth, shining dark reddish-brown or bronze with pale conspicuous lenticels, not separable into layers or peeling on the surface; branchlets densely glandular-resiniferous, slender, graceful, somewhat pendulous; leaf-blades 2–4 cm. long and nearly or quite as wide, often larger on sturdy young shoots, broadly ovate to suborbicular, with acute apex and mostly rounded base, sharply and often doubly serrate, thin, firm, bright green, resinous, with 3–5 pairs of slender veins; fruiting aments 2–3 cm. long, 5–10 mm. thick; bractlets pubescent, ciliate, middle lobe acute, narrowly triangular, much longer than the ascending, acute, obliquely rhombic lateral ones; samara wings much wider than the ovate or obovate puberulous nutlet. [FIGURE 9.]

This is one of the most common birches of the West, being found throughout the Rocky Mountain region and readily distinguished by its densely resinous slender branchlets, its smooth, shining reddish bark and small broadly ovate acute shining leaves. It is often called cherry birch and has been confused with *Betula occidentalis* through a mistake of Hooker's (Fl. Bor.-Am. **2**: 155) in confusing the large western tree form with this, which is usually small and shrub-like, forming clumps like willows along streams. Sargent's explanation (Bot. Gaz. **31**: 239) is doubtless correct and his name for the species very aptly chosen.

10. BETULA KENAICA Evans, Bot. Gaz. **27**: 481. 1899

A tree up to 13 m. in height with thin dark brown bark separable into layers; twigs glandular-resiniferous, though not densely so, red-brown and shining; leaf-blades about 6 cm. long, nearly as wide, ovate, slightly hairy when young, soon becoming glabrous, dull dark green above, paler beneath, acute at apex, obtuse or nearly truncate at base, sharply, coarsely, and irregularly serrate,

FIGURE 9. *Betula fontinalis* Sarg. From *B. T. Butler 327*, near Helena, Montana.

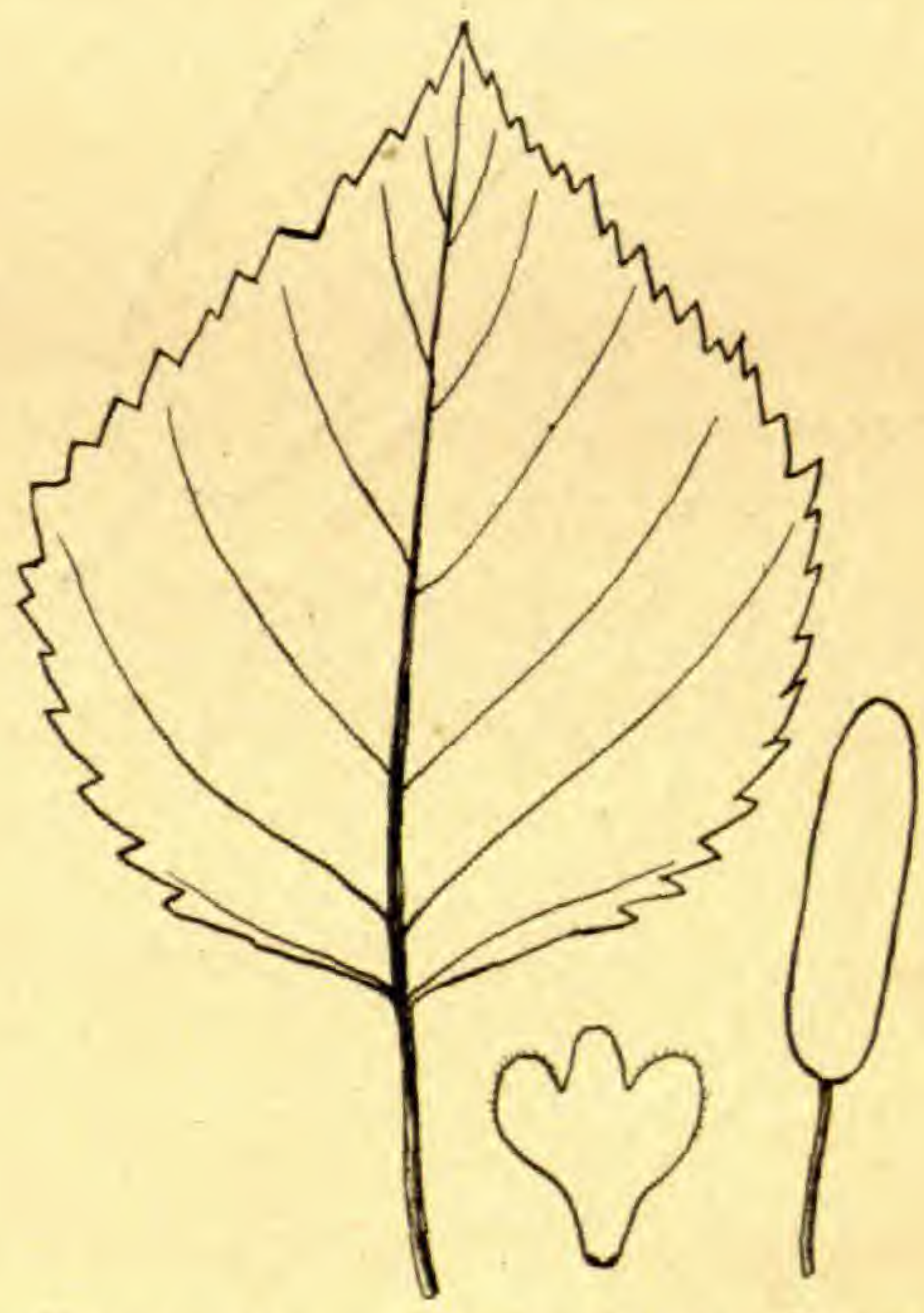

FIGURE 10. *Betula kenaica* Evans. From *C. V. Piper 4480*, Kenai, Alaska.

with abruptly tipped teeth, veins 4 or 5 pairs; petioles 15–25 mm. long; fruiting aments about 2 cm. long, 5 mm. thick; bractlets about 3 mm. long, ciliate, the middle lobe rounded, slightly narrower and as long as or but slightly longer than the erect rounded lateral ones; samara wings about as wide as the small oblong nutlet. [FIGURE 10.]

This is an Alaskan species found along the northwestern coast and locally known as red or black birch. It resembles *B. fontinalis* but has larger, more coarsely serrate leaves, less resiniferous branchlets, separable bark, and entirely different fruiting aments and bractlets.

11. BETULA UTAHENSIS Britton, Bull. Torrey Club **31**: 165. 1904

A small tree with dark yellowish-brown or bronze bark, not separable into layers, lenticels pale gray and rough; twigs and branchlets slender, more or less densely glandular-resiniferous, greenish- or reddish-brown, becoming very dark brown or gray,

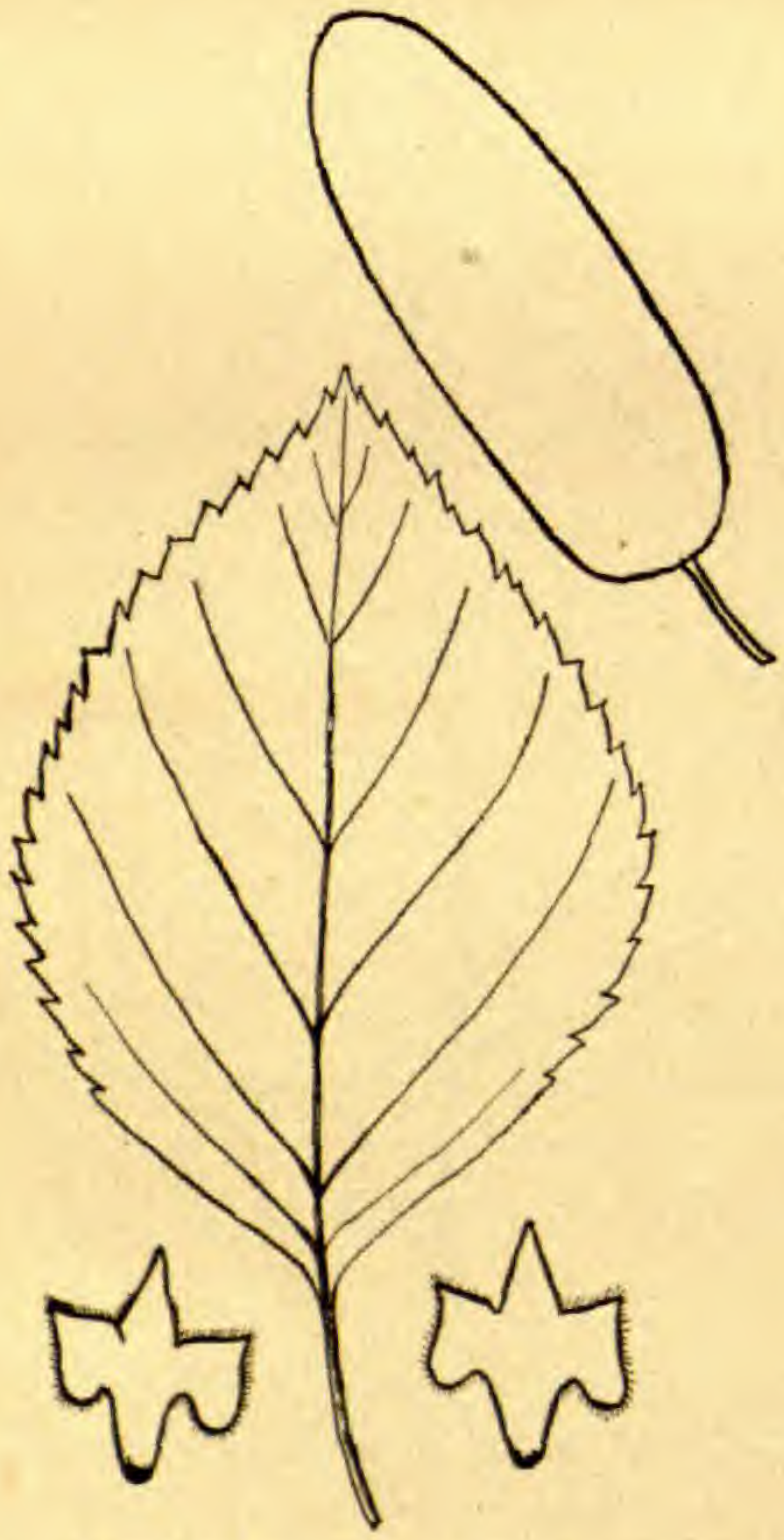

FIGURE 11. *Betula utahensis* Britton. From type, *S. G. Stokes*, City Creek Canyon, Salt Lake City, Utah.

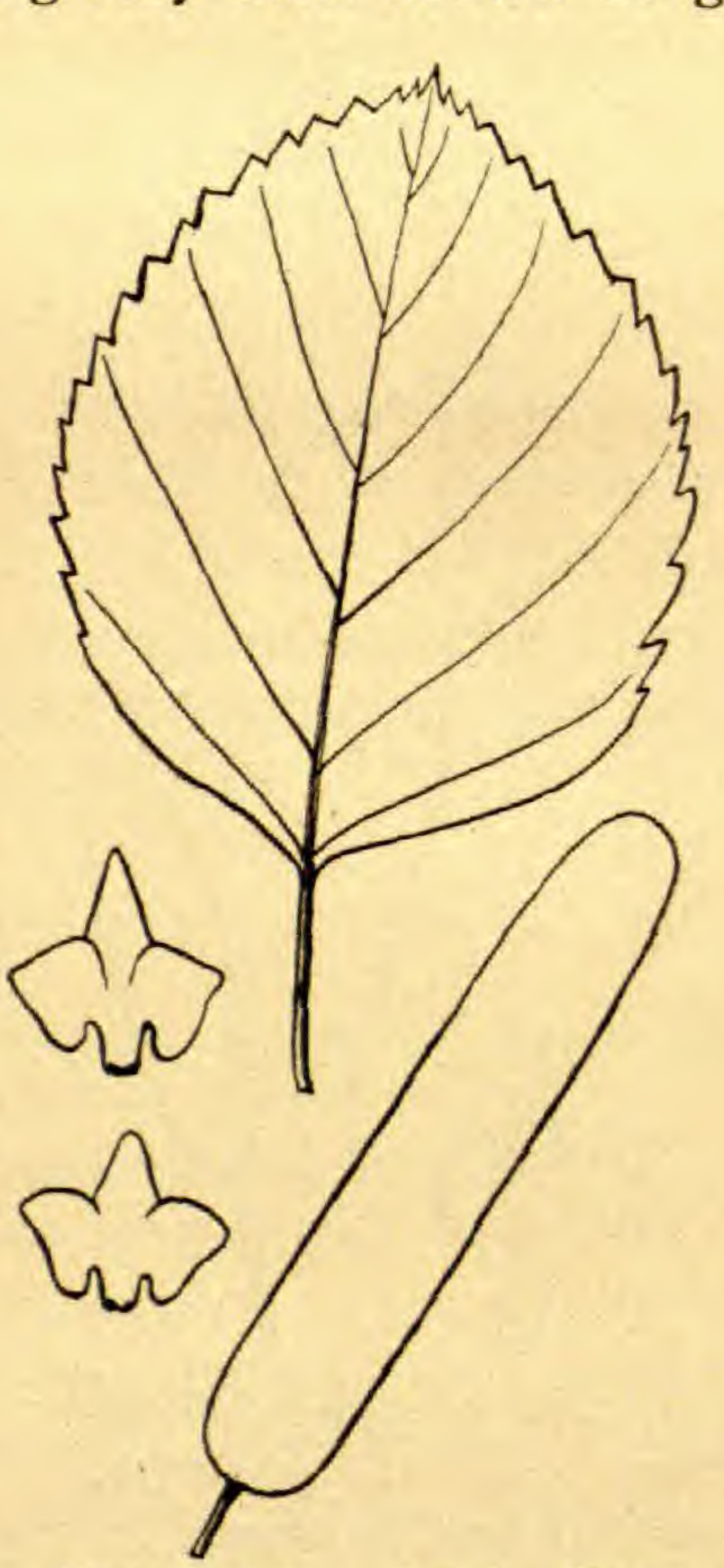

FIGURE 12. *Betula Piperi* Britton. From type, *C. V. Piper 3527*, near Pullman, Washington.

often with a few scattered hairs; leaf-blades 3–6 cm. long, broadly ovate to suborbicular, with acute apex and rounded to cuneate base, sharply dentate with abruptly tipped teeth, hairy at first, becoming glabrous except along veins beneath and on basal margin, veins 5 or 6 pairs; fruiting aments cylindrical, stout, 3–4 cm. long, 8–12 mm. thick; bractlets 4–5 mm. long, nearly as wide, the middle lobe triangular, acute or obtuse, the lateral lobes obliquely ovate or rhombic, acute, widely spreading, distinctly auricled at the base; samara wings broader than the oval or obovate nutlet. [FIGURE 11.]

The bractlets resemble those of *Betula Piperi*, differing in the more rhombic acute lateral lobes, which are more spreading and broadest at the base, the claw being much longer. The leaves resemble those of *B. fontinalis* but are larger, thicker and more cuneate. The species occurs in the Flathead region, Montana, but with this exception is not known outside of the type locality near Salt Lake City, Utah.

12. BETULA PIPERI Britton, Bull. Torrey Club **31**: 165. 1904

A tree up to 15 m. high, with slender, graceful, drooping branches; bark dark brown, not separable into layers, lenticels nearly white; twigs very delicate, slender, greenish brown and glandular-resiniferous, becoming nearly black; leaf-blades 5–6 cm. long and 4–5 cm. wide, ovate or oval, often somewhat lobed, very thin, dark rich green, shining above, very pale and whitish beneath, coarsely, sharply, and irregularly serrate, pubescent at first, becoming glabrous, apex acute, base mostly cuneate; fruiting aments slender, narrowly cylindrical, 3–5 cm. long, about 8 mm. thick; bractlets puberulent and ciliate, the lateral lobes widely spreading, rounded, obliquely ovate, distinctly auricled, the middle lobe triangular, acute or obtuse, the claw very short, cuneate, about equaling the lateral lobes; samara wings usually not wider than the nutlet. [FIGURE 12.]

The type is *no. 3527* of C. V. Piper, collected near Pullman, Washington. I have found several sterile specimens along the Kootenai River in northwestern Montana and also in the Flathead region. The name black birch is aptly applied to it, this color, with the very thin coarsely toothed leaves and the slender fruiting aments with their characteristic auricled, short-clawed bractlets, making it very distinct. It ranges from Oregon and Washington to western Montana.

13. BETULA ALASKANA Sarg. Bot. Gaz. **31**: 236. 1901

A tree reaching a height of 26 m. with bark varying from nearly white to brown, separating more or less freely into layers; branchlets densely glandular-resiniferous; leaf-blades 4–8 cm. long and nearly as wide, triangular-ovate or deltoid, with long acuminate apex and truncate base, coarsely serrate with abruptly pointed teeth, dull dark green above, paler beneath, somewhat hairy when young; petioles 15–30 mm. long, slender; fruiting aments 3–3.5 cm. long, 8–12 mm. thick; bractlets glabrous or puberulous, sometimes ciliate, lateral lobes spreading, wider but scarcely longer than the narrow, triangular, acute middle one; samara wings broader than the small oval nutlet. [FIGURE 13.]

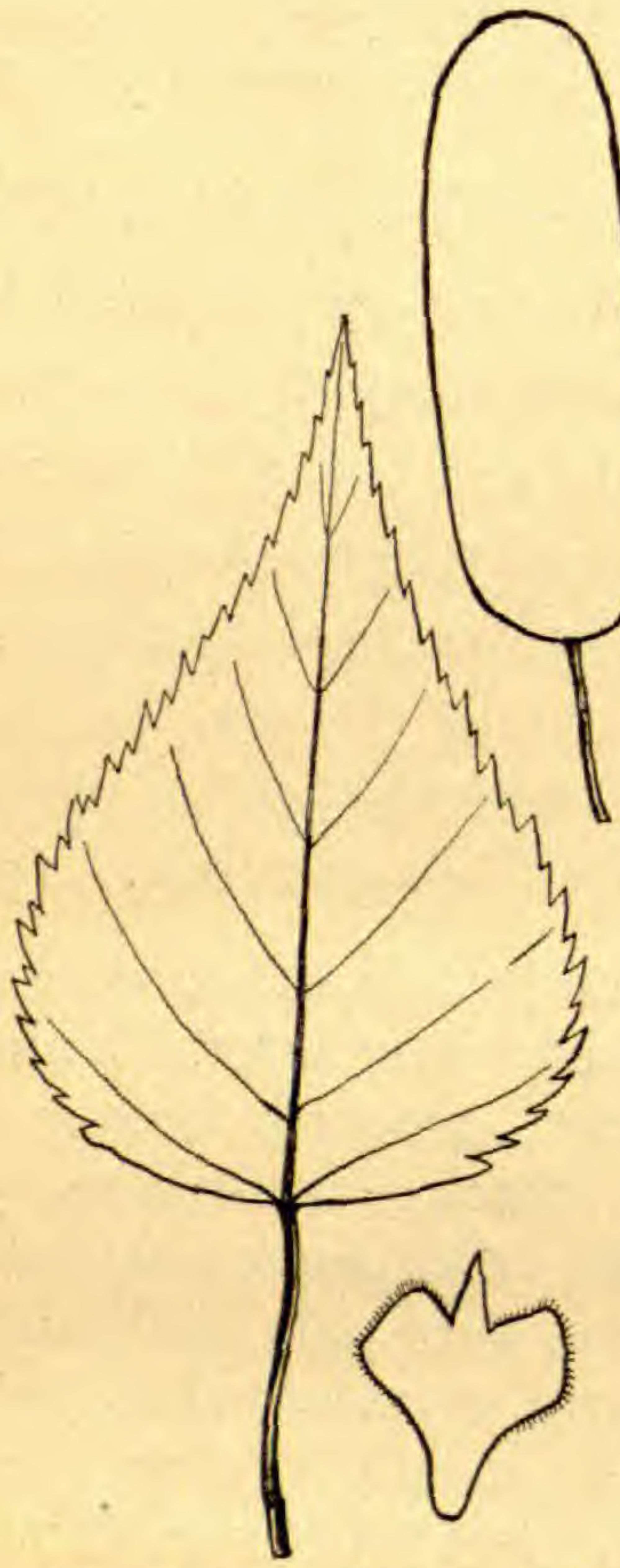

FIGURE 13. *Betula alaskana* Sarg. From *J. B. Tarleton 138*, Fort Selkirk, Yukon Territory.

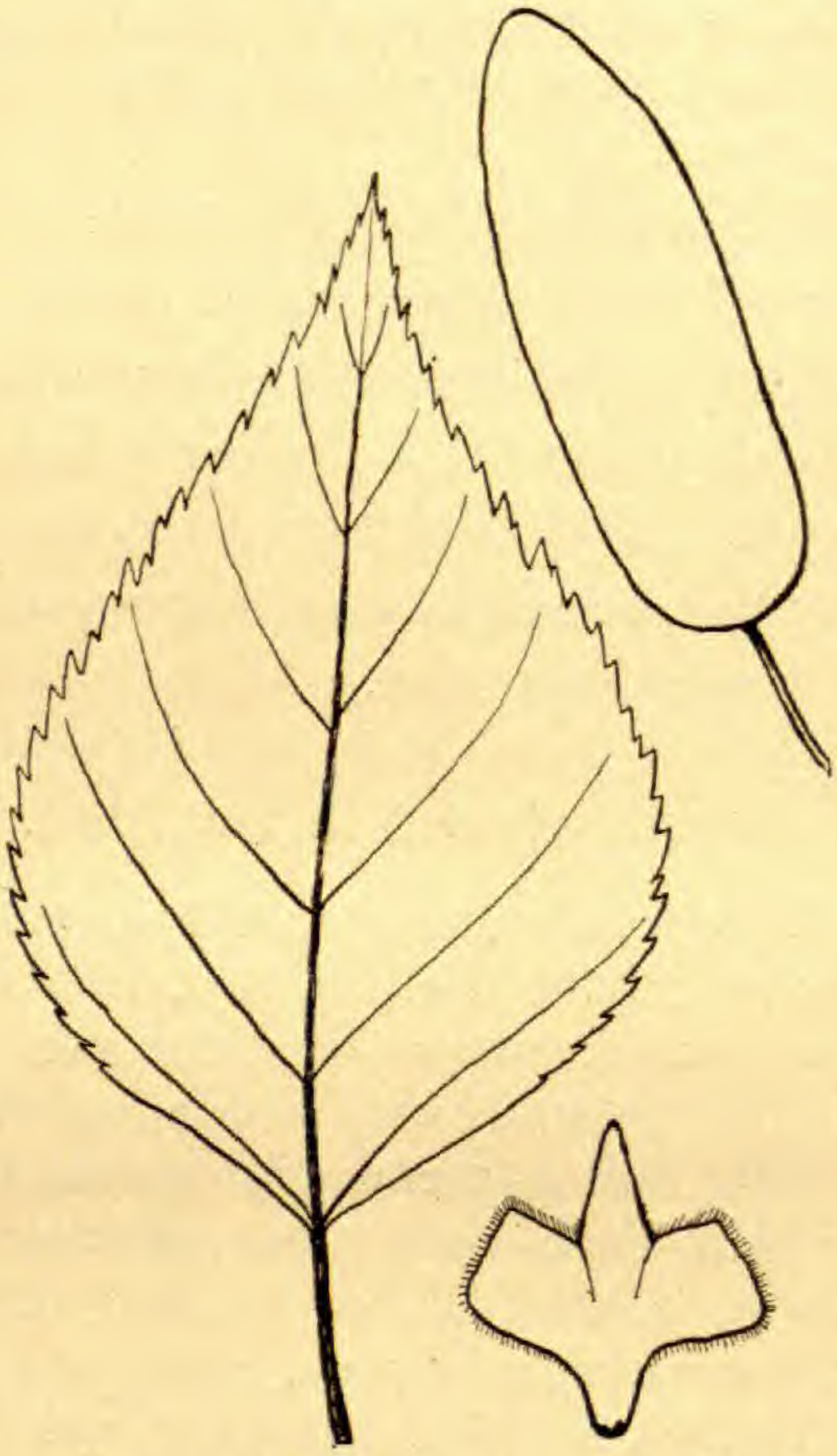

FIGURE 14. *Betula papyrifera* Marsh. From *B. T. Butler 322*, Big Fork, Montana.

This species is distinguished by the very long-pointed leaves and densely resinous branchlets. All the specimens I have seen have dark brown bark not readily separating into layers and have a very thin superficial outer layer. It is found from the Saskatchewan Valley to the Yukon, being common in the Yukon Basin.

14. BETULA PAPYRIFERA Marsh. Arbust. Am. 19. 1785

B. papyracea Ait. Hort. Kew. **3**: 337. 1789.
B. alba var. or subsp. of Regel and others.

A forest tree 15 to 25 m. high with slender, graceful branches and smooth chalky white bark with large conspicuous brown or yellow lenticels, easily separated into thin paper-like layers, peeling naturally upon the tree into narrow horizontal plates, the exposed red or orange-brown inner bark making a striking contrast to the white, the bark near the base of the tree thicker and rough, nearly black and irregularly furrowed; branchlets more or less pubescent, densely so on vigorous young shoots in the western forms, but not usually resinous-dotted, greenish or light brown at first with paler lenticels, becoming dark shining brown, sparingly hairy or glabrous; leaf-blades 4–8 cm. long, 2–5 cm. wide (or more on vigorous young shoots), narrowly ovate to oval, with acute or acuminate apex, and rounded or cuneate, sometimes truncate, often oblique base, finely or coarsely serrate, sometimes slightly lobed, hairy when young, becoming glabrous, dull bronze-green, mostly free from resin-dots; fruiting aments 2–5 cm. long on slender resinous stalks; bractlets about 5 mm. long, middle lobe narrow, elongated, rounded, lateral lobes more or less ciliated, obliquely rhombic, acute or obtuse, claw short, cuneate; wings of samara broader than nutlet. [FIGURE 14.]

The leaves of the eastern forms of this species are usually densely resin-dotted, the bractlets are mostly glabrous and the bark peels very readily into thin papery layers. The western form usually differs in these respects, the bark often remaining close and firm, peeling only with difficulty and then into small scale-like plates. Nelson describes one of the western forms from Colorado (Bot. Gaz. **43**: 279. 1907) and proposes the name *Betula Andrewsi* should it prove distinct from those of the East. I do not think there is sufficient ground for separating the two. I would not include, however, all the western forms heretofore known as *B. papyrifera*, at least three distinct species having been included under this name, *B. papyrifera* proper, *B. occidentalis*, and *B. subcordata*. The last two are more common in the Rocky Mountain region, *B. papyrifera* being rare and, so far as known, not found west of the Bitter Root Mountains. It ranges from western Montana and Alberta to Colorado and eastward across the continent.

15. **Betula subcordata** Rydb. Ms., sp. nov.

A small tree with silvery gray purple-tinged bark with nearly black lenticels 1–4 cm. long, inner bark pale purple-brown to dark brown, separating with difficulty into shreds but not into sheets, outer bark very thin and semi-transparent, peeling into flakes, the old bark much roughened by peeling into shreds displaying the purplish inner layers; branchlets red-brown, glabrous or slightly puberulent, often covered with a bluish glaucous bloom, becoming brown or gray, usually shining red-brown, with very small, pale conspicuous lenticels and very rarely with minute resinous glands, the older branches red-brown, shining, the lenticels pale, numerous and conspicuous; leaf-blades ovate, 5–10 cm. long, 4–8 cm. wide, with acute apex and rounded to cordate base, thick, dull, bronze-green above, dull and paler beneath, with 5–7 pairs of prominent pale brown, nearly white veins, glabrous above and below except along veins and midrib, rarely slightly pubescent at the base, finely or coarsely serrate with sharp spreading teeth which are mostly ovate with abruptly pointed tips and 2–4 mm. broad at the base; petioles 1–2.5 cm. long, stout, pubescent at first or glabrous; fruiting ament 3–4 cm. long, 6–10 mm. thick, cylindrical or oblong, its stalk more slender than the leaf-petiole, 1–1.5 cm. long, glabrous or slightly resin-dotted; bractlets 6–8 mm. long, 3–4 mm. wide, finely pubescent and ciliate, middle lobe narrow, acute or obtuse, a little longer than the spreading, obliquely rhombic or

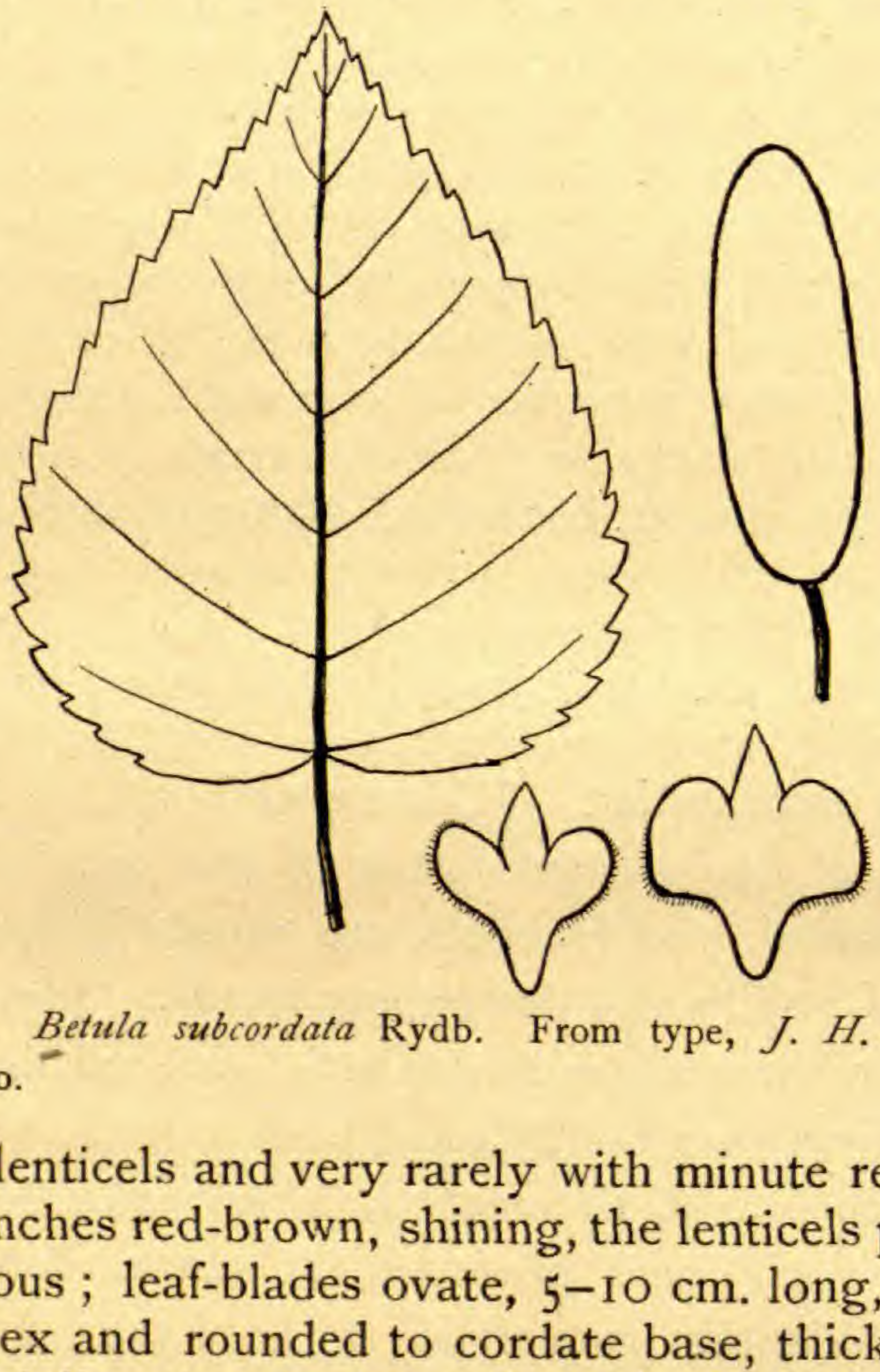

FIGURE 15. *Betula subcordata* Rydb. From type, *J. H. Sandberg 32*, Nez Perces Co., Idaho.

rounded lateral lobes; samara wings mostly broader than the more or less puberulent nutlet. [FIGURE 15.]

The type is J. H. Sandberg's *33* from Hatwai Creek, Nez Perces Co., Idaho. It is common throughout the Rocky Mountains west of the main divide from Idaho and Montana northward into British Columbia and Alberta. It differs from *B. papyrifera* in the color and character of the bark, the form and toothing of the leaves, the character of the bractlets, and in the glabrous branchlets; from *B. occidentalis* in the above characters and also in having thicker dull green leaves. It stands between these species, but is wholly distinct from either. It has also been called *B. cordifolia* Regel, but that species has laciniately cut leaves, which are also larger with usually 8 pairs of veins, slightly lobed, with long-pointed apex and slightly cordate base, petioles and venation hairy, bark white and peeling readily, bractlets quite unlike *B. subcordata* in form and almost glabrous, with lobes all rounded and about equal in width, the middle twice as long as the ascending lateral ones.

16. BETULA OCCIDENTALIS Hook., in part, Fl. Bor.-Am. **2**: 155. 1839

A large tree reaching 40 m. in height in the type locality (the region about Puget Sound); bark yellow-brown, orange, or dark bronze-brown, outer layer very thin and peeling into small curling shreds, inner layers varying from pale tan to dark reddish-brown, separable into layers though often with difficulty and not until old; branchlets usually very glandular-resiniferous, sometimes hairy or puberulent, slender, pale brown, becoming dark, glabrous, and lustrous; leaf-blades 6–10 cm. long, 5–6 cm. wide, ovate, with acute or acuminate apex and truncate or rounded, occasionally subcordate or subcuneate base, furnished with 7 or 8 pairs of coarse brown or yellowish veins, doubly serrate with irregular, very slender, long-pointed teeth, slightly lobed, bright green, glabrous, or puberulent beneath, resinous when young, hairy along the venation beneath with tufts of hairs in the vein-axils; petioles 1–2 cm. long, hairy or puberulent, becoming glabrous; fruiting aments 3–4 cm. long, 10–12 mm. thick, cylindrical or oblong, on stout stalks 12–18 mm. long; bractlets ciliate, 5–6 mm. long, 3–4 mm. wide, broadest at the apex of the widely spreading obliquely ovate or rhombic, rounded, lateral lobes, middle lobe elongated, acute, awl-shaped, claw short, cuneate; nutlet oval, nearly as wide as the wings. [FIGURE 16.]

This birch is distinguished by its thin bright green doubly serrate leaves with fine very slender lanceolate-attenuate teeth, curved toward the apex, by the slender, very resinous branchlets, and by the orange or bronze bark with its curling, shreddy, outer layer. It is common along the Pacific Coast region of Washington and British Columbia, reaching eastward to western Montana, where it is found along the Kootenai River and about the shores of Flathead Lake. It is locally known as yellow birch, black birch, and western birch.

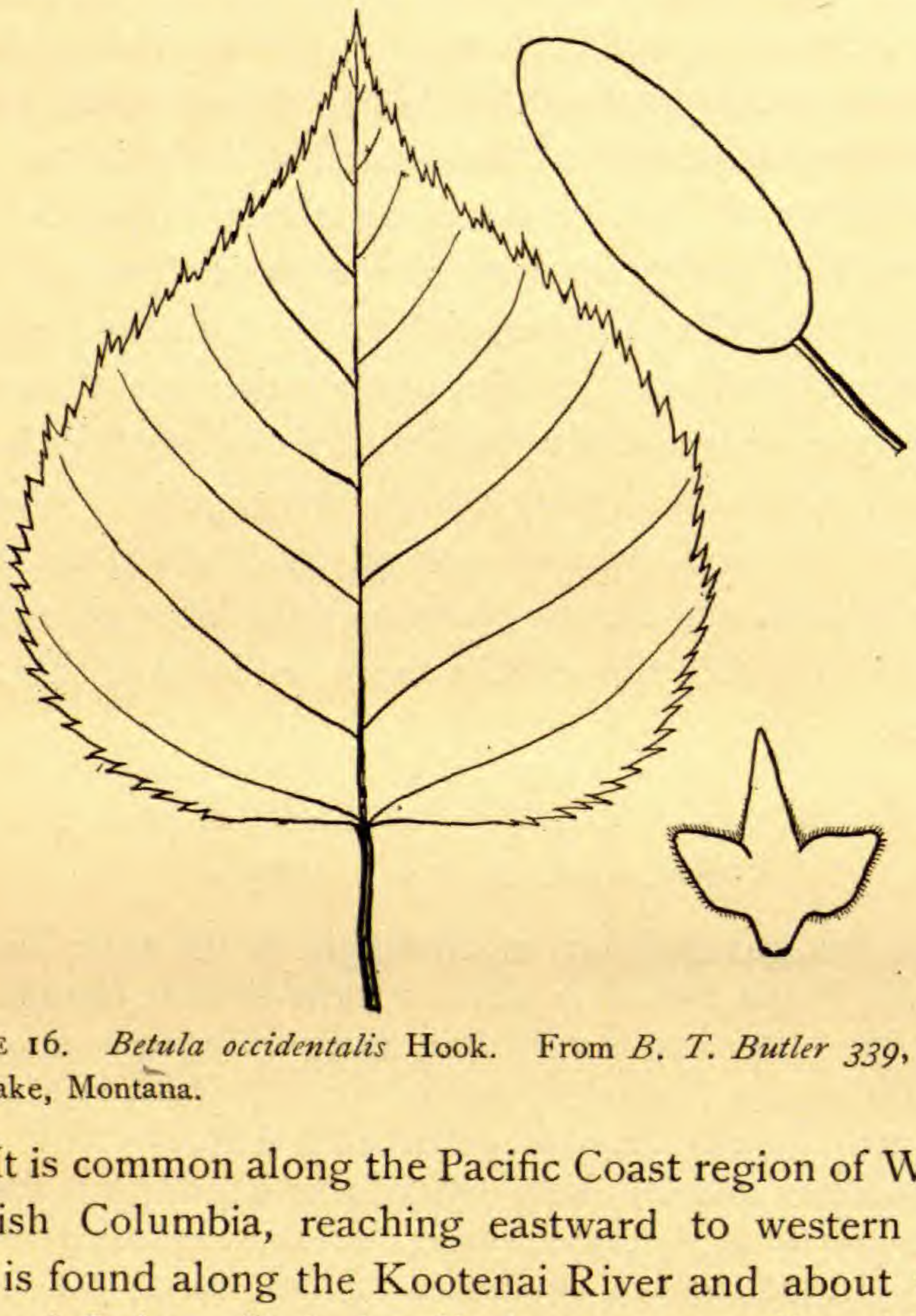

FIGURE 16. *Betula occidentalis* Hook. From *B. T. Butler 339*, Yellow Bay, Flathead Lake, Montana.

17. **Betula montanensis** sp. nov.

A large tree with dark gray or brown bark often mottled with orange or bronze, somewhat roughened but not peeling into shreds or separating into layers, lenticels 2–4 cm. long, inner bark reddish brown, very dark; branchlets red-brown, more or less resinous, becoming ashy gray and much roughed by leaf-scars; leaf-blades 4–6.5 cm. long, 3–5.5 cm. wide, thick and firm, dull bronze-green, glabrous, slightly lobed, ovate, apex acute, base truncate, often subcuneate on young leaves, margins finely serrate with abruptly tipped teeth, veins 6–8 pairs, impressed above, conspicuous and hairy beneath with small tufts of hairs in the axils, lower surface with numerous small resin-dots, the basal margins sometimes hairy; petioles 1–2 cm. long, puberulent, often with a few scattered hairs; fruiting ament 2.5–3.5 cm. long, about 1 cm. thick, cylindrical or narrowly oval, narrowed toward the rounded base and apex, stalks slender, 10–15 mm. long, puberulent and resinous; bractlets puberulent or pubescent, strongly ciliate, 5–7 mm. long, about 3 mm. wide, broadest at the base of the spreading obliquely rhombic, rounded, lateral lobes, middle lobe acute or obtuse, triangular, long and tapering, claw elongated, cuneate; samaras about 4 mm. wide, wings broader than the oval, puberulent nutlet. [FIGURE 17.]

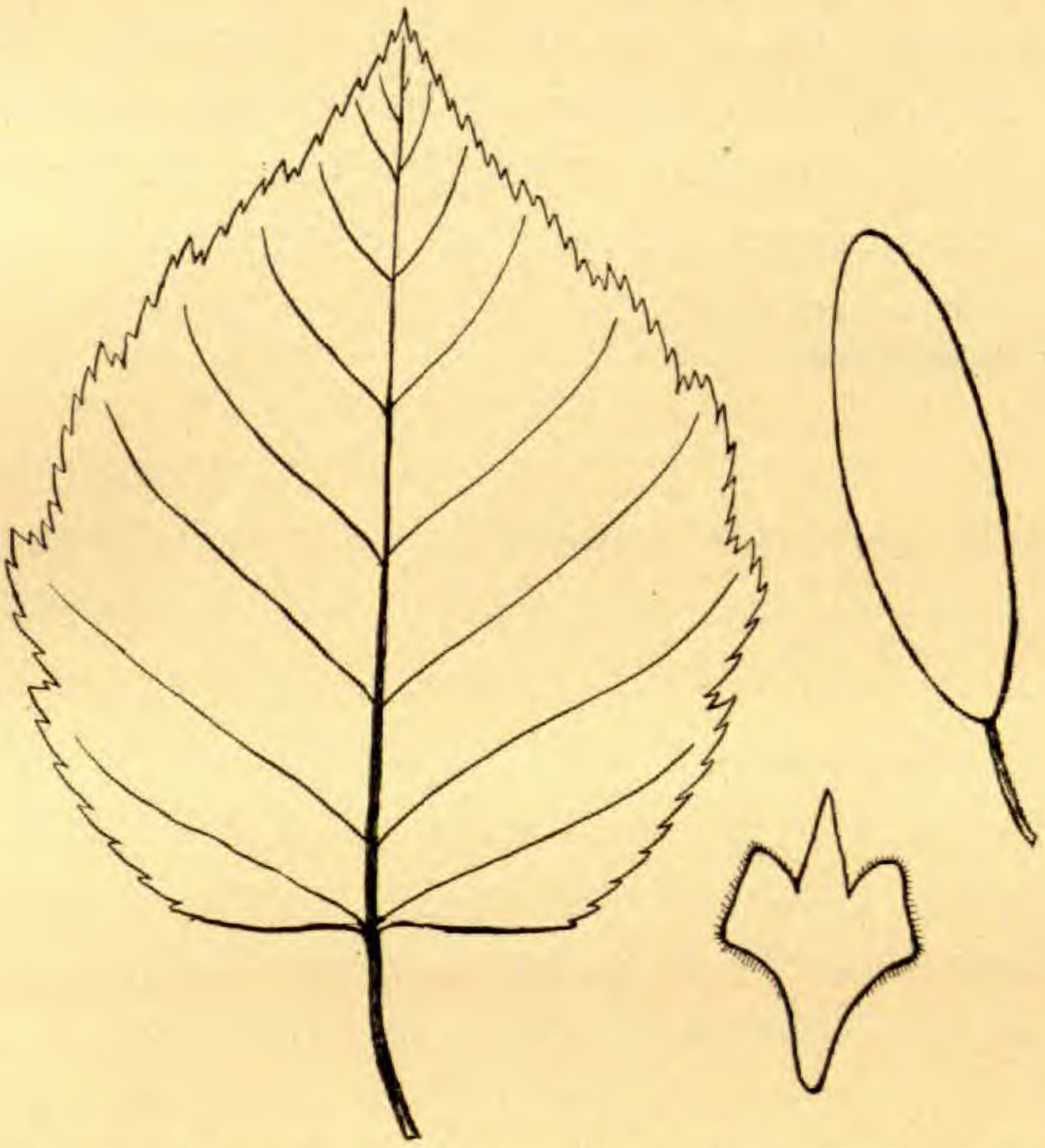

FIGURE 17. *Betula montanensis* Butler. From type, *B. T. Butler 360*, Yellow Bay, Flathead Lake, Montana.

Type, *B. T. Butler 360*, collected at Yellow Bay, eastern shore of Flathead Lake, Montana, and deposited in the herbarium of the N. Y. Botanical Garden.

This is distinguished by its thick dull green somewhat lobed truncate leaves and its non-peeling dark gray bark. In appearance the trunk suggests the alder with its mottled gray and brown slightly roughened bark, which is never shining and smooth as in other birches. In size and shape, the leaves are much like those of *Betula occidentalis* but they are thick and dull and have short teeth. The bark has sometimes the same bronze color but is dull, never peels and is always mottled with gray. The twigs are less resinous, dull, and roughened. The bractlets are also quite different. It may possibly be a hybrid between *Betula occidentalis* and some one of the thick-leaved species. It is apparently not common, being known at present only in the type locality. It is even more distinct in the field than in the herbarium, and not likely to be confused with any other species.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

The ferns and flowering plants of Nantucket—V

EUGENE P. BICKNELL

POLYGONACEAE

RUMEX BRITANNICA L.

Common in wet swamps. In flower and fruit August and September.

RUMEX CRISPUS L.

A common weed; in flower and fruit through summer and autumn.

RUMEX OBTUSIFOLIUS L.

Less common than the preceding, flowering and fruiting at the same seasons.

RUMEX CRISPUS × OBTUSIFOLIUS.

This hybrid is reported in Mrs. Owen's catalogue, on the authority of Mr. Dame, as being quite common at Siasconset. I observed it at a number of places in low-lying grassy fields and lots in and near the town, where it is certainly frequent, if not common. It appears to be quite intermediate in its characters between the two parent species, but is sometimes, at least, sterile or nearly so, although flowering abundantly. Specimens collected agree closely with an example in herb. N. Y. Botanical Garden ex herb. Torrey, labeled as a hybrid by Doctor Engelmann and collected by him at St. Louis, Mo., Aug., 1842.

RUMEX PERSICARIOIDES L.

Occurs sparingly on the shores of Sachacha Pond and more commonly about brackish ponds along the south side of the island; Madequecham, Nobadeer, Miacomet, and Hummock Ponds; Long Pond (*M. L. O.*). In full flower August and September.

RUMEX ACETOSELLA L.

Abundant all over the island, often growing in pure dry sand. In early June, when in full flower, it is one of the conspicuous plants of the season, reddening the fields and plains and damp sandy levels along the shores.

Note. — Mrs. Owen's catalogue includes *Rumex salicifolius* Weinm. and *Rumex verticillatus* L. It has been recently shown by Professor Fernald (Rhodora **10**: 17–20. 1908) that our coastwise dock formerly referred to *R. salicifolius* should properly bear the name *R. pallidus* Bigel. This plant may well occur on Nantucket, although I saw nothing of it. Neither was *R. verticillatus* met with.

POLYGONUM MARITIMUM L.

Somewhat locally common on the coast sands, flowering through August and September.

In damp sand it sometimes flowers abundantly when erect and less than 10 cm. high; vigorous plants on dry white sand spread widely from a deep woody root, the prostrate branches becoming 6 dm. in length.

POLYGONUM AVICULARE L.

Under this name alone it is not possible to report the status of *Polygonum aviculare* on Nantucket with the definiteness proper to a local flora. The name has long been so loosely construed that it fails to convey an unmistakable meaning, nor can it be understood from its use what particular plant of a considerable group is sought to be referred to. Some form of definition is necessary in order to give definite expression to the name. The binomial has here succumbed to the polynomial and we have one of those cases where so-called breadth of treatment in the interpretation of species has served to obscure the facts of nature rather than to make them clear.

The botanical history of the plant furnishes also an excellent example of the futility of multiplying varietal names. Many varietal subdivisions have been proposed under the species, yet, notwithstanding the authentic bases of a number of them, few or none remain in current use.

As I apprehend the problem, the species *Polygonum aviculare*, as commonly accepted, embraces a group of organic units more or less clearly outlined which it is very expedient that we should be able to deal with under distinctive names. An understanding of the geographical, ecological, and organic relations of these units depends in a measure on this matter of names and will scarcely be assisted by that timorous method in taxonomy which abandons its species at the least evidence of intergradation, however obscure or exceptional the case may be.

In our present imperfect knowledge of this group I have refrained from treating as a species any of its members for which a published specific name was not found to be available.

As *Polygonum aviculare* L. occurs on Nantucket in grassy places along the streets and here and there at outlying points, it is a dull bluish-green plant, ascending or erect, slenderly branched from the base, the leaves neither crowded nor greatly reduced in size on the ultimate branches, rather thin, often only obscurely veined, oblong-lanceolate, acute or obtusely pointed, distinctly petioled; ochreae thin-membranous, at first silvery white and acute, becoming pale brown and more or less shriveled-lacerate; flowers distinctly pedicelled; mature flowering calyx 2–2.5 mm. long, margined with white or purplish; achene 2–2.5 mm. long, 1.5 mm. thick, unevenly trigonous, the broader faces ovate, nearly plane, dark, dull, rugulose-striate.

A slender often erect form, found in grassy plots on shady streets, seems to answer the description of var. *agrarium* Koch.

There is a form of this plant that appears to be well entitled to recognition which was not found on Nantucket, being apparently more common northward or at higher elevations. It is characterized by slender elongated branches, straggling or prostrate habit, and very pale color; the leaves, which are sometimes almost whitened beneath, are rather small, well separated, oblong or somewhat spatulate, mostly rounded or obtuse at the apex, and, except the midvein, nerveless or nearly so; stems usually floriferous in all the axils; calyx margined with white or clear pink. It is perhaps the *Polygonum aviculare* var. *diffusum* of Meisner.

* POLYGONUM MONSPELIENSE Thieb. in Pers. Syn. **1**: 439. 1805.
? *P. aviculare* var. *vegetum* Ledeb. Fl. Ross. **3**: 532. 1849.

Found only in the neighborhood of the town, occurring in sandy places, or in pure sand, near the shore. This was the only *Polygonum* found in flower in June, being in full bloom and with mature fruit as early as June 20.

This plant seems to have been little recognized in our flora and very imperfectly understood. A detailed description may therefore be of service:

Pale glaucescent green, relatively stout, usually rather low, erect or ascending with mostly short branches, the main internodes often 2–5 cm. long, conspicuously striate, usually hollow with firm often thin walls; leaves commonly rather thin, relatively broad, elliptic to obovate-oblong, sometimes narrower, the main stem-leaves narrowed to distinct, even slender, petioles, rather abruptly acute or acutish or the upper ones obtuse, 2–6 cm. long, 0.5–2 cm. wide, smaller, narrower, and crowded towards the ends of the branches, prominently veined beneath, the margins distinctly crisped; ochreae conspicuous, silvery white, often purplish at base, becoming pale brown, narrowly acute, finally lacerate into weak divisions; flowers clustered in the axils, often distinctly pedicelled, rather large, at maturity mostly 3–3.5 mm. long, green with strongly contrasting white margins, rarely slightly purplish-tinged; achene broadly trigonous-ovoid with concave faces, commonly 3 mm. long by 2 mm. thick, rather acute, dark, dull, finely rugulose-striate.

A shorter, stiffer, and usually stouter, plant than *Polygonum aviculare*, paler green, with broader, more venose and crisped leaves, usually more crowded on the fewer and shorter branches, larger and more conspicuous ochreae, larger flowers, commonly with little or no purplish tinge and larger, broader, more sharply trigonous achenes with the faces more concave.

Large forms are sometimes mistaken for *Polygonum erectum* L., which differs materially in its distinctive yellowish green color, solid woody stem of shorter internodes, less whitened ochreae, more dilated and often somewhat crested angles of the mature calyx and broader, less dark-colored achene; it is also later-flowering, often by several weeks.

Note. — *Polygonum erectum* L. is said in Mrs. Owen's catalogue to be found occasionally on the wharves. It may well have occurred, but I could find nothing of it, and the species was formerly so poorly understood that *Polygonum monspeliense* might easily have been mistaken for it.

* POLYGONUM BUXIFORME Small, Bull. Torrey Club **33**: 56. 1906.

P. littorale Small, in part. Mem. Dept. Bot. Columbia Coll. **1**: 102. 1895. Not *P. littorale* Link.

P. aviculare var. *depressum* Meisner in DC. Prod. **14**: 98. 1856.

P. aviculare var. *procumbens* Torrey. Probably not Meisner. Frequent along roads and pathways.

Pale glaucescent green, prostrate; stems stiff, becoming somewhat lignescent, often of nearly uniform thickness throughout, bearing short, divergent branches nearly to the tip, or sometimes with elongated branches with short and stiff ultimate divisions; internodes very short, sharply angled; ochreae very short, brownish-tinged, becoming bright light-brown, finally cleft into rather broad, weakly acuminate divisions; leaves small, numerous, crowded, mostly 0.5–1 cm. long, 2–3 mm. wide, oval, elliptic, or short-oblong, obtuse or rounded at the apex, contracted or narrowed to a very short rather broad petiole, thickish, strongly venose beneath, scarcely revolute, mostly with involute tendency, often minutely crisped; flowers small, crowded, appearing subsessile, 2–2.5 mm. long, at maturity sometimes as broad as long, green, the divisions narrowly white-margined or tinged with reddish-purple; achene included, mostly broadly ovoid, usually abruptly contracted above, obtusely pointed, unevenly trigonous or sublenticular, 2–2.5 mm. long, 1.25–1.75 mm. wide, dark brown, finely rugulose-striate, dull or sometimes obscurely rugulose and somewhat shining.

A smaller plant than *Polygonum aviculare*, commonly stiffly prostrate, with relatively thicker, more woody stems of shorter, more angled internodes, much smaller, thicker, more venose leaves, mostly oval or short-oblong and obtuse, smaller, more crowded flowers on shorter pedicels, smaller and somewhat different achenes.

The *Polygonum littorale* Link, of Europe, to which this plant has been referred, appears to be quite distinct. Specimens labeled by Meisner in the herbarium of the New York Botanical Garden differ obviously, among other characters, in the smaller, brighter reddish-brown achene, which is narrower, more gradually pointed, smooth, or nearly so, more or less shining, and distinctly exposed at the tip when fully mature. That *Polygonum littorale* also occurs in this country seems to be attested by specimens from Mt. Desert, Maine, which I have been unable to refer to any other species.

* POLYGONUM PROVINCIALE C. Koch. Linnaea **22**: 204. 1849.

Similar to *Polygonum buxiforme* Small, but more slender and and often longer-branched, the internodes usually rather longer and less prominently striate and angled; leaves small, 0.5–15 mm. long, 1–3 mm. wide, numerous, often crowded, thickish, linear to linear-oblong or lanceolate-linear, narrowed to base and apex, very short-petioled or subsessile, mostly acute, distinctly veined on the lower surface, the margins more or less revolute; ochreae mostly acute, longer, closer, and more firmly lacerate than in *P. buxiforme*, becoming darker and more purplish-brown; flowers rather smaller and narrower than in *P. buxiforme* and less closely clustered, mostly 1.5–2 mm. long, greenish and white or slightly purplish-tinged; achene included, commonly rather smaller and narrower than in *P. buxiforme* and lighter brown, unevenly trigonous or sublenticular, somewhat contracted towards the top, rugulose-striate.

Nearly related to *P. buxiforme*, differing in more slender, less sharply angled stems, narrower, more acute revolute leaves, somewhat longer ochreae with narrower more attenuate final divisions, often smaller flowers and mostly narrower paler brown achenes. It is frequent on Nantucket in the same situations as *P. buxiforme*. It is also common on Long Island.

The original description of *P. provinciale* appears to justify the adoption of the name for the plant here discussed.

* POLYGONUM NEGLECTUM Besser, Enum. Pl. Vol. 45. 1822.

P. aviculare var. *laxum* Ledeb. Fl. Ross. **3**: 532. 1849.
P. aviculare var. *latifolium* C. Koch, Linnaea **22**: 204. 1849. (Probably, — not *P. aviculare* var. *latifolium* Michx.)
P. aviculare var. *angustifolium* C. Koch, *loc. cit.* (Probably.)
P. aviculare var. *tenuissimum* C. Koch, *loc. cit.*
P. aviculare var. *angustissimum* Meisner in DC. Prod. **14**: 98. 1856.
P. aviculare var. *neglectum* Aschers. Fl. Brandenb. 51. 1864.

A characteristic knotweed of Nantucket, growing in sand or sandy soil especially about some of the south shore ponds and along the borders of salt marshes.

The name *Polygonum neglectum* Besser is adopted for this knotweed by authority of the exact fitness of the original description of the species to the prevailing form of the Nantucket plant. While therefore it can scarcely be doubted that the name is correctly taken up, so widely divergent are extreme forms of the plant that only the broadest application of the name will embrace the species as a whole. It is quite possible, however, that certain of these forms, for the present so treated, will be found to be essentially distinct plants.

The species itself has been so obscurely known and little recognized that detailed descriptions may be useful:

What may be understood as being the typical plant is dull light-green in color, erect, ascending, or prostrate, rather stiff, widely slender-branched from the base; internodes rather short, often zigzag, striate, usually minutely roughened; leaves firm, elliptic to narrowly elliptic-lanceolate, acute, narrowed to the base, sessile or very short-petioled, prominently veined on the lower surface and somewhat scurfy-punctate, the margins often distinctly crisped or cartilaginous-roughened, and revolute when dry; leaves of the branchlets gradually reduced upwards and becoming very small, linear-lanceolate and acute to linear and obtuse; ochreae silvery brown when young and narrowly lanceolate-attenuate, finally lacerate into narrow stiffly ascending bristleform divisions, or sometimes weak and flexuous, the base mostly funnelform, becoming blackish; terminal inflorescence appearing more or less subspicate, the flowers with very short pedicels, mostly sessile or two together; mature flowering calyx 2–3 mm. long, often strongly venose, the margins commonly purplish red; achene mostly exserted at tip, usually somewhat unevenly trigonous with the faces nearly plane, commonly rather smaller than in *P. aviculare*, less strongly rugulose and lighter and more reddish brown in color, often more abrupt at base and apiculate.

A broader-leaved, often larger form bears diffuse, decompound, widely ascending branches, sometimes 7.5 dm. in length, the ultimate branches slender and flexuous; longer internodes 5 cm. long, the uppermost very short; larger leaves sometimes obovoid-oblong, becoming 3.5 cm. long and 1.2 cm. wide, the margins firmly crenulate; ochreae relatively short and not usually stiffly bristly-lacerate; flowers distinctly pedicelled, large, becoming 3–3.5 mm. long, the bright carmine, somewhat petaliferous segments concealing the tip of the achene; achene large, 2.5–3 mm. long, 1.5–2 mm. wide, evenly trigonous with deeply concave faces, red-brown, dull but shining on the angles, strongly rugulose and apiculate.

The examples here described were collected at York Harbor, Maine, on August 15, 1893, and August 19, 1894, and grew in stony places back of the beaches. The same plant although less strongly developed is common on Mt. Desert, Maine, where I collected it in 1895, growing in the same situations as at York Harbor. That it occurs as far east as Newfoundland is attested by reduced examples from Torbay (*C. D. Howe & W. F. Lang, 1367*, August 21–26, 1901, ledges of damp sea-cliffs).

In the herbarium of the New York Botanical Garden are specimens closely similar to the Maine plant collected by Professor B. Jönsson in Scandinavia and labeled *P. aviculare* var. *maximum* and from Geneva, ex herb. Meisner, labeled *P. aviculare* var. *vegetum* Ledeb. This latter determination may be correct, but var. *vegetum*, as it has been interpreted, is a very different plant, the *P. monspeliense* Thieb. of Persoon's Synopsis, which represents a parallel development along the collateral *P. aviculare* line. The plant is probably the *P. aviculare* var. *latifolium* of Koch (Linnaea **22** : 204).

The opposite extreme of *P. neglectum* from this larger form is seen in a delicate, slender-stemmed and widely branched form which grew flatly prostrate on damp sand about ponds on the south shore of Nantucket. The pale yellowish-green linear leaves are very small and, excepting the midvein, nerveless or nearly so, 0.5–1.5 cm. long, 1–2 mm. wide, obtuse or acutish; ochreae rather short, the divisions often weakly scarious; flowers very small; achene exserted at tip, 1.5–2 mm. long, 1.25–1.50 mm. wide, plumper than in the typical form and more abruptly contracted at the base and blunter at the tip.

There would seem to be little doubt from Koch's description (Linnaea **22** : 204) that this plant may be referred to his *P. aviculare η tenuissimum*. The similarity of the flowering branches of the plant to those of the erect *P. tenue* Michx., which is remarked by Koch, is obvious in the Nantucket specimens.

Another very distinct-appearing form found sparingly on Nantucket, perhaps not to be referred to this species, is rather dark green, often becoming black when dry, erect or erect-ascending, 2–3.5 dm. high, with very slender and fragile, often zigzag, stems and branches, the leaves relatively thin, narrowly lanceolate and very acute, tapering to base and apex and distinctly slender-petioled; the ochreae are large and funnelform and show an extreme development of the stiffly lanceolate final divisions. In this form the inflorescence is not in the least spicate, its very small flowers being rather distant and axillary and the leaves scarcely, if at all, reduced in size towards the tips of the branches. Some specimens of this from European herbaria are labeled *P. aviculare* var. *erectum*.

Still another noteworthy form collected at York Harbor, Me., Aug. 16, 1893, is characterized by erect habit, slender, somewhat fastigiate branches and narrowly linear and acute, appressed or ascending leaves of firm texture and more or less revolute.

The main points of difference distinguishing typical *P. neglectum* from *P. aviculare* are more elliptic, prominently venose leaves of firmer texture, usually somewhat scurfy beneath, firmer, more prominent ochreae becoming stiffly laciniate and finally blackish, upper leaves greatly reduced in size, with a subspicate inflorescence towards the ends of the more sharply angled branches, and usually brighter red flowers. Other but less constant differences are more striate and roughened stem of shorter internodes, at least above, more flexuous branchlets, leaves revolute on margins or with revolute tendency instead of with involute tendency as in *P. aviculare*, the ochreae brownish-tinged from the first with firmer attenuate divisions, achene more reddish in color and more exserted.

* POLYGONUM PROLIFICUM (Small) Robinson.

Along salt marshes and brackish creeks, in saline mud, less often in sandy soil. Frequent along the harbor from near the town to Quaise; more common at the western end of the island towards Eel Point; not seen on the south or east side.

A very distinct species, abundant along our coast from Maine to New Jersey and flowering from the middle of July until killed by frost. In its various forms it exhibits an unusually wide range of variation. Although commonly erect, as required by descriptions, it may be straggling and ascending, prostrate or even flatly depressed in dense mats 1–2 dm. in diameter. Such a form used to grow along the Harlem River in New York and would not be easily recognized as the same species as the normal erect form. It is numerously short-branched with very short internodes, the small leaves and the flowers numerous and crowded. Specimens are deposited in the herbarium of the New York Botanical Garden. A wide-spreading and ascending slender form has elongated internodes and flexuous branches sometimes 5 dm. long, the leaves much reduced in size towards their extremities. The stoutest form of the plant is erect and densely bushy-branched with solid woody stem sometimes 0.5 cm. in diameter below. In a frequent state of the plant the ochreae become enlarged and imbricated towards the ends of the branches and of a reddish or bright purple color, the leaves remaining very small or even wholly undeveloped. In saline mud the plant is sometimes deep bluish-green in color, and the leaves and joints of the stem are somewhat succulent; such plants often become much blackened in drying. In drier sandy soil it is erect and paler green, often very slender and only sparingly branched. This is the prevailing form on Nantucket, although the thicker-leaved and widely branched bluish-green form also occurs.

The normal achene of *Polygonum prolificum* is about 2 mm. long, ovoid, light brown, somewhat dull, minutely punctate, with hard bony walls, and wholly included. Late in the season the plant commonly produces many achenes which become lanceolate and conspicuously exserted and 3–3.5 mm. long. These elongated achenes differ further from the normal in being olivaceous and shining with membranous walls. These profound modifications result from the premature germination of the embryo which, while still wholly enclosed, will be found to be bright green and purplish in color and with elongating radicle.

The elongated achene of *Polygonum exsertum* Small is of precisely the character of that of *P. prolificum* and I am unable to see that *P. exsertum* is anything more than a semiviviparous state of *Polygonum ramosissimum* Michx. In this species and in its eastern representative, as well as in *P. prolificum*, both kinds of achenes frequently occur on the same plant. This is also true of *Polygonum Fowleri* Robinson, and *P. buxiforme* and other species occasionally develop similar achenes with viviparous tendency.

Polygonum atlanticum (Robinson) comb. nov.

P. ramosissimum Michx. forma *atlanticum* Robinson, Rhodora **4**: 72. 1902.

Occurs rather sparingly on the borders of salt marshes and along brackish tidal creeks: Acquidness Point, nearly three feet in height; Quaise; near Pocomo Head; Little Neck. Observed in full flower from before the middle of August until late in September.

Professor Robinson in distinguishing our coastwise representative of *Polygonum ramosissimum* as a form of the typical western species has pointed out a noteworthy difference between the two plants in the color of their flowers. In the western species the calyx lobes are green and yellow; in the eastern plant they are green and white, usually tinged with rose. The color differences between the two plants are not however confined to the flowers. The foliage of our coastwise plant is of a pale glaucescent green which contrasts strikingly with the bright or deep yellowish-green color characteristic of *P. ramosissimum*, the difference affording a close parallel to the color contrast between *Polygonum aviculare* L. and *P. erectum* L. Nor are the differences between the two plants only those of color. The leaves of the eastern plant are as a rule more uniformly acute and more tapering to base and apex, longer-petioled, of thicker texture with revolute margins when dry and much more strongly venose. In the western plant they are commonly very smooth and flat and only obscurely venose. The ochreae of the eastern plant are firmer, usually longer and more stiffly laciniate and darker in color, the base often blackish. The mature calyx of *P. ramosissimum* is longer than that of *P. atlanticum* and of a somewhat different shape, 3.5–5 mm. long as against 2.5–4 mm., ovoid-oblong rather than ovoid and more gradually narrowed towards the base; the calyx segments are commonly broader, especially above, and more strongly venose notwithstanding the less venose leaves. The achene of *P. ramosissimum* is larger and broader than that of *P. atlanticum* and of somewhat lighter and more reddish color.

I have found no difficulty in properly assigning a large series of specimens without reference to locality. Each species, however, occurs well within the range of the other. Doctor Robinson has recorded *P. ramosissimum* from eastern Massachusetts and I have seen specimens of typical *P. atlanticum* from North Dakota.

P. ramosissimum appears to be more closely related to *Polygonum Bellardi* All. of Europe than is *P. atlanticum* and certain specimens of the European and of the more western American plant are scarcely distinguishable.

In the study of these plants it has appeared that a beautifully distinct unnamed species which has been included in *P. ramosissimum* occurs in Missouri — Atherton, Sept. 7, 1895, *B. F. Bush*, in herb. New York Botanical Garden. This plant may be at once distinguished by the flowering calyx, which is small, 2.5 mm. long and wide, and deltoid-ovate from a broad subcordate base, the segments much compressed basally and becoming conspicuously carinate or even auricled. The achenes are much smaller than in *P. ramosissimum*, broadly ovoid with abruptly rounded base, shining as if polished and deep reddish brown in color.

* PERSICARIA PENNSYLVANICA (L.) Small.

The common erect form of this plant with lanceolate tapering leaves and cylindric spikes of rather pale pink ovoid-oblong flowers is uncommon on Nantucket and was met with only twice — at Wauwinet and in Quaise. The prevailing form is mostly prostrate or ascending and is confined almost exclusively to the sandy shores of ponds near the ocean on the south and east sides of the island. In its extreme development it is notably different from the erect narrow-spiked form but appears to be a state of the latter, rather than an intrinsically diverse plant. By comparison it is characterized by short-oblong or even subglobose more densely flowered spikes, usually of a bright rose-color or carmine-red, although sometimes pale, the flowers shorter and almost orbicular in outline, the achenes rather larger, thicker, and more broadly orbicular, often more abruptly narrowed to a rather shorter style; the leaves are often marked above by a dark chevron and are commonly shorter, broader and less attenuate to a blunt or rounded apex and on shorter petioles, the upper most often sessile. The plant is often firmly prostrate and is sometimes very small, stems bearing mature spikes being sometimes only 1 dm. long.

PERSICARIA INCARNATA (Ell.) Small.

Common along the shores of Sachacha Pond back of the beach and about the ocean ends of Hummock and Miacomet Ponds; sparingly on the sandy shore of Gibbs' Pond. In full flower August and September. Frequently semi-prostrate in the sand, or dwarfed and strictly prostrate.

* PERSICARIA LAPATHIFOLIA (L.) S. F. Gray.

Sparingly in waste ground by stables in the town near Mill Street, Sept. 16, 1907.

* **Persicaria tomentosa** (Schrank) comb. nov.

Polygonum tomentosum Schrank, Baier. Fl. **1**: 669. 1789.

A few good-sized plants back of the sandy shore of Miacomet Pond, Sept. 21, 1899, in full flower. Plants erect, the larger about 6 dm. high, some of the leaves invested on the lower surface with bluish-white tomentum, others quite glabrous; many with a dark medial blotch on the upper surface.

PERSICARIA PERSICARIA (L.) Small.

Common, especially in and near the town. In full flower through August and September.

PERSICARIA HYDROPIPEROIDES (Michx.) Small.

Common in ponds and water holes, flowering through August and September.

* PERSICARIA OPELOUSANA (Ridd.) Small.

Frequent in wet places in meadows and about ponds, flowering in August and September: Tom Never's Swamp; near Acquidness Point; Reed Pond and other ponds west and southwest of the town.

The range of this species is not understood to extend north of Louisiana and Missouri, yet it is common enough in our eastern flora and has doubtless been passed over as a pale-flowered form of *P. hydropiperoides*, to which it is nearly allied. Indeed the two species have recently been united (Gray's New Manual, seventh edition), but I have found myself unable to accept this ruling. Some years ago I used to find both plants in the neighborhood of Van Cortlandt Park, New York City, and carefully studied them out as distinct without then suspecting that one was a southern species already described. The eastern pale-flowered plant does, indeed, differ in some respects from typical *P. opelousana*, but apparently not by any character stable enough to justify their separation.

The most obvious differences between our eastern plant here referred to *P. opelousana* and *P. hydropiperoides* are seen in the flowers. In the latter species these are ovoid-oblong, 2.5–4 mm. long at maturity, purplish-pink to clear pink and white, the segments petaliferous and completely concealing the achene; in *P. opelousana* the flowers are greenish-white, obovoid, 2–3 mm. long, the tip of the achene distinctly visible. In *P. hydropiperoides* the spikes are commonly longer and more slender than in *P. opelousana* and often interrupted at the base; the ochreolae are longer (2.5–3.5 mm. as against 1.5–2.5 mm.); the flowers on longer less spreading pedicels, 3–5 mm. long as against 1.5–3 mm; the achene of *P. opelousana* is commonly shorter and broader than that of *P. hydropiperoides*, more abruptly narrowed to a shorter point, the sides more concave, the angles decidedly more tumid, the surface less shining. *Persicaria opelousana* is more erect in habit than *P. hydropiperoides*, which is often decumbent, is less strigillose throughout, commonly with narrower, thicker, paler-green leaves, less distinctly veined, and characteristically pale beneath.

In the type specimen of *Persicaria opelousana* (herb. New York Bot. Garden) and other southern material the flowers are of the same form and color as those of our eastern plant but are rather smaller with smaller and narrower achenes; the leaves are somewhat thicker and more obscurely veined and more stiffly setulose-strigillose along the midrib and margins; the ochreae are closer, of firmer texture, more strigose, with a longer and stiffer ciliate fringe, 5–13 mm. long as against 2–5 mm. long in the northern plant; the ochreolae are also longer-fringed, the hairs 1–5 mm. long whereas in the northern form they are often obsolete and rarely exceed 1 mm. in length.

* PERSICARIA SETACEA (Baldw.) Small.

The occurrence of this species on Nantucket is altogether surprising, since, although a well-known species of the Southern States, it seems never to have been recorded from north of the Carolinas. It was first collected on Nantucket, Sept. 11, 1907, in full flower, growing in the water at the border of Reed Pond, the plants being essentially identical with typical examples from the South Atlantic States. It was again collected, June 17, 1908, along a wet ditch near the head of Millbrook Swamp. Although then only in leaf it appeared notably different from any of our northern species and unmistakable by reason of its large elliptic-lanceolate leaves narrowed to base and apex, at least the upper ones densely short-strigillose over both surfaces, the larger 13 cm. long by 3 cm. wide; the plants were erect from a prostrate rooting base and 3–4 dm. high.

PERSICARIA PUNCTATA (Ell.) Small.

P. punctata var. *leptostachya* (Meisner) Small.

Very common in swampy places and along wet meadows and pond shores. In full flower through August and September.

I am unable to see in the so-called var. *leptostachya* anything more than a reduced and slender state of the ordinary plant — and the most common form of the species appears to be more or less intermediate between these two extremes. It does not appear from Elliott's description which form of the plant, if either one, he had particularly in view.

* **Persicaria robustior** (Small) comb. nov.

Polygonum punctatum robustior [*ius*] Small, Bull. Torrey Club **21**: 477. 1894.

Wet ditch in Quaise; Watt's Run; muddy ditch north of the town, just in flower, Aug. 15, 1906. Leaves sometimes 15 cm. long by 3.25 cm. wide.

My experience with this plant, even before it was described, led me to regard it as distinct from *P. punctata* and further acquaintance with it at many localities has only confirmed this view. Although closely related to *P. punctata*, its characters seem to be very constant and it has a distinctive appearance which announces its identity at sight. It comes into flower definitely later than *P. punctata*.

Note. — *Polygonum amphibium* L. is included in Mrs. Owen's catalogue. What particular plant was intended is now impossible to say unless specimens should be somewhere preserved. I did not myself meet with any species of the *amphibium* group.

Polygonum Zuccarinii Small is planted in the town and shows some tendency to escape from cultivation.

TRACAULON SAGITTATUM (L.) Small.

Polygonum sagittatum L.

Common in low grounds, flowering through August and September.

TINIARIA CONVOLVULUS (L.) Webb. & Moq.

Polygonum Convolvulus L.

Common about cultivated grounds and in waste places. In flower through August and September.

TINIARIA DUMETORUM (L.) Opiz.

Polygonum Dumetorum L.

Frequent about the borders of thickets mostly in dry open ground, flowering through August and September.

In the shade of dense thickets in Squam and on Coskaty a delicate very thin-leaved form, simulating *Tiniaria cristata* (Engelm. & Gray) Small, but with the much larger achenes of *P. Dumetorum* — 3.5 mm. long by 2.5 mm. wide. I have collected the same plant on Long Island, New York, and on La Rue Island, Canada, near Alexandria Bay. It is further characterized by very short and few-flowered leafy-bracted racemes or the flowers in merely axillary very small clusters. It contrasts rather strikingly with the common form of *P. Dumetorum* and may even be distinct.

FAGOPYRUM FAGOPYRUM (L.) Karst.

The buckwheat is mentioned by Mrs. Owen as being common in old fields. It was casually noted on my earliest visit to the island but has not been observed since and would therefore appear to have generally died out.

POLYGONELLA ARTICULATA (L.) Meisn.

Common throughout, usually in pure sand; often growing entirely alone, but also mingling with the xerophytic vegetation of the dry commons. Saul's Hills. First flowers, Aug. 9, 1906.

Notes on the effect of mechanical pressure on the roots of Vicia Faba

LOUISE HOYT GREGORY

According to the second law of Hertwig,* "the axis of the mitotic figure typically lies in the longest axis of the protoplasmic mass, and division therefore tends to cut this axis at a right angle." Pflüger † and Driesch, ‡ experimenting with sea-urchin eggs, found that Hertwig's law held true even when the eggs had been compressed, and, as a result of the pressure, the long axis of the body was modified.

Conditions among plants do not always verify this law. Berthold § has shown that the cells of the cambium layer may divide lengthwise, in which case the mitotic figure would lie in the shortest axis of the body. Kny, || from his experiments of pressure on the division wall of plants, comes to the conclusion that the orientation of the mitotic figure, and with it the position of the division wall, may be influenced by pressure.

My work has been done with the purpose primarily of seeing if there is a definite effect of pressure on the mitotic figure, and secondarily of studying the morphological changes that take place in the compressed root-cells. The problem was given me by Professor H. M. Richards, whom I wish to thank for his helpful suggestions.

The material used in the work was *Vicia Faba*, whose roots are large and well adapted for experimental purposes. Roots of *Zea Mays* and *Helianthus annuus* were tried, but gave poor results.

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* Hertwig, O. Welchen Einfluss übt die Schwerkraft auf die Teilung der Zellen? Jenaische Zeitschrift **18** : —. 1884.

† Pflüger, E. Über die Einwirkung der Schwerkraft und anderer Bedingungen auf die Richtung der Zelltheilung. Arch. ges. Physiologie **34** : 607–616. 1884.

‡ Driesch, H. Entwicklungsmechanische Studien IV. Zeitschrift wiss. Zoologie **55** : —. 1893.

§ Berthold, G. Studien über Protoplasmamechanik. Leipzig, 1886.

|| Kny, L. Ueber den Einfluss von Zug und Druck auf die Richtung der Scheidewände in sich theilenden Pflanzenzellen. Ber. Deut. Bot. Gesell. **14** : 378–391. 1896.

The methods used in the experiments were of the simplest kind. The seeds were germinated and allowed to grow normally for three or four days (roots having secondary roots were never used). The roots were then placed between two plaster of Paris blocks in order to have the pressure lateral. The blocks were held together by different widths of elastic bands, the amount of pressure depending on the number and the width of the bands used. The roots remained under pressure usually during twenty-four hours, the actual time being from one P. M. to one P. M., in which case the roots were fixed during the secondary period of maximum growth as determined by Kellicott.* Some roots were compressed during twelve hours only; in this case they were killed at eleven P. M. during the primary period of maximum growth. The roots were fixed in alcohol acetic, sublimate acetic, Flemming's fluid, and chromic acid. Alcohol acetic was found to be the best fixative. Serial sections, 5 μ in thickness were made, and stained with iron haematoxylin, which proved to be the most satisfactory stain. Control experiments were carried out under the same conditions, the roots being fixed at the same periods and the sections stained in the same manner.

Seventeen roots were compressed and sectioned. These may be divided into three groups:

1. Those least compressed, the pressure varying from 650 to 1000 grams. Exp. I, II, VIII, IX, XV;

2. Those with a medium amount of compression, the pressure varying from 1000 to 1400 grams. Exp. VII, XII, XIV;

3. Those with a maximum amount of compression, varying from 1400 to 2000 grams. Exp. III, IV, V, VI, X, XI, XIII, XVI, XVII.

The table of measurements shows the number of experiments performed, the time during which pressure was applied, the length and approximate thickness of the roots after compression, and finally the total amount of pressure. This amount of pressure was determined empirically only. The width of the crack between the blocks was measured before the roots were taken out, records being made of the number of strips of pasteboard necessary just to

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* Kellicott, W. E. The daily periodicity of cell division and the elongation of the root of *Allium*. Bull. Torrey Club **31**: 529–550. 1904.

fill the crack. The blocks were kept with the bands upon them. To estimate the amount of pressure : the number of cardboard strips that had been determined before was placed between the blocks ; the upper block was then fastened in a clamp on a standard and a weighing pan attached to the lower block ; weights were then applied until the blocks were stretched apart enough to allow the cardboard strips to slip out.

TABLE OF MEASUREMENTS.

No. of experiment.	Time of compression.	Length of root after pressure.	Thickness of root after pressure	Total amount of pressure
I	24 hours.	14 mm.	.66 mm.	858 gm.
II	“	8 “	1.045 “	860 “
III	“	9 “	.38 “	1559 “
IV	“	12 “	.45 “	1650 “
V	“	12 “	.75 “	1902 “
VI	“	11 “	.74 “	1553 “
VII	“	13 “	.605 “	1103 “
VIII	“	7 “	.735 “	958 “
IX	“	6 “	1.020 “	958 “
X	“	5 “	1.035 “	1759 “
XI	“	7 “	.775 “	1759 “
XII	12 hours.	8 “	.828 “	1359 “
XIII	“	8 “	.750 “	2050 “
XIV	“	7 “	1.615 “	1253 “
XV	“	7 “	.805 “	662 “
XVI	10 hours.	10 “	.500 “	1625 “
XVII	“	10 “	1.025 “	1625 “

Very little of importance can be deduced from the thickness of the compressed roots since a measurement was not taken before the pressure was applied. As a result there are many cases giving seemingly contradicting results. For example, in experiment IX, after a pressure of *958* grams, the root measured 1.02 mm. in thickness ; in experiment X, however, after a pressure of *1759* grams, the root measured 1.03 in thickness. This could probably be explained if the measurements of the roots before pressure were known. In the first seven experiments the roots used were of approximately equal size. Here the average thickness of roots affected by the minimum amount of pressure is .85 mm.; by the maximum amount of pressure, .58. In either case the normal root has been greatly compressed.

An examination of the material shows that contrary to the view of Kny and to the results of Pflüger and of Driesch, pressure has had no effect on the mitotic figure or division wall in the root cells of *Vicia Faba*. At first it was thought that the pressure had caused an increased number of transverse and oblique spindles. In one series a row of transverse spindles was found in the periblem layer at a point near the meristematic region. The control series, however, showed transverse spindles in an equally anterior region, and also as many oblique spindles as had been found in the compressed roots. In no way did the mitotic figure

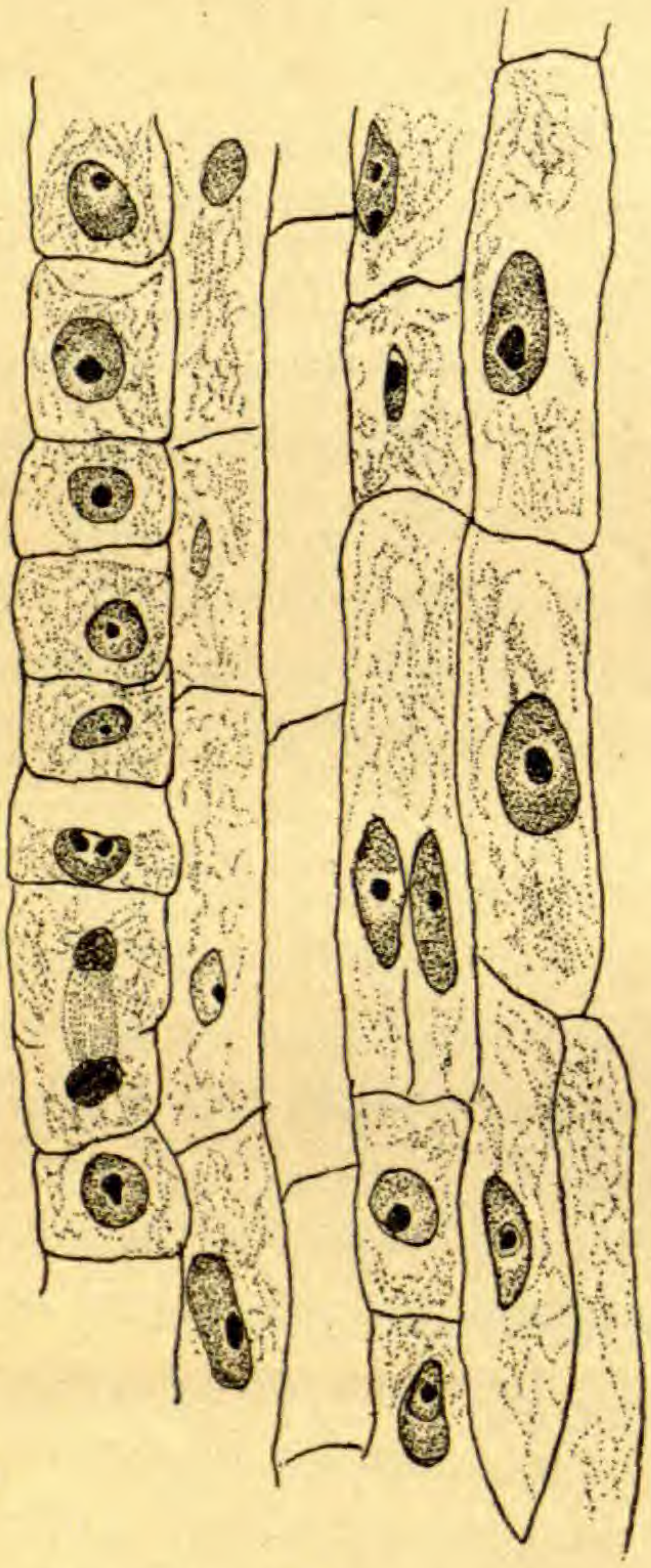

FIGURE 1. A median longitudinal section through a root to which 858 grams of pressure had been applied. Note the empty cells in which the split will take place, also the degenerating plerome cells on either side. The periblem layer is only slightly affected by the pressure. × 530.

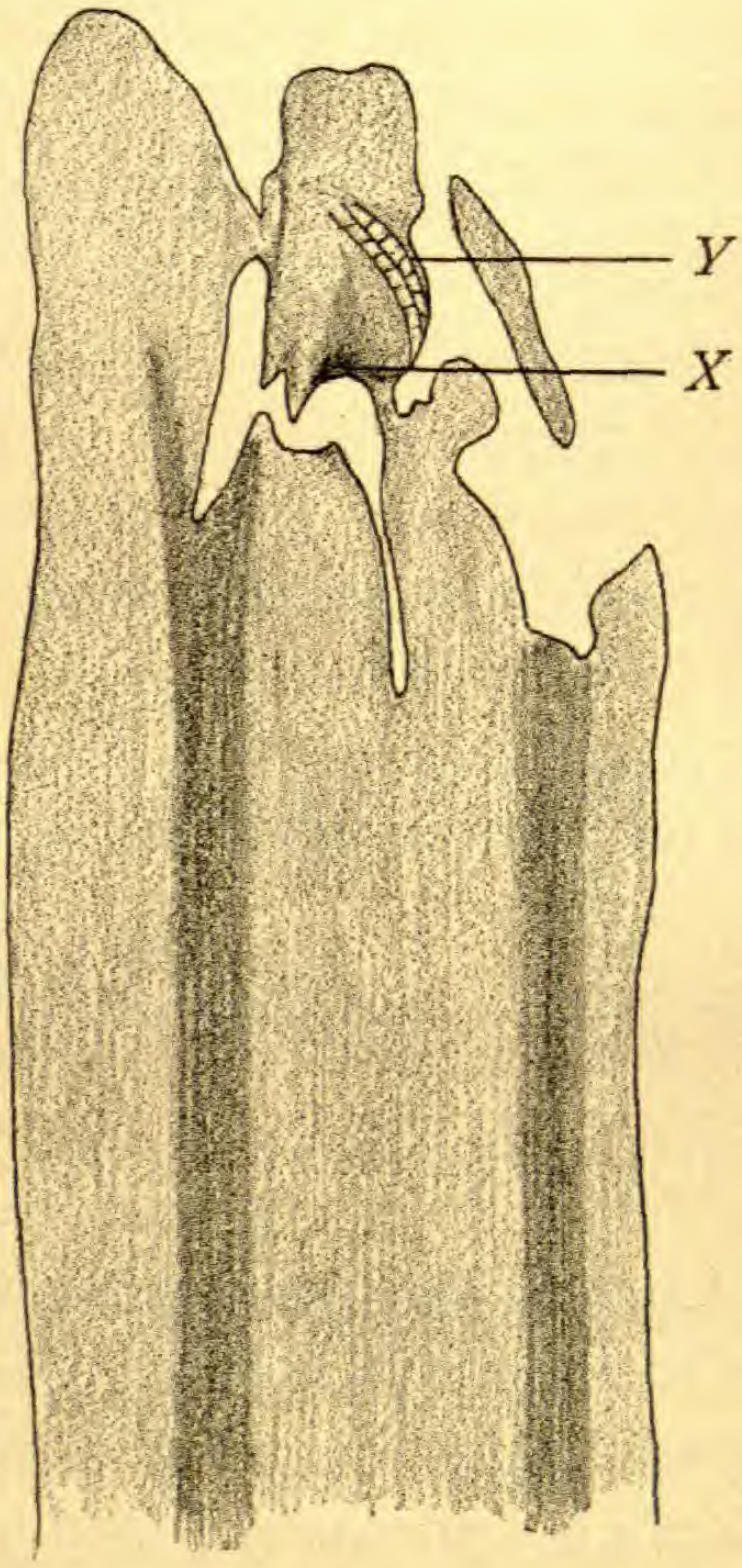

FIGURE 2. A low power sketch of the condition found in a root to which 1560 grams of pressure had been applied. The dark area represents the periblem tissue in which rifts have occurred. X = periblem cells which have been displaced. Y = plerome cells which also have been displaced.

seem to be affected by the pressure. In one case, I noticed a fragmentation of nucleoli taking place in almost every case, but as this was observed in one series only, it was thought to be due to some other cause than pressure.

A few interesting morphological points were noticed in the changes taking place in the cells of the compressed roots. In all cases, splits or rifts in some stage of formation were seen in the tissues. The beginnings of these splits can be found in the least compressed roots. The first indication of a definite split was the appearance of cells which had lost their entire contents, still retaining, however, their cell walls. These cells were found either in the extreme layer of plerome cells or just within the plerome layer. On either side of this layer were plerome cells in different stages of degeneration. In general, the protoplasm had become vacuolated and had shrunken from the wall. In some cases their nuclei showed signs of abnormality (see FIGURE 1).

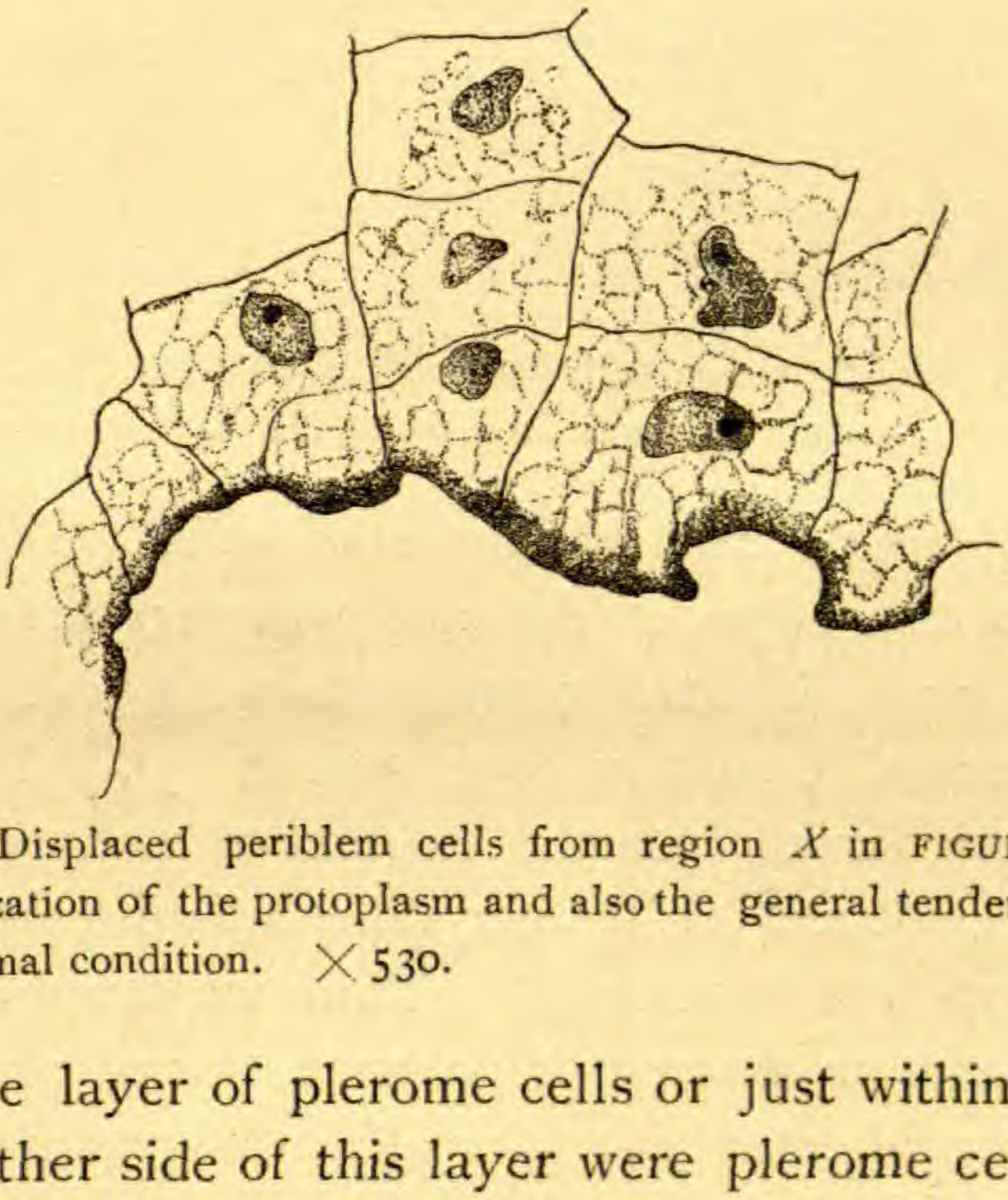

FIGURE 3. Displaced periblem cells from region *X* in FIGURE 2. The cells show the vacuolization of the protoplasm and also the general tendency of the cells to assume their normal condition. × 530.

In the second group of experiments, which includes the roots that were subjected to a pressure varying from 1000 to 1400 grams, the plerome cells were still more vacuolated, and definite splits had appeared not only in the extreme layer of plerome cells but also throughout the central portion. Even with this pressure but few changes were observed in the periblem and dermatogen tissues.

In the third group of experiments, which includes the roots subjected to an extreme amount of pressure varying from 1400 to 2000 grams, marked changes had taken place. The plerome cells were well broken up. Splits had appeared in the periblem layer, and groups of both plerome and periblem cells were greatly displaced (see FIGURE 2).

In general, the greatest amount of injury was found in the region directly posterior to the initial meristematic region. Roots which had been subjected to the greatest amount of pressure showed cavities and rifts in all regions and in many cases displacement of single cells or masses of cells. The protoplasm of the cells on the edges of the rifts was very much vacuolated and the nuclei were distorted in many cases; a few, however, had assumed a normal condition (see FIGURE 3). Plerome cells, which had been forced into the extreme anterior portion of the root, showed evidences of further differentiation into the future vascular system (see FIGURE 4). Thus we may conclude that not even a maximum amount of pressure, nor an absolute change in environment will entirely stop or affect the normal development of the cells of *Vicia Faba*.

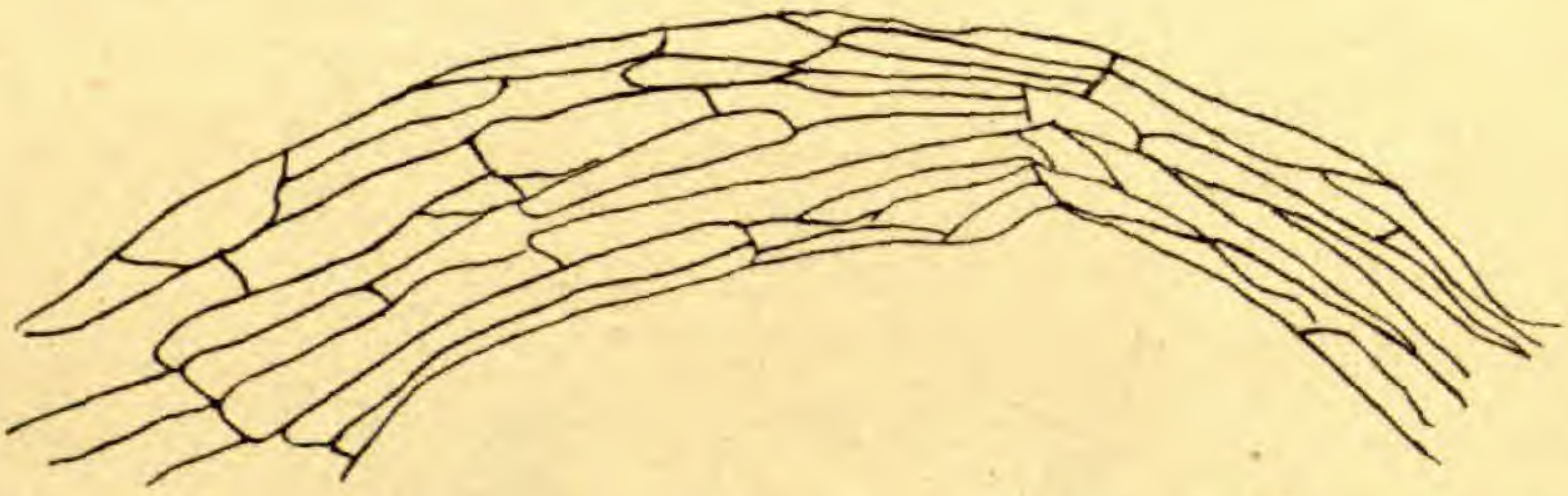

FIGURE 4. Displaced plerome cells from region *Y* in FIGURE 2, showing elongated cells which have become further differentiated into fibrovascular tissue. × 530.

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The genus Ceratopteris: a preliminary revision

RALPH CURTISS BENEDICT

The genus *Ceratopteris* comprises a complicated group of hydrophytic leptosporangiate ferns which vary considerably not only in leaf-form, habit, etc., but also in the more fundamental characters of the sporangium, but which for nearly a century have commonly been regarded as constituting but a single species. Recently, however, Hieronymus,* and Underwood † have dissented from this view and have recognized a second species, but without attempting any revision of the genus as a whole. The present paper has as an object the presentation of such a revision. Owing to insufficient material the revision is necessarily incomplete, but it is believed that it represents a step in advance, and will aid in the further study of these plants.

In reaching conclusions as to the taxonomic status of the various forms, it has been necessary to examine microscopically the sporangia of a large amount of material from many localities. This has resulted in the discovery, of some general morphological interest, that the number of spores per sporangium varies with the different species. Also of interest is the establishment of the fact that this variation, and the variation in the development of the annulus, can be correlated with the variation in leaf-form and that the genus consists not of a single species, anomalous both in variation and distribution, but of several species whose variations do not exceed reasonable limits, and whose distribution, although possibly anomalous in one case, is for the most part comparable with that of the great majority of species. This correlation is furthermore of interest as additional evidence, if additional evidence is needed, as to the value of the study of minute characters in connection with taxonomic work with the ferns. The synopsis finally obtained seems clear enough now, even with respect to the grosser differences in leaf-form, but these differences became clear only

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* Bot. Jahrb. **34** : 561. 1905.

† Torreya **7** : 195. 1907.

after tentative groupings on the basis of the sporangial characters.

In the Engler & Prantl, Die Natürlichen Pflanzenfamilien, the number of spores in each capsule is given as sixteen, and Miss Ford also records this number for the material she examined, but in most of the numerous specimens I have seen, the number was certainly more than sixteen, and for many plants was definitely determined as thirty-two. Only in *C. deltoidea* was sixteen found to be the maximum number. Indeed in some of the material provisionally identified as this species (Porto Rico, *Sintenis*), sporangia with fewer than sixteen spores were apparently present, although this count was not verified. The accurate counting of the spores was rendered difficult by the fragile texture of the sporangium walls. In many well-fruited leaves the capsules seemed to be all ruptured, or would become so in transferring to a slide, and in such cases the full number accredited to the species was often not certainly determined, but an intermediate number, *i. e.*, more than sixteen, was assumed to indicate the larger number.

The genus is peculiar in that it varies as previously noted in characters usually very constant in fern groups of higher rank than genera, *viz.*, the number of spores per sporangium, and the development of the annulus. The discovery of the form with the vestigial annulus so impressed Hooker that he made it the basis of a new genus and two new species, but he later withdrew both genus and species. Now, although there is no question as to the generic identity of all the plants, the specific identity of all seems hardly probable, and one of Hooker's species, *pteridoides*, has again been accepted by Hieronymus and by Underwood for the American plants, which with few exceptions differ markedly from the Old World plants in leaf-form, habit, and habitat.

But the difficulty does not end here. *C. pteridoides* as thus recognized itself includes a complex of forms which differ in form and cutting and in sporangial characters, and probably also in habit and habitat as well, and it was with a view of finding out whether there exists any correlation of these differences among the various forms that the present study was undertaken. The results obtained are so simple that it seems strange that they have not been obtained before. However, as stated in the title, the present revision is merely preliminary, and the indications are that the genus contains not only the several species included here, but probably several more, which further collections and field work will bring more clearly to light.

The principal difficulty that arose was due to the lack of complete series of the different forms through which the leaves pass in their seasonal development. The conditions seem somewhat analogous to those which exist in such plants as *Campanula rotundifolia*, etc., in which the juvenile leaves are often more distinctive than the later growth but may have disappeared before these develop. Thus a large proportion of the material studied represents only the mature sporophyls which, although necessary in determining the sporangial characters, may yet leave the exact identity of the specimen very much in doubt.

A knowledge of the ecology of the various forms would also assist greatly in their classification. The evidence of this sort at hand indicates that some of the plants occupy very different habitats. They have been found growing in merely damp soil, floating or submerged in water which may be running or stagnant, fresh or brackish, at sea-level and up to two thousand feet altitude. All seem to require at least wet soil, and it is not unlikely that all are accustomed to temporary if not continuous submergence, during which the young vegetatively formed plants are borne floating until stranded in some situation favorable to further growth.

The genus (and the monotypic family Ceratopteridaceae *) may be described as follows:

Aquatic or semi-aquatic plants of tropical or subtropical regions. Stem creeping or ascending, reduced, sparsely scaly. Roots borne on the stipes. Leaves alternate, successive, viviparous, soft-herbaceous, dimorphic, the venation reticulate, without included veinlets, the stipes in some species horizontal at first, then bent abruptly upwards, bearing the roots on the horizontal parts. Sterile leaves erect or spreading, floating in some cases, 2–4 times pinnately or subternately divided. Sporophyls taller, erect, 2–5 times divided, the ultimate segments linear, with the margins narrowly and evenly revolute, often meeting along the midvein, covering two or three rows of areolae. Sporangia abaxial, scattered in one or two lines along the longitudinal veinlets, and protected at first by the reflexed margins, thin-walled, sessile, globose, the wall-cells sinuate,

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* Underwood, Our Native Ferns 78. 1900. [Ed. 6.]

containing chlorophyl, the annulus longitudinal, few-celled (4–10), and causing irregular dehiscence, or many-celled (20–70), and with 8–10 lip-cells and consequent regular dehiscence. Spores 16 or 32 per sporangium, ephemeral, triplanate, the inner faces smooth, the dorsal (outer) face rounded and regularly marked with three series of anastomosing ridges.

Some of the characters noted are decidedly unusual. The bracing of the plant by means of the elbowed stipes is peculiar, and the place of origin of the roots is even more anomalous. Attention has already been called to these facts by Miss Sibille Ford in connection with a study of the vascular anatomy of *Ceratopteris* "*thalictroides*." * The bent stipe seems to be a feature present only in the plants which grow rooted in the soil. In the floating plants the stipes are swollen and bulbous, but not bent. Goebel † has noted in the field that one species, probably *C. pteridoides*, may assume either the floating or the anchored habit, and this statement is borne out by the herbarium material of this species examined, but is true for this species only, as all the other forms seem to be adapted at maturity to a fixed habit only.

The genus was described in 1821 by Brongniart, based on the Linnaean species *Acrostichum siliquosum* and *A. thalictroides.* Within seven years six other names had been proposed for the same genus, two of which, however, were not properly published but were merely cited as synonyms. In addition to these, the synonymy contains, besides the already mentioned *Acrostichum*, *Pteris* Swartz and others, *Belvisia* Mirbel, *Onychium* Hasskarl, and *Naias* Blanco.‡

As may be seen, many different views have been held as to the natural position of this genus. Brongniart, who distinguished five families of ferns, *viz.*, Ophioglossaceae, Osmundaceae, Marattiaceae, Polypodiaceae, and Gleicheniaceae, placed *Ceratopteris* with the last because he considered its annulus to be transverse. But he clearly misinterpreted the facts, since the annulus, although sometimes rather crooked, is undoubtedly longitudinal, and its structure resembles that of the Polypodiaceae, from which it differs principally in the size, shape, and number of the component

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[*] Ann. Bot. **16**: 95–121. *pl. 1.* 1902.

[†] Pflanzenbiol. Schild. **2**: 281. 1893.

[‡] Citations are given under the head of Synonymy.

cells. Diels has recognized this relationship in Engler & Prantl's Pflanzenfamilien, where *Ceratopteris* is ranked as a family (Parkeriaceae) coördinate with the Polypodiaceae, Gleicheniaceae, and others in the group Eufilicinae. This seems to be a logical grouping but the indeterminate fructification is perhaps evidence of a less highly organized development and, as has been suggested by Dr. Underwood,* may be taken to indicate for this family a low position in the order to which it belongs.

The conclusions reached as to the classification of these plants are based on an examination of the material in the Underwood Fern Herbarium in the New York Botanical Garden, the Eaton Herbarium at Yale University, and the National Herbarium, and in the citation of specimens, these herbaria are indicated by the letters U, E, and N. I wish to take this opportunity to thank Professor Alexander W. Evans of Yale, and Mr. W. R. Maxon of the National Museum, for the privilege of examining the material in their care.

The following forms seem to deserve recognition as species:

Lamina of the mature sterile leaf usually oblong or narrowly deltoid, pinnately divided; spores 32.
  Annulus well developed, 20–70-celled, lip-cells present; segments of the sporophyl mostly more than 2 cm. long............1. *C. thalictroides.*
  Annulus few-celled, 4–10, lip cells wanting; segments of the sporophyl mostly less than 1.5 cm. long............2. *C. Lockharti.*
Lamina of the sterile leaves broadly deltoid or pentagonal.
  Spores 32; the annulus few-celled, lip-cells wanting; mature sterile leaves floating, the lamina pentagonal, not more than 20 cm. long, 2–4-pinnatifid............3. *C. pteridoides.*
  Spores 16; the annulus well developed, lip-cells present; mature sterile leaves emergent, the lamina deltoid, 25–40 cm. long, 2-pinnate............4. *C. deltoidea.*

1. Ceratopteris thalictroides (L.) Brongn. Bull. Sci. Soc. Philom. **1821**: 186. *f. 3, 4.* 1821

Acrostichum thalictroides L. Sp. Pl. 1070. 1753.
Acrostichum siliquosum L. Sp. Pl. 1070. 1753.

Leaves erect, 6–75 cm. long, the stipes 4–27 cm. long; lamina of the sterile leaf narrowly deltoid or oblong, 3.5–28 cm. long, 2–13 cm. broad, 1–2-pinnate-pinnatifid, the pinnae ovate-lanceolate or oblong, the segments linear-lanceolate to oblong or

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* Fernwort Papers, Linn. Fern Chapt. 17. 1900.

ovate-lanceolate, blunt or acute, 1–2.5 cm. long, 2–5 mm. broad: fertile leaves taller than the sterile, the lamina oblong, 20–55 cm. long, 10–30 cm. broad, 2–5 times pinnately divided, the pinnae and smaller divisions often distant, the ultimate segments flagelliform, 1–6 cm. long, the margins revolute, covering 2 or 3 rows of areolae, and 1 or 2 rows of sporangia with well-developed annulus and lip-cells: spores 32. [FIGURE 1.]

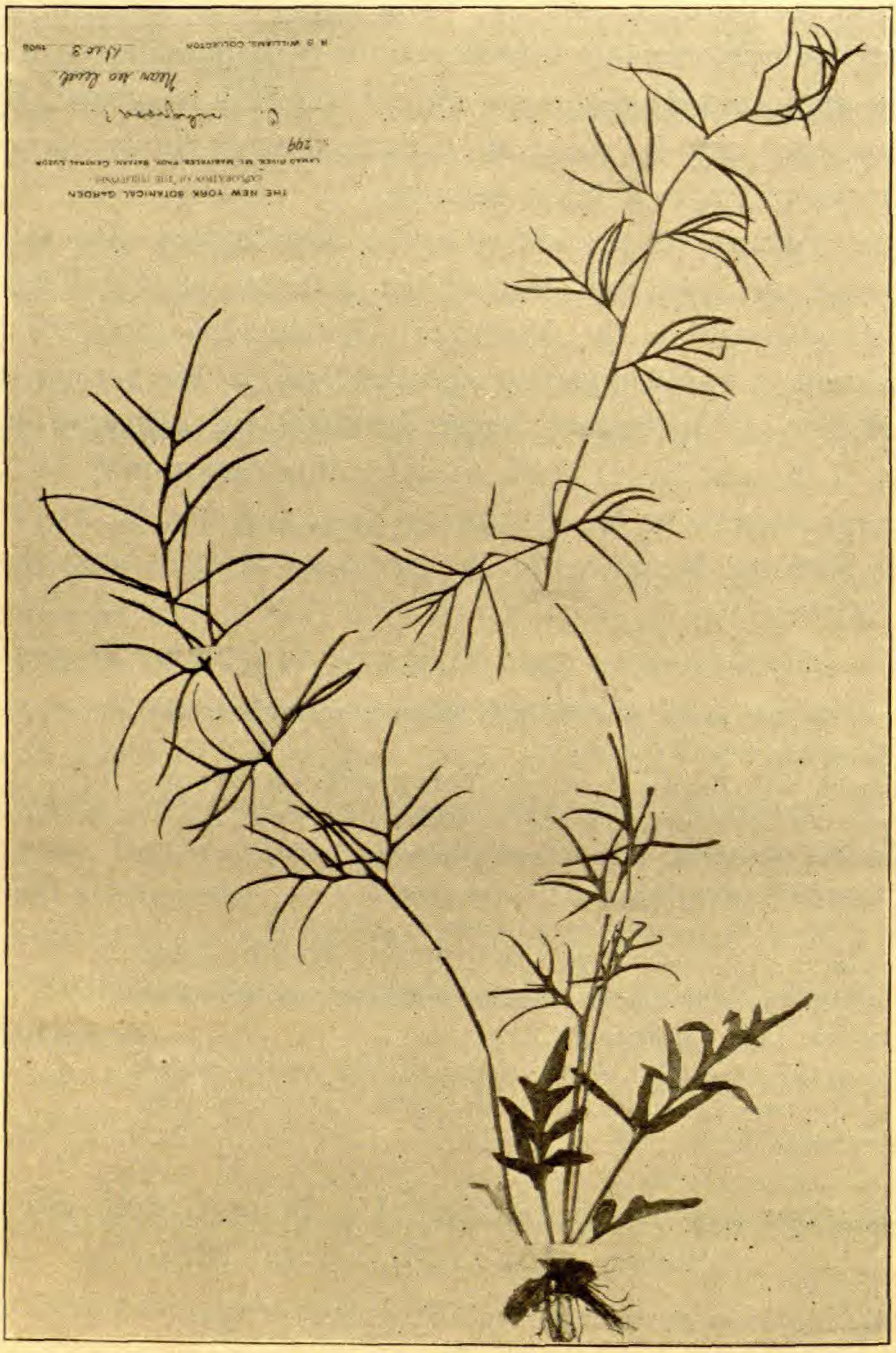

FIGURE 1. *Ceratopteris thalictroides* (L.) Brongn., Lamao River, Mt. Mariveles, Prov. Bataan, Central Luzon, Philippine Islands, *R. S. Williams 299*. About one third the natural size.

Type from Ceylon.

The Old World material appears to be all alike in sporangial characters. In leaf-form there is considerable variation, and probably also in habit and habitat, but the information at hand does not furnish any clue for the separation of the various forms as species. Linnaeus recognized two species, *Acrostichum siliquosum* and *A. thalictroides*, both based on Ceylon material and both forms which can be identified with material of recent collections, but it is not clear that they are more than seasonal variations of the same plant, or perhaps modifications induced by adaptations to different habitats. Mr. R. S. Williams, who has collected the *siliquosa* form in the Philippines, tells me that he found it in grassy hollows, forming small clumps not very dissimilar in appearance to the grass itself, and in situations in which it may not have been submerged at any time. Such a plant would perhaps lend itself more readily to variation in the moisture available than the strictly aquatic American plants, so that its wider distribution and variation are not so anomalous as might first appear.

It appears to be generally distributed in the Old World tropics. From the material seen the following distribution may be recorded: Japan, Formosa, the Philippines, Himalayan region to Ceylon, Malay Peninsula, Java, Andaman Islands, Queensland (Moreton Bay), Madagascar, and Jamaica (?). As already noted some striking forms are included which probably deserve separation. I have not seen any West African material (*C. cornuta*) so do not know whether this should also be included in the *thalictroides* complex or not. The reference to Jamaica is based on a specimen in the National Herbarium * which agrees almost exactly with some of Mr. Williams' Philippine material. It is, however, without data other than that of a stock printed label, no time or place of collection being given, so that it is possible that the plant is not really Jamaican.

2. CERATOPTERIS LOCKHARTI (Hook. & Grev.) Kunze, Linnaea 23: 241. 1850

Parkeria Lockharti Hook. & Grev. Icon. Fil. *pl. 97*. 1828. (In footnote.)

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* The label heading reads as follows: Flora Jamaicensis | No. 124. Coll. John Hart, Supt. Govt. Cinchona Plantation, | Gordon Town, Jamaica, W. I. | *Ceratopteris thalictroides* Brong.

? *Ceratopteris Richardii* Brongn. Dict. Class. Hist. Nat. **3**: 351. 1823.

Slender plants, growing partly submerged: leaves slender, up to 35 cm. long, the stipes slender, terete or flattened, 5–24 cm. long: sterile leaves erect and emergent when mature, 8–18 cm. or more long, the lamina oblong or deltoid, 4.5–9 cm. long, 4–5 cm. broad, 1–2-pinnate-pinnatifid, the pinnae varying from deltoid below to lanceolate above, acute, the ultimate segments lanceolate to deltoid: sporophyls somewhat taller, 10–35 cm. long, the lamina 4 times divided, the ultimate segments linear, 0.5–2 cm. long: sporangia in one row along each margin, the annulus few-celled; spores 32. [FIGURE 2.]

Type from Trinidad, *Lockhart.*

Specimens seen: Trinidad, *no. 1260* Botanical Garden Herbarium, N; Guiana: *Leprieur*, Cayenne, U, N; *Jenman*, Demerara, Glen Island, Essequibo River, "growing in the lake with *Victoria*," U.

Aside from the sporangial differences, this plant resembles *C. siliquosa* considerably, but differs somewhat in general habit, frequents apparently a different habitat, and is particularly unlike the Old World species in the length of its stipes and in the shortness of its fertile segments. A figure of the Jenman sheet is shown in FIGURE 2. The sterile leaves are from a different plant from the sporophyls and probably represent the floating stage. The Cayenne sheet in the National Herbarium had been identified by Leprieur as *C. Richardii* Brongn., but I have been unable to verify this identification, so cannot vouch for its correctness. If it proves to be authentic, Hooker & Greville's name will become a synonym.

3. CERATOPTERIS PTERIDOIDES (Hook.) Hieronymus, Bot. Jahrb. **34**: 561. 1905

Parkeria pteridoides Hook. Exot. Fl. **2**: 147. 1825.

Ceratopteris Parkeria J. Smith, Jour. Bot. Hook. **4**: 70. 1841.

Plants growing floating or near shore and rooted in soil: leaves of the floating plants up to 25 cm. long, the stipes expanded midway, bulbous: lamina in earliest sterile leaves simple, ovate or deltoid, in following leaves broadly 3-lobed, deltoid or rhombic, in still later leaves pentagonal, 6–20 cm. long, 6–20 cm. broad, 1–3 times pinnatifid, with 2–4 pairs of primary divisions, the ultimate segments broadly ovate or deltoid, usually blunt or rounded: lamina in succeeding leaves 2–4 times divided with narrowly oblong, rounded segments, grading into the slightly taller sporophyls with linear segments: leaves in the anchored plants as above but with the stipes not bulbous, with the sporophyls about twice as tall as the sterile leaves and without intermediate forms: sporangia in one row along each margin, without lip-cells, the annulus 4–10-celled, rarely more; spores 32.

FIGURE 2. *Ceratopteris Lockharti* (Hook. & Grev.) Kunze, Glen Island, Essequibo River, Demerara, British Guiana, *Jenman*. About one third the natural size.

Type from British Guiana, Essequibo, *Parker.*

Specimens seen: British Guiana, *Parker; Jenman*, U; *Leprieur;* Brazil: *Riedel; Regnell;* Florida: *A. H. Curtiss*, St. John's River, *3690*, U, E, and N, Withlacoochee River, *5973*, N; Cuba: *Wright 3936*, E.

It is hard to understand how this very distinct species has so long been considered merely a form of the very different Old World species. Judging from the information obtainable, the two occupy entirely different habitats, the American species occurring always in the water, either floating or at least with the stem and roots submerged, the other, according to Mr. Williams' notes, only occasionally if at all in normally inundated soil. Goebel, who has seen Hooker's species growing in Guiana, states that it occurs either floating or rooting in the mud nearer shore, and that the two types differ considerably in habit. In the floating plants, the stipes are, as noted in the description, bulbous, and the leaves are all rather short. This is the form collected by A. H. Curtiss in the St. John's River, Florida, where, according to D. C. Eaton, he found it in water ten feet deep, and probably also that figured in the Engler & Prantl Pflanzenfamilien under the family Parkeriaceae. It is in this form that the sterile leaves grade into the sporophyls by insensible modifications in the shape of the ultimate segments. In the near shore form this gradation does not occur, the sporophyls are much taller than the sterile leaves, and the stipes are not bulbous. This form has been well figured by Hooker & Greville, Icones Filicum *pl. 97. f. 2.*

4. **Ceratopteris deltoidea** sp. nov.

Stem slender, rootless, the roots developed from a swollen place in the stipe a short distance from the stem: leaves alternate, successive in development, up to 65 cm. long; youngest leaves sessile or short-stalked, the lamina simple, ovate or deltoid: following leaves broadly pentagonal or deltoid, 3–7-lobed, the lobes mostly deltoid, acute, the basal division sometimes also lobed: mature sterile leaves 25–50 cm. long, the stipes 10–20 cm. long, sparsely scaly below, flattened, the lamina deltoid, acute, 20–35 cm. long, 15–25 cm. broad, pinnate-pinnatifid or 2-pinnate-pinnatifid on the lowest pinnae: pinnae broadly deltoid, 9–12 cm. long, 9–14 cm. broad, acute, oblique, the penultimate divisions cut half way to the mid-vein, the ultimate segments large and full, 3–4 cm. long, 2–3 cm.

FIGURE 3. *Ceratopteris deltoidea* Benedict, Orange Bay River, Jamaica, *N. L. Britton & Arthur Hollick 2158*. About one third the natural size.

broad, broadly deltoid, acute, the margins broadly and shallowly lobed, viviparous in the sinuses and in the axils of the larger divisions, the venation reticulate, the areolae without included veinlet, narrow: fertile leaves 40–65 cm. long, the stipes 15–20 cm. long, the lamina deltoid, 30–40 cm. long, 25–37 cm. broad, 4 times pinnately divided, the ultimate segments linear, falcate, 0.5–2 cm. long, 0.5–2 mm. broad, the ultimate and penultimate divisions viviparous in the axils, with narrow evenly revolute margins, each covering a single row of sporangia. [FIGURE 3.]

Type from Jamaica, Orange Bay River, *N. L. Britton & Arthur Hollick 2158*, 14 March, 1908, — in the Underwood Fern Herbarium. Collected at the same time and place by Harris, *no. 10,255*. Also collected in Jamaica by Jenman, Clarendon, 1874–79.

Additional material:

Porto Rico: "Coamo in fossis," 1886, *P. Sintenis 3277*, N. Consists mostly of sporophyls; ultimate segments of the sterile leaves lanceolate. Spores possibly sometimes fewer than 16 per sporangium.

Florida: *A. P. Garber*, Prairie Creek, So. Florida, July, 1878. E. (Vide D. C. Eaton, Bull. Torrey Club **6**: 264. 1878.) Only sterile leaves seen, these with somewhat narrower segments than those of the type.

Louisiana: *R. S. Cocks*, Shores of Lake Ponchartrain, rooting in mud, 1890, U. *Hasse*, in water, New Orleans, 1885, U — an imperfect specimen, with the segments narrower than in the type.

Guiana: *Jenman*, Demerara, coast lands, in trenches, 1895. U. Only sporophyls seen.

There seems at present little reason to doubt that all this material may be comprised in one species, but for the purposes of greater exactness, only the Jamaican material was considered in drawing up the above description. The only modification made necessary by the inclusion of the remaining collections is in connection with the width of the sterile segments as noted in the various citations. As far as I have seen, this is the only species in which the number of spores is typically 16 to each sporangium.

In the type locality, the Orange Bay River is, as I learn from Dr. Britton, a small clear flowing stream, a foot or two in depth. The plants grew abundantly for some distance along the river, mostly in the quieter reaches near shore, but sometimes well out in the current. The plant does not float except possibly in its juvenile stage of growth.

In the synonymy which follows, the species recognized as valid are indicated in small capitals, the names which deserve further investigation are in Roman and the straight synonyms are in italics:

CERATOPTERIS Brongn. Bull. Sci. Soc. Philom. **1821**: 186. 1821.

Teleozoma R. Br., Richardson in Franklin, Narrative of Journey, 767. 1823.

Ellobocarpus Kaulf. Enum. Fil. 147. 1824.

Parkeria Hook. Exot. Fl. **2**: *pl. 147.* 1825.

Furcaria Desv. Mém. Soc. Linn. Paris **6**: 292. 1827.

Ceratopteris cornuta Le Prieur, Ann. Sci. Nat. I. **19**: 103. *pl. 4, A.* 1830.

Pteris cornuta Pal. de Beauv. Fl. Owar. **1**: 63. *pl. 37.* 1807 (?). (Type from Wari [Owari], West Africa.)

Ellobocarpus cornutus Kaulf. Enum. Fil. 148. 1824.

Furcaria cornuta Desv. Mém. Soc. Linn. Paris **6**: 292. 1827.

Onychium cornutum Hasskarl, Tijdschr. Nat. Gesch. **10**: 115. 1843.

Ceratopteris Gaudichaudii Brongn. Bull. Sci. Soc. Philom. **1821**: 186. 1821. (Type from the Marianne Islands.)

CERATOPTERIS LOCKHARTI Kunze, Linnaea **23**: 241. 1850.

Parkeria Lockharti Hook. & Grev. Ic. Fil. *pl. 97.* 1828. (Type from lakes near Arima, Trinidad.)

CERATOPTERIS PTERIDOIDES Hieronymus, Bot. Jahrb. **34**: 561. 1905.

Parkeria pteridoides Hook. Exot. Fl. **2**: *pl. 147.* 1825. (Type from British Guiana, Essequibo, *Parker.*)

Ceratopteris Parkeria J. Smith, Jour. Bot. Hook. **4**: 70. 1841.

Ceratopteris Richardii Brongn. Dict. Class. Hist. Nat. **3**: 351. 1823.

CERATOPTERIS THALICTROIDES Brongn. Bull. Sci. Soc. Philom. **1821**: 186. *f. 3, 4.* 1821.

Acrostichum thalictroides L. Sp. Pl. 1070. 1753. (Type from Ceylon.)

Acrostichum siliquosum L. Sp. Pl. 1070. 1753. (Type from Ceylon.)

Pteris thalictroides Swartz, Jour. Bot. Schrad. **4**: 651. 1801.

Pteris siliquosa Pal. de Beauv. Fl. Owar. **1**: 63. 1807 (?).

Ellobocarpus oleraceus Kaulf. Enum. Fil. 148. 1824.

Furcaria thalictroides Desv. Mém. Soc. Linn. Paris **6**: 292. 1827.

Teleozoma thalictroides R. Br., Richardson in Franklin, Narrative of Journey, 767. 1823.

Naias obvoluta Blanco,* Flora Filip. 460. 1845. [Ed. 2.]

NEW YORK BOTANICAL GARDEN.

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* I am indebted to Dr. C. B. Robinson for this reference.

Notes on Carex—V

KENNETH KENT MACKENZIE

Carex salinaeformis sp. nov.

" *Carex salina* Wahl. var. *minor* Boott," W. Boott in Bot. Calif. **2**: 242. 1880.

Culms low and rather slender, 5 15 cm. high, from long-creeping, slender rootstocks, phyllopodic, smooth or nearly so on the bluntish angles, generally exceeded by the leaves, not reddened or fibrillose at base. Leaves with well-developed blades usually five to eight to a fertile culm, the blades flat, 2–3 mm. wide, 3–12 cm. long, roughened towards the apex; terminal spike staminate, short- to long-peduncled, 8–12 mm. long, 2–5 mm. wide, the scales obovate, obtuse, reddish brown with lighter center and often strongly developed hyaline margins; pistillate spikes three or four, widely separate, or upper approximate, erect, the upper shortly exsert-peduncled, the lower strongly exsert-peduncled, narrowly oblong, 6–12 mm. long, 3–4 mm. wide, containing 8–15 appressed ascending perigynia closely packed in few ranks; bracts leaflet-like, often exceeding inflorescence, their sheaths conspicuous, 3–15 mm. long; scales ovate, from cuspidate (the lower) to obtuse (the upper), reddish brown with broad lighter center and slightly hyaline margins, as wide as the perigynia but generally shorter; perigynia oblong-ovate, flattened-suborbicular in cross-section, rather lightly several-nerved, 3 mm. long, 1.75 mm. wide, rounded at base and apex, beakless but slightly constricted at apex; achenes lenticular, their faces suborbicular, 1.5 mm. long; stigmas two.

The above species is founded on Bolander's *4702*, collected in 1866 and represented by two sheets in the Torrey herbarium. In the Botany of California the plant in question is referred to *Carex salina* Wahl. var. *minor* Boott, but the strongly developed sheaths of the bracts forbid any such disposition as do also the noticeably nerved perigynia. It is, indeed, a well-marked species, and is one of several such furnished by Mendocino County.

Carex macrosperma sp. nov.

Culms tall, stiff and erect, but rather slender, 6–10 dm. high, from thick rootstocks, phyllopodic, smooth or nearly so on the bluntish angles, exceeding the leaves, fibrillose at base. Leaves with well-developed blades about seven to fifteen to a fertile culm, the blades 2.5–6 mm. wide with strongly developed midrib and revolute margins, strongly scabrous, usually 2–4 dm. long, attenuate; spikes in erect peduncled panicles, the lower panicle solitary, on a peduncle 6–12 cm. long, the upper panicles in pairs, shorter-peduncled, the panicle bracts leaflet-like, strongly sheathing; panicles ovoid, 2.5–5 cm. long, 1.5–2 cm. wide, containing 8–15 sessile and often somewhat compound widely spreading spikes; spikes 5–10 mm. long with 2–5 pistillate flowers in the middle and about as many staminate flowers at apex, the lower scales usually empty; spathella prominent; bracts small, awn-pointed, 2–5 mm. long; scales obovate, obtuse or short-awned, brown with lighter center and hyaline margins, the pistillate half the length of the perigynia; perigynia 4.5–5 mm. long, 1.9 mm. wide, the body obovoid, sharply triangular, bright green, rather faintly nerved, tapering at base, abruptly contracted at apex into a somewhat roughened and bent beak, 1.5 mm. long, with bidentate apex; achenes triangular, 3 mm. long, ovoid, short-stipitate, closely invested by perigynia; stigmas three.

Type, C. G. Pringle's *4840*, collected August 27, 1894, Sierra de San Felipe, Oaxaca, Mexico, 6,000–7,000 feet, distributed as *Carex polystachya* Swartz, and preserved in the herbarium of Columbia University.

This species is closely related to *Carex cladostachya* Wahl., but has been readily distinguished from the rather numerous specimens of that species which I have examined, by the few-flowered spikes and the noticeably larger perigynia. *Carex polystachya* Swartz is in all probability nothing more than *Carex cladostachya*. The differences attempted to be drawn between these two plants do not hold good in any very large series of specimens, and Dr. N. L. Britton, who has had Jamaica (from which both species came) thoroughly explored, is strongly of the opinion that they are the same.

Carex fuscotincta sp. nov.

Culms tall, stiff and erect, but rather slender, 5–8 dm. high, from thick elongated rootstocks, phyllopodic, smooth or nearly so on the bluntish angles, exceeding the leaves, somewhat fibrillose at base. Leaves with well-developed blades some 7–15 to a fertile culm, the blades 2.5–4 mm. wide, flat with slightly revolute margins, strongly roughened, usually 1.5–3 dm. long, attenuate; spikes in erect peduncled panicles, the lower panicle solitary on a peduncle about 8 cm. long, the upper panicles in pairs, shorter-peduncled, the panicle bracts leaflet-like, strongly sheathing; panicles ovoid, 1.5–4.5 cm. long, 1–2 cm. wide, containing 6–12 sessile and sometimes somewhat compound widely spreading spikes; spikes 4–7 mm. long, 3.5–6 mm. wide with 5–12 pistillate flowers at base and with a few very inconspicuous staminate flowers at apex, which are usually exceeded by the perigynia; lower scales frequently empty; spathella prominent; bracts usually scale-like, but occasionally 3–15 mm. long; scales ovate, very obtuse, or rarely awned, brown with lighter center and hyaline margins, the pistillate half the length of the perigynia; perigynia 3–3.5 mm. long, 1.2 mm. wide, the body obovoid, sharply triangular, green, rather faintly nerved, tapering to a substipitate base, abruptly contracted at apex into a somewhat roughened and slightly bent beak 1 mm. long, with bidentate apex; achenes triangular, 2 mm. long, closely invested by perigynia; stigmas three.

Type, C. G. Pringle's *4839*, collected August 19, 1894, Sierra de San Felipe, Oaxaca, Mexico, 7,500 feet, distributed as *Carex cladostachya* Wahl., and preserved in the herbarium of Columbia University.

The following key will serve to distinguish this species from its allies:

Perigynia 4.5–5 mm. long...*C. macrosperma.*
Perigynia 2.5–4 mm. long.
  Scales generally very obtuse, brown; spikes short, oblong or suborbicular; perigynia sides weakly nerved.............................*C. fuscotincta.*
  Scales acuminate to cuspidate, green or straw-colored; spikes oblong to linear-oblong; perigynia sides strongly nerved.............*C. cladostachya.*

Carex perstricta sp. nov.

Culms densely tufted from thick matted rootstocks, phyllopodic, 2.5–5 dm. high, exceeding leaves, smooth or nearly so on angles, prominently fibrillose at base. Leaves with well-developed blades six to ten to a fertile culm, mostly clustered at the base, the blades 1.5 mm. wide or less, the margins strongly revolute, glaucous, usually 1–2 dm. long, much roughened; spikes 5–7, androgynous, forming a head 2.5–5 cm. long, the lower two or three more or less strongly separate and distinct, the upper closely aggregated (the lowermost rarely slightly compound), strictly erect, short-peduncled or sessile, linear-oblong, 5–12 mm. long, 2.5–3.5 mm. wide and containing 5–12 appressed-ascending perigynia below in few ranks, and with about as many staminate flowers above; bracts leaflet-like, not sheathing, exceeding the inflorescence;

scales ovate, obtuse or acute, white-hyaline with green center, the pistillate two thirds the length of perigynia; perigynia 2.5 mm. long, strongly white-scabrous, the body oblong-obovoid, sharply triangular, 1 mm. wide, nerved, tapering at base, abruptly contracted into a short bidentate beak 0.5 mm. long; achenes triangular, oblong-obovoid, nearly 2 mm. long, closely surrounded by perigynia; stigmas three.

Type, C. G. Pringle's *2630*, collected June 5, 1889, mountains near Monterey, Nuevo Leon, Mexico, named *Carex Schiediana* Kunze by Professor L. H. Bailey, and preserved in the herbarium of Columbia University.

To be distinguished from *Carex Schiediana* Kunze, to which it is related, as follows:

Blades 1.5 mm. or less wide, strongly revolute, glaucous; perigynia 1 mm. wide.. *C. perstricta.*
Blades 2–3 mm. wide, flat, green; perigynia 1.5 mm. wide.............. *C. Schiediâna.*

Carex nubicola sp. nov.

Carex festiva var. *decumbens* Holm, Am. Jour. Sci. **166**: 20, 26. 1903. Not *Carex decumbens* Ehrh.

In dense clumps, not stoloniferous, nor with long running rootstocks, the culms 12–35 cm. high, aphyllopodic, erect or more or less strongly curving, usually exceeding the leaves, smooth or nearly so on the angles. Leaves with well-developed blades usually three to five to a fertile culm, clustered near the base, the blades flat, 2–3 mm. wide, 6–12 cm. long, roughened at apex; inflorescence consisting of four to seven spikes densely clustered in an ovoid or globular head 12–18 mm. long and 9–18 mm. wide, the bracts inconspicuous, the upper scale-like, the lower cuspidate-prolonged, usually much shorter than the head; spikes ovoid or subglobose, 5–9 mm. long, 4.5–8 mm. wide, containing above 15–35 closely packed ascending perigynia with erect or ascending beaks, and below a few inconspicuous staminate flowers; scales ovate, acute, blackish, with lighter center and hyaline margins, much narrower and shorter than perigynia; perigynia rather narrowly to broadly ovate, very flat and strongly winged, 2–2.75 mm. wide, 4.5–5.5 mm. long, rather weakly nerved, blackish or brownish-tinged, rounded at base, serrulate above, abruptly contracted into a somewhat bidentate beak about one third the length of whole; achenes lenticular, oblong-obovoid, stipitate, 1.75 mm. long, 0.75 mm. wide; stigmas two.

This is one of the most marked of the numerous forms which have been referred to *Carex festiva* Dewey, and must be kept distinct if any effort at all is made to understand the closely related species of this group. It is most closely related to *Carex ebenea* Rydb., but usually may be quickly distinguished as follows:

Perigynia narrowly to broadly ovate, their beaks spreading.................... *C. nubicola.*
Perigynia lanceolate, their beaks generally appressed........................... *C. ebenea.*

The large perigynia, very dark-appearing heads, and generally low height separate it from *Carex festiva* itself.

The following specimens have been examined:

COLORADO: High mountains about Empire, 12,000 ft., *Patterson 291*, Sept. 6, 1892; Pagosa Peak, 12,000 ft., *Baker 232.*

WYOMING: Buffalo Fork, 10,500 ft. to 10,800 ft., *Tweedy 425, 435*, Aug., 1897; Mt. Leidy, 9,000 ft., *Tweedy 407*, Aug., 1897; Dunraven Peak, *A. & E. Nelson 6692*, Aug. 27, 1899; Headwaters Cliff Creek 9,000 ft., *C. C. Curtis*, Aug. 9–18, 1900.

MONTANA: Electric Peak, 10,000 ft., *Rydberg & Bessey 3811*, Aug. 18, 1897; Long Baldy, Little Belt Mts., 7,000–8,000 ft., *Flodman 304*, Aug. 19, 1896.

Carex Holmiana sp. nov.

Culms slender, 4–7 dm. high, phyllopodic, much exceeding the leaves, roughened above on the sharp angles, reddened and somewhat filamentose at base. Leaves with well-developed blades five to ten to a fertile culm, clustered near the base, the blades flat with somewhat revolute margins, 2–3.5 mm. wide, usually 1–3 dm. long, somewhat roughened towards apex; inflorescence consisting of three or four strictly erect, oblong-cylindric, approximate or slightly separate spikes, 16–30 mm. long, 7–10 mm. wide, the lateral pistillate, short-peduncled or nearly sessile and with 30–50 ascending perigynia closely packed in several or many ranks, the terminal similar, short-peduncled, but the lower fourth or third staminate; lowest bract leaflet-like, shorter than the inflorescence or exceeding it, auricled at base, the upper bracts reduced; scales ovate or ovate-lanceolate, abruptly more or less strongly cuspidate, brown with conspicuous lighter center and narrowly hyaline margins, the pistillate about as wide as and exceeding perigynia; perigynia oval, much flattened except where distended by ripening achene, 4 mm. long, 2 mm. wide, not darkened, finely many-nerved, rounded at base and apex, and beakless, the orifice entire; achenes triangular, obovoid, 2.2 mm. long, 1.2 mm. wide, sessile, dark-colored; stigmas three.

Type in the herbarium of the New York Botanical Garden, collected by F. K. Vreeland, *no. 1121*, in marshy ground at John's Lake, northern Montana, altitude 1050 m., on Aug. 19, 1901. Professor Umbach's *303*, collected in a peat bog at Lake MacDonald, Montana, on Aug. 20, 1901, is also to be referred to this species.

While outwardly resembling *Carex Idahoa* Bailey, this species is easily differentiated from that species, as follows:

Perigynia strongly flattened, many-nerved, beakless, 4 mm. long; scales abruptly cuspidate..........*C. Holmiana.*
Perigynia not flattened, not nerved, beaked, 2.5 mm. long; scales acuminate-tapering..........*C. Idahoa.*

Named in honor of Dr. Theodor Holm who has done much to make known obscure species of North American Cyperaceae, and who indicated the type specimen as a distinct species several years ago.

Carex Abramsii sp. nov.

Culms very slender, 4–7 dm. high, phyllopodic, very much exceeding the leaves, somewhat roughened above on the angles, fibrillose at base, the rootstocks slender, elongate. Leaves with well-developed blades seven to fifteen to a fertile culm, mostly clustered near the base, and with the blades flat, 1.75–2.5 mm. wide, 5–15 cm. long, and roughened towards apex, but the two to four upper very widely separated, with elongated sheaths 2–4 cm. long and often with reduced blades; terminal spike staminate, sessile or short-peduncled, 6–12 mm. long, 2.5–3.5 mm. wide, the scales obovate, obtuse, brownish, with lighter midrib and hyaline margins; pistillate spikes three or four, erect, the upper approximate and sessile or short-peduncled, the lowest more or less strongly remote and exsert-peduncled, the spikes linear-oblong, staminate at apex, 5–14 mm. long, 2.5–4 mm. wide, and containing 5–15 ascending perigynia rather closely packed in few ranks; lowest bract leaflet-like, strongly sheathing, exceeded by inflorescence, the upper bracts much reduced; scales very broadly ovate, obtuse to short-acute, brown with lighter center and broad hyaline margins, wider but slightly shorter than mature perigynia; perigynia 3.5 mm. long, glabrous, tinged reddish brown, the body triangular, obscurely few-nerved on outer and several-nerved on inner face, broadly obovoid, 1.25 mm. wide, tapering to a substipitate base, abruptly beaked, the beak 1 mm. long, somewhat oblique, 2-edged, slightly serrulate, the orifice 2-toothed, somewhat hyaline; achenes triangular, suborbicular, sessile, filling perigynia; stigmas three.

Type in the herbarium of the New York Botanical Garden, collected by Le Roy Abrams, *no. 2816*, in *cienaga* between Bear Valley and Bluff Lake, San Bernardino County, California, July 31, 1902: Mr. Abrams' *no. 2050*, collected at Deep Creek, altitude 5,500 feet, in the same county, in July, 1901, is also to be referred to this species.

This very distinct plant is unlike anything else known from the United States. It is probably most closely related to species like *Carex luzulaefolia* W. Boott, but the small few-flowered spikes and small perigynia quickly distinguish it.

Carex Smalliana sp. nov.

Carex folliculata β Boott, Ill. Car. **2**: 91. *pl. 269*. 1860.

Carex folliculata var. *australis* Bailey, Proc. Am. Acad. **22**: 62. 1886.

Clumps large, with slender elongated rootstocks, the culms 4–8 dm. high, exceeding the leaves, smooth or nearly so on the angles, somewhat fibrillose at base. Leaves with well-developed blades three to twelve to a fertile culm, the lower clustered, the upper widely separate and with conspicuous elongated sheaths, the blades flat, 4–12 mm. wide, usually 1–4 dm. long, much roughened towards apex; staminate spike one, short-peduncled, 2–3 cm. long, 2.5 mm. wide, the scales oblanceolate or oblong-obovate, obtuse, or the lower acute or acuminate, whitish-hyaline with green center; pistillate spikes one to three, widely separate, erect, the lower on long rough peduncles, the upper short-peduncled or nearly sessile, the spikes suborbicular, 1.5–2.5 cm. long, 2–3 cm. wide, conspicuously staminate at apex, and with 8–20 widely spreading perigynia below, rather loosely arranged in few ranks; bracts leaf-like with conspicuous elongated sheaths, exceeding inflorescence; scales ovate, varying from acute to cuspidate, whitish-hyaline with strongly nerved green center, somewhat narrower and about half the length of perigynia; perigynia narrowly lanceolate, 10–14 mm. long, 2.5 mm. wide at base, very green, finely many-nerved, rounded at base, gradually tapering into the bidentate beak, the teeth 0.5–1 mm. long; achenes triangular, sessile, obovoid, 3.5 mm. long, 2 mm. wide; stigmas three.

Named for Dr. John K. Small.

This well-marked southern species is to be separated from the northern *Carex folliculata* L. as follows:

Perigynia narrowly lanceolate, 2.5 mm. wide at base; pistillate scales acute to cuspidate, averaging half length of perigynia; pistillate spikes staminate at apex..*C. Smalliana.*

Perigynia lanceolate, 3 mm. wide at base; pistillate scales strongly cuspidate, averaging three fourths the length of perigynia; pistillate spikes not normally staminate at apex..*C. folliculata.*

Specimens examined:

GEORGIA: Reidsville, Tattnall Co., *Harper 2159,* April 26, 1904; Muckalee Creek, Sumter Co., *Harper,* July 3, 1897; Bullock Co., *Harper 882,* June 11, 1901.

SOUTH CAROLINA: Summerville, *Gibbs,* May 25, 1855.

ALABAMA: Mobile Co., *Mohr,* May, 1885; Auburn, Lee Co., *Earle & Underwood,* May 9, 1896.

FLORIDA: Duval Co., *Fredholm 5160,* May 5, 1902; St. Augustine, *Canby,* April, 1869; "Florida," *Chapman.*

MISSISSIPPI: Ocean Springs, *Tracy 4830,* April 9, 1898, also March 30, 1887; Sandersville, *Tracy 3335, 3337,* June 10, 1897; Beauvoir, *Tracy 4827,* May 13, 1898.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909) ✓

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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North American Flora

THIS work is designed to present descriptions of all plants growing independently of cultivation, in North America, here taken to include Greenland, Central America, the Republic of Panama, and the West Indies, except Trinidad, Tobago, and Curaçao and other islands off the north coast of Venezula, whose flora is essentially South American.

It will be published in parts at irregular intervals by the New York Botanical Garden through the aid of the income of the David Lydig Fund bequeathed by Charles P. Daly.

It is planned to issue parts as rapidly as they can be prepared, the extent of the work making it possible to commence publication at any number of points. The completed work will form a series of volumes with the following sequence:

Volume 1. Mycetozoa, Schizophyta, Diatomaceae.
Volume 2 to 10. Fungi.
Volumes 11 to 13. Algae.
Volumes 14 and 15. Bryophyta.
Volume 16. Pteridophyta and Gymnospermae.
Volumes 17 to 19. Monocotyledones.
Volumes 20 to 30. Dicotyledones.

The preparation of the work has been referred by the Scientific Directors of the Garden to a committee consisting of Dr. N. L. Britton, Dr. W. A. Murrill and Dr. J. H. Barnhart.

Professor George F. Atkinson, of Cornell University, Professors Charles R. Barnes and John M. Coulter, of the University of Chicago, Mr. Frederick V. Coville, of the United States Department of Agriculture, Professor Edward L. Greene, of the United States National Museum, Professor Byron D. Halsted, of Rutgers College, and Professor William Trelease, of the Missouri Botanical Garden, have consented to act as an advisory committee.

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SEPTEMBER, 1909

Stimulation of storage tissues of higher plants by zinc sulphate

BERENICE SILBERBERG

The fact that chemical poisons under certain conditions and in certain quantities are of a stimulating nature to plants has been well established through the work of Raulin, Richards, Ono, Yashudi, Latham, Watterson, and others. A complete list of the references on the work done in this field may be found in the papers by M. E. Latham * and A. Watterson.† These investigations, however, have been conducted chiefly upon lower plants and the seedlings of higher ones. Little has been done upon the mature forms of the higher plants, or upon their various parts and tissues. This article attempts to describe some investigations on the effect of zinc sulphate stimulation on the storage tissues of some of the higher plants.

The work was done in the botanical laboratory of Barnard College, Columbia University, during the years 1907 and 1908, under the direction of Dr. H. M. Richards, to whom the writer is deeply indebted for his kind interest and assistance.

The investigation was in two parts, — first, the effect of solutions of zinc sulphate of various strengths upon the formation of periderm and callus, and second, the effect of such solutions upon the respiration of the tissue.

All zinc sulphate solutions weaker than normal were made up

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* Latham, M. E. Stimulation of *Sterigmatocystis* by chloroform. Bull. Torrey Club 32: 337. 1905.

† Watterson, A. The effect of chemical irritation on the respiration of fungi. Bull. Torrey Club 31: 291. 1904.

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from a normal solution, prepared as follows: The zinc sulphate used was Merck's "highest purity reagent." For 100 c.c. of a normal solution, 14.3786 gm. of $ZnSo_4$ would be theoretically required (allowing $7H_2O$ for water of crystallization). 14.51923 gm. were weighed out, this differing from the required by 0.14063 gm. 14.3786 : 100 :: 0.14063 : x. $X = 0.978$ c.c. of water. Therefore, 100.978 c.c. of water added to 14.51923 gm. of zinc sulphate makes a normal solution. The water was the distilled water used in the laboratory. This was used also for washing all apparatus.

The apparatus used, and the results obtained in regard to the first part of the work, that is, the effect upon the periderm and callus formation, will first be described.

The glass dishes into which the specimens were to be placed, after being washed in distilled water, were put in the steam sterilizer, and heated at boiling point for not less than thirty minutes. The first experiments were made in an atmosphere dried by having a solution of potassium hydrate present in a small open dish. But the specimens dried out too much and were unsatisfactory for examination. Thereafter the experiments were conducted in a saturated atmosphere, the dishes being prepared in the following manner. All glassware was washed as stated above before using. The bottom of a glass dish was covered about a half or three quarters of an inch deep with very moist sphagnum. Then a side of a Petri plate which fitted closely into the glass dish was placed on the sphagnum. Then another glass dish slightly larger than the first was placed over it, forming a closely fitting cover. After heating in the steam sterilizer as aforesaid and cooling, the cover was lifted as little as possible at the side, and the specimens placed in an upright position on the Petri plate (see FIGURE 1, *a*). The covers of the dishes were never taken completely off during the experiments. They were always plainly labeled with the strength of the solution into which the specimens had been dipped, and the date the experiment was started, so no errors could arise through confusing the dishes — for example, "N/12 $ZnSO_4$, Jan. 23/09." The dishes for the control and the poisoned specimens were always prepared at the same time and in exactly the same manner. In some cases where it was thought possible that a variation in results was due to a difference in the atmosphere in the two dishes, the experiment was repeated, placing both the control and the poisoned specimens in the same dish.

For cutting the tissues a copper tube was first used. Then a silver tube was substituted, as it was thought that the copper might have some effect upon the tissue with which it came in contact. But on comparing results, it appeared that the copper had had no effect upon the tissue. The tube, and the scalpel and forceps used in handling the specimens, were always placed in boiling water for a few minutes before each time they were used. The poisoned specimens and the control specimens were always taken from the same plant and were prepared in the following way: The potato, kohl-rabi, or whatever plant was used, was thoroughly washed and dried. Then the silver tube was pushed through the fleshy part of the plant root or tuber, and the cylinder thus cut was pushed out onto a piece of clean filter-paper. It was then usually cut into pieces 20 mm. long,— the tube was 7 mm. in diameter. The part closer than 3 or 4 mm. to the end was never used. In the cases of the roots, where there was a longitudinal axis, the pieces were cut with the longitudinal axis. This was repeated until a sufficient number of pieces of each plant was cut.

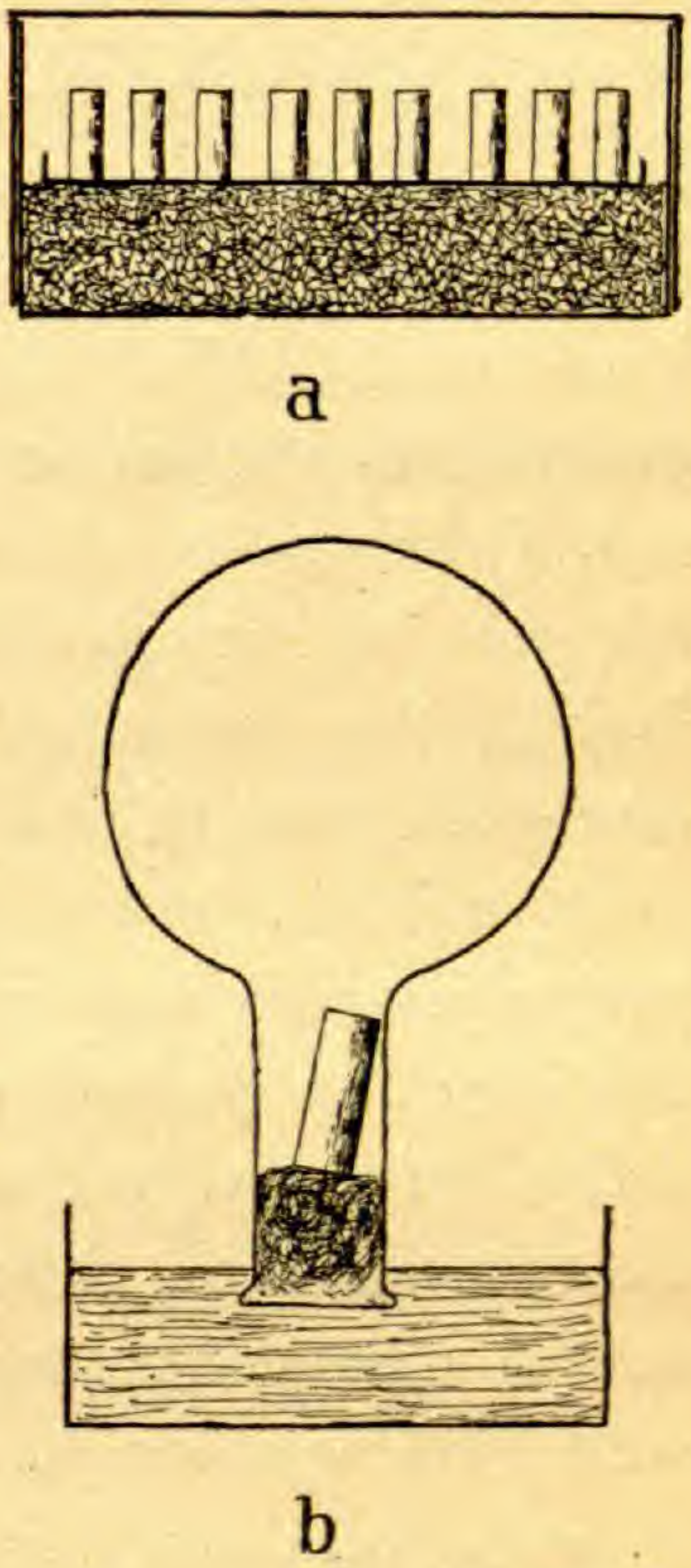

FIGURE 1. *a*, Diagram showing the manner in which the cylinders of tissue were placed in the culture dishes; *b*, diagram showing arrangement for collecting CO_2 given off for relatively short periods from small portions of tissue. The liquid in the dish is mercury.

Three pieces of each kind successively were put into a small bottle containing the zinc sulphate solution of required strength; and the same number was put into a like bottle containing distilled water. This was done in order that all factors of moisture, etc.— except that of the poison — might be as nearly the same as possible. After being left in the solution, or the water, for two or three minutes, the pieces were taken out with forceps, rolled upon clean filter paper, and placed in the glass dishes previously prepared.

Examination to determine results was made by cutting sections of the cylindrical specimens, always about 5 mm. from the end. The sections were mounted in water and examined immediately after mounting.

PART I

Before making any experiments with zinc sulphate, several kinds of tissue were tested for their power to produce callus and meristem under the conditions to be used for the control. It was found that *Allium Cepa* (onion) could not be used because it decayed in the moist atmosphere. *Radicula Armoracia* (horseradish) formed a suberized layer with meristematic tissue inside it, but was so susceptible to moulds that its use was abandoned. During the course of the experiments, *Brassica Rapa* (turnip) was tried, but it, too, proved unsatisfactory, because it was too easily affected by moulds and rot. *Helianthus tuberosus* (Jerusalem artichoke) was experimented with at the same time, but did not give the desired response. *Daucus Carota* (carrot) formed callus but so very slowly that it was considered unfavorable for experimentation. After this process of elimination, those which at first appeared to lend themselves favorably to the work in hand were *Beta vulgaris* (beet), *Ipomœa Batatas* (sweet potato), *Brassica oleracea* (kohl-rabi), *Solanum tuberosum* (potato), and, later, *Tragopogon porrifolius* (salsify). Of these the potato was quite the most satisfactory.

The sweet potato, which formed callus very readily at first, proved to be very suspectible to rot. It was probably due partially to this that the results obtained were so variable that they could not be used as a basis for any conclusions.

The beet, also, which seemed very desirable in the preliminary tests, did not form callus so readily after the experiments had been in progress for a few weeks, but dried out so much as to be useless for examination. When this trouble was encountered, freshly grown Bermuda beets were secured, but they gave no better satisfaction than the old ones. The results that were obtained, as in the case of the sweet potato, were so variable that no conclusions could be drawn with regard to them. The variability in the results, in this instance, was largely due to the presence of vascular bundles running through the pieces used for experimentation.

The presence of the vascular bundles also confused, somewhat, the results obtained from salsify. In four cases out of seven, however, when the control pieces and the poisoned pieces were cut as nearly alike as it was possible to make them, and always taken from the same plant, the specimens dipped in twelfth- and fourteenth-normal zinc sulphate solutions showed a greater formation of callus than the control specimens. In the other three experiments, the stimulated specimens formed less callus than the control specimens. In one of these three experiments, however, more meristem had formed in the poisoned piece than in the control.

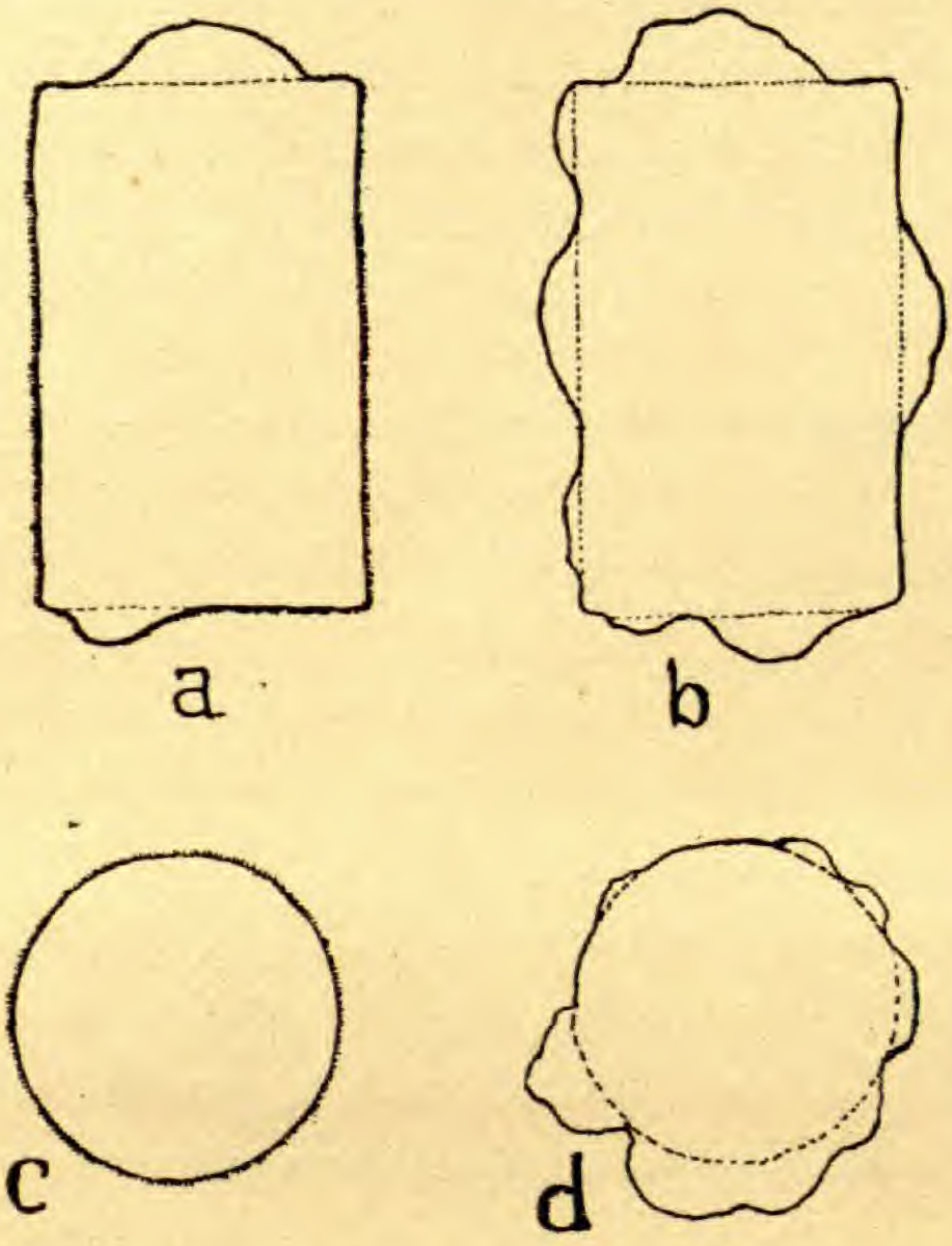

FIGURE 2. Transverse and longitudinal sections of cylinders of tissue from "kchlrabi" for comparison of extent of callus formation with and without stimulation by zinc sulphate. *a* and *c* are the control specimens; *b* and *d* were stimulated with N/12 zinc sulphate. The drawings represent the condition two weeks after cutting, the stimulated specimens having been treated at once after the cylinders of tissue had been removed. Magnified 3 diam.

In the experiments with the kohl-rabi, the same precautions were taken as with salsify, because of the presence of bundles.

Nevertheless, this was one factor which made the callus formation irregular, although it does not fully account for the fact that in most instances the callus formed in clumps, instead of making a uniform covering over the entire surface of the specimen. For this reason the observations on the gross appearance were thought to be of greater significance than any microscopical observations made on the specimens would be. In regard to the formation of meristem beneath the surface, none at all was formed in many experiments, even when callus was abundantly present. Its formation seemed to be dependent somewhat upon the age of the plant, and was too variable to furnish a basis for any conclusion. In regard to the callus, observations were taken upon twelve experiments using solutions of zinc sulphate from tenth to twentieth normal. In six of the experiments, the specimens poisoned with twelfth- and fourteenth-normal solutions formed callus more quickly than the

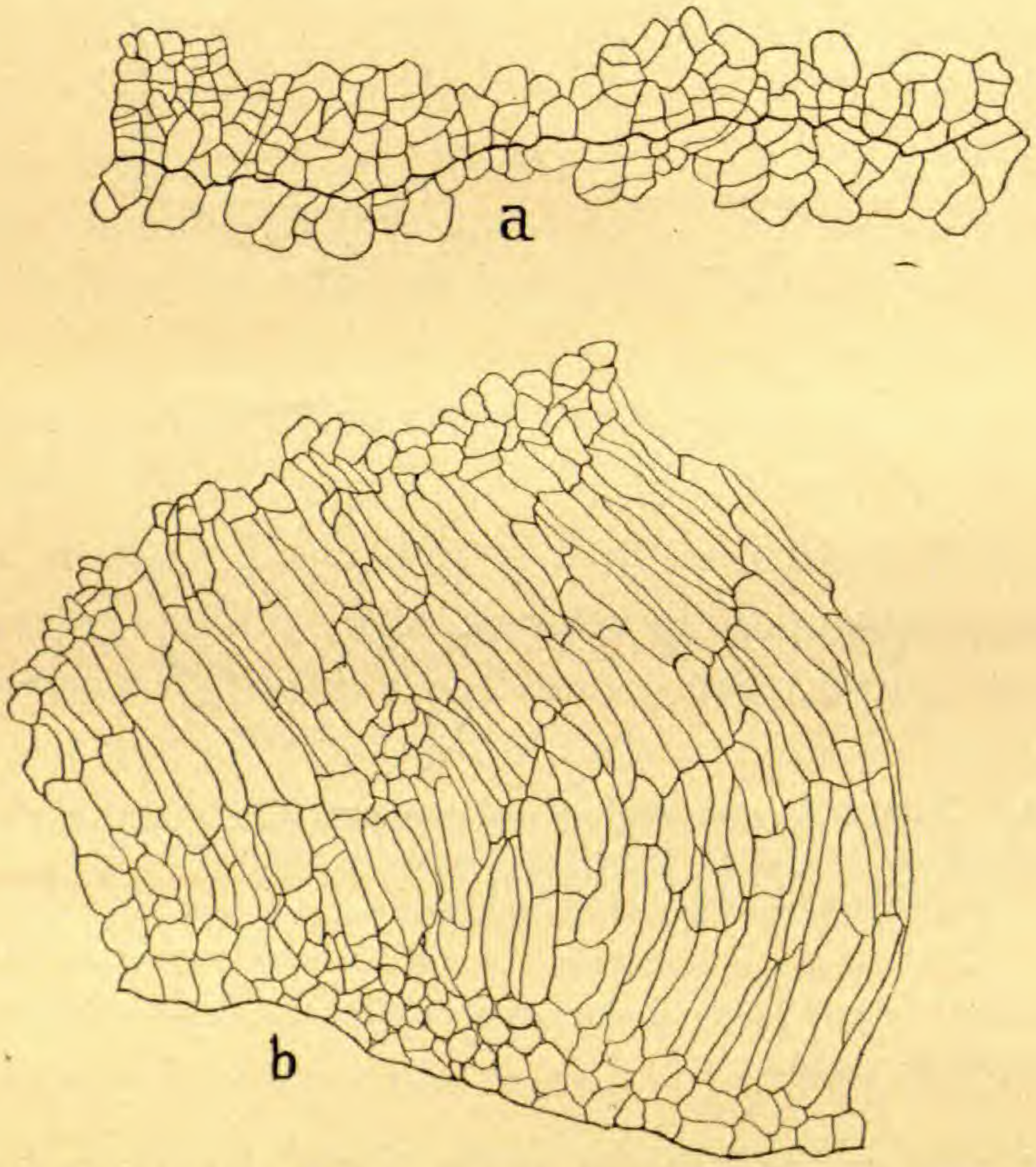

Figure 3. Sections of stimulated and unstimulated tissue of "kohl-rabi," cut vertically to the surface. Two weeks after setting up experiment; *a*, showing the callus formation as it appears pretty evenly all over the surface of the tissue, in the control; *b*, showing the callus formation in tissue stimulated with N/12 zinc sulphate, which is more irregular in its formation. See Figure 2. Magnified 38 diam.

control, but irregularly and in large masses (see FIGURE 3). These pieces were also more susceptible to attacks of bacteria and moulds than were the control. In the control pieces callus was formed more slowly, but in a uniform layer over the entire surface of the specimen (see FIGURE 2). In two cases, the control had more callus formed than the poisoned pieces. In the other four experiments the results varied on the different occasions when the specimens were examined, making them valueless. Solutions stronger than tenth or twelfth normal inhibited the formation of callus. Those weaker than fourteenth normal, seemed to have little, if any, effect upon the callus formation.

Since the results in the formation of meristem in the potato were, by far, the most constant and satisfactory, the experiments on the potato will be described in detail:

EXPERIMENT I. Normal and half-normal solutions of zinc sulphate were used.

After four days:

Control. — One row of meristematic cells formed beneath the dried exterior.

N. — No meristem.

N/2. — No meristem.

After seven days:

Control. — A well-defined layer of meristem.

N. — No meristem.

N/2. — A few scattered meristematic cells two or three rows of cells beneath the surface, which was deeper than the location of the meristem in the control.

After fifteen days:

Control. — A meristematic layer several cells in thickness.

N. — Looked as if it may have recovered from the poison about two days before, as there were a great many scattered meristematic cells.

N/2. — A distinct layer of meristem a little beneath the surface.

EXPERIMENT II. Fourth- and eighth-normal solutions of zinc sulphate were used in this experiment.

After four days:

Control. — A distinct meristematic layer forming.

N/4. — No meristem.

N/8. — A number of meristematic cells but not so many as in the control.

After ten days:

Control. — A great deal of meristem close under the dried exterior.

N/4. — A good deal of meristem but not so much or so close to the exterior as in the control.

N/8. — Nearly as much as in the control. Also close to the exterior.

After twenty-one days:

Control. — A very thick layer of meristem.

N/4. — A great deal of meristem but not so much as in the control.

N/8. — Layer of meristem varies in thickness. Sometimes about the same as in the specimen poisoned with N/4 $ZnSO_4$ and sometimes nearly as thick as in the control.

EXPERIMENT III. Tenth- and twelfth-normal solutions of zinc sulphate were used.

After six days:

Control. — One row of cells meristematic.

N/10. — Almost the same as in the control.

N/12. — More meristem than in the control.

After fourteen days:

Control. — Outer meristematic cells dried and new layer forming within.

N/10. — About the same as in the control.

N/12. — Much heavier meristematic layer than in the control. (See FIGURE 4.)

EXPERIMENT IV. Twelfth- and fourteenth-normal solutions were used.

After five days:

Control. — Fairly thick layer of meristem.

N/12. — A little more meristem than in the control.

N/14. — More meristem than in the control — about the same as in the specimen stimulated with N/12 $ZnSO_4$.

After twelve days:

Control. — Heavy layer of meristem.

N/12. — About the same as in the control — impossible to say definitely whether there is more or less meristem formed.

N/14. — About the same as in the other two specimens.

After twenty-one days :

Control. — Exposed tissue dried to the edge of the meristematic layer, and some new meristem forming inside the first layer.

N/12. — Quite a little more meristem than in the control.

N/14. — About the same amount as in the specimens poisoned with N/12 $ZnSO_4$.

In view of these results it seems fair to make the following conclusions. Twelfth- and fourteenth-normal solutions of zinc sulphate stimulate the formation of meristematic tissue in the potato. A tenth-normal solution neither stimulates nor inhibits the formation of meristem. The tissue recovers from the effects of eighth-normal solution in about three or four days, from fourth-normal solution in eight or ten days, from half-normal solution in about seven days, and from the normal solution in from thirteen to fifteen days. Owing to the method by which the solutions must necessarily be applied, it is, of course, impossible to determine definitely

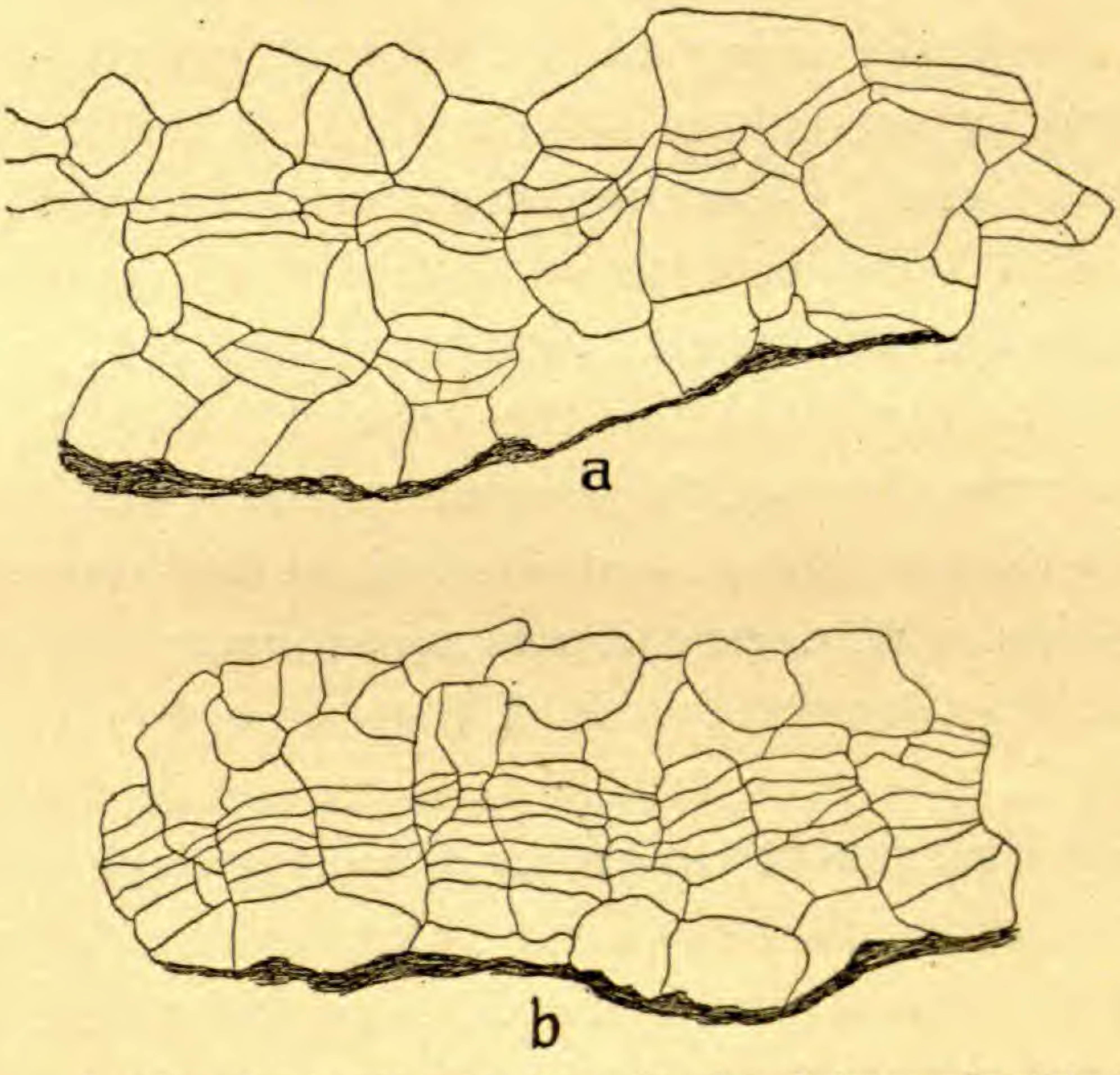

FIGURE 4. Section of stimulated and unstimulated tissue of potato tuber, cut vertically to surface. Three weeks after setting up experiment; *a*, showing the callus formation in control specimen; *b*, showing callus formation in tissue subjected to the stimulus of N/12 zinc sulphate. Magnified 53 diam.

the exact concentration of zinc sulphate which reaches the cell. In this method, however, the critical or optimum point of concentration for this tissue is the twelfth and fourteenth normal.

PART II

In the second part of the work, the object was to determine the effect of the zinc sulphate stimulation upon the respiration of the storage tissue. Since the results with the potato in the foregoing experiments were the most nearly constant, it was the only tissue used in these latter experiments. The pieces were prepared in exactly the same manner as those used in Part I. They were then put into flasks which had been previously prepared in the following manner: The flask was weighed, then filled with distilled water, and weighed again. The first weight was subtracted from the second, the remainder being the number of grams of water the flask contained, or the volume of the flask in cubic centimeters (1 gm. $H_2O = 1$ c.c.). The three flasks used were always labeled I., II., and III. The volume of flask I. was 94.093 c.c.; the volume of flask II., 90.506 c.c., and that of flask III., 105.433 c.c. Flask I. was always used for the control. Before using, the flasks were always thoroughly washed in tap water, then rinsed three times in distilled water, and allowed to dry over night in an inverted position. Whenever it was necessary to use them again on the same day they were washed, they were dried in a drying oven at 100° C.

In the first experiment ten pieces of potato were used; in the second, fifteen; and in all the following experiments, twelve. After the pieces had been dipped and rolled on filter paper, they were put into the respective flasks, and cotton stoppers were inserted in the mouths of the flasks, which were then inverted over mercury cups (see FIGURE 1, *b*).

For analyzing the gas the Bonnier-Mangin instrument for gas analysis was used. In transferring the flasks from the mercury cup to the Bonnier-Mangin apparatus, a moistened finger tip was always held over the mouth of the flask until it was inserted in the mercury cup of the gas-analyzer. Before inserting it in the cup, the pieces in the flask were always shaken about a little to make sure that the gas in the flask would be uniform in composition.

The gas in every flask was analyzed twice and the average of the two results taken. Between each analysis hydrochloric acid was run in to remove all traces of the potassium hydroxide, after which the apparatus was rinsed three times with distilled water.

STIMULATED				CONTROL		DIFF. IN C C. OF CO_2 IN CONTROL AND STIMULATED.
Strength of $ZnSO_4$ sol.	Original per cent. of CO_2	Per cent. of CO_2 corrected for vol. of flask	Actual amount of CO_2 in c.c.	Original per cent. of CO_2	Actual amount of CO_2 in c.c.	+ = control more — = control less
$\frac{N}{2}$	12.01	11.46	9.46	16.93	15.93	+ 6.47
	7.61	7.27	6.29	12.63	11.89	+ 5.60
$\frac{N}{12}$	12.40	11.84	10.05	13.48	12.68	+ 2.63
	10.41	9.94	8.44	10.67	10.14	+ 1.70
	8.59	8.21	6.97	9.52	8.96	+ 1.99
$\frac{N}{14}$	16.35	15.64	13.25	16.67	15.69	+ 2.44
	16.90	19.15	16.26	16.67	15.69	— 0.57
$\frac{N}{16}$	17.87	20.26	17.19	15.44	14.53	— 2.66
	17.80	20.18	17.13	17.54	16.50	— 0.63
	16.90	19.18	16.27	16.11	15.16	— 1.11
$\frac{N}{24}$	16.12	15.43	13.07	16.11	15.16	+ 2.09
	18.50	17.67	15.00	21.03	19.79	+ 4.79
$\frac{N}{32}$	18.14	17.33	14.71	17.54	16.50	+ 1.79
	20.96	23.76	20.16	21.03	19.79	— 0.37

It may be of interest to describe the method of analysis and the method of calculating results. A sample of gas was drawn into the tube of the apparatus and measured. It measured, for example, 51.10 c.mm., the correction having been made for the water present in the tube. Then a ten per cent. solution of potassium hydroxide was drawn in, run back and forth in the tube several times, and the remaining gas measured. In this case it was 43.05 c.mm., the difference between the two amounts, 8.05 c.mm., or 15.75 per cent., being the amount of carbon dioxide present in the sample. In the next analysis, 16.5 per cent. was the result gotten, the average being 16.125 per cent. This experiment was performed in flask II., the volume of which was 90.306 c.c. But 9.236 c.c. of the flask was occupied by the twelve pieces of potato 20 mm. long and 7 mm. in diameter. Therefore the complete amount of gas present in the flask was 81.07 c.c., 16.125 per cent. of which, or 13.072 c.c., was carbon dioxide. The volume of the control flask was 94.093 c.c. Subtracting the bulk of potato, the volume of gas present would be 84.857 c.c. If 13.072 c.c. of the total gas volume, 84.857 c.c., was carbon dioxide, the per cent. of carbon dioxide present would be 15.43. This is an example of the method used in all the analyses and calculations, the results of which will be found on page 499.

These investigations are merely the introduction to what might be done in the way of experiments showing the effect of zinc sulphate stimulations upon the respiration of storage tissues, but they serve to indicate that fourteenth-normal solutions, or any solutions stronger than that, inhibit the respiration of the storage tissue of potato. A sixteenth-normal solution stimulates respiration. Further than that, the results so far obtained do not justify any definite statements. It is hoped that at some future time the data already obtained in these investigations may be amplified and the work carried on to a far greater extent.

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The Crataegi of Mexico and Central America

W. W. EGGLESTON

In the autumn of 1905, Dr. C. G. Pringle sent me, from Mexico, fruiting material of what he considered a new species of *Crataegus*. Study of the literature of both the Mexican and the South American species satisfied me that he was correct in his diagnosis; but I asked him to get me flowering material from the same station. This he did in April, 1906, and *Crataegus Baroussana* was then described (Torreya 7: 35). Since then I have seen specimens of this species, *J. Gregg 433*, "mountains near Saltillo, 1848 or 49," both in the herbarium of the Missouri Botanical Garden and in the Gray Herbarium. Dr. Pringle tells me that his *C. Baroussana* ravine overlooks the battlefield of Buena Vista and therefore his station might be Dr. Gregg's as well.

The study required for this species led me to a more extensive investigation of this group as it is represented south of the Mexican boundary. I had trouble in finding important literature; many of the types were in Europe; and all of the South American species were inaccessible to me. The literature has now all been secured and a good idea of most of the types obtained, but to find material of the South American species has been a harder proposition. There is but one sheet of a South American *Crataegus* in the great herbaria of the United States. This is a flowering specimen of *C. spinosa* DC. in the herbarium of the New York Botanical Garden.

Happily, most of the South American species can easily be eliminated from the problem by their descriptions. *C. stipulosa* (H.B.K.) Steud. and *C. quitensis* Benth. were the only ones that troubled me, and a flowering specimen (from the type locality) of *C. stipulosa* and a drawing of the type of Bentham's *C. quitensis* were very kindly sent me by Lt. Col. Prain, Director of the Royal Botanic Gardens, Kew.

Dr. C. G. Pringle and Dr. Edward Palmer have made special trips in Mexico for me; and Dr. J. N. Rose, Mr. J. N. Painter, and Mr. W. R. Maxon, of the U. S. National Museum, and Mr. E. W. Nelson and Mr. E. A. Goldman of the U. S. Biological Survey have also given me information in regard to the Mexican species. In fact, without the recent work of these gentlemen in Mexico our knowledge would be very limited indeed. I have also had full access to the material in the Gray Herbarium, the National Museum, the Missouri Botanical Garden, and the Arnold Arboretum.

The first notice we have of *Crataegus* in Mexico was by Dr. F. Hernandez who resided in Mexico from about 1570 to 1580. His Nova Plantarum, Animalium et Mineralium Mexicanorum Historia was published at Rome in 1651, and his De Historia Plantarum Novae Hispaniae at Madrid in 1790.

The first definite work on the group was that of Mocino & Sessé (about the City of Mexico), but this work was not given to the world until De Candolle published the Pomaceae of his Prodomus in 1825. Baron von Humboldt found the rare *C. pubescens* (H.B.K.) Steud. in Real de Moran, Hidalgo, and published it in 1824. It seems remarkable that he should have picked up this rare and little-known species and not have observed the more common *C. mexicana* Moc. & Sessé. Around these two species and that of Bonpland's *C. stipulosa* (H.B.K.) Steud. from Ecuador, there has been a storm center ever since. One will find herbarium sheets about equally marked with these names, when as a matter of fact most of them are *C. mexicana* Moc. & Sessé.

Although the type of *Crataegus mexicana* Moc. & Sessé has not been seen, it is easy to settle the status of the species, for it was collected in the vicinity of the City of Mexico and the tracing of Mocino & Sessé's drawing is extant; this, with the fact that only one species is known near the City of Mexico seems to settle the status of *C. mexicana*. *C. stipulosa* (H.B.K.) Steud., as to description, matches very well with *C. mexicana*, but the flowering material sent from Kew seems different, and until *C. stipulosa* is well known it is better to hold to the name *C. mexicana*, although they may prove to be one species, in which case, *C. stipulosa*, being the older name, will replace the other. *C. pubescens* (H.B.K.) Steud. has been another stumbling-block. It was collected in flower by Humboldt and is finely described and figured by Kunth in the Nova Genera et Species ; but flowering material of closely allied species of *Crataegi* furnishes very unsatisfactory data for determination and should be reinforced by mature fruiting material whenever possible. Dr. Rose's Jalapa plant supplied immature fruiting material for me ; and last fall, Dr. Pringle collected mature fruit at Honey Station, Hidalgo (this station is within a mile or two, at least, of Humboldt's locality, Real de Moran).

My purpose in this article is to describe the wild species of Mexico and Central America but my final treatment of the group will require also a good deal of notice given to the different forms raised in and described from the various European botanical gardens. I have no evidence that either *C. pubescens* or *C. stipulosa* has ever been cultivated in botanical gardens but in the early thirties *C. mexicana* (*C. stipulacea* Lodd.) was of much interest to the English gardeners and there was some controversy at the time in regard to when and by whom it was introduced. The evidence seems to point to the fact that it must have been received in England from two sources in 1824 or a few years before that (see Gard. Mag. **9** : 496, 630 ; **11** : 473, 583. — G. Don, Gen. Dict. **2** : 598. — D. Don, in Sweet, Brit. Flow. Gard. **6** : 300). From England it was introduced to the continent. It does not seem to have been raised in the United States, although it might easily be grown from Washington or St. Louis south. Of the garden species *C. lobata* Bosc, *C. grandiflora* Smith, *C. Carrierei* × Carrière, *C. Lavallei* Hérincq, and *C. grignoniensis* Mouillefert, I have seen fresh fruiting material of only *C. Lavallei;* this was sent me last fall from Segrez, France, by Mr. Lavallée and might well be a hybrid between *C. mexicana* and *C. Crus-galli*, as it has been called. The colored plates of this and *C. Carrierei* are much alike and seem to me to represent practically the same form. *C. grandiflora* Smith and *C. lobata* Bosc may be Mexican species or at least partially derived from them, but these are doubtful points, needing more careful investigation. However, I have not sufficient knowledge of these species as yet, having but recently seen some of the important literature on the subject.

The genus *Crataegus*, south of the United States, seems confined to the tablelands of Mexico and southward through the highlands of the Andes. In Mexico the fruit is of much economic importance, being often found in the markets, and the trees are guarded as carefully as other fruit trees are with us.

Key to Mexican and Central American Crataegi in flower

1. Vegetative twigs, corymbs, and lower surface of leaves glabrous; leaves broadly ovate; stamens about 10; styles 4 or 5, calyx-lobes serrate; fruit red.......... *C. Baroussana.*
1. Vegetative twigs, lower surface of leaves, and corymbs tomentose... 2.
    2. Leaves broadly ovate, tomentose on both sides; stamens about 10; styles 4 or 5; calyx-lobes serrate; fruit red.......... *C. Greggiana.*
    2. Leaves narrower, — elliptical, lanceolate, etc.......... 3.
        3. Stamens 5–10; styles 3 or 4; calyx-lobes serrate; fruit red.......... *C. Rosei.*
        3. Stamens about 20.......... 4.
            4. Calyx-lobes serrate, styles usually 2 or 3; fruit yellow. *C. pubescens.*
            4. Calyx-lobes entire.......... 5.
                5. Leaves oblanceolate.......... *C. stipulosa.*
                5. Leaves lanceolate, elliptical, etc. .... 6.
                    6. Styles 2–3; leaves glabrous above; fruit yellow.......... *C. Parryana.*
                    6. Styles 3–5, leaves tomentose above.......... 7.
                        7. Leaves 3–9 cm. long, styles usually 3 or 4; fruit orange.......... *C. mexicana.*
                        7. Leaves 1.5–5 cm. long; styles usually 4 or 5.......... *C. Nelsoni.*

Key to Mexican and Central American Crataegi in fruit

1. Vegetative twigs glabrous.......... *C. Baroussana*
1. Vegetative twigs tomentose.......... 2.
    2. Leaves broadly ovate.......... *C. Greggiana.*
    2. Leaves elliptical, etc. .... 3.
        3. Fruit large, 15–30 mm. thick.......... 4.
        3. Fruit small, 8–15 mm. thick.......... 5.
            4. Leaves oblanceolate.......... *C. stipulosa.*
            4. Leaves lanceolate, etc.......... 6.
                6. Nutlets 3–5; calyx-lobes erect, entire; fruit orange.......... *C. mexicana.*
                6. Nutlets 2 or 3; calyx-lobes reflexed, glandular-serrate; fruit light yellow.......... *C. pubescens.*
                    5. Nutlets 2 or 3; fruit yellow; calyx-lobes entire.......... *C. Parryana.*
                    5. Nutlets 3 or 4; fruit red; calyx-lobes serrate.......... *C. Rosei.*
                    5. Nutlets 4 or 5; calyx-lobes entire.......... *C. Nelsoni.*

CRATAEGUS PUBESCENS (H.B.K.) Steud. Nom. Bot. 433. 1841 [ed. 2]

Mespilus pubescens H.B.K. Nov. Gen. et Sp. **6**: 213. *pl. 565.* 1824.

Leaves 1–7.5 cm. long, 0.8–4 cm. wide, rhomboid-elliptical to ovate or sometimes obovate or spatulate, often one-sided towards the base, serrate or crenate-serrate, often doubly so, with gland-tipped teeth, leaves of the vegetative shoots often three-lobed towards the apex and extremely variable as to size, acute at the apex, cuneate at base, subcoriaceous, slightly appressed-pubescent and impressed-veined above when young, bright green becoming nearly glabrous above when mature, paler and tomentose below; petioles 2–10 mm. long, slightly winged and pubescent; stipules falcate to half-ovate, strongly glandular-serrate, fugacious; corymbs 6–10-flowered, tomentose, flowers 10–12 mm. wide, the lanceolate acute strongly glandular-serrate calyx-lobes nearly glabrous; stamens about 20; styles usually 2 or 3, occasionally 4; fruit compressed-globose to globose, light straw-colored (according to Pringle), 15–25 mm. thick; calyx-lobes reflexed, mostly deciduous; flesh light yellow; nutlets 2–4, strongly ridged on the back, 8–10 mm. long, nest of nutlets 10–12 mm. thick. Young twigs slightly tomentose becoming glabrous, light chestnut-brown. Thorns 1–3 cm. long, slender, straight, frequent. Habit of the common apple tree, sometimes 10 m. high.

This species has been infrequently found in the moister region (1000–3000 m.) of the eastern border of the tableland, ranging from Hidalgo southwards.

Type locality, Real de Moran, State of Hidalgo (2420 m.), *Humboldt.*

Specimens examined:

Jalapa, Vera Cruz, *C. J. W. Schiede*, 1828. (Herb. Columbia Univ. and Gray Herb.)

Jalapa, *C. L. Smith 1484*, Apr. 11, 1894, 6900 ft. (Gray Herb.)

Jalapa, *C. G. Pringle 8081*, Mar. 30, 1899.

Jalapa, *J. N. Rose & W. Hough 4250*, May 17–22, 1899. (Herb. U. S. Nat. Museum and herb. N. Y. Bot. Gard.)

Honey Station, Hidalgo, *C. G. Pringle*, Oct. 22, 1908. (Herb. N. Y. Bot. Gard.)

The next number probably belongs to this species:

E. W. Nelson 1334, eighteen miles southwest of city of Oaxaca, Sept. 10–20, 1897. (Gray Herb. and herb. U. S. Nat. Mus.)

Crataegus pubescens Botterii var. nov.

Leaves shorter than those of the type, tomentose above, more rugose than in the type, densely white-tomentose; corymbs densely white-tomentose.

This may prove a distinct species when better known.

Type: *Botteri 1121.* (Gray Herb.)

Specimens examined:

Orizaba, *Botteri 1121*, about 1850. (Herb. U. S. Nat. Mus. and Gray Herb.)

Huatasco, Vera Cruz, *C. Mohr*, 1856. (Mohr Herb., U. S. Nat. Mus.)

Eugenio, Rincón de la Carbonera, Orizaba, *F. Müller*, 1853. (Herb. Columbia Univ.)

Boca del Monte, Orizaba, *E. W. Nelson 218*, May 13, 1894. (Herb. U. S. Nat. Mus.)

CRATAEGUS MEXICANA Moc. & Sessé; DC. Prod. **2**: 629. 1825. — Moc. & Sessé, Dessins Fl. Mex. *pl. 299.* 1874. — Bot. Reg. **22**: *pl. 1910.* 1836. — Loudon, Arb. et Frut. Brit. **2**: 843, 867; **6**: 156. 1838. — D. Don in Sweet, Brit. Flow. Gard. **6**: *pl. 300.* 1835

C. subserrata Benth. Plantae Hartweg. 10. 1839.

C. hypolasia K. Koch, Hort. Dend. 167. 1853.

Leaves elliptical-lanceolate or oblanceolate, 3–9 cm. long, 1.5–4 cm. wide, serrate-crenate, with gland-tipped teeth, sometimes slightly lobed towards the apex, often irregularly so or the margin repand, entire towards the base, obtuse or acute at the apex, cuneate at the base, dull, coriaceous, tomentose above, sometimes becoming nearly glabrous, impressed-veined and slightly corrugated; tomentose below, particularly along the veins; petioles 5–10 mm. long, slightly winged, tomentose; corymbs 4–10-flowered, densely white-tomentose; flowers 15–20 mm. wide; calyx-lobes less tomentose, about 6 mm. long, lanceolate, entire except at the apex, which is usually obtuse and often has two to four nearly equal gland-tipped teeth; stamens about 20, anthers pink, styles 3–5, densely tomentose about the base; fruit ovoid, short-ellipsoidal or short-pyriform, 15–25 mm. thick, edible, orange or rusty orange, calyx-lobes erect, thickened at the base;

nutlets 3–5, broadly ridged on the back, obtuse at the ends, 8–10 mm. long, nest of nutlets 10–12 mm. thick. A small tree sometimes 10 m. high, resembling the common apple tree in habit. Young twigs tomentose. Thorns often wanting or trees occasionally armed with short thorns.

A tree of the higher altitudes (1000–3000 m.) of the central tableland, ranging from central Mexico (San Luis Potosi, *Parry & Palmer 228*) southward.

Type station, vicinity of the City of Mexico, *Mocino & Sessé.*

Specimens examined:

C. G. Pringle 13736, Eslava, Federal District, Mexico, 7800 feet, Mar. 22, 1906. Tree 15–25 feet. Also fruit from this station, Nov. 7, 1907. (Herb. N. Y. Bot. Gard.)

C. G. Pringle 6547, base of Sierra de Ajusco, Federal District, Mexico, 7800 feet, Sept. 29, 1896.

C. G. Pringle 6631, river banks near Tula, Hidalgo, 6800 feet, June 15, 1897.

C. G. Pringle 6983, fields about Tepoxtlan, Morelos, Mexico, 7500 feet, Mar. 15, 1899. A large tree.

C. G. Pringle 11400, Eslava, State of Mexico, 8000 feet, Sept. 17, 1903.

C. G. Pringle 1467, Marquess, State of Mexico, 8000 feet, Apr. 20, 1887.

J. Gregg 618 and *618b*, valley and hills below Real del Monte, Mexico, 1848–49.

Graham, Mexico. (Gray Herb.)

Herb. de la Commission Scientifique du Méxique *50*. Santa Fé près México.

J. G. Schaffner Herb. San Luis Potosi, May, 1881. (Gray Herb.)

Parry & Palmer 228, San Luis Potosi, 1878.

E. Palmer, San Luis Potosi mountains, 1878.

Rose & Painter 7118, Eslava, Valley of Mexico, Sept. 17, 1903.

Rose & Painter 7894, Nevada de Toluca, State of Mexico, Oct. 15, 1903.

Rose, Painter, & Rose 9483 and *9484*, San Angel, Valley of Mexico, Aug. 15, 1905.

Rose & Hough 4532, near Tlalpam, Valley of Mexico, June 9, 1899.

Rose & Hough 4710, between Tepeaca and Santa Rosa, Pueblo, Mexico, June 27, 1899.

Rose & Hay 5293, near Dublan, Hidalgo, Mexico, July 2, 1901.

Ta

W. Trelease 40, above Malhalla, Vera Cruz, Mexico, Feb. 19, 1905.

C. subserrata Benth., *Hartweg 47*, Mexico, as seen in the Gray Herbarium, seems to represent a rather entire-leaved form of *C. mexicana*, which, as to the Gray Herbarium specimen, is not worthy of even a varietal name.

Crataegus mexicana microsperma var. nov.

C. pubescens Watson, Proc. Am. Acad. **22**: 396. 1887. Not *Mespilus pubescens* H. B. K.

Leaves narrower than those of the type ; fruit pyriform, yellow, with red cheeks, 10–15 mm. thick ; nutlets 3–5, about 6 mm. long, grooved on the back, with calyx-scar, nest of nutlets 7–8 mm. thick.

This may prove a good species.

Type, *E. Palmer 465*, Guadalajara, Jalisco, Mexico, Sept., 1886.

The following numbers also I would refer here :

E. W. Nelson 553, west slope of Mt. Zempoaltepec, Oaxaca, Mexico, 7700–8000 feet, July 5–13, 1894.

E. W. Nelson 4092, roadside between San Sebastian and the summit of the mountain known as the Bufa de Mascote, Jalisco, Mexico, 7200 feet, Mar. 20, 1897.

M. E. Jones 136, Chiquilistlan, Jalisco, Mexico, June 1, 1892.

I doubtfully refer the following numbers to this variety :

E. W. Nelson 6555, Patamban, Michoacan, Mexico, 6500–8500 feet, Jan. 27, 28, 1903.

E. Langlassé 45, Village du Durarno, Michoacan et Guerrero, Mexico, Mar. 20, 1899.

Of no. 465 Dr. Palmer says, "Twenty feet high ; fruit yellow with black dots, and often a red blush on one side, Guadalajara ; September (465). *Tejocote*, a jelly, is made from the fruit, resembling that from the quince."

CRATAEGUS STIPULOSA (H.B.K.) Steud. Nom. Bot. 433. 1841 [ed. 2]

Mespilus stipulosa H.B.K. Nov. Gen. et Sp. **6** : 213. 1824.

Material from Gautemala matches this species better than any other I have seen. The leaves are oblong or obovate-oblong, tomentose, acute at the apex, cuneate at the base, crenate-serrate, tomentose; corymbs densely white-tomentose, few-flowered; stamens about 20; fruit globose or short-pyriform, (yellow?), 15–30 mm. thick, calyx deciduous; nutlets 2–4.

Specimens examined:

J. D. Smith 2531, Las Delicias, Depart. Sacatepéquez, Guatemala, 7000 feet, Mar. 1892.

Heyde & Lux 3324, Santa Rosa, Depart. Santa Rosa, Guatemala, 4000 feet, Apr. 1892.

W. A. Kellerman 7071, Volcano Agua, Depart. Sacatepéquez, Guatemala, 9000 feet, Feb. 4, 1908.

W. A. Kellerman 4529, Volcano Agua, Guatemala, Feb. 18, 1905.

Maxon & Hay 3668, Volcano Agua, Guatemala, 1800 m., Mar. 21, 1905.

W. R. Maxon, fruit bought in the market of Mazatenango, Guatemala, Feb. 1905.

The following I would refer to this species with some doubt:

E. W. Nelson 3162, near San Cristobal, Chiapas, Mexico, 7000–8800 feet, Sept. 18, 1895.

E. A. Goldman 941, Teopisca, Chiapas, Mexico, May 7, 1894.

Crataegus Rosei sp. nov.

Leaves short-spatulate to obovate, obtuse at the apex, cuneate at the base, serrate-creneate with fine teeth, slightly pubescent along the veins, finely rugose, shining, yellow-green above, paler and tomentose along the veins below; petioles 5–10 mm. long, slightly winged, pubescent, stipules of the vegetative twigs semilunate, 3–4 mm. long, glandular-serrate; corymbs 3–9-flowered, whitish-villose; flowers 12–15 mm. wide, calyx and lobes slightly villose, calyx-lobes remotely serrate or entire, lanceolate, acute, 2–3 mm. long; stamens 5–10; styles 2–4, surrounded at the base by a dense tuft of tomentum; fruit ellipsoidal or pyriform, red, 8–12 mm. thick, slightly villose, flesh soft, calyx-lobes reflexed or spreading, nutlets usually 3, strongly ridged on the back, 6–7 mm. long, nest of nutlets 8–9 mm. thick. Vegetative twigs villose, yellow-green, becoming glabrous and ash-gray, armed with chestnut-brown, slightly curved spines 2–4 cm. long.

Type *E. Palmer 74*, Alvarez, San Luis Potosi, Mexico, Sept. 5–10, 1902. (Herb. N. Y. Bot. Gard.).

Of no. 74 Dr. Palmer says, "*Tejocote colorado.* The fruits are sold in San Luis Potosi for making *cayata*. A small tree; 15 feet may cover the height of the tallest. It has the habit of the hawthorn with an immense crop of fruit which is eaten raw by the people."

Of no. 47, "Small tree like the hawthorn of the United States, very thorny; the fruits are edible, very productive; of the general height of 10–15 feet, very bushy, known as *Tejocote;* the fruit hangs on the tree a long time."

Of no. 229, "*Tejocote*, one of the most useful trees found here, has a thick compact top of dark green leaves that have a fine polish, thus enabling it to stand dryness, is loaded with fruit. The wood is white, tough and durable, used for handles of tools; the fruits are of a red color, are eaten raw and made into preserves and jelly. Height 20–30 feet and diameter 6–15 inches, flowers white and sweet-scented, found in secluded nooks in ravines or by mountains near water-courses."

Specimens examined:

E. Palmer 74. (Herb. N. Y. Bot. Gard., Gray Herb., herb. U. S. Nat. Mus. and herb. Arn. Arbor.)

E. Palmer 47, Santiago Papasquiaro, Durango, Mexico, Apr., 1896. (Herb. N. Y. Bot. Gard., Gray Herb., herb. U. S. Nat. Mus., herb. Arn. Arbor.)

E. Palmer 229, Tobar, Durango, Mexico, May 28–31, 1909. (Herb. N. Y. Bot. Gard. and herb. U. S. Nat. Mus.)

E. Palmer 333, vicinity of Chihuahua, Mexico, June 5–10, 1908. (Herb. U. S. Nat. Mus. and herb. N. Y. Bot. Gard.)

E. W. Nelson 4673, Papasquiaro, Durango, Mexico, Aug. 7, 1898. (Herb. U. S. Nat. Mus.)

This species of the interior plateau seems to take the place of *C. mexicana* in northern Mexico. It will be surprising if it is not found in southern New Mexico and Arizona.

Crataegus Parryana sp. nov.

Leaves 1.5–4 cm. long, 1–3 cm. wide, oblong-rhomboidal to elliptical-ovate, serrate nearly to the base, sometimes doubly serrate, with gland-tipped teeth, coriaceous, bright yellow-green, glabrous, rugose, impressed-veined above, paler and strongly tomentose along the midrib below, acute at the apex, cuneate at the base; petioles 2–5 mm. long, slightly pubescent; corymbs few-flowered

(2–4-fruited), pedicels slightly whitish tomentose; fruit yellow, compressed-globose, 12–18 mm. thick, slightly pubescent; calyx-lobes appressed, lanceolate, acute, slightly tomentose; stamens about 20, tomentose about the base; nutlets 2 or 3, obtuse, strongly ridged on the back, 7–9 mm. long, nest of nutlets 8–10 mm. thick. Young twigs light chestnut-brown, slightly pubescent, becoming gray and glabrous. Thorns numerous, at first chestnut-brown, 2–4.5 cm. long, nearly straight. In habit like the apple or the hawthorn.

Type, *E. Palmer 75*, Alvarez, San Luis Potosi, Mexico, Sept. 5–10, 1902. (Herb. U. S. Nat. Mus.)

Of this number Dr. Palmer says. "*Tejocote ameco.* The fruit of this form is sometimes a little larger than no. 74 [*C. Rosei*], and if it can be a larger crop of fruit. Has a fine odor. A small tree; 15 feet may cover the height of the tallest. It has the habit of the hawthorn. Quite thorny. May not the cultivated yellow ones of San Luis Potosi originate here?" He also told me that the locality where he found this species and no. 74, in the mountains about twenty miles southeast of the city of San Luis Potosi, had the greatest number of individual trees of any place he had seen, and was also the only place that he would be sure that *Crataegus* was wild in Mexico.

Dr. Pringle, however, says that although *Crataegus* is frequently cultivated in the Mexican gardens, still a great many of the seemingly cultivated trees are undoubtedly in their native habitats.

Crataegus Greggiana sp. nov.

C. pubescens Watson, Proc. Am. Acad. 17: 354. 1882. Not *Mespilus pubescens* H.B.K.

Leaves 2–7.5 cm. long, 2–6 cm. wide, broadly ovate to elliptical-ovate, tomentose on both sides, becoming scabrous above, finely and doubly serrate, or lobed towards the apex, with often irregular lobes, acute or obtuse at the apex, broadly cuneate at the base, subcoriaceous, dull; petioles 5 mm. long, tomentose; corymbs 4–8-flowered, corymbs and calyx densely white-tomentose, calyx-lobes lanceolate, acuminate, remotely and irregularly serrate, about 6 mm. long; stamens about 10; styles 3–5; fruit brick-red, about 10–12 mm. thick, globose, tomentose; calyx-lobes appressed, persistent; nutlets usually 4 or 5, grooved on the back, with a conspicuous calyx-scar, 6–7 mm. long, nest of nutlets 7–9 mm. thick. Twigs tomentose, becoming glabrous. Thorns numerous, straight, slender, chestnut-brown, 3–6 cm. long.

Type, *E. Palmer 300*, Saltillo, Coahuila, Mexico, Sept., 1898. (Gray Herb.)

Description of flowers drawn from *E. Palmer 2123*, Mts. 6 miles east of Saltillo, Apr. 15–20, 1880. (Gray Herb.)

"Garden spots, low hills and little hollows between hills, common. No. 300, hawthorn, prolific bearer of brick-red fruit, edible, sold in the market; the pulp has an apple taste; 15–20 feet high, symmetrical top, rough bark, many long thorns, six inches to one foot in diameter, the seeds are taken out of the top of the fruit, which is cooked in sugar and forms a fine preserve."

Specimens examined:

E. Palmer 300. (Gray Herb., herb. N. Y. Bot. Gard., herb. U. S. Nat. Mus., and herb. Arn. Arbor.)

E. Palmer 704, Saltillo, July 28, 1905. (Herb. N. Y. Bot. Gard. and herb. U. S. Nat. Mus.)

E. W. Nelson 6729, General Cépida, Coahuila, Mexico, Apr. 20, 1902. (Herb. U. S. Nat. Mus.)

Crataegus Nelsoni sp. nov.

Leaves 1.5–5 cm. long, 1.5–4 cm. wide, elliptical-ovate to obovate, acute at the apex, cuneate at the base, serrate or doubly serrate, somewhat tomentose below, finely rugose and slightly pubescent above, subcoriaceous; petioles less than 5 mm. long, slightly pubescent; corymbs 3- or 4-fruited, pedicels slightly pubescent; fruit globose, 10–15 mm. thick, slightly pubescent, stamens about 20, calyx-lobes persistent and appressed, entire, slightly pubescent; nutlets 4 or 5, grooved on the back, 7–9 mm. long, nest of nutlets 9–11 mm. thick. Vegetative twigs somewhat pubescent. Thorns very numerous, 3–5 cm. long.

Type, *E. W. Nelson 3217*, near San Cristobal, Chiapas, Mexico, alt. 7000–8800 feet, Sept. 19, 1895. (Herb. U. S. Nat. Mus.)

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BIBLIOGRAPHY OF MEXICAN AND CENTRAL AMERICAN CRATAEGI

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North American Plantaginaceae — III *

E. L. Morris

An earlier publication requires the putting on record of

Plantago xerodea nom. nov.

Plantago picta Morris, Bull. Torrey Club **28**: 118. 1901. Not *Plantago picta* Colenso, Trans. New Zeal. Inst. **22**: 481. 1890.

Since the publication of the last paper of this series, the writer has been favored by the opportunity of studying several hundreds of specimens in various herbaria, covering not only the species heretofore treated but others in the different groups under the genus. To this has been added much field work upon some of the species in their natural surroundings.

If we consider Decaisne's treatment of the Plantaginaceae, in DeCandolle's Prodromus, 1852, as the first full and modern treatment, we must consider Asa Gray's treatment of the American species in the Synoptical Flora of North America, 1886, as the first full revision of the group including the then known North American species. Among the perennial plantains there has been little change since 1886 except for the addition of a few new species. Among the annual plantains considerable revision has been made by several authors. So much for the group of species with four stamens, the flowers all perfect and the corolla remaining open and expanded after the stage of anthesis.

For the species with the stamens two or sometimes four, with flowers mainly other than strictly perfect and the corolla mainly, at least in the fertile plants, remaining closed after anthesis, it is necessary that considerable revision be made. The first group of

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* [North American Plantaginaceae — I =] "A revision of the species of *Plantago* commonly referred to *Plantago patagonica* Jacquin." Bull. Torrey Club **27**: 105–119. 1900.

North American Plantaginaceae — II. Bull. Torrey Club **28**: 112–122. *pl. 12.* 1901.

species, here considered, are those narrow-leaved annuals whose flowers at the stage of anthesis are *minute* and quite inconspicuous; and whose treatment by American taxonomists has been quite variable.

Plantago elongata Pursh was for many years lost sight of and became almost forgotten. Its nearest relative, *Plantago pusilla* Nuttall, was collected in larger quantities, more often from a wider range, and with such profusion as to swamp the identity of the other species even when recently collected. Pursh described the species as follows:

"*Plantago elongata.* — P. foliis linearibus integerrimis glabris, scapo spicis elongatis subimbricatis foliis longioribus, bracteis ovatis acutis margine membranaceis.

In Upper Louisiana. *Bradbury. v. s. in Herb. Bradbury.* Resembles *P. pauciflora.*"

In 1871, Sereno Watson described a plant which he collected in Salt Lake Valley near the mouth of the Jordan River as *Plantago Bigelovii* A. Gray. He noted it as "resembling *Plantago pusilla*, but with twice larger flowers and fruit, and the capsule (1″ or more in length) more protruded."

In 1883, Engelmann observed a different form from Nuttall's species in plants in his herbarium which had been collected by Geyer on the Nicollet Northwestern Expedition and by Hayden during the survey of Nebraska and the adjacent territories. This form he described under the name *Plantago pusilla*, var. *macrosperma.* His point of emphasis was the measurement of the seeds, and in his herbarium there is extant a sheet containing the following measurement notes:

" 1. St. Louis	1.3 mm.
2. Indian Territory broad-leaved form	1.8 "
3. Nicollet, Shienne River	2.4 "
4. Hayden, Yellowstone	2.4 " "

His diagnosis specifies the "larger form, 4 to 7 inches high, with longer much exsert capsules; seeds nearly twice the length of the last, 2.4 mm. or 1.2 lines long. Saline soil of the Western Plains; on the Shienne [etc.]." Engelmann further states "Dr. Gray thinks that he has proofs that this species [*P. pusilla*], or probably the second form of it [*P. pusilla*, var. *macrosperma*], is the lost *P.*

elongata Pursh, * * * but even if so Nuttall's name, now well known since more than 60 years, ought to be retained in place of a doubtful and very inappropriate one."

Asa Gray in the Synoptical Flora gives, in the synonymy of *P. pusilla* Nuttall, "*Plantago elongata* Pursh proves to be this, a bad name." Asa Gray "received Jany. 1, 1883" a specimen from Engelmann with his handwritten label, as follows:

"Plantago pusilla Nutt.
sem. 4. maximis foveolatis
High Prairies. Fort Union
on Yellowstone
F. V. Hayden 1853–4."

— an evident copy of one of Hayden's labels. Of this specimen, Gray annotated in his own hand on the herbarium sheet, below the label, as follows:

"Received Jany. 1, 1883.
This just answers to, and is
from the district of the
Plantago elongata, Pursh
(seen in Hb. Kew.)
But original of Pursh seems to have
several ovules!"

The expression "seen in Hb. Kew.," quoted above, at first suggested that Dr. Gray may have believed the Kew specimen to be Pursh's type of the species, but the following extract from a memorandum by the Director of the Royal Botanic Gardens, Kew, clearly indicates that this is not the type: "The specimen of Plantago elongata, Pursh, in Kew Herbarium seen by Dr. Asa Gray, was collected by Dr. Taylor at Sepulchre Bluffs, Bradbury. There is no specimen at Kew of any Plantago collected by Pursh. . . . The words 'No. 28, Dr. Taylor, Sepulchre Bluffs, Bradbury' and the name 'Plantago elongata Psh.' are in ink, in the handwriting of Sir William Hooker. But the words '= P. pusilla, *Nutt.*' and the mark of '!' . . . are in pencil, in the handwriting of Dr. Asa Gray."

Later than this treatment of the species, the principle of priority as a *rigid* rule of taxonomic work was renewed; and *Plantago elongata* Pursh was given, by many, the benefit of its publication in 1814 as against the date of 1818 for Nuttall's

Plantago pusilla. This action has been followed, more or less consistently, including the writer's work, since that time. It is evident from herbarium annotations, and synonymy wherever it occurs, that the identity of Pursh's species and Nuttall's species has been taken for granted, thus following Asa Gray.

In 1900, P. A. Rydberg, also without reference to *P. elongata* Pursh, segregated from *Plantago pusilla* Nuttall a northern and western form which he called *Plantago myosuroides.* In his description of the species he cites two of the specimens already referred to, namely, Watson's "*Plantago Bigelovii*" from Utah, and Geyer's material from the upper Missouri. The latter is clearly designated by Engelmann. It is quite evident that Rydberg was without knowledge of Engelmann's publication, for his characterization is remarkably like that by Engelmann. He says "nearest related to *P. pusilla* Nutt., differing in the larger size, larger flowers, the longer capsule which is twice as long as the sepals," etc.

From the foregoing it seems evident that Asa Gray had not finished comparing Pursh's type and other material of the species, and that Engelmann and Rydberg were unfortunate in coming no nearer to the identity of Pursh's type. The type specimen, according to present information, is in the Academy of Natural Sciences of Philadelphia; and when placed beside specimens from Geyer, Hayden, Macoun, and Watson, it is hardly distinguishable from some of them, and is readily recognizable as belonging with them and later collections in distinction from the species occurring mainly east and south of the range of *Plantago elongata.* Engelmann and Rydberg each described characters not noted by Pursh; also, in addition to those quoted, characters not noted by the other; and the combination of Pursh's diagnosis with Engelmann's and Rydberg's makes a nearly complete description of the species.

Plantago elongata occurs, so far as ascertained, only in saline and subsaline localities, and only above the 1000 foot contour. The type locality is determinable from the following, kindly sent by Mr. Stewardson Brown of the Philadelphia Academy: "Regarding locality for Pursh's *Plantago:* in Bradbury's Journal page 335 in a 'Catalogue of some of the more rare and valuable plants discovered in the neighborhood of St. Louis and on the Missouri' he says '*Plantago elongata,* near the Maha Village.' According to the detail part of the Journal this must have been some distance up the Missouri, as the time between March 14 and May 11 was spent in reaching that point; in another place he says, in referring to the distribution of the honey bee, which was not known west of the Mississippi up to 1797, 'They are now found as high up the Missouri as the Maha Nation . . . a distance of 600 miles.'" The name "Maha" in recent bibliographies refers to an Indian tribe now situated in New Mexico. But doubtless Bradbury's use of the name "Maha," among several spellings, was for "Omaha." The location of the Omahas is indicated by the following from Alice C. Fletcher's "Historical sketch of the Omaha tribe of Indians in Nebraska": "The Omaha tribe of Indians live in the State of Nebraska, about 80 miles north of the city of Omaha, on a reservation 12 miles in length north and south, and bound on the east by the Missouri River and on the west by the Sioux City and Omaha Railroad. Of the various tribes living in Nebraska when the white settlers first entered the Territory the Omahas are the only Indians remaining upon their ancient home lands. In the absence of any written records it is almost impossible to fix dates, but it seems probable that the Omahas have dwelt near their present location for the past two centuries or more. Their traditions point to an earlier home in the Ohio valley, whence they were driven by wars; slowly migrating across the Mississippi River, up the Des Moines and its tributaries to their headwaters, thence westward until the Missouri was reached. Crossing this river, the people gradually made their way south to their present place of residence." Edwin James, in the narrative of the Long Expedition, also refers to the location of the "Omawhaws," as follows: "What length of time the Omawhaws have resided on the Missouri is unknown; but it seems highly probable that they were not there when Mr. Bourgmont performed his journey to the Padoucas, in the year 1724, as he makes no mention whatever of them. It would seem, indeed, that they had separated from the great migrating nation . . . on or near the Mississippi, and that they had since passed slowly across the country, or perhaps up the St. Peter's, until they finally struck the Missouri at the mouth of the Sioux River. This is rendered highly probable by the circumstance of Carter having met with them on the St. Peter's in the year 1766, associated with the Shienne and others, all of whom he represents as bands of the Naudowessie nation." C. A. Geyer collected his specimens (*no. 279*) in "arid saline plains valley of Shian River near its mouth (upper Missouri)," now the Cheyenne River, which empties into the Missouri about 35 miles, air line, northwest of Pierre, South Dakota. One of Hayden's specimens of *Plantago elongata* bears the following label:

"FLORA NEBRASKANA
Plantago pusilla Nuttall
Semminibus 4 maximis
High Prairies, Ft. Union.
DR. F. V. HAYDEN, Leg. 1853–4."

A map of Nebraska and Dakota, etc., by Maj. John Warren, Mch. '67, accompanying Final (4th) Report of U. S. Geological Survey of Nebraska, etc. by F. V. Hayden, Washington, 1872, contains location of Ft. Union, Long. 104° west, Lat. 48° north, on the north bank of the Missouri River, about five miles above the mouth of the Yellowstone River. This location is given on the map of 1870. There is no modern use of this name for this location within the information of present day atlases. Pound & Clements, in their "Phytogeography of Nebraska," indicate the limited habitat of the species, when they say of " . . . Xerophytes of high prairies and sand hills. . . . P. elongata, which is confined almost wholly to alkaline situations, seems to exhibit a tendency to become a halophyte."

The limiting of this species accomplishes two fortunate things: It recognizes the applicability of Pursh's name, because of the elongated (more or less interrupted) spikes, and long carinate bracts; second, the retention of the well-known and long-used name published by Nuttall for the species common in the lower Mississippi Valley and its tributaries, and eastward along the Ohio, the Tennessee, the Gulf Coast, and up the Atlantic seaboard to Massachusetts.

Plantago pusilla Nuttall has been well known to all collectors east of the Mississippi and south of the Great Lakes. The name had become almost a "household word" among botanists. This name was retired because of the priority of Pursh's name, during the latter part of the now long period in which the species were constantly confused. The name *pusilla* is applicable in every sense of the word to practically every condition of the species, as commonly found in its sandy or otherwise characteristic habitat. In distinction from it, *Plantago elongata* Pursh is noticeably lank and lean and its strength is most emphasized in the woody character of its tissues, especially the tap root, which is heavy in proportion to the rest of the plant, as is typical for plants in saline localities.

Plantago pusilla Nuttall, 1818, and the less used and often forgotten *Plantago hybrida* Barton, 1818, applied to the same species, may yet be the cause of some nomenclatorial controversy. The writer has tried by every known method to determine the priority of one of these names. Dr. Barnhart * has discussed the question quite fully. And Nuttall's name is here retained as prior on the following "internal evidence":

Philadelphia, 1818	Nuttall, Gen.	Barton, Comp. Fl. Phila.
Title deposited to secure copyright	April 3, 1818.	July 9, 1818.
Preface dated	May 27, 1818.	July 11, 1818.
Cross references		Preface acknowledgment of Nuttall's kindness in permitting use of Nuttall's work. Text citations to Nuttall's work.
Certified by	D. Caldwell, *Clerk of the District of Pennsylvania.*	D. Caldwell, *Clerk of the District of Pennsylvania.*

Against this, however, is the argument (?) of Otto Kuntze,† for Barton, January 1818. For this, Kuntze gives no basis or reference.

Barton goes to some length to explain his separation of *P. hybrida* from *P. maritima*, by which name he had called it in his Prodromus Florae Philadelphicae, 1815, but *P. hybrida* he now (1818) emphasizes by being "destitute of everything like woolliness at the base," and other distinctive characters.

Plantago pusilla and *P. heterophylla* have been confused by many collectors who failed to consider the seeds, in the forms of the first with slight toothing of the leaves, and in the forms of the latter without such toothing. It is interesting to note that Nuttall so confused them in a collection of his own from Arkansas (not his type), one plant of *P. heterophylla* with entire leaves and 10

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* See his Nomenclatural notes, Bull. Torrey Club **24**: 409. 1897; **26**: 379. 1899.

† Rev. Gen. Pl. 3^2: 160. 1898.

seeds being placed with typical *P. pusilla* with entire leaves and 4 seeds, these being now in the Academy of Natural Sciences of Philadelphia.

Plantago pusilla from the Columbia River and neighboring parts of Washington and Oregon varies somewhat from the eastern forms. It is noteworthy that the earliest record, available at this time, of the species from the Columbia drainage is May, 1887. It seems probable that the plant is here introduced and naturalized. But present data afford no explanation of the method of introduction. Few specimens attain normal dimensions, and the spikes often are but few-flowered.

The species has long been known as far east as Long Island and Connecticut, more recently from Rhode Island, and now, by the careful search of Mr. E. B. Chamberlain, from Massachusetts, at Seekonk, June 13, 1901.

Plantago pusilla Engelmanni (see below, p. 528) was described by Engelmann, in 1883, as a variety *major* of *P. pusilla*, characterized as: "much larger and stouter, leaves lanceolate-linear, often 1½ to 2 lines wide, the larger ones laciniate with few long teeth or lobes; scapes densely woolly at base, with the elongated spike often 9 inches high; bracts acute, longer than the sepals; seeds intermediate in size between the two other forms — Near Atoka, north of Red River in the Indian Territory." The size of these seeds is given in the note quoted above (under *P. elongata*) as 1.8 mm. for the "Indian Territory broad-leaved form." Several specimens belonging here are intermediate with *P. pusilla* in the woolliness at the base. The extreme form in this respect is Engelmann's own type. So, this character must be considered as relatively unimportant. This woolliness at the base, together with the laciniate toothing of many of the leaves and the extension of the bracts beyond the calyx, superficially confuse this subspecies with some plants of *P. heterophylla*, but the difference may be at once recognized by the number of seeds and their size and shape, as well as the more rigid habit. This subspecies seems to be limited to Missouri, Arkansas, Indian Territory, and Oklahoma. There is no apparent intergradation with *P. elongata* Pursh, but there is regular intergradation with *P. pusilla* in Missouri and Arkansas, and questionably in Kansas.

Plantago Bigelovii A. Gray requires little discussion. With a range from south central California northward into British Columbia, and only in low valleys and along the seacoast, it is readily distinguished from the other annuals of the genus. In the low valley forms, the habit tends to be slender, with a somewhat tardy maturing of the seeds. In the coastal forms, the habit is pronouncedly stockier, with an early maturity. About the region of San Francisco Bay the two forms strongly intergrade. The type, from Benicia, in the Gray Herbarium, is a depauperate plant. Evidently the remaining Bigelow specimens, if any, were destroyed in drawing the diagnosis in 1857. Additional plants, collected by Dr. E. L. Greene in 1874, were used in the emended description in the "Botany of California" as there cited, and as labeled "Syn. Fl. N. Amer." in the Gray Herbarium.

Plantago heterophylla Nuttall was described from Arkansas material which was without flowers or fruit. The plants were in a fine vegetative condition, showing well the fibrous roots, the mass of woolly hairs at the crown of the short caudex, long narrow herbaceous somewhat fleshy leaves with prominent scattered teeth. The spikes, flowers, and fruit were early described by Asa Gray in 1856 in his Manual, second edition. The extremes of the species are very unlike but they are connected by an innumerable number of intermediate forms. There are those so similar to depauperate forms of *P. pusilla* that they may be recognized only by the number and form and surface of the seeds. Others are so tall and erect and slight that they simulate *P. pusilla Engelmanni;* others so depressed-spreading and laciniate-toothed that they scarcely seem to be the same species. But the fruits and seeds run true.

Between 1880 and 1890, there was collected a series of plants of this species which were apparently new to the known California flora. They were from the environs of San Francisco Bay southward, here and there, to Tia Juana, Lower California, just over the international boundary. E. L. Greene described these as *P. californica,* in 1885. The vegetative characters of the Californian specimens vary as do (and parallel to) the southern and eastern forms. There is one difference in the fruiting stage, namely, the smaller number of seeds, often only five to eight, due very probably to incomplete fecundation of the ovules. It is highly significant, too, that the collections of this species in California seem to have ceased with the 1890's; especially significant, with such men as Heller, Abrams, Orcutt, Parish, and others in the field since that time. Under the data available, the present conclusion is that *P. heterophylla* Nuttall, 1837 (*P. californica* Greene, 1885), was for a few years adventive in California.

It is a pleasure gratefully to acknowledge the kindness and interest of officers of institutions, and others, who have offered or sent material for study; and duly to credit them under each species.

Key to species treated in this paper

[Biennials (normally). *P. virginica* group.]
Annuals, seeds pitted.
  Seeds 4, small, symmetrical.
    Pacific Slope native species. Bracts carnulose-keeled, pitted when dry .... *P. Bigelovii.*
    Central and Eastern native species. Bracts not pitted when dry.
      Campestrian, above 305 meters elevation (= ± 1000 ft.). Bracts saccate-keeled; seeds four times as long (2 mm.) as broad .... *P. elongata.*
      Mississippi drainage, Gulf region, Atlantic Slope and Coast, low elevations. Bracts not keeled, though somewhat swollen; seeds not more than three times as long as broad.
        Leaves usually entire; seeds about two and a half times as long (1 mm.) as broad. (Introduced and naturalized in Puget Sound region and tributaries.) .... *P. pusilla.*
        Leaves usually distantly laciniate-toothed; seeds about three times as long (1.8 mm.) as broad. (Known only from Indian Territory east to Missouri River.) *P. pusilla Engelmanni.*
  Seeds 10–30 (or fewer by abortion), minute, unsymmetrical .... *P. heterophylla.*

PLANTAGO BIGELOVII A. Gray, in Whipple, Pacif. R. R. Rep. **4**: 117. 1857; *descript. emend.* Bot. Calif. **1**: 612. 1876. Not *P. Bigelovii* S. Watson, Bot. King Exped. **5**: 212. 1871.

A low, erect, subcarneous, acaulescent annual. Roots one or two, with the secondaries fibrous, slender, numerous. Leaves basal, erect to ascending, more or less carnulose, glabrous to sparingly pubescent, several to many, sessile, linear to linear-filiform, scarious-expanded at the base, entire, obtusely (callous-) tipped, obscurely 1–3-nerved, 3–10 cm. × 1–4 mm. Scapes basal and axillary, erect, slightly to twice surpassing the leaves, terete, a little thickened at the summit, appressed-pubescent, one to ten (even fifteen?), 5–15 cm. tall. Spikes cylindrical, with the flowers more or less imbricate, few- to thirty-flowered. Bracts closely subtending the flowers, about equaling the calyx, carnulose-keeled and saccate, broadly ovate, margins scarious and as wide as the herbaceous center, obtuse, 2.5 mm. × 3 mm. The flowers inconstantly dimorpho-subdioecious. Calyx glabrous, its divisions scarious, with slightly herbaceous midribs, obovate, rounded, 2 mm. × 1.5 mm. Corolla minute, just exceeding the capsule, its lobes spreading, often not closing in fruit, scarious, with darker midrib, lanceolate-triangular, acute. Stamens two, little if at all exserted. Pyxis one third longer than the calyx, oblong-ovoid, abruptly rounded, circumscissile just below the middle. Seeds four to six, black, rough, oblong, 1.5 mm. × 0.5 mm.

Type specimen is Bigelow's collection, April 23, 1854, from Benicia, California, in the Gray Herbarium.

Sixty-one sheets or specimens from British Columbia, Washington, and California have been examined, in herbaria as follows: 6, Geological and Natural History Survey of Canada; 9, Columbia University and New York Botanical Garden; 4, Field Museum of Natural History; 12, Gray Herbarium; 6, Doctor Edward Lee Greene; 7, Missouri Botanical Garden; 3, Academy of Natural Sciences of Philadelphia; 10, United States National Herbarium; 1, University of Pennsylvania; and 3, my own herbarium.

PLANTAGO ELONGATA Pursh, Fl. Am. Sept. **2**: 729. 1814

P. pusilla Decaisne, *pro parte*, in DC. Prod. **13′**: 696. 1852.

P. Bigelovii S. Watson, Bot. King Exped. **5**: 212. 1871. Not A. Gray, in Whipple, Pacif. R. R. Rep. **4**: 117. 1857.

P. pusilla var. *macrosperma* Engelmann, Bot. Gaz. **8**: 175. 1883. Not *P. macrosperma* Steudel, Flora **32**: 405. 1849.

P. pusilla A. Gray, *pro parte*, Syn. Fl. **2**^{1}: 392. 1886. Not Nuttall, Gen. N. Am. Pl. **1**: 100. 1818.

P. elongata Auct. Am. plur., *pro parte*.

P. myosuroides Rydberg, Mem. N. Y. Bot. Gard. **1**: 369. 1900.

A relatively low, erect, rather coarse, acaulescent annual, of subsaline and saline situations, noticeably cinereous-pubescent in its lower half, with the general habit of being erect, usually higher than wide, and with the oldest scapes becoming decumbent with age. Root normally one, long, stout, woody, and large in proportion to the plant; secondaries few, filiform, and shorter than the primary. Leaves basal, erect or slightly spreading, sometimes with tips recurved, one half to three fourths as high as the plant, herbaceous or slightly fleshy in larger forms, strongly cinereous-pubescent for the lower half, few to numerous, gradually expanded into the semi-clasping base (two to four times as long as wide), linear, entire or remotely callous-denticulate, callous-tipped even when long-acuminate, 1-nerved, 3–10 cm. × 0.5–2 mm. Peduncles axillary, erect, or the oldest bowed outward from the crown, equaling or shorter than the leaves, rarely longer, terete, not striated, or but slightly so below the spike, one to many, 3–8 cm. high. Spike erect, cylindrical, slender, with the flowers often distant, 1–10 cm. long. Bracts closely subtending the flowers, rather uniformly ascending, about equaling the calyx, herbaceous-carnose, distantly spur-keeled to 0.5 mm. below basal attachment and 0.5 mm. divergent from peduncle, triangular-ovate, scarious, with margins one third as wide as the herbaceous center, entire, acute or acutish, 2 mm. (from spur to apex) × 1.5 mm. Flowers subperfect. Calyx glabrous, inequilateral, its divisions obovate, scarious margins wider than the distinctly herbaceous midrib, apex truncate-rounded, about the width of the bract, 1.75 mm. long. Corolla very minute, rarely closing to form a beak, throat as long as the lobes, the lobes triangular, entire, acute, 0.5 mm. × 0.25 mm. Stamens two, included. Pyxis glabrous, twice surpassing the calyx, oblong-ovate, truncate-rounded, with the base of style persistent as a distinct tubercle, circumscissile just below the middle, 2.5–3 mm. × 1.5 mm. Seeds four, finely rugose-pitted, dark seal-brown, elliptical, 2 mm. × 0.5 mm.

Type specimen is Bradbury's collection from "Upper Louisiana," in the herbarium of the Academy of Natural Sciences of Philadelphia.

Thirty-seven sheets or specimens from Assiniboia, North Dakota, South Dakota, Nebraska, Oklahoma, Montana, Colorado, and Utah, have been examined, in herbaria as follows: 5, Geological and Natural History Survey of Canada; 6, Columbia University and New York Botanical Garden; 5, Gray Herbarium; 1, Doctor Edward Lee Greene; 8, Missouri Botanical Garden; 2, Academy of Natural Sciences of Philadelphia; 5, United States National Herbarium; 5, University of Nebraska.

PLANTAGO PUSILLA Nuttall, Gen. N. Am. Pl. **1**: 100. 1818

P. maritima Barton, Prod. Fl. Phila. 26. 1815. Not Linnaeus, Sp. Pl. 114. 1753.

P. hybrida Barton, Comp. Fl. Phila. **2**: 214. 1818; Fl. N. Am. **3**: 77. *pl. 98. f. 1.* 1823.

P. linearifolia Muhlenberg (?), Cat. ed. 2, 15. 1818, *nomen nudum.* — Torrey, Fl. U. S. 185. 1824, *cit. excl.**

P. pusilla Decaisne, *pro parte*, in DC. Prod. $\mathbf{13}^1$: 696. 1852.

P. elongata Auct. Am. plur. Not Pursh, Fl. Am. Sept. **2**: 729. 1814.

An inconspicuous, very low acaulescent annual, of sandy or dry situations, occasionally intruding upon woodlands, mostly glabrous or with slight pubescence about the crown. Roots one or two, normally short, small in proportion to the plant, weak, the secondaries numerous, filiform-fibrous, and usually longer than the primaries. Leaves basal, erect or somewhat spreading, one fourth to one half as high as the plant or even shorter in depauperate individuals, herbaceous or slightly fleshy, 4 or 5 to numerous, abruptly expanded into the semi-clasping base (a little longer than broad), filiform to linear, sometimes narrowed below, entire or rarely remotely callous-denticulate, apex callous, blunted or sometimes acutish, 1-nerved or in wider forms obscurely 3-nerved, the outer nerves being about equidistant from midrib and margin, 1–5 cm. × 0.5–2 mm. Peduncles axillary, erect to spreading-ascending, four times as long as, to a little shorter than, the leaves, terete, becoming striate when dry especially near the base of the spike, 1 to many (160 counted on one individual from Long Island), 3–10 cm. high. Spikes erect, cylindrical, slender, with flowers at first imbricate, at length even much scattered. Bracts closely subtending the flowers, at first erect, later spreading by the expanding fruit, equaling the calyx, surpassing it in etiolated forms, herbaceous, carnulose, tending to subsaccate dorsally, triangular-ovate, scarious, with margins one half as wide as the herbaceous center, entire, rounded-obtuse or blunt, 1.5–2 mm. × 1.25–1.5 mm. Flowers subperfect. Calyx glabrous, inequilateral, its divisions obovate, with scarious margins wider than the

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* Torrey, *loc. cit.*, gives "Muhl. Cat. p. 15?." Torrey later, and many others, give "Muhl. Cat. p. 15? ex Torr. Fl. U. St. 185." This citation, by its form, naturally refers to Muhl. Cat. ed. 1, Lancaster, 1813. The Plantaginaceae are listed on page 16; and *P. linearifolia* is not included in the list. Torrey did specify the second edition of Muhlenberg's Catalogue in his bibliography at the beginning of his Flora, but it must have been constantly overlooked. Accordingly, Torrey's citation, and those following it, must be considered incomplete and misleading.

distinctly herbaceous midrib, apex rounded or bluntly apiculate by the excurrent midrib, less than the width of the bract. Corolla very minute, forming an incompletely closed beak above a hardly discernible throat; its lobes triangular, entire, acute, 0.5 mm. × 0.25 mm. Stamens two, included. Pyxis one third surpassing the calyx or little more, glabrous, ovate--ovoid, truncate-rounded or with the base of the style persistent in the slightly depressed apex, circumscissile just above the lower third, 1.75 mm. × 1 mm. Seeds 4, coarsely rugose-pitted, dark olive-brown, elliptical-oblong, 1.25 mm. × 0.5 mm.

Woodland forms intergrade with the following subspecies.

Type specimen is Nuttall's collection, from "Arkansas," in the herbarium of the Academy of Natural Sciences of Philadelphia.

One hundred and seventy-four sheets or specimens from Massachusetts, Rhode Island, Connecticut, New York (Long Island), New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, Virginia, South Carolina, Georgia, Florida (?), Illinois, Kentucky, Tennessee, Alabama, Missouri, Arkansas, Kansas, Indian Territory, and Texas; and (introduced) in Washington, Oregon, and California, have been examined, in herbaria as follows: 2, Brooklyn Institute Museum; 28, Columbia University and New York Botanical Garden; 14, Field Museum of Natural History; 16, Gray Herbarium; 6, Doctor Edward Lee Greene; 47, Missouri Botanical Garden; 22, Academy of Natural Sciences of Philadelphia; 7, Mr. Wilhelm N. Suksdorf; 21, United States National Herbarium; 1, University of Nebraska; 6, University of Pennsylvania; and 4, my own herbarium.

Plantago pusilla Engelmanni nom. nov.

P. pusilla var. *major* Engelmann, Bot. Gaz. **8**: 175. 1883. Not *P. major* Linnaeus, Sp. Pl. 112. 1753.

A rather large annual, varying in height to 25 cm., about twice the dimensions of *P. pusilla* when at the same stage of development, noticeably herbaceous, densely woolly at the base. Root usually one, secondaries about the length of the primary, numerous, filiform, fibrous, the crown densely pubescent or even woolly among the leaf-bases. Leaves basal, erect or strict-ascending, glabrous to cinereous-pubescent, numerous, with petiole distinguishable from the lanceolate-linear blade, attenuate at both ends, in maturity with few prominent scattered callous teeth which are either straight or falciform, acute except for the callous tip, 1–3-nerved, 4–12 cm. × 1–4 mm. Peduncles axillary, erect to strict-ascending, much surpassing the leaves, terete below, channeled above, cinereous above, densely woolly below, numerous, 5–25 cm. high. Spikes erect, thin, with the flowers scattered or in false pairs and clusters. Bracts closely subtending the flowers, erect or nearly so, typically one half surpassing the calyx, herbaceous, saccate, triangular-lanceolate, margins narrowly scarious, apex strictly acute, about 2.5 mm. long. Flowers apparently perfect. Calyx glabrous, its divisions inequilateral, with the scarious margins distinctly wider than the herbaceous midrib, apex obtuse, equaling the width of the bract. Corolla very minute, forming incompletely closed beak, with throat short, its lobes triangular, entire, acute, about 0.5 mm. long. Stamens 2, included. Pyxis more than one third surpassing calyx, ovoid-oblong, obtusish, circumscissile at about the lower third. Seeds four, obscurely pitted, very dark brown, oblong, 1.8 mm. (or a little less) × 0.33 mm.

This subspecies intergrades strongly with woodland or otherwise sheltered individuals of the typical form.

Type specimen is G. D. Butler's collection from near Atoka, Indian Territory, in the Missouri Botanical Garden, Engelmann Herbarium.

Ten sheets or specimens from Indian Territory and Missouri have been examined, in herbaria as follows: 4, Gray Herbarium; 4, Missouri Botanical Garden; 2, New York Botanical Garden.

PLANTAGO HETEROPHYLLA Nuttall, Trans. Am. Phil. Soc. II. **5**: 177. 1837

P. caroliniana Pursh (?), Fl. Am. Sept. **1**: 98. 1814. Not Walter, Fl. Carol. 85. 1788.

P. pusilla Decaisne, *pro parte*, DC. Prod. **13**^{1}: 696. 1852. Not Nuttall, Gen. **1**: 100. 1818.

P. perpusilla Decaisne, in DC. Prod. **13**^{1}: 697. 1852.

P. californica Greene, Bull. Calif. Acad. I. **3**: 123. 1885. Not *P. Durvillei* var. *californica* Fischer & Meyer, Ind. Sem. Petrop. 1839–40.

A very variable, low, erect or spreading, herbaceous, glabrous, or partly woolly-pubescent annual. Roots one or two, often very short; secondaries fibrous, slender, usually very numerous. Leaves basal, erect or spreading, herbaceous, usually very thin, few to many, blade and petiole indistinguishable or very gradually expanded below, linear, narrow, acute or rarely blunt, 1–3-nerved, 3–12 cm. × 0.75–2.5 mm., entire to toothed, the straight or curved teeth sometimes 1 cm. long. Peduncles axillary, erect to spreading, terete, slender, glabrous, or often woolly at the base, few to many, 4–15 cm. high. Spikes racemiform, often much and irregularly interrupted, 10–30- or more-flowered. Bracts usually conspicuous, twice surpassing to equaling the calyx in fruit, closely involving the calyx, herbaceous, with scarious margins at the lower half (half as wide as the herbaceous center), triangular, ovate, entire, blunt or obtusish at the apex, 2 mm. × 1.5 mm. when mature. Flowers normally perfect. Calyx glabrous, equilateral or slightly inequilateral, its divisions ovate, with wide scarious margins and narrow prominent green midrib, ovate, blunt, about the width of the bract. Corolla minute, with hardly distinguishable throat, its lobes erect over the fruit, triangular, entire, acute, 0.25 mm. × 0.10–0.15 mm. Stamens two, included. Style slender, exserted, about 1 mm. long, at length its base persistent as a distinct tubercle. Pyxis fusiform-ovoid, circumscissile just below the middle, 2.5–3 mm. × 2 mm. Seeds 10–25 or more, or by abortion fewer, irregular by mutual pressure, blackish brown, oblong, 0.75 mm. × 0.35–0.40 mm.

Type specimen is Nuttall's collection, from Arkansas, in the herbarium of the Academy of Natural Sciences of Philadelphia.

One hundred and ninety-five sheets or specimens from New Jersey, Pennsylvania, Delaware (?), Maryland, North Carolina, South Carolina, Georgia, Florida, Illinois, Kentucky, Tennessee, Alabama, Mississippi, Missouri, Arkansas, Louisiana, Texas, and (introduced) in California and Lower California, have been examined, in herbaria as follows: 3, President Ezra Brainerd; 2, Brooklyn Institute Museum; 38, Columbia University and New York Botanical Garden; 15, Field Museum of Natural History; 32, Gray Herbarium; 7, Doctor Edward Lee Greene; 45, Missouri Botanical Garden; 22, Academy of Natural Sciences of Philadelphia; 1, Mr. Wilhelm N. Suksdorf; 20, United States National Herbarium; 7, University of Pennsylvania; and 3, my own herbarium.

MUSEUM OF THE BROOKLYN INSTITUTE
OF ARTS AND SCIENCES.

Studies on the Rocky Mountain flora — XIX

Per Axel Rydberg

Muhlenbergia squarrosa (Trin.) comb. nov.

Vilfa squarrosa Trin. Mém. Acad. Pétersb. VI. Sci. Nat. **5**^{2}: 100. 1840.

Vilfa depauperata Torr. in Hook. Fl. Bor.-Am. **2**: 257. 1840. Not *Muhlenbergia depauperata* Scribn. 1884.

Sporobolus depauperatus Scribn. Bull. Torrey Club **10**: 63. 1883.

The group of grasses which Torrey, Trinius, and Thurber included under the generic name *Vilfa* has been transferred from *Sporobolus* to *Muhlenbergia*. See Bull. Torrey Club **32**: 599, 600. As this species is a member of that group, it also should be transferred. It is doubtful which of the two specific names, *squarrosa* or *depauperata* is the older, but the latter is not available, as there is already a *Muhlenbergia depauperata* Scribn.

Agrostis atrata sp. nov.

A somewhat tufted perennial; stems 1.5–3 dm. high, few-leaved, more or less bulbous at the base; sheaths glabrous, shorter than the internodes; ligules ovate, 1.5–2.5 mm. long; leaf-blades 5–10 cm. long, about 2 mm. wide, flat, smooth; panicle 5–8 cm. long, rather open; branches ascending, the lower ones 2–3 cm. long; spikelets dark purple, about 2 mm. long; empty glumes nearly equal, abruptly acute or acuminate; flowering glume nearly as long, obtusish; palet slightly shorter and more than half as broad.

The type number of this species was determined by Professor A. S. Hitchcock as *A. Thurberiana*, but it differs from that species in the following respects: The empty glumes are dark purple as in *A. aequivalvis*, abruptly acute or acuminate; the inflorescence is short and open and the stem is few-leaved. In *A. Thurberiana* the empty glumes are green, only tinged with purple at the apex, narrowly lanceolate and gradually acute; the inflorescence is long and narrow, and the stem is very leafy. It differs from *A. aequivalvis* in the smaller spikelets, only 2 mm. long, instead of 3 mm., and the shorter rachilla, which is barely one third as long as the flower.

BRITISH COLUMBIA: Yoho Valley, Sept. 6, 1904, *John Macoun 64787* (type, in herb. N. Y. Bot. Gard.); also *64788;* Selkirk Mountains, 1904, *C. H. Shaw 424;* Roger's Pass, July 31, 1890, *John Macoun.*

Agrostis Bakeri sp. nov.

A cespitose perennial; stem about 3 dm. high, erect, slightly geniculate below, glabrous; basal leaves numerous; sheaths close, slightly scabrous, those of the stem-leaves often shorter than the internodes, ligules ovate, 2 mm. long, dentate; leaf-blades flat, 1–2 mm. wide, 5–10 cm. long; panicle ovoid, 8–10 cm. long, open; branches ascending, branched above the middle, the lower 3–5 cm. long; pedicels somewhat scabrous, thickened below the spikelets; empty glumes nearly equal, purple, 2–2.5 mm. long, acuminate; flowering glume three fourths as long, obtuse, bearing above the middle a dorsal straight awn a little exceeding the glume; palet none or minute.

The type specimen of this species was determined as *A. tenuis erecta* by Professor Scribner and included by Professor Hitchcock in *A. idahoensis* (the latter united *A. idahoensis* Nash and *A. tenuis* Vasey). Professor Hitchcock remarked that Baker's *no. 150* "is yet more robust and there is a short straight awn on the flowering glume." These are the essential characters by which it is to be separated from *A. idahoensis.* The empty glumes are also larger and more acuminate. One of the other specimens referred to *Agrostis Bakeri*, viz. *no. 37*, was included in *A. hiemalis geminata* by Hitchcock. Of this he remarked that it has "the awn but a more diffuse panicle." It is evident that Baker's *no. 37* and *no. 150* belong to the same species, the former being younger and less well developed. *Agrostis Bakeri* is most closely related to *A. geminata* Trin., differing in the broader leaves, ascending instead of divaricate branches of the panicle, smaller spikelets, and shorter awns. In *A. geminata* the basal leaves are filiform and involute, the spikelets about 3 mm. long and the awn equaling the empty glumes. *A. Bakeri* grows in the mountains at an altitude of 3000–3200 m.

COLORADO: Near Pagosa Peak, August, 1899, *C. F. Baker 150* (type, in herb. N. Y. Bot. Gard.); *no. 37* and *no. 148.*

Deschampsia confinis (Vasey) sp. nov.

Deschampsia caespitosa confinis Vasey; Beal, Grasses N. Am. **2**: 369. 1896.

The only character given by Professor Beal is the unusual length of the ligules. To this should be added a narrow inflorescence with strongly ascending branches and a long awn inserted near the base of the floral glume. I think that these characters make the plant specifically distinct from *D. caespitosa*. *D. confinis* ranges from southern Utah and Arizona to southern California.

Sphenopholis intermedia (Rydb.) comb. nov.

Koeleria truncata major Torr. Fl. U. S. **1**: 117. 1824.
Eatonia intermedia Rydb. Bull. Torrey Club **32**: 602. 1905.
Sphenopholis pallens major Scribn. Rhodora **8**: 145. 1906.

Poa callida sp. nov.

Perennial, with a creeping rootstock; stem 3–5 dm. high, somewhat flexuose, striate and glabrous; ligules lanceolate, long-attenuate, 5–6 mm. long; leaf-blades flat, flaccid, 5–12 cm. long, about 3 mm. wide, smooth; sheaths exceeding the internodes; panicle open, 1–1.5 dm. long; branches spreading or reflexed, scabrous; the lower ones in 4's to 6's, 5–7 cm. long, spikelet-bearing above the middle; spikelets about 3 mm. long, 2- or 3-flowered, light green, strongly compressed; first empty glume subulate, 1-nerved, 2 mm. long; the second slightly broader, 3-nerved, 2.5 mm. long, glabrous; floral glumes 3 mm. long, strongly 5-nerved, acuminate, glabrous except the keel, which is slightly silky below; cobweb scant but long.

This species is related to *Poa occidentalis* Vasey, but is a weaker and more flaccid plant, has very long and conspicuous ligules, narrow flowering glumes, which are still more strongly nerved. The spikelets resemble those of *P. nervosa*, but are smaller; the floral glumes are smooth and with a distinct cobweb. The type was named *P. serotina*, which also it resembles, but in that species the floral glumes are less compressed, with obsolete intermediate nerves.

MONTANA: Warm Springs, Helena, July 13, 1895, *Rydberg 2145* (type, in herb. Columbia Univ.).

Poa scaberrima sp. nov.

A tufted perennial, with numerous intravaginal innovations; stem 3–5 dm. high, 2- or 3-leaved, glabrous; ligules lanceolate, acuminate; leaf-blades filiform, involute, very scabrous, pale green; blades of the basal leaves 8–15 cm. long, less than 1 mm. wide; those of the stem-leaves 1–5 cm. long, erect; panicle elliptic, dense, 4–7 cm. long; branches short, strongly ascending; spikelets about 1 cm. long; empty glumes ovate, nearly equal, 4–5 mm. long, glabrous; floral glumes ovate, acuminate, pale, slightly tinged with purple, 5–6 mm. long, strongly 5-nerved, and conspicuously scabrous.

The type was named by Professor Scribner *Poa Cusickii*, from which it differs, however, in the larger, paler, very scabrous, acuminate floral glumes and the pale scabrous filiform leaves. In habit it more resembles *P. idahoensis* and *P. subaristata*. From the former it differs in the dense inflorescence and broader glumes; from the latter in the broader glumes and the lanceolate ligules.

IDAHO: Beaver Cañon, June 27, 1895, *Rydberg 2055* (type, in herb. N. Y. Bot. Gard.).

Poa Helleri sp. nov.

A tufted perennial; stem slender, 4–6 dm. high, often purple-tinged below; ligules lanceolate, acuminate; leaf-blades very slender, flaccid, 5–15 cm. long, 1 mm. wide, more or less involute, scabrous; panicle rather loose, 8–10 cm. long; branches ascending; spikelets about 1 cm. long, 4- or 5-flowered; empty glumes linear-lanceolate, 3-nerved, glabrous, unequal, 4–5 mm. long; floral glumes linear-lanceolate, about 5 mm. long, strigulose below, scabrous on the upper part.

The type was named *Poa Sandbergii*, but it can scarcely be referred to that species. It differs in the pale inflorescence, larger and much narrower, conspicuously strigose floral glumes. In habit it resembles *P. idahoensis*, but evidently belongs to the same group as *P. nevadensis*, from which it differs in the slender habit and the narrower glumes with a different pubescence.

IDAHO: Lake Waha, *A. A. & E. Gertrude Heller 3274* (type, in herb. Columbia Univ.).

Poa curta sp. nov.

Perennial, with a horizontal rootstock; stem glabrous, 4–5 dm. high; sheaths short, glabrous; ligules about 1 mm. long, truncate;

leaf-blades 2–5 cm. long, 3–5 mm. wide, abruptly acute, spreading, dark green; inflorescence short, open, 4–5 cm. long; branches in 2's to 4's, spreading, 1–2 cm. long, spikelet-bearing above the middle; spikelets light green, strongly compressed, about 6 mm. long, 2–4-flowered; empty glumes glabrous, but scabrous on the veins, lanceolate, the first 3 mm. long, 1-nerved, the second 4 mm. long, 3-nerved; floral glumes lanceolate, scabrous-strigulose, strongly 5-nerved, 5 mm. long.

This species is related to *P. occidentalis* (Vasey) Rydb. (*P. flexuosa occidentalis* Vasey), but differs in the short ligules and the short broad leaves.

WYOMING: Spread Creek, at an altitude of 2900 m., July, 1897, *F. Tweedy 13* (type, in herb. N. Y. Bot. Gard.).

Poa subreflexa sp. nov.

Perennial, with a horizontal rootstock; stem ascending, 5–6 dm. tall; lower sheath finely and retrorsely strigulose; ligules very short and truncate; leaf-blades flat, flaccid, 7–10 cm. long, 3–4 mm. wide, spreading; panicle open, about 1 dm. long; branches reflexed, the lower in 3's or 4's, 1–3 cm. long; spikelets pale green, 6–7 mm. long, 3- or 4-flowered; empty glumes glabrous, with broad scarious margins, lanceolate, the first 1-nerved, about 3 mm. long, the second 3-nerved and about 4 mm. long; flowering glumes lanceolate, 5 mm. long, scabrous-strigulose, strongly 5-nerved.

This species is related to *P. Wheeleri* and *P. Olneyae*, but differs from both in the reflexed branches of the panicle and the broad flaccid leaves.

COLORADO: In shade of spruces on the bank of a creek, mountains north of Steamboat Springs, July 26, 1891, State Agricultural College distribution *no. 3731* (type, in herb. N. Y. Bot. Gard.).

Poa subtrivialis sp. nov.

Perennial, with a rootstock; stem slender, 4–6 dm. high, smooth; ligules very short and truncate; sheaths narrow, striate, exceeding the nodes; leaf-blades erect, flaccid, 8–15 cm. long, about 2 mm. wide, flat, dark green; panicle narrow, 1–2 dm. long; branches erect, scabrous, spikelet-bearing above the middle; spikelets light green, 3–4 mm. long, 2–3-flowered; first empty glume very narrow, 2 mm. long, smooth; the second lanceolate, 2.5 mm. long, prominently 3-nerved; floral glumes 2.5 mm. long, glabrous, obscurely nerved; cobweb very scant.

This is closely related to the European *P. nemoralis*, but differs in the truncate ligules, the smaller spikelets, and more strongly nerved empty glumes. It has the narrow inflorescence and narrow empty glumes of *P. nemoralis* and thereby differs from *P. interior*, which also has been confused with the European relative.

WYOMING: Big Horn Mountains, July, 1899, *F. Tweedy 2141*, (type, in herb. N. Y. Bot. Gard.); Gros Ventre River, Aug., 1897, *F. Tweedy 101*.

IDAHO: Northern Idaho, 1892, *J. H. Sandberg 373*.

Distichlis dentata sp. nov.

Perennial, with a creeping branched scaly rootstock; stem 1–3 dm. high, very leafy; leaf-blades 5–12 cm. long, 2–3.5 mm. wide, flat or slightly involute; panicle of the pistillate plant 4–8 cm. long, 2–2.5 cm. wide; spikelets 1–2 cm. long, 5–8 mm. wide, 7–17-flowered; empty glumes lanceolate, about 5 mm. long, short-acuminate, scarious-margined; floral glume ovate in lateral view, 6 mm. long, fully 2 mm. wide from keel to margin, short-acuminate; palet nearly as long, dentate on the keels; panicle of the staminate plant looser, 5–10 cm. long; spikelets more compressed, floral glumes lanceolate in lateral view, straw-colored, acute, thin.

This species differs from *D. spicata* and *D. stricta* in the broader leaves, larger and broader spikelets, larger and broader floral glumes and palets in the pistillate plant, and the distinct dentation on the keels of the latter. It has the broad leaves and the habit of *D. thalassica*, but lacks the loose sheaths of that species. The latter lacks the dentation of the palet characteristic of *D. dentata*.

WASHINGTON: 1893, *Sandberg & Leiberg 463* (♀, type, in herb. Columbia Univ.); Okanagon Valley, 1897, *Elmer 508* (♀.)

OREGON: Wild Horse Meadow, Southeastern Oregon, 1901, *Griffiths & Morris 504* (♂).

SASKATCHEWAN: Carlton House, *Richardson 28* (Franklin's Second Journ.).

NEVADA: Pleasant Valley, 1865, *Stretch 203* (♂); Carson, *248* (♀).

Festuca saximontana sp. nov.

? Festuca ovina pseudovina Beal, Grasses N. Am. **2**: 595. 1896.
Festuca pseudovina Rydb. Mem. N. Y. Bot. Gard. **1**: 56. 1900.
Not *F. pseudovina* Hack. 1880.

Festuca ovina pseudovina Piper, Contr. U. S. Nat. Herb. **10**: 26, 27. 1906. Not *F. ovina pseudovina* Hack. 1881.

Densely cespitose, perennial, with intravaginal innovations; stem 2–4 dm. high, slender, glabrous; basal leaf-sheaths short, closed only at the base, loose above; ligules very short and rounded; leaf-blades very slender, 3–10 cm. long, less than half a millimeter wide, strongly involute, in age becoming strongly striate; panicle very narrow and spike-like, 4–10 cm. long; its branches erect or nearly so, short; spikelets 4–6–flowered; first empty glume 1-nerved, about 2 mm. long, the second 3-nerved, 2.5 mm. long; floral glumes lanceolate, 3–5 mm. long, glabrous; awn 1–2 mm. long.

This species is rather common on dry hillsides and mountains from Saskatchewan to Colorado and British Columbia up to an altitude of 3600 m.

It has been mistaken for the European *F. pseudovina* Hackel. The latter was based on *F. ovina* Host, Gram. Aust. **2**: *pl. 84*. This plate does not at all represent our North American plant. The figure represents a small plant with a short open panicle, while our plant has a very narrow, rather long panicle with erect branches. Piper in his monograph (Contr. U. S. Nat. Herb. **10**: 27. 1905) cites Host's plate *no. 86*, instead of *no. 84*. Whether this is a mere misprint or whether Piper really had the former plate in mind, I do not know. Plate 86, representing *F. stricta*, illustrates a plant in habit much more like our plant. Whether Beal (Grasses N. Am. **2**: 595) had in mind the same plant as Piper and myself is very doubtful, as he cites only specimens from Michigan, and I have seen no specimens of *F. saximontana* from that state. As the type the following may be assigned:

ALBERTA: Vicinity of Banff, 1899, *W. C. MacCalla 2331* (type, in herb. N. Y. Bot. Gard.).

Festuca calligera (Piper) sp. nov.

Festuca amethystina asperrima Hack.; Beal, Grasses N. Am. **2**: 601. 1896. Not *F. asperrima* Link, 1822.

Festuca ovina calligera Piper, Contr. U. S. Nat. Herb. **10**: 27. 1906.

This I think is specifically distinct from *F. ovina*. In the herbaria at the New York Botanical Garden are found the following specimens:

ARIZONA: Southern slope of San Francisco Mountains, 1904, *Cannon & Lloyd;* Flagstaff, 1883, *Rusby 901* (dupl. of type); near Tucson, 1892, *Toumey.*

UTAH: Fish Lake Plateau, Aug. 9, 1905, *Rydberg & Carlton 7689* and *7680.*

COLORADO: Camp on Grizzly near foot of Rabbit Ear Range, State Agric. College distribution *no. 3649;* Breckenridge, 1896, *Shear 1080.*

Vulpia megalura (Nutt.) comb. nov.

Festuca megalura Nutt. Jour. Acad. Phila. II. **1**: 188. 1848.

The group of annual grasses with usually but one stamen, generally included in *Festuca,* is so unlike the typical species of that genus that it very well deserves generic rank. The genus *Vulpia* Nees should therefore be reëstablished.

Vulpia reflexa (Buckley) comb. nov.

Festuca reflexa Buckley, Proc. Acad. Phila. **1862**: 98. 1863.

Vulpia pacifica (Piper) comb. nov.

Festuca pacifica Piper, Contr. U. S. Nat. Herb. **10**: 12. 1906.

Vulpia octoflora (Walt.) comb. nov.

Festuca octoflora Walt. Fl. Car. 81. 1788.

Bromus Flodmanii sp. nov.

Bromus aleutensis Rydb. Mem. N. Y. Bot. Gard. **2**: 61. 1900. Not *B. aleutensis* Trin. 1853.

A short-lived perennial; stem glabrous, 6–10 dm. high; sheaths retrorsely pilose; ligules 3–4 mm. long, laciniate; leaf-blades 2–3 dm. long, 6–10 mm. wide, minutely scabrous; panicle 1–2 dm. long; branches erect or nearly so; spikelets 2.5–3.5 cm. long, 5–7 mm. wide; empty glumes lanceolate in lateral view, about 1 cm. long, glabrous, acute, the first 3-nerved, the second 5-nerved; floral glumes about 15 mm. long, scabrous, narrowly margined, acuminate, slightly bifid; awn 4–6 mm. long; palet nearly as long as the floral glumes.

The first two specimens cited below were included in *B. marginatus latior* by Shear. He, however, has made on the sheet the following note: "very near *aleutensis,*" to which species the specimens were originally referred. *B. Flodmanii* differs from *B. marginatus latior* in the scabrous, not pilose floral glumes, and the narrow inflorescence; from *B. aleutensis* it differs in the shorter awns, the smaller florets, and the less open inflorescence, and from *B. Hookerianus* in the smaller spikelets, shorter awns, and narrower scarious margins of the floral glumes. It agrees very well with the description and figure of *Ceratochloa breviaristata* Hook., but the palet is nearly as long as the floral glume.

MONTANA: Sheep Creek, Aug. 8, 1896, *J. H. Flodman 187* (type, in herb. N. Y. Bot. Gard.); same locality and date, *Rydberg 3308*.

UTAH: Mount Nebo, 1905, *Rydberg & Carlton 7595*.

WYOMING: Buffalo Fork, 1897, *F. Tweedy 65*.

Agropyron latiglume (Scribn. & Smith) sp. nov.

Agropyron violaceum latiglume Scribn. & Smith, U. S. Div. Agrost. Bull. **4**: 30. 1897.

Agropyron inerme (Scribn. & Smith) sp. nov.

Agropyron divergens inermis[*e*] Scribn. & Smith, U. S. Div. Agrost. Bull. **4**: 27. 1897.

Hordeum depressum (Scribn. &. Smith) sp. nov.

Hordeum nodosum depressum Scribn. & Smith, U. S. Div. Agrost. Bull. **4**: 24. 1897.

Elymus jejunus (Ramaley) sp. nov.

Elymus virginicus jejunus Ramaley, Minn. Bot. Stud. **1**: 114. 1894.

Elymus virginicus minor Vasey; Rydb. Contr. U. S. Nat. Herb. **3**: 193. 1895.

This was well described by Professor Ramaley. The description was overlooked when I a year later took up Dr. Vasey's manuscript name.

Elymus marginalis sp. nov.

Perennial, with a rootstock, somewhat tufted; stem 6–10 dm. high, glabrous or pubescent at the nodes; sheaths close, at least the lower ones retrorsely pilose; leaf-blades spreading, 1–2 dm.

long, 7–10 mm. wide, flat, scabrous beneath, usually pilose above; ligules almost obsolete; spike 1.5–2 dm. long; spikelets usually in pairs, 4–5-flowered; empty glumes 10–12 mm. long, narrowly lanceolate, scabrous on the 4 or 5 nerves, with white or pink scarious margins; floral glumes 10–12 mm. long, glabrous and shining; awns 8–20 mm. long.

This is closely related to *E. glaucus*, but differs in the glabrous floral glumes and the hairy sheaths and the hairy upper surface of the leaf-blades.

BRITISH COLUMBIA: Lower Arrow Lake, June 18, 1890, *Macoun 44* (type in herb. Columbia University).

WASHINGTON: Clallam, 1900, *Elmer 1905*.

Elymus Petersonii sp. nov.

Perennial, with a rootstock; stem 6–8 dm. high, slender, glabrous; sheaths glabrous, striate, shorter than the internodes; ligules very short and truncate; leaf-blades flaccid, 1–1.5 dm. long, 4–5 mm. wide, light green, minutely scabrous on the veins of both sides, or sparingly pilose above; spike very slender and lax; spikelets in pairs or single; empty glumes narrowly lanceolate, acuminate or awn-pointed, about 8 mm. long, 3-nerved, purple-tinged; floral glumes about 1 cm. long, glabrous; awn about 1 cm. long.

This species is also related to *E. glaucus*, but differs in the lax, interrupted spike, glabrous glumes, and the flaccid and more or less hairy leaf-blades.

BRITISH COLUMBIA: Roger's Pass, Selkirk Mountains, Aug. 9, 1904, *H. Peterson* [Shaw's distribution no.] *446* (type, in herb. N. Y. Bot. Gard.).

Elymus vulpinus sp. nov.

Perennial, with a short rootstock; stems 5–7 dm. high, striate, erect; sheaths close, striate, glabrous, often shorter than the internodes; ligule 1 mm. long or less, truncate, brown; spike exserted, 1–1.5 dm. long, 6–7 mm. thick, sometimes slightly nodding; spikelets 1 or 2 at each node, 4–6-flowered; empty glumes linear-lanceolate, 8–10 mm. long, 5-nerved, scabrous on the back; awn scabrous, of about the same length; floral glumes linear-lanceolate, long-acuminate, about 8 mm. long, hispidulous; awn 8–10 mm. long, scabrous.

This is one of the species connecting the genera *Elymus* and *Agropyron*. The type was originally named *Agropyron cani-*

num unilaterale (Cassidy) Vasey, which is the same as *A. Richardsonii.* J. G. Smith in his revision referred it to *A. Gmelini.* It resembles both a great deal in habit, but is distinguished by the hispidulous floral glumes and by the empty glumes, which are attached more or less obliquely, a character which would place the species in *Elymus* rather than in *Agropyron.* It is a close relative of *E. Saundersii* and *E. Macounii*, which also could be referred almost equally well to either genus. In habit *E. vulpinus* is intermediate between the two, but is distinguished by the hispidulous, instead of glabrous, floral glumes and broader empty glumes.

NEBRASKA: Lake region of Grant Co., northeast of Whitman, *Rydberg 1617* (type, in herb. N. Y. Bot. Gard.).

ALBERTA: Devil's Head Lake, Aug. 8, 1891, *Macoun 11452* in part, mixed with *Agropyron subvillosum* and named *A. dasystachyum.*

NEW YORK BOTANICAL GARDEN.

Helleborine Hill or Epipactis Adans.?

G. Claridge Druce

I first suggested the above change of names in the Annals of Scottish Nat. Hist. 48. 1905, because during my work at the herbaria of Morison and Dillenius I became saturated with pre-Linnean names and found how often and how needlessly Linnaeus had changed well-defined generic names. The above is an example. The *Helleborine* of Dioscorides has been attributed by various authors to different species, but the figure of the plant representing it in the plate 155 of the very rare copy of the Vienna Ms. from Constantinople, which we have at Oxford, appears to be *Asphodelus ramosus*. Turner (Herball 128. 1562) quotes Dioscorides under the name *Satyrion* for the British typical species (*H. latifolia*). Gerarde (Herball 358. 1597) describes three species; the first *Helleborine* refers to *H. latifolia*, the second is *Cephalanthera Damasonium*, and the third is probably *Helleborine palustris*. Parkinson (Theatrum 218. 1640) has eight Elleborines, one being *Cypripedium*, while Caspar Bauhin (Pinax 187. 1671) under *Helleborine* has ten species. These are mainly adopted by Ray (Historia Plantarum **2**: 1230. 1688), who describes *Helleborine* and distinguishes the genus by "Radice fibrosa foliis nervosis ab Orchide differt," and puts in it thirteen species, which include the plants more recently called *Epipactis*, *Cephalanthera*, and *Cypripedium*, but excludes those with tuberous roots called *Serapias* by Linnaeus, which Ray puts with *Orchis*.

In his Synopsis . . . Stirpium Britannicarum, 174. 1690, six species are included:

No. 1, being *H. latifolia* (All.) as of the Historia.

No. 2, which = no. 5 of the Historia = *H. atropurpurea* (Raf.).

No. 3, which = no. 6 of the Historia = *Cephalanthera Damasonium* (Mill.) and partly *C. longifolia*, so far as the Westmoreland locality is concerned.

No. 4, which = *C. longifolia* Fritsch.

No. 5, which = no. 10 of the Historia = *H. palustris* Schrank. (This was first recorded as British in Lobel's Illustrationes, 94 1655, as "Tertiae Clusii Helleborines similem facie. . . .")

No. 6, which = no. 12 of the Historia = *Cypripedium Calceolus* L.

In the second edition, 242, 1696, Ray inserts a new no. 4, "*Helleborine latifolio flore albo clauso* . . . Found by Dr. Eales near Digges-Well in Hartfordshire," which was identified by the authors of the flora of that county as *C. ensifolia*, but Mr. Britten says the plant representing Miller's *Serapias latifolia* based on this is *C. grandiflora.* Dillenius (in the third edition of the Synopsis 384. 1724) adds to the description of no. 4 "Eadem cum priore," but there is no specimen in his herbarium. Bobart (Plantarum Historia Universalis Oxoniensis 486. 1699) describes seventeen species, which, like those of Ray, contain no specimens of the restricted genus *Serapias.* Tournefort (Institutiones Rei Herbariae **1**: 436) in 1700, under the name *Helleborine*, says "est plantae genus," describes it, and adds "His notis addendae sunt radices fibratae." Six species are given, three being species of *Cephalanthera.* Tournefort includes *Serapias* with *Orchis*, but keeps as distinct genera *Calceolus, Limodorum, Ophris* (which includes *Listera, Malaxis*, etc.) and *Nidus avis*, showing that despite the unwieldy nature of his genus *Orchis*, he really possessed a truer conception of the genera of Orchidaceae than did Linnaeus.

Therefore prior to Linnaeus (with the exception of Haller) we have practical unanimity among botanists in using the name *Helleborine* so as to exclude the tuberous-rooted species now known as *Serapias.* Unfortunately, Linnaeus (Species Plantarum, 1753) seeing that some of Tournefort's species of *Orchis* were generically distinct, established the genus *Serapias*, adding, wrongly, the various species of *Helleborine* of previous authors, a pernicious example unfortunately followed by more recent authors. A contemporary botanist, John Hill, of Denham, Bucks, a voluminous writer, who was much disliked by other British botanists, and whose volumes have for long remained ignored, published in 1756 the British Herbal. In this work Hill points out with great acumen the errors Linnaeus had made, describes the faulty characterization of many of his genera, and shows clearly the differences which mark as distinct such genera as *Limonium* and *Statice*, *Valeriana* and *Valerianella*, *Linaria* and *Antirrhinum*, and *Trifolium* and *Melilotus*. This work has escaped the attention of non-British botanists, and from its not adopting the binomial system remained unquoted, even in the Index Kewensis. But from the description of the species and genera, the reference to other writers, as well as the engraved plates and its valid data of publication, it is available for citation of genera.* In the British Herbal Hill not only separates the genera given above, but also distinguishes *Centaurium* from *Gentiana*, *Glaucium* from *Papaver*, *Polygonatum* from *Convallaria*, *Radiola* from *Linum*, *Nymphoides* from *Menyanthes*, *Onobrychis* from *Hedysarum*, *Foeniculum* from *Anethum*, *Petasites* from *Tussilago*, *Oxyria* from *Rumex*, *Damasonium* from *Alisma*, *Phyllitis* from *Asplenium*, *Meum* from *Athamanta*, *Alnus* from *Betula*, *Castanea* from *Fagus*, *Cirsium* from *Carduus*, *Oxycoccus* from *Vaccinium*, *Pneumaria* from *Pulmonaria*, *Cammarum* from *Helleborus*, *Radicula* from *Sisymbrium*, *Lens* from *Ervum*, and, as we shall see, *Helleborine* from *Serapias*, genera which had been wrongly united by Linnaeus.

In the British Herbal, 477, Hill defines *Helleborine* so as to exclude *Serapias Lingua* (itself a composite species), as described by Linnaeus, practically in this following Ray and Tournefort, but excluding *Cypripedium*. Hill goes on to say "Linnaeus places this among the *Gynandria decandria*, the filaments being two and inserted in the pistil. He takes away the received name and calls it *Serapias*." We have thus in Hill's description a proper definition of Tournefort's genus made more accurate by the exclusion of *Cypripedium*, and limited to the true *Helleborine*, and the plants afterwards separated by Richard as *Cephalanthera*. Of the six species described by Hill five are cited from Caspar Bauhin and one (*Cephalanthera longifolia*) from Ray's Historia. Unfortunately, Adanson (Familles des Plantes **2**: 70. 1763) established (what has been called a genus) *Epipactis*; he separates no new genus

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* In passing, one may say if Thellung (Bull. Herb. Boiss. II. **8**: 778. 1908) is correct in quoting Garsault for specific names, Hill is also available and has undoubted priority, but as the binomials used by both authors are accidental, it is wiser to ignore them.

apart from *Serapias*, as understood by Linnaeus, but, on the contrary, adds vastly and most unscientifically to it. His description, compared with that of Hill, is quite indefinite, covering as it does *Serapias*, *Helleborine*, *Cypripedium*, *Pogonia*, and many other genera, as is shown by his synonymy in the erratic table or index (**2** : 554); it is a rubbish-heap rather than a properly formulated genus and is wisely to be ignored. It may, however, be contended that *Epipactis* as established by Crantz (Stirpes Austriacum 456. 1769) is available. This author writes *Epipactis* Haller, giving also synonyms "*Ophrys*, *Nidus avis*, *Helleborine* Tourn. aliorum, *Ophrys*, *Serapias*, *Neottia*, *Herminium* Linn.," but his definitions do not separate *Serapias* from *Helleborine*, indeed, as the synonyms quoted show, it is meant to cover both. The first and second species of his *Epipactis* are Cephalantheras; others included belong to the genera *Goodyera*, *Listera*, *Spiranthes*, *Neottia*, and *Helleborine*, eight different genera in all being included in this extraordinary group, which is scarcely less inchoate than that of Adanson. Doubtless, if *Serapias* grew in that portion of Austria treated of by Crantz, that also would have been included. *Epipactis* is however rendered invalid by Boehmer's restoration of Haller's genus *Epipactis* established in 1741 (Stirpes Helv. 277) and adopted by Allione in the Flora Pedemontana, to define the plant more recently known as *Goodyera*, as his description and synonyms clearly show. It is true Haller subsequently lost grip of its characters and added many other plants, some even generically different species, to his original *Epipactis*, but this was done in works published before 1753 and are therefore not valid for citation.

The publication in 1805 by Willdenow of his edition of the Species Plantarum in which he followed Swartz (Act. Holm. 231. 1805) in using the name *Epipactis* to represent *Helleborine*, *Cephalanthera*, *Listera*, *Neottia*, etc., led Brown (Aiton, Hort. Kew. **5**: 201. 1813), Gray (Nat. Arr. Brit. Pl. **2**: 212. 1821), and Smith (English Flora **4**: 40. 1828) to adopt that name, which has been in general use since that time.

It being thus evident that Hill's genus *Helleborine* must supersede *Epipactis* Adans., the species will stand as follows:

Helleborine africana (Rendle, Jour. Bot. **33**: 252. 1895, as *Epipactis*).

H. atropurpurea (Raf. Car. 87. 1810, as *Epipactis*).

= *Serapias atrorubens* Hoffm. Deutsch. Fl. 1^2: 182. 1804, as a subspecies.

H. babianifolia (Roxb. Hort. Bengal. 63, as *Epipactis*).

H. consimilis (Wallich, Cat. no. 7403, as *Epipactis*).

H. gigantea (Dougl.; Hook. Fl. Bor.-Am. **2**: 202, as *Epipactis*).

= *Epipactis Royleana* Lindl. in Royle, Illust. Bot. Himal. 368.

H. LATIFOLIA Druce *vice Epipactis latifolia* All.

H. microphylla (Sieb. Sv. Vet.-Akad. Nya Handl. 232. 1800, as *Epipactis*).

H. orbicularis (C. Richt. Verh. Zool.-Bot. Ges. Wien **37**: 190. 1887, as *Epipactis*).

H. PALUSTRIS Schrank, Fl. Monac. **2**: 190. 1814.

= *H. longifolia* Rendle, Jour. Bot. **45**: 441. 1907.

H. papillosa (Franch. & Sav. Enum. Pl. Jap. **2**: 519. 1879, as *Epipactis*).

H. pycnostachys (C. Koch, Linnaea **22**: 289. 1849, as *Epipactis*).

H. somaliensis (Rolfe in Fl. Trop. Afr. **7**: 189. 1897, as *Epipactis*).

H. Thunbergii (A. Gray in Perry Exp. Jap. **2**: 319. 1857, as *Epipactis*).

H. trinervia (Roxb. Fl. Ind. **3**: 455. 1832, as *Epipactis*).

It will be observed that I have followed all the recent British and most continental authorities in keeping distinct the two genera *Cephalanthera* and *Helleborine* (*Epipactis* R. Br. not Boehmer), thus differing from A. A. Eaton (Proc. Biol. Soc. Washington **21**: 63–68. 21 Mr 1908), who follows Wettstein in uniting them.

Mr. Eaton is quite correct in stating that Linnaeus' genus *Serapias* is composite — so too are his species. But since Hill in 1756 first separated *Helleborine* from that composite genus, leaving *Serapias* as understood by Swartz, and restored the name which for centuries previously had been used, his genus has priority according to the Vienna Rules. Hill's genus, it is true, included *Cephalanthera*, subsequently separated by Richard; but even if Wettstein be correct in uniting them, the application of the name

Helleborine to the whole group would not be invalidated, and the plants more recently called *Cephalanthera* would have to be termed *Helleborine*. To attempt to restrict the name *Serapias* to species of *Cephalanthera* and *Epipactis* is contrary to both the first and second editions of the Species Plantarum.

OXFORD, ENGLAND.

A new species of Puccinia

R. E. Stone

The genus *Puccinia* has so many species and so many of them are so hard to determine that it seems almost an imposition to describe a new species. However, in collecting, something is occasionally found that can not be referred correctly to any known species.

The "rusts" on plants of the Cyperaceae most frequently belong to the genus *Puccinia*. However, *Rynchospora* seems to be an exception and the only "rust" I find listed for that genus belongs to the *Uromyces* type of the Uredineae. For this reason, when I discovered on *Rynchospora corniculata* (Lam.) A. Gray, a *Puccinia*, I immediately began to try to find some place for it among the species recorded on the various Cyperaceae. After careful comparisons this species of *Puccinia* was found to agree fairly well with *Puccinia angustata* Peck but differs from it sufficiently to warrant its description as a new species.

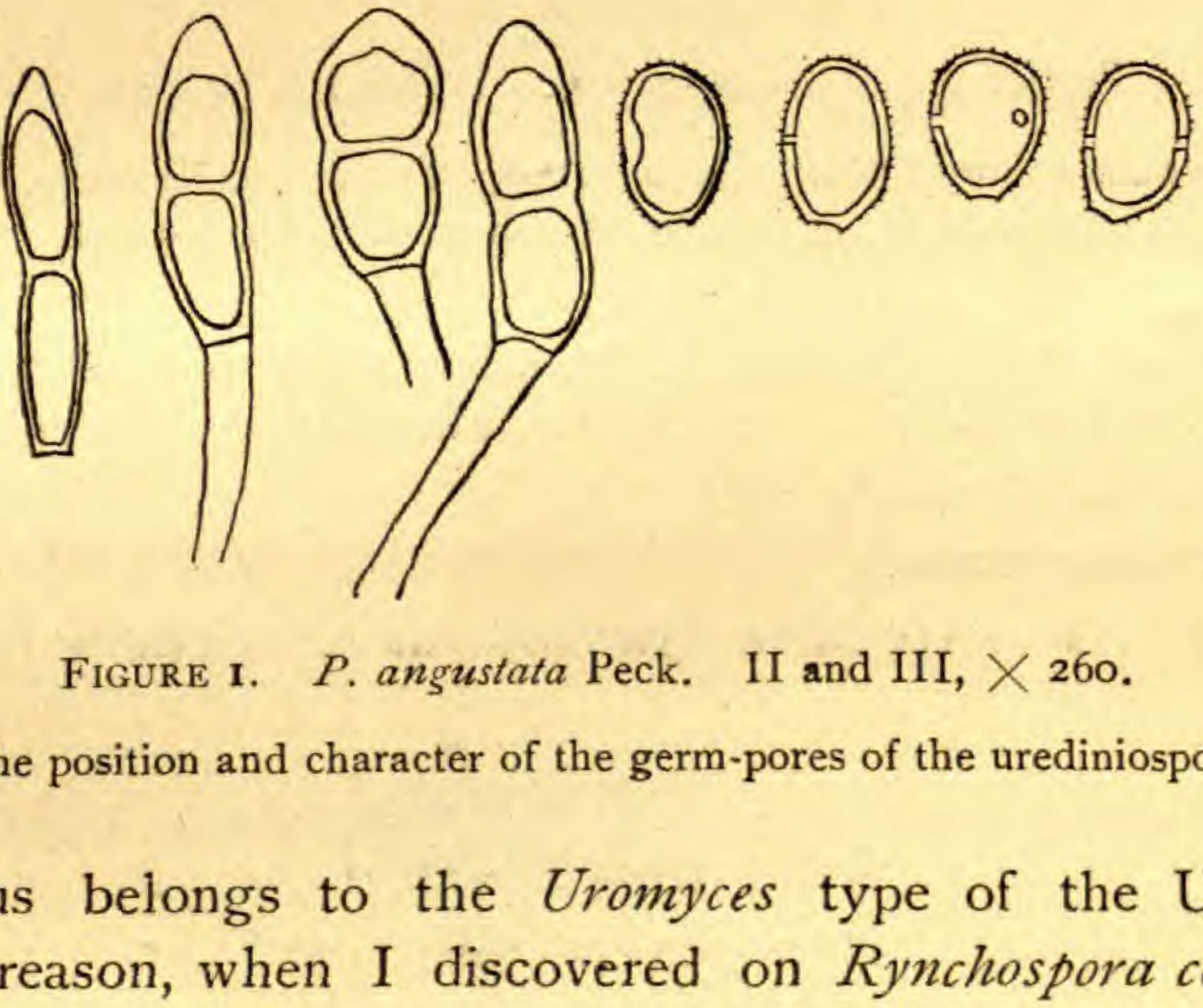

FIGURE 1. *P. angustata* Peck. II and III, × 260.

Notice the position and character of the germ-pores of the urediniospores.

Puccinia angustatoides sp. nov.

O et I. Incognatis.

II. Urediniosoris hypophyllis, minutis, linearibus, 0.5–1 mm., cinnamomeo-brunneis, pulverulentis, sparsis, epidermide diu tectis.Urediniosporis subglobosis v. obovoideis, echinulatis, ferrugineo-brunneis, 19–22 μ × 10–17 μ, poris germinationis 2 supra aequetorem praeditis.

III. Teliosoris hypophyllis, atro-brunneis, linearibus, 0.5–1.5 mm., sparsis, epidermide tectis. Teliosporis castaneo-brunneis, inaequalibus, clavatis, 40–70 μ × 15–26 μ, medio constrictis, apice valde incrassatis 5–10 μ, obtusis v. acuminatis; pedicello persistente, brunneo, 19–40 μ.

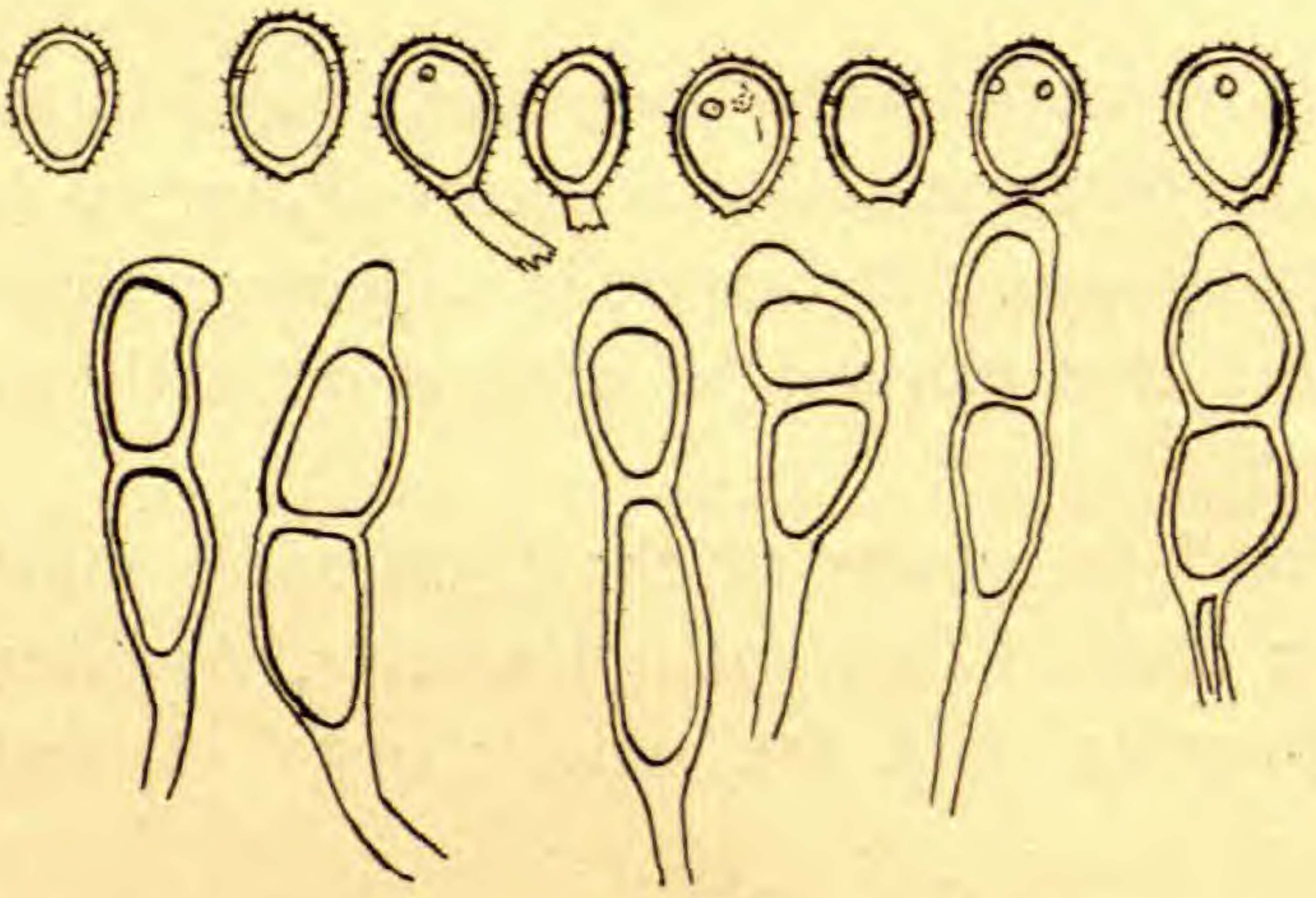

FIGURE 2. *P. angustatoides.* II and III, × 260.

The figures show more difference in the teliospores than usually exists. The urediniospores are very characteristic, as is also the position of the germ-pores.

O et I. Incognatis.

II et III. In vivis foliis *Rynchosporae corniculatae* (Lam.) A. Gray, Auburn, Alabama, Sept. 17, 1908, *R. E. Stone.*

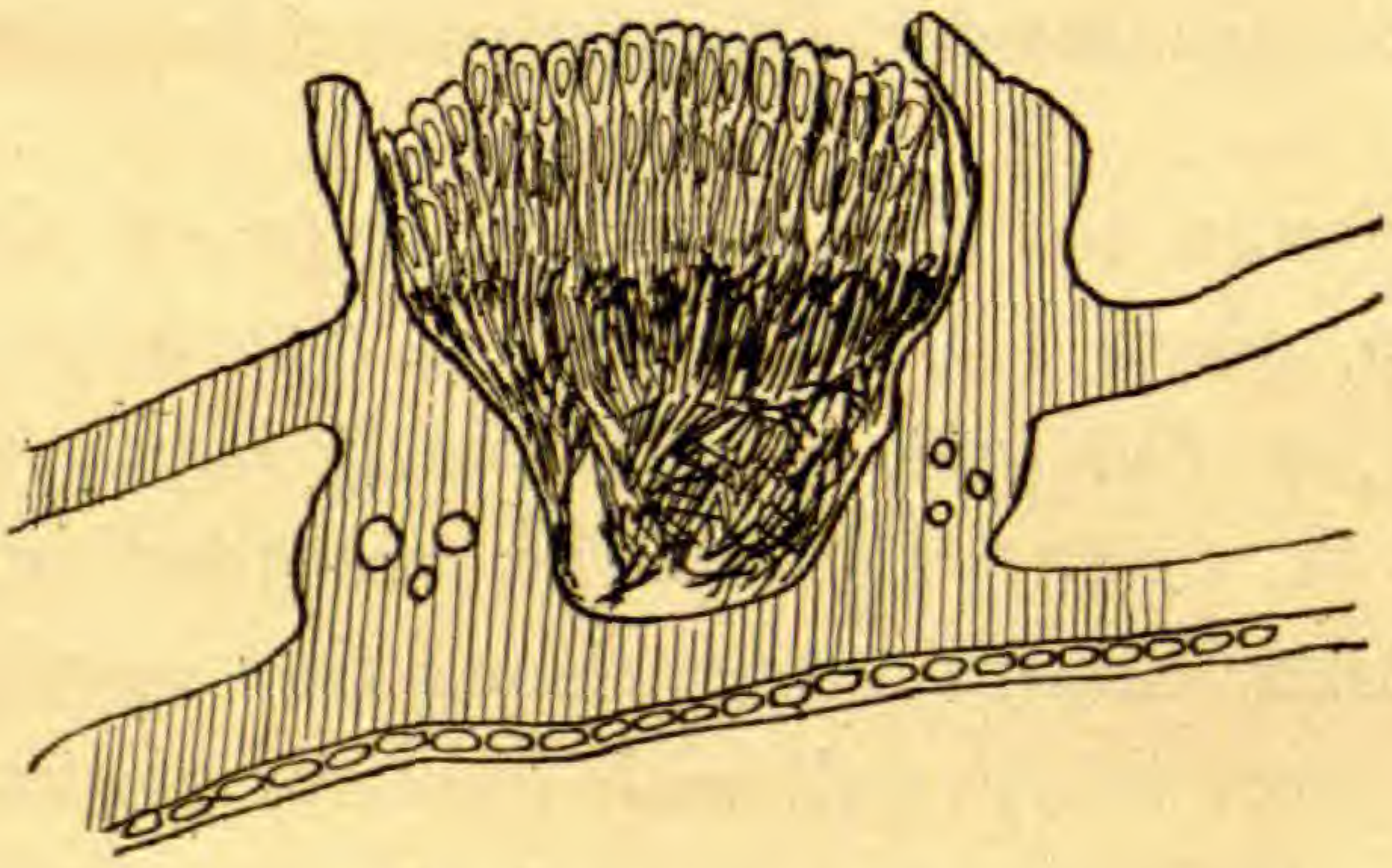

FIGURE 3. Section through a sorus of *P. angustata* Peck, as found on *Scirpus atrovirens*, × 80. The mass of hyphae in the lower part is very characteristic.

III. Auburn, Alabama, Jan. 1, 1909, *E. E. Binford.*

This rust has a close resemblance to *P. angustata* Peck on *Scirpus atrovirens.* The teliospores are of about the same size and shape and have the same position on the leaf. However the sori are more scattered, a little lighter in color and do not become confluent. The most prominent difference between the telia becomes apparent upon examining a section through a sorus. In all the specimens of *P. angustata* which I have been able to secure, there is a very prominent development of the hyphae in the large intercellular spaces of the leaf, especially immediately under a sorus. In fact the very large intercellular space between the vascular bundles is almost filled with hyphae. In *P. angustatoides* this development is much less pronounced, although the space between the vascular bundles is filled with stellate cells and would, apparently, offer a much better chance for the hyphae to develop. In studying the fungus this was the first thing to become apparent. Also, the telia are much more deeply sunken in *P. angustata* Peck.

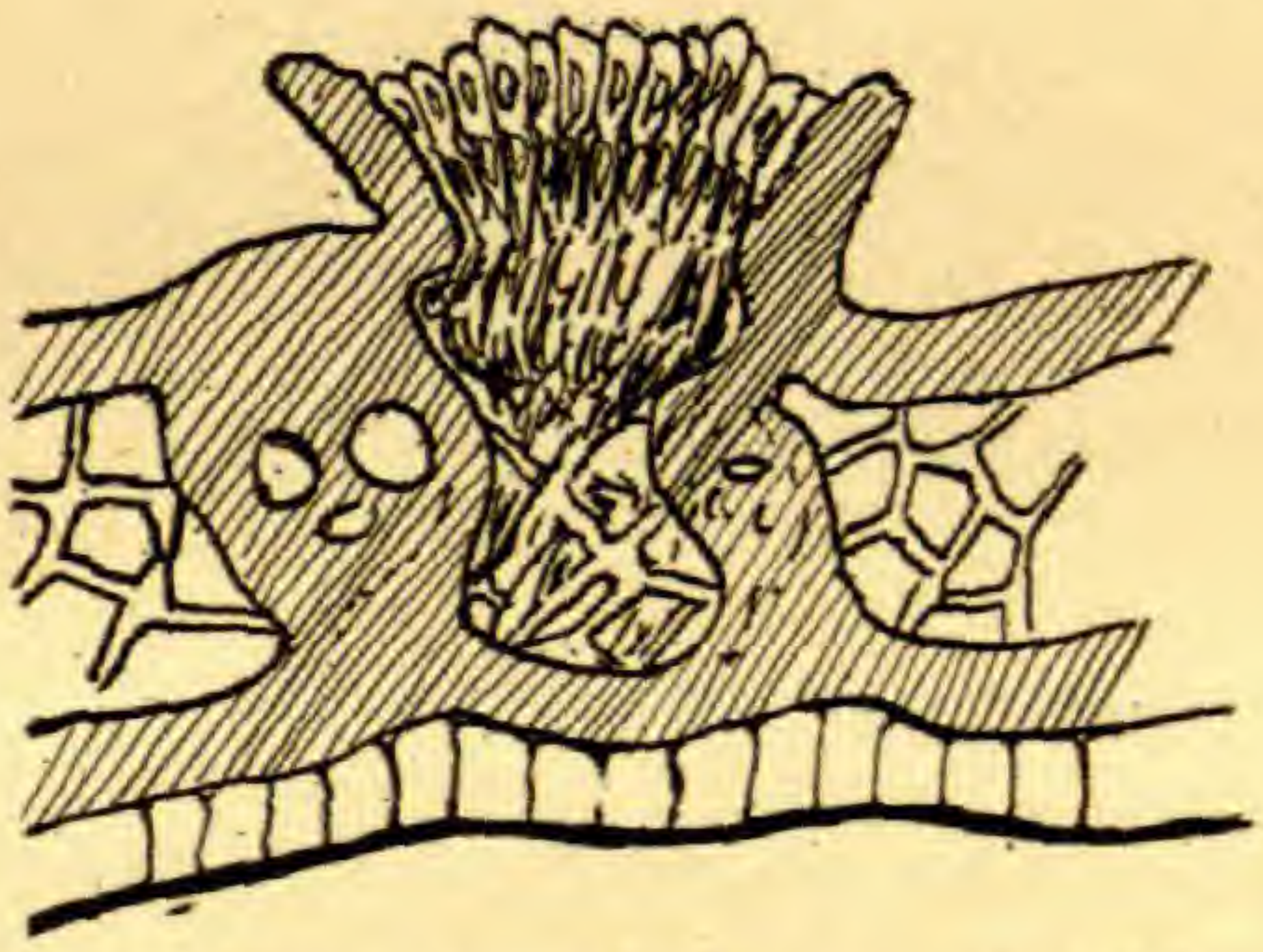

FIGURE 4. Section through a sorus of *P. angustatoides* on *Rynchospora corniculata*, × 80. This sorus is more superficial in every way than that of *P. angustata.*

The most distinctive difference between these two rusts is found in the uredinia and urediniospores. The uredinia in *P. angustatoides* are a little darker than in *P. angustata*, are more definite, scattered, rarely confluent. The urediniospores of *P. angustatoides* are several μ smaller than those of *P. angustata*, $19–22\,\mu \times 10–17\,\mu$ as against $21–30\,\mu \times 16–21\,\mu$; they are subglobose to obovoid as against globose to elliptical in *P. angustata.* The last point of difference lies in the distribution of the germ-pores. In *P. angustata* the pores are 2, opposite and approximately equatorial; in *P. angustatoides* they are considerably above the equator, at least half way to the distal end of the spore, two in number and without a prominent thickening of the wall.

The accompanying figures show the most prominent differences.

Type specimens gathered by R. E. Stone, at Auburn, Alabama, Sept. 17, 1908, on *Rynchospora corniculata* (Lam.) A. Gray, deposited in the herbarium of the University of Nebraska.

AGRICULTURAL EXPERIMENT STATION,
THE UNIVERSITY OF NEBRASKA,
LINCOLN, NEBRASKA.

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(1909)

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The development of the imbedded antheridium in Dryopteris stipularis (Willd.) Maxon and "Nephrodium molle"*

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(WITH PLATES 26–28)

The discovery by Farmer and Digby ('07) of the development of a sporophyte from the essential fusion of two vegetative cells of the gametophyte has aroused a keen interest in the study of apogamy in ferns and other higher plants as well, and has given a somewhat different meaning to the already variously interpreted term, apogamy.

These authors have found that in the prothallia of *Lastrea pseudo-mas*, var. *polydactyla* Dadds, and *Lastrea pseudo-mas*, var. *polydactyla* Wills, developed from normal spores and therefore possessing the gametophytic number of chromosomes, a doubling of the chromosomes was secured in an apogamous embryo by the migration and fusion of vegetative nuclei. The region of migrating nuclei, while not confined to a definite area on a prothallium, was always found to be in the younger portions. The basis of the entire process of the migration and fusion of nuclei was observed to be chemotactic. The elongated migrating nucleus coming in contact with the wall of the receptive cell was seen to slip through an opening, made, probably, by a fermentative action, and fuse with the nucleus of the invaded cell directly or after some time. It is believed by Farmer and Digby that this fusion of the nuclei of adjacent vegetative cells, accompanied by the doubling of the

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* *Nephrodium molle*, according to Christensen (Index Filicum 444. 1905), is a synonym of *Dryopteris parasitica*.

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number of chromosomes, takes the place of the normal sexual fusion of the two gametes.

In addition to the above, the following ferns were studied: *Athyrium Filix-foemina*, vars. *clarissima* Bolton, *clarissima* Jones, and *unco-glomeratum* Stansfield; *Lastrea pseudo-mas*, var. *cristata apospora* Druery; and *Scolopendrium vulgare* var. *crispum Drummondae.* From these five forms, being aposporous, naturally or induced, there resulted prothallia having the double or sporophytic number of chromosomes. Different types of sporophytes were produced from these aposporous prothallia, namely: from the prothallia of *Athyrium Filix-foemina*, var. *clarissima* Bolton, and *Scolopendrium vulgare*, var. *crispum Drummondae*, the embryo arose in each case from an egg-cell, fecundation being unnecessary as the egg-cell already possessed the full complement of chromosomes. While the complete details were not made out for the origin of the embryo produced in *Athyrium Filix-foemina*, var. *unco-glomeratum* Stansfield, the probabilities are that it is like the preceding. The two remaining forms are examples of sporophytic budding. In *Athyrium Filix-foemina*, var. *clarissima* Jones, the sporophyte appears as the direct outgrowth of the apical surface in connection with an endogenous foot. The sporophyte in *Lastrea pseudo-mas*, var. *cristata apospora* Druery, makes its appearance as a small excrescence directly behind the growing point.

Lang ('98) presented a detailed account of the grosser phenomena of apogamous sporophytic outgrowths from prothallia grown from spores. The following fourteen forms are described: *Aspidium aculeatum* Sw., var. *multifidum* Woll., *A. angulare* Willd., var. *foliosum multifidum*, var. *acutifolium multifidum* (no results), *A. frondosum* Lowe; *Athyrium nipponicum* Mett., var. *cristatum*, *A. Filix-foemina* Bernh., var. *percristatum* Cousens, var. *cruciato-cristatum*, var. *coronatum* Lowe; *Nephrodium dilatatum* Desv. var. *cristatum gracile*, *N. Oreopteris*, var. *coronans* Barnes; *Polypodium vulgare* L., var. *grandiceps* Fox; *Scolopendrium vulgare* Sm., var. *ramulosissimum* Woll., var. *marginale.* His results were obtained from experimental cultures of prothallia, watering them only from below and exposing them to bright sunlight, diminishing in this way the frequency of fecundation. The most usual type of sporophytic budding cited in his paper is that of the continuation of the prothallium as a cylindrical process. This process continues as a leaf or bears upon it leaves, roots, and ramenta. Sporophytic growths occur also on prothallia without the intervention of a cylindrical process, or as tracheids in the prothallium or cylindrical process. Sporangia also were observed to occur on the process.

Quite recently a paper has been published by Yamanouchi ('08, III) on apogamy in *Nephrodium*. This details an account of an embryo produced apogamously, with the gametophytic or x number of chromosomes. The writer in his previous papers on Sporogenesis and on Spermatogenesis, Oogenesis, and Fertilization in *Nephrodium* showed that under ordinary conditions the life history of this fern was quite orthodox. Under somewhat artificial cultural conditions, *e. g.*, keeping the prothallia rather dry and exposed to bright sunlight, watering only from below, fertilization was prevented. According to Yamanouchi the prothallia grown under such conditions developed slowly with larger cells than those grown under normal conditions. Antheridia were produced in abundance with active sperms, to all appearances capable of fertilizing an egg-cell, and reacting positively to 0.01 per cent. solution of sodium malate (*loc. cit.* 298). The rarely found archegonia were seen to be in a collapsed or poorly developed condition, probably incapable of functioning. The development of the sporophytic outgrowth was observed to be simultaneous with the growth of the archegonial cushion and to originate from a superficial cell in this region, in connection with cells just below it. No migration or fusion of nuclei was observed. The cells that comprise the apogamous embryo are distinguished from the cells of the prothallium by their smaller size, their relatively larger nuclei and denser cytoplasm. There is described here an embryo with the gametophytic number of chromosomes, arising from a single superficial cell and the vegetative cells beneath it, differing only in appearance from a normal embryo by the absence of the foot. This is the first case recorded of an apogamous embryo with the alleged gametophytic number of chromosomes.

During the autumn of 1908 several fine specimens of a southern fern,* *Dryopteris stipularis* (Willd.) Maxon, which were being

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* The original specimen was brought from Cuba by Prof. C. H. Eigenmann.

grown in the greenhouse of the botanical laboratory of Indiana University, were placed at my disposal, with the suggestion that a study of the embryology be made with the view of ascertaining whether apogamy existed or could be induced in this species. Through the kindness of Mr. Alois Frey, a number of fruiting fronds of "*Nephrodium molle*" were obtained from the Lincoln Park Gardens, Chicago, from which cultures were also made and the prothallia studied in regard to the same problem.

METHOD OF CULTURE

Spores were sown upon sterilized soil in shallow earthen saucers. These were then placed in larger saucers of about the same depth. The cultures were watered with just enough distilled water after the spores had germinated to allow the prothallia to grow slowly. Water poured into the outer dish soaked up very slowly through the inner dish into the soil. This regulated the rapidity in the absorption of water by the soil and prevented the cultures from being alternately dry and moist. Evenness of moisture in the soil was further effected by placing a bell jar upon small blocks of wood, about one inch and a half high, above each culture. This allowed free circulation of air around the culture. This method prevented the collecting of moisture upon the dome of the bell jar and falling upon the culture, thereby making fertilization possible. The bell jars further protected the cultures from spores of fungi, etc. The prothallia grown under such conditions grew slowly but thrivingly. A glance at a culture presented the picture of a deep green carpet; closer inspection revealed the prothallia to be large, much larger than those, on which, under normal culture, embryos appear. No sporophytes occurred on the prothallia grown under these conditions. Material was fixed from time to time in chrom-osmic acetic and chrom-acetic acids. Prothallia were washed, dehydrated, and imbedded in paraffin. Sections were cut 5 and 6 microns in thickness and stained in safranin, Bismarck brown, and gentian violet. A detailed account of observations on each fern will now be given.

I. DRYOPTERIS STIPULARIS (Willd.) Maxon

Upon examining the sections, the prothallia were found to be unusually large. The archegonial cushion presented, in most cases, a thickness twice as great as that of the normally grown prothallium; the apical sinus consisted of a large number of apical cells as seen in the consecutive sections of a prothallium. The wings were correspondingly large and somewhat wavy-margined. The entire prothallium, not having its period of functioning and usefulness ended by the production of a sporophyte, appeared overgrown in all directions. Archegonia and antheridia were produced on the upper as well as the lower surface. It is in the actively growing portion of the prothallium, *i. e.*, the vicinity of the apical sinus that one would look for some manifestation of apogamy. Well up in this region of the prothallium a structure was seen in a position to suggest an apogamous embryo, but this proved to be an imbedded antheridium (*figure 7*). Normal, as well as one or more imbedded, antheridia were found on the same prothallium. The initial cell of an imbedded antheridium is not distinguished in any way from the initial cell of an archegonium. The first wall laid down in the development of an archegonium is a periclinal one cutting off the initial cell of the neck. In a deep-seated antheridium the first division is likewise periclinal. The outer or superficial cell forms the cover, while the inner cell gives rise to the spermatogenous tissue. In all cases thus far observed, the second division of the inner cell of such an antheridium is an oblique one (*figure 1*). The resulting cells in this instance were unequal. In other cases, the division, also oblique, resulted in more nearly equal cells, as in *figure 2*. The nuclei in these cells were large, the cytoplasm dense and granular, and in staining characteristics typical of cells in young archegonia or antheridia. Three almost equal cells are seen in a developing antheridium in *figure 3*. Further divisions now take place in three planes until the structure becomes quite massive (*figures 4–7*). In *figures 5* and *6*, the identity of the structure is shown in its shrinking away from the surrounding cells. The proximity of these developing imbedded antheridia to the apical region is seen in *figures 1, 2, 4, 5*, and *6*. In *figure 7* is pictured the most typical form of a deep-seated antheridium. This is globular, projecting slightly above the surface of the prothallium. As the antheridium nears maturity the tendency to bulge outward is more pronounced. In the earliest stages the antheridium is usually even with the surface of the prothallium, and it may remain so when mature (*figure 9*). *Figure 8* shows a form of antheridium occasionally met with. There is here a slight projection above the surface of the prothallium. This antheridium is peculiar in that it extends so deeply into the prothallium.

There seems to be no definite method for the further divisions of the outer cell. In sections, two or more cells are seen in the cover, irregular in size and depth. From this it will be seen that there is no definite arrangement or number in the cells comprising the cover. In most cases the antheridium was situated under one layer of cells, occasionally under two layers (*figure 10*). There was a marked variety in the size of imbedded antheridia. All degrees of size and shape were found from those about as large as the superficial type and rather globular to those more than twice as large and very irregular in shape (*figures 7–9*). The finding of imbedded antheridia upon these prothallia was not an occasional thing but a common occurrence, the majority of the prothallia grown under the above-detailed conditions bearing one or more imbedded antheridia. As a rule these were found upon the largest prothallia, although occasionally one was seen on a smaller prothallium. These deep-seated structures were always found to be in the apical region or within a few cells of it.

Typical of cell divisions in normal antheridia, the cells in the imbedded type divide simultaneously. The development of the sperms in the imbedded antheridium was followed closely and was found to differ in no way from that of the sperms in normal antheridia, a sperm from an imbedded organ appearing exactly like a sperm from a superficial one. Owing to the occurrence of both normal and imbedded antheridia on the same prothallium and the similarity between the sperms, sperms from a deep-seated antheridium could not be isolated.

In *figure 11* is seen a section of a prothallium immediately back of the apical region, in which are two imbedded antheridia and a normal archegonium. More than one half of the antheridium, the lower one in the figure, consists of sperm mother-cells, the rest of the antheridium being made up of four large cells. These cells have the granular cytoplasm characteristic of developing sex-cells. Another case similar to the foregoing was observed (*figure 10*), in which instance the antheridium, also in the apical region, was imbedded under two layers of cells. Approximately half of this antheridium consisted of mature sperms, the other half, that nearer the surface, was composed of three cells, two smaller and one very large with a corresponding large nucleus. This last cell bore a striking resemblance to an egg-cell.

The development of the imbedded antheridium is very similar to that of the antheridium in a lower order of ferns as described by Campbell ('07) in the Ophioglossaceae, with the exception of the first divisions and the development of the cover-cell. An approach to the imbedded antheridium of *Dryopteris stipularis* and "*Nephrodium molle*" is found in the antheridium of *Ceratopteris* (Engler & Prantl, Nat. Pflanzenfam. '02). This antheridium projects but slightly above the surface of the prothallium, although it has the customary lid- and ring-cells. The basal cell, assuming a more irregular shape, is designated as the pedicel-cell.

II. "NEPHRODIUM MOLLE"

The origin of the imbedded antheridium in "*Nephrodium molle*" is similar to that of an archegonium and not unlike that described for *Dryopteris stipularis*. After the first division of the initial cell into the outer and inner cells, the inner cell divides periclinally into two unequal cells (*figure 12*), recalling the development of an archegonium. If a division of the larger cell should take place obliquely, a condition would be found as shown in *figure 13*. Further divisions of the two inner cells give rise to the condition seen in *figure 14*. That such structures would develop into imbedded antheridia seems positive. The structure shown in *figure 24*, for example, may have originated in a manner similar to that of an imbedded antheridium, but it is certain that none of these structures would become sporophytes.

These developing structures found in the apical portion of the prothallia will be seen to be similar to the early stages in the development of the imbedded antheridium of *Dryopteris stipularis*. *Figure 14* in "*Nephrodium molle*" could represent an early stage in the development of *figure 8* in *Dryopteris stipularis*. The cells in these structures differ markedly from the surrounding cells in their granular cytoplasm and large nuclei. In *figures 12–14*, the nuclei of the cover-cells have recently divided, whereas the nuclei of the inner cells are in a resting stage. A typical imbedded antheridium similar to those found in *Dryopteris stipularis* is seen in *figure 15*. It projects slightly above the surface now but probably did not in its earlier stages. Three cells of the cover are shown in the section. The developing sperms are quite normal, the cells having rounded up, with the blepharoplast showing plainly in some of them. As was the case in *Dryopteris stipularis*, both kinds of antheridia appear on the same prothallium. In some cases an imbedded antheridium will be seen very near a superficial one. In *figure 16*, a small imbedded antheridium is seen adjoining one of the superficial type. There is a slight variation in the basal cell of this last antheridium, inasmuch as it has redivided until it consists of at least three cells. In the imbedded antheridium are a few almost mature sperms, lying loosely in the antheridial cavity. Two very narrow cells are at the base of this antheridium. It is very often the case that some of the cells immediately surrounding the antheridium are narrow. An antheridium, which had a deep-seated origin but in its development projected considerably above the surface of the prothallium, is pictured in *figure 17*.

Figures 18 to *24* comprise a series of drawings from consecutive sections of one prothallium. There are three structures here whose origin is similar to three adjacent archegonia. In *figure 18* two cells with the superficial or cover-cell are seen. The wall separating these two cells is diagonal, recalling a similar condition in *Dryopteris stipularis* (*figure 2*). This in itself is an irregularity for the normal division of an archegonium initial. The next section (*figure 19, a*) shows the same two cells; the innermost cell is a little the larger as is seen in the successive sections. This first structure contains, in all, four cells (*figures 21–23*). The other two cells are also divided by a diagonal wall, the position of this wall being at right angles to the wall separating the first two cells. The wall dividing the two pairs of cells is in the plane of the page. The beginning of the second structure is seen in *figure 19, b*. It appears here as a little hump of three cells, part of the cover. The next section (*figure 20, b*) shows that beneath this cover are two cells, one projecting up into the little hump. In *figure 21, b*, these cells are seen plainly with their large nuclei. The similarity between this and the two-celled stage of an archegonium is striking. Below these two cells in the second structure (*b*) are three more cells (*figures 21–23, b*). In these three cells, of which all three nuclei are seen, one cell is superimposed on the one below, the two nuclei appearing one above the other. The wall of the third cell is indicated by the dotted lines. The second structure (*b*) consists therefore of five cells, lying beneath a cover which arches slightly upward.

The third structure (*c*) is first seen in *figure 21, c*. Three small cells here project slightly at the left of the second structure (*b*). The next section (*figure 22, c*) shows this projection, corresponding to the neck of an archegonium, to be much larger. In this figure are seen three cells belonging to the third structure. The cells of the three formations are seen here (*figure 22*) to lie together as one mass of actively growing cells. From their position in the apical region of the prothallium and from their dissimilarity to the surrounding cells, *i. e.*, their granular, densely staining cytoplasm, large nuclei and absence of chloroplasts, these structures undoubtedly came from potential sex-cells. *Figure 23, c*, shows a section cut through the so-called neck of the third structure. Two small cells are seen in the neck-like projection, beneath which are three cells (*figures 23, 24, c*). Below these three cells are two more, making a total of nine in this structure (*figure 24, c*). The character of these last two cells justifies the opinion that this structure is of archegonial origin. The two cells mentioned seem to correspond to an egg- and ventral canal-cell of an archegonium.

The cultures of "*Nephrodium molle*" presented the same general characteristics as those of *Dryopteris stipularis* grown under these conditions, differing only in the rapidity of growth, these prothallia not growing quite so slowly as those of *Dryopteris stipularis*. No apogamous sporophytes were found on these prothallia.

GENERAL CONSIDERATIONS

From the foregoing description of the structures obtained through varying the normal cultural conditions, it will be seen that the prothallia of *Dryopteris stipularis* and "*Nephrodium molle*" present a remarkable mobility. As dryness and the exposure to direct sunlight were the only cultural changes from the normal state, the results obtained may be attributed to those causes, none of these structures being found in the normal control cultures. The fact that one form of the expression of the potentialities of these prothallia is that of a deep-seated antheridium is of interest from a number of standpoints. Morphologically the imbedded antheridium is interesting, in that its origin and development is very similar to the origin and development of the normal antheridium of a much lower order of ferns. The detailed development of the antheridium in the Ophioglossaceae (Campbell '07) is essentially similar to the development of the imbedded antheridium as found in *Dryopteris stipularis*. The position of these antheridia in the actively growing part of the prothallium is evidence of the manifestation of an active response to a forced environment and not a condition due to degeneracy or a reversion to more primitive characters. The presence of normal antheridia on the same prothallium bearing the imbedded kind shows that, while the conditions are equal for producing either, the condition of dryness is essential for the formation of the deep-seated antheridium. The imbedded antheridium in the dry cultures was not an occasional occurrence, as one and frequently two or three were found on the majority of the prothallia.

That the response to this dry condition was the production of imbedded antheridia, shows the far-reaching effect of such an environment, as well as the success of the prothallia in combating it. A superficial organ on a prothallium grown in dryness is more in danger from drought than one deeper in the prothallial tissue. To protect the antheridia from the disasters of drying out and thus becoming incapable of functioning, an antheridium has been developed, completely imbedded in the prothallium. Deep seated in its origin and development, such an antheridium is protected from the effects of drought, obtaining from the surrounding prothallial cells the maximum amount of moisture supplied the plants. The improbability of a sperm from a superficial antheridium reaching an egg is apparent in these prothallia due to the lack of the necessary medium, *i. e.*, water. If there could be an internal way for the sperm to reach an egg, another suggestion of the meaning of the imbedded antheridium would be evident. If the migrating and fusing nuclei, producing the apogamous embryo as described by Farmer and Digby, could be traced to such sexual elements as might mature into a deep-seated antheridium or an archegonium, the adaptation there would be more complete. The morphological position of an imbedded antheridium, then, can be regarded as only the expression of the potentialities of the plant, one evidence of the response to environmental conditions.

The sperms from either antheridium apparently differ in no particular. There was a greater variation in the number of sperms in the imbedded antheridia than in those of the normal type, the imbedded antheridia being larger on the whole than the superficial ones. The individuality of the deep-seated antheridium is shown in its slight shrinkage from the surrounding cells.

The case of the imbedded antheridium in which half consists of mature sperms and the other half of three large cells, one resembling very much an egg-cell (*figure 10*), presents another standpoint from which these structures may be considered. This is the subject as to the determination of sex. The question arises, has any cell of a prothallium destined to be a sex-cell the potentialities of either sex? When we remember that these are monoecious prothallia, that each cell came from a spore and that all spores are alike, it would seem as if there were some basis for such a supposition. If we accept this supposition as true, the earliest stages of the imbedded antheridium may be interpreted as the earliest stages of an archegonium. After the first division of a superficial cell into an inner and an outer cell, the inner cell instead of developing into an archegonium becomes the initial of a deep-seated antheridium. The origin of the case above cited may then be explained as a sex-cell, the potentialities of either sex being almost equal, so that half of the structure consists of sperms or the male element, and the other half, composed of three cells, one especially resembling an egg-cell, represents the female element.

Another case, the lower antheridium in *figure 11*, is shown where more than one half of the structure consists of sperm mother-cells, the rest of the antheridium being taken up by a number of large cells, which may represent the female element of the original cell. The fact that maleness dominates in these structures and that imbedded antheridia are the result of dryness and not abortive archegonia, may be due to the amount of moisture supplied. In dioecious ferns the archegonia are found on the larger prothallia, the antheridia on the smaller. Good cultural conditions may favor the probability of a destined sex organ, female; poor cultural conditions, male, although experimental evidence is conflicting on this point.

While the data are not so complete for "*Nephrodium molle*" as for *Dryopteris stipularis*, less material of the former having been prepared and studied, the origin of the imbedded antheridium found in this fern is undoubtedly similar to that of *Dryopteris stipularis*. That the structures seen in *figures 12–14* would develop into imbedded antheridia can not be definitely stated, but that deep-seated antheridia could originate in this manner is certain. A more exhaustive study of both ferns may bring out more facts. Normal antheridia, imbedded antheridia, and a transitional stage (*figure 11*) where an antheridium had a deep-seated origin but in its development projected beyond the surface of the prothallium, were all found in "*Nephrodium molle*."

The condition represented in *figures 18–24* is a different expression of "*Nephrodium molle*" under a dry state. The origin of the structure (*c*) in *figures 22–24*, at the base of which are the apparent egg- and ventral canal-cell, is without question a cell which under normal conditions would have given rise to a normal archegonium. The impossibility of this egg being fertilized, due to its position and the improbability of a sperm being attracted to it, is obvious. What the other two structures would give rise to is unknown. That they might produce egg-cells is a possibility, or that they might become imbedded antheridia is also to be considered.

It is impossible to draw any parallel between the imbedded antheridium of these ferns and the antheridium of *Ceratopteris*, the latter being borne on an aquatic fern, and structurally similar to the ordinary antheridium.

No apogamous sporophytes were found in the cultures of either fern. In anticipating the production of apogamy in these ferns, a type of sporophyte was expected similar to that described by Lang, *i. e.*, sporophytic budding from the prothallium or upon a process from the prothallium. If the sporophytes produced from the spore-grown prothallia of Lang do not originate from vegetative fusion of nuclei, their life history, as far as the number of chromosomes is concerned, is similar to the life history of the apogamous "*Nephrodium molle*" described by Yamanouchi. The figures of Yamanouchi, illustrating the development of this apogamous embryo, are not convincing. There is no evidence that the shaded cells in his figure 1 (*loc. cit.* 299) develop into the embryo shown in figure 29 (*pl. 10*). If apogamy is present in "*Nephrodium molle*," this plant shows greater potentialities than *Dryopteris stipularis* at the present time. A study of just how much dryness will cause the development of imbedded antheridia and how much will bring forth apogamy seems desirable.

While the main object in carrying on this investigation, namely, to obtain apogamy, has not been accomplished, an antheridium has been found that, so far as the writer knows, has not been obtained before. Acknowledgment is due here to the courtesy of Professor D. H. Campbell, who confirmed the above opinion as to the newness of such an imbedded antheridium in the higher ferns.

I wish to express my deep gratitude to Dr. David M. Mottier for his constant advice and encouragement throughout this study.

CONCLUSION

At the present time I have found no apogamy in either *Dryopteris stipularis* or "*Nephrodium molle*," although, as far as I was able to determine, the cultural conditions described by Yamanouchi were repeated. An imbedded antheridium similar to the antheridia of lower ferns was found on the majority of the prothallia of *Dryopteris stipularis* and on a number of the prothallia of "*Nephrodium molle*." In *Dryopteris stipularis*, in addition to imbedded antheridia, deep-seated structures were found, half of which consisted of sperms and the remainder of large cells. In "*Nephrodium molle*" a deep-seated egg- and ventral canal-cell were found.

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Explanation of figures in plates 26-28

All figures were drawn with the aid of a camera lucida, using homogeneous oil-immersion objective 2 mm. combined with ocular 4.

1–11. *Dryopteris stipularis*

1. Two-celled stage of an imbedded antheridium in the apical sinus.

2. Similar stage as above, the antheridium projecting slightly above the surface of the prothallium. The two cells are more equal in size.

3. Three-celled stage of an imbedded antheridium.

4. Young stage in the development of an imbedded antheridium. Apical cell not shown.

5. Stage similar to that in fig. 4. Antheridium shows no projection from the prothallium.

6. Antheridium in the apical portion, showing slight shrinkage from the surrounding cells. Relative density of cells in antheridium and in the prothallium is seen. Figs. 1, 4, and 6 indicate the width of the cushion.

7. Globular imbedded antheridium, causing a slight mound on the surface of the prothallium.

8. Wedge-shaped antheridium projecting deeply into the prothallium. Cytoplasmic contents of cells beginning to round up.

9. Large mature antheridium, not projecting from the prothallium at all. Irregular outline of antheridium is seen.

10. Deep-seated antheridium in which only half has developed into sperms. The other half consists of three large cells, one, that nearer the surface, resembling an egg-cell. This antheridium is situated under two layers of cells. The cover of those pictured in figs. 1–9 consists of but one layer of cells.

11. Section showing two imbedded antheridia and a normal archegonium in the apical region. The lower antheridium in the figure consists partly of sperm mother-cells. The remainder is made up of four large cells.

12–24. *Nephrodium molle.*

12. A structure, similar to a young archegonium, which may be the beginning of an imbedded antheridium.

13. An older stage. This could represent a stage in the formation of an imbedded antheridium.

14. A five-celled, deep-seated structure similar to a step in the development of imbedded antheridia. The densely granular cytoplasm and large resting nuclei are indicated.

15. Imbedded antheridium, projecting slightly. Cells beginning to round up.

16. Small imbedded antheridium, with almost mature sperms, adjacent to a superficial one.

17. An antheridium of deep-seated origin, projecting half way above the surface of the prothallium.

18. Two cells under a cover-cell *a* of a deep-seated four-celled structure. This and the following figures are from consecutive sections of a prothallium.

19. The same two cells of structure *a* are seen. Three cells in the cover of structure *b* project slightly from the surface.

20. More cells of the cover of structure *a* are seen. The lower cell of the first pair is below this cover. In structure *b* there are two cells, one projecting up into the cover.

21. The beginning of the third structure *c* is indicated here by three small cells, part of the cover. Two cells of structure *b* show. In structure *a* the second pair of cells, with the wall dividing them at right angles to the wall dividing the first pair fig. 19, *a*, is seen.

22. The cells of three structures appear as one contiguous mass of actively growing cells. Both nuclei of the second pair of cells of structure *a* are present. In structure *b* three cells in addition to those already described are seen beneath them. The cover of structure *c* projects considerably above the surface. Only three cells of this last structure show.

23. Structure *a* presents about the same appearance as in the preceding figures. Two cells of structure *b* are visible. This section passing through the neck-like projection of structure *c* discloses two small cells in it. Beneath this are four cells.

24. The two lowest cells of structure *c* are seen to resemble strikingly an egg- and ventral canal-cell. Above this so-called ventral canal-cell, three cells appear, two of which were present in fig. 23, *c*. Structure *c* consists, then, of nine cells, running through figs. 21–24. The cells in these three structures differ from the surrounding cells in their granular contents and large nuclei.

Notes on the anatomy of Parosela spinosa (A. Gray) Heller

AMELIA RICHARDSON GOODLATTE

(WITH PLATE 29)

The synonymy of this plant is considerable and though the generic name *Parosela* of Cavanilles has priority, in the somewhat scanty literature on the species it usually appears as *Dalea*. It belongs in the order Papilionaceae under the tribe Galegeae. The species is distributed from Arizona northward to Colorado and the California desert and southward to Sonora and Lower California. In stature it is a small tree, sometimes attaining a height of 18–20 feet, with a short trunk and very numerous branches. It is densely spinose, the spines being apparently modified branches, and the older stems are covered with a rough scaly light brown bark. The younger portions, up to stems of the third year, are densely clothed with hairs, and both the stems and spines bear small epidermal emergences or scales, and a few leaf-buds. These, together with the numerous large glands which form noticeable brown spots and protuberances on the surfaces of spines, stems, and leaves, give a decidedly rough and lumpy appearance.

The hairs are of a single type ; each consists of two short basal cells and a long, pointed end-cell, the outer part of the walls being cutinized, especially in the basal cells, while the remainder is formed of unmodified cellulose. The small scales or epidermal emergences are conical in shape, hollow in the center, their walls formed of two or three layers of small, nearly cubical cells, the outer ones cutinized like the epidermis.

The system of branching proves to be one of the most interesting of the external features. The superficial appearance is almost that of a dichotomous branching, but investigation shows that in every case a branch arises from a leaf axil. The apparent confusion is due to the fact that the spines are really the main axis transformed, while the axillary shoot, continuing to grow, takes the place of the main axis and itself gives off a shoot, which, developing rapidly into another branch, in its turn gives rise to a spine and a shoot. Thus, with very few exceptions, in the material examined, there was a regular alternation ; first, an axillary shoot, becoming the axis, the main axis being arrested and developed into a spine, then a fork with both axis and shoot developing into equal branches, then again, on each of these a spine and a shoot, and so on. At the growing tip it can be seen that the transformation of axis into spine takes place at a very early stage, the tip becoming horny and the stereome tissue strongly developed before the shoot is well out of the enfolding leaf and considerably before the formation of the axillary shoot which is to take its place as axis.

The most striking internal characters are, in general, the great development in the stem of chlorophyl-bearing tissue to assume the functions of the fugacious leaves, the occurrence in great numbers of crystals of calcium oxalate, and especially the very general distribution and prominence of glands and secretory apparatus.

The leaves, as has been said, remain on the plant only a very short time, and are comparatively few, even in the season. The minute paired stipules each have a large, persistent gland at the base, of the same anatomical character as the glands which are scattered irregularly over the stem and leaf. The hairs cover both surfaces of the leaf, clustering most densely in an irregular arrangement around the stomata. Weyland finds it characteristic of the tribe of the Galegeae, almost without exception, that the stomata are surrounded by cells arranged without any special order, neighboring the guard cells. *P. spinosa* possesses this character in common with the rest of the tribe. The stomata occur on both surfaces of the leaf, but are more numerous on the under side. They are simple in type, the guard cells not being even deeply sunk, though their outer walls are heavily cutinized, in common with the other epidermal cells.

In addition to this layer of cutin, the epidermis of the leaf is noteworthy because of the occurrence of rhomboidal crystals of calcium oxalate in a few of its cells. In regard to the shape of the crystals found by him in the epidermis of the single species *Dalea versicolor* Zucc., Weyland describes them as being short and rod-shaped, the cells containing them lying either singly or in groups, and being smaller than the surrounding cells. In *P. spinosa*, however, the crystals are distinctly rhomboidal and the small cells containing them are always single in the midst of the larger, ordinary cells (FIGURE 3).

Crystals, in greater or less numbers, in the accompanying tissue of the vascular bundles and in the palisade cells, Weyland finds to be a general character for the order, and he further states that those in the palisade cells are rod-shaped throughout the genus *Dalea*, while the rhomboidal form also occurs in some species. This proves to be true in the case of *Parosela spinosa*. In the layer of cells immediately under the epidermis, and in the mesophyl in general, these rhomboidal crystals are very numerous, especially in the cells surrounding the bundle-strands. The crystals in the palisade tissue are rod-shaped and sometimes partly imbedded in the cell-wall.

The further structure of the leaf is quite simple. It consists of palisade and spongy tissue, the leaf-edges being rolled so that the palisade cells extend round to the under side. The bundles are concentric, surrounded by a considerable layer of stereome tissue, and around that again, as has been mentioned before, a layer of cells with numerous crystals. Weyland cites the case of *Dalea polyadenia*, where these cells with crystal-complexes apparently take the place of bast-fibers as strengthening material, and it may very well be that in *P. spinosa* also they are of auxiliary use in giving rigidity to the leaf-bundles.

The secretory apparatus of the leaves can best be discussed in connection with that of the stem, as the anatomical character of the two is the same. The stem up to the third year has a highly developed chlorophyl-bearing tissue in the cortex, consisting of five or six rows of palisade cells. The stomata are of the same simple type as those of the leaves, being perhaps rather more deeply sunk, in a pit formed by the thickened outer walls. The epidermis has a heavy outer layer of cutin from a very early stage, and this increases until in the third year the entire outer wall, and the radial wall as well, are completely cutinized. As in the leaves, rhomboidal crystals are sparsely scattered through the epidermal cells. The hairs form a thick coating until the formation of the periderm supplants the primary cortex.

Sanio, speaking of periderm formation in general, states that

" Der Sitz der Korkbildung ist übrigens für jeden Species, ja man kann sagen Gattung, constant." Solereder, on the other hand, quoting as authorities Sanio, J. E. Weiss, and Douliot, on cork formation in the Papilionaceae, says that the position of the cork-forming layer differs not only within the limits of a genus but also " bemerkenswert ist, dass zuweilen bei derselben Art der Ort der Korkentstehung zwischen der zweiten und sechsten Zellschicht der primären Rinde wechseln kann." * Weyland finds that in *Dalea*, in the genus as a whole the cork is formed in the second to sixth cell-row of the cortex. In the plant under discussion it is formed, however, on the very inner row of the primary cortex, immediately outside the primary stereome bundles. This would be about the ninth or tenth row, as the number of rows of palisade cells is variable. Hence there is considerable variability in the genus in this respect (FIGURE 4).

A cross-section of a young stem shows, first, the epidermis, with a layer beneath it of cells containing rhomboidal crystals; then five or six rows of palisade cells, many of them containing rod-shaped crystals; then, a layer of parenchyma cells, with rhomboidal crystals; next, the row of collateral bundles and a cambial ring, rather ill-defined, each bundle being accompanied on the side toward the periphery of the stem by a strand of primary stereome tissue. In the center, of course, are the pith cells, with rather thickened walls, some of them transformed into tracheidal parenchyma with simple pores, and many of them, especially those nearest the wood, containing rhomboidal crystals, sometimes in the cell-cavity, sometimes imbedded in the wall. The only interruption in the simple regular character of the stem structure is the occasional appearance of a few cauline bundles, of the collateral type, accompanied by a stereome strand outside the leptome (FIGURE 5).

As the young stem develops, the layer of cutin, as has been remarked, becomes more strongly developed. When the cortex is supplanted by cork cells the outer ones of these have cutinized walls, the inner (phellogen) layer retaining unmodified cellulose walls. Traces of suberin appear in a few cells of the hadrome,

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* Anat. Dicot. 313.

from the third year on. The crystals are increasingly numerous as the stem develops. Lignification begins, naturally, in the ducts and tracheids even of the very young stem, and proceeds as the plant grows older, through the walls of the primary stereome, the pith, the inner walls of the parenchyma cells lying next the primary bast bundles, the walls of the secondary stereome, of many scattered palisade cells, and finally occurs in the cells of the bark when this is formed in the sixth year. As the lignified areas increase, the areas containing walls of unmodified cellulose become reduced to those of the leptome, cambium, phellogen, and whatever remains of the palisade tissue. Starch is found from the first to the third year in the contents of the palisade, pith, parenchyma, and medullary ray cells. After this it disappears as the stem becomes less and less an assimilating organ. Proteids, likewise, occur in conjunction with the green tissue and decrease with it.

In the parts of the stem which become modified into spines the process of lignification takes place much more quickly than in the stem that continues to grow. In place of parenchyma cells a stereome ring fills the spaces between the hadrome masses of the bundles. This is especially noticeable as a point of difference between a very young spine and a very young shoot (FIGURES 1 and 2). After this rapid development of tissue that serves to give strength and rigidity, the growth of a spine is limited to simple thickening and enlarging, for there is no secondary thickening.

In the growing stem secondary thickening takes place according to the ordinary dicotyledonous type from a cambial ring. The sieve-tubes are comparatively short and wide. The vessels differ greatly as to size, but all have simple, oval pores, as is characteristic of the family. The walls of the smaller tracheids are spirally thickened. The medullary rays, as usual in the greater number of Papilionaceae, consist of about three cell-rows, somewhat increased toward the outer part in a wedge shape.

Solereder * quotes Saupe to the effect that the medullary ray cells of the Galegeae are small and round in tangential section. In this case, however, they prove to be oblong and almost rectangular. The wood-prosenchyma cells, where they come into contact with the ducts, have, like them, simple oval pores. There

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* *Loc. cit.* 310.

are no distinct bundles of secondary bast, not in direct contact with the medullary rays and marked off by a distinct sheath. On the contrary, the secondary stereome is in direct contact with the medullary rays and with the wood. The masses are composed mainly of prosenchymatic or perhaps sclerenchymatic cells, while those of the bast type, with long, pointed ends, are mixed with them in small groups.

The secretory system is extremely well developed, all the varieties of internal secreting organs that are mentioned as occurring in the tribe being found in this species. (This does not include the glandular hairs possessed by a few Galegeae.)

The material used for this work was, first, a dried herbarium specimen which was soaked in a mixture of glycerine, alcohol, and water, to make cutting possible, and afterwards some branches that had been obtained in a living state, through the courtesy of Dr. D. T. MacDougal, but were preserved in the same mixture. Probably something in this method of preserving affected the secretions of the glandular tissues. At all events, all tests for determining their exact contents were unsatisfactory, so that the only conclusion to be obtained is that, since they are analogous in anatomical structure to the organs tested by other observers, their contents are presumably of the same nature.

Throughout the stem and spines there are strands of elongated cells with thin walls and a large cavity, sometimes lying singly, but more often two or three together, in the innermost layer of the primary cortex. In some cases they are immediately adjacent to the bundles of primary stereome, in others they lie opposite the medullary rays (FIGURE 5). Trécul found a similar set of cells with tannin contents in the cortex and also on the outer edge of the pith in *Dalea alopecuroides*. He describes them as " ces sortes de vaisseaux à tannin dont les cellules ne sont ordinairement pérforées." Baccarini describes similar ducts in many Leguminosae, which he says may appear in one stage of the plant's growth and disappear subsequently, or may be permanent. These tannin elements are situated: 1, around the pith and outside the stereome; 2, in the periphery of the pith, grouped around the vascular apex of the wood triangle of each bundle, and on the sides of the stereome; 3, around the pith, within the stereome and on its sides;

4, around the pith and within the leptome. These tannin elements are not of invariable occurrence, he finds, in the Leguminosae, and part of the tribe of the Galegeae is without them. *Dalea*, however, belongs to the series provided with this sort of secretion organ. These ducts contain in addition to tannin, he says, albuminous material which will stain bright yellow in iodine, although the tannin interferes somewhat with the reaction. Weyland verifies Baccarini's results in general, but finds that what he interpreted as a transitory appearance of tannin-bearing elements is due to the difference of the contents of the ducts at different stages. In the young stem the contents are almost wholly albuminous and the tannin appears later, which explains, he adds, the great size of the ducts relative to the amount of tannin contained.

In *Dalea*, Weyland observed these ducts in the pith, Trécul in the pith and the primary cortex as well. In the species under discussion, as far as the available material showed, they occur only in the cortex. As has been said, the tests to determine the contents were most unsatisfactory. The ducts were filled with a substance of red-brown color, and this of course made all those tests for tannin which depend upon a red or a brown color-reaction, unavailable. Copper acetate, iron sulphate, and iron acetate, which should give green, black, or blue color, had apparently no effect. It seems probable that the preserving liquid must have affected the contents in some way, although the liquid itself, when tested for tannin, showed no result, so that this could not have been extracted in any large quantity. The arguments, then, for considering these ducts as part of the albuminous-tanniferous apparatus similar to that of other members of the genus and tribe, are simply based upon the similarity in structure and position. The similarity in structure is at once apparent and that in position is evident when one considers Baccarini's statement that the cells normally lying on the sides of the bundles of hard "libro," are sometimes pushed out till they lie between the bundles.

Another type of secretory organ which is very prominent in *P. spinosa* is an ovoid schizogenous gland with an opening to the exterior through a small slit, and surrounded by a firm layer of close-set cells, which show traces of lignification, lined by a layer of papillary epithelium, with densely granular cell-contents, light brown in color (FIGURE 6). Weyland speaks of finding only traces of this epithelium at an early stage in the formation of the gland, and says that it later breaks down and a schizogenous-lysigenous gland results. In the species *P. spinosa* this is not the case, as the epithelium is plainly marked even in a gland occurring on an old spine, where it is presumable that the gland is of a considerable age. It is glands of this type which form the lumps on the young branches, alluded to by Solereder, and which occur at the bases of the stipules. They occur in numbers in the palisade tissue of the primary cortex, but are naturally absent from the older branches on which the periderm has supplanted the cortical tissue.

In the attempt to decide on the nature of the contents secreted by these glands, we have again to record no result. In this case it would seem that the contents have been extracted. Weyland finds round glands of the same type in all the genera of the subtribe Psoraleae that he examined. They contained a light or dark yellow resin, which was soluble in alcohol. The occurrence of these glands with resinous contents is a character for divisions greater than a genus, he claims. Therefore, since glands of the same structure and position contain resin in other species of the genus and subtribe, and since the resin is soluble in alcohol, it seems safe to conclude that the contents were resinous and have been extracted by the alcohol in which the material was placed.

This completes the secretory apparatus of the stem. The leaves contain the same round glands, which appear in either the palisade or spongy tissue, opening toward either surface. No trace of tannin ducts nor of the single isodiametric tannin-secreting cells, nor of the layer of tannin cells in the mesophyl, mentioned by Baccarini as present in the group, could be found. In addition to the resin-bearing glands, however, the leaves contain a peculiar type of gland, the so-called intercellular glands. These are composed of elongated cells which have split apart from each other, so that in the mature gland they present the appearance of strands of tissue running through the cavity of the gland. Around the whole is a sheath of close-set cells, developed from the mesophyl (FIGURE 7). It is only in the mesophyl tissue and opening on the under side of the leaf that glands of this type occur. Their contents are small pieces of hardened brown stuff, which is undoubtedly tannin but refuses to respond to any of the tests, like the tannin in the other cases. Solereder describes an exactly similar gland in *Psoralea.* It is the brown coloring of these glands which causes the noticeable brown spots on the leaves of dried material in this species.

This completes the survey of the anatomical characters of *Parosela spinosa* as far as they have been ascertained. The work was done under the direction of Dr. Herbert M. Richards, to whom thanks are due for his many kind suggestions and encouragement.

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Explanation of plate 29

1. Stem in first year, showing distribution of main tissue areas. Chlorenchyma, stippled; stereome, black; vascular bundles indicated in outline. Magnified 12 diameters.

2. Spine in first year, as above, showing the greater development of the stereome. Magnified 12 diameters.

3. Surface view of epidermis of leaf. Magnified 250 diameters.

4. Periderm formation in stem of third year. Magnified 136 diameters.

5. Transverse section of portion of stem in third year. The vessels indicated by cross-hatching contain the dark brown albuminous substance. Magnified 136 diameters.

6. Gland in stem. Magnified 250 diameters.

7. "Intercellular" gland of leaf. Magnified 250 diameters.

The figures were all drawn with the aid of an Abbé camera, and the magnifications given above are $\frac{2}{3}$ of that of the original drawings.

Some coastal plain plants in the Piedmont region of Georgia

ROLAND M. HARPER

In the indigenous flora of North America there are several hundred species, perhaps more than a thousand, which, whatever their distribution may have been in prehistoric times, are now known only from the coastal plain. Up to a time within the memory of every living botanist the coastal plain was scarcely recognized by phytogeographers (I have found very few distinct references to it in botanical literature earlier than 1900), and the fact that so many species are endemic to it was therefore only dimly realized if at all. In the last two decades, since botanists have begun to pay more attention to plant distribution, many species formerly known only from the coastal plain have been found in the older regions farther inland; and this may have led some to believe that all species now supposed to be confined to the coastal plain will be found also outside of it when the country is more thoroughly searched. But at the rate that such discoveries are being made it would seem that the limit has almost been reached, and that there are still hundreds of species which do not (and probably never did) grow outside of the coastal plain.

Those species which are common in the coastal plain and rare elsewhere constitute an interesting though naturally not well-defined class, and it is chiefly through a study of these that we may hope to learn something of the origin and history of those of more restricted distribution above mentioned. It is impossible to say how many should be included in this class, since there is no sharp distinction between them and those species which are equally common in and out of the coastal plain on the one hand, and those now supposed to be confined to the coastal plain, but hereafter to be found at isolated stations outside of it, on the other.*

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* For the names of a number of plants of pioneer tendencies which are about as common in the highlands as in the coastal plain, see Bull. Torrey Club **27**: 328 (near bottom). 1900; Torreya **5**: 56. 1905; **8**: 4–6. 1908; Plant World **9**: 226. 1907. — Kearney, Plant World **1**: 33–35. 1897; Science II. **12**: 832–836 (in part). 1900.

But, no matter how many or how few species we include in this class, present knowledge is sufficient to indicate with certainty that outside of the coastal plain their number is greatest in western Georgia and eastern Alabama, gradually decreasing northward, until in the highlands of Virginia and Kentucky there are very few such plants worth mentioning. Just why this is so is a problem to be solved in the future by the aid of geology; the object of the present paper is not to inquire into that, but to present a few additional examples recently discovered in a part of the region of greatest promise above indicated, and to indulge in a few speculations regarding their history.

One of the earliest papers dealing primarily with the exceptional occurrence of coastal plain plants farther inland is that by Mr. Kearney on the Lower Austral element in the flora of the southern Appalachian region, in Science for November 30, 1900. In Mohr's Plant Life of Alabama, published eight months later, are many details of the local distribution in that state of such species as are here discussed. Additional information about some of them can be gathered from Harbison's Sketch of the Sand Mountain Flora * and Earle's Flora of the Metamorphic Region of Alabama,† both published in the spring of 1902. In 1906 the writer published two papers ‡ giving several more instances of the same kind from northern and eastern Alabama.

Comparatively little field work has been done in those parts of the metamorphic or Piedmont region of Georgia where coastal plain plants are most likely to be found, and almost nothing has been printed about the vegetation there. In the latter part of the summer of 1908 I had occasion to spend about a month in west-

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—Mohr, Contr. U. S. Nat. Herb. **6**: 60–62, 73–74, 75 (near bottom), 97. 1901. Much less was known about the details of plant distribution in the South at the beginning of this century than now, and some of the earlier discussions of geographical affinities are based on such imperfect data as to be somewhat misleading. "Austroriparian" plants especially have been discussed at considerable length without being sufficiently defined.

* Biltmore Bot. Stud. **1**: 151–157.

† Bull. 119, Ala. Agric. Exp. Sta. In this, unfortunately few details of distribution are given, and the boundary between the metamorphic region and coastal plain is not drawn sharply enough to exclude several species which are strictly confined to the latter.

‡ Torreya **6**: 111–117; Bull. Torrey Club **33**: 523–536.

ern Middle Georgia, during which I took advantage of the opportunity to examine a good deal of territory never explored botanically before, with the not unexpected result that I found several species, most widely distributed in the coastal plain, which had not previously been seen in Middle Georgia, though nearly all were already known from upper Alabama. There is no need of apology for placing on record those which are entirely new to the known flora of the Piedmont region, and there are a few others which have been seen so few times outside of the coastal plain that they deserve to be mentioned here in order to strengthen what little evidence we already have about their distribution and habitats in these older regions. Notes on a few of the trees observed at this time have already been published in Southern Woodlands * for December, 1908.

The species which are confined to the coastal plain or nearly so are largely if not chiefly pioneer plants growing in wet places † (especially moist pine-barrens), but a few prefer dry or comparatively rich soil. The localities in Middle Georgia which yielded the most interesting results in the way of coastal plain plants last year may be briefly described as follows:

For pioneer xerophytes, the Pine Mountains stand preëminent. Some allusion has already been made to this interesting outlying range of mountains,‡ but a little further description will not be out of place here. The Pine Mountains extend from the Atlantic and Gulf divide in Pike County in a general west-southwest direction to the Chattahoochee River in Harris County, a distance of about sixty miles. They are best developed midway between the two ends, in the southern part of Meriwether County, where they are divided into several ridges, the highest rising about 1,300 feet above sea-level and 500 feet above the average of the surrounding country. These mountains are formed of sandstone (the surrounding country is granitic), and their soil is naturally rather sterile from the standpoint of the agriculturist, scarcely any crops being

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* A bi-monthly magazine of forestry published at Athens, Ga. With the third volume the title was changed to *Forest, Fish and Game*.

† Conversely, those confined to the neighboring highlands are mostly climax plants preferring comparatively dry soil.

‡ Bull. Torrey Club 30: 292–294. 335. 1903; Southern Woodlands 1^3: 13. 1907.

raised there except peaches, and those only in a few places. *Pinus palustris* is or has been abundant the whole length of the Pine Mountains (whence their name), and the flora of the summits and drier slopes has much in common with the dry pine-barrens of the coastal plain. Most of the species are of pretty wide distribution, however, and few need to be mentioned here. These mountains were visited four times in September, in Upson County on the 8th, Harris on the 12th, Pike on the 19th, and Meriwether on the 24th. Oak Mountain, in Talbot and Harris counties, is a ridge about half as high as Pine Mountain, a few miles south of it and nearly parallel to it, with similar vegetation except that the long-leaf pine seems to be absent, its place being taken by *Pinus echinata*. A few minutes were spent on the western end of this ridge near Hamilton about sunset on September 12th.

For pioneer bog or moist pine-barren plants the best places in Middle Georgia seem to be a number of bogs and meadows a few miles north of the Pine Mountains, some of which have been mentioned in a previous paper.* On September 19th last year I found another such meadow just south of Zebulon, in Pike County, and a most interesting area about four miles farther south, or half a mile north of Meansville, in the same county. Here there is a shallow, nearly level valley, with sandy soil, and tall slender specimens of *Pinus Taeda*, the only kind of tree in about 25 acres, except a few small gums (*Nyssa* and *Liquidambar*). *Pinus palustris* grows sparingly on higher ground close by, but the valley is apparently a little too moist for it. The vegetation of the low grounds (which might be called the Meansville flatwoods for convenience, as it will be referred to several times hereafter) is somewhat intermediate in character between that of low pine woods in southeastern Virginia † and that of the pine region of Limestone County, Alabama, ‡ and has many species in common with both regions and with several other places where *Pinus Taeda* is the prevailing tree. Besides the more noteworthy plants to be mentioned farther on, I found at this place in passing through: — *Helianthus angustifolius*, *Sericocarpus linifolius*, *Eupatorium ver-*

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* Bull. Torrey Club **30**: 294, 326. 1903.

† See Kearney, Contr. U. S. Nat. Herb. **5**: 396–405. 1901.

‡ See Torreya **6**: 115–116. 1906.

benaefolium, *E. rotundifolium*, *Viburnum nudum*, *Cephalanthus*, *Diodia virginiana*, *Cholisma ligustrina*, *Azalea viscosa*, *Ludwigia alternifolia*, *Viola primulifolia*, *Rhus copallina*, *Lespedeza angustifolia*, *Aronia arbutifolia*, *Magnolia glauca*, *Juncus aristulatus*, *J. scirpoides*, *Scleria triglomerata*, *Rynchospora glomerata*, *Scirpus Eriophorum*, *Cyperus pseudovegetus*, *Uniola laxa*, *Panicum virgatum*, *P. agrostoides*, *Pteridium aquilinum*, and a few others of similar distribution.

Species of more climax tendencies, but still chiefly confined to the coastal plain, were found in the swamps and bottoms of the Flint River and some of its larger tributaries in the southern part of Fayette County and on the borders of Spalding and Coweta adjoining, on August 22 and September 22.

The species of greatest interest observed at the localities above described are mentioned below. The most complete statements as to their known distribution up to the beginning of the present century can be found in Mohr's Plant Life of Alabama (Contr. U. S. Nat. Herb., vol. 6. 1901). In Ann. N. Y. Acad. Sci. vol. 17, part 1, I have given the latest information I had up to the summer of 1905 about the ranges of such of them as are known to occur in the Altamaha Grit region of Georgia. Specimens of several of them were collected, and such are referred to by number.

VERNONIA ANGUSTIFOLIA Michx.

In dry long-leaf pine woods on the Pine Mountains in Pike and Meriwether Counties, and among short-leaf pines on Oak Mountain in Harris County. Otherwise known only from the coastal plain.

LOBELIA GLANDULOSA Walt.

In the meadow just south of Zebulon, September 19, in bloom (*no. 2242*). Apparently never seen outside of the pine-barrens before.

OLDENLANDIA UNIFLORA L.

With the preceding. Not definitely reported outside of the coastal plain before.

AFZELIA PECTINATA (Pursh) Kuntze.

In dry woods on the northern slopes of the Pine Mountains near Warm Springs, Meriwether County. Previously known range and habitat similar to that of *Vernonia angustifolia*.

TRACHELOSPERMUM DIFFORME (Walt.) A. Gray.

On August 22 I found this evergreen vine in the Flint River swamp in Spalding County, which was not very surprising, as it had already been found farther inland in Alabama.*

SABBATIA CAMPANULATA (L.) Torr.

Abundant in the Meansville flatwoods. I had never seen this in Middle Georgia before, but Dr. Small has reported it from the mountains, † and it is known to occur at several places in the coal region of Alabama.

CYNOCTONUM SESSILIFOLIUM (Walt.) Gmel.

In 1901 I found this in a sandy bog near Molena, Pike County,‡ and last year I found it in similar situations near Zebulon, about ten miles away. No other stations seem to be known for it outside of the coastal plain, or indeed outside of the pine-barrens except near Americus, Ga.

FRAXINUS CAROLINIANA Mill.

On muddy banks of Big Potato Creek where that stream cuts through the Pine Mountains in Pike County, September 19. This is chiefly confined to the coastal plain, but Dr. Mohr has reported it from one place in northeastern Alabama,§ and Mr. C. L. Boynton from the rocky bed of a stream near Wadesboro, N. C. ||

LUDWIGIA HIRTELLA Raf.

In the sandy bog or meadow near Zebulon. Previously supposed to be confined to the coastal plain, and almost to the pine-barrens.

LUDWIGIA LINEARIS Walt.

In the Meansville flatwoods (*no. 2244*). Known range very similar to that of the preceding, except that Dr. Mohr reported it once from Lookout Mountain.

? VIOLA DENTICULOSA Pollard.

What looks more like this species than any other I am

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* See Bull. Torrey Club **33** : 535. 1906.

† Bull. Torrey Club **24** : 332. 1897.

‡ See Bull. Torrey Club **30**: 294. 1903.

§ Contr. U. S. Nat. Herb. **6** : 67. 1901. (This locality is not mentioned in his catalogue of species.)

|| Biltmore Bot. Stud. **1** : 144. 1902.

acquainted with grows sparingly in the Meansville flatwoods. At the known stations for it in the coastal plain it is associated with a good many species which range as far inland as this, and there is no known reason why it should not do likewise.

TRIADENUM PETIOLATUM (Walt.) Britton.

In a creek swamp about two miles north of Zebulon, September 19. Professor F. S. Earle reports it from Tallapoosa County, Alabama (which is mostly in the metamorphic region), but with that possible exception it seems to have been known only from the coastal plain before.

ASCYRUM STANS Michx.

In the Meansville flatwoods, also in a sort of natural meadow about two miles east of Senoia, Coweta Co., which I visited on September 22. Rare at both places. I had previously seen it in Marshall and Clay counties, Alabama, but not in the Piedmont region of either state.

ILEX GLABRA (L.) A. Gray.

This is common in nearly all parts of the coastal plain in Georgia and frequent in southern Alabama, but it had apparently never been seen in the highlands of either state by a botanist until Mr. C. L. Boynton found it near Carrollton, Ga., several years ago.* Last year I found many small bushes, some with fruit, around the edges of the low pine woods or flatwoods near Meansville (*no. 2247*). I have heard some rumors of its occurrence in Coweta County also.

CYRILLA RACEMIFLORA L.

On the banks of Big Potato Creek where it cuts through the Pine Mountains in Pike County, which is probably a little farther above the fall-line than this species had ever been seen before.†

? NYMPHAEA FLUVIATILIS Harper (Bull. Torrey Club **33**: 234–236. *f. 2.* 1906).

What seems to be this species occurs in Line Creek on the

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* See Ann. N. Y. Acad. Sci. 17: 209. 1906. It cannot be very common there, for in January, 1904, I walked out from Carrollton a few miles in several different directions, bearing this species in mind, but I could not find a trace of it, though I did see a good many species which commonly associate with it.

† See Bull. Torrey Club 30: 294. 1903.

boundary between Fayette and Coweta counties. At the time I described it I knew of no floating-leaved *Nymphaea* outside of the glaciated region and coastal plain.*

QUERCUS CATESBAEI Michx.

On dry rocky northern slopes (apparently not on the summit) of the Pine Mountains near Warm Springs, which is a few miles from where I found it in 1901. It is accompanied there usually by two related species with similar leaves, *Q. coccinea* and *Q. georgiana*, and always by *Pinus palustris.*

QUERCUS LAURIFOLIA Michx.

On sandy banks of Big Potato Creek in the Pine Mountains, Pike County. This seems to be the first station on record for this oak in Middle Georgia, but I had already found it about the same distance above the fall-line in Alabama.†

MYRICA CAROLINENSIS Mill.

Grows about four feet tall in the Meansville flatwoods (*no. 2250*). Rare in a damp ravine on the north side of the Pine Mountains between Meansville and Barnesville in the same county. Like the preceding, this had not been known to occur outside of the coastal plain in the South until I found it in upper Alabama in 1906.‡

MYRICA PUMILA (Michx.) Small.

With the preceding, about two feet tall (*no. 2251*). Dr. Mohr had reported this from Cullman County, Alabama, but otherwise it was known only in the coastal plain, and at very few places outside of the pine-barrens.

SMILAX LAURIFOLIA Walt.

In two or three branch-swamps between Zebulon and Meansville, Pike County, September 19. This too was previously unknown in Middle Georgia, but Dr. Gattinger found it long ago in East Tennessee, and the writer in 1905 on Lookout Mountain, Alabama, § and later in Randolph and Chilton counties, in the metamorphic region of the same state.

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* In this connection see Rhodora **8** : 29. 1906; and the last paragraph of the original description of this species.

† See Bull. Torrey Club 33 : 529. 1906.

‡ See Bull. Torrey Club 33 : 528. 1906; 34 : 373. 1907.

§ See Torreya **6** : 114. 1906.

JUNCUS TRIGONOCARPUS Steud.

Occurs in the meadow south of Zebulon, which is not surprising, as I had found it in the adjoining county of Meriwether seven years before.

XYRIS FLEXUOSA Muhl. (*X. torta* of many authors.*)

Rather common in the Meansville flatwoods. Previously known from the coastal plain only.

CAREX GLAUCESCENS Ell.

In the swamp of the Flint River, Spalding County, and in the Meansville flatwoods; not abundant. Accompanied by *Erianthus strictus* and *Panicum agrostoides* at both places, as well as in the pine woods of Limestone County, Alabama,† which seems to be the only other locality outside of the coastal plain recorded for this *Carex*.

SCLERIA TRICHOPODA Wright.

The first sentence and half of the second, in the remarks under *Cynoctonum sessilifolium* above, will apply as well to this species.

ELEOCHARIS TUBERCULOSA (Michx.) R. & S.

Grows in the low places near Zebulon and Meansville already mentioned several times. Chiefly confined to the coastal plain, but known also from several stations in the glaciated region and mountains.‡ In 1906 I found it in the Coosa valley, in Cherokee County, Alabama.

PANICUM VERRUCOSUM Muhl.

Abundant in some parts of the Meansville flatwoods. As this ranges as far north as eastern Massachusetts, its occurrence outside of the coastal plain is not surprising.

ERIANTHUS STRICTUS Baldw.

See remarks under *Carex glaucescens*, above. The distribution of this rather rare grass is not very well understood, but it is seldom found outside of the coastal plain.

LYCOPODIUM ALOPECUROIDES L.

In the Meansville flatwoods, not abundant (*no. 2249*). Previ-

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* See Torreya **5**: 129. 1905.

† See Torreya **6**: 116. 1906.

‡ See Rhodora **7**: 72. 1905; **8**: 27. 1906.

ously known only from the coastal plain, and from Henderson County in western North Carolina.*

ANCHISTEA VIRGINICA (L.) Presl.

With the preceding, more abundant (*no. 2248*). Like *Myrica carolinensis*, which grows with it, this was not known outside of the glaciated region and coastal plain until I found it in northeastern Alabama in 1906.†

To trace the history of these species which have a wide distribution in the coastal plain and are rare and local in the older regions will be one of the most fascinating problems of the phytogeography of the future. At first thought it would seem easy enough to dismiss the matter in a few words by saying that these organisms have pushed out in comparatively recent times (since the glacial period, for instance) from the regions where they are common to the scattered localities where they are rare. Up to the beginning of the present century, when Dr. Cowles brought the idea of succession of vegetation prominently before the botanists of this country, such an explanation would have seemed sufficient. Mr. Kearney in his extremely valuable and interesting paper in Science ‡ already mentioned, which was published just before what might be called the dawn of a new era of botanical investigation in America, gives scarcely a hint of succession from pioneer to climax, though he does point out that most of the species he discusses are xerophytes, growing in poor sandy soils. Even as late as the spring of 1905, the writer, not having fully grasped the idea of succession, made the suggestion, which now seems absurd, that *Pinus palustris* might have been extending its range in Middle Georgia within historic times.§

But according to the laws of succession as now understood, it is as impossible for pioneer plants to encroach on territory occupied by climax vegetation (except where the latter is weakened or destroyed by some other cause) as it is for a savage to establish himself unaided in a civilized country, or for an American farmer

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* See Lloyd & Underwood, Bull. Torrey Club **27**: 157. 1900.

† See Bull. Torrey Club **33**: 523. 1906.

‡ Science II. **12**: 830–842. 1900. The author calls this "A preliminary note," but unfortunately never followed it up with anything more on the same subject.

§ Torreya **5**: 57. 1905.

or lumberman to move to Europe and continue the same occupation there. The tendency is always for climax vegetation to gain ground and pioneer vegetation to lose,* and this tendency is counteracted only by such forces as erosion, fire, and civilization. The species discussed in this paper, or the majority of them, must therefore have once been more widely distributed in the highlands than they are now; and doubtless not a few species now strictly confined to the coastal plain were more or less common farther inland in past epochs.

It is not likely that all species now endemic to the coastal plain have had such a history, however. The distribution and relationships of many of them make it seem most likely that their ancestors came in by way of Florida after the coastal plain last emerged from the sea, probably about the close of the Pleistocene period. (The Pleistocene submergence of the greater part of the coastal plain has been overlooked by nearly all botanists who have discussed the phytogeographical problems of the southeastern United States, but it is pretty generally accepted by geologists, and must have had a far-reaching effect upon the present composition of the flora.) Many species now growing in the Piedmont region have indeed near relatives in the tropics, and such (as Mr. Kearney has already suggested) probably date back to the Miocene period, when semi-tropical vegetation extended to Greenland.

After the last emergence of the coastal plain it doubtless received plant immigrants both from the north and from the south, and the present endemic coastal plain species must have been derived (by mutation or otherwise) from at least two different sources. Perhaps in the not distant future it will be possible to separate them all into two or more classes on this basis.

COLLEGE POINT, N. Y.

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*See Bull. Torrey Club 33: 529, 531. 1906; 34: 373. 1907; Southern Woodlands 1^3: 8–9. 1907.

Studies in the North American Convolvulaceae — V. Quamoclit

Homer Doliver House

The genus *Quamoclit* dates back to Tournefort, but was merged by Linnaeus into *Ipomoea*. The type of the Tournefortian genus *Quamoclit* is the species herein recognized under the name of *Quamoclit pinnata* (Desr.) Boj. (*Quamoclit Quamoclit* Britton). This species is by priority of citation the technical type of *Ipomoea* and in restoring *Quamoclit* to generic rank, Moench unfortunately takes up only *Ipomoea coccinea* in the genus, but credits the genus to Tournefort.

The writer has already expressed his opinion regarding the validity of *Quamoclit* and *Ipomoea* (Ann. N. Y. Acad. Sci. **18**: 181. 1908), and proceeds here to maintain the genus *Quamoclit* in the sense typified by the Tournefortian type, and recognized under the name of *Quamoclit* in all subsequent literature wherever *Ipomoea Quamoclit* of Linnaeus is not regarded as congeneric with the species usually placed in *Ipomoea.*

QUAMOCLIT Moench, Meth. 453. 1794

Calboa Cav. Ic. **5**: 51. 1799.
Macrostemma Pers. Syn. **1**: 185. 1805.
Mina Llav. & Lex. Nov. Veg. Descr. **1**: 3. 1824.
Morenoa Llav. & Lex. *loc. cit.* 5.
Doxema Raf. Fl. Tellur. **4**: 75. 1838.
Neorthosis Raf. *loc. cit.* 125.

Annual or perennial, twining, mostly herbaceous vines. Leaves alternate; blades entire, lobed or divided. Flowers in axillary usually 2-forked, few- or many-flowered clusters. Sepals 5, membranaceous or herbaceous, equal or nearly so, often awned at or near the apex with straight or recurved appendages. Corolla small or medium-sized, the tube not expanding at the base, the limb subsalverform, cup-shaped or rarely funnelform, usually more or less lobed. Stamens 5, with the style exserted and usually conspicuously declinate; filaments filiform. Ovary 2-celled, ovules 4; stigma capitate. Capsules subglobose or somewhat elongated, the style often persistent in fruit. Seeds smooth.

TYPE SPECIES: *Quamoclit pinnata* (Desr.) Boj. (*Ipomoea Quamoclit* L., *Quamoclit vulgaris* Choisy).

Key to the North American species

- Sepals without awns; leaves pinnately divided; pedicels thickened; corolla-tube clavate. (Section *Euquamoclit* Peter.) 1. *Q. pinnata.*
- Sepals awned; leaves entire or lobed. Corolla-limb shorter than the tube. (Section *Calboa* Peter.)
  - Corolla-limb expanding abruptly from a slender tube, the limb campanulate or cup-shaped.
    - Limb of the corolla deeply campanulate, deeply lobed.
      - Lobes of the corolla-limb rounded.
        - Corolla red or scarlet, the tube about 3–4 cm. long.. 2. *Q. Lindleyi.*
        - Corolla yellow, the tube about 2 cm. long........ 3. *Q. Langlassei.*
      - Lobes of the corolla-limb oblong-lanceolate, acute; tube about 1.5 cm. long; corolla yellowish, tinged with purple.. 4. *Q. globosa.*
    - Corolla-limb shallowly cup-shaped, about 1.5 cm. broad, angulately lobed, the tube 3–5 cm. long...................... 5. *Q. coccinea.*
  - Corolla-limb expanding funnelform or tubular from a slender and often bent tube.
    - Corolla-limb 5-angled, about 1.5 cm. broad, the tube fully 5 cm. long.. 6. *Q. grandiflora.*
    - Corolla-limb deeply 5-lobed, lobes acute; the tube about 3 cm. long.. 7. *Q. vitifolia.*
  - Corolla-limb cylindrical and bent, longer than the tube, yellow, tinged with red. (Section *Mina* House.)........................ 8. *Q. lobata.*

1. QUAMOCLIT PINNATA (Desr.) Boj. Hort. Maurit. 224. 1837

Ipomoea Quamoclit L. Sp. Pl. 159. 1753.
Convolvulus pennatus Desr. in Lam. Encyc. **3**: 567. 1789.
Convolvulus pennatifolius Salisb. Prodr. 124. 1796.
Convolvulus Quamoclit Spreng. Syst. **1**: 591. 1825.
Quamoclit vulgaris Choisy, Mém. Soc. Phys. Genèv. **6**: 434. 1833.
Ipomoea cyamoclita St. Lag. Ann. Soc. Bot. Lyon **7**: 128. 1880.
Quamoclit Quamoclit Britton; Britton & Brown, Illust. Fl. **3**: 22. 1898.

Stems several m. long, glabrous: leaf-blades 2–10 cm. long, the pinnate segments narrowly linear; petioles shorter than the blades with numerous short leafy branches in their axils appearing stipule-like: peduncles commonly longer than the leaves; pedicels 25–30 mm. long, thickened and fleshy at least in fruit: sepals oblong, obtuse, mucronate, 3–5 mm. long: corolla scarlet or white, 25–35 mm. long, the tube clavate, the limb nearly flat, the short ovate lobes acute: capsules ovoid, 4-celled, 8–10 mm. high.

TYPE LOCALITY: India.

DISTRIBUTION: Circumtropical and extended by cultivation and as an escape throughout the southern United States, north to Virginia and Kansas.

ILLUSTRATIONS: Rumph. Amb. *pl. 155. f. 2.* — Tourn. Inst. *pl. 39.* — Rheede, Mal. **11**: *pl. 60.* — Bot. Mag. *pl. 188, pl. 244.* — Britton & Brown, *loc. cit. f. 2944.* — Bailey, Cyclop. Am. Hort. *f. 1166.*

2. **Quamoclit Lindleyi** nom. nov.

Calboa globosa Lindl. Jour. Hort. Soc. **5**: 82. 1850. Not *Morenoa globosa* Llav. & Lex. 1824, or *Quamoclit globosa* G. Don, 1838.

Perennial, twining, glabrous: leaf-blades ovate, usually 3–5-lobed, lobes lanceolate, entire, acute or some of the blades merely angulate or dentate, and cordate-hastate at the base; petioles longer than the blades: peduncles exceeding the subtending leaves, 25–35 cm. long, 3–9-flowered; pedicels filiform, 3–10 cm. long: sepals ovate, blunt, the infraterminal awns 6-8 mm. long: corolla deep red, 5–6 cm. long, the cylindrical tube about as long as the deep cup-shaped limb, the lobes of the limb broad and rounded with wavy crenulate margins: capsules about 10 mm. high.

TYPE LOCALITY: Guatemala.

DISTRIBUTION: Southern Mexico and Central America.

ILLUSTRATIONS: Lindl. *loc. cit.* (text fig.).

SPECIMENS EXAMINED: Guanajuato: *A. Duges*, 1880 (Gray Herb.). Oaxaca: Cuyamecalco, *L. C. Smith 604*, 1895 (Gray Herb.).

3. **Quamoclit Langlassei** sp. nov.

Perennial, twining, glabrous: leaf-blades oblong-ovate, 8–10 cm. long, cordate-hastate and fiddle-shaped, the basal auricles spreading, rounded or obtuse, often with lateral acuminations, about 4 cm. broad at the base, constricted above, the apex abruptly acute; petioles 3–4 cm. long: peduncles elongated, 20 cm. long or longer, few-flowered; pedicels slender, about 2 cm. long: sepals oblong, somewhat unequal, obtuse or rounded, the infraterminal awns 8–10 mm. long: corolla bright yellow, 3.5–4 cm.

long, the tube about 2 cm. long and bent, the limb campanulate, fully 3 cm. broad with 5 rounded lobes: style persistent in fruit.

"Crète de la Sierra Madre" (southern Mexico). Plants of Michoacan & Guerrero, 2250 m. alt., *E. Langlassé 875*, Nov. 16, 1899. Type, sheet *no. 386,249* in the U. S. National Herbarium.

4. QUAMOCLIT GLOBOSA (Llav. & Lex.) G. Don, Gen. Syst. **4**: 259. 1838. — Benth. Pl. Hartw. 89. 1839

Morenoa globosa Llav. & Lex. Nov. Veg. Descr. **1**: 5. 1824.

Ipomoea globosa Meissn. in Mart. Fl. Bras. **7**: 220. 1869. (Excl. syn. Lindl., Cav., and Choisy.)

Ipomoea Hartwegii Meissn. *loc. cit.* Not *Ipomoea Hartwegi* Benth. 1839.

Perennial, twining, glabrous: leaf-blades ovate, cordate, deeply 3–5-lobed, 10–15 cm. long, lobes acute or acuminate, the middle lobe largest, ovate, scarcely or not at all constricted at the base, lateral lobes obliquely triangular, their outer margins usually with 1–3 sharp teeth; petioles usually longer than the blades: peduncles exceeding the subtending petioles and usually the blades, 15–25 cm. long, stout; pedicels filiform, 1–2 cm. long: sepals ovate or oval, 3–4 mm. long, the awns 2–3 mm. long: corolla 2.5–3 cm. long, erect, yellowish, the tube one third as long, cylindrical and bent, ventricosely dilated above into a subglobose or deeply campanulate limb, throat and base of the tube tinged with purple, the 5 short ovate obtuse lobes erect or spreading: capsules ovoid, 4–5 mm. high.

TYPE LOCALITY: San José del Corral, Mexico.

DISTRIBUTION: Southern Mexico to Brazil.

SPECIMENS EXAMINED: Mexico: Colipa, *Karwinsky 598*, 1841; Colima, *Palmer 1104*, 1891. Guatemala: Aceituna, *J. D. Smith 1874*, 1890. Salvador: *Carlos Renson 82*.

5. QUAMOCLIT COCCINEA (L.) Moench, Meth. 453. 1794

Ipomoea coccinea L. Sp. Pl. 160. 1753.

Ipomoea angularis Willd. Nov. Act. Cur. **4**: 197. 1770.

Convolvulus coccineus Salisb. Prodr. 124. 1796.

Ipomoea acuminata Ruiz & Pav. Fl. Per. **2**: 11. 1799.

Ipomoea angulata Ruiz & Pav. *loc. cit.*

Ipomoea cholulensis H.B.K. Nov. Gen. et Sp. **3**: 112. 1819.

Ipomoea dichotoma H.B.K. *loc. cit.*

Ipomoea phoenicea Roxb. Hort. Beng. 14. 1814. Fl. Ind. **1**: 502. 1832.

Convolvulus acutangularis Spreng. Syst. **1**: 599. 1825.

Convolvulus indivisus Vell. Fl. Flum. **2**: *pl. 50.* 1827.

Quamoclit cholulensis G. Don, Gen. Syst. **4**: 259. 1838.

Quamoclit Ruiziana G. Don, *loc. cit.* 258.

Quamoclit dichotoma G. Don, *loc. cit.* 259.

Ipomoea erythraea Moc. & Sessé; Choisy, in DC. Prodr. **9**: 335. 1845.

Ipomoea parviflora Sessé & Moc., Fl. Mex. 42. 1893.

Quamoclit indivisa Hallier f. Bot. Jahrb. **25**: 5. 1898.

Annual, twining, glabrous: stems several m. long: leaf-blades ovate, 3–10 cm. long, cordate, acute or acuminate at the apex, usually thin and submembranaceous, pale beneath, entire or somewhat hastate or angulately lobed; petioles as long as the blades or shorter: peduncles about equaling the leaves or longer, few-flowered or sometimes many-flowered: sepals oblong, 4–6 mm. long, the outer ones with subulate, infraterminal awns 2–5 mm. long: corolla scarlet, white or orange, the tube 3–4 cm. long, slightly enlarged above, the shallowly cup-shaped limb 1.5–2 cm. broad, 5-angled: capsules globose, 6–7 mm. high.

TYPE LOCALITY: St. Domingo.

DISTRIBUTION: Circumtropical. In America north to Florida, Texas, and Arizona. Extended as an escape from cultivation to Pennsylvania, Ohio, Missouri, and Arkansas.

ILLUSTRATION: Jacq. Ic. Pl. Rar. **1**: *pl. 35.* — Bot. Repos. *pl. 499.* — Bot. Mag. *pl. 221.* — Ruiz & Pav. *loc. cit. pl. 120. f. b.* — Naves, in Blanco, Fl. Filipp. Ic. **2**: *pl. 17.* — Bailey, Cyclop. Am. Hort. *f. 1168.* — Britton & Brown, Illust. Fl. **3**: *f. 2945.*

QUAMOCLIT COCCINEA HEDERIFOLIA (L.) House, Ann. N. Y. Acad. Sci. 18: 262. 1908

Ipomoea hederifolia L. Syst. ed. 10, 925. 1759.

Ipomoea sanguinea Vahl, Symb. Bot. **3**: *pl. 33.* 1794.

Ipomoea hastigera H.B.K. Nov. Gen. et Sp. **3**: 111. 1819.

Ipomoea Humboldtiana Roem. & Schult. Syst. **4**: 789. 1819.

Convolvulus hederifolius Spreng. Syst. **1**: 594. 1825.

Convolvulus sanguineus Spreng. *loc. cit.*

Convolvulus hastigerus Spreng. *loc. cit.*

Quamoclit hastigera G. Don, Gen. Syst. **4** : 259. 1838.

Quamoclit hederifolia Choisy, in DC. Prodr. **9** : 336. 1845.

Quamoclit russelliaefolia Mart. & Gal. Bull. Acad. Brux. **12** : 271. 1845.

Ipomoea coccinea var. *hederifolia* A. Gray, Syn. Fl. N. Am. 2[1] : 209. 1878.

Quamoclit gracilis Hallier f. Bull. Herb. Boiss. **7** : 416. 1899.

Quamoclit brevipedicellata Hallier f. *loc. cit.*

Similar to the type in size and habit : leaf-blades deeply 3-lobed, lobes, especially the middle, narrowed at the base, lateral lobes angulate-dentate or lobed on the outer margins.

TYPE LOCALITY : America.

DISTRIBUTION : Texas, New Mexico, and Arizona, throughout tropical America.

ILLUSTRATIONS : Plum. Am. *pl. 93. f. 2.* — Vahl, *loc. cit. pl. 33.* — Bot. Reg. *pl. 9.* — Bot. Mag. *pl. 1769.* — Bailey, Cyclop. Am. Hort. *f. 1169.*

QUAMOCLIT COCCINEA PUBESCENS (Cham. & Schlecht.) Choisy, in DC. Prodr. **9**: 335. 1845

Ipomea coccinea var. *pubescens* Cham. & Schlecht. Linnaea **5**: 118. 1830.

Leaf-blades usually entire, or the basal auricles of the cordate-hastate blades angulately toothed, thick and firm in texture, softly and densely appressed-pubescent.

TYPE LOCALITY : Hacienda de la Laguna, prope Palapam, Mexico.

DISTRIBUTION : Southern Mexico and Guatemala.

Quamoclit coccinea luteola (Jacq.) comb. nov.

Ipomea luteola Jacq. Ic. Pl. Rar. **1** : *pl. 35.* 1781–86.

Ipomea coccinea β Willd. Sp. Pl. **1** : 880. 1798.

Convolvulus luteolus Spreng. Syst. **1**: 599. 1825.

Ipomea coccinea var. *luteola* Meissn. in Mart. Fl. Bras. **7**: 218. 1869.

Quamoclit lutea Hemsley, Biol. Cent.-Am. Bot. **2**: 389. 1882.

Merging into *Q. coccinea*, but in its typical form somewhat larger and stouter than the type : petioles longer than the blades :

sepals ovate, 4–7 mm. long, the awns 4–8 mm. long: corolla yellow, the tube bent and somewhat contracted at the throat, 4–5 cm. long.

TYPE LOCALITY: St. Domingo.

DISTRIBUTION: Tropical America.

ILLUSTRATIONS: Jacq. Ic. Pl. Rar. *pl. 35.* — Hemsley *loc. cit. pl. 60.*

Quamoclit coccinea jaliscana var. nov.

Glabrous: leaf-blades rather thick and firm in texture, oblong-lanceolate, usually attenuate or long-acuminate at the apex, 5–10 cm. long, 3–4 cm. broad, the base cordate-sagittate or subtruncate, the basal auricles obtusely angled: sepals equal, about 5 mm. long, the awns only 2–4 mm. long: corolla scarlet.

MEXICO: Between San Sebastian and summit of Mt. Bufa de Mascota, 4800 ft. alt., Jalisco, *E. W. Nelson 4094*, 1897. Type, sheet *no. 327,133* in the U. S. National Herbarium.

6. QUAMOCLIT GRANDIFLORA (Llav. & Lex.) G. Don, Gen. Syst. **4**: 259. 1838

Morenoa grandiflora Llav. & Lex. Nov. Veg. Descr. **1**: 17. 1824.
Ipomoea Funis Cham. & Schlecht. Linnaea **5**: 118. 1830.
Ipomoea Llaveana Meissn. in Mart. Fl. Bras. **7**: 219. 1869.

Perennial, twining, somewhat woody below: leaf-blades ovate, 6–15 cm. long, cordate or cordate-hastate, 3-lobed, acuminate, the sides of the lateral lobes angular or toothed, finely pubescent beneath on the veins, younger parts finely pubescent, otherwise glabrous; petioles as long as the blades or longer: peduncles much exceeding the subtending leaves, 30–40 cm. long, 3–9-flowered; pedicels filiform, 1–3 cm. long; sepals ovate-lanceolate or suborbicular, 3–5 cm. long, the awns as long: corolla scarlet, about 5 cm. long, the tube slender, bent, expanding above into a 5-angled limb about 2 cm. broad: capsules 10 mm. in diameter or less.

TYPE LOCALITY: Near Jalapa and San Andres, Mexico.

DISTRIBUTION: Southern Mexico and Central America.

ILLUSTRATIONS: Cham. & Schlecht. *loc. cit.*

SPECIMENS EXAMINED: Prope Jalapa et San Andres, *Schiede 228, 556*, 1828. Orizaba, *Müller 1869*, 1853; *Vischer*, 1838. Chiapas: Chicharras, *E. W. Nelson 3768*, 1896 (Gray Herb.); between Teneapa and Yajalon, 3000–5000 ft. alt., *E. W. Nelson 3297*, 1895 (Gray Herb.).

7. QUAMOCLIT VITIFOLIA (Cav.) G. Don, Gen. Syst. 4: 259. 1838

Calboa vitifolia Cav. Ic. 5: 51. 1799.
Macrostemma vitifolia Pers. Syn. 1: 185. 1805.
Convolvulus Neei Spreng. Syst. 1: 593. 1825.
Ipomoea peduncularis Bertol. Fl. Guatem. 8. 1840.
Exogonium umbellatum Moc. & Sessé; Choisy, in DC. Prodr. 9: 336. 1845.

Perennial, twining, glabrous: leaf-blades ovate, 8–15 cm. long, cordate or cordate-sagittate, entire or usually 3-lobed, lobes ovate or oblong-lanceolate, acuminate, the middle lobe constricted below; petioles usually longer than the blades: peduncles exceeding the subtending leaves, 25–40 cm. long, 3–many-flowered: sepals ovate or suborbicular, 4–5 mm. long, the infraterminal awns as long: corolla 3.5–4 cm. long, the tube cylindrical, yellowish, slender, somewhat expanded toward the top, the limb scarlet, 2–2.5 cm. broad, deeply 5-lobed, the lobes lanceolate or oblong-lanceolate, acute, the exserted stamens elongated and declinate.

TYPE LOCALITY: Near Santa Blas, Mexico.

DISTRIBUTION: Southern Mexico and Central America.

ILLUSTRATIONS: Cav. Ic. 5: *pl. 476.* — Bertol. *loc. cit. pl. 2.*

SPECIMENS EXAMINED: Tres Marias Islands: Maria Madre, *Nelson 91, 4235,* 1897. Sinaloa: Esquinapa, *Lamb 501,* 1895. Michoacan: near Los Reyes, *E. W. Nelson 6850,* 1903. Guerrero: Sierra Madre, *Langlassé 810,* 1899. Guatemala: Santa Rosa, *Heyde & Lux 4349,* 1892; between Rodes and Malacate, *E. W. Nelson 3733,* 1896.

8. **Quamoclit lobata** (Llav. & Lex.) comb. nov.

Mina lobata Llav. & Lex, Nov. Veg. Descr. 3. 1824.
Quamoclit Mina G. Don, Gen. Syst. 4: 259. 1838.
Ipomoea versicolor Meissn. in Mart. Fl. Bras. 7: 220. 1869.

Perennial, slender and twining, herbaceous above: leaf-blades ovate, deeply cordate, deeply 3-lobed, the middle lobe constricted below, the lateral lobes often again lobed: peduncles much longer than the subtending leaves, 30–40 cm. long, dichotomously several-flowered, the flowers somewhat secund on the two main branches of the inflorescence: sepals equal, 3–4 mm. long, the awns recurved: corolla yellow, tinged above with red or scarlet, the tube shorter than the limb, only 5–6 mm. long and about 2 mm. in diameter, almost wholly included in the calyx; the limb cylindrical or flask-shaped, about 2 cm. long and 1 cm. in diameter, bent, the stamens and style declinate against the upper side of the limb, their tips recurved along the lower side in bud, long-exserted when the limb expands, margin of limb somewhat constricted, with 5 small, acute lobes.

TYPE LOCALITY: Mexico.

DISTRIBUTION: San Luis Potosi to Central and South America.

ILLUSTRATIONS: Bot. Reg. *pl. 24.* — Paxt. Bot. Mag. **14**: 100. — Morren, Ann. Soc. Agric. Gand **5**: *pl. 259.*

SPECIMENS EXAMINED: San Luis Potosi; *Schaffner 111, 355,* 1897.

NEW YORK BOTANICAL GARDEN.

Two new spermatophytes from California

ERNEST A. McGREGOR

Oxytheca Abramsii sp. nov.

Acaulescent or nearly so, 7–18 cm. high or less, sparingly dichotomously branched : stems glabrous mostly, but glandular just above the axils, herbaceous, becoming later more wiry : leaves spatulate, gradually narrowed to a wide petiole, 1.25–3 cm. long, scabrous-margined and the midvein slightly scabrous beneath ; bracts ternate, slightly unequal, mucronate, ovate-lanceolate, connate and deflected mainly to one side, 3 mm. long : involucres broadly obconical, on peduncles 1–1.5 cm. long, those from the main axils rarely 2.5 cm. long ; involucre-tube 1.5–2 mm. high ; awns 10 (rarely 12), very fine, weak, but straight, 4 mm. long or less, the interval between the involucral ribs much wider than the ribs : flowers 6–8, at length nearly equaling the awns ; pedicels equaling the perianth, well exserted from the involucre-tube : perianth about 4 mm. broad, cleft to base, lobes equal, elliptical, 2 mm. long, white or pinkish with wine-red midvein, slightly glandular and scabrous beneath : stamens inserted on perianth at base, shorter than the segments : styles 3, capitate : ovary glabrous.

O. Abramsii is nearest to *O. Parishii,* from which it differs in the following characters :

O. Parishii: Involucral ribs very prominent, firm, with the intervals almost lacking ; awns 18–20, 3 times length of tube, strong, stiff, wiry ; umbels 5–14-flowered ; stems pale-glaucous, wiry.

O. Abramsii: Involucral ribs barely discernible, with intervals much wider than ribs ; awns usually 10, not greatly exceeding the tube, inclined to be weak and herbaceous, though straight ; umbels 6–8-flowered ; stems green or reddish, not wiry.

Topatopa Mountains, Ventura Co., California. Growing on slopes in loose shale, elev. 1700 m. Collected by Abrams & McGregor (*no. 72*), June 5, 1908.

Malacothrix arachnoidea sp. nov.

Perennial herb, with stout, freely branching, and very leafy herbaceous stem, 4.5–6 dm. high ; herbage hoary throughout with a dense woolly pubescence: leaves broadly lanceolate to linear-lanceolate, attenuate above, apiculate, tapering gradually below but sessile, and never at all auriculate or clasping, entire, or the

FIGURE 1. *Oxytheca Abramsii* McGregor. Natural size.

lower rarely remotely and obscurely dentate, 4–9 cm. long, reduced upward: heads terminating numerous branches, many-flowered; involucre 13–15 mm. high, hemispherical; bracts in about two series, becoming somewhat glabrate, the inner linear-lanceolate, acuminate, the outer similar but narrower and half as long; calyculate scales few: corolla white or pinkish; ligule 10 mm. long; tube 6 mm. long, puberulent on its upper third: achenes (not matured) broadly obovate-oblong, apparently 10-ribbed, the slightly contracted summit bearing a well-expanded crown whose rim is merely crenulate; pappus-bristles snow-white, all falling together.

Carmel Valley, Monterey Co., California; by the roadside. Collected by the writer (*no. 1575*), July 1, 1906.

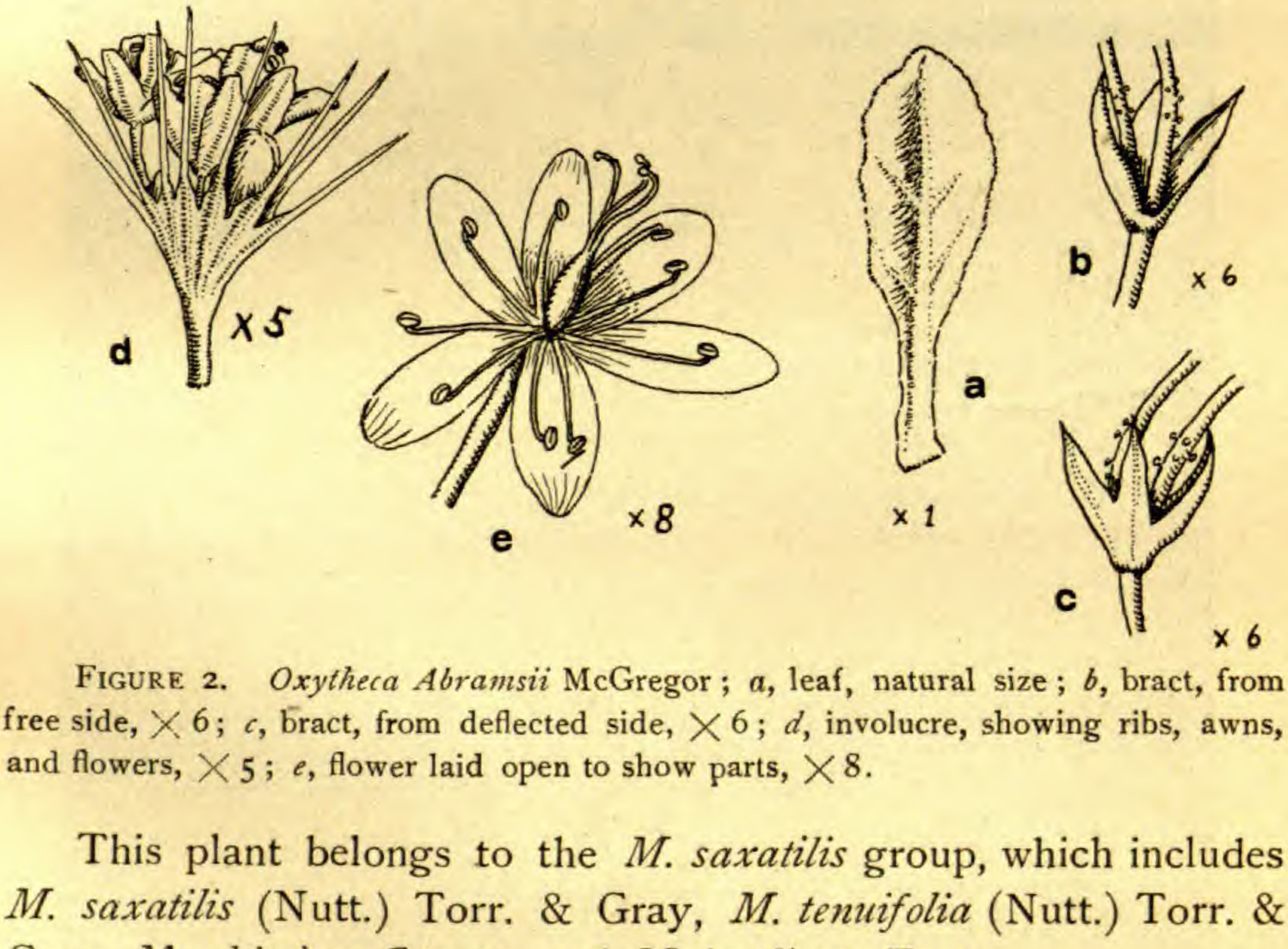

FIGURE 2. *Oxytheca Abramsii* McGregor; *a*, leaf, natural size; *b*, bract, from free side, × 6; *c*, bract, from deflected side, × 6; *d*, involucre, showing ribs, awns, and flowers, × 5; *e*, flower laid open to show parts, × 8.

This plant belongs to the *M. saxatilis* group, which includes *M. saxatilis* (Nutt.) Torr. & Gray, *M. tenuifolia* (Nutt.) Torr. & Gray, *M. altissima* Greene, and *M. implicata* Eastw.

On the whole these species are very closely related and form a very natural group, differing from the other members of the genus in the following characters: tall, leafy perennials; involucral scales in two appressed equal series; receptacle with no bristles; no persistent pappus-bristles. It would seem that they might well constitute at least a valid subgenus.

The characters of the flower and those of the achene of the different species are much alike, the important differences being

FIGURE 3. *Malacothrix arachnoidea* McGregor. One half natural size.

in the aspect of the plants and the form of the leaves which, for a given type, seem quite distinctive.

Malacothrix arachnoidea is nearest to *M. saxatilis*, from which it is to be distinguished as follows :

M. saxatilis: Green, often woolly on young parts ; leaves obtuse, lower occasionally pinnatifid, auriculate, and partly clasping toward the base ; calyculate scales very numerous ; achenes crowned with a denticulate border.

M. arachnoidea: Hoary throughout with a dense woolly pubescence ; leaves apiculate-acute, apparently never pinnatifid, auriculate, or clasping ; the well-expanded crown of the achene with a merely crenulate border.

LELAND STANFORD JUNIOR UNIVERSITY.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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C. A. Black, del.

BLACK, THE IMBEDDED ANTHERIDIUM IN DRYOPTERIS STIPULARIS, ETC.

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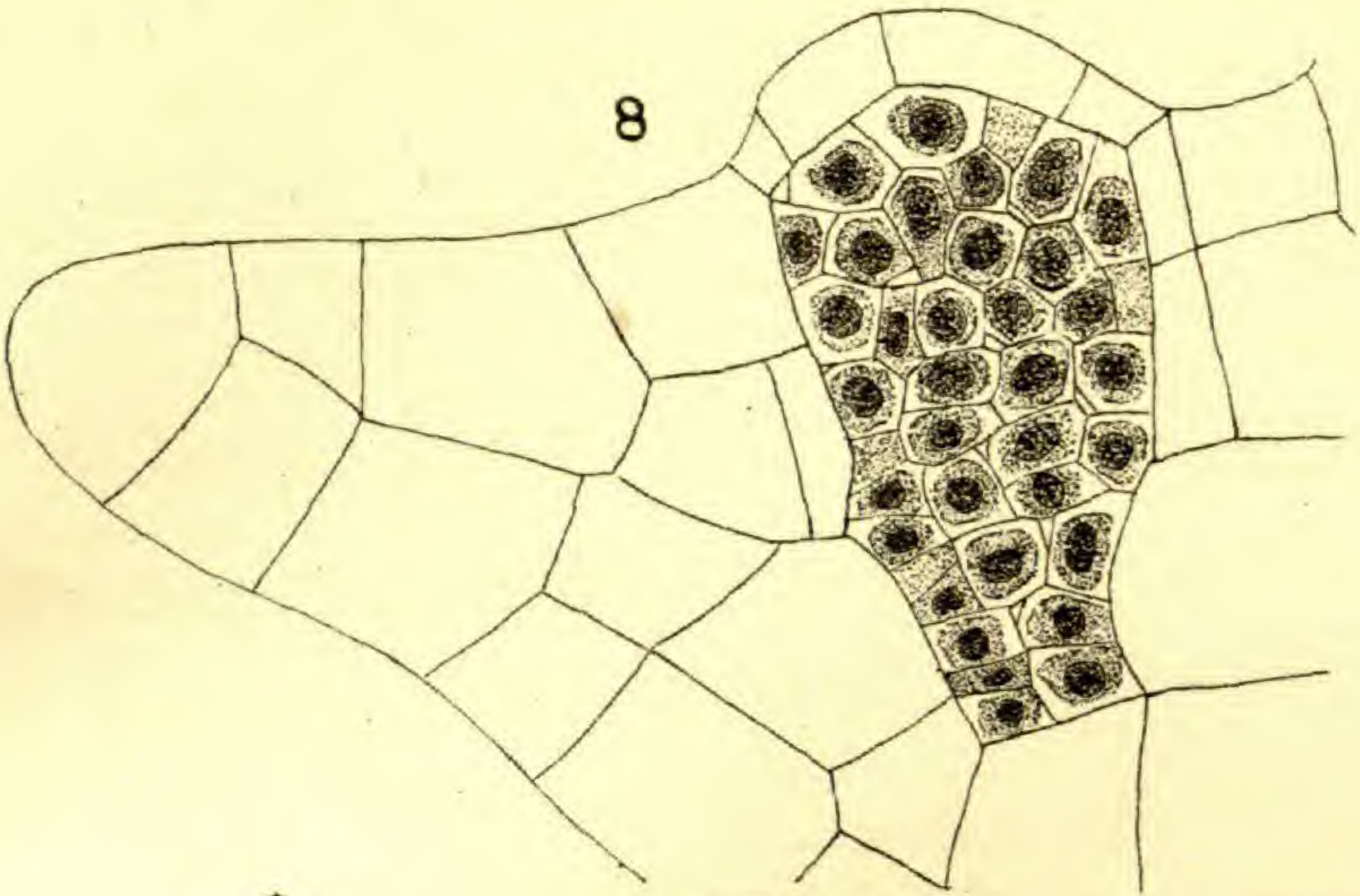

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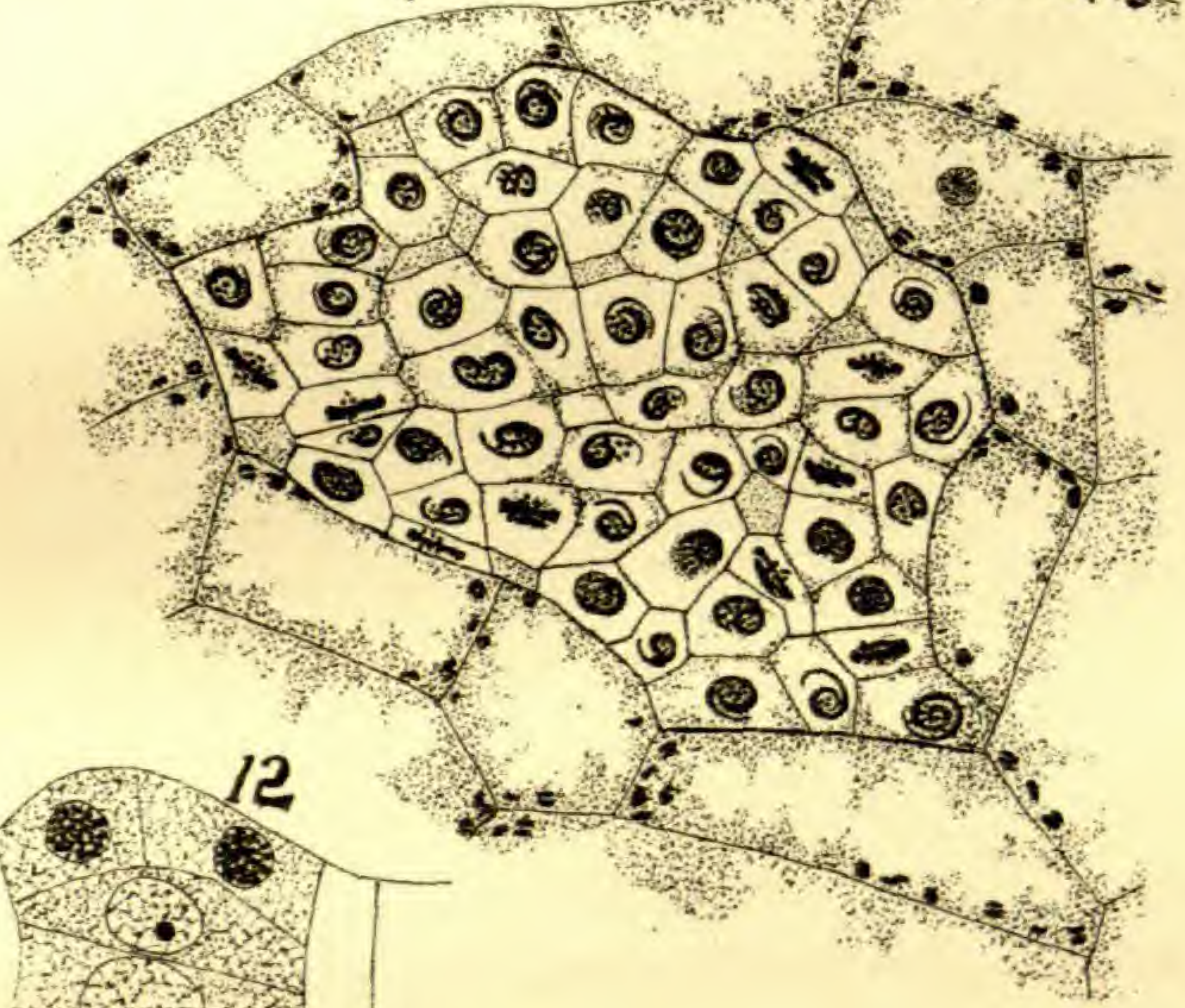

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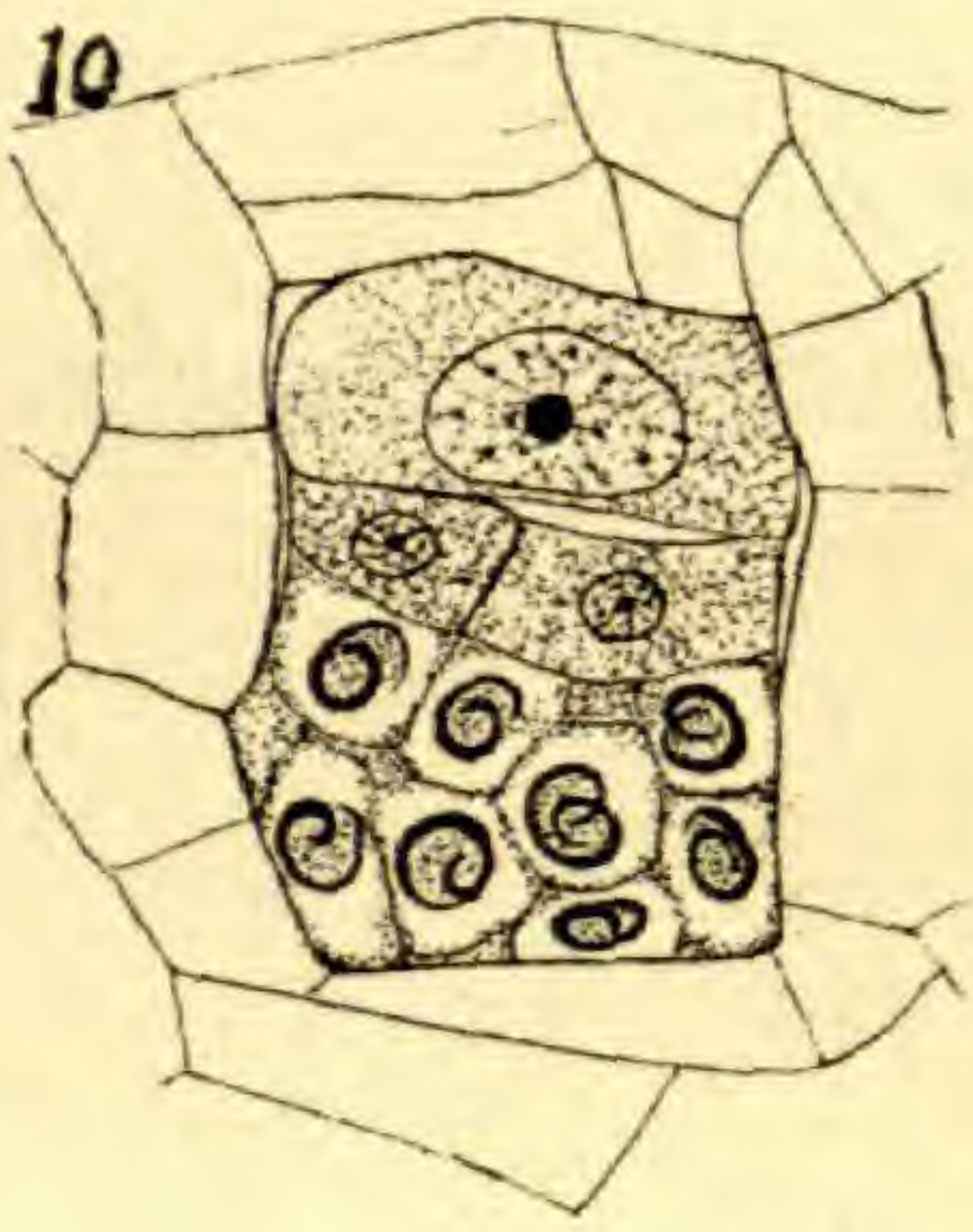

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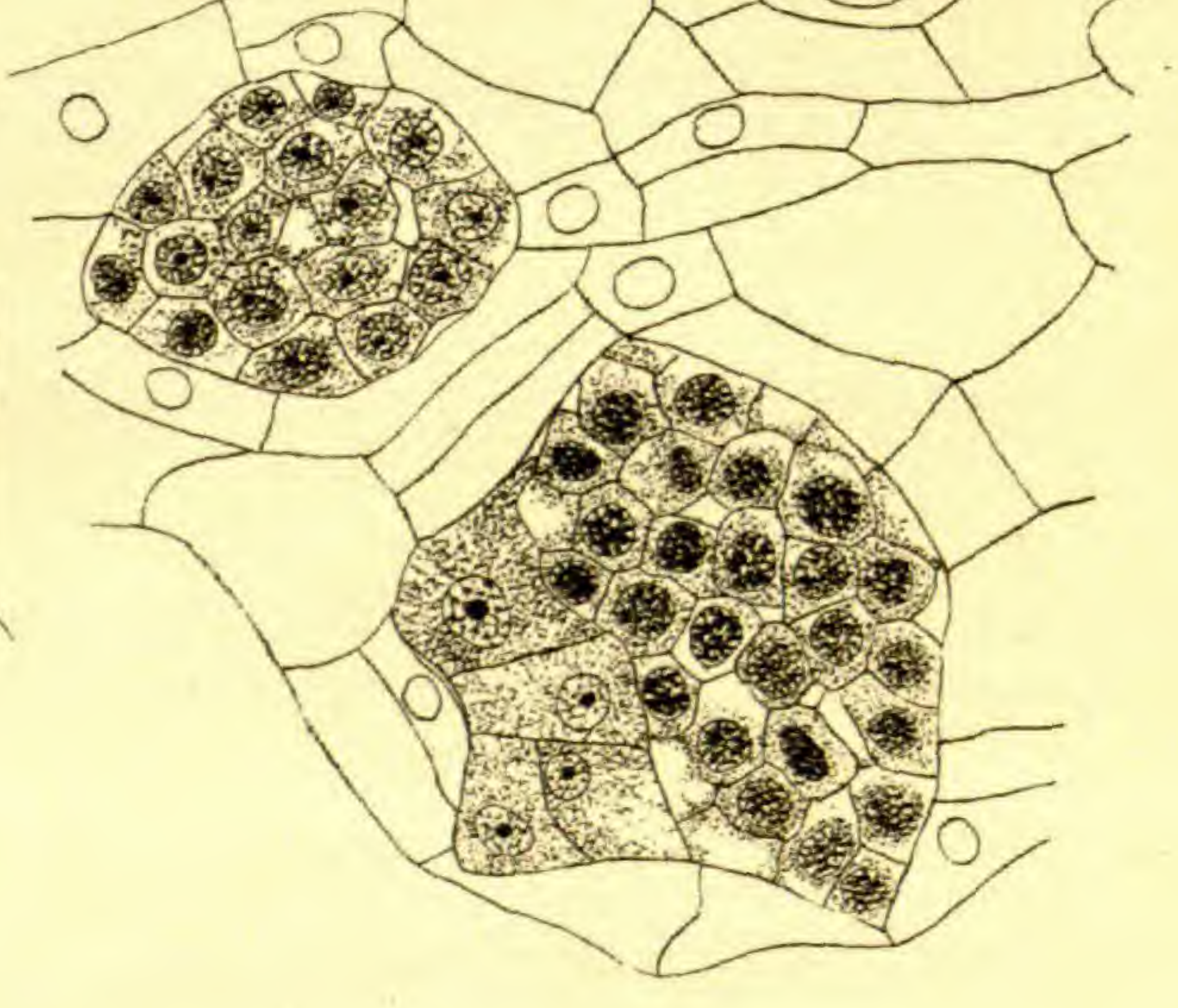

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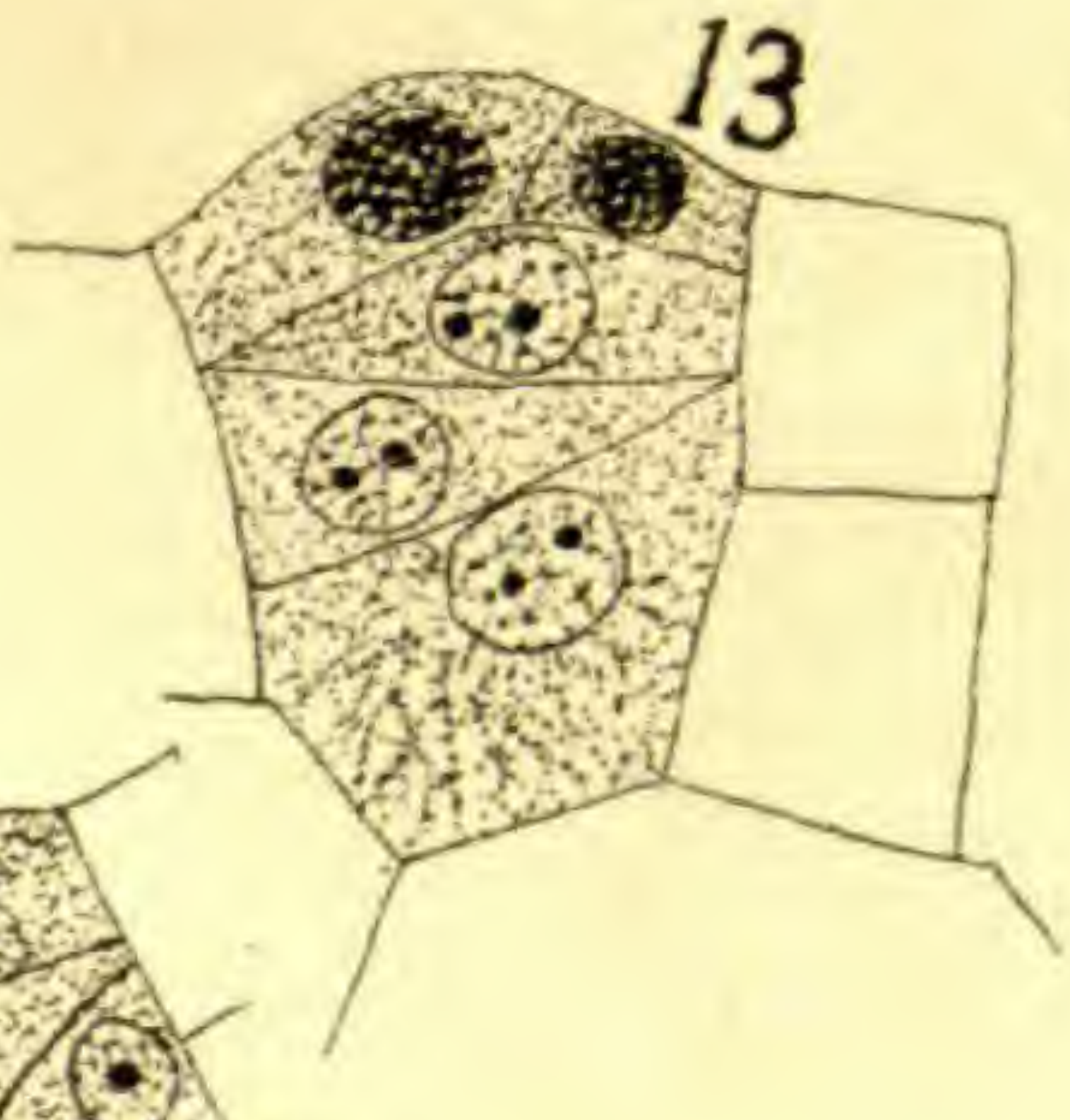

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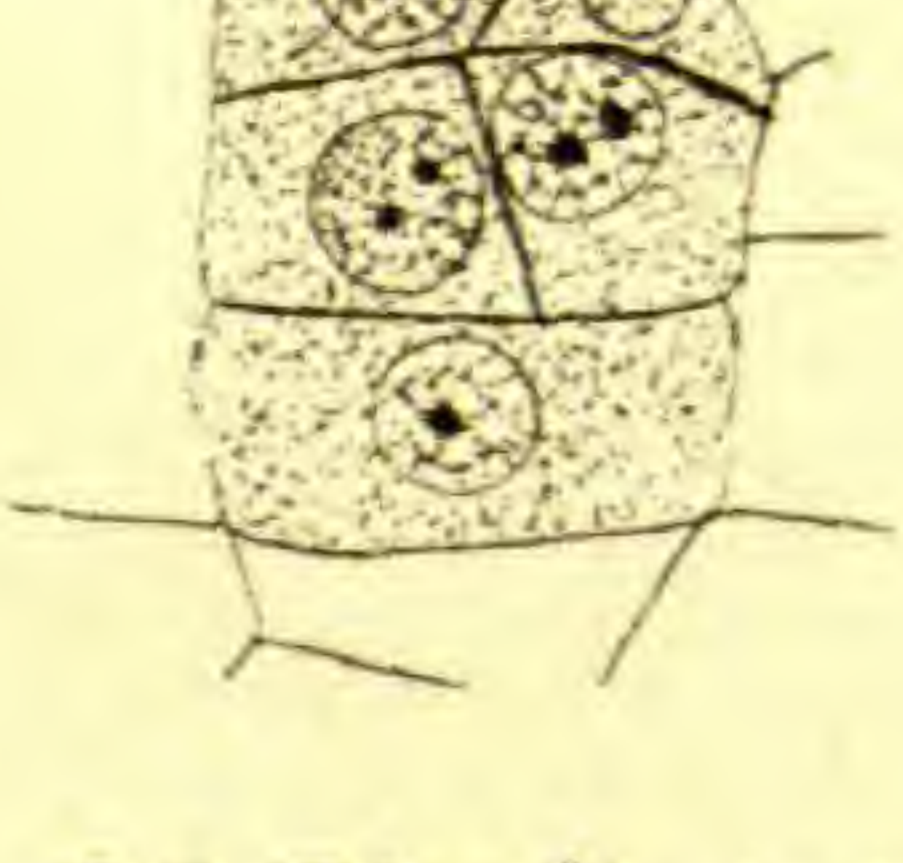

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BLACK, THE IMBEDDED ANTHERIDIUM IN DRYOPTERIS STIPULARIS, ETC.

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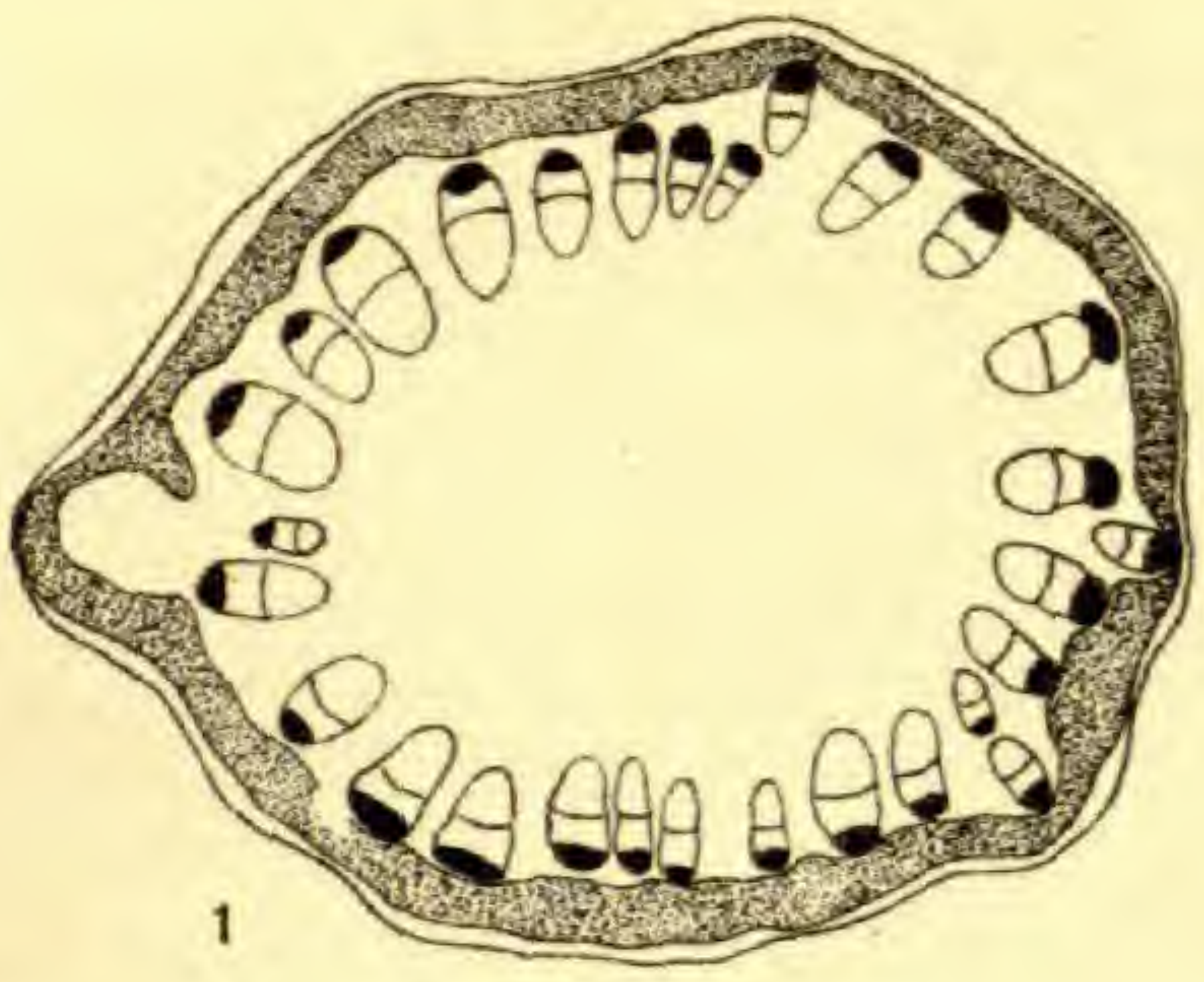
BLACK, THE IMBEDDED ANTHERIDIUM IN DRYOPTERIS STIPULARIS, ETC.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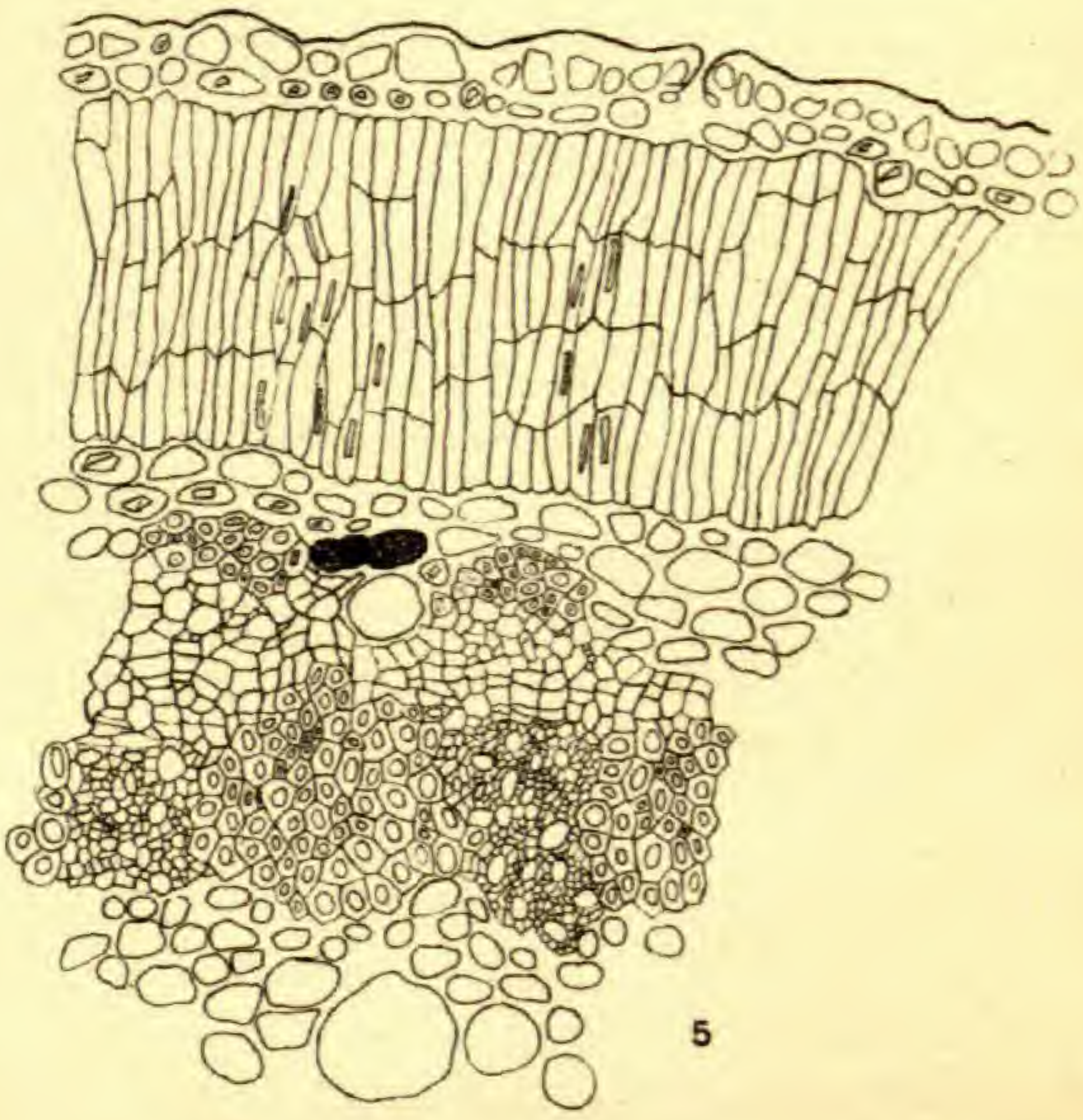
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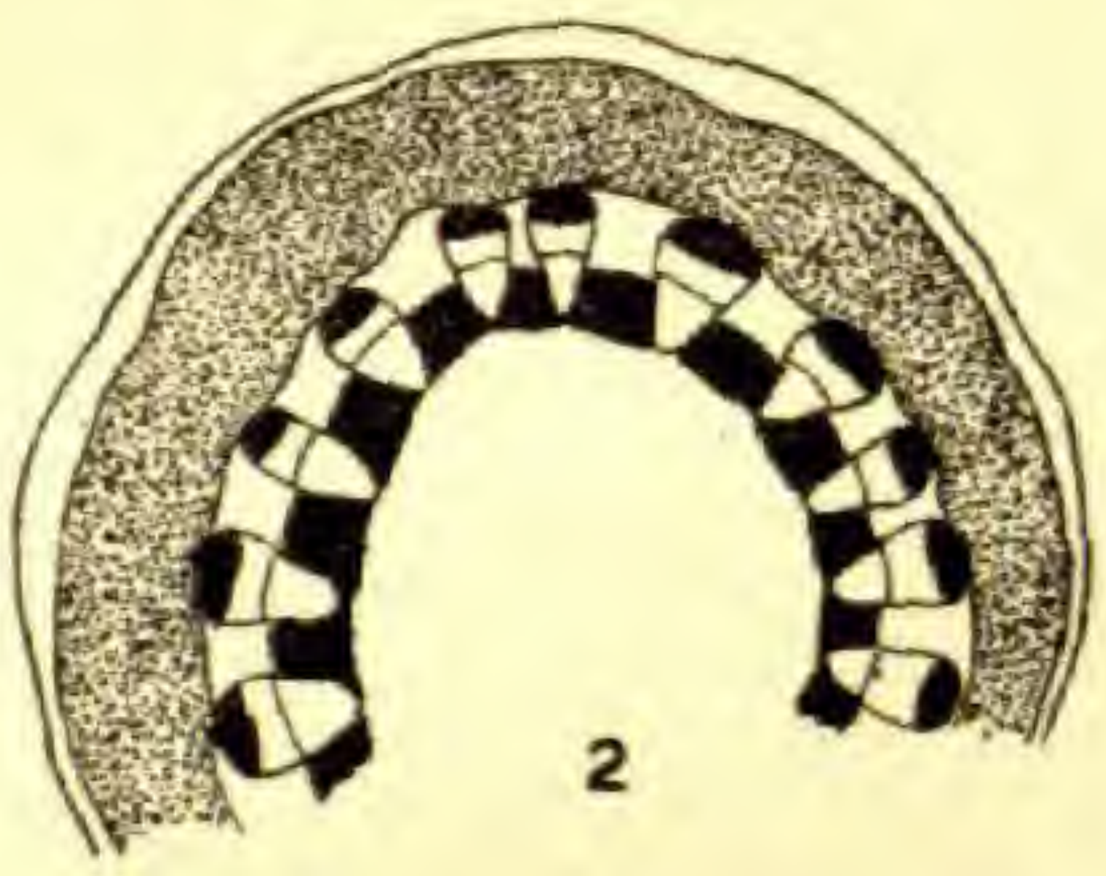
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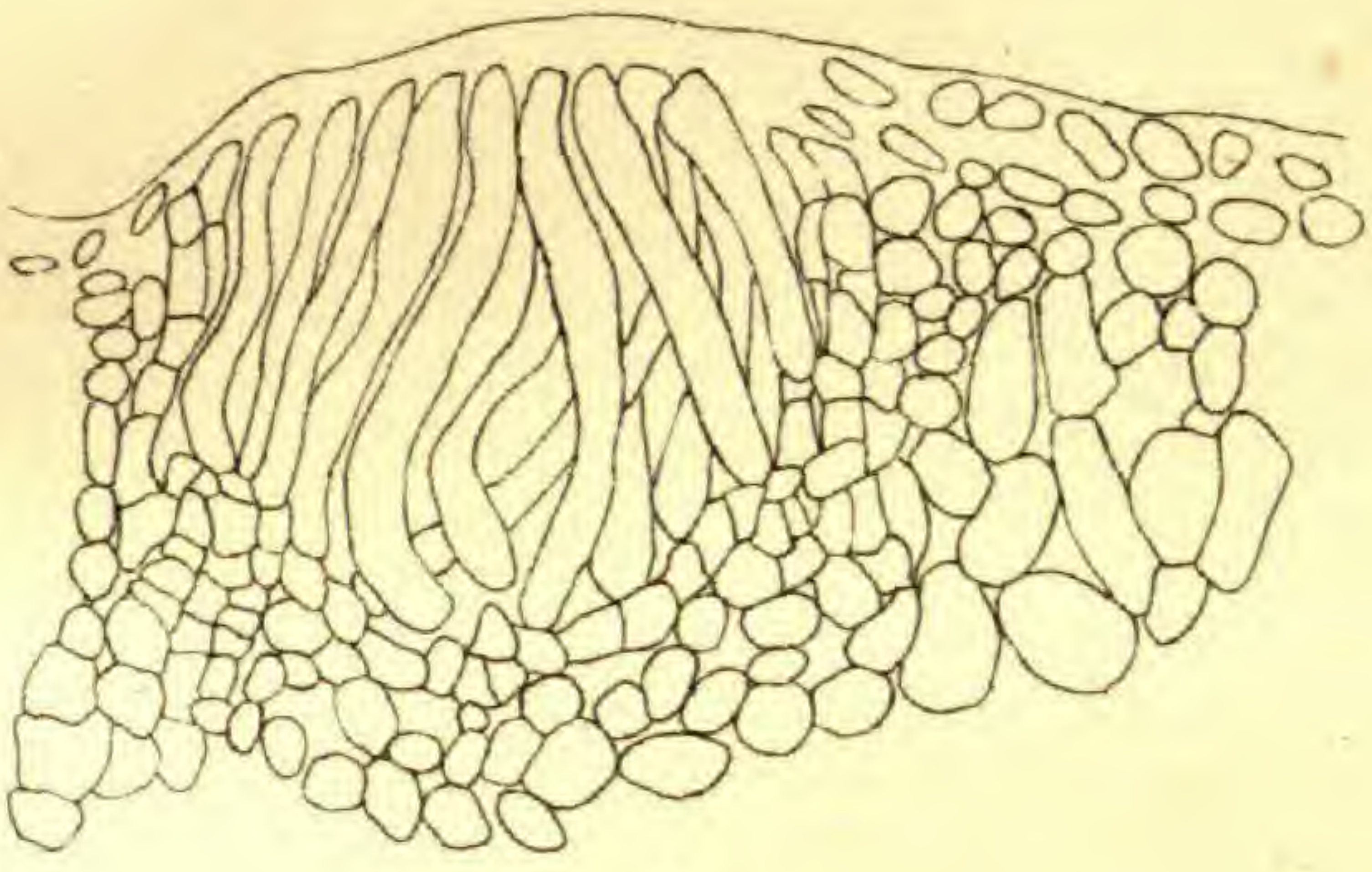
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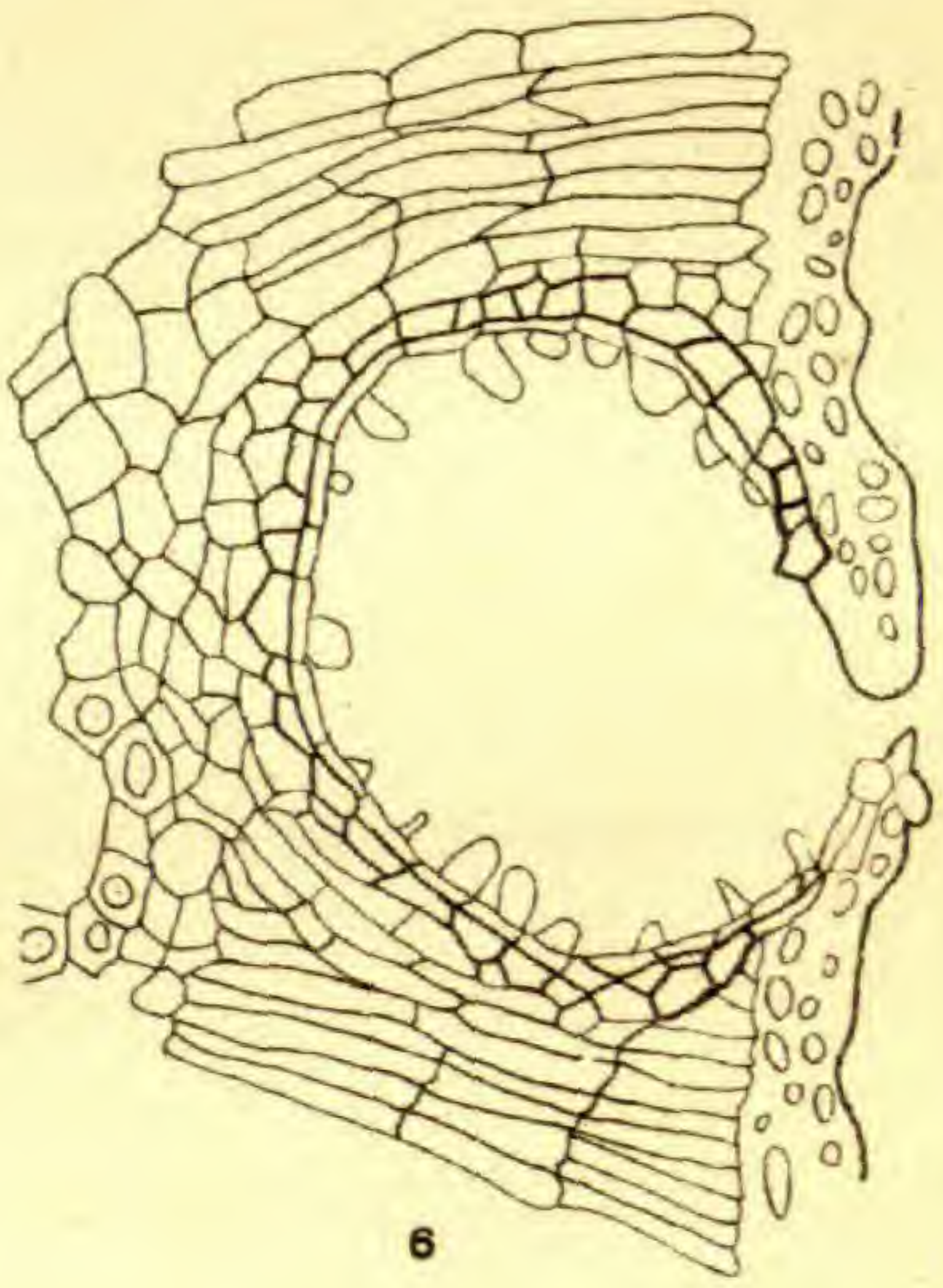
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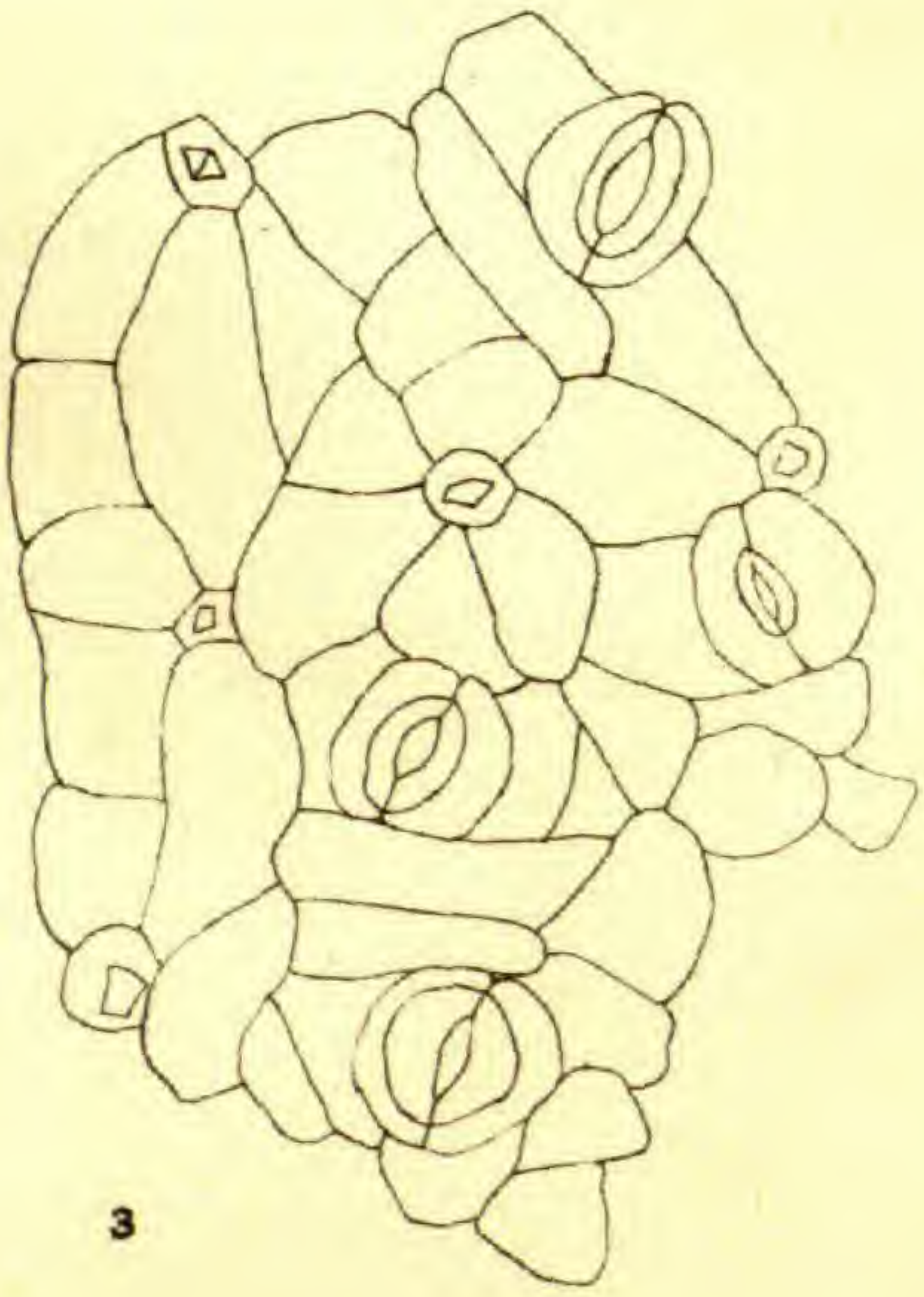
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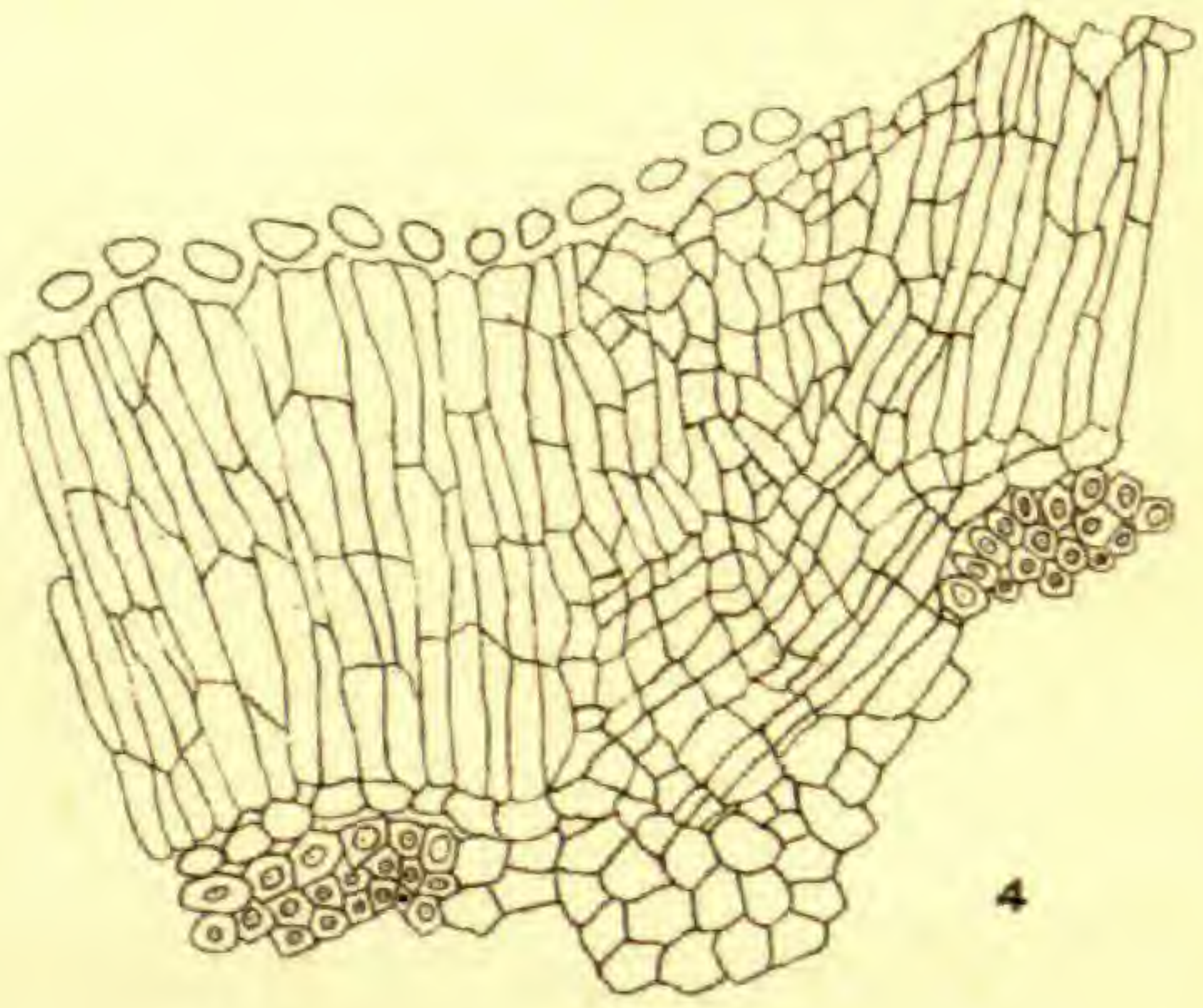
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GOODLATTE, THE ANATOMY OF PAROSELA SPINOSA

North American Flora

THIS work is designed to present descriptions of all plants growing independently of cultivation, in North America, here taken to include Greenland, Central America, the Republic of Panama, and the West Indies, except Trinidad, Tobago, and Curaçao and other islands off the north coast of Venezula, whose flora is essentially South American.

It will be published in parts at irregular intervals by the New York Botanical Garden through the aid of the income of the David Lydig Fund bequeathed by Charles P. Daly.

It is planned to issue parts as rapidly as they can be prepared, the extent of the work making it possible to commence publication at any number of points. The completed work will form a series of volumes with the following sequence:

Volume 1. Mycetozoa, Schizophyta, Diatomaceae.
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Volumes 14 and 15. Bryophyta.
Volume 16. Pteridophyta and Gymnospermae.
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The preparation of the work has been referred by the Scientific Directors of the Garden to a committee consisting of Dr. N. L. Britton, Dr. W. A. Murrill and Dr. J. H. Barnhart.

Professor George F. Atkinson, of Cornell University, Professors Charles R. Barnes and John M. Coulter, of the University of Chicago, Mr. Frederick V. Coville, of the United States Department of Agriculture, Professor Edward L. Greene, of the United States National Museum, Professor Byron D. Halsted, of Rutgers College, and Professor William Trelease, of the Missouri Botanical Garden, have consented to act as an advisory committee.

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Vol. 36 No 11

BULLETIN

OF THE

TORREY BOTANICAL CLUB

NOVEMBER, 1909

The development of the sporogonium and adjacent tissues of the gametophore of Conocephalum conicum*

MARGARET GRAHAM

(WITH PLATES 30–33)

Although several rather extensive articles on the morphology and development of the liverwort *Conocephalum conicum* † have appeared, there are certain interesting and important features of this plant that do not seem, as yet, to have been described. This investigation was undertaken for the purpose of tracing the development of the sporogonium and the surrounding tissue of the gametophore in order to determine the origin of a sheath which surrounds and encloses the calyptra and to see if it bears any relation to the pseudoperianth long known to exist in the related genera *Marchantia* and *Preissia* but said to be lacking in *Conocephalum.* This seemed especially desirable, since the two most recent and important articles ‡ dealing with this plant do not touch upon this interesting structure.

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* *Conocephalum conicum* (L.) Dum. (*Fegatella conica* of most European authors) is one of the larger Marchantiaceae. It is widely distributed in Europe and North America. It grows abundantly in the ravines near Ithaca, N. Y., on moist or dripping rocks. The original post-Linnaean spelling of the generic name appears to be *Conocephalum* Wigg. Prim. Fl. Hol. 82. 1780, though Dumortier and some others have used the form *Conocephalus.*

† Contribution from the Department of Botany, Cornell University, No. 136.

‡ Cavers, F. On the structure and biology of *Fegatella conica.* Ann. Bot. 18: 87–120. *pl. 6, 7.* 1904.

Bolleter, E. *Fegatella conica* (L.) Corda. Eine morphologisch-physiologische Monographie. Beih. Bot. Centralb. 18^1: 327–408. *pl. 12, 13.* 1905.

[The BULLETIN for October, 1909 (36: 557–614. *pl. 26–29*) was issued 30 O 1909.]

The gametophore of *Conocephalum conicum* begins to develop early in June. The archegonia are ready for fertilization about the first of July. The sporogonia develop rather slowly but the spores and elaters are fully formed by the time winter sets in, when growth ceases. At this time the stalk of the gametophore is very short, so that the conical receptacle appears to be sessile on the thallus. During the warm days of the following May, the stalk of the gametophore elongates with some rapidity, lifting the receptacle high above the surface of the thallus. The stalk of the sporogonium itself then elongates, after which the spores are set free by the rupture of the capsule. *

Each archegonium is developed in a flask-shaped cavity or depression on the under side of the archegoniophore. Usually only one archegonium appears in each depression, but rarely two may be found. The archegonium arises from and is attached to the tissue at the base of the cavity in which it is developed, but the neck of the mature archegonium projects through the circular opening of this depression and curves upward toward the lateral margin of the gametophore (*figure 37*). At the time of fertilization the wall of the venter is about two layers of cells in thickness (*figures 1, 6, 37*).

The fertilized egg enlarges until it nearly or quite fills the oblong cavity of the venter (*figure 1*) and becomes enveloped by

---

* *Note.* — The first material was put up in May, 1908, when the sporogonia were mature on elongated stalks, and in the beginning of June when there was evidence that the archegoniophores were beginning to develop at the tips of the new thalli. Beginning with July 14, 1908, until August 10, 1908, material collected at Ithaca was carefully packed in moist sphagnum and shipped to New York City where it was kept in a moist vigorously growing condition until it was needed. Collections were made from this material two or three times weekly until September 21, 1908.

All the material used for this work was fixed in chrom-acetic fixing fluid. The gametophores were fixed entire. In all cases care was taken to remove the air from the tissue. For the material put up at Ithaca the large air-pump in the laboratory was used, but for the material fixed elsewhere a small suction pump attachable to a faucet was found as effective as the large air-pump. This treatment of the tissue was necessary for, as is well known, the thalli and gametophores of all the Marchantiaceae contain air which prevents the entrance of fixing fluids as well as other reagents, especially those used in infiltrating and embedding.

All the sections were cut 8–10 μ in thickness, except those of the mature sporogonium containing germinated spores; these were sectioned 5 μ thick. The sections were stained with Delafield's haematoxylin alone or with a counterstain of Bismarck brown.

a deeply staining membrane. The inner surface of the venter is stained intensely (*figures 1, 6, 37*). The nucleus also is stained deeply, its membrane being easily made out, but the cytoplasm is stained diffusely.

The nucleus of the fertilized egg soon divides into two, which usually lie close together (*figures 2, 3, 6, 10*), but in some cases they may be separated (*figure 4*). These nuclei are of approximately equal size. They may be parallel or transverse to the long axis of the archegonium. A cell wall is not laid down immediately after the first division of the nucleus but follows tardily.

The first division wall is transverse and is, as are all the walls when newly formed, a delicate membrane. In order to be certain that no walls were overlooked, Bismarck brown, which is well known to be one of the best counterstains for cell walls, was used. This division is followed by two or three successive transverse divisions forming either four or five cells (*figures 7, 8, 9, 11, 13, 16, 17, 32*). As in the case of the first division, the formation of a wall is always subsequent to the division of the nuclei.

In all the material studied, no longitudinal wall was formed until the tier of four or five cells was completed, although about fifty were seen in approximately this stage (*figures 7, 8, 9, 11, 13, 16, 17, 32*). Considerable attention was given to this sequence in the formation of cell walls, since the method observed is at variance with that usually described for this family and especially for this species by Cavers ('04). This author describes the young embryo as divided into octants by one transverse and two longitudinal walls at right angles to each other. My observations accord more nearly with those of Bolleter ('05), but this author describes and figures only four cells formed by three transverse walls.

The outline of the young embryo differs considerably from that of *Preissia* and *Marchantia*, being elongated parallel to the long axis of the archegonium and broader at the distal than at the proximal end (*figures 11, 12, 16*). In the two plants first mentioned it is nearly spherical.

Figure 12 shows the first longitudinal division at the lower or distal end of the young sporogonium; *figure 24* shows a cross section at this stage; *figure 18* a variation, the only one observed.

This first longitudinal wall is soon followed by a second one at right angles to it, so that each one of the original cells is divided into four. These two longitudinal walls are shown in cross section in *figures 14*, *23*, and *25*.

While the development just described is progressing in the embryo, periclinal division takes place rapidly in the venter of the archegonium, so that the wall is finally four or five layers of cells in thickness, and the whole structure becomes much more massive (*figures 14* and *16*). Moreover, the tissue forming the original stalk of the archegonium increases, and its cells become rich in protoplasm. Because of their deeply staining contents and their smaller size, there is a strong contrast between them and the adjacent tissue of the gametophore (*figure 37*). The whole calyptra is much thicker and more massive than that of *Marchantia* and *Preissia*.

The young sporogonium next increases decidedly in length (*figures 19*, *20*, *22*, *30*) and the elongating proximal end forces its way into the tissue developed from the stalk of the archegonium, from which it derives its nourishment (*figures 16*, *22*, *28*). This elongated more slender proximal portion of the sporogonium is the foot or absorbing organ. It is apparent, therefore, that the foot in *Conocephalum conicum* becomes differentiated much earlier in the life history of the sporophyte than in *Marchantia* or *Preissia*. The mature foot is a conical structure deeply imbedded in the tissue of the gametophyte, while in *Marchantia* and *Preissia* it is very short and broad.

The elongation of the embryo is accompanied by repeated transverse division, so that it becomes a clavate structure, many cells in length (*figures 15*, *26*, *28*, *29*). Some of the original transverse walls appear heavy and prominent at this stage (*figures 15*, *26*, *28*, *29*). It seems certain that one of the original four or five transverse walls formed in the embryo separates the capsule primordium from the stalk and foot portion, but whether this is the first original wall cannot be stated positively. *Figure 29* shows a slightly older stage in which one of the original walls is distinct.

Growth is now more rapid in the distal or capsular portion of the sporogonium. By the formation of periclinal and transverse walls it increases in breadth and massiveness (*figures 21*, *26*, *28*, *29, 31*). During the continued growth of the sporogonium both the foot and capsular portion expand, so that a definite constriction appears (*figures 27, 29, 36*). This constricted portion is the part which later gives rise to the stalk.

In the capsular portion cell division soon gives rise to a single superficial layer of cells which is distinguished from the tissue within, in that its cells are larger and less rich in protoplasm and therefore stain less deeply. This superficial layer becomes the wall of the capsule, while the deeply staining inner tissue, the cells of which have now become arranged in longitudinal rows, is the sporogenous tissue (*figures 27, 36, 39*). At this time the sporogonium fills the cavity of the venter, pressing against its wall.

Certain cells of the alternate rows of the sporogenous tissue become larger than those lying between them, are richer in protoplasm, and have larger nuclei. These are the mother-cells of the spores (*figure 47*). *Figure 53* shows a slightly older stage. These enlarged cells are separated from those surrounding them, become rounded and undergo a period of growth, after which each divides into four tetrahedral spores (*figure 46*).

By the time the tetrads are formed the cells that are to form the elaters have elongated considerably as is shown in *figure 48*, but the characteristic elater-form does not appear until after the spores have become mature in the autumn.

The sporogenous tissue in the capsule of *Conocephalum*, *Preissia*, and *Marchantia* is arranged in longitudinal rows. In the two former plants some of the cells in alternate rows enlarge, separate from the adjacent cells, and become the spore mother-cells, each of which divides into four tetrahedral spores. In the last-named plant, the sporogenous cells divide into groups of four or eight cells each, which always retain their identity as groups, each cell of the group ultimately dividing to form four spores. It has long been known that the spores of *Conocephalum conicum* germinate while still within the capsule (*figure 54*). The spores of *Marchantia* and *Preissia* do not germinate until after they have escaped from the capsule.

During the development of the sporogonium prominent changes take place in the surrounding tissue of the gametophyte, so that at the time of its maturity, it is enclosed not only in the calyptra, but in an additional covering or sheath which lies outside of the calyptra and is derived from the adjacent tissue of the gametophore. This outer sheath does not seem to have been described by any writer on *Conocephalum*, although it was figured in outline by Bolleter (*loc. cit.* 364, *f. A*). This writer makes no reference to this feature, either in the text or in the explanation of his figure. Since no similar organ seems to have been described for any of the other Marchantiaceae, its origin and development will now be considered in detail.

As already pointed out in a previous paragraph, the archegonium of *Conocephalum conicum* is developed in a flask-shaped cavity in the tissue on the under side of the gametophore (*figure 37, 38*). The gametophore of this plant, in common with all other Marchantiaceae, possesses numerous large air-chambers separated by plates of cells. The chambers in the upper part of the gametophore are large and nearly isodiametric. Toward the lateral margin they become smaller and the smallest ones are at the base. The tissue making up the wall of the archegonial cavity on the side toward the stalk of the gametophore is solid at the time of fertilization (*figure 37*), but after this time air-chambers appear in this also (*figure 38*). In the vicinity of the archegonial depression these chambers are long, narrow, and compressed, so that they appear much more slender in longitudinal section than those in the upper part of the gametophore.

At the time of fertilization the archegonial cavity opens to the outside. Through this opening the neck of the archegonium protrudes as has already been stated (*figure 37*). After fertilization the neck of the archegonium withers and turns brown (*figures 34, 38, 40*), as is usual in the bryophytes. Then the lip-cells forming the margin of the opening of the archegonial cavity elongate transversely and grow until those on opposite sides meet and the opening is nearly or quite closed (*figures 40, 44, 45, 52*). As a result of this growth the archegonium with its embryo is contained in a closed cavity.

As the embryo and the calyptra enlarge, the tissue of the gametophore bounding the archegonial cavity on the side adjacent to the stalk of the gametophore elongates rapidly in a vertical direction and since little or no growth takes place on the opposite side the closed mouth of the archegonial cavity is pushed around toward the outside of the gametophore (*figures 40, 45*). Further growth of the sporogonium and calyptra is accompanied by still further development of the tissue separating the air-chambers adjacent to the stalk, so that at maturity the closed opening is found nearly opposite the foot of the sporogonium on the outer side of the gametophore (*figure 44*). The whole outer enveloping sheath is therefore formed by the elongation of the laminae or plates of cells separating the air-chambers in the wall of the archegonial cavity adjacent to the stalk of the gametophore.

At the time the sporogonium has reached the stage of development shown in *figure 45*, and at the time when the spore mother-cells have separated from one another, it may be observed that its growth has not kept pace with that of the calyptra or the enveloping sheath, so that a considerable space appears between the wall of the sporogonium and the surrounding calyptra. The calyptra and sheath, having no support from within, are infolded or collapsed into this depression. As further development takes place the sporogonium comes to fill this space so that the enveloping calyptra and sheath are tightly stretched about the distal end of the sporogonium (*figures 35, 41*).

That the calyptra and sheath do not form one continuous tissue is clearly shown by the fact that the shriveled neck of the old archegonium is found lying between these two envelopes, sometimes closely squeezed between them (*figures 34, 35, 40 41, 50*). That the outer sheath is made up of plates of cells representing the boundaries between air-chambers is clearly shown in *figures 34, 35, 41, 43, 49*, and *51*. An examination of these figures shows that the tissue of the calyptra is composed of cells closely united while the outer sheath is composed, in longitudinal section, of several rows of cells entirely separated from one another (*figures 34, 35, 41*). It should be mentioned that the apparent continuity of the cell walls of the different plates of the sheath, shown in *figures 49, 50*, and *51*, is due to the overlapping of the cells, because the sections are cut in a slightly oblique direction. The true condition is, however, perfectly apparent in *figures 34, 35, 41, 43*, and *45*.

This outer sheath formed from the tissues of the gametophore should not be confused with the pseudoperianth such as appears in certain other Marchantiaceae, *e. g.*, in *Marchantia* and *Preissia.* That structure originates as a collar-like outgrowth from the cells immediately beneath the base of the archegonium, which are descendants from the original cell from which the mother-cell of the archegonium was cut off. Only the slightest indication of this organ appears at the time of fertilization, so that it is an entirely new structure which develops after fertilization has taken place. At its maturity it is a tubular sheath, a single layer of cells in thickness and is never closed or continuous around the distal end of the sporogonium. Such a true pseudoperianth does not exist in *Conocephalum conicum.* It is replaced by the sheath which has already been described as being a further development of the walls of the cavity in which the archegonium is developed. It is composed of several distinct laminae, which are morphologically the plates of cells separating the air-chambers on one side of the archegonial cavity and at maturity completely enclosing the sporogonium and calyptra.

The function of this enveloping sheath may possibly be protective. Since the sporogonium rests over winter in the nearly mature condition, this extra covering, with its air spaces, may serve to prevent excessive radiation and transpiration.

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Explanation of plates 30-33

The figures are so freely alluded to in the accompanying text that further explanations would perhaps involve unnecessary repetitions. It should be stated, however, that all the figures were drawn with the aid of a camera lucida. Figures 1–26, 28–33, 46–48, and 51–53 were drawn with a Bausch and Lomb ⅛-inch objective and 1-inch ocular; 27, 36, 37, 39, 42, 49, 50, and 54, with a ⅛-inch objective and 2-inch ocular; 34, 35, 38, 40, 41, and 43, with a ⅔-inch objective and ½-inch ocular; and 44 and 45, with a ⅔-inch objective and 1-inch ocular. The original drawings have been reduced one half.

Notes on the anatomy of Sesban macrocarpa Muhl.*

MAUD J. STABER

(WITH PLATE 34)

Sesban macrocarpa was first described by Muhlenberg in 1818; later, Pursh changed the generic name to *Sesbania*, which form is used by some authors. The species under consideration is the only representative of the genus known in North America, although there are a number in other parts of the world in warm or tropical regions. *Sesban macrocarpa* is one of the annuals which flourish under the conditions that exist in Arizona and the southwest in general, and further south to Central America, although it is known in the eastern section as far north as Pennsylvania. It is placed in the Papilionaceae near *Robinia*, *Astragalus*, etc., in the tribe Galegeae.

Before going into details of the anatomical structure of the plant in question the following review of the anatomical features common to the Papilionaceae will be of interest. The characteristics common to these forms are: † (1) ducts with simple openings, (2) simple pitted wood-prosenchyma, (3) lack of crystal glands, and (4) scarcity of the usual one-celled hairs, (5) ducts filled with brown albuminous substance, (6) hairs which usually consist of one row of cells having one or more short basal cells and one long end-cell, besides (7) excretion of calcium oxalate in the form of staff-like crystals. As the other characteristics are not common to all species, they will not be considered here.

The material used was chiefly raised from seed at the New York Botanical Garden. That from which most of the work was done was fully mature, having flowered. The plants all averaged about the same height, the particular one studied being 105 cm. in length. In order to facilitate orienting the sections, the plant was cut into seven lengths, successively shorter, and the parts were

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* Britton, Manual of the flora of the Northern States and Canada, 550.

† Solereder, Anatomie der Dicotyledonen, 288.

mapped out on paper. In this way any section could be cut and its position in the plant ascertained and recorded. Microtome sections were prepared by embedding in paraffin, this method being found suitable even for the older, tougher portions when the harder paraffin was used.

The general structure of the stem was determined by a transverse section at 5 cm. from the tip. This showed 39 definite open collateral bundles arranged in a circle about a central cylinder of pith (FIGURE 1). These were enclosed by a stereome ring separated from the cortex by an endodermis. To determine the changes which had taken place in the development of the stem, a section was taken just above the root (FIGURE 3). Here the bundles had enlarged considerably, forming a complete woody cylinder by the growth of interfascicular cambia, and not by the interpolation of new bundles; the width had increased from 67.8 μ to 2.36 mm. The first evidence of a complete woody cylinder appeared at 88.5 cm. from the base, or at 16.5 cm. from the tip. Another change was in the broken appearance of the stereome, which at 17 cm. from the base showed 44 groups, giving evidence of the inability of these cells to stretch with the growth of the stem in circumference. Besides this a superficial periderm had formed, just above the roots, of six or seven layers in thickness. In several places where wounding had occurred it was deep enough to cut off a portion of the stereome. Very prominent, because of their brown color, were cells filled with tannin, occurring in the cortex, leptome, and pith. In the cortex the tannin filled separate cells without particular order, but in the leptome long ducts, usually three to each bundle, formed a ring concentric with the epidermis, stereome, and cambium. Besides this, single ducts appeared in the periphery of the pith at the base of the large bundles (see FIGURE 2). As the general plan of the plant has been given, the separate elements will now be considered in detail.

The pith, constituting the central cylinder of the stem, was formed of more or less spherical cells, the lignified walls of which were very delicately pitted. In the older stem the cells at the periphery contained considerable starch. The diameter of the pith averaged thirty-nine cells throughout, the increase in the size of the cells causing the enlargement in the diameter of the stem.

The hadrome elements of the bundle varied according to the age of the stem. In the younger sections the annular and spiral ducts only were lignified. In the older portions, the libriform and medullary ray cells formed by far the main percentage of the woody cylinder. The ducts were typical, comprising the annular, spiral, reticulated, and pitted. In the latter the edges of the pits were slightly thickened. They had a very large lumen averaging 71.85 μ in width with a heavy wall of 3 μ in thickness, in contrast to the spiral and ring ducts which measured 28.2 μ across their lumen, with a wall 3 μ thick also. On the innermost edge of the bundles were ducts which differed from the regular annular ring ducts in having lateral lignified circular thickenings. In some sections they appeared like distorted annular ducts, in others, the openings were decidedly lateral and showed no distortion. The long pointed libriform cells averaged to have a wall of 1.5 μ and lumen of 26.1 μ in the older parts. The walls were strongly lignified and but slightly pitted by oblique slits. The parenchyma cells surrounding the base of the bundles became lignified only in the older stem. There was little wood-prosenchyma, but what there was contained starch.

Of particular interest in the study of any Galegeae are the medullary rays in tangential section. Although these plants have no common anatomical character, still three groups have been found whose differences lay in the medullary ray construction.* In cross section in this species, they were one cell wide, had pitted walls, and were filled with starch in the older stem. In radial section they appeared rectangular in shape, forming long horizontal rows, a characteristic of the Papilionaceae and of the Caesalpiniaceae. Some rows comprised taller cells than others, which is true, too, of *Amorpha*, *Indigofera*, and *Psoralea* of the Podalyrieae.† In the younger sections the cells were found to be taller than those in the older parts. The story-like appearance of the cells in the horizontal layers was pointed out by von Höhne and verified by Saupe as occurring mostly in the Papilionaceae, also in the Caesalpiniaceae. In tangential section, the cells form long columns one cell wide, except that in some places, being two

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* Saupe, Flora 70:303. 1887.

† Saupe, *loc. cit.* 303.

cells in width and of irregular shape, they marred the otherwise "story-like" appearance.

The cambium ring separating the woody cylinder from the outer leptome mass, varied from three to seven layers according to the age of the plant (FIGURE 6). The leptome with its long sieve-tubes and companion or cambiform cells, was cut off on its outer edge. The sieve-plates were visible only after being stained with Delafield's haematoxylin or with methylene blue. Besides the ordinary transverse oblique plates, twin sieve-plates (FIGURE 7), and a number of lateral ones were found (FIGURE 5). This may be peculiar to this particular species, for no mention is made of this point in the various Leguminoseae which hitherto have been examined.

Scattered throughout the leptome portion, in the older stem, especially near the root, were single spindle-shaped cells or groups of them, more or less sclerenchymatous in character. Their outer wall was lignified, whereas their inner more or less gelatinous or mucilaginous lining consisted of cellulose.* This cellulose lining was quite separate from the wall, as the plant had been in alcohol. There was evidence, in the portion just above the root, that these fibers migrate to the outer edge of the leptome and combine to form the stereome. These cells were most abundant in the root, forming the mechanical tissue in the center in the leptome.

The stereome, formed of long thick-walled lignified cells, 1.807 mm. long, with walls 4.6μ thick and a lumen of 6.25μ, pectinated to form a tough fiber of considerable strength. In India, *S. aculeata* Pers. is especially cultivated for its fiber,† from which fishing nets are made. We are told that it is tough and durable, but on account of its shrinkage when wet, is not suitable for ship's cordage. In the younger portions of the stem, the stereome was thin-walled, not being lignified until one reaches a point 22.7 cm. back from the tip, or at 82.8 cm. from the base. After lignification set in, the walls began to thicken (FIGURE 8) and became more rigid. As the circumference of the stem

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* Tschirch, Angewandte Pflanzenanatomie 1: 295. Chloriodide of zinc stained the lignified walls yellow, and the cellulose red-violet.

† Maiden, Some Australian vegetable fibers, Agri. Gaz. of N. S. Wales, Misc. Pub. 550: 8. 1902.

increased, the stereome, unequal to the strain, split up into masses (FIGURE 3). At a point 20 cm. from the root, it showed forty-four groups. But just above the roots were only fourteen groups, the number of cells composing each being considerably less than higher up in the stem. But added to these and serving as mechanical tissue were the scattered fibrous cells with the cellulose lining and lignified walls, or bast fibers,* which, as mentioned above, formed the transition stage between the mechanical cells of the root and stem.

Enclosing the stereome was a well-defined endodermis (FIGURE 4). In transverse section the cells were longer than they were wide. This endodermis was not constant throughout the stem. It was very definite in the younger portion, but was lacking in the old. The amount and relation of the starch to the sheath varied in the different sections. At a point 94.8 cm. from the base the starch was confined to the endodermis, where it occurred plentifully. Ten cm. lower, hardly any starch appeared. A cross section taken at 73 cm., or 11 cm. lower, showed very few starch grains scattered in the endodermis. Still lower down, or at 57 cm., the amount of starch in the endodermis was somewhat greater; while at 40.5 cm., no starch was found in the sheath, but considerable in the leptome, some in the medullary rays and some in the periphery of the pith. Still older portions showed the endodermis lacking starch. But in the leptome, in the medullary rays and in the periphery of the pith, there was a great abundance of it. Therefore the amount of starch varied according to the age of the stem. In the young or actively growing region practically none or very little starch was stored, whereas in the older portions large quantities were kept for reserve material until the time for fruiting.

According to Solereder † one often finds as characteristic of the Papilionaceae, glandular cells having a wide lumen and containing brown albuminous substance. For a long time these vessels were considered laticiferous, but the researches of Trécul ‡ showed conclusively that the contents were tannin. He classifies

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* Tschirch, Angewandte Pflanzenanatomie 1: 295.

† Solereder, Anatomie der Dicotyledonen 288.

‡ Trécul, Compt. Rend. 60: 225. 1865.

the principal ways that the tannin is found to occur in the plants. For *Sesban* he states that it "has tannin-like latex vessels in the external bark, under the phloem and among the pith." The species under consideration, however, had tannin in the cortex, in the leptome, and at the base of the bundles in the periphery of the pith. In the preserved condition in which this plant was studied, the cells containing this secretion appeared brown and granular and were very noticeable under the microscope. The test used for their determination was as follows: The sections were placed in concentrated aqueous solution of copper acetate for three days, and then were treated with a 20 per cent. solution of ferric acetate for a few minutes. The tannin present became greenish blue. In the cortex the tannin cells appeared without any particular order, but in the leptome long ducts had been formed which were quite regularly placed, usually three to each bundle (FIGURE 3). The cross-walls of the ducts were missing, but slight traces of their former position were observed in several places as projections from the wall into the lumen.* Researches of Avetta, Borzi, Baccarini, and Weyland show them to be syncytic in nature.† The tannin cells, themselves, were cylindrical structures, slightly constricted in the center, fitting end to end, averaging 28.16 μ long and 1.76 μ wide in the old stem.

The collenchyma forming a definite ring of three to five layers was interrupted by an aerenchyma (FIGURE 4) of more or less spongy tissue throughout the length of the stem. This was lacking in the root. In *Sesban aculata* Pers. and *Sesban marginata* Benth.,‡ however, a considerable aerenchyma was developed in place of cork in the roots, which functioned as floating tissue.

The cells forming the epidermis appeared polygonal in shape when viewed from above. The stomata were of the usual type, and were surrounded by four neighboring cells. The number of stomata varied considerably; in one strip of epidermis with an area of 7.5 sq. mm. at a point 40 cm. from the base 6, only, were found, while in a smaller piece of 4.7 sq. mm. at 14.7 cm., 22 stomata were present. No hairs of any kind were present.

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* Meyen, Ueber Secretions-organe der Pflanzen, 47. Berlin, 1837.

† Solereder, Anatomie der Dicotyledonen, 294.

‡ Scott & Wagner, Floating roots of *Sesbania aculeata*. Ann. Bot. **1**: 301–314. 1888. Also Schenck, Aerenchym. Jahrb. Wiss. Bot. **20**: 554–557. 1889.

The structure of the root next claims our attention. The plant examined had a well-developed primary root with a thick mass of secondary ones, upon which nodules had formed. Examination of the root of a seedling showed it to be of the radial tetrarch type, the bundles enclosed by pericambial and endodermal layers. As in most Papilionaceae, there was a common meristematic zone extending across the plerome and periderm areas.* An older root showed the bundles meeting in the center, and the leptome pushed out until it formed a ring about the central woody cylinder. The bundles were formed of libriform cells and pitted ducts, but there were no ring ducts. Many of the ducts had cross-walls formed of a fan-like radiating structure† or of ladder-like construction. In this respect the root differed from the stem and from Leguminosae in general, that is, in having simple openings between ducts, as mentioned at the beginning. The medullary rays, too, showed some variation, in being from one to three cells wide. On entering the leptome area, they broadened considerably, becoming wedge-shaped. As in the stem, the cells were filled with starch. The leptome was well developed. The cells contained starch, and were interrupted in a few places by tannin ducts. Scattered in the leptome was a great number of stereome fibers, having lignified walls and a cellulose lining, being of the same kind as occurred in the stem above the root (FIGURE 9). The libriform cells, throughout the center and towards the edge of the hadrome, were of like construction. We are told that the appearance of this "3d membrane" among libriform cells is an irregular one.‡ They showed most prominently after treatment with chlor-iodide of zinc, the lignified walls becoming yellow, and the cellulose lining or "3d membrane" (Tschirch), a red-violet.

The leaf (FIGURE 10) showed the usual dorsi-ventral structure. Weyland § summed up the characteristics in his researches on the Galegeae, one of which was *Sesban.* Examination of the leaf of *S. macrocarpa* showed an agreement in all the details. The stomata appeared on both sides of the leaf, but were somewhat

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* De Bary, Comparative anatomy of phanerogams and ferns, 12. [Eng. Trans.]

† "Gefächerte" prosenchyma-cells found by Saupe in species of *Sabinea* and *Sophora;* Solereder, *loc. cit.* 311.

‡ Tschirch, Angewandte Pflanzenanatomie 1 : 298.

§ Weyland, Bull. Herb. Boiss. 1 : appendix 3. 1893.

sunken owing to the papillose character of the epidermal cells. The neighboring cells, three or more, were arranged in no particular order. Epidermal hairs and glandular cells were lacking, the latter often being found among the Galegeae. The leaf-bundles had no sclerenchyma sheath, but lay embedded in the mesophyl. A few crystals of calcium oxalate were found in the bundles. The palisade parenchyma of two layers was rich in chlorophyl; some of the cells, however, were full of tannin. The spongy parenchyma, below, was two-layered, many cells of which also contained tannin.

The seeds of this plant were invested by an unusually hard resistant seed coat, which refused to split after the usual soaking, except for a very small percentage. Heroic measures were then resorted to. The seeds were put into boiling water and boiled for a minute or a trifle more. After this treatment every one sprouted.

Very little anatomical work has been done upon this genus. The tannin-ducts have been examined by Trécul, the leaf by Weyland, and the floating roots by Schenck and by Scott and Wagner, all of which have been referred to in the preceding pages.

In summing up, therefore, we find in *Sesban macrocarpa* the commonly recognized anatomical characters of the Leguminosae, except that some of the ducts in the roots have fan-like cross-walls in place of simple openings. As for the further characteristics of the Papilionaceae, we find that *Sesban macrocarpa* has the tannin-ducts, but wholly lacks hairs of any kind. As for the calcium oxalate secretion, it was found only in the leaf-bundles. Of special interest may be mentioned the lateral and twin sieve-plates, lateral openings in the annular ducts, the bast or stereome and the libriform fibers having the third membrane, and the resistant coat of the seeds, besides the disappearance of the endodermis in the old stem.

The study of *Sesban macrocarpa* was carried on in the Barnard Botanical Laboratory, under the direction of Professor Herbert M. Richards, to whom his student gratefully acknowledges her appreciation of his help and interest. The original material and seeds were kindly supplied by Dr. D. T. MacDougal of the Carnegie Institution of Washington, to whom the writer wishes to express her thanks. Thanks are due also to Miss Alice A. Knox for her

trouble and work in the sprouting and growing of the seedlings for examination.

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Explanation of plate 34

FIG. 1. Transverse section of stem near tip, showing separate bundles; × 8.

FIG. 2. Detail of fig. 1. *d*, ducts; *t*, tannin; × 39.

FIG. 3. Transverse section of stem at 21 cm. from base, showing complete woody cylinder of 39 bundles; *c*, cambium; *epi*, epidermis; *lept*, leptome; *p*, pith; *st*, stereome; *t*, tannin; × 8.

FIG. 4. Transverse section of stem at 40.2 cm., showing the aerenchyma; *aer*, air space; *col*, collenchyma of 4 layers; *end*, endodermal sheath bordering *st*, stereome; *t*, tannin duct in leptome tissue; × 55.

FIG. 5. Longitudinal section of leptome with lateral sieve-plate, *l. s. p.*; *c. w.*, cell wall; × 318.

FIG. 6. Transverse section at 18 cm., showing cambium, *c*; *med*, medullary ray cells; *l. c*, libriform cells; *s. p*, sieve plates; *t*, tannin cell; *c. c*, companion cell; *c. m*, cambiform cell; × 318.

FIG. 7. Transverse section at 18 cm., showing twin sieve-plates *s, p*; *c. c*, companion cells; *c*, cambium; × 318.

FIG. 8. Transverse section at 16.7 cm., showing width of stereome walls; × 318.

FIG. Transverse section of root; *c. d*, central duct; *d*, duct; *med*, medullary ray cells; *s. f*, stereome fiber, outer wall lignified, black portion known as third membrane is of cellulose; × 318.

FIG. 10. Transverse section of leaflet near tip of the plant; *epi*, epidermis; *pal. par*, palisade tissue; *sp. par*, spongy parenchyma; *t*, tannin; *had*, hadrome; *lep*, leptome; × 318.

Additions to the flora of the Carolinas

W. C. Coker

Collections made at intervals at Chapel Hill, Orange County, North Carolina, and in Darlington County, South Carolina, have resulted in the addition of the following species to the known flora of these states :

ACER FLORIDANUM (Chapman) Pax.

This tree is not uncommon on the sandy banks and alluvial bottoms of Morgon's Creek near Chapel Hill, North Carolina. I have found it at several places here ; and there are a number of medium-sized trees on the streets in the town of Chapel Hill that have been brought in from the surrounding country. In the creek bottoms the tree grows to a large size, forty feet or more high and two or more feet in diameter. The species has not been reported before from North Carolina, and the only South Carolina collection seems to be from "near Charleston" by J. H. Mellichamp 1896 (herb. N. Y. Bot. Garden). It is possible that this collection was made from a tree brought in from a distance and planted by Michaux, but supposing it to be native at Charleston, the discovery of this species at Chapel Hill extends its known range about 230 miles northward.

Acer floridanum seems to approach nearest to *Acer leucoderme* Small, but according to Dr. Small the two are quite distinct, not only in characters of foliage and fruit, but also in habit. I have not seen *A. leucoderme* in the field, but it is said to be a shrub or small tree, preferring rocky banks in the piedmont or middle districts, while *A. floridanum* is a large tree of alluvial bottoms, and confined principally to the coastal regions. That *A. leucoderme* also is present in Orange County seems certain, as it has been collected in the adjoining county of Durham to the east (herb. N. Y. Bot. Garden, from Biltmore Herb.).

HABENARIA NUTTALLII Small.

Collected in wet soil on the south side of Paper Mill Lake, Hartsville, South Carolina, August, 1908. This orchid has not been collected before in the state of South Carolina, and only at Wilmington in North Carolina (herb. N. Y. Bot. Garden, *W. M. Canby*, 1867). Towards the south it has not been found nearer than Florida and southern Georgia.

SOLIDAGO VERNA M. A. Curtis.

Collected on earth dam opposite Paper Mill, Hartsville, South Carolina, May, 1909. Hitherto this very rare plant has not been found except in eastern North Carolina and no exact locality is known except near Wilmington, where it was discovered by Rev. M. A. Curtis.

In the Flora of North America, Torrey and Gray (**2**: 205. 1842), *S. verna* is given on authority of Curtis from "open sandy pine woods near Wilmington, and Lenoir County, North Carolina," to which is added "(Florida, *Herb. Rafinesque !*)." But in Gray's Synoptical Flora of North America, Lenoir County, North Carolina, and Florida are omitted from its habitat and it is given only from "open and sandy pine woods near Wilmington, N. Carolina, *Curtis*." From this it would seem that its occurrence in Florida has not been established; but as to Lenoir County, which lies some seventy miles north of Wilmington, if Curtis said he found it there, its occurrence there can scarcely be doubted. In his 'Catalogue of the Indigenous and Naturalized Plants" of North Carolina (Geol. and Nat. History Survey of North Carolina, Part III, Raleigh, 1867) Dr. Curtis himself gives *S. verna* only from the low districts "(low dist.)."

So far as I have been able to discover, *S. verna* has been distributed only by Rev. M. A. Curtis, Dr. T. F. Wood, and Mr. Gerald McCarthy, all of whom seem to have collected their plants around Wilmington. The species is listed in Wood and McCarthy's Wilmington Flora (Journal of the Elisha Mitchell Scientific Society, **3**: 77. 1886), and in McCarthy's distribution list of "Flora of Eastern North Carolina" of 1885.

The occurrence of the plant at Hartsville, South Carolina, extends its range about one hundred and ten miles to the westward.

JUNCUS ABORTIVUS Chapman.

Four plants were collected in a damp grassy meadow in Burnt

Bay about one third of a mile behind the residence of Maj. J. L. Coker, Hartsville, South Carolina. Comparison with a sheet from Chapman's own herbarium leaves no doubt that this determination is correct. The species has heretofore been known only from western Florida near the coast. The Hartsville station extends its range over four hundred miles northward.

SCIRPUS SUBTERMINIALIS Torr.

A large quantity of this rush, hitherto supposed to be entirely northern, was found in the stream just below the "race" at Kilgore's Mill, about one mile from Hartsville. The species ranges across the northern part of the United States and Canada and has not been reported before south of New Jersey. However, on examining the sheets of this species at the New York Botanical Garden, it was found that it had been collected at Morrisonville, Mississippi, by S. M. Tracy in 1898. It is therefore probable that the species will be found to extend over the Southeastern and Gulf states.

CYPERUS MARTINDALEI Britton.

This small sedge is very common in the sand hills near Hartsville, S. C. It has not been known before except from Florida and the Gulf Coast.

CROTALARIA PURSHII DC.

Reported in Small's Flora from "Georgia and Florida to Louisiana," and it does not seem to have been reported farther to the northeast. It was collected by me at Hartsville, South Carolina, in flat sandy pine-barrens and it has been collected by House in Oconee County, South Carolina, in 1906, and by Huger in North Carolina (herb. N. Y. Bot. Garden).

VACCININIUM FUSCATUM Ait.

Given in Small's Flora from "Georgia to Florida, Arkansas, and Louisiana," and supposed to be a Florida and Gulf Coast plant. The species was collected in wet soil in "Burnt Bay," Hartsville, South Carolina, May 24, 1909. This extends its range three hundred miles northward.

GENTIANA ELLIOTTII Chapman [*Dasystephana parvifolia* (Chapm.) Small].

In the fall of 1907 a pure white form of this species was collected on the side of a ditch near the Pee Dee river at Society Hill, Darlington County, South Carolina, and sent me by Mr. P. H. Rogers.* The plant was again collected by Mr. Rogers at the same place in October, 1908. The plants are said to have been rather numerous in 1907, but the ditch was worked over soon after and in 1908 there were only a few to be found. I now have four specimens of this interesting form. Albinos seem not to have been previously recorded for this species.

LIMODORUM TUBEROSUM L. (*Calopogon pulchellus* R. Br.).

Three plants of the white form were found among sphagnum on the edge of a bay on the north side of Paper Mill Lake, Hartsville, S. C., May 23, 1909, and Mr. P. H. Rogers has since collected it in the vicinity of Hartsville. This albino has been reported from Moor's Landing, New Jersey, by Dr. Britton (Bull. Torrey Club **17**: 125. 1890) and by Paine from Genesee County, New York (Cat. Pl. Oneida County, 86. 1865), but I can find no record of its occurrence in the Carolinas. The normal form is plentiful at Hartsville.

In conclusion I wish to thank Dr. John K. Small and Dr. N. L. Britton for assistance extended me in the preparation of this paper.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

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* It is interesting to note that Society Hill was for several years the home of the gifted botanist, Rev. M. A. Curtis.

New North American Crataegi

W. W. EGGLESTON

Crataegus Tracyi Ashe in herb. N. Y. Bot. Gard.

Leaves obovate to ovate, 2.5–4.5 cm. long, 1.5–3.5 cm. wide, obtuse or acute at the apex, cuneate at the base, finely serrate, sometimes with a pair of irregular obtuse lobes towards the apex, occasionally lobed on one side only, membranaceous, bright, appressed-pubescent above, tomentose along the veins and paler below; petioles about 1 cm. long, slightly winged above, and somewhat tomentose; corymbs many-flowered, corymbs and calyx slightly villose, flowers about 15 mm. broad, calyx-lobes lanceolate-acuminate, glandular-laciniate, often irregularly so; stamens about 10; styles 3 or 4, with tuft of tomentum at base; immature fruit ellipsoidal, pubescent, about 7 mm. thick; calyx-lobes appressed; nutlets usually 3, about 6 mm. long, nest of nutlets about 6 mm. thick, ridged on the back. Round-topped trees 5–6 m. high; young twigs tomentose, soon becoming glabrous, armed with numerous straight, slender, chestnut-brown spines 3–6 cm. long.

Closely allied to *C. Greggiana* Eggl. of Mexico.

Type, *Tracy & Earle 172*, foothills of Davis Mts., Texas, Apr. 23, 1902. (Herb. N. Y. Bot. Gard.)

A part of the description was drawn from the following specimen:

Mexican Boundary Survey *351*, Rio Limpio, Texas, July 20, *Bigelow*. (Herb. N. Y. Bot. Gard.)

I would also refer to this species:

W. L. Bray 176, Turtle Creek, Kerr Co., Texas, May 1, 1899. (Herb. U. S. Nat. Mus.)

The station of Bigelow's on Limpio Creek and that of *Tracy & Earle* near the head of Toyah Creek are within a few miles of each other and but a short distance from Fort Davis.

Professor Tracy says in regard to his station: "*C. Tracyi* Ashe, was from the foothills on the north side of Davis Mts. We camped for a late dinner at the head of Toyah Creek, south of

Phantom Lake and Sargossa at Toyahvale P. O. It is my recollection that we went about five miles south before we struck the hills, but, whatever the distance, the *Crataegus* was found quite abundantly at the southeast foot of the first hill we reached, a round-topped hill on the west of the road just where the road makes a sharp turn from south to east.

"South of the hill is a level meadow, a part of which is in cultivation, while to the north and west the country is almost barren desert, and east of this hill is a still higher hill which is the beginning of a long range of high hills. The specimens were taken about a hundred yards west from the road, where it runs through a fenced lane in a depression between the hills."

Crataegus Brittonii sp. nov.

C. Vailiae Beadle in Small, Fl. Southeast. U. S. 561. 1903. Eggleston, in Gray's Manual ed. 7, 467. 1908. Not *C. Vailiae* Britton, Bull. Torrey Club **24**: 53. 1897.

Leaves ovate or broadly ovate, 2–4 cm. long, 1.5–3.5 cm. wide, acute or obtuse at the apex, cuneate, sometimes abruptly so, at the base, crenate or crenate-serrate with two or three pairs of shallow crenate lobes, membranaceous, rather dark green and shining, somewhat impressed-veined and slightly appressed-pubescent becoming glabrous above, paler and tomentose along the veins below; petioles 5–10 mm. long, rough-tomentose; corymbs 1–6-flowered, flowers about 15 mm. wide, pedicels and calyx-tube tomentose; calyx-lobes glabrous below, sometimes slightly pubescent above, ovate, obtuse, laciniate, three or four of the apical teeth often equal; stamens about 20, anthers white; styles 5, tomentose about the base; fruit globose or short-pyriform, 8–12 mm. thick, reddish-brown, slightly pubescent, falling about September 15th; calyx prominent, calyx-lobes reflexed, persistent; flesh firm; nutlets 5, 5–6 mm. long, grooved on the back, with a calyx-scar, nest of nutlets 7–8 mm. thick. Vegetative twigs light brown, slightly tomentose becoming glabrous, armed with numerous straight, slender thorns 2–5 cm. long. Tall ascending branched shrubs, sometimes 3 or 4 m. high.

Type, *Eggleston 4134*, Biltmore, North Carolina, Sept. 15–19, 1908, altitude 660 m. (Herb. N. Y. Bot. Gard.)

Other specimens used in description:

Biltmore Herb. *5881*^{b}, Biltmore, North Carolina, May 21 and Sept. 18, 1898. Biltmore Herb., May 15 and Sept. 17, 1902.

Eggleston 4162, along French Broad River, Paint Rock, North Carolina, alt. 450 m., Sept. 22, 1908.

Thomas H. Kearney, Jr. 696. Along the French Broad River, near Wolf Creek Station, Cocke County, Tennessee, Aug. 24, 1897.

A. Ruth 286 (in part), Wolf Creek, East Tennessee, July 18, 1898.

John K. Small, Canyon at Tallulah Falls, Rabun Co., Northern Georgia, 480 m., Aug. 4, 1893.

Eggleston, N. Y. Bot. Garden Fruticetum *17496*, Oct. 1906.

C. Vailiae Britton, known only on the Roanoke River, at Roanoke, Va., and the James River at Clifton Forge, Va., is one of the *Macracanthae* Loudon; while *C. Brittonii* belongs to the group *Parvifoliae* Loudon.

C. Brittoni differs from *C. tomentosa* L. (*C. uniflora* Muench.) by much higher and more regular habit; globose, smaller, brown, and early ripening fruit; larger corymbs; less tomentose, short and blunt calyx-lobes; less tomentose, crenate-lobed leaves; and slightly tomentose twigs.

Crataegus Williamsii sp. nov.

Leaves ovate, 2–9 cm. long, 1.5 to 6 cm. wide, acute or acuminate at the apex, cuneate, often sharply so, at the base, serrate with fine gland-tipped teeth excepting towards the base, cut towards the apex with 2–4 pairs of ascending, shallow acute lobes, membranaceous, slightly appressed-pubescent above, glabrous below excepting along the midrib and junctions of the veins, which are often slightly tomentose; petioles 1–3 cm. long, slightly winged above, somewhat pubescent; corymbs many-flowered, pilose, flowers 14–18 mm. wide; calyx and lobes nearly glabrous outside, calyx-lobes pubescent inside, ovate, acuminate, with occasional stalked glands; stamens about 10; styles usually 3 or 4; fruit globose, 8–10 mm. thick, red, slightly pubescent, calyx-lobes reflexed, persistent; nutlets 3 or 4, strongly ridged on the back, 5–7 mm. long, nest of nutlets 5–6 mm. thick. Twigs glabrous, armed with sharp thorns 3–6 cm. long. Round-topped shrubs, sometimes 4 m. high, belonging to the group *Rotundifoliae* Eggl.

Type, *R. S. Williams*, Columbia Falls, Montana, Sept. 14, 1892. (Herb. N. Y. Bot. Gard.)

Other specimens used in description:

R. S. Williams, Columbia Falls, Montana, May 19, 1897.

D. T. MacDougal 475, Flathead Plains, northwestern Montana, June 29, 1901, alt. 1000 m.

L. M. Umbach 253, ravines, Polson, Montana, Aug. 19, 1901.

B. T. Butler 500, 501, 503, 504, and *507*, Big Fork, northeastern border of Flathead Lake, Montana, Aug. 23, 1908.

B. T. Butler 512, Yellow Bay, Flathead Lake, Montana, Aug. 8, 1908.

B. T. Butler 525 and *526*, Ravalli, Montana, Aug. 26, 1908.

B. T. Butler 521–523, southwest border of Flathead Lake, Aug. 19, 1908, represents a form with leaves two cm. wider than the type.

This species occurs with *C. Douglasii* Lindl. and in leaf might easily be mistaken for it, having the appressed pubescence of the upper surface and the nearly glabrous lower surface, like *C. Douglasii;* but *C. Williamsii* has red fruit with unpitted nutlets, while *C. Douglasii* is black fruited with pitted nutlets. It is much nearer *C. columbiana* Howell but has larger, less pubescent leaves, with their apexes and lobes less acuminate, while the fruit is larger and matures at least two weeks later than *C. columbiana* fruit.

This species seems to be local in the Flathead River basin, and the nearest station from which I have seen *C. columbiana* is at Dixon, Montana, near the mouth of the Flathead River.

NEW YORK BOTANICAL GARDEN.

New combinations in Araliaceae

RICHARD C. SCHNEIDER

ACTINOPHYLLUM [Ruiz & Pavon] * Pavon †

Sciodaphyllum P. Browne, Nat. Hist. Jam. 190. *pl. 19. f. 1, 2.* 1756.

P. Browne's genus *Sciodaphyllum* (*Sciadophyllum* Rchb.), one of the several instances in which he neither described nor cited a binomial species, was renamed *Actinophyllum* by Ruiz and Pavon.* They also failed to describe or cite a binomial species; therefore, as *Actinophyllum* was the first to receive such species, described by Pavon in 1797, *Sciodaphyllum* not receiving species until 1804, *Actinophyllum*, according to the provisions of the "American Code," must be retained.

The following are the known West Indian species, which may be keyed thus:

Umbels panicled.	1. *A. Belangeri.*
Umbels racemed.	
Leaflets glabrous above and below.	2. *A. Sciadophyllum.*
Leaflets glabrous above, pulveraceous below.	3. *A. troyanum.*

1. **Actinophyllum Belangeri** (E. March.) R. C. Schneider

Sciadophyllum Belangeri E. March. Bull. Acad. Roy. Soc. Belg. II. **47**: 92. 1879.

On the Island of Martinique, *Bélanger.*

2. **Actinophyllum Sciadophyllum** (Sw.) R. C. Schneider

Aralia Sciodaphyllum [*Sciadophyllum*] Sw. Prod. Veg. Ind. Occid. 55. 1788.

Occurring on the mountains of the Island of Jamaica, W. I., as a large shrub or small tree, at an altitude of 700 to 1,000 m., attaining a height of about 7 meters.

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* Prod 51. *pl. 8.* 1794.

† Mem. Acad. Mad. 1: 194. 1797.

3. **Actinophyllum troyanum** (Urb.) R. C. Schneider

Sciadophyllum troyanum Urb. Symb. Ant. **5**: 451. 1908.

On the Island of Jamaica as a tree about 5 m. high, at an altitude of 660 meters, near Troy, collected by Harris, *no. 9369*, (type). (Co-type in herb. N. Y. Bot. Gard.)

DENDROPANAX Decaisne & Planchon, Rev. Hort. IV. **3**: 107. 1854

Gilibertia Ruiz & Pavon, Prod. 50. *pl. 8.* 1794 (without species); Fl. Per. et Chil. **3**: 75. *pl. 312.* 1802. Not *Gilibertia* J. F. Gmelin, 1791.

Dendropanax brachypodum (Urb.) R. C. Schneider

Gilibertia brachypoda Urb. Symb. Ant. **5**: 452. 1908.

Dendropanax insulare (Rose) R. C. Schneider

Gilibertia insularis Rose, U. S. Dept. Agric. N. Am. Faun. 14: 83. 1899.

Dendropanax laurifolium (E. March.) R. C. Schneider

Gilibertia laurifolia E. March.; Urb. Symb. Ant. **1**: 203. 1899.

?*Dendropanax laurifolium* Decaisne & Planchon, Rev. Hort. IV. **3**: 107. 1854. (Nomen nudum.)

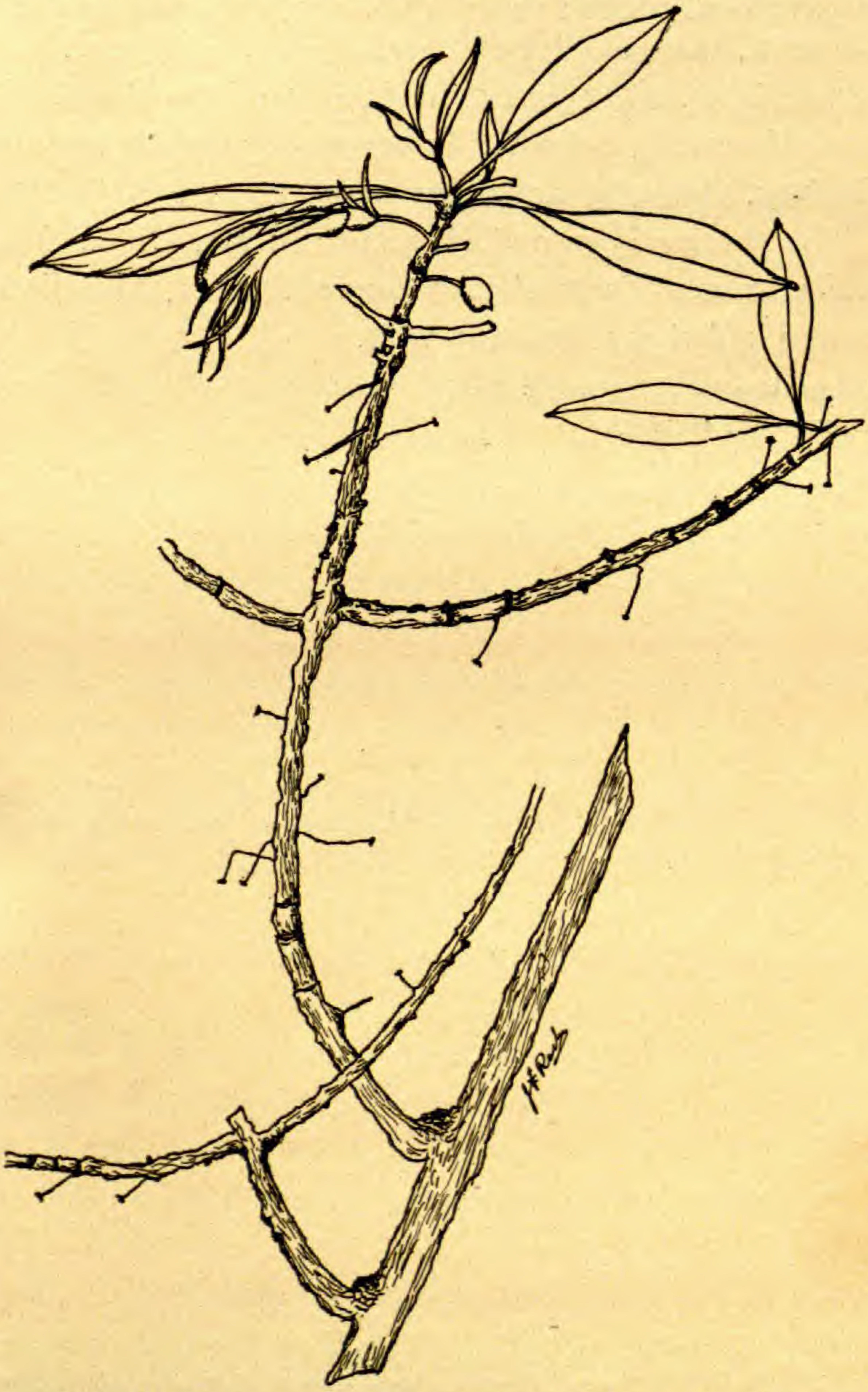
NEW YORK BOTANICAL GARDEN.

A new Hawaiian Scaevola

JOSEPH F. ROCK

Scaevola Swezeyana Rock

A shrub 9–12 dm. high, with stiff, glabrous, rambling branches. Leaves glabrous, oblanceolate, 38–76 mm. × 12–18 mm., on



Scaevola Swezeyana Rock. About one half the natural size.

petioles 6–13 mm. long, mucronate, entire, somewhat fleshy; peduncle single-flowered, 4–6 mm. long, entire, slightly pubescent, with two oblanceolate, foliaceous bracts below the calyx 6–18 mm. long by 2 mm. broad; calyx 4 mm., glabrous, with short, bluntish teeth of unequal size; corolla pubescent, 5-lobed, yellowish green with reddish brown streaks; tube 18 mm. long, erect, corolla-lobes linear-lanceolate, sharp-pointed, scarcely margined, 16 mm. × 3 mm.; stamens somewhat longer than the tube; style incurved, pubescent throughout, little shorter than the corolla, indusium glabrous, ciliate; drupe glabrous, crowned by the calyx-teeth, 5–6 mm., two-celled, putamen black, crustaceous.

The type is *no. 4804* (in the herbarium of the Board of Agriculture and Forestry), collected in the woods on the middle ridge of Niu Valley, Oahu, at an elevation of 1200 feet (August 22, 1909). The species is named in honor of Mr. O. H. Swezey of the Hawaiian Sugar Planters' Experiment Station, who discovered the plant and called my attention to it.

HAWAIIAN BOARD OF AGRICULTURE,
HONOLULU, HAWAII.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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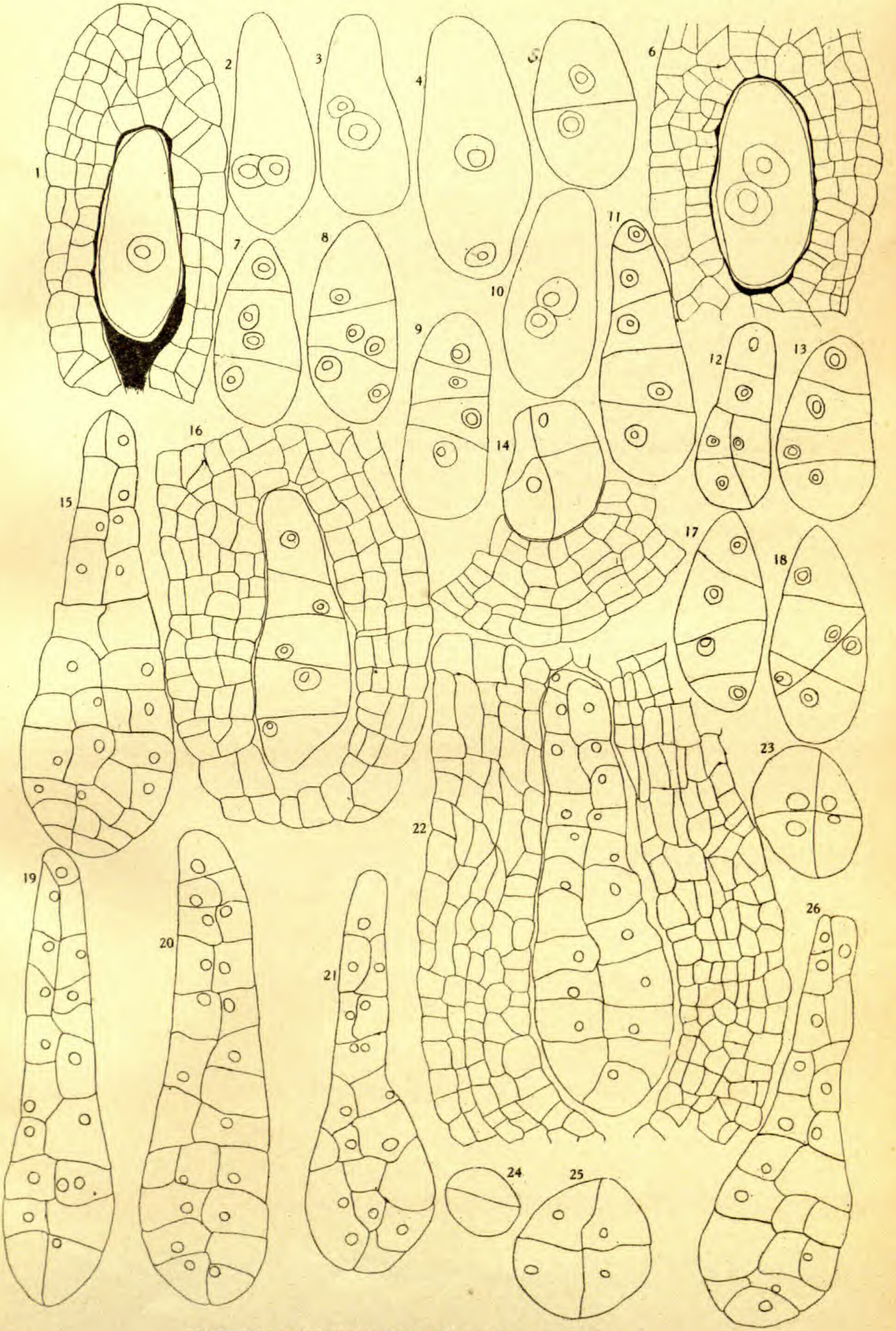

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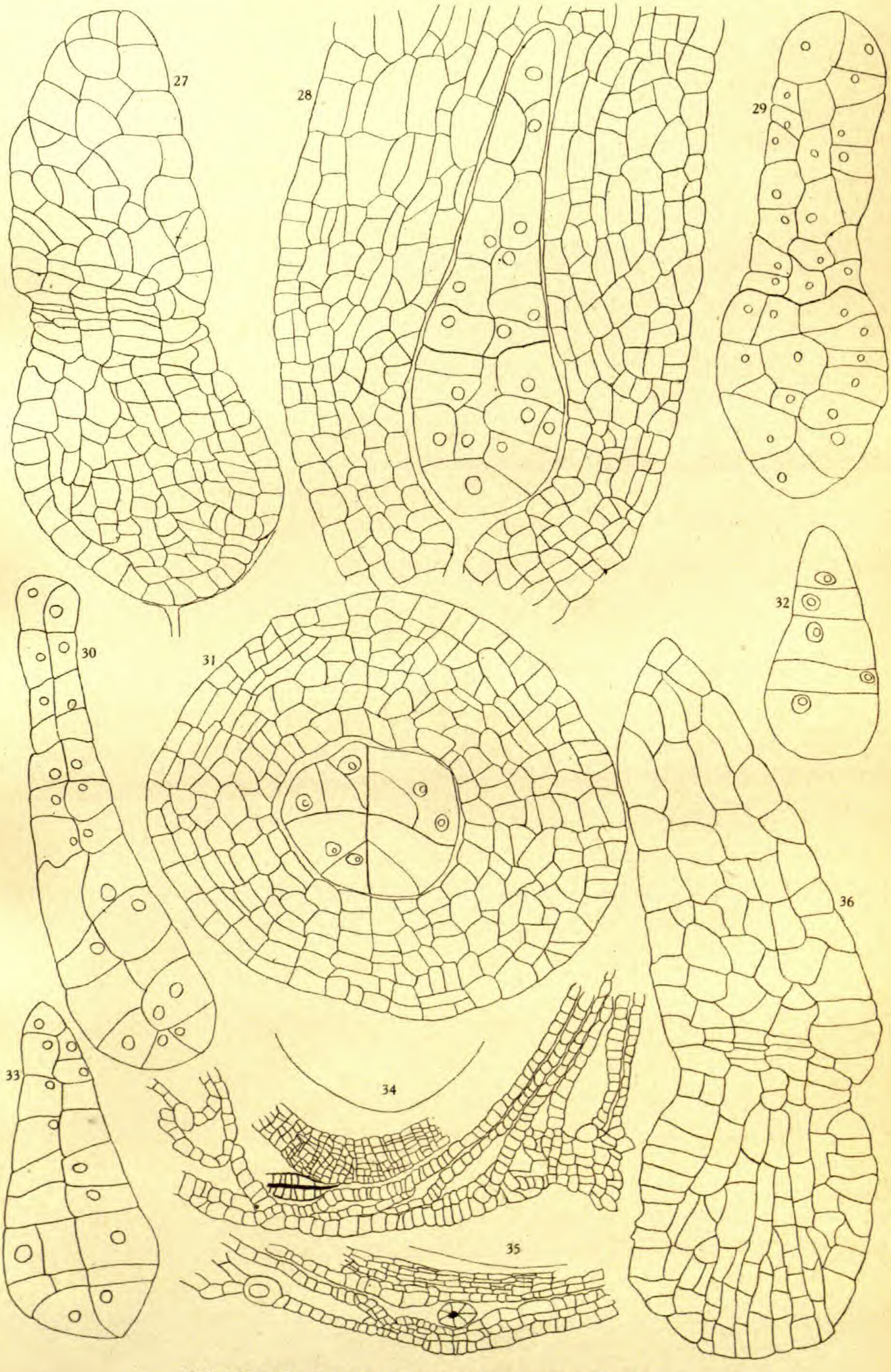

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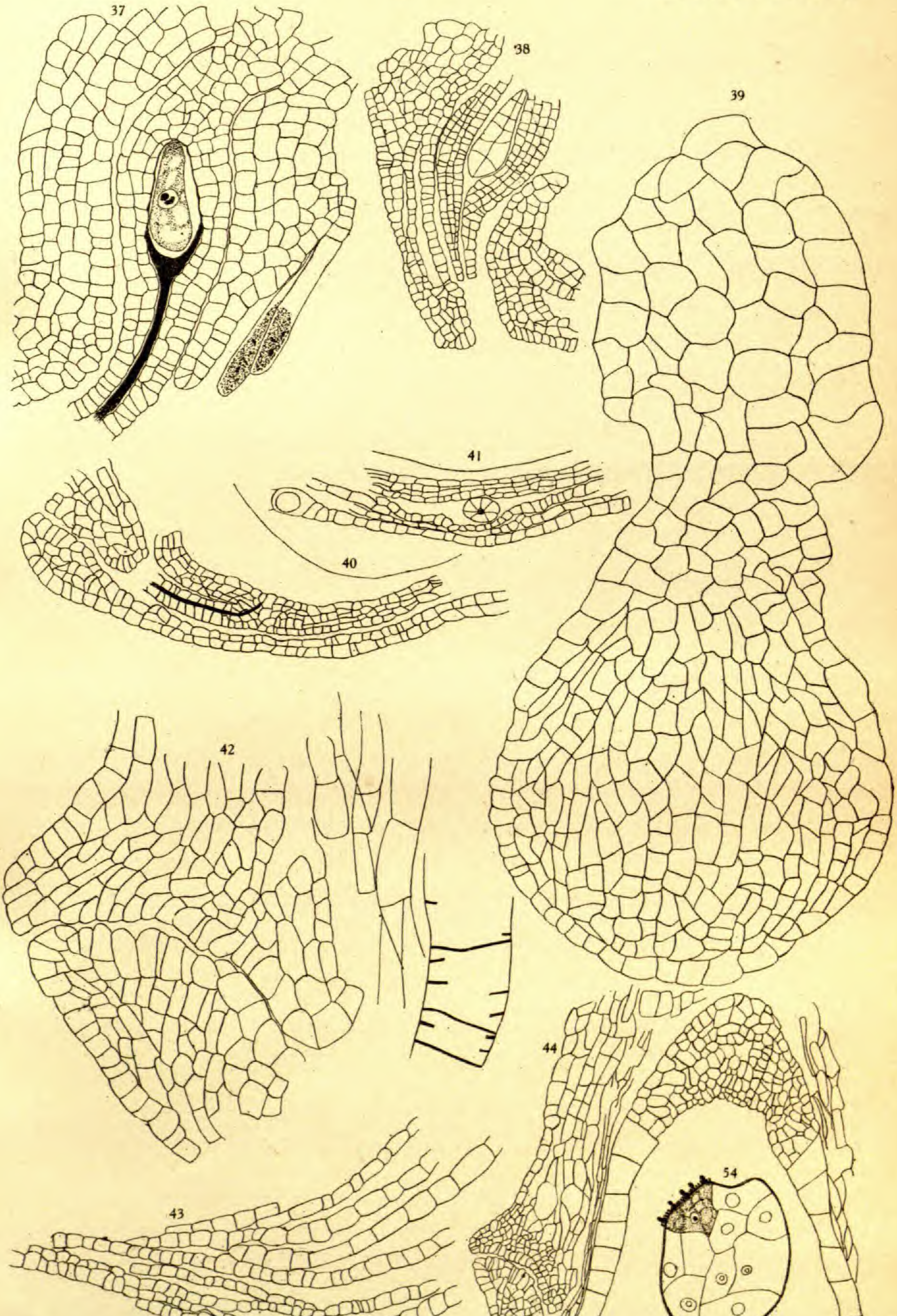

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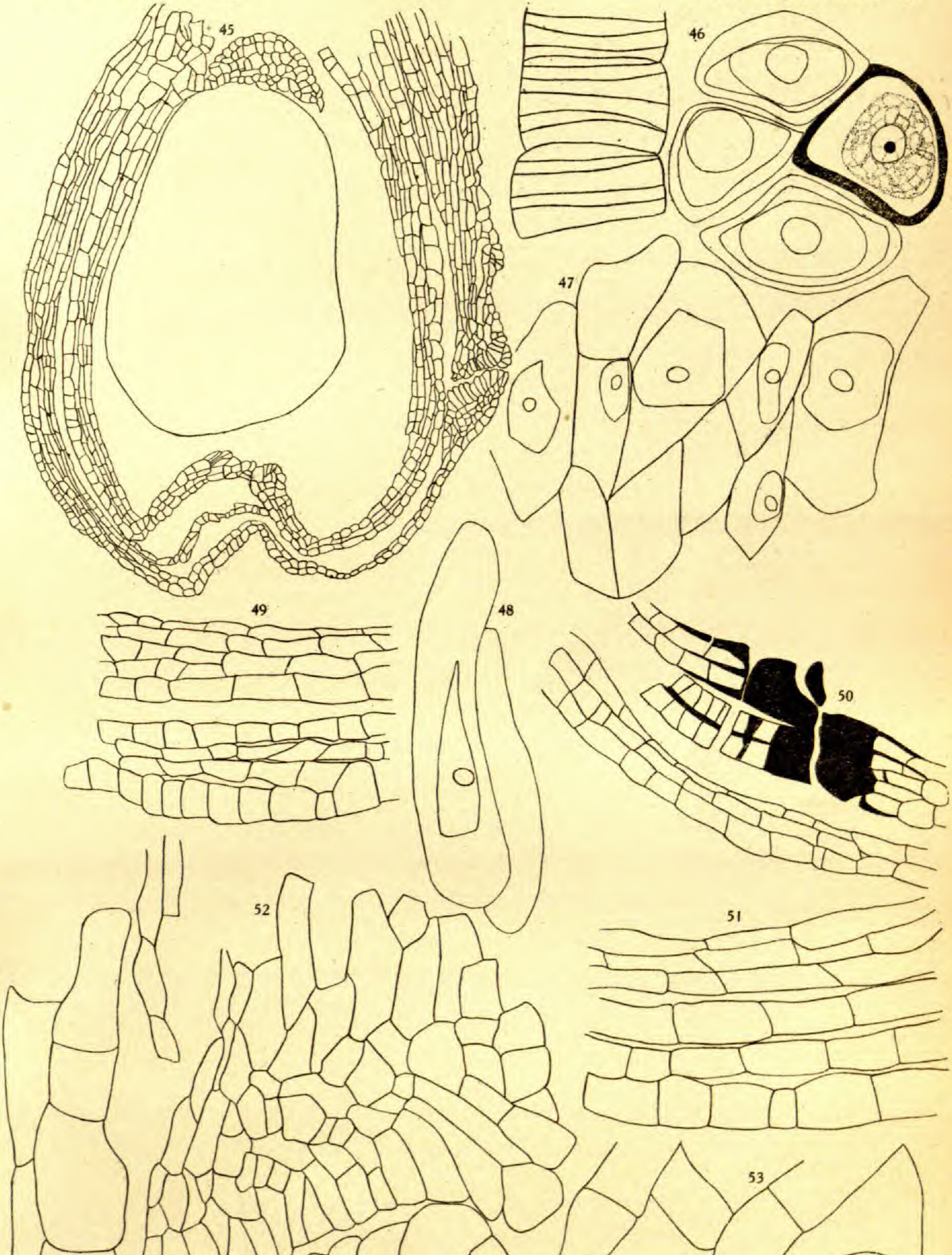

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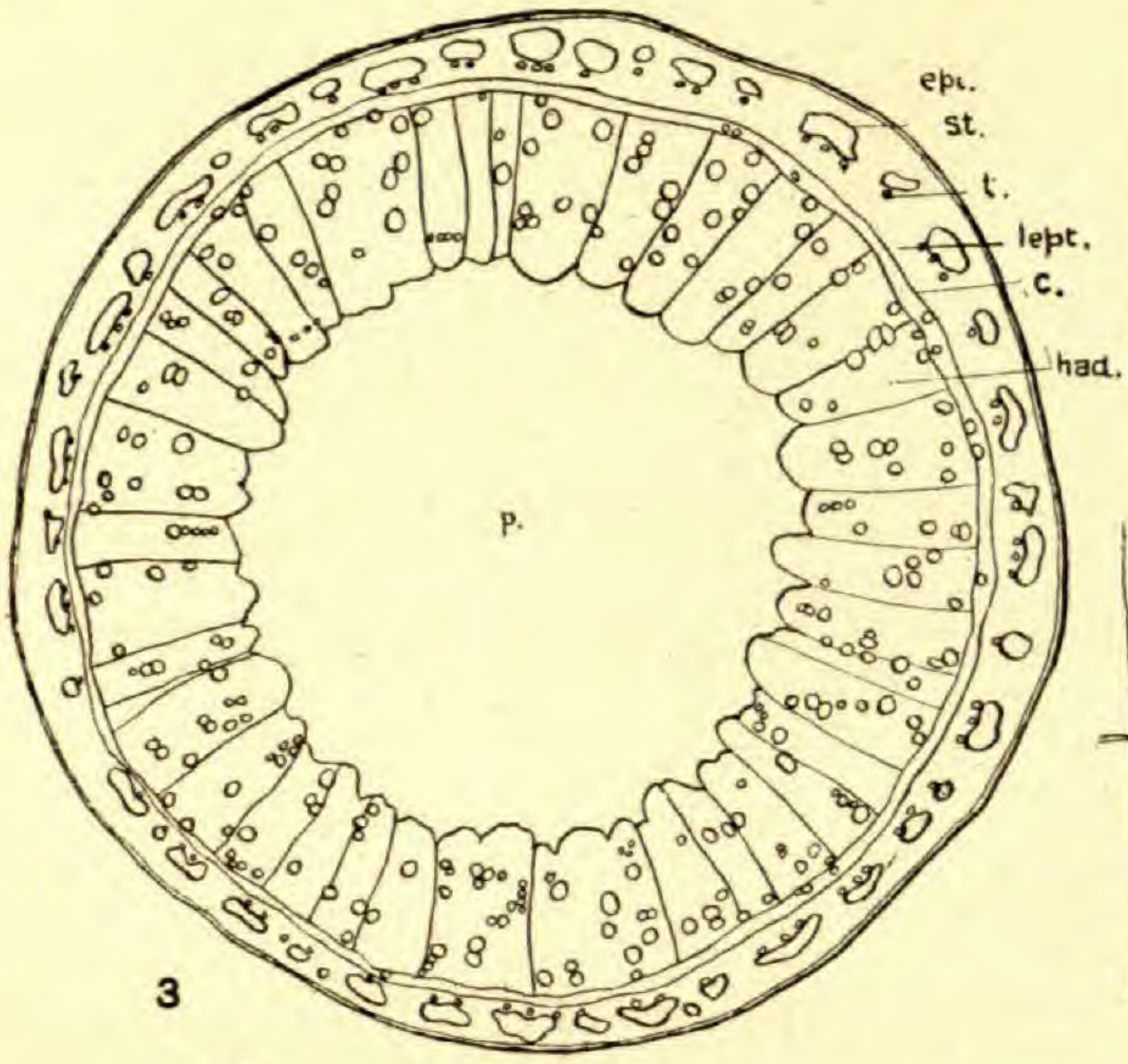

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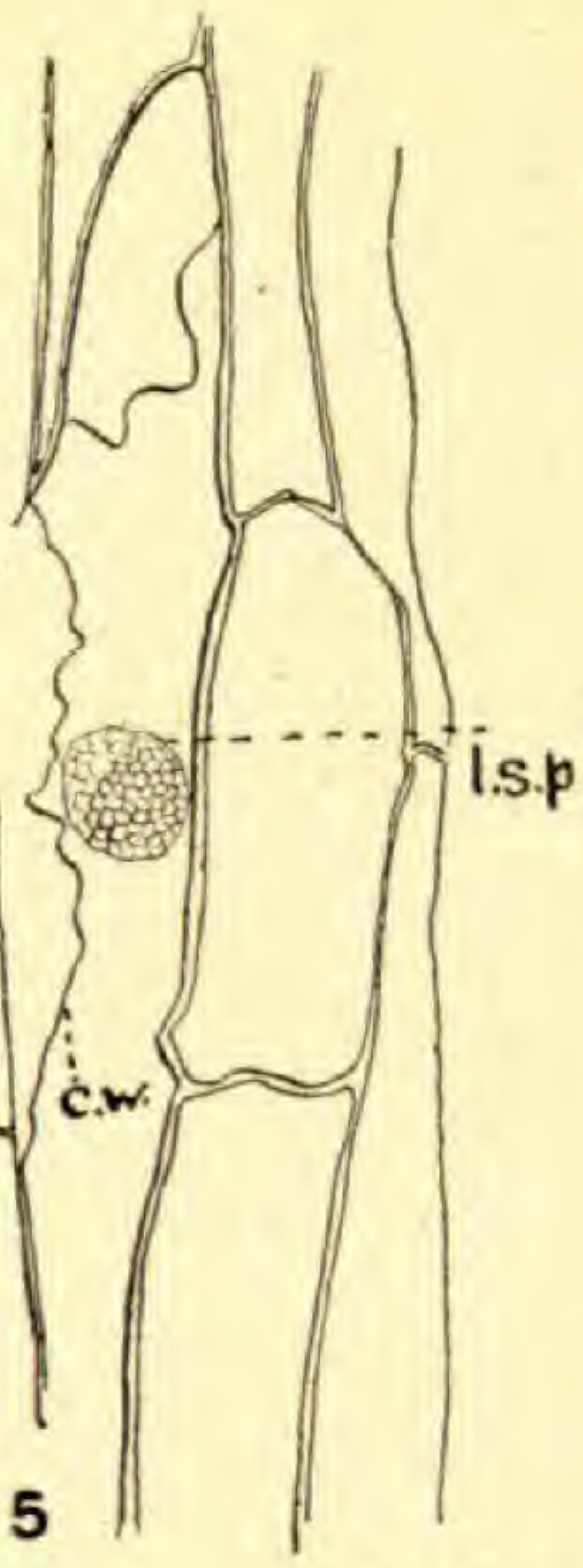

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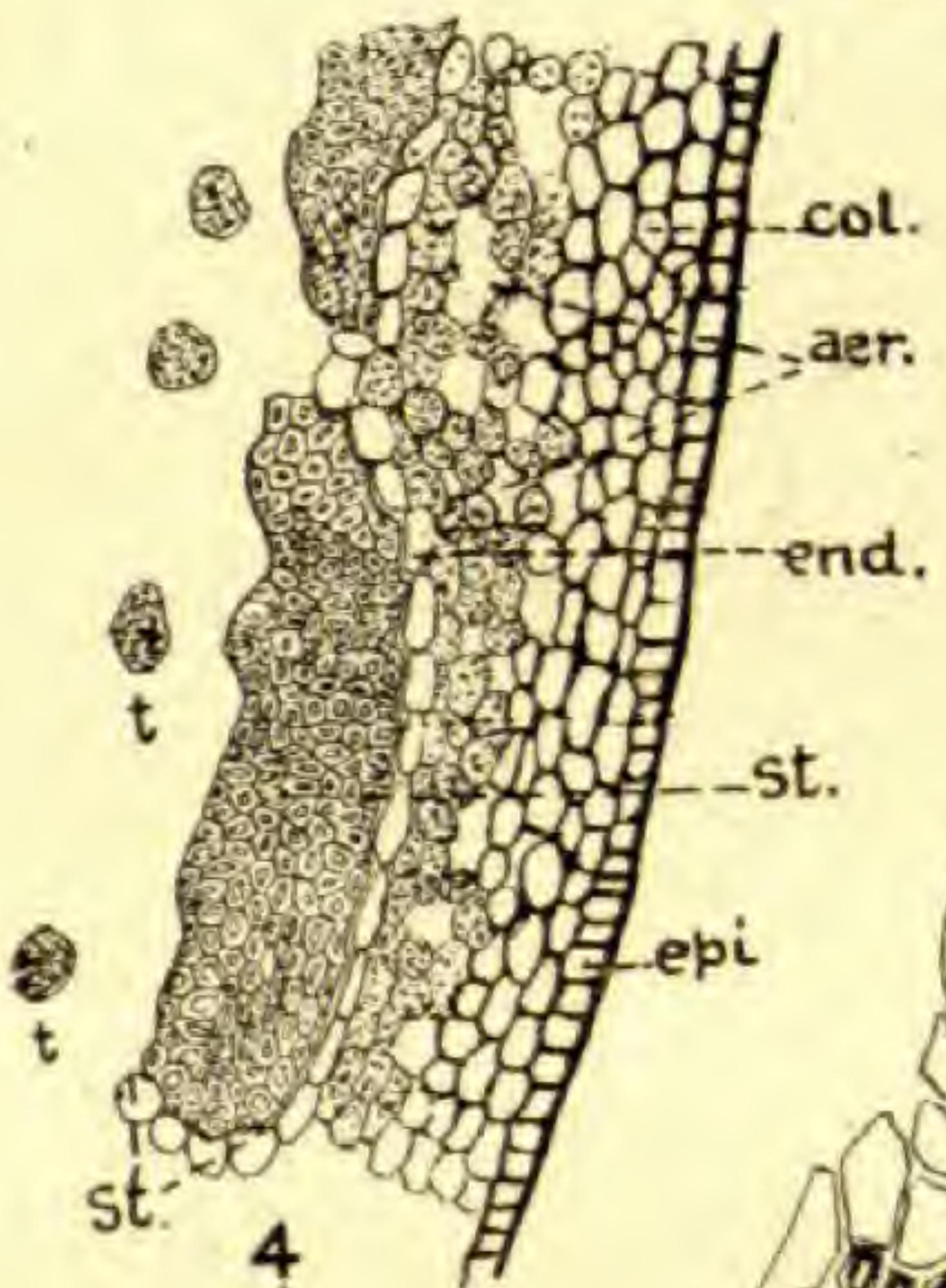

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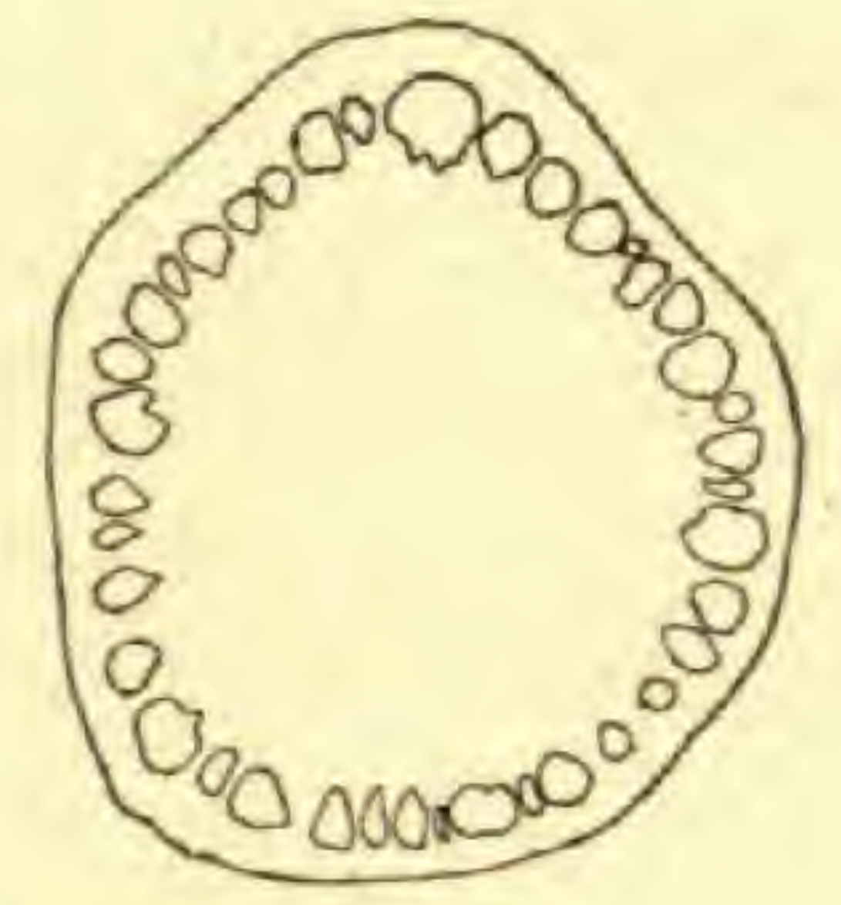

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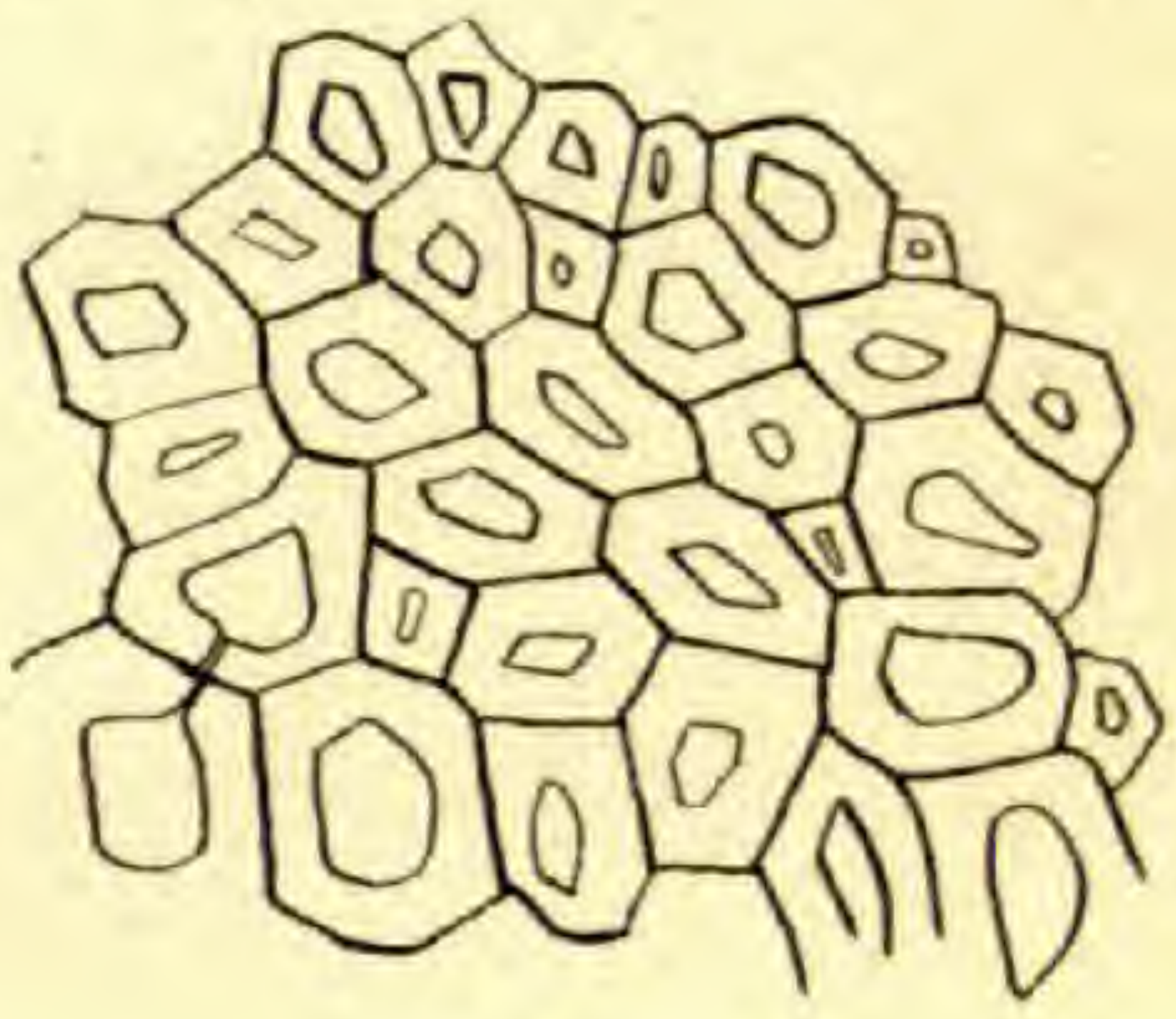

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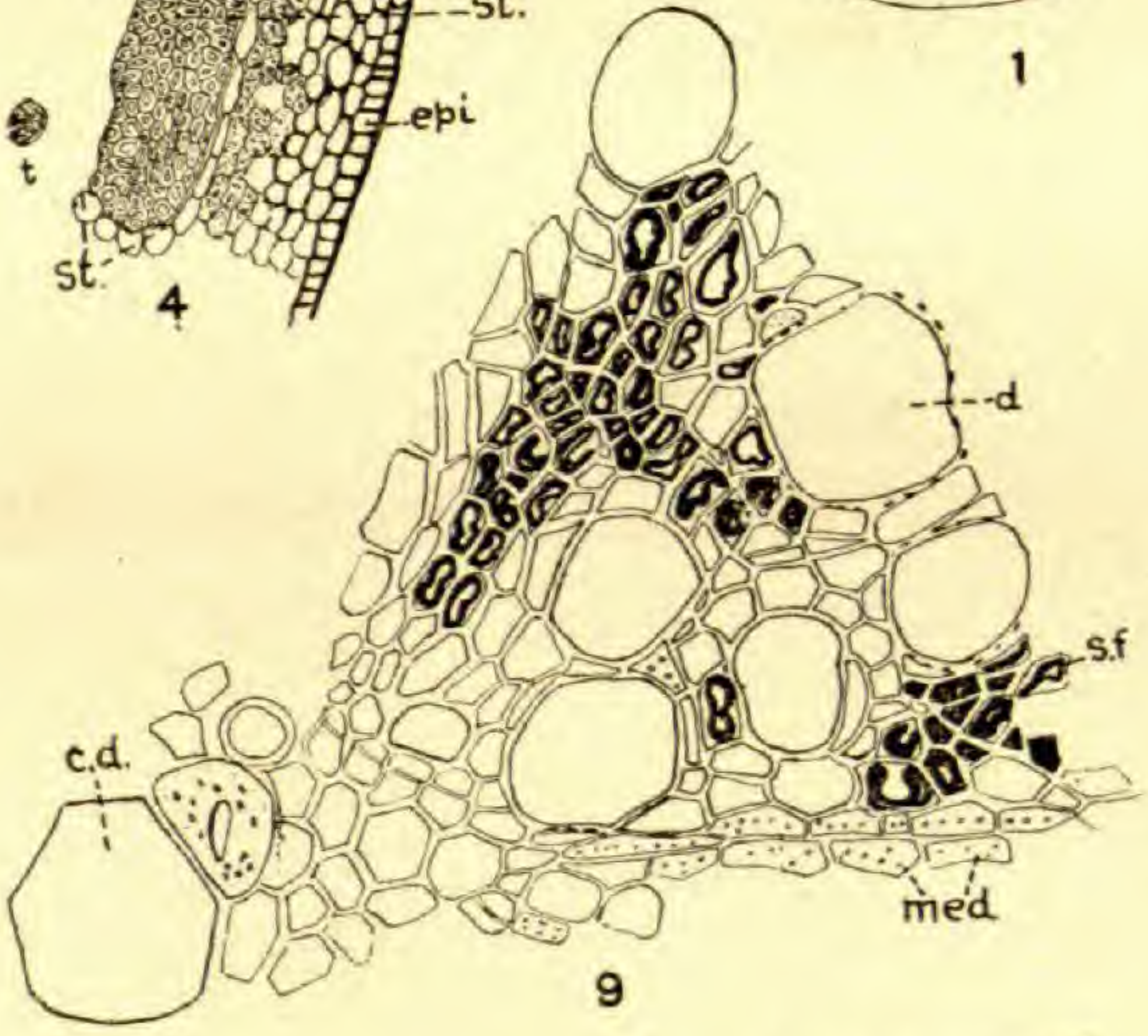

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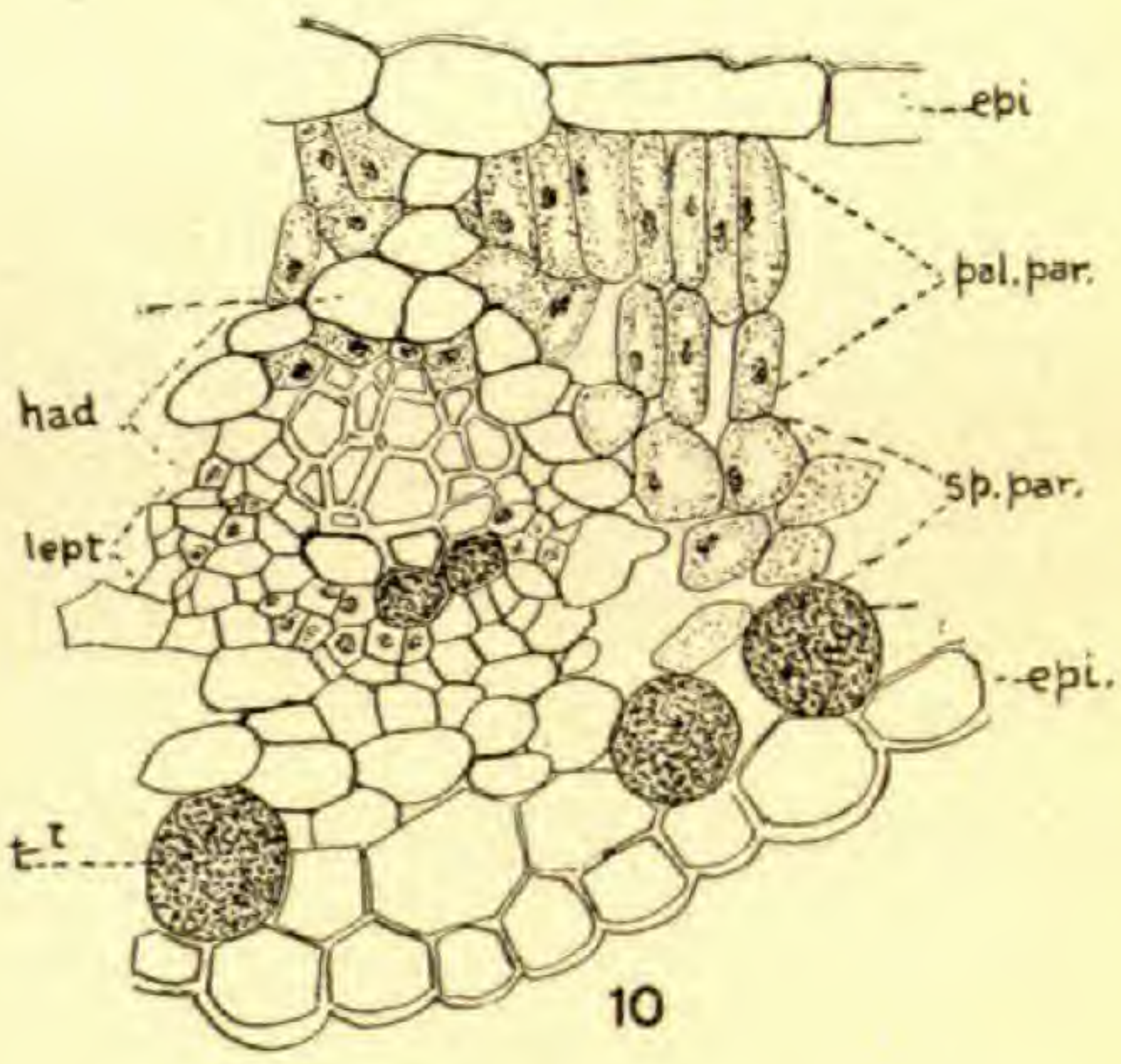

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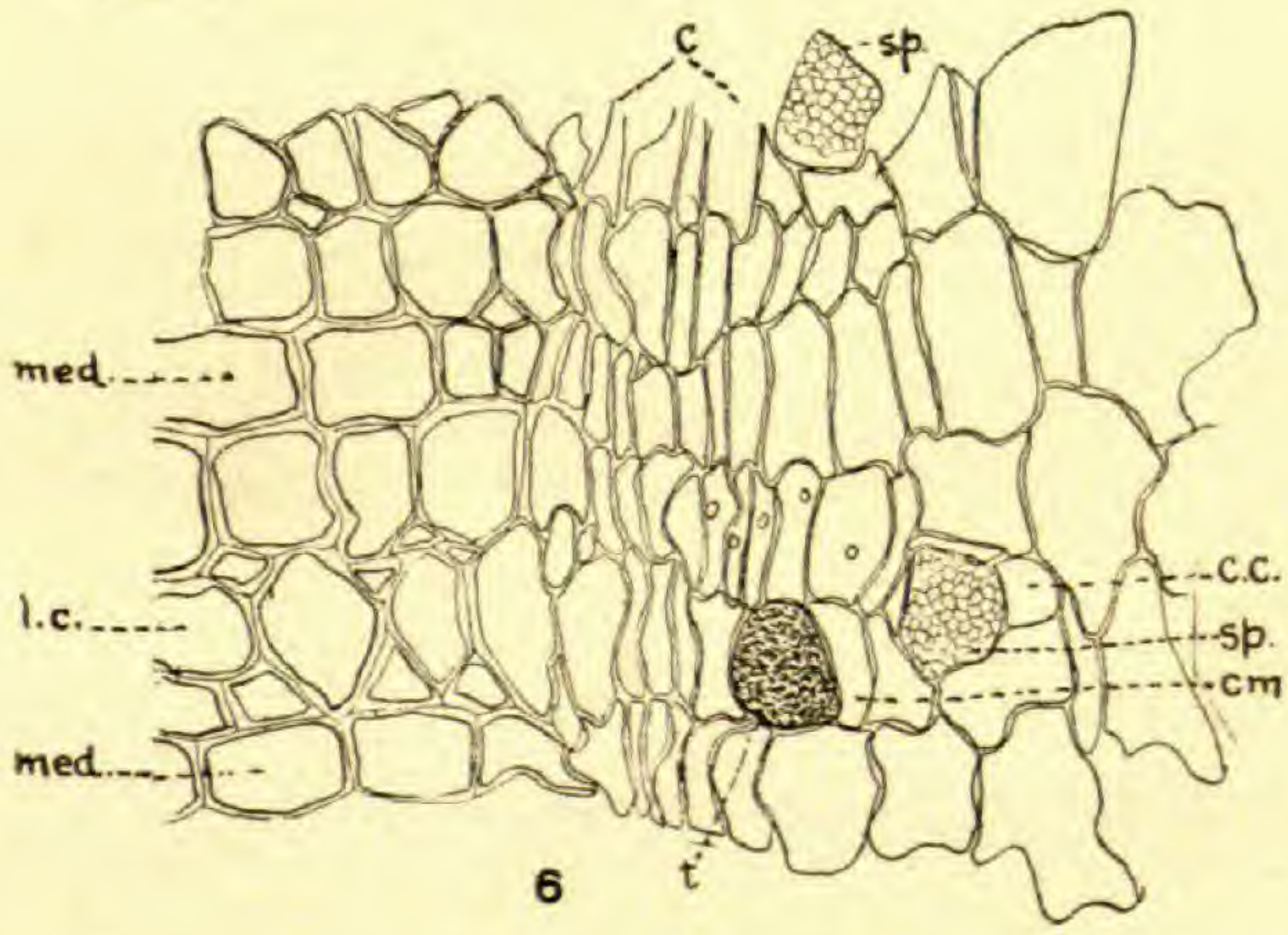

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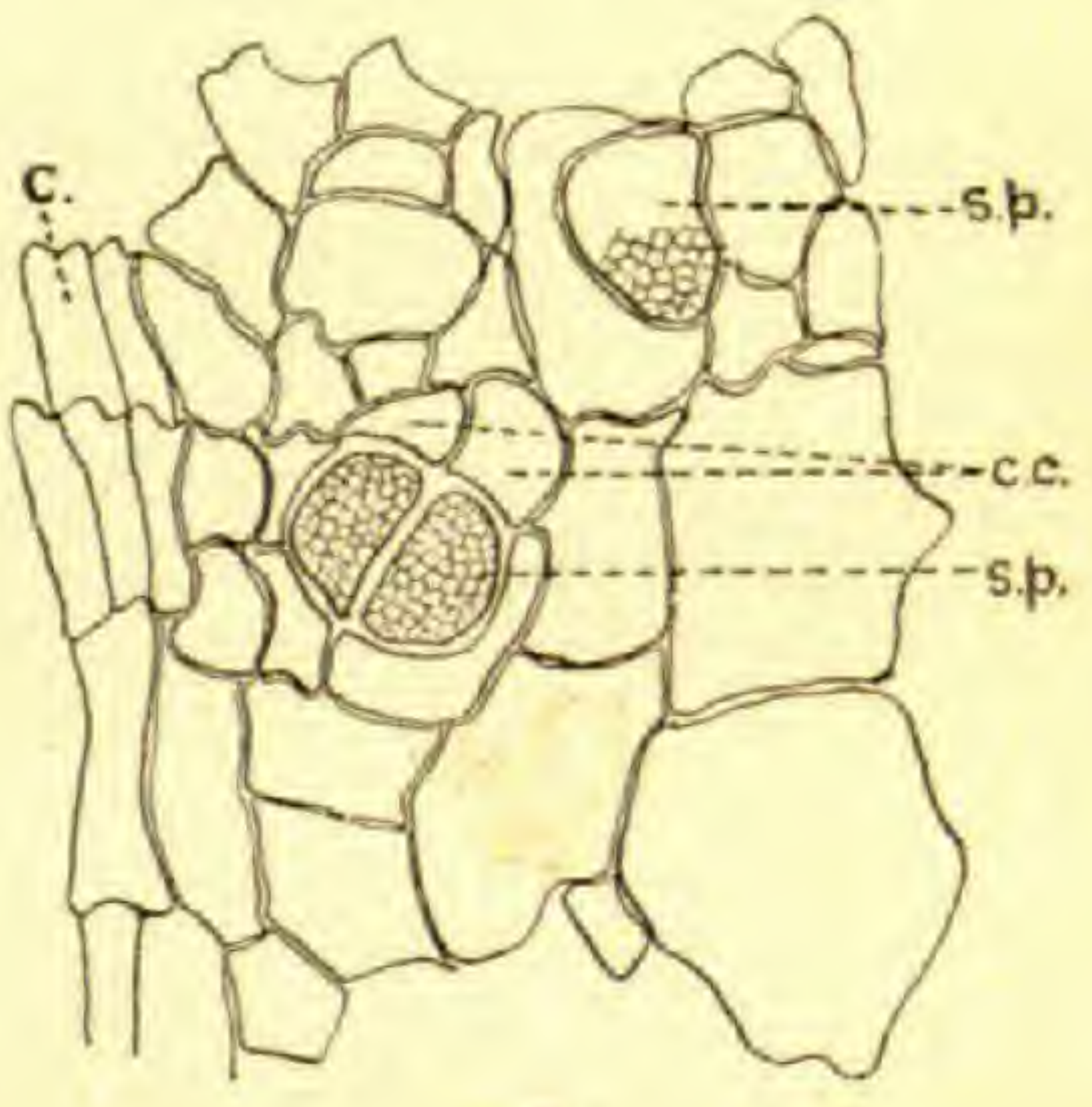

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STABER, THE ANATOMY OF SESBAN MACROCARPA

North American Flora

THIS work is designed to present descriptions of all plants growing independently of cultivation, in North America, here taken to include Greenland, Central America, the Republic of Panama, and the West Indies, except Trinidad, Tobago, and Curaçao and other islands off the north coast of Venezula, whose flora is essentially South American.

It will be published in parts at irregular intervals by the New York Botanical Garden through the aid of the income of the David Lydig Fund bequeathed by Charles P. Daly.

It is planned to issue parts as rapidly as they can be prepared, the extent of the work making it possible to commence publication at any number of points. The completed work will form a series of volumes with the following sequence:

Volume 1. Mycetozoa, Schizophyta, Diatomaceae.
Volume 2 to 10. Fungi.
Volumes 11 to 13. Algae.
Volumes 14 and 15. Bryophyta.
Volume 16. Pteridophyta and Gymnospermae.
Volumes 17 to 19. Monocotyledones.
Volumes 20 to 30. Dicotyledones.

The preparation of the work has been referred by the Scientific Directors of the Garden to a committee consisting of Dr. N. L. Britton, Dr. W. A. Murrill and Dr. J. H. Barnhart.

Professor George F. Atkinson, of Cornell University, Professors Charles R. Barnes and John M. Coulter, of the University of Chicago, Mr. Frederick V. Coville, of the United States Department of Agriculture, Professor Edward L. Greene, of the United States National Museum, Professor Byron D. Halsted, of Rutgers College, and Professor William Trelease, of the Missouri Botanical Garden, have consented to act as an advisory committee.

Vol. 7, Part 1, Ustilaginales, including Ustilaginaceae and Tilletiaceae, by G. P. Clinton, was issued Oct. 4, 1906. Vol. 7, Part 2, Coleosporiaceae, Uredinaceae, and Aecidiaceae (pars), of the Uredinales, by J. C. Arthur, was issued March 6, 1907. Vol. 9, Parts 1 and 2, Polyporaceae, by W. A. Murrill, were issued Dec. 19, 1907, and March 12, 1908. Vol. 22, Part 1, including Podostemonaceae by George V. Nash, Crassulaceae by N. L. Britton and J. N. Rose, and Penthoraceae and Parnassiaceae by P. A. Rydberg, was issued May 22, 1905. Vol. 22, Part 2, including Saxifragaceae and Hydrangeaceae by J. K. Small and P. A. Rydberg, Cunoniaceae, Iteaceae, and Hamamelidaceae by N. L. Britton, Pterostemonaceae by J. K. Small, Altingiaceae by Percy Wilson, and Phyllonomaceae by H. H. Rusby, was issued Dec. 18, 1905. Vol. 22, Part 3, Grossulariaceae by F. V. Coville and N. L. Britton, Platanaceae by H. A. Gleason, Crossosomataceae by J. K. Small, Connaraceae by N. L. Britton, Calycanthaceae by C. L. Pollard, and Rosaceae (pars) by P. A. Rydberg, was issued June 12, 1908. Vol. 22, Part 4, Rosaceae (pars) by P. A. Rydberg, was ssued Nov. 20, 1908. Vol. 25, Part 1, including Geraniaceae by L. T. Hanks and J. K. Small, Oxalidaceae and Linaceae by J. K. Small, and Erythroxylaceae by N. L. Britton, was issued Aug. 24, 1907.

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OF THE

TORREY BOTANICAL CLUB

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Vol. 36 No 12

BULLETIN

OF THE

TORREY BOTANICAL CLUB

DECEMBER, 1909

The plant formations of the Nockamixon Rocks, Pennsylvania

JOHN W. HARSHBERGER

After the Delaware River is joined by the Lehigh River, it flows almost due south, but in a sinuous course for a distance of ten miles to a point a mile below Riegelsville, then it flows southeastward a mile and five-eighths to Kintnersville. At this place, it makes a sharp bend and flows directly eastward to Milford on the New Jersey side, or Black's Eddy on the Pennsylvania side. The south bank of the river rises between Kintnersville and Narrowsville into a series of precipitous cliffs known as the Nockamixon Rocks (FIGURE 1). More accurately, if the east sheet of the topographic map of Bucks and Montgomery counties (No. 12, Pennsylvania Geological Survey, Final Report) is consulted, these cliffs are found to be situated between 75° 6′ and 75° 10′ west longitude and 40° 34′ north latitude. The boldest rocks frown down on three miles of the river's bank (FIGURE 2). According to the Pennsylvania survey, the crest of the cliffs is 500 feet above the river. The cliffs form a sheer wall of rock in many places (FIGURE 3), cut by ravines down which the streams tumble in cascades, or waterfalls. An expert mountain-climber might ascend the precipitous rocks, but a less expert climber must clamber the ledges of rock from cascade to cascade in the severa ravines that seam the rocks. As the streams that descend from above have an extremely limited watershed, they usually run dry during the summer months and little pools are left in the hollows of the water courses, where the wild birds are accustomed to drink.

[The BULLETIN for November, 1909 (36: 615–650. *pl. 30–34*) was issued 16 N 1909.]

Rogers* fifty years ago described these cliffs as follows: "One stretch of precipice on the Pennsylvania side, known by the name of the Nockamixon Rocks is an exceedingly striking and picturesque range of beetling cliffs, rising sheer for 200 or 300 feet from the brink of the river with only a narrow roadway between them, through a length of nearly three miles. Some of the views from the base of these crags are almost grand; and the pictures they make with the river below are beautiful (FIGURE 2).

FIGURE 1. North part of Bucks County, Pennsylvania, north of Tohickon Creek, displaying the contour lines of the rock cliffs along the Delaware River, known as the Nockamixon Rocks. Between the 200-foot contour and canal lies the talus slope, between 200 feet and 400 feet, the precipices, while above 400 feet are the crest slopes Between Milford and Kintnersville lies the part surveyed botanically.

Tufts of bushes and trees and climbing vines heighten by their green hues the rich brown tints of the rocks, to the bold faces and narrow ledges of which they lend a grace which no cliffs without vegetation ever possess. There are few more attractive drives or walks by the river borders of Pennsylvania than the one at the foot of the Nockamixon Rocks." From the New Jersey side of

---

* Rogers, Henry D. The geology of Pennsylvania 1: 48. 1858.

the river, these rocks suggest the well-known Palisades of the Hudson River, but their color and origin are different, as they are composed of red shale. From this distance, the cliffs seem to be unbroken and higher than actual measurement indicates. The vegetation from the opposite bank of the river appears confined to the talus and the upper more gradual slopes near the crest of the cliffs. A nearer approach confirms the distant view, but in addition the botanist notes that every ledge, shelf, and crevice is occupied by trees, shrubs, and herbaceous plants which grow either in the bare rocky soil or where a poor soil has been formed by the disintegration of the rock masses (FIGURE 4). Viewed from the towpath of the canal at the base of the cliffs, the impression is that of a mixed deciduous forest with clumps of hemlocks, here and there, or a facies of the red cedar (*Juniperus virginiana*) to break the more even crown of the broad-leaved forest trees. Back of the cliffs the forest has been cleared and the nearly level surface is devoted to the cultivation of the ordinary farm crops. Beyond the fields to the south rises a group of rounded hills, ranging from 600 to 780 feet, the highest point being three quarters of a mile south of the edge of the rocks. A canal and a dirt road occupy the shore between the lower edge of the talus and the river bank (FIGURE 2). The talus, which is considerable at the west end, but almost absent in the middle and at the east end, consists of extremely loose broken pieces of the shale rock. It is difficult to climb over such material, because it constantly slides from beneath the feet. The mass of rock is a hard red slate, but the edges of the rock-shelves break off only too easily, as the climber finds out in attempting to ascend from shelf to shelf by his hands and knees (FIGURES 4 and 5). Care must be exercised not to lay hold of a piece that breaks away from the cliff. Numerous cracks appear in the rocks following the natural cleavage-planes, so that the rock soil and talus material is extremely porous, permitting the rapid percolation of the rain-water, which, when it first falls, makes the soil and rocks extremely slimy and slippery. Such a substratum upon which the characteristic plants of the locality are found growing is noted for its physiologic dryness, which is especially noteworthy in the summer, when little rain falls, and yet it is surprising what a large number of plants will grow and carry on their life processes to fruition in such an excessively dry soil. There must be considerable water in the rocky strata beneath, because here and there in the ravines in the driest summer weather, water is seen oozing out where the water-bearing seams are exposed. Various hepatic mosses, true mosses, and several other plants remain green in such spots, while many other plants of the drier cliff faces, having long since perfected their flowers and fruits, have dried up completely, all but their underground parts, which are reserved for perennation.

GEOLOGIC CHARACTER OF THE CLIFFS

The American New Red rocks extend across Bucks County into New Jersey. They are penetrated by eruptive dikes of trap rock which in our region form Haycock Mountain on the one hand and the celebrated Ringing Rocks on the other, while a crescent-shaped mass just back of the edge of the cliff at the time of its appearance probably altered the original color and texture of the surrounding Mesozoic red shales. In the center of the horseshoe shaped trap there is apparently a small trap hill on a higher

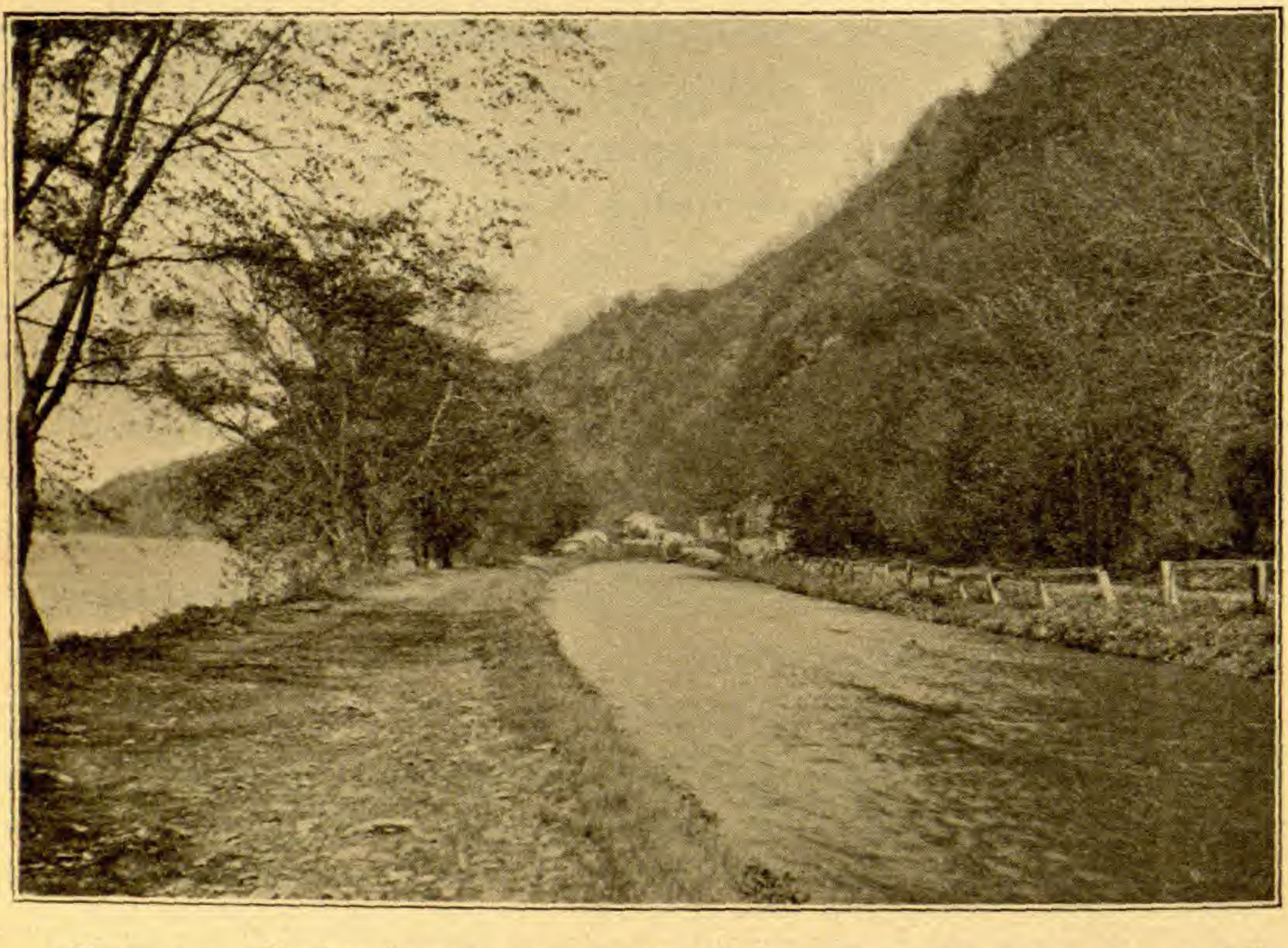

FIGURE 2. Nockamixon Rocks, Bucks County, Pa. General view of cliffs, canal, and Delaware River, looking east.

geologic horizon in the lower part of the Pottstown shales. The whole country hereabouts, elevated between 300 and 400 feet, is a table-land covered with trap rubbish and goes by the name of "the swamp" from the undrained condition of the soil, which is cold, wet, and unproductive. The whole series of New Red rocks comprises at least five subdivisions, beginning at the top, viz., the Pottstown; the Perkasie shales, 2000 feet thick; the Lansdale shales, 4700 feet; the Gwynedd shales, 3500 feet; and the Norristown shales, 6100 feet in thickness. The Nockamixon Rocks consist of shales of the second subdivision, viz., the Perkasie shales. These shales are comparatively hard, mostly green, dark red, or gray in color. Fossil traces of plants and animals occurring in these beds and mentioned by Professor Newberry, though few and imperfect, would seem to show that the shales are Jurassic.* The land underlaid by the Perkasie shales is generally less fertile than that of the neighboring red shales above (Pottstown) and below (Lansdale).

PLANT FORMATIONS OF THE CLIFFS

The vegetation of the cliffs may be considered conveniently as it covers the talus slope, the precipitous rock faces, the sides of the ravines, and the crest of the escarpment. As the contour lines of the map will show, the upper part of the cliffs slopes away from the edge of the precipice until the crest is reached. The vegetation of the talus is a part of that characteristic of the Piedmont Region and it therefore belongs to the

Deciduous Forest Formation

The constitution of this formation on the rocks depends upon the historic development of the flora which in all probability occupied the ground when the surrounding country was covered with a forest similar to that which now exists farther north in the Catskill and Adirondack mountains. So that the facies, as it exists here along the Delaware River, is a fragment or remnant of a more extensive forest which exists in a climate somewhat colder than that of the Bucks County of to-day. The tree and associated vegetation of the talus slopes is as follows (FIGURES 2, 3, 4, and 5):

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* Lyman, Benjamin Smith. Report on the New Red of Bucks and Montgomery counties. Summary description of the geology of Pennsylvania. Final report Geological Survey of Penna. 3: 2589–2638. 1895.

TALUS VEGETATION

FACIES SPECIES: *Fagus americana* (*F. grandifolia*), *Acer Saccharum*, *Betula lenta*.

DOMINANT SPECIES: *Tilia americana*, *Ulmus americana*, *Quercus Prinus*, *Ulmus racemosa*, *Fraxinus americana*, *F. pubescens* (*F. pennsylvanica*), *Acer rubrum*, *Carpinus caroliniana*, *Ostrya virginiana*, *Juglans cinerea*, *J. nigra*.

UNCOMMON SPECIES: *Acer nigrum* (*A. Saccharum*, var. *nigrum*), *Morus rubra*, *Celtis occidentalis*, *Robinia Pseudo-acacia*.

GREGARIOUS SPECIES: *Tsuga canadensis*, *Juniperus virginiana*.

RARE SPECIES: *Betula nigra*, *Liriodendron Tulipifera*.

VERY RARE TREES: *Castanea dentata*, *Platanus occidentalis*. The absence of the white oak, *Quercus alba*, and the almost entire absence of the chestnut, *Castanea dentata*, and the tulip tree, *Liriodendron Tulipifera*, are noteworthy. The facies, consisting of beech, sugar maple, and cherry birch, suggests a similar one in the Catskill and Adirondack mountains, which I have denominated elsewhere * the beech-maple-birch facies.

SECONDARY TREE SPECIES (underwood): The secondary species of the talus are those which can grow under the leafy canopy of the dominant trees of the forest. Such are *Acer pennsylvanicum*, *Prunus americana*, *P. virginiana*, *P. serotina*, *Hamamelis virginiana*, and *Rhododendron maximum*, which occurs in association thickets.

SHRUBBY UNDERGROWTH (third layer = Niederwuchs): The species are arranged in the order of their prevalence, as follows: *Taxus canadensis*, *Hydrangea arborescens*, *Acer spicatum*, *Staphylea trifolia*, *Physocarpus opulifolius*, *Diervilla trifida* (*D. Lonicera*), *Viburnum acerifolium*, *Cornus circinata*, *C. paniculata*, *Rubus odoratus*, *R. occidentalis*, and *Sambucus racemosa*. The yew forms extensive matted growths on the rough talus slopes and is one of the most abundant of the plants which are found as an undergrowth in the forest. It occurs also on the upper cliff slopes near the crest. Here and there along the road at the edge of the forest are colonies of the staghorn sumach, *Rhus typhina*. It is hardly to be included as a component of the natural vegetation of

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* Harshberger, John W. The plant formations of the Adirondack Mountains, Torreya **5**: 187–194. 1905. The plant formations of the Catskills, The Plant World **8**: 276–281. 1905.

the talus slope. The woody vines, or lianes, which form a part of the Deciduous Forest Formation may be enumerated in the order of their importance.

LIANES: *Ampelopis quinquefolia*, *Rhus radicans*, *Vitis Labrusca*, *V. aestivalis*, *V. cordifolia*, *V. vulpina*, *Celastrus scandens*, *Clematis virginiana*, *Menispermum canadense*, *Lonicera grata* (*L. Caprifolium*). Some of these ascend the rock faces, others reach the light by climbing the forest trees.

TREE MOSSES: The following mosses and hepatics, according to Lydia P. Borden, occur on the trunks and projecting roots of the forest trees. Near the base are found *Geocalyx graveolens*, *Lophocolea heterophylla*, *Dicranella heteromalla*, *Bryum roseum*, and, elsewhere, *Frullania eboracensis*, *Anomodon apiculatus*, *A. rostratus*, and *A. attenuatus*.

The forest floor is occupied by herbaceous plants which are commonly associated with the broad-leaved forest trees throughout the Piedmont Region. But it should be remarked here, that the numerical preponderance of certain of these herbs is to be accounted for by the peculiar habitat surroundings, as well as by the composition of the characteristic tree facies.

HERBACEOUS SPECIES (fourth, or ground layer): The classification of the herbaceous species of the forest is a difficult matter for several methods might be adopted according to the viewpoint of the observer. The following groups are adopted to arrange the herbs in the formation under consideration:

ABUNDANT FERNS: *Dryopteris marginalis*, *Polystichum acrostichoides*, *Adiantum pedatum*. Each of these ferns forms clumps on the forest floor. The first two species remain green during winter, while *Adiantum pedatum* is destroyed with the first sharp frost.

ROCK FERNS: *Polypodium vulgare* (abundant), *Cystopteris bulbifera* (not common), *Camptosorus rhizophyllus* (frequent on rock faces), *Asplenium Trichomanes*.

COMMON FERNS: *Asplenium ebeneum* (*A. platyneuron*), *Phegopteris hexagonoptera*, *Dennstaedtia punctilobula*, *Lycopodium clavatum*, *L. complanatum*, *Botrychium obliquum*, *B. virginianum*.

ABUNDANT HERBS: *Laportea canadensis*, *Impatiens fulva* (*I. biflora*), *Polygonatum biflorum*, *P. giganteum* (*P. commutatum*), *Smilacina racemosa*, *Asarum canadense*, *Mitella diphylla*, *Sangui-*

naria canadensis, *Aquilegia canadensis* (on the talus and on rocks), *Geranium Robertianum*, *Viola canadensis*, *Cimicifuga racemosa*.

SECONDARY HERBS: *Trillium erectum*, *T. cernuum*, *Thalictrum purpurascens*, *T. dioicum*, *T. polygamum*, *Hydrophyllum canadense*, *H. virginicum*, *Eupatorium ageratoides* (*E. urticaefolium*), *Parietaria pennsylvanica*, *Aralia racemosa*, *A. trifolia*, *Osmorrhiza brevistylis*, *Zizia cordata*, *Thaspium aureum*, *Cryptotaenia canadensis*, *Viola striata*, *V. blanda*, *V. cucullata*, *V. palmata*, *Galium Aparine*, *G. triflorum*, *Helianthus decapetalus*, *Aster cordifolius*, *Cerastium arvense* var. *oblongifolium*, *Actaea alba*.

WINTERGREEN SPECIES: On October 23, 1908, the writer observed the following species of the talus slopes which are the most important elements of the wintergreen flora: *Taxus canadensis*, *Asarum canadense*, *Geranium Robertianum* (in flower), *Carex platyphylla*, *Saxifraga pennsylvanica*, *Dryopteris marginalis*, *Polystichum acrostichoides*, *Polypodium vulgare*, *Tsuga canadensis*, and *Rhododendron maximum*, which the writer has shown elsewhere takes advantage of every mild, sunny day during the winter to manufacture starch and other organic products.

TALUS AND CLIFF ROCK MOSSES: The mosses and hepatics that grow on the talus and cliff rocks are: (Hepaticae), *Conocephalum conicum*, *Marchantia polymorpha*, *Pellia epiphylla*, *Geocalyx graveolens*, *Lophocolea heterophylla*, *Plagiochila asplenioides*, *Porella platyphylla*, *Scapania nemorosa;* and (Musci) *Catharinea angustata*, *C. undulata*, *Pogonatum brevicaule*, *Polytrichum commune*, *Webera sessilis*, *Fissidens osmundioides*, *F. bryoides* (wet and damp places), *Ceratodon purpureus*, *Dicranella heteromalla*, *D. h. Fitzgeraldi*, *D. scoparium*, *Ditrichum tortile*, *D. pallidum*, *Leucobryum glaucum*, *Weisia viridula*, *Funaria hygrometrica*, *Aulacomnium heterostichum*, *Bartramia pomiformis*, *Bryum argenteum*, *B. caespiticium*, *B. roseum*, *Mnium affine*, *M. punctatum*, *M. rostratum*, *M. sylvaticum*, *Anomodon apiculatus*, *A. rostratus*, *A. attenuatus*, *Thuidium delicatulum*, *Cirriphyllum Boscii*, *Hylocomium proliferum*, *H. triquetrum*, *Climacium americanum*, and *C. dendroides*.

The following list of additional plants arranged by families was furnished me by Dr. S. P. Seese, of Lansdale, Pennsylvania. All of them grow on the talus slopes of the Nockamixon Rocks.

Arisaema triphyllum,
" *Dracontium,*
Medeola virginiana,
Erythronium americanum,
Oakesia sessilifolia,
Uvularia perfoliata,
Allium tricoccum,
Liparis liliifolia (rare),
Orchis spectabilis,
Habenaria lacera,
Cypripedium pubescens,
Aristolochia Serpentaria,
Claytonia virginica,
Anemone nemorosa,
Hepatica triloba,
Anemonella thalictroides,
Hydrastis canadensis (now extinct),
Podophyllum peltatum,
Caulophyllum thalictroides,
Dicentra Cucullaria,
" *canadensis* (present years ago),
Corydalis glauca,
" *aurea,*
Dentaria laciniata,
" *diphylla,*
Arabis laevigata,
" *perfoliata* (*A. glabra*),
canadensis,
Gillenia trifoliata,
Vicia americana,
Amphicarpa monoica,
Epilobium coloratum,
Circaea lutetiana,
Sanicula marilandica,
Thaspium barbinode,
Pyrola rotundifolia,
Monotropa uniflora,
Gentiana quinquefolia,
Obolaria virginica,
Asclepias tuberosa,
" *purpurascens,*
" *phytolaccoides,*
Polemonium coeruleum (*P. Van Bruntiae*),
Cynoglossum officinale,
Mertensia virginica,
Myosotis palustris (*M. scorpioides*),
Lophanthus nepetoides,
Teucrium canadense,
Scutellaria lateriflora,
" *pilosa,*
Pentstemon laevigatus var. *digitalis,*
Pedicularis canadensis
Epiphegus virginiana
Veronica virginica,
" *scutellata,*
" *officinalis,*
" *serpyllifolia,*
" *peregrina,*
Triosteum perfoliatum,
Mitchella repens,
Galium circaezans,
Campanula americana,
Lobelia spicata,
" *inflata,*
Aster oblongifolius,
" *Novae-Angliae,*
" *laevis,*
" *vimineus,*
Erigeron bellidifolius (*E. pulchellus*),
" *philadelphicus,*
Eupatorium purpureum,
Helianthus decapetalus,
Solidago speciosa,
" *nemoralis.*

RAVINE VEGETATION

The trees and shrubs which extend into the ravines are essentially broad-leaved species which form a constituent part of the

Deciduous Forest Formation. The composition of the vegetation of the ravines is somewhat different from that of the talus slope, indeed, the dominant trees found in the glens are so associated as to form a distinct facies of the formation. As the flora of the ravines differs somewhat in each case, it will be considered with reference to the particular gully in which it occurs. The most characteristic ravine is one which cuts back into the middle portion of the cliffs. A stream cascades over precipitous rocks covered with mosses and liverworts, among them *Marchantia polymorpha*. The tree vegetation is as follows:

FACIES: *Tilia americana*, *Ulmus americana*.

DOMINANT ASSOCIATED SPECIES: *Quercus Prinus*, *Acer Saccharum*, *Ostrya virginiana*.

SHRUBBY UNDERGROWTH (Niederwuchs): *Taxus canadensis* (covering slopes extensively), *Hydrangea arborescens*, *Physocarpus opulifolius*, *Rubus odoratus*, *Celastrus scandens*.

HERBS OF FOREST FLOOR: The soil of the ravine slopes is utilized in the growth of *Asarum canadense*, *Impatiens fulva* (*I. biflora*), *Chelone glabra*, *Solidago flexicaulis* (*S. latifolia*), *Eupatorium ageratoides* (*E. urticaefolium*).

ROCK HERBS: The characteristic rock flora of these ravines includes *Aquilegia canadensis*, *Campanula rotundifolia*, *Arabis lyrata*, *Geranium Robertianum*, *Heuchera americana*, *Cerastium arvense* var. *oblongifolium*, *Saxifraga pennsylvanica*, *Lonicera grata* (*L. Caprifolium*), *Agrostis scabra* (*A. hyemalis*), *Polypodium vulgare*, *Camptosorus rhizophyllus*, *Celastrus scandens*, *Salix cordata*, *Physocarpus opulifolius*.

The most western ravine is filled with such an association of trees that a new facies may be said to exist.

FACIES: *Acer Saccharum*, *Fagus americana*, *Tsuga canadensis*. These trees comprise the maple-beach-hemlock facies.

ASSOCIATED TREES: Here grow in association such dominant trees as *Tilia americana*, *Betula lenta*, *Quercus Prinus*, *Morus rubra*, and *Acer rubrum*. The hemlock, *Tsuga canadensis*, is not sufficiently abundant to constitute a formation, but it is mixed with the broad-leaved trees in such proportion as to necessitate its inclusion in the deciduous forest proper. Associated with these trees as an *undergrowth* are found *Taxus canadensis* (abundant), *Hydran-*

gea arborescens, *Rhododendron maximum* (in thickets), *Viburnum acerifolium*, and the Virginia creeper, *Ampelopsis quinquefolia*.

SHADE HERBS : The herbs that grow in the dense shade are *Pilea pumila*, *Laportea canadensis*, *Hepatica triloba*, *Thalictum purpurascens* (*T. revolutum*), *Mitella diphylla*, *Smilacina racemosa*, *Maianthemum canadense*, *Impatiens fulva* (*I. biflora*), and *Adiantum pedatum*, which occupies the outcropping rock masses. As this ravine is ascended, the woods become drier and the hill slopes more gradual and the ravine vegetation fuses with that of the crest.

The valley back of the Narrowsville Hotel is characterized by a stream the flat banks of which show the presence of *Juglans cinerea*, *Fraxinus americana*, *Carpinus caroliniana*, *Betula lenta*, *Tilia americana*, *Liriodendron Tulipifera* (sparingly), and such shrubs as *Amelanchier canadensis*, *Lindera Benzoin* (*Benzoin aestivale*), *Hydrangea arborescens*, and *Rubus occidentalis*. On the slopes above a small waterfall are assembled *Dryopteris marginalis*, *Polystichum acrostichoides*, *Asarum canadense*, *Aquilegia canadensis*, *Impatiens fulva* (*I. biflora*), while on the steep rocks overhanging the stream are found the walking fern, *Camptosorus rhizophyllus* and the columbine, *Aquilegia canadensis*.

In the bottom of another ravine, the forest consists of such trees as *Acer Saccharum*, *Fagus americana* (*F. grandifolia*), *Quercus coccinea*, and, sparingly, *Liriodendron Tulipifera*. The shrubs are *Hamamelis virginiana*, *Corylus americana*, *Hydrangea arborescens*, *Rubus odoratus*, *Lindera Benzoin* (*Benzoin aestivalis*), *Sambucus racemosa*, and *Viburnnm acerifolium*. The yew, *Taxus canadensis*, forms extensive masses, as elsewhere on the cliffs, while the marginal shield fern occurs in extensive patches. The forest floor is occupied by a covering of quite a few characteristic herbaceous plants, such as *Sanguinaria canadensis*, *Smilacina racemosa*, *Arisaema triphyllum*, *Asarum virginicum*, *Adiantum pedatum*, *Botrychium virginianum*, and on the rocks dripping with water occur the moss *Eurynchium hians* and the liverwort *Marchantia polymorpha*. Lower down, where the stream breaks over a rock face about 15 feet high, the ravine narrows and the hemlock, *Tsuga canadensis*, becomes more abundant, associated with *Betula lenta* and *Acer Saccharum* to form a facies (the maple-birch-hemlock facies), including *Quercus rubra*, *Rhododendron maximum*, *Corylus americana*, *Hy-*

drangea arborescens, *Acer spicatum*, *Taxus canadensis*, and the jewel weed, *Impatiens fulva*, together with the ferns, *Polystichum acrostichoides* and *Polypodium vulgare*, which adorn the tops of the projecting slate rocks. *Ampelopsis quinquefolia* drapes the mossy rocks of the ravine. The distribution of the mosses on the rocks is determined by the places where in midsummer the last water is found, in small trickling streams affording sufficient moisture to keep the mosses alive, while the rock-faces, where the stream, when full, falls over the slopes, are practically without any mossy covering.

RAVINE ROCK MOSSES: The mosses and hepatics found on the rocks of the ravines, according to Lydia P. Borden, are: (Hepaticae) *Marchantia polymorpha*, *Conocephalum conicum*, *Pellia epiphylla*, *Metzgeria conjugata*, *Cephalozia curvifolia*, *Lophocolea heterophylla*, *Geocalyx graveolens*, *Odontoschisma prostratum*, *Scapania nemorosa*, *Plagiochila porelloides*, *P. asplenioides*, *Porella platyphylla*; and (Musci), *Catharinea undulata*, *Fissidens bryoides*, *Dicranella heteromalla*, *Funaria hygrometrica*, *Aulacomnium palustre*, *Philonotis fontana* (wet rocks), *Bryum argenteum*, *B. roseum*, *B. caespiticium*, *Mnium sylvaticum*, *M. punctatum*, *Anomodon apiculatus*, *A. rostratus*, *A. attenuatus*, *Thuidium delicatulum*, *Climacium americanum*, *C. dendroides*, *Cirriphyllum Boscii*, and *Plagiothecium denticulatum*.

In addition to the species mentioned in the above description, the ravine flora includes, according to Dr. S. P. Seese, of Lansdale, Pennsylvania:

Osmunda regalis,
" *cinnamomea*,
Asplenium Filix-foemina,
Dryopteris noveboracensis,
" *spinulosa*,
" *spinulosa* var. *intermedia*,
" *simulata*,
Corallorhiza odontorhiza,
Goodyera pubescens,
Adlumia cirrhosa (*A. fungosa*),
Cercis canadensis,
Cornus alternifolia,
Kalmia latifolia,
" *angustifolia*,
Senecio obovatus,
Nabalus altissimus.

SUMMIT-SLOPE AND CLIFF-CREST VEGETATION

Ascending the hills back of the Narrowsville Hotel, the botanist encounters a forest which covers the slopes up to the crest of the hill. Here the woods consist of such trees as *Quercus Prinus*, *Q. coccinea*, *Q. rubra*, *Q. alba* (rare), *Fagus americana* (*F. grandifolia*), *Tsuga canadensis*, *Acer rubrum*, *Betula lenta*, *Carya porcina* (*Hicoria glabra*), *Hamamelis virginiana*, and *Viburnum dentatum*, and in dry rocky situations a facies is formed of red cedar, *Juniperus virginiana*. The woody vines of these woods are *Ampelopsis quinquefolia*, *Rhus radicans*, *Vitis Labrusca*, and *Celastrus scandens*. *Ceanothus americanus*, the New Jersey tea, forms pure associations in open places well lighted by the sun.

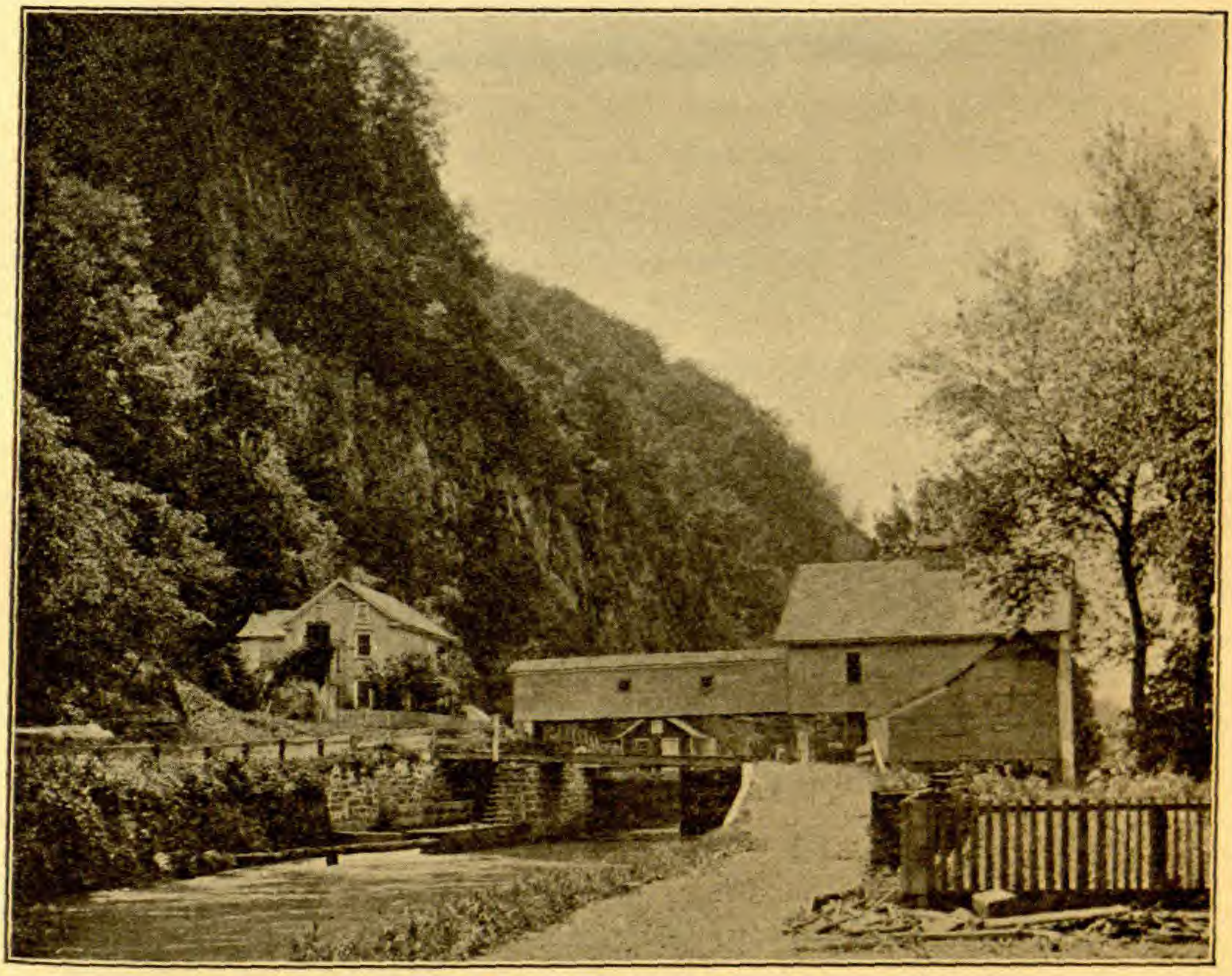

FIGURE 3. Talus slopes, precipitous rocks, and summit slopes showing the Deciduous Forest Formation.

Reaching the head of a large ravine, the character of the woods changes somewhat, merging into the cliff-crest vegetation. Prominent in this transition forest are *Quercus Prinus*, *Castanea dentata* (the only place where the chestnut is prominent), *Quercus rubra*, *Acer Saccharum*, and as secondary species, *Hamamelis virginiana*, *Viburnum acerifolium*, and the herb *Cunila Mariana* (*C. origanoides*). This is a forest growth which connects the facies of the talus slope with the tree growth and other vegetation, which typically covers the crest slopes above the precipitous rocks below. All along the cliffs just back of the crest slope are cultivated fields where the gullies cut back into the tableland, so that the crest flora forms a narrow fringe which is continuous with the slopes that gradually dip to the precipices below. The soil of these slopes (FIGURES 3 and 5) is edaphically dry and the tree vegetation is conditioned largely by the character of the underlying substratum.

FACIES: The steeper slopes where the crest flora is most typically developed are occupied by *Quercus Prinus* (the most abundant tree), *Ulmus americana*, *Ostrya virginiana*, *Acer Saccharum*, *Quercus rubra*, *Rhododendron maximum* (on the steepest slopes).

The rocks which jut out beyond the general crest (FIGURE 5) and from which the escarpment falls abruptly to the river below are tenanted by such trees as *Quercus rubra*, *Q. tinctoria* (*Q. velutina*), *Q. Prinus*, *Ostrya virginiana*, *Betula lenta*, *Cornus florida*, and at the extreme edge are found wind-tossed forms of the red cedar, *Juniperus virginiana*. Perhaps such vegetation should be included as a part of the Rock-Cliff Formation, later to be described. Before considering that formation it should be mentioned that at one point the soil of the tableland is too barren for profitable cultivation of agricultural crops, although the attempt was made years ago to till these barren fields. The abandoned fields are grown up to *Pinus rigida* and *Juniperus virginiana*, dotted over in an open formation (park-like); associated with *Ceanothus americanus* and *Rhus typhina*, together with various weeds.

DOMINANT TREE SPECIES: *Tilia americana*, *Acer rubrum*, *Carya alba* (*Hicoria ovata*), *Nyssa sylvatica*, *Sassafras officinalis*, *Prunus serotina*, *Fraxinus americana*, *Castanea dentata* (rare), *Pinus Strobus* (rare), and *Populus grandidentata*.

SECONDARY UNDERGROWTH SPECIES: The brinks of the precipices (FIGURE 3) show masses of the yew, *Taxus canadensis*, together with *Diervilla trifida* (*D. Lonicera*), *Gaylusaccia frondosa*, *G. resinosa* (*G. baccata*), *Ribes rubrum*, *R. rotundifolium*, *Physocarpus opulifolius*, and *Lonicera grata* (*L. Caprifolium*). In addition the crest is occupied by *Amelanchier canadensis*, *Hamamelis virginiana*, *Staphylea trifolia*, *Viburnum dentatum*, *V. pubescens*, and *Celastrus scandens*.

LIANES: The trees are festooned with such vines as *Vitis cordifolia*, *V. Labrusca*, *Clematis virginiana*, *Smilax rotundifolia*, and *Menispermum canadense*.

HERBACEOUS CREST SPECIES: The ground under the above-mentioned trees and shrubs is covered by *Impatiens fulva* (*I. biflora*), *Smilacina racemosa*, *Arisaema triphyllum*, and *Sedum Telephium* (*S. purpureum*), which retains its green color as late as November, and in addition the botanist finds the plants in the list below.

FIGURE 4. Details of Rock Cliff Plant Formation with the Deciduous Forest Formation to the right, covering the talus slopes.

CREST ROCK MOSSES: According to Lydia P. Borden, the crest rocks are characterized by *Catharinea angustata*, *Polytrichum commune*, *P. piliferum*, *Leucobryum glaucum*, *Weisia viridula*, *Funaria hygrometrica*, *Bryum roseum*, *Mnium sylvaticum*, *Cirriphyllum Boscii*, *Climacium americanum*, and *C. dendroides*.

LIST OF ADDITIONAL CREST HERBS (furnished by Dr. S. P. Seese)

Selaginella rupestris,
Smilax herbacea,
Lilium philadelphicum,
Hypoxis erecta,
Spiranthes gracilis,
" *cernua*,

Comandra umbellata,
Polygonum tenue,
Silene stellata,
Anemone virginiana,
Arabis canadensis,
Spiraea salicifolia,
Fragaria virginiana,
“ *vesca*,
Apios tuberosa,
Baptisia tinctoria,
Tephrosia virginiana,
Oxalis violacea,
“ *stricta*,
Linum virginianum,
Polygala sanguinea,
“ *verticillata*,
Acalypha virginica,
Hypericum ellipticum,
Lechea major (*L. villosa*),
“ *minor*,
Viola sagittata,
“ *pubescens*,
“ *fimbriatula*,
“ *scabriuscula*,
Cuphea viscosissima (*C. petiolata*),
Ipomoea Quamoclit,
“ *pandurata*,
Pimpinella Saxifraga,
Lithospermum arvense,
Trichostema dichotomum,
Cunila Mariana (*C. origanoides*),
Pycnanthemum lanceolatum,
Hedeoma pulegioides,
Monarda fistulosa,
“ *punctaia*,
Gerardia flava,
Melampyrum americanum,
Sicyos angulatus,
Aster corymbosus (*A. divaricatus*),
Aster macrophyllus,
“ *patens*,
“ *cordifolius*,
“ *sagittifolius*,
“ *multiflorus*,
“ *prenanthoides*,
Eupatorium ageratoides (*E. urticaefolium*),
Helianthus divaricatus,
“ *strumosus*,
Hieracium canadense,
“ *paniculatum*,
“ *scabrum*,
“ *venosum*,
Sericocarpus conyzoides (*S. asteroides*),
Solidago bicolor,
“ *caesia*,
“ *latifolia*,
“ *rugosa*.

The following additional species, not allocated to any of the various habitats previously mentioned, are characteristic of the dry woods, Nockamixon Rocks, according to Dr. Seese, who has botanized here over forty years:

Anychia dichotoma (*A. polygonoides*),
Geum album
“ *virginianum*,
Agrimonia Eupatoria (*A. gryposepala*),
“ *parviflora*,
Desmodium nudiflorum,
Desmodium acuminatum (*D. grandiflorum*),
“ *canescens*,
“ *viridiflorum*,
Lespedeza procumbens,
“ *capitata*,
“ *Nuttallii*,
“ *violacea*.

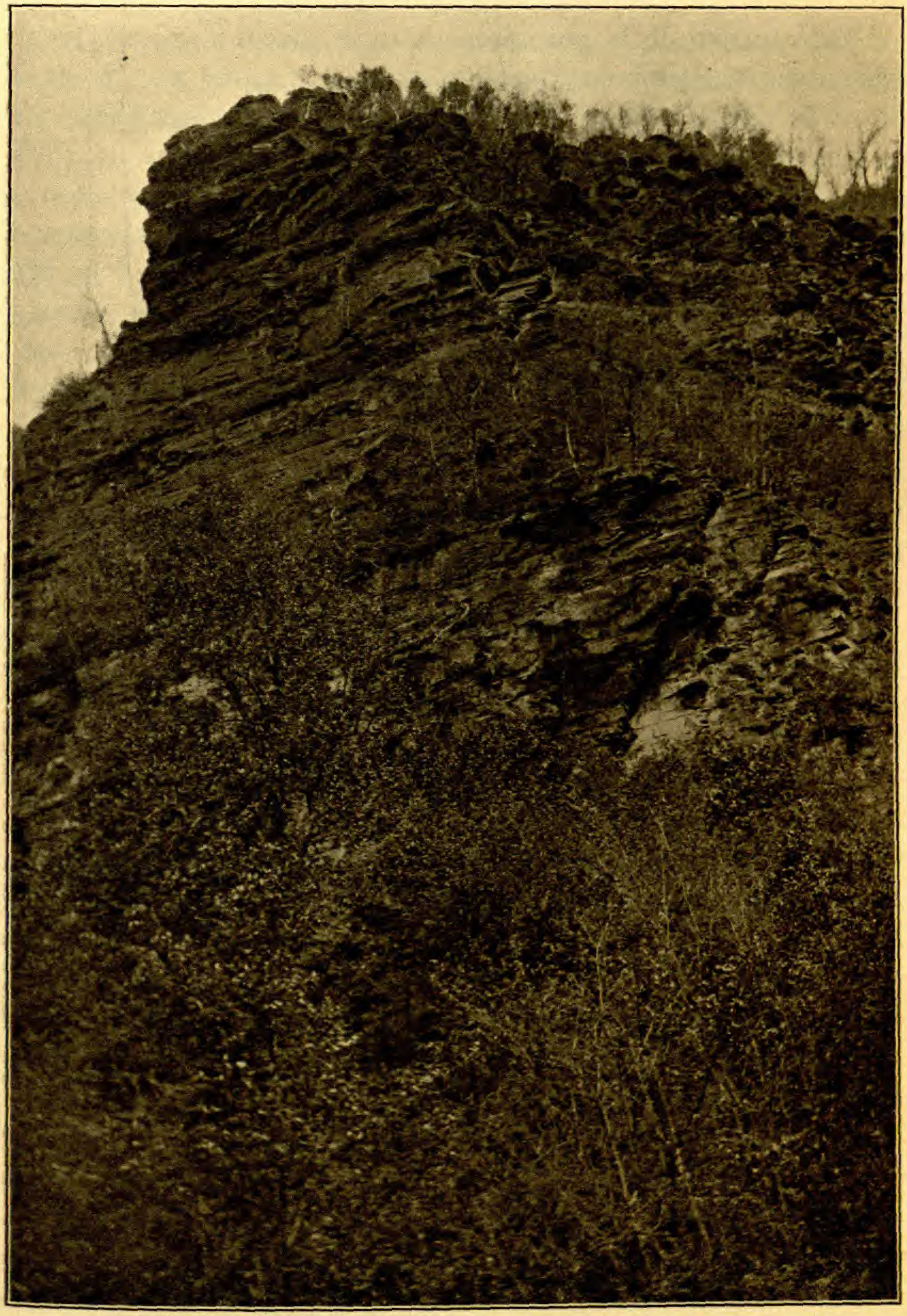

FIGURE 5. Top Rock, Delaware Narrows, showing Deciduous Forest Formation of the talus slopes, the Rock-cliff Plant Formation and the xerophytic deciduous forest covering the almost bare rocks of the summit.

Rock-cliff Formation

The escarpment is precipitous in most places along the entire front of the Nockamixon Rocks (FIGURES 2, 3, 4, and 5). Some of the cliffs rise as a sheer wall for a distance of 300 feet above the country road at their base. The face of the precipice is irregular owing to the numerous clefts, pockets and shelves, or platforms which are found at various elevations and in various positions and exposures (FIGURES 4 and 5). The pockets are formed by the falling of masses of rock. The shelves are flat ledges running along the face of the precipice (FIGURE 5). One such shelf runs at least two thousand feet in an upward sloping direction toward the west. In places, it is ten feet wide, in other places it narrows down to a width of one or two feet. The smaller ledges are occupied by grasses and other herbaceous plants, while the larger projecting flats accommodate various trees, shrubs, and lianes which climb up the vertical rock surfaces.

VEGETATION OF LARGER ROCK SHELVES: The vegetation of the long shelf just mentioned consists of such trees as *Ostrya virginiana*, *Celtis occidentalis*, *Ulmus americana*, *Acer Saccharum*, *Juniperus virginiana* (abundant), *Juglans cinerea*, *Quercus rubra*, *Prunus virginiana*, *Hamamelis virginiana*, *Tilia americana*, and *Prunus serotina*, while the most characteristic shrub is *Physocarpus opulifolius*. Other shrubs are associated with the trees and the nine-bark, viz., *Rubus occidentalis* (in sunny exposures), *Rubus odoratus*, *Taxus canadensis* (in dense masses), *Staphylea trifolia*, *Sambucus racemosa*, and on small rock shelves, *Lonicera grata* (*L. Caprifolium*). In the shade of the trees grow clumps of *Dryopteris marginalis*, *Impatiens fulva* (*I. biflora*), *Smilacina racemosa*, *Hepatica triloba*, and *Aquilegia canadensis*. The unshaded rock exposures are characterized by *Pentstemon hirsutus* (*P. pubescens*), *Heuchera americana*, *Achillea Millefolium*, *Linaria vulgaris*, *Verbascum Thapsus*, *Cerastium arvense* var. *oblongifolium*, *Aquilegia canadensis*, *Geranium Robertianum*, *Saxifraga virginiensis*, and *Nepeta Cataria*.

West of the main outlook, the rocks present a series of easily descended, serially arranged shelves (FIGURE 5), each occupied by an association of plants. *Phlox subulata* grows in masses on the bare shale rock, while the broad rock shelves here are occupied by *Amelanchier canadensis*, *Rubus canadensis*, *R. hispidus*, *R. strigosus*, *Rhus typhina*, *Fraxinus pubescens*, *Populus grandidentata* (rare), *Betula lenta*, *Ostrya virginiana*, *Aster cordifolius*, *Baptisia tinctoria*, and *Sedum Telephium* (*S. purpureum*). The lianes begin their growth on a shelf, or in a rock pocket and ascend the cliffs, as if directed on a trellis. Such are *Ampelopsis quinquefolia*, *Vitis cordifolia*, and *Rhus radicans*. Near the top of the cliffs on some shelves (FIGURE 5) sheltered by the overhanging rocks and associated with *Campanula rotundifolia*, *Anemone pennsylvanica*, *Chelone glabra*, *Steironema ciliatum*, *Salix cordata*, *Physocarpus opulifolius*, *Maianthemum canadense*, *Polypodium vulgare*, and *Geranium Robertianum*, grows the most unique plant of the Nockamixon Rocks, viz., *Sedum Rhodiola* (*S. roseum*). This plant, which grows on the bare shale rock, is anchored by thick, succulent, coral-like, branching rhizomes, which give rise in summer to the grayish green leaves and small yellowish green flowers. Each season the leaves fall from the plant, and the bare rhizomes, with the additional annual growth, perennate until the next growing season. The writer measured one plant with a rhizome six inches long and with roots that penetrated the rock crevices over two feet. This plant is perhaps most abundant beneath the shelving rocks at the head of one of the ravines, which is kept cool by the currents of air which strike the rocks in such a direction as to be deflected into the rocky amphitheater at the head of the glen, where the roseroot grows so abundantly. On several hot days last summer, the temperature was perceptibly lower in the shadow of the beetling cliffs, fanned by the breezes, which blew into the glen from the north. In all probability, *Sedum Rhodiola* (*S. roseum*) is a relict of the time when the climate was much colder than now — a time characterized by the retreat of the glacial ice sheets that covered the headwaters of the Delaware River. The present distribution of the plant supports this view, because it occurs in Greenland and Labrador, on the high alpine peaks from Alberta and Alaska to Colorado and California (altitude 9,000–14,000 feet), also along the coast to rocky islands and cliffs in eastern Maine * and locally at Chittenango Falls, New York, on the high cliff off Port Jervis, Wayne County, Pennsylvania, and the

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* Cushman, Joseph A. Some interesting Maine plants. Rhodora 11 : 12. 1909.

Nockamixon Rocks, Pennsylvania. Its preservation on the Nockamixon cliffs is probably due to two factors, viz., the coolness of the habitat under the rocks at the head of the glen with a northern exposure and the isolation or inaccessibility of the shelves upon which the plant grows.

VEGETATION OF THE SMALLER ROCK SHELVES: The vegetation of the smaller rock shelves varies (FIGURE 4). One shelf is occupied by *Cerastium arvense* var. *oblongifolium*, another by *Geranium Robertianum*, another is fringed with a grass, *Muhlenbergia tenuiflora* (*M. Willdenowii*). Still other shelves are characterized by *Poa debilis*, *Oryzopsis melanocarpa* (*O. racemosa*), *Anemone virginiana*, *Potentilla canadensis*, *Heuchera americana*, *Saxifraga virginiensis*, *Galium boreale*, *Solidago caesia*, while *Physocarpus opulifolius* and *Juniperus virginiana* are found occasionally on the cliff face in rock pockets.*

PLANTS OF THE CREVICES AND ROCK POCKETS: The characteristic plants of the rock crevices and smallest rock depressions (FIGURE 4), apparently growing out of the precipice itself, are: *Dryopteris marginalis*, *Asplenium Trichomanes*, *Polypodium vulgare*, *Cystopteris fragilis*, *Woodsia ilvensis*, *W. obtusa*, *Aquilegia canadensis*, *Cerastium arvense* var. *oblongifolium*, *Arabis lyrata*, *A. laevigata*, *Geranium Robertianum*, *Heuchera americana*, *Verbascum Thapsus*, and *Campanula rotundifolia*. The species seize every vantage ground and it is surprising to find how their roots can penetrate and hold fast to a narrow crack, or fissure, in the face ot the smooth rock faces.

WEED VEGETATION

NATIVE MIGRANTS: The native plants which have left their original habitats and have spread along the roadside form an element of the vegetation which illustrates what species have adapted themselves to the new environmental conditions. The species of composite plants owe their spread to the light fruits which are wind-distributed.

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*The writer wishes to state with reference to the identification of the plants mentioned in this and other of his phyto-geographic papers that the following plan is pursued. If he feels no doubt as to the identity of the plant, it is noted in the field notebook; if he is in doubt, a specimen is collected, tagged, and identified at field headquarters by means of some manual · and, if unable after such study to name the plant, a specimen is dried for more careful study with herbarium material at hand.

Cystopteris fragilis,
Tradescantia virginiana,
Commelina nudiflora (*C. communis*),
Euphorbia maculata,
“ *Preslii*,
“ *hirsuta*,
Crotalaria sagittalis,
Cassia marilandica,
“ *Chamaecrista*,
“ *nictitans*,
Lysimachia quadrifolia,
“ *Nummularia*,
Castilleja coccinea,
Nepeta Glechoma (*N. hederacea*),
Leonurus Cardiaca,
Lamium maculatum,
Aster multiflorus,
“ *dumosus*,
Eclipta alba,
Helenium autumnale,
Mikania scandens,
Solidago lanceolata (*S. graminifolia*),

INVADING WEED SPECIES: The original formations have been disturbed but little by the invasion of weed species, because the original vegetation has remained in possession of the rocks and talus slopes and, therefore, the formations are closed ones in the phytogeographic sense. The following species of foreign introduction are elements which might strongly alter the existing formations, if not held in check by the native vegetation. However, it is important to recognize this element and enumerate the species belonging to it. The species in small capitals were introduced by the early Pennsylvania German settlers, who cultivated them.

Urtica dioica,
HUMULUS LUPULUS
Rumex crispus,
“ *obtusifolius*,
“ *Acetosella*,
Polygonum orientale,
“ *Persicaria*,
FAGOPYRUM ESCULENTUM,
Chenopodium album,
“ *Botrys*,
Amaranthus retroflexus,
Phytolacca decandra,
Mollugo verticillata,
Dianthus Armeria,
“ BARBATUS (established for years),
Saponaria officinalis,
Lychnis vespertina (*L. alba*),
Agrostemma Githago,
Stellaria media,
Cerastium vulgatum,
Portulaca oleracea,
Ranunculus bulbosus,
Helleborus niger (escaped),
Sisymbrium officinale,
Brassica nigra,
Capsella Bursa-pastoris,
Lepidium campestre,
Potentilla norvegica,
Trifolium arvense,
“ PRATENSE,
“ REPENS,
“ *procumbens*,
“ *agrarium*,
“ INCARNATUM,
Melilotus alba,
“ *officinalis*,
Medicago sativa,
LINUM USITATISSIMUM,
Malva rotundifolia,

Malva sylvestris,
Sida spinosa,
Hibiscus Trionum,
Abutilon Avicennae (*A. Theophrasti*),
Hypericum perforatum,
Daucus Carota,
PASTINACA SATIVA,
FOENICULUM OFFICINALE,
Echium vulgare,
Brunella vulgaris,
Lamium amplexicaule,
" *maculatum*,
Nepeta Cataria,
" *Glechoma* (*N. hederacea*),
MENTHA ROTUNDIFOLIA,
" *viridis* (*M. spicata*),
" *piperita*,
Verbena urticifolia,
" *hastata*,
Solanum Dulcamara,
Datura Stramonium,
Convolvulus arvensis,
Plantago lanceolata,
Valerianella olitoria (*V. Locusta*),
Dipsacus sylvestris,
Achillea Millefolium,
Anthemis Cotula,
" *arvensis*,
Arctium Lappa,
ARTEMISIA ABSINTHIUM (pretty well established),
Cirsium lanceolatum,
" *arvense*,
Chrysanthemum Leucanthemum,
" *Parthenium* (established),
Galinsoga parviflora,
TANACETUM VULGARE,
Taraxacum officinale.[*]

HISTORIC SKETCH

The Nockamixon Rocks have been visited by a number of local botanists, who have spent a day or two in the study of its interesting flora. Nothing has been published on this flora except a short note by E. Newlin Williams, entitled "Botanizing in the Delaware Narrows" which appeared in Meehan's Monthly, March, 1897, pages 43 and 44. The flora of the Rocks was first carefully studied by Professor Thomas C. Porter of Lafayette College, Easton, Pa. He was followed by Professor J. T. Rothrock, Dr. S. P. Seese, Dr. J. Bernard Brinton, Mr. Stewardson Brown, Dr. C. D. Fretz, who notes some of the Nockamixon plants in his "Flora of Bucks County," and by Dr. N. L. Britton. The Torrey Botanical Club and the Philadelphia Botanical Club made a joint excursion to the place on May 30, 1893, under the leadership of Professor Thomas C. Porter. The Botanical Society of Pennsylvania botanized here on Decoration Day, May 30, 1908, under the guidance of Dr. Samuel P. Seese of Lansdale, Pa. The writer has made three successive trips to the Narrows, viz., on May, 30, 1908, June 30, 1908 and October 23, 1908, several

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[*] Dr. S. P. Seese, of Lansdale, Pennsylvania, is authority for this list.

days being spent during June and early July in the collection of plants and in a study of the flora. Collections of Nockamixon plants repose in the herbaria of Lafayette College, Easton, Pennsylvania, of the Academy of Natural Sciences of Philadelphia, of the New York Botanical Garden, and of the University of Pennsylvania.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, PA.

Studies on the Rocky Mountain flora — XX

PER AXEL RYDBERG

Phacelia nervosa sp. nov.

Phacelia alpina Rydb. Fl. Colo. 283, in part, as to the Colorado specimens. 1906.

Perennial, with a short rootstock; stems decumbent at the base, 1–3 dm. high, more or less hirsute and with short grayish hairs intermixed; lower leaves with petioles 2–7 cm. long, simple or with a pair of smaller lobes on the petioles; blades lanceolate, 2–5 cm. long, acute, hirsute on both sides, veins rather strong beneath; upper leaves subsessile; inflorescence soon open; the racemes peduncled, in fruit 4–9 cm. long; calyx more or less tinged with purple, about as long as the corolla; sepals narrowly linear, acute, hirsute, with a strong midrib; corolla white or nearly so, pubescent, about 5 mm. long; filaments about twice as long as the corolla, slightly bearded at the base with short hairs; seeds lance-ovoid, 2.5 mm. long, brown, faveolate.

This was mistaken for *Phacelia alpina*, which it resembles in habit, but it differs in the longer and more open racemes, the longer calyx-lobes, which about equal the corolla and have a strong midrib, in the almost glabrous filaments, in the whitish instead of lilac corolla, and in the more acute seeds. It grows on high mountains at an altitude of 3000 m. or more.

COLORADO: Silver Plume, Aug. 24, 1895, *P. A. Rydberg* (type, in herb. N. Y. Bot. Gard.); same locality and date, *C. L. Shear 3253;* Mt. Harvard, Aug. 17, 1896, *C. L. Shear 3790;* 1896, *F. E. Clements 408;* near Ironton, San Juan County, July, 1899, *C. C. Curtis.*

Phacelia Burkei sp. nov.

Perennial, with a taproot; stems 2–3 dm. high, canescent; basal leaves 3–10 cm. long, petioled; blades lanceolate, entire, strongly veined, densely white-canescent on both sides; inflorescence branched, open; racemes elongated, 2–8 cm. long; calyx canescent and hispid-ciliate; lobes narrowly linear, obtuse, two thirds as long as the corolla, with a rather strong midvein; corolla pubescent, white, 4–5 mm. long; stamens about twice as long as the corolla, villous-bearded; seeds 4, dark chestnut-brown, 2 mm. long, puberulent, ellipsoid, strongly but finely faveolate.

This resembles *P. leucophylla* Torrey in general habit, but differs in the narrow and more strongly ribbed calyx-lobes, the smaller and white corolla, and the more finely faveolate seeds.

Idaho: Snake Country, *Burke* (type, in herb. Columbia Univ.).

Washington: Collector not given.

Phacelia leptosepala sp. nov.

Perennial, with a taproot and a more or less cespitose rootstock; stems ascending, hirsute, 1–3 dm. high; leaves usually simple, hirsute on both sides, 5–10 cm. long, oblanceolate or elliptic; the lower ones petioled; inflorescence with several short branches; calyx hirsute; lobes narrowly linear, hirsute, nearly as long as the corolla, acute; corolla white, glabrous or nearly so, 5 mm. long; filaments about twice as long, sparingly villous-bearded.

This species is probably most nearly related to *Phacelia nemoralis* Greene, but differs in the low, slender, ascending stems, the cespitose habit, the longer and narrower, acute sepals, and the less bearded stamens. It somewhat resembles *P. alpina* in habit, but differs in the narrow calyx-lobes almost equaling the white corolla and in the hirsute pubescence, which consists only of coarse hairs.

British Columbia: Vermilion Lake, Aug. 5, 1905, *Edith M. Farr 1013* (type, in herb. N. Y. Bot. Gard.); Avalanche débris above Lardo, Selkirk Mountains, June 16, 1905, *Shaw 695*.

Montana: Mount MacDougal, 1901, *Umbach 139;* Sperry Glacier, 1903, *Umbach 826*.

Lappula leucotricha sp. nov.

Annual; stem 2–4 dm. high, slender, branched above, densely pilose, especially below, with long white hairs; basal leaves oblanceolate, 2–4 cm. long, softly pilose on both sides; stem-leaves linear or oblong, numerous; bracts linear-lanceolate; sepals linear, 2.5–3 mm. long, in fruit 4–5 mm.; corolla white, 3–3.5 mm. long, 3 mm. broad; fruit erect, about 5 mm. wide; nutlets about 2.5 mm. long, light, almost straw-colored; marginal prickles in one row, not united into a disk, but broadened below and flat, scarcely grooved; back strongly muricate.

This species is related to *Lappula occidentalis* (S. Wats.) Greene, but differs in the soft white spreading pubescence, the white flowers, the smaller fruit with broader, flattened prickles. In *L. occidentalis* the prickles are only slightly broadened below, not flattened, and strongly grooved on the inside.

ARIZONA: Tucson, Apr. 20, 1894, *Toumey* (type, in herb. N. Y. Bot. Gard.); vicinity of Flagstaff, June 16, 1898, *MacDougal 122;* Clifton, Apr., 1881, *Rusby 281.*

UTAH: St. George, 1877, *Palmer 359.*

Eremocarya muricata sp. nov.

Annual; stem slender, branched throughout with ascending branches, strigose; leaves linear, 2–5 mm. long, hispidulous, the hairs with pustulate bases; racemes short and dense, usually less than 1 cm. long; bracts oblong, 1–2 mm. long; sepals linear, obtuse, 1.5 mm. long, hispidulous on the margins and midvein; corolla white, 1 mm. long; limb scarcely 0.5 mm. wide; nutlets lanceolate in outline, long-acuminate, dull, finely muricate.

This species is somewhat intermediate between *Eremocarya micrantha* and *E. lepida.* It resembles the former most in habit, but differs in the more ascending branches, the shorter leaves, and especially in the narrower, muriculate and dull, instead of smooth and shining, nutlets. The latter resemble much those of *E. lepida*, but are narrower and more tapering upwards. *E. lepida* has much broader leaves and larger flowers.

UTAH: Southern Utah, 1874, *Parry 164* (type, in herb. Columbia Univ.).

ARIZONA: Near Camp Lowell, Apr. 13, 1881, *Pringle;* Prescott, 1883, *Rusby 745;* Tucson Mountains, Apr. 12, 1903, *Thornber;* Plains of Tucson, Apr., 1881, *Lemmon 203;* Mesa, near Tucson, May 14, 1883, *Pringle;* Apr. 25, 1906, *Shear 4235;* Tucson, Apr. 3, 1894, *Toumey.*

Greeneocharis circumscissa (H. & A.) Rydb. comb. nov.

Lithospermum (?) *circumscissum* H. & A. Bot. Beech. 370. 1840.

Piptocalyx circumscissus Torr.; S. Wats. Bot. King's Exp. 240. 1871.

Eritrichium circumscissum A. Gray, Proc. Am. Acad. **10**: 58. 1874.

Krynitzkia circumscissa A. Gray, Proc. Am. Acad. **20**: 275. 1885.

Wheelerella circumscisssa Grant, Bull. So. Calif. Acad. Sci. **5**: 28. 1906.

Piptocalyx Torr. of 1871 is antedated by *Piptocalyx* Oliver of 1870 and therefore *Greeneocharis* Gürke & Harms was proposed instead of the former in the appendix to the Register of the Engler & Prantl, Natürlichen Pflanzenfamilien.* This name was properly published, although no binomials were used. There was therefore no need of substituting another generic name *Wheelerella* as was done by Grant. The fact that the etymology is not as good as it might be does not at all invalidate *Greeneocharis*. Reluctantly the writer is forced to add another binomial to the already too many names of this plant.

Oreocarya spicata sp. nov.

Perennial, with a taproot; stem solitary and simple, virgate, hispid throughout; basal leaves numerous, spatulate, 2–5 cm. long, hispid on both sides; the hairs usually with pustulate bases; stem-leaves linear-oblanceolate or linear, 4–9 cm. long, those of the inflorescence many times longer than the short flower clusters; inflorescence elongated, spike-like; calyx hispid, 4–5 mm. long, lobes oblong-lanceolate, obtuse; corolla 6 mm. long, 4 mm. broad; nutlets 4 mm. long, ovate in outline, scarcely keeled on the back, white and shining, smooth on the back, margins merely acute.

This species is closely related to *Oreocarya virgata*, from which it differs in the light-colored, smooth nutlets, the smaller corolla-limbs, shorter and broader basal leaves. The nutlets in *O. virgata* are more acuminate, brown or brownish gray, with a more distinct ridge on the back, more or less transversely rugose and tubercled on the back, and with sharper margins.

COLORADO: Artist's Glen, Aug. 1, 1901, *Clements 102* (type, in herb. N. Y. Bot. Gard.); North Cheyenne Cañon, July 14, 1896, *Ernst A. Bessey;* "Colorado," *G. W. Hulse.*

Cryptanthe leptophylla sp. nov.

Annual; stem simple, slender, erect, strigose throughout, 1.5–3 dm. high; leaves narrowly linear, 1–3 cm. long, 0.5–1.5 mm. broad, strigose; inflorescence cymose, short, at the end of the stem, and on a few small branches; calyx-lobes linear-filiform,

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* Gesamtregister 462. 1899.

3–4 mm. long, in fruit 8–10 mm. long, white-silky with long spreading hairs; corolla minute, shorter than the calyx; limb hardly 0.5 mm. wide; nutlets 3 mm. long, narrowly lanceolate, long-acuminate, strongly muricate; groove closed, 2-forked at the base.

The type sheet of this species was determined by Dr. Watson as *Eritrichium barbigerum*. It is abundantly distinct from *Cryptanthe barbigera*, however, the main distinctions being the narrow strigose leaves, the strigose instead of hirsute or hispid stem, the minute corollas, and the narrower and differently shaped nutlets.

UTAH: St. George, 1877, *E. Palmer 350* (type, in herb. Columbia Univ.).

Cryptanthe confusa sp. nov.

Cryptanthe affinis Rydb. Mem. N. Y. Bot. Gard. **1**: 330, in part. 1900.

Annual; stem rather stout, hispid, branched; leaves oblong or oblong-oblanceolate, 2–5 cm. long, 3–8 mm. wide, coarsely hirsute; spikes at first very short, subcapitate, in age 4–5 cm. long; calyx-lobes 2 mm. long, lance-subulate, hispid, in fruit 3–4 mm. long; corolla about 3 mm. long; limb scarcely 1 mm. wide; nutlets ovate, 2 mm. long, light-colored, smooth, shining, thin-walled, attached by the lower half or two thirds; groove closed and simple to the base.

This species is related to *Cryptanthe affinis* and *C. leiocarpa*, but differs from both in the broader leaves. The nutlets are most like those of the former but the attachment extends somewhat higher.

WYOMING: Upper Madison Cañon, Yellowstone Park, Aug. 3, 1897, *Rydberg & Bessey 4884* (type, in herb. N. Y. Bot. Gard.).

IDAHO: Beaver Cañon, June 27, 1895, *Rydberg*; Latah County, July 6, 1894, *Piper 1940*.

UTAH: Central Utah, 1875, *Parry 67* (?).

Cryptanthe grandiflora sp. nov.

Annual; stem branched, 2–4 dm. high, hirsute with white hairs; leaves broadly linear, lanceolate, or oblong, 3–5 cm. long, 5–10 mm. wide, hirsute, the hairs with pustulate bases; spikes lax, in fruit often 1 dm. long; calyx-lobes 3 mm. long, in fruit 5 mm., very hispid; corolla white, 4–5 mm. long; limb 5–6 mm. wide; nutlets ovate, 2.5 mm. long, shining, smooth, rather thin-walled; groove narrow, 2-forked at the base.

This species has been variously named *Cryptanthe leiocarpa*, *C. ambigua*, and *C. Torreyana*. It differs from the first in the 2-forked groove, from the second in the smooth nutlets, and from all in the large corolla. It is most related to *C. Torreyana*, having somewhat similar nutlets, but is easily distinguished from it by the large flowers and broad leaves. It may be the same as the large-flowered form of *C. Torreyana calycosa* referred to by Piper; * but it does not have the elongated calyx-lobes of that species and has three to four times as broad corolla.

IDAHO: Valley of Clearwater River, April 23, 1892, *Sandberg, MacDougal & Heller 10* (type, in herb. N. Y. Bot. Gard.); about Lewiston, April 30, 1896, *A. A. & E. Gertrude Heller 2998.*

WASHINGTON: Wawawai, May, 1897, *Elmer 775;* near Montesano, June 10, 1898, *A. A. & E. Gertrude Heller 3924.*

Mertensia pallida sp. nov.

Perennial, with a thick rootstock; stem glabrous, very pale, 5–8 dm. high, leafy; lower leaves oblanceolate, the upper narrowly lanceolate, 5–8 cm. long, glabrous or minutely muriculate, ciliolate on the margins, pale; inflorescence narrowly paniculate; pedicels usually strigulose or sometimes the hairs represented only by the somewhat pustulate bases; calyx-lobes oblong, about 1 mm. long, obtuse, ciliate on the margin; corolla about 1 cm. long, the tube about equaling the limb; filaments about 1 mm. long, dilated and at the apex broader than the anthers, which are about 2 mm. long.

This is related to *Mertensia ciliata* but differs in the paler narrower leaves, the smaller corolla, and the usually strigulose pedicels.

MONTANA: Lima, June 28, 1895, *Rydberg 2777* (type, in herb. N. Y. Bot. Gard.); June 30, 1895, *Shear 3395;* Spanish Basin, July 11, 1896, *Flodman 751.*

Mertensia Leonardi sp. nov.

Perennial, with thick rootstock; stem erect, glabrous, pale, 5–10 dm. high, leafy; leaves thin, glabrous and smooth beneath, more or less pustulate-muricate above, and ciliolate on the margins; the lower short-petioled; blades oblanceolate, 4–7 cm. long; the upper sessile, lanceolate or ovate, 5–15 cm. long; inflorescence much branched; pedicels sparingly pustulate; calyx-lobes lanceo-

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* Contr. U. S. Nat. Herb. 11: 484. 1906.

late, 4 mm. long, twice as long as the calyx-tube, ciliolate on the margins; corolla-tube 6–7 mm. long; limb 8–10 mm. long, 7–8 mm. wide.

This is related to *Mertensia arizonica*, *M. intermedia*, and *M. stenoloba*. From the former it differs in the long calyx-lobes and the short calyx-tube and from the latter two in the long and ample limb of the corolla. It is a larger plant than any of the three and often reaches a height of 1 m.

UTAH: Mill Creek Cañon, July 31, 1884, *F. E. Leonard* (type, in herb. N. Y. Bot. Gard.).

Mertensia humilis sp. nov.

Perennial, with a woody tap-root and cespitose caudex; stem 1–2 dm. high, ascending or decumbent, glabrous; basal leaves petioled, 3–8 cm. long; blades thick, elliptic to ovate, glabrous beneath, pustulate-muricate above, ciliolate on the margins, stem-leaves sessile, elliptic or ovate, rarely oblong, 2–4 cm. long; pedicels with scattered large pustules; calyx-lobes lanceolate, 2–3 mm. long, hispid-ciliolate on the margins; corolla 7–8 mm. long; tube slightly shorter than the limb; stamens inserted in the tube of the corolla; filaments short and narrow.

The specimens referred to this species were all named *Mertensia alpina* by the collectors. A few years ago the present writer regarded them as representing the typical *M. alpina* and redescribed the true *M. alpina* (Torr.) Don under the name *M. obtusiloba*. A reëxamination of James's plant (type of *M. alpina*) has convinced me of the identity of *M. alpina* and *M. obtusiloba*. *M. humilis* combines the corolla and stamens of *M. alpina* with the leaf-surface, pedicels, and calyx of *M. lanceolata*. In habit it is intermediate between the two.

WYOMING: Sand Creek, Albany Co., June 2, 1900, *A. Nelson 7043*; (type, in herb. N. Y. Bot. Gard.); Laramie Hills, May 16, 1894, *A. Nelson 33*; May 14, 1900, *E. Nelson 184*.

Scutellaria veronicifolia sp. nov.

Perennial, with creeping rootstock; stem 2–4 dm. high, finely puberulent, more or less purplish; leaves below the inflorescence ovate, obtuse, coarsely crenate, 1–4 cm. long, minutely puberulent or glabrate, short-petioled; those of the inflorescence and branches oblong and entire or nearly so; pedicels 3–5 mm. long; calyx finely pubescent, 6 mm. long; corolla 25–30 cm. long, its tube rather abruptly widening, 7–8 mm. broad at the throat.

This species is related to *Scutellaria angustifolia* and *S. antirrhinoides*, but differs from both in the broader corolla-tube. From the former it differs also in the broader and usually toothed stem-leaves and from the latter in the large flowers.

IDAHO: *Sandberg, MacDougal, & Heller 115* (type, in herb. N. Y. Bot. Gard.).

CALIFORNIA: Mokelumne Hill, 1853–4, *Bigelow* (Whipple Exp.); 1846, *Fremont LIII.*

Stachys asperrima sp. nov.

Perennial, with a rootstock; stem stout, 4–6 dm. high, coarsely hispid on the angles with spreading or reflexed hairs; leaves nearly sessile, oblong, elliptic, or oblong-lanceolate, 5–8 cm. long, truncate or rounded at the base, coarsely crenate, hispid above, hispid on the veins and also puberulent beneath; spike 1–2 dm. long; calyx densely hispid and somewhat glandular; lobes lance-subulate, spinulose-tipped; corolla purplish, 10–12 mm. long, puberulent, and more or less hirsute on the lips outside.

This species belongs to the *Stachys palustris* group, but little resembles that species in general habit. In leaf-form, pubescence, and general habit, it reminds one of *S. arenicola* Britton, but the leaves are crenate instead of serrate and the pubescence is coarser. It resembles also *S. rivularis* Heller, but the pubescence is coarser and the calyx-lobes are lance-subulate instead of lanceolate.

UTAH: Towards Jordan City, July 7, 1884, *F. E. Leonard 138* (type, in herb. N. Y. Bot. Gard.).

Stachys Leibergii sp. nov.

Perennial, with a horizontal rootstock; stem 3–6 dm. high, sharply angled, glabrous below, softly hirsute above; leaves sessile, lanceolate, acute, 4–8 cm. long, crenate-dentate, pubescent on both sides with short appressed hairs or in age glabrate; bracts lanceolate, mostly entire, often purplish-tinged; calyx softly pubescent, often purplish; tube obpyramidal, about 4 mm. long; lobes lanceolate, gradually setose-acuminate, almost as long as the tube; corolla about 12 mm. long, rose-colored, glabrous.

This species is related to *Stachys palustris* and *S. scopulorum.*

From the former it differs in the more gradually acuminate and almost erect calyx-teeth, and from the latter in the short appressed pubescence of the leaves, and the usually glabrous lower part of the stem.

IDAHO: Low meadow, Blue Creek, alt. 700 m., Coeur d'Alene Mountains, July 20, 1895, *John B. Leiberg 1328* (type, in U. S. Nat. Herb. *no. 250,811*); Valley of Coeur d'Alene River, Kootenai Co., July 13, 1892, *Sandberg, MacDougal, & Heller 639*, in part.

Stachys ampla sp. nov.

Perennial, with a rootstock; stem 5–7 dm. high, softly hirsute and more or less viscid, especially above; leaves ovate to lanceolate, 5–10 cm. long, sessile or nearly so, rounded or subcordate at the base, acute at the apex crenate-serrate, softly pubescent on both sides and more or less glandular-granuliferous; spike interrupted, very leafy; calyx soft-pubescent and glandular, about 9 mm. long; lobes lance-subulate, spinulose-tipped; corolla rose-colored or pink, about 15 mm. long, somewhat puberulent without; lower lip very broad; lateral lobes half as broad and three fourths as long as the middle one.

This species is related to *S. scopulorum* and *S. teucriformis* but differs from both in the larger corolla, the broader lower lip, and the unusually large lateral lobes of the lip.

SOUTH DAKOTA: Custer, Black Hills, Aug. 20, 1892, *Rydberg 1208* (type, in herb. N. Y. Bot. Gard.).

Audibertiella argentea sp. nov.

A low shrub; branches cinereous-puberulent; leaves petioled, 1–2 cm. long; blades rounded, obovate-spatulate, rounded or retuse at the apex, scurfy-cinereous, at first silvery white; bracts broadly obovate, about 1 cm. long, membranous, strongly veined, puberulent and ciliate; corolla blue, about 1 cm. long; lower lip only slightly longer than the upper one, its lobes short and rounded; longer filaments about 12 mm. long, anther-bearing connective 2.5–3 mm. long, sterile connective lacking.

Dr. E. L. Greene* separated *Audibertia polystachya* Benth. from the rest of the genus, as understood by Bentham and Gray, and proposed the name *Ramona* for this species. The other species he reduced to *Salvia*. Briquet, ignorant of Greene's work, discov-

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* Pittonia 2: 235.

ered (as Greene had done) that *Audibertia* could not hold for this genus, as the name had been applied two years earlier to a section of *Mentha*, proposed the name *Audibertiella*,[*] and renamed all the known species under this genus. Later he discovered that Greene had proposed the name *Ramona* for one of the species. He, however, did not agree with Greene that the genus, with that species excepted, should be merged in *Salvia*. He therefore restored the genus as understood by Bentham and Gray, adopted Greene's name, and renamed the species under *Ramona*. The writer agrees with Greene in keeping *Ramona* as a distinct genus for *Audibertia polystachya*, but agrees with Briquet that none of the species should be merged into *Salvia*. It is therefore necessary to restore *Audibertiella* Briq. As this name was a substitute for the invalid *Audibertia*, the type species of the latter becomes the type of the former. The type is therefore *Audibertia incana* Benth. The type of *Ramona* was *Audibertia polystachya*. *Audibertia grandiflora* may represent a third genus.

The present species is a close relative to *A. incana* and has been confused with it. It differs in the broad rounded obovate-spatulate leaves, the smaller flowers and the comparatively shorter lower lip of the corolla. In *A. incana* the leaves are oblong-spatulate, often 3–4 cm. long, the corolla almost 1.5 cm. long, and its lower lip about half longer than the upper one. *A. incana* ranges from Washington to Idaho and Oregon. The range of *A. argentea* is much more southerly.

ARIZONA: Mokia Pass, 1877, *Palmer 395* (type, in herb. Columbia Univ.); 1876, *Palmer 358*.

UTAH: St. George, 1874, *Parry 159*; 1872, *Bishop*.

NEVADA: Monitor Valley, 1868, *S. Watson 829*; Kernan, Meadow Valley Wash, April 29, 1902, *Goodding 655*; Palisade, June 14, 1882, *M. E. Jones 4035*; Miller Mountain, 1883, *Shockley*; Charleston Mountain, 1898, *Purpus 6072*.

CALIFORNIA: Surprise Cañon, Panamint Mountains, *Coville & Funston 601*; Panamint Cañon, May 4, 1897, *M. E. Jones*; Providence Mountains, May, 1902, *Brandegee*; Mojave Desert, May 30, 1901, *Parish 4935*.

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[*] Bull. Herb. Boiss. 2: 73.

Hedeoma longiflora sp. nov.

Perennial, with a slender taproot; stems branched at the base, decumbent or ascending, finely puberulent; leaves spreading, linear-lanceolate, lanceolate or oblong, 1–2 cm. long, grayish-puberulent, subsessile; calyx 7–8 mm. long, strongly ribbed, puberulent, somewhat saccate below; teeth subulate, the lower 2 mm., the upper 1 mm. long; corolla about 12 mm. long, puberulent, with an ample limb.

This has been confused with *Hedeoma Drummondii*, but differs in the broader leaves, which are divergent, and in the calyx, which is distinctly saccate. *H. Drummondii* differs from the related species in the narrow, ascending or suberect leaves and the narrow calyx, scarcely at all saccate. *H. longiflora* has the long corolla of *H. Drummondii* and is distinguished thereby from *H. sancta*, *H. thymoides*, and *H. ovata*, which have all been included in *H. Drummondii*. It grows on cliffs and in cañons of the Great Plains region.

NEBRASKA: Cliffs of cañons of Banner Co., 1890, *Rydberg X297* (type, in herb. N. Y. Bot. Gard.); Court House Rock, 1891, *Rydberg 297*.

SOUTH DAKOTA: Custer, June 16, 1892, *Rydberg 941*; Rapid Creek, 1891, *T. A. Williams*.

KANSAS: Wet rocks, Stanton Co., Aug. 5, 1895, *Hitchcock 402*.

Madronella sessilifolia sp. nov.

Perennial, with a short caudex; stems stout, about 3 dm. high, finely puberulent, densely so above; leaves sessile or nearly so, ovate or lanceolate, entire, obtuse, rather pale, finely puberulent or in age glabrous; bracts oval, 10–12 mm. long, puberulent on the back, ciliate on the margins; calyx 8–9 mm. long, pilose, striate; lobes lanceolate, about 1 mm. long; corolla 12–13 mm. long, pubescent.

The type was determined as *Monardella odoratissima*, but it differs from that species in the pale foliage, the shorter and finer pubescence, the broader leaves, and the less distinctly ciliate calyx-lobes.

UTAH: St. George, 1877, *Palmer 393* (type, in herb. N. Y. Bot. Gard.).

Madronella oblongifolia sp. nov.

Perennial, suffruticose at the base; stems 1–3 dm. high, grayish puberulent or in age glabrate; leaf-blades oblong, 1–3 cm. long, minutely puberulent, or in age glabrate, entire, obtuse, usually with distinct, but short, slender petioles; bracts pale or tinged with rose, finely puberulent, ciliate on the margins, oval, 9–12 mm. long; calyx about 1 cm. long, pilose; its teeth lanceolate, and strongly ciliate; corolla white to rose-colored, 12–14 mm. long, puberulent.

This has been confused with *M. odoratissima*, but differs in the shorter pubescence, which is sometimes wholly lacking on the older leaves, the merely puberulent instead of pilose bracts, the more distinctly petioled leaves, and more suffruticose habit. It grows on mountain sides at an altitude of 1500–3000 m.

UTAH: Mount Nebo, 1905, *Rydberg & Carlton 7706* (type, in herb. N. Y. Bot. Gard.), *7757* and *7700;* mountains north of Bullion Creek, near Marysvale, *7178;* American Fork, 1885, *Leonard 178;* Logan, Aug. 9, 1895, *Shear 3164;* same locality and date, *Rydberg;* Alta, July 30, 1879, *M. E. Jones 1109;* Central Utah, 1873, *Parry 75*.

Mentha glabrior (Hook.) Rydb. sp. nov.

Mentha canadensis glabrata Benth. Lab. 181. 1833. Not *M. glabrata* Vahl. 1794.

Mentha canadensis glabrior Hook. Fl. Bor.-Am. **2**: 111. 1838.

Mentha canadensis borealis Piper, Contr. U. S. Nat. Herb. **11**: 492, in part. 1906. Not *M. borealis* Michx. 1803.

This differs from *Mentha canadensis* in the almost glabrous leaves and stem, and much shorter pubescence on the calyx. Recently several botanists have included *M. Penardi* (*M. arvensis Penardi* Briq.) in *M. canadensis glabrata* or *M. arvensis glabrata*, but I think they are distinct. In *M. Penardi* the leaves have much shorter petioles, nearly always shorter than the flower-clusters, the stem is more hairy and the calyx-teeth are lanceolate and acute, much longer than broad. *M. glabrior* has the abruptly acuminate calyx-lobes of *M. canadensis* but they are not so short. This species has been taken as *M. borealis* Michx., and even Bentham cited the latter as a synonym, but by reading Michaux's description, one can easily see that it without any doubt refers to the true *M. canadensis.* *M. canadensis* is not found in the Rocky Mountain region, and *M. glabrior* is very rare. The common plant of the Rockies is *M. Penardi* and that of the Pacific slope is *M. lanata*, discussed below.

Mentha lanata (Piper) Rydb. sp. nov.

Mentha arvensis lanata Piper, Bull. Torrey Club **29**: 223. 1902.

Mentha canadensis lanata Piper, Contr. U. S. Nat. Herb. **11**: 492. 1906.

I think that this deserves specific rank, differing not only in the amount but also in the kind of pubescence and in the shape of the calyx lobes. Sometimes the leaves are very densely villous, almost white. Its range extends from British Columbia to Idaho and California. The specimens from Maine accredited to this by Robinson and Fernald * probably represent unusually hairy specimens of *M. canadensis* and not this.

Mentha occidentalis sp. nov.

Perennial, with a rootstock; stem 3–6 dm. high, with short crisp pubescence, at least on the angles above; petioles 5–10 mm. long; leaf-blades ovate or ovate-lanceolate, short-acuminate, strongly serrate, 4–8 cm. long, minutely pubescent on both sides or in age glabrate; bracts linear-lanceolate, 1 cm. long or more, usually exceeding the flowers; calyx about 3 mm. long, pilose, teeth lanceolate, acute or acuminate, longer than broad; corolla white or pink, 5–6 mm. long; its lobes oblong, obtuse.

This has been confused with *Mentha canadensis* and *M. glabrata*, but differs from all the species of this group in the long linear-lanceolate bracts, longer than the flower clusters, and the larger corollas. Otherwise it comes nearest *M. Penardi.*

IDAHO: Forest, Nez Perces County, 1896, *A. A. & E. Gertrude Heller 3486* (type, in herb. Columbia Univ.).

WASHINGTON: 1889, *Vasey 463*; Chehalis River, 1897, *Lamb 1235*.

MONTANA: Jocko River, Aug. 27, 1897, *Elrod and assistants 213*.

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* Gray's New Manual 711. 1908.

Scrophularia serrata sp. nov.

Perennial; stem 1–2 m. high, angled, sparingly puberulent or glabrous, slightly glandular in the inflorescence; leaf-blades ovate or cordate, 5–15 cm. long, regularly serrate with the teeth directed forward, acute or short-acuminate, minutely glandular-puberulent on both sides; bracts rather conspicuous, linear-lanceolate, the lowest 2–3 cm. long; calyx-tube hemispheric, glabrous or nearly so, 2 mm. long; lobes rounded, 2 mm. long; corolla-tube short, 6–7 mm. long, nearly 5 mm. thick; upper lip 4–5 mm. long; sterile stamen obovate-spatulate, purple.

This species is related to *Scrophularia marilandica* and *S. neglecta.* From both it differs in the stout, strongly ascending, instead of more or less spreading branches of the inflorescence; from the former in the larger corolla (about twice as large) and from the latter in the shorter corolla-tube, scarcely twice as long as the calyx, and the finely glandular-puberulent, instead of densely pubescent lower leaf-surfaces. In *S. neglecta* the corolla-tube is about three times as long as the calyx. *S. occidentalis*, the common Rocky Mountain species, has doubly toothed or incised leaves with spreading teeth and a reniform greenish sterile stamen.

IDAHO: Wet places, Granite, N. Idaho, July, 1887, *J. H. Sandberg* (type, in herb. N. Y. Bot. Gard.).

Pentstemon subglaber Rydb. nom. nov.

Pentstemon glaber utahensis S. Wats. Bot. King's Exp. 217. 1871.

Pentstemon utahensis A. Nels. Bull. Torrey Club **26**: 242. 1899. Not *P. utahensis* Eastw. 1893.

PENTSTEMON ALPINUS [A] Torr. Ann. Lyc. N. Y. **1**: 35. 1823

Pentstemon oreophilus Rydb. Bull. Torrey Club **31**: 642. 1905.

A reëxamination of the type of *Pentstemon alpinus* has persuaded me that it is the same as my *P. oreophilus* and not as I thought, the same as *P. riparius* A. Nelson. The latter should therefore be restored.

Pentstemon auricomus A. Nels. sp. nov.

Pentstemon Jamesii A. Nelson, Bull. Torrey Club **25**: 547. 1898. Not *P. Jamesii* Benth. 1846.

I had some correspondence with Professor A. Nelson in 1898, when the latter segregated *Pentstemon similis* from *P. Jamesii.* I think that I then led Professor Nelson astray. At least, I had made a rather serious mistake. Professor Nelson made the following statement in his article in the BULLETIN cited above:

"Before I began work upon these collections Dr. Rydberg had satisfied himself that his Dakota plant closely duplicated the type of *P. Jamesii* which is preserved in the Torrey Herbarium at Columbia University, and with which he has done me the favor of comparing my specimens."

A more thorough investigation of the South Dakota plant shows that the sterile stamens are but slightly bearded and of a different shape and the specimens must be referred to a form of *P. albidus.* The type of *P. Jamesii* consists of two scraps, only the tops of the plant. The bracts, the calyx, and corolla of these scraps resemble closely those of Nelson's plants from Wyoming. The basal leaves of *P. Jamesii* are, however, entirely different from those of Nelson's plant. At the time, there were no good specimens of *P. Jamesii* in the herbaria here in New York, but I have myself collected good specimens near the type locality, which was somewhere on the upper Arkansas River. These show that *P. Jamesii* is much closer to *P. similis* A. Nels., differing in the smaller corolla, the less secund inflorescence, the longer bracts and narrower basal leaves. Typical *P. Jamesii* is represented by *Rydberg & Vreeland 5637, 5636, 6610, 5635* and *5633;* also by *Baker 6* of 1901 and *Osterhout 2084* of 1900.

As the plant described by Professor Nelson at the place cited above is very distinct I adopt the name under which Professor Nelson had distributed the plant, viz., *Pentstemon auricomus*, especially as I, at least indirectly, was the cause of its being suppressed.

PENTSTEMON SUFFRUTESCENS Rydb. Bull. Torrey Club **28**: 503. 30 S 1901

P. caespitosus suffruticosus A. Gray, Syn. Fl. **2**^{1}: 270. 1878.

P. procumbens Greene, Pl. Baker. **3**: 23. 18 N 1901.

Professor A. Nelson, in describing *Pentstemon Xylus,** expressed his opinion that the latter was the same as *P. caespitosus suffruti-*

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* Bot. Gaz. **34**: 31. 1902.

cosus A. Gray. A careful reading of the original short description of Gray's variety will reveal to anyone that it cannot apply to *P. Xylus*. As *P. suffrutescens* was based exclusively on Gray's variety, it can by no means be called a *nomen nudum* as Professor Nelson is inclined to regard it. To it I refer also *P. procumbens* Greene published nearly two months later.

Pentstemon Thompsoniae (A. Gray) Rydb. sp. nov.

Pentstemon pumilus Thompsoniae A. Gray, Syn. Fl. **2**^{1}: 269. 1878.

This is a very distinct species, not related to *P. pumilus*. Dr. Gray at first* placed *Pentstemon pumilus* with *P. albidus*, *P. Jamesii*, and *P. cristatus*, *i. e.*, in a group to which it rightly belongs, notwithstanding its small size. Afterwards,† he transferred it wrongly to the *P. caespitosus* group, with which it has little in common. *P. Thompsoniae* on the contrary belongs to this group and is a close relative to *P. caespitosus*. I suspect that Dr. Gray has redescribed the true *P. pumilus* Nutt. under the name *P. miser*.‡ I have not seen the type of the latter but the description agrees well with *P. pumilus*.

Pentstemon platyphyllus sp. nov.

Pentstemon heterophyllus latifolius S. Wats. Bot. King's Exp. 222. 1871. Not *P. latifolius* Hoffmgg. 1824.

Dr. Gray in the Synoptical Flora § refers this doubtfully to *Pentstemon azureus Jaffrayanus* Gray (*P. Jaffrayanus* Hook.). The two resemble each other in leaf form and general habit, but there are differences important enough to make them distinct species. I am also inclined to think that *P. Jaffrayanus* is specifically distinct from *P. azureus*, although I have not seen any authentic specimen of the latter. The leaves in *P. Jaffrayanus* are strongly glaucous and the upper are subcordate and clasping at the base; the calyx-lobes are oval or obovate, abruptly short-acuminate or mucronate with an erect tip; the anthers are somewhat hirsutulous at the sinus as well as papillose-hispidulous on the margins; and the sterile

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* Proc. Am. Acad. **6**: 67. 1862.

† Syn. Fl. **2**^{1}: 269. 1878.

‡ Syn. Fl. ed. 2, **2**^{1}: 441. 1886.

§ **2**^{1}: 272. 1878.

stamen is filiform. In *P. platyphyllus* the leaves are less glaucous, never subcordate or clasping at the base; the calyx-lobes are ovate, long-acuminate, with more or less spreading tips; the anthers are merely papillose-hispidulous on the margins but otherwise without pubescence; and the sterile stamen is decidedly broadened upwards. *P. platyphyllus*, as far as the writer knows, is found in Utah only, while *P. Jaffrayanus* grows in California and Oregon. To the former belong the following specimens:

UTAH: Cottonwood Cañon, July, 1869, *S. Watson 787;* City Creek Cañon, July 25, 1879, *M. E. Jones 1080;* also July 7, 1880; same locality, July 4, 1883, *Leonard 141*, and Aug. 9, 1884, *208;* mountains near Ogden, July, 1871, *Coulter*.

Pentstemon coccinatus sp. nov.

(?) *Pentstemon Eatonii undosus* Jones, Proc. Calif. Acad. **5**: 715. 1895.

Perennial, with a woody caudex; stem erect, 3–6 dm. high, puberulent; basal leaves petioled; blades ovate or elliptic, acute at both ends, 3–7 cm. long, densely puberulent; lower stem-leaves spatulate to elliptic; the upper ovate or ovate-lanceolate, acuminate; inflorescence lax, more or less secund; calyx about 5 mm. long, puberulent; lobes broadly ovate, abruptly short-acuminate, scarious-margined and denticulate; corolla red, about 2.5 cm. long, nearly tubular, not ventricose, slightly bilabiate, lobes short, rounded; anthers papillose on the margin, glabrous; sterile stamen glabrous, club-shaped, truncate; capsule about 1 cm. long.

This has been confused with *P. Eatonii*, but differs in the puberulent stem and leaves, the more acuminate upper leaves and sepals.

ARIZONA: Grand Cañon of the Colorado, 1898, *MacDougal 173* (type, in herb. N. Y. Bot. Gard.); Oak Creek, June 23, 1883, *Rusby;* Red Cañon Trail, June 10, 1901, *L. F. Ward*.

UTAH: Court House Wash, May, 1892, *Eastwood;* South Utah, 1877, *Palmer 372;* 1874, *Parry 149*.

Synthyris dissecta sp. nov.

Synthyris pinnatifida Rydb. Mem. N. Y. Bot. Gard. **1**: 353. 1900. Not S. Wats. 1871.

Acaulescent perennial, with a short, thick, erect rootstock; leaves 5–10 cm. long, petioled, villous-tomentose; blades oval in outline, twice or thrice pinnatifid into oblong or lanceolate divisions; scape villous-tomentose, 5–20 cm. high; spike dense or in fruit more lax; bracts and calyx densely white-villous; corolla about 6 mm. long, dark-blue or purple, or in age paler; lobes broadly obovate; stamens slightly exserted; ovary villous; fruit obovate, 6 mm. long, villous or in age glabrate.

This species is related to *Synthyris pinnatifida*, and has been mistaken for it, but it differs in the more copious pubescence, especially on the calyx and ovary (in *S. pinnatifida* these are glabrous or merely puberulent on the margins), in the larger dark corolla with obovate instead of oblong lobes, and in the larger fruit. *S. dissecta* grows at an altitude of 2000–3000 m.

MONTANA: Near Bozeman, June 11, 1900, *Chesnut & Jones 199* (type, in herb. N. Y. Bot. Gard.); Bridger Mountains, June 15, 1897, *Rydberg & Bessey 4927*; same locality, 1899, *Flaherty*, and June 26, 1899, *Blankinship*; Old Hollowtop, July 7, 1897, *Rydberg & Bessey 4926*; Beaver Head Co., June, 1888, *Tweedy 70*.

WYOMING: Headwaters, Cliff Creek, Aug. 9–18, 1900, *C. C. Curtis* (good fruit).

Thalesia Sedi (Suksd.) Rydb. comb. nov.

Aphyllon Sedi Suksd. Deuts. Bot. Monats. **18**: 155. 1900.

The three species of the Columbia River region, which have usually been included in *Thalesia uniflora*, differ from the plant of the eastern United States in their longer attenuate calyx-lobes. In all three the lobes are about twice as long as the calyx-tube and narrowly subulate from a broad base; in *T. uniflora* they are scarcely longer than the tube, lanceolate and gradually tapering from the base of the apex. *T. Sedi* differs from the other two Columbian species in the lighter-colored corolla, with narrower, oblong acutish or obtuse lobes, while *T. purpurea* Heller and *T. minuta* (see below) have dark purple corolla and broad, oval or semiorbicular lobes rounded at the apex or sometimes even retuse. It grows on species of *Sedum* and is distributed through parts of Oregon, Washington, and western Montana.

Thalesia minuta (Suksd.) Rydb. comb. nov.

Aphyllon minutum Suksd. Deuts. Bot. Monats. **18**: 155. 1900.

This resembles *Thalesia purpurea* in the color of the flower and the form of the calyx, but the corolla is much smaller, only 15–20 mm. long, more strongly curved, and less funnelform. The corolla of *T. purpurea* is 2–3 cm. long, and more open at the throat. *T. minuta* has been reported parasitic on *Lithophragma*, but may grow on other hosts. It has been collected in Oregon, Washington, Montana, and British Columbia.

Thalesia lutea (Parry) Rydb. comb. nov.

Phelipaea lutea Parry, Am. Nat. 8: 214. 1874.

Aphyllon fasciculatum luteum A. Gray, Syn. Fl. 2^1: 312. 1878.

This differs from *Thalesia fasciculata* not only in the sulphur-yellow corolla, but also in the acutish corolla-lobes and in the acute rather than acuminate calyx-lobes. It is parasitic on grasses instead of on composites, etc.

MYZORRHIZA Philippi, Linnaea 29: 36. 1857

Aphyllon § *Nothaphyllon* A. Gray, Bot. Calif. 1: 584. 1876.

Orobanche § *Myzorrhiza* G. Beck, Bibl. Bot. 4: 78. 1890.

Following Beck von Mannagetta, many botanists in this country have reduced Gray's section *Nothaphyllon* of *Aphyllon* to *Orobanche*, while they have kept *Thalesia* distinct. Both, as well as a part of *Boschniakia*, were included in *Orobanche* by Beck. The editors of Gray's New Manual evidently took the genus *Orobanche* in the same sense as Beck. In contrasting *Conopholis* and *Orobanche* in the generic key, they give as characters for the former: "Calyx deeply cleft in front"; and for the latter: "Calyx 5-cleft." On the following page, however, they give as characters of *Orobanche minor:* "Calyx cleft before and behind almost or quite to the base," and for *O. ramosa:* "Calyx 4-lobed." *O. minor* is the only typical *Orobanche* found in this country, and this does not agree with the characterization of the genus, as given in the New Manual. Evidently the editors had Gray's genus *Aphyllon* in mind when the key was made.*

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* Another inaccuracy in the treatment of *Orobanche* in the New Manual may be pointed out: *Orobanche purpurea* and *O. ramosa* are there characterized as having "each flower with 3 bracts (1 large and 2 small) at the base of the calyx," *O. minor* and *O. ludoviciana* as having "each flower with 1 or 2 bracts at the base of the calyx," and *O. uniflora* and *O. fasciculata* as being "without bracts." The characters

The typical *Orobanche* has the calyx characteristic of, for instance, *Castilleja* in Scrophulariaceae, *i. e.*, the calyx is deeply cleft in front and behind, with the lateral divisions entire or 2-cleft. None of our native American plants has this structure. They have all (except those included in *Boschniakia* by Gray) an almost equally 5-toothed calyx. There is a group of Old World plants, of which *Orobanche purpurea* and *O. ramosa* are introduced into this country, which have a 4-toothed or only occasionally 5-toothed calyx, but in that case the upper tooth is much smaller. In Gray's New Manual the former is described as having a "5-lobed" calyx. This is only occasionally the case. These species constitute the genus *Kopsia* Dum. or *Phelipaea* Nees (not Desf.). The writer thinks that the five sections of Beck's monograph should be regarded as genera. *Myzorrhiza* Philippi is the only available name for *Aphyllon* § *Nothaphyllon* Gray. This genus differs from *Thalesia* in habit and in the arrangement of the placentae, from *Orobanche* in the regularly 5-toothed instead of 2-cleft calyx, and from both in the presence of bractlets. The type of the genus is

MYZORRHIZA CHILENSIS Philippi, Linnaea **29**: 36. 1857
Orobanche chilensis G. Beck, Bibl. Bot. **4**: 82. 1890.

This is closely related to our most common North American species:

MYZORRHIZA LUDOVICIANA (Nutt.) Rydb.; Small, Fl. SE. U. S. 1093. 1903
Orobanche ludoviciana Nutt. Gen. **2**: 58. 1818.
Phelipaea ludoviciana Walp. Rep. **3**: 461. 1844.
Aphyllon ludovicianum A. Gray, Bot. Calif. **1**: 585. 1876.
? *Aphyllon arenosum* Suksd. Allg. Bot. Zeits. **12**: 27. 1906.

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given for the two first are correct; there are three scales under the flower, one bract and two lateral bractlets; *Orobanche minor* has one bract and no bractlets, while *O. ludoviciana* has 1 or 2 bractlets under the flower. It has exactly the same arrangement as *O. purpurea* and *O. ramosa*, except that one of the bractlets is sometimes lacking and the bract is usually some distance below the calyx. *Orobanche uniflora* and *O. fasciculata* are not without bracts. They are without bractlets, but the bract is found at the base of the longer pedicel. They are like *O. minor* (a typical *Orobanche*) in having no bractlets, but differ in the 5-toothed instead of 2-cleft calyx. *O. ludoviciana* has bractlets and should have been associated with the two first species, if the presence or absence of bractlets was taken as the dividing character. In all the species the bracts are present although situated at different distances from the calyx, depending upon the length of the pedicels.

MYZORRHIZA MULTIFLORA (Nutt.) Rydb. Bull. Torrey Club **33**: 151. 1906

Orobanche multiflora Nutt. Jour. Acad. Nat. Sci. Phila. II. **1**: 179. 1848.

Phelipaea erianthera Engelm.; A. Gray, Proc. Am. Acad. **7**: 372. 1867.

Aphyllon multiflorum A. Gray, Bot. Calif. **1**: 585. 1876.

Myzorrhiza Cooperi (A. Gray) Rydb. comb. nov.

Aphyllon Cooperi A. Gray, Proc. Am. Acad. **20**: 307. 1885.

Orobanche ludoviciana Cooperi G. Beck, Bibl. Bot. **4**: 81. 1890.

Myzorrhiza tuberosa (A. Gray) Rydb. comb. nov.

Phelipaea tuberosa A. Gray, Proc. Am. Acad. **7**: 371. 1867.

Aphyllon tuberosum A. Gray, Bot. Calif. **1**: 585. 1876.

Orobanche bulbosa G. Beck, Bibl. Bot. **4**: 83. 1890.

Myzorrhiza pinorum (Geyer) Rydb. comb. nov.

Orobanche pinorum Geyer; Hook. Kew Jour. Bot. **3**: 297. 1851.

Phelipaea pinetorum A. Gray, Proc. Am. Acad. **7**: 371. 1867.

Aphyllon pinetorum A. Gray, Bot. Calif. **1**: 585. 1876.

Myzorrhiza Grayana (G. Beck) Rydb. comb. nov.

Orobanche comosa Hook. Fl. Bor.-Am. **2**: 92. 1838. Not *O. comosa* Wallroth. 1822.

Anoplanthus comosus Walp. Rep. **3**: 480. 1844.

Phelipaea comosa A. Gray, Pac. R. Rep. **4**: 118. 1857.

Aphyllon comosum A. Gray, Bot. Calif. **1**: 584. 1876.

Phelipaea carnosa [error] T. & G.; Coop. & Suckl. Nat. Hist. Wash. 50. 1859.

Orobanche Grayana G. Beck, Bibl. Bot. **4**: 79. 1890.

Myzorrhiza californica (Cham. & Schlecht.) Rydb. comb. nov.

Orobanche californica Cham. & Schlecht. Linnaea **3**: 134. 1828.

Phelipaea californica G. Don, Gen. Syst. **4**: 632. 1838.

Aphyllon californicum A. Gray, Bot. Calif. **1**: 584. 1876.

Myzorrhiza violacea (Eastw.) Rydb. comb. nov.

Aphyllon violaceum Eastw. Zoe **5**: 85. 1900.

Myzorrhiza xanthochroa (Nels. & Cockerell) Rydb. comb. nov.

Orobanche xanthochroa Nels. & Cockerell, Bot. Gaz. **37**: 278. 1904.

Myzorrhiza corymbosa sp. nov.

Stem 5–10 cm. high, corymbosely branched, glandular-puberulent; scales about 1 cm. long, lance-ovate, acute; bracts linear, about 1 cm. long; pedicels 5–10 mm. long; bractlets linear-subulate, half as long as the calyx; calyx-tube obconic, glandular-puberulent, 4 mm. long; lobes lance-subulate, about 1 cm. long; corolla dark purple, about 2.5 cm. long, tube 4–5 mm. wide; upper lip 7–8 mm. long, cleft about one third its length into ovate, obtuse or sometimes retuse lobes; lower lip cleft to the base into three lanceolate acutish divisions; anthers woolly.

This species has been confused with *M. californica* and *M. ludoviciana*, but is evidently most nearly related to *M. Grayana* (*Orobanche comosa* Hook.). In Hooker's Flora, the latter is described and figured as having emarginate corolla lobes. I doubt if that is a constant character. There is a fragment of Hooker's type in the Torrey herbarium; some of the lobes are evidently so, but in others this character is rather obscure. Good specimens, collected by Dr. Cooper on the Stevens' Expedition and also preserved in the Torrey herbarium, and a colored drawing, made for the report of the Wilkes' Expedition but never published, illustrate a plant with the lobes of the lower lip lanceolate, acute and entire at the apex. These and the specimen received from Hooker agree otherwise wholly in habit, size, structure, and color of the corolla. Whether the notching of the lower lobes is a specific character or not, may be decided by further field study. It is evident that the specimens cited here below are distinct enough from both. Hooker's and Cooper's plants have a corolla fully 3 cm. long, light purple and of a thinner texture, the lips are 12–15 mm. long, *i. e.*, about twice as long as in the plant here described, the upper lip is cleft to about the middle and the lobes of the lower lip are relatively narrower. The corolla of *M. corymbosa* resembles more in form, size, texture, and color that of *M. ludoviciana*, although the upper lip is less deeply 2-cleft. Occasionally one finds stunted specimens of *M. ludoviciana*, which in habit resemble this, but they can easily be recognized by the shorter calyx-lobes and the glabrous anthers. The type of *M. corymbosa* was labeled *Aphyllon californicum*, but *M. californica* is a much larger plant in every respect, and its anthers are glabrous or nearly so.

IDAHO: Reynold's Creek, July 2, 1892, *Isabel Mulford* (type, in herb. Columbia Univ.).

WYOMING: Jackson's Hole, July 30, 1901, *Merrill & Wilcox 1177*.

MONTANA: Mountains near Indian Creek, July 22, 1897, *Rydberg & Bessey 4988*.

Valeriana pubicarpa sp. nov.

Perennial, with a rootstock; stem 2–4 dm. high, finely puberulent, not bearded at the nodes; basal leaves spatulate or oblanceolate, 2–6 cm. long, thin, glabrous or nearly so; stem-leaves 2-4 pairs, the lowest pair similar to the basal ones, the rest 3–5-foliolate or the uppermost minute and simple; leaflets oblong or lanceolate, rarely elliptic, 2–5 cm. long, entire; inflorescence short and dense, corymbiform or subcapitate; flowers mostly perfect; corolla funnelform, 4–6 mm. long, more or less pubescent; limb about 4 mm. wide; fruit finely pilose, 5 mm. long, 2 mm. wide.

This species has the habit of *Valeriana occidentalis* and *V. micrantha*, but the corolla of *V. Scouleri*. From the first, it differs in the longer corolla and the pubescent fruit; from the second, in a corolla twice as long and a denser inflorescence; from the last, in the narrower entire leaflets, and the pubescent fruit; and from all in the puberulent stem, which lacks the beard at the nodes and on the sheaths. It grows in the mountains at an altitude of 2,000–3,000 m.

UTAH: Mount Nebo, Aug. 15, 1905, *Rydberg & Carlton 7717* (type, in herb. N. Y. Bot. Gard.); also Big Cottonwood Cañon, June 28, *6374* and *6517*; Provo, June 16, 1902, *Goodding 1148*.

IDAHO: Ketchum, July 23, 1892, *Miss Mulford*.

MONTANA: Lima, June 29, 1895, *Rydberg 2794*; also *C. L. Shear 3389*.

Valeriana puberulenta sp. nov.

Perennial, with a thick rootstock; stem finely puberulent, not bearded at the nodes, 1.5–3 dm. high; basal leaves spatulate, 2–5 cm. long; stem-leaves 1–3 pairs, usually 3-foliolate; terminal leaflet elliptic or oblong, or in the uppermost reduced pair lanceolate, 1–3 cm. long, the lateral ones oblong or lanceolate, about half as long; plant usually polygamo-dioecious; inflorescence of the essentially pistillate plant dense-corymbiform, that of the somewhat smaller essentially staminate plant subcapitate; corolla funnelform, 4–5 mm. long; limb 2.5–3 mm. wide; fruit glabrous, nearly 5 mm. long and 2 mm. wide.

This species has the pubescence of the preceding, but differs in the smaller stature, the smaller flowers, fewer and smaller leaves, glabrous fruit and a stronger tendency to be polygamo-dioecious. It grows in the mountains of Utah, at an altitude of 2,000–3,000 m.

UTAH: Mountains north of Bullion Creek, near Marysvale, July 23, 1905, *Rydberg & Carlton 7065* (type, in herb. N. Y. Bot. Gard.); also Big Cottonwood Cañon, June 28, *6390*, *6371*, and *6532*; Mount Barette, July 26, *7238*; near Alta, July 10, 1883, *Leonard 177*; Central Utah, 1875, *Parry 36*; Wahsatch Mountains, Aug., 1869, *S. Watson 488*, in part.

CORRECTION

Mertensia cana Rydb. nom. nov.

Mertensia canescens Rydb. Bull. Torrey Club **31**: 640. 1904. Not *Mertensia canescens* Kaulf. 1824.

Professor T. D. A. Cockerell has called my attention to the fact that my *Mertensia canescens* is antedated by *M. canescens* Kaulf., a fern.

NEW YORK BOTANICAL GARDEN.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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