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OF THE

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VOL. 43

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Errata

Page 92, line 2 from bottom, omit "about half natural size."

Page 345, lines 15–22, omit all species of *Potamogeton* and *Triglochin*, except *P. alpinus*.

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

JANUARY, 1916

Physiological observations on Drosera rotundifolia *

HENRY D. HOOKER, JR.

(WITH ELEVEN TEXT FIGURES)

CONTENTS

1. INTRODUCTION

The object of the work, which this paper presents, was to determine whether the bending of *Drosera* tentacles was connected with a temporary acceleration of the rate of growth or with differences of turgidity; in physiological terms, whether the bend-

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* Contribution from the Osborn Botanical Laboratory.

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ing was a nutation or a variation movement. Analogy with the behavior of tendrils, which has been thoroughly investigated by Fitting, indicates that the reactions of *Drosera* are phenomena of growth, and this is substantiated by Batalin's ('77, p. 36) somewhat meager measurements. These are, in Pfeffer's words ('06, 3: 85), "not fully satisfactory." Although the primary purpose of this paper is to settle this point, a number of observations were made during the work which pertain to other matters. These minor points are of some physiological interest and will be mentioned before proceeding to the main discussion.

2. Material

The material used was collected during the months of July and August from Beaver Swamp in the city of New Haven, Connecticut. It was found advisable to use only fresh material for experimentation.

Plants of *Drosera rotundifolia* and *D. longifolia* were found growing in *Sphagnum*. In removing them, large pieces of the substratum were taken along with the plants to prevent injury to the roots and to insure their further development in the laboratory. Slight injuries to the roots cause the secretion of the glands to stop and render the tentacles inactive, so that they fail to respond to the customary stimuli. The root-hairs are particularly remarkable, for they are not restricted to a small region above the root-tip but cover the entire length of the root. They do not die, but continue to grow and function. In this way they increase the effectiveness of the small root-system.

The plants were placed in flat dishes, made wet with distilled water and covered with bell-jars. Under these conditions the development of the plants was far from normal. The rosette arrangement of the leaves was lost, a typical stem was developed by lengthening of the internodes and every trace of red pigment disappeared. No gradations from purple to green leaves were observed. All the leaves, which unfolded in the moist atmosphere and subdued light of the culture, were green. The size of the leaves diminished and their petioles made a more acute angle with the stem, causing them to point obliquely upward instead of horizontally outward.

3. PIGMENT

The red pigment of *Drosera* occurs predominantly in the leaves and the root-cap. Young leaves frequently have the pigment restricted to the glands of the tentacles. Later it appears in the epidermal cells of the marginal pedicels. Leaves of old plants often have the entire leaf-blade pigmented and, as the leaf matures, the color spreads down the petiole and often into the stalk. In general young plants are much greener than old ones, but wide variations are found.

The red pigment of *Drosera rotundifolia* and *D. longifolia* is identical with one of the pigments which Rennie ('87, '93) extracted from rhizomes of *D. Whittakeri.* Its formula is $C_{11}H_8O_5$, and it is probably trihydroxymethylnapthoquinone, since it gives the reaction of Brissemoret and Combes ('07) characteristic of α-napthoquinones.

To obtain the pigment, place a deep red leaf on a slide, add a few drops of hot alcohol, put on a cover-glass and heat directly over boiling water. The pigment is extracted from the leaf and, on the evaporation of the alcohol, it is deposited around the edges of the cover-glass. It forms crystals which are small red disks. It is insoluble in cold water, hardly soluble in cold alcohol and glacial acetic acid, but dissolves readily in boiling water, hot alcohol and ether, and to a lesser extent in benzol and carbon disulphide. It is soluble in alkalis. When a leaf is treated with ammonia, the pigment turns dark violet or brown; on standing the color fades. A timely treatment with dilute acid precipitates the pigment and restores the red color, but this does not occur after prolonged action of the ammonia. Reduction with stannous chloride and alcoholic hydrochloric acid gives a yellow product which crystallizes in needles. This is reoxidized to the original compound, when allowed to stand in alcoholic or alkaline solution exposed to the air. These properties were found for the pigment of *D. rotundifolia.* They coincide with those given by Rennie for the compound $C_{11}H_8O_5$, and confirm the suggestion of their identity put forward by Kraemer ('10, p. 285).

Experiments were made with the green plants to determine under what circumstances the pigment reappeared. Several plants of *D. longifolia* were cultivated for a month in a moist atmosphere, without being fed with insects. They lost all traces of pigment. Six of these were fed with small flies and two days later pigment was observed in the marginal tentacles of the youngest leaves, that had just unrolled. A similar reappearance of color was observed in three other plants which caught insects. This is the opposite of the results obtained by F. Darwin ('08, p. 23) and by Büsgen ('83, p. 592), who found that plants fed with insects had much greener leaves than those which relied solely on photosynthesis for their nourishment. The contradiction may be owing to different environmental conditions, such as the chemical composition of the substrate, the intensity of the light, or the humidity of the atmosphere. The question merits further investigation.

4. HABIT

Another peculiarity observed in plants cultivated in a moist atmosphere was the peculiar habit assumed by the plant. The internodes became lengthened, and this was the case with plants exposed either to the diffuse light of the laboratory or to direct sunlight. Plants exposed to dry air were observed to retain the rosette habit under both light conditions. This shows that the rosette habit characteristic of *D. rotundifolia* is dependent upon transpiration and not upon light, as Diels ('06, p. 32) suggests. This relation represents an interesting adaptation, for as long as the plant is beneath the surface, the internodes lengthen, since transpiration is reduced to a minimum. In this way the terminal bud is brought to the surface, where rapid transpiration from the exposed leaves causes the development of a rosette.

5. PARASITES

A great many of the plants cultivated in the laboratory were destroyed by larvae accidentally brought with the material from the swamp. They were larvae of one of the cut-leaf moths or noctuids. Since the adult form has not been obtained, it has been as yet impossible to identify them. The young larvae are about a quarter of an inch long and very pale. They climb up the under side of the leaf-petioles and eat the blade from behind. In this way they avoid the tentacles which could easily catch and digest such small creatures. The larvae select the youngest leaves and destroy the plant by eating the terminal bud. Many of the fragments of partially eaten leaves fall onto the *Sphagnum* and produce new plants by regeneration. Here again is an arrangement which may be considered a reciprocal adaptation; the larvae are protected from the leaves which could consume them, and the destruction of the plant by the larvae results in vegetative reproduction. As the larvae grow older they increase greatly in size and become green. Even after they have reached a size which renders their capture by a *Drosera* leaf impossible, they continue to crawl along the under surface and eat the leaves from behind. They become exceedingly voracious and a single insect can devour a dozen flourishing plants in two days.

6. CULTIVATION

The *Drosera* plants used for experimentation were grown in uncovered dishes exposed for at least six hours a day to direct sunlight. Small flies and other insects were placed on the leaves from time to time. The best leaves were selected for reactions and were not fed. In one remarkable instance, a house-fly was placed on a small fresh leaf which was only slightly pigmented. A copious secretion resulted which enveloped and digested the fly. After five days, however, the entire leaf-blade had disappeared, being digested by its own fluid. The plant was not vigorous and the fly was too large for the leaf, but normally anti-enzymes or other adequate means must be present to prevent autolysis.

7. MECHANICS OF MOVEMENT

(*a*) NORMAL DEVELOPMENT

The blade of the undeveloped *Drosera* leaf is rolled up. As it expands the marginal tentacles are seen to be bent over the blade, the glands pointing against the leaf and the pedicels arranged like rays around the edge. As the leaf grows, these tentacles increase considerably in length, the growth being greater on the adaxial side. By this means the incurved tentacles are straightened, a process which is assisted by the simultaneous flattening of the leaf-blade. When all the tentacles are straight, the leaf is mature and able to catch insects. The full grown tentacles do not increase perceptibly in length. They remain in this condition for about two weeks, during which time their glands secrete actively. At the end of this period the tentacle begins to bend backward. In old leaves the marginal tentacles are much recurved, and in extreme cases the gland may pass through a complete revolution by the rolling up of the distal portion of the pedicel. The petiole of young leaves points up. As the leaf ages, its petiole bends down so that the mature leaf is horizontal.

The pedicels of the exterior tentacles are dorsi-ventrally flattened at the base. The abaxial side has numerous short glandular hairs distributed over its entire length. On the adaxial side they are fewer in number and are confined more or less to the base.

(*b*) EXPERIMENTAL METHOD

Fresh leaves which had not been previously touched were selected for experimentation. The entire plant was removed from the *Sphagnum* in which it grew and was placed in a large Stender dish. A piece of cork was fastened with sealing wax inside the dish and another piece attached to it by two pins. The petiole of the selected leaf was clamped horizontally between the two pieces of cork in such a way that the leaf-blade was vertical. The bottom of the dish was covered with water and the roots were wrapped in wet sphagnum. The cover of the Stender dish was replaced or discarded, as desired. A binocular microscope was used, because the greater distance from the objective to the object made it more convenient when the Stender dish was covered. An horizontal tentacle, which showed glandular hairs on both upper and lower sides and which was not obscured by its neighbors, was selected from the edge of the leaf opposite the petiole. Its pedicel was marked with China ink to facilitate identification.

Each tentacle was measured with a micrometer scale and drawn with a camera lucida before an experiment. The gland was then stimulated by placing upon it some object such as the leg of a fly. This was removed as soon as movement began. At each subsequent observation the time was recorded and the tentacle was sketched. This was continued at intervals until the pedicel was again straight. The tentacle was then measured for the second time with the micrometer scale.

The figures given in the tables are in hundredths of a millimeter. Measurements were made on the drawings, which were checked by the direct measurements. The time at the head of the first column shows when the gland was stimulated. The column to the right of the heavy line shows the first indication of unbending. The segments were marked off naturally by the presence of glandular hairs on the two flattened surfaces. They are numbered from the apex to the base. The segments on the concave side do not always correspond to those on the convex side.

TABLE I

	No. of Segment	10.00 A. M.	10.15 A. M.	10.35 A. M.	11.00 A. M.	11.20 A. M.	11.40 A. M.	12.00 M.	1.15 P. M.	2.00 P. M.	3.00 P. M.	3.30 P. M.	4.00 P. M.	4.30 P. M.	5.00 P. M.	7.35 P. M.	9.00 P. M.	9.10 P. M.
Abaxial side	1	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
	2	23	23	23	23	23	25	25	25	25	25	25	25	25	25	25	25	25
	3	24	25	25	25	28	28	28	28	28	28	28	28	28	28	28	28	28
	4	29	31	31	32	34	35	35	35	35	35	35	35	35	35	34	34	34
	5	36	41	41	42	43	45	49	49	49	48	48	48	48	48	48	48	46
	6	43	51	52	53	55	57	59	59	59	59	58	57	55	55	55	55	55
	7	59	60	60	60	61	69	70	72	72	72	71	69	69	69	69	69	69
	Total..	294	311	312	315	324	339	346	348	348	347	345	342	340	340	339	339	337
Adaxial side	1	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
	2	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	24
	3	24	25	25	25	25	25	25	25	25	25	25	25	26	26	26	27	27
	4	31	31	31	29	29	29	28	28	28	29	29	29	29	31	32	33	34
	5	40	40	40	40	40	40	40	40	41	41	41	41	41	41	43	44	46
	6	28	29	29	29	31	32	32	32	34	35	35	35	35	35	35	36	38
	7	28	28	28	28	28	28	28	28	28	29	31	32	33	34	34	35	37
	8	45	45	45	45	46	48	49	50	50	50	50	50	50	51	51	52	54
	Total..	297	299	299	297	300	303	303	304	307	310	312	313	315	319	322	328	338

(*c*) EXPERIMENTAL DATA

Measurements of the dorsal and ventral sides of a tentacle in the process of bending and unbending are given in TABLE I. The tentacle was selected from next to the outermost row on a fresh, red, young leaf which was secreting copiously. The leaf had been protected during its development and was not touched, or stimulated in any other way, prior to the experiment. Its reaction is typical of the marginal tentacles on young leaves, unless perhaps it is more than usually vigorous.

The straight tentacle measured 2.94 mm. in length. The leg of a small house-fly was laid on the gland. One minute and a half after stimulation movement was detected, whereupon the fly-leg was removed. After fifteen minutes the tentacle was well bent and the gland had moved through an angle of about fifty degrees. Marked elongation took place on the convex side near the base in Segment 6, and to a lesser extent in Segment 5. The concave side remained nearly of the same length as before. The region of bending is coincident with the region of elongation on the convex side. As the tentacle continued to bend, the area of curvature and elongation was extended upward toward the gland, including Segments 4, 3, and 2, and to a lesser extent downward so as to include a portion of Segment 7. In the ultimate stage the curved region subtended an angle of approximately 215 degrees. Both sides increased in length, but the increase of the convex side was eight times that of the concave. FIG. 1 is a series of camera lucida drawings made during the inflexion of this tentacle. In *b* the bending region is seen to be restricted at first to the lower end and to extend apically in *c* and *d*. The final

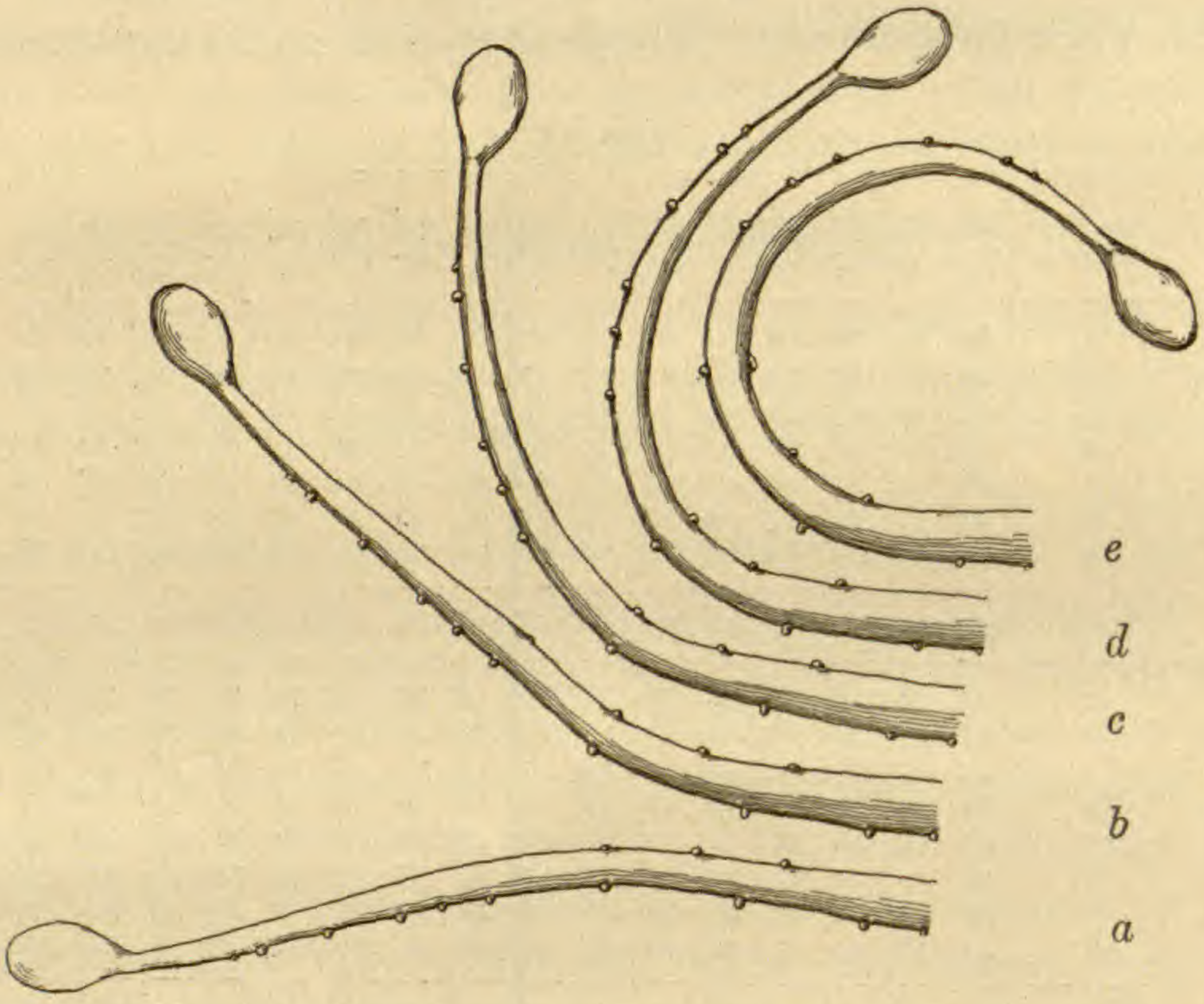

FIG. 1. Side views of a tentacle in the process of bending, × 22. *a*, before stimulation; *b*, *c* and *d*, successive stages of inflexion; *e*, the fully bent tentacle.

condition attained 3 hours and 15 minutes after stimulation is shown in *e*.

Unbending commenced immediately. TABLE I shows that this resulted from elongation of the concave side and contraction of the convex side. The region of elongation is at first near the base in Segment 7, which lies opposite the lower portion of Segment 6 on the convex side. This region gradually extends apically. The contraction on the convex side is mostly confined to the base, and it is moreover relatively slight, being only one fourth the amount of elongation on the concave side. FIG. 2 shows the result of these alterations in length. Since the reaction commences near the base, this portion is the first to straighten; as successive portions on the concave side further removed from the base elongate, the straight part of the pedicel lengthens. In unbending the tentacle is therefore curved in a different manner than during bending. In the latter case, the principal curve is near the base, in the former, nearer the apex. A comparison of

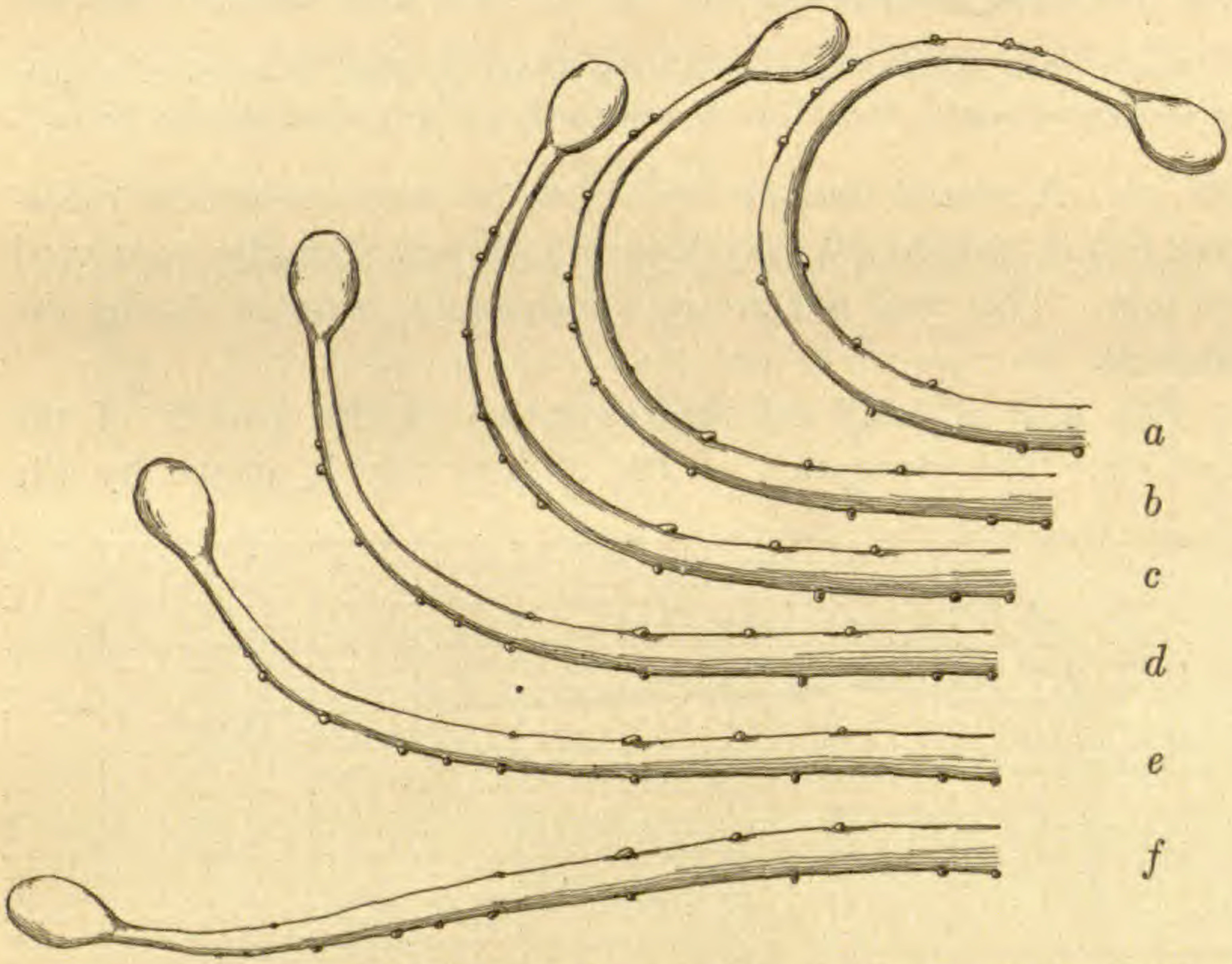

FIG. 2. Side views of the tentacle shown in FIG. 1 in the process of unbending. × 22. *a–e*, successive stage in the expansion; *f*, the tentacle at the completion of the reaction.

FIG. 1, *a* and *b*, with FIG. 2, *d* and *e*, illustrates this. The most apical part which elongated during the process of bending is the last to regain its original position. The basal portion, however, does not stop increasing its length until the entire tentacle is straight. At the end of the reaction, after 23 hours and 10 minutes, the tentacle measured 3.37 mm. It had therefore *grown* during the process of bending and unbending 0.43 mm. (See FIG. 3). A control tentacle which had not been stimulated measured before and after the experiment 2.57 mm. Another measured 2.6 mm. They had not grown a measurable amount during the interval.

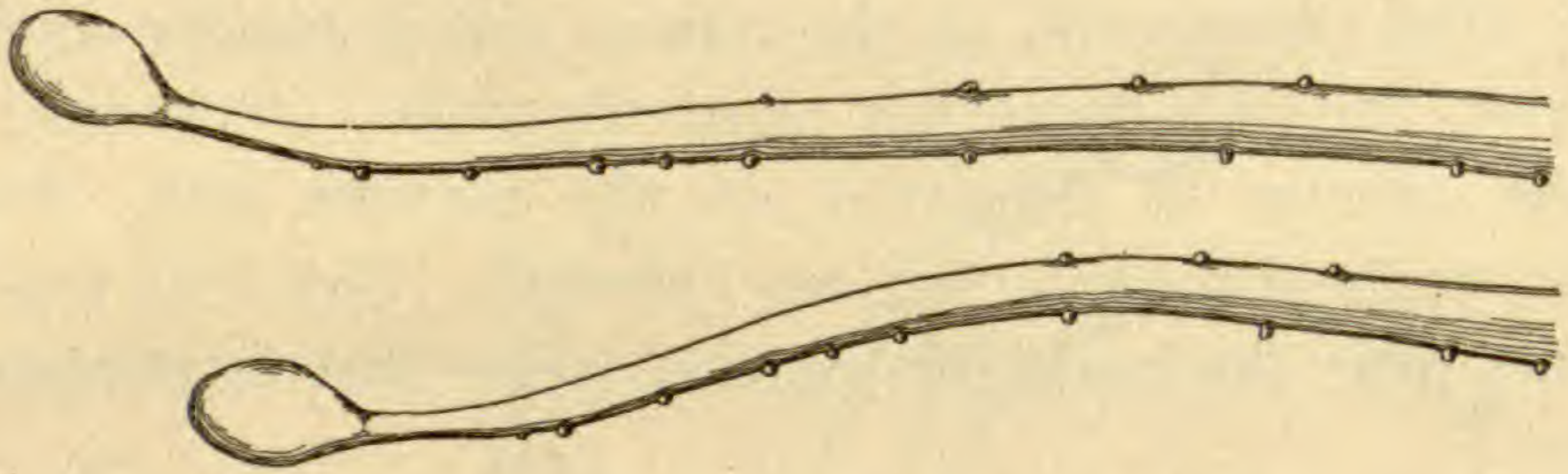

FIG. 3. Side views of the same tentacle before and after the reaction, to show the increase in length, × 22. *a* is the same as FIG. 1, *a*; *b* is the same as FIG. 2, *f*.

FIG. 4 is a graphical representation of the growth of the tentacle. The elongation of the abaxial side is shown by the

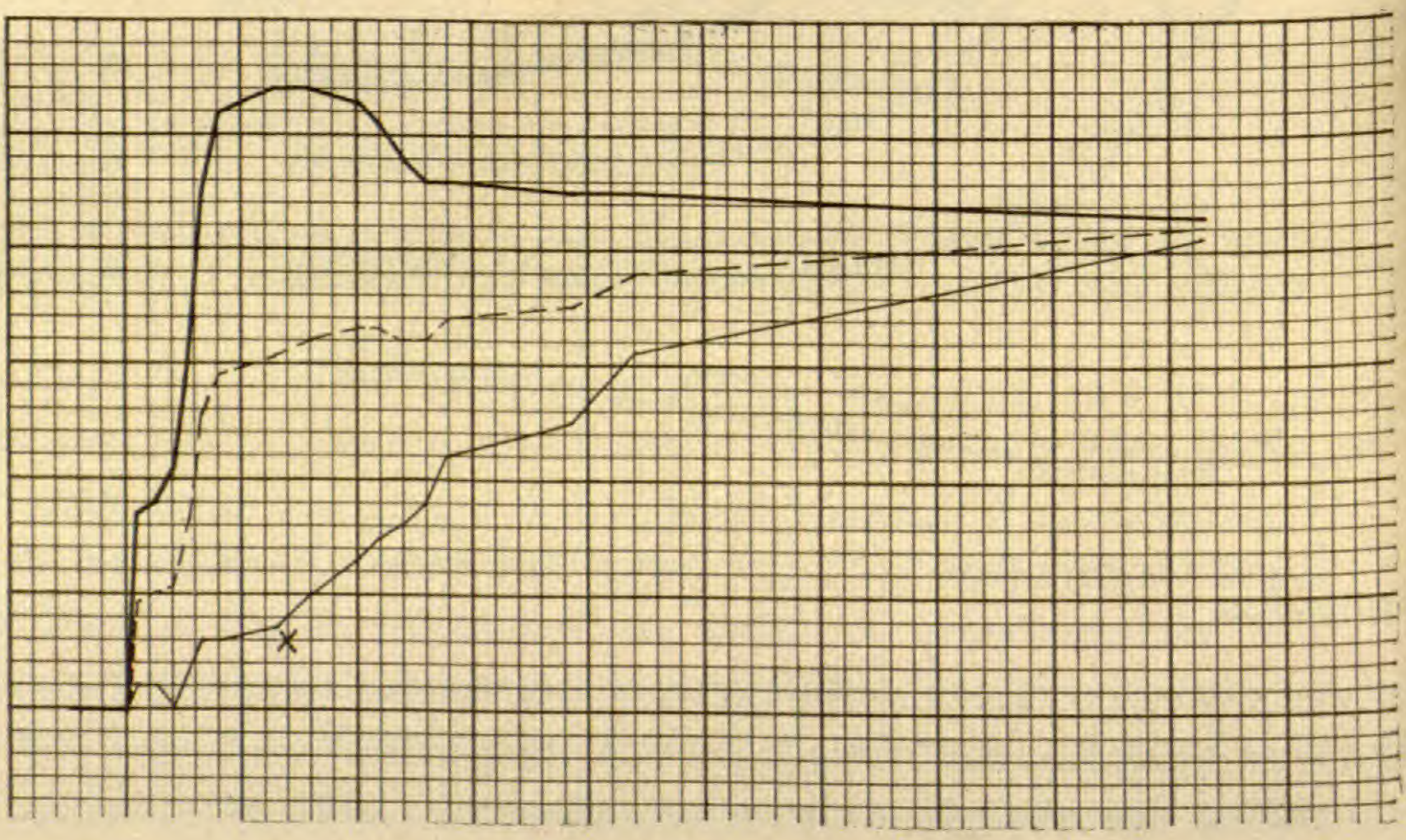

FIG. 4. A graph representing the reaction shown in FIGS. 1 and 2, drawn according to data in TABLE I. See text for explanation.

heavy line; the growth of the adaxial side is shown by the light line. The calculated growth of the median section of the tentacle is given by the broken line. The time is plotted on the abscissae; each space is thirty minutes. The changes in length are plotted on the ordinates; each space represents 0.02 mm. The reaction time is not indicated. The cross shows when the bending was completed and when unbending began. It is evident from the figure that the inflexion of the tentacle is produced by a considerable acceleration of the rate of growth on the abaxial side and in the median section. The unbending is more gradual and takes six times as long as the bending. Moreover the unbending is produced by a similar but less intense acceleration of the growth on the adaxial side and in the median section together with contraction of the abaxial side during the beginning of the process.

The reaction of another tentacle is shown in TABLE II and FIG.

TABLE II

	No. of Segment	10.16 A. M.	10.54 A. M.	11.18 A. M.	11.28 A. M.	11.31 A. M.	11.36 A. M.	12.09 P. M.	12.38 P. M.	3.58 P. M.	9.45 A. M.
Abaxial side	1	72	72	72	72	72	72	72	72	72	72
	2	118	118	118	118	118	118	119	119	119	119
	3	26	27	28	28	31	32	33	34	36	34
	4	54	54	54	58	58	58	58	59	59	58
	Total	270	271	272	276	279	280	282	284	286	283
Adaxial side	1	72	72	72	72	72	72	72	72	72	72
	2	121	121	121	121	121	121	120	120	120	121
	3	35	35	35	35	35	35	35	34	33	43
	4	38	37	37	37	36	35	35	34	34	42
	Total	266	265	265	265	264	263	262	260	259	278

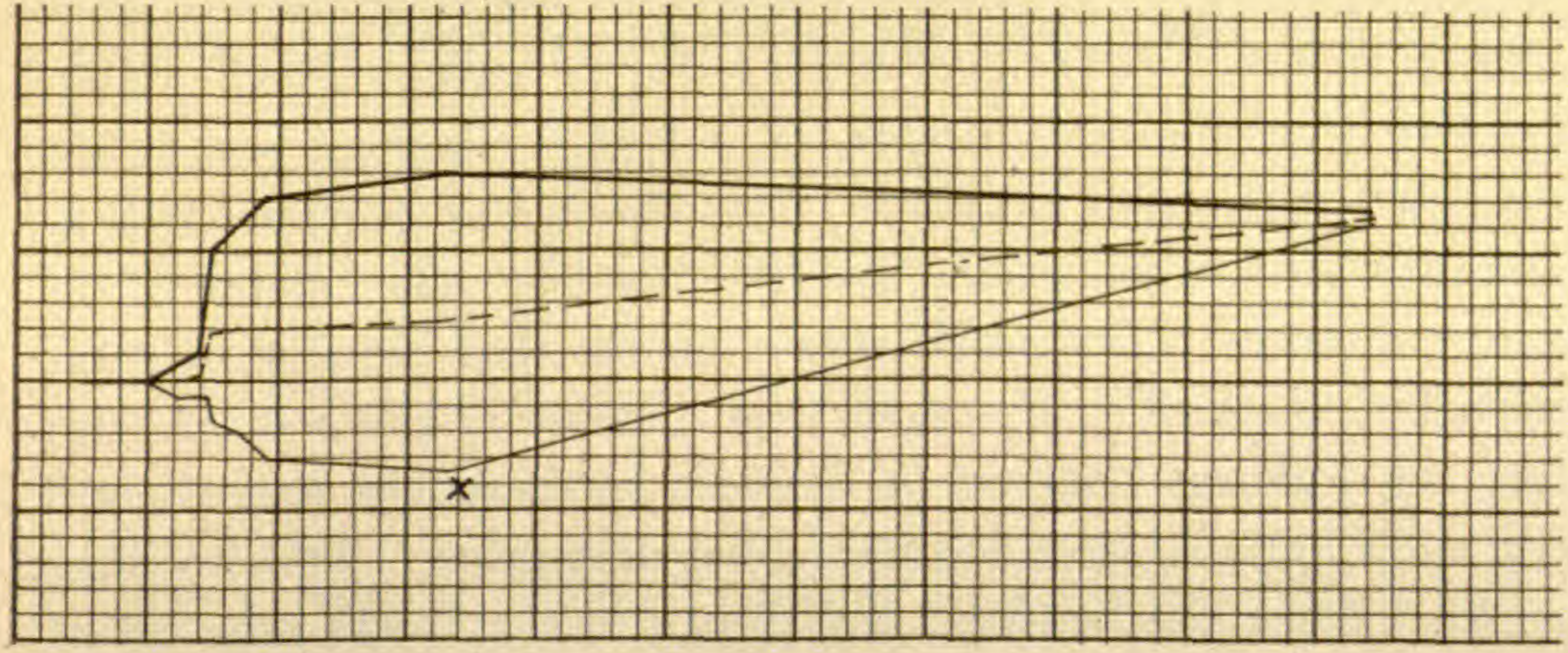

FIG. 5. A graph representing the bending and unbending of a tentacle, drawn according to data in TABLE II, and on the same scale as FIG. 4.

5. Before the experiment it measured 2.7 mm. The reaction is in all essential respects similar to the previous example, but there are important differences. The tentacle was on a mature leaf. It had not, however, been stimulated before the experiment. Bending was produced by an elongation of the convex side and the median section, accompanied by contraction of the concave side. The increase in length on the abaxial side was twice as great as the contraction of the adaxial side. The ultimate stage of bending was reached 5 hours and 45 minutes after stimulation. Unbending was caused by gradual growth on the concave side and in the median section together with slight contraction of the convex side. The original position was reached after 23 hours and 30 minutes. The tentacle then measured 2.83 mm. It had grown 0.13 mm. during the experiment.

A third example is given in TABLE III. This tentacle was in the third row from the outside, on a leaf in excellent condition. It reacted with great rapidity. Movement was detected within a minute after stimulation, and the bending was completed in twenty minutes. The table shows clearly that elongation commenced in Segment 5, the most basal portion of the abaxial side; after ten minutes Segment 4 likewise increased in length; and after three minutes more Segment 3 began to grow. The drawings in FIG. 6 show the bending, and illustrate the apical progress of the reaction. As in the previous case, the bending was produced

TABLE III

	No. of Segment	3.45 P. M.	3.52 P. M.	3.55 P. M.	3.58 P. M.	4.01 P. M.	4.05 P. M.	9.20 A. M.	4.00 P. M.	9.00 A. M.
Abaxial side	1	84	84	84	84	84	84	84	84	84
	2	57	57	58	58	58	58	58	58	58
	3	37	37	37	37	40	41	42	43	43
	4	31	31	31	34	40	43	43	43	43
	5	45	47	52	53	57	57	54	50	49
	Total...	254	256	263	266	279	283	281	278	277
Adaxial side	1	82	82	82	82	82	82	82	82	82
	2	57	57	57	57	57	57	58	59	61
	3	58	58	58	58	59	59	60	62	66
	4	46	46	42	37	37	40	42	42	42
	5	12	12	12	12	12	12	23	23	24
	Total...	255	255	251	246	247	250	265	268	275

by acceleration of the growth on the convex side and in the median section, with contraction of the concave side.

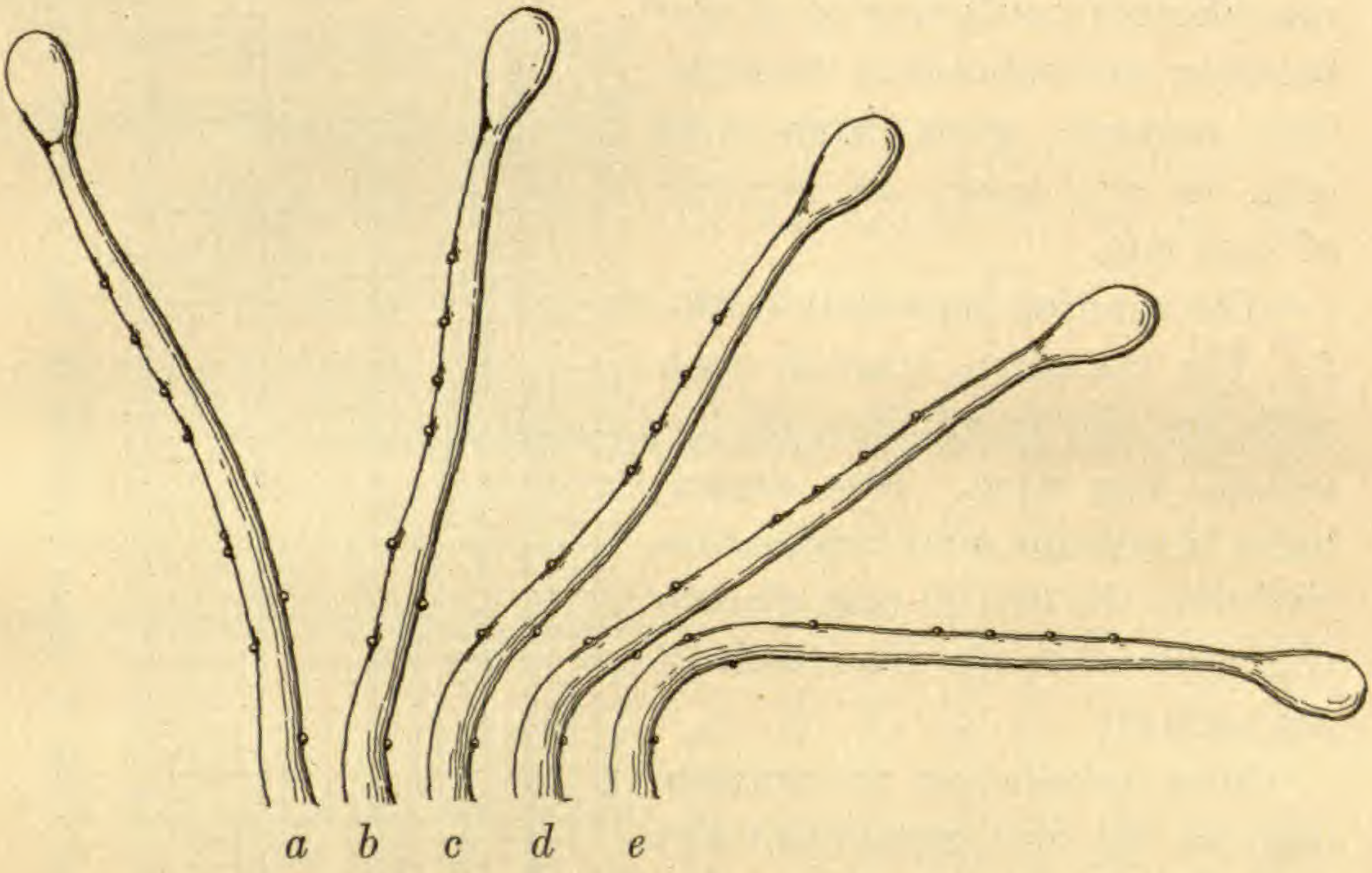

FIG. 6. Side views of a tentacle in the process of bending, × 22. *a*, the straight tentacle before stimulation; *e*, the inflected tentacle twenty minutes after stimulation.

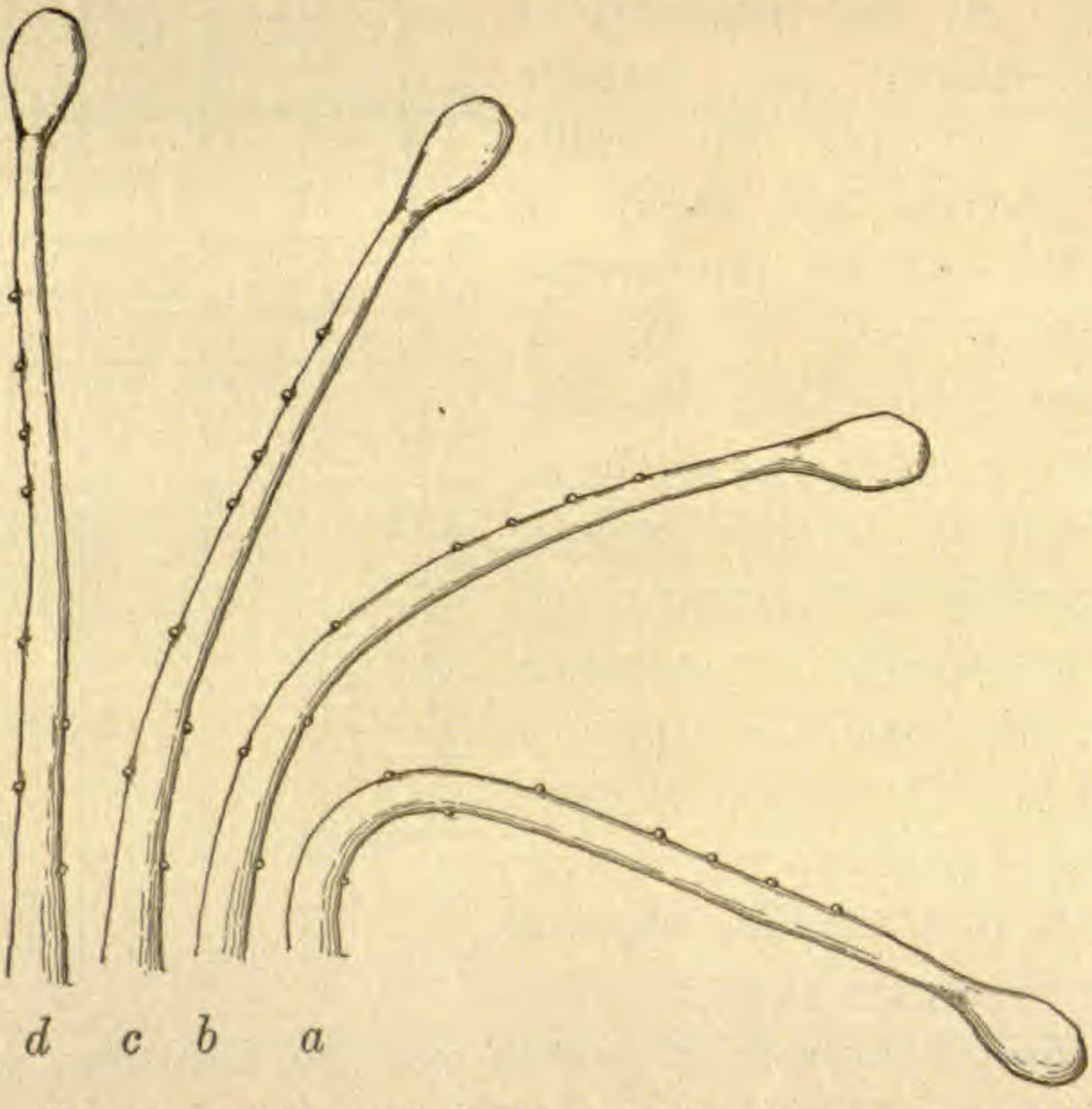

FIG. 7. Side views of the tentacle shown in FIG. 6 in the process of unbending, × 22. *a*, the fully inflected tentacle; *d*, the straight tentacle at the end of the reaction.

The unbending presents no new features. FIG. 7 shows successive stages in the process and comparison with FIG. 6 emphasizes the different configuration of the bending and unbending tentacle. The tentacle grew from 2.54 mm. to 2.77 mm., an increase of 0.23 mm.

The reaction is plotted in FIG. 8. The complete reaction took 39 hours and 15 minutes, an unusually long time. This experiment is perhaps more representative than the first in that growth was confined to the lower half of the pedicel.

After a day's rest, the tentacle used in the first experiment was stimulated a second time. The leaf was still fresh and actively secreting. At the beginning of this experiment the tentacle measured 3.37 mm. The results of the reaction are shown in TABLE IV, and are represented in graphical form in FIG. 9. Movement began within two minutes. The bending was produced by elongation of the abaxial side beginning in Segment 6 and extending apically to Segments 5 and 4, and basally to a part of Segment 7. The region of elongation and curvature was shorter than in the first reaction, where it included Segments 3 and 2. The acceleration of the rate of growth was also less than during the first inflexion. The time required for the bending was increased to four hours. The time taken to regain the original position was

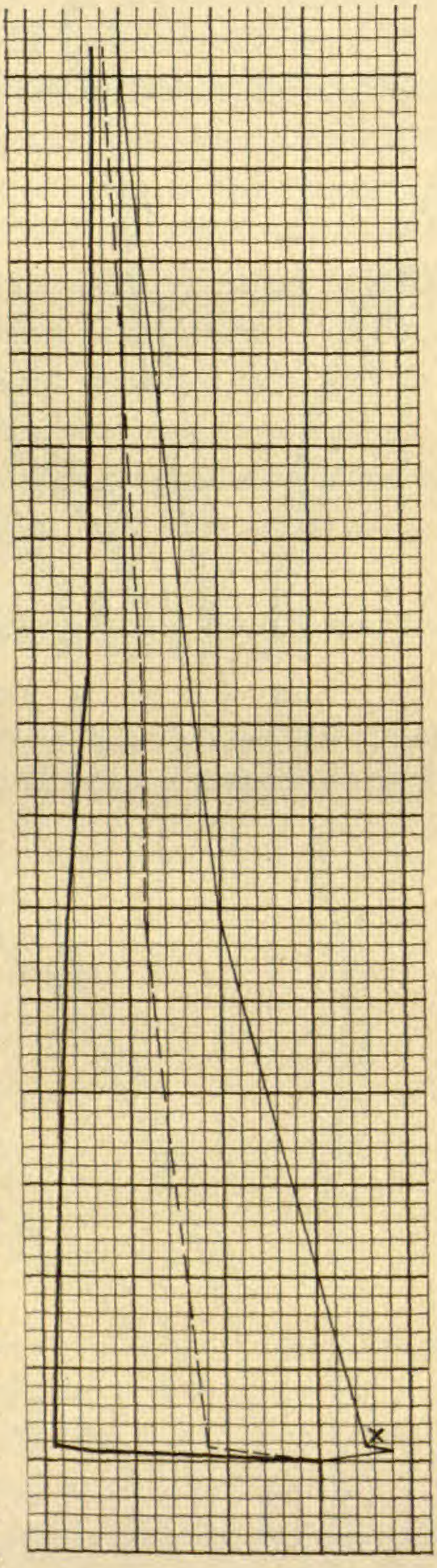

FIG. 8. A graph representing the reaction shown in FIGS. 6 and 7, drawn according to data in TABLE III, on the same scale as FIG. 4.

approximately the same as before, 22 hours and 45 minutes. At the end of the reaction the tentacle measured 3.74 mm. It had increased 0.37 mm. in length. A control, that like this tentacle had made one previous inflexion, measured 2.85 mm. before and after the experiment. Another that had never reacted measured similarly 2.3 mm.

TABLE IV

	No. of Segment	10.15 A. M.	10.30 A. M.	10.45 A. M.	11.00 A. M.	*11.30 A. M.	11.45 A. M.	12.45 A. M.	2.15 P. M.	3.00 P. M.	7.00 P. M.	10.10 P. M.	9.00 A. M.
Abaxial side	1	80	80	80	80	80	80	80	80	80	80	80	80
	2	25	25	25	25	25	25	25	25	25	25	25	25
	3	28	28	28	28	28	28	28	28	28	28	28	28
	4	34	35	35	35	35	36	36	36	36	36	36	36
	5	46	46	49	53	54	55	55	57	57	57	54	53
	6	55	64	64	69	69	69	69	71	71	71	71	70
	7	69	69	69	71	73	76	76	82	82	82	82	82
	Total	337	347	350	361	364	369	369	379	379	379	376	374
Adaxial side	1	78	78	78	78	78	78	78	78	78	78	79	79
	2	24	24	24	24	24	24	24	24	24	24	25	25
	3	27	27	27	27	28	28	28	28	28	28	28	28
	4	34	35	35	35	35	35	35	35	35	35	35	36
	5	46	46	47	47	47	47	47	47	47	47	53	54
	6	55	59	59	59	59	59	59	59	59	59	60	69
	7	75	75	75	75	75	76	77	78	79	84	84	84
	Total	339	344	345	345	346	347	348	349	350	355	364	375

* Controls well bent.

This tentacle was allowed to rest over another day and it was stimulated for the third time. At this time it measured 3.74 mm.

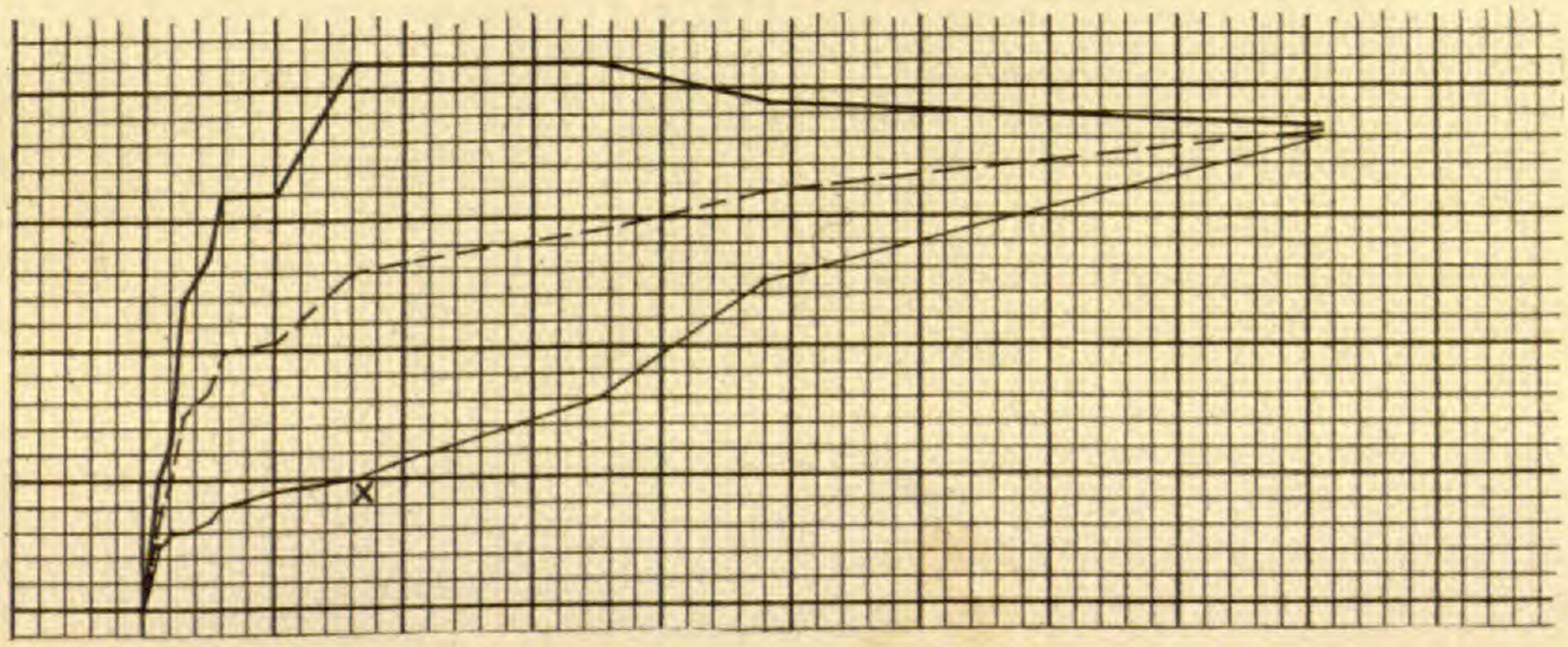

FIG. 9. A graph representing the second reaction of the tentacle shown in FIGS. 1–4; drawn according to data in TABLE IV, and on the same scale as FIG. 4.

The reaction is represented in Table V and Fig. 10. No movement was observed for an hour after stimulation. The region of elongation and curvature was shorter than in the second reaction.

Table V

	No. of Segment	12.00 M.	2.55 P. M.	7.30 P. M.	10.40 P. M.	9.15 A. M.	1.00 P. M.
Abaxial side	1	80	80	80	80	80	80
	2	89	90	92	92	92	92
	3	53	54	54	54	54	54
	4	70	79	79	79	78	77
	5	82	98	98	98	96	95
	Total	374	401	403	403	400	398
Adaxial side	1	79	79	79	79	79	79
	2	89	94	93	93	93	93
	3	54	53	54	54	54	54
	4	69	68	68	68	75	77
	5	84	84	85	85	90	93
	Total	375	378	379	379	391	396

The acceleration of growth on the convex side was less than in the previous reaction, and the tentacle was not fully bent for 7 hours and 30 minutes. It remained in this condition 2 hours and 30 minutes before unbending again. The tentacle was again straight 25 hours after stimulation. It measured 3.98 mm., an increase of 0.24 mm. After this experiment the tentacle stopped secreting, and no further reaction could be obtained.

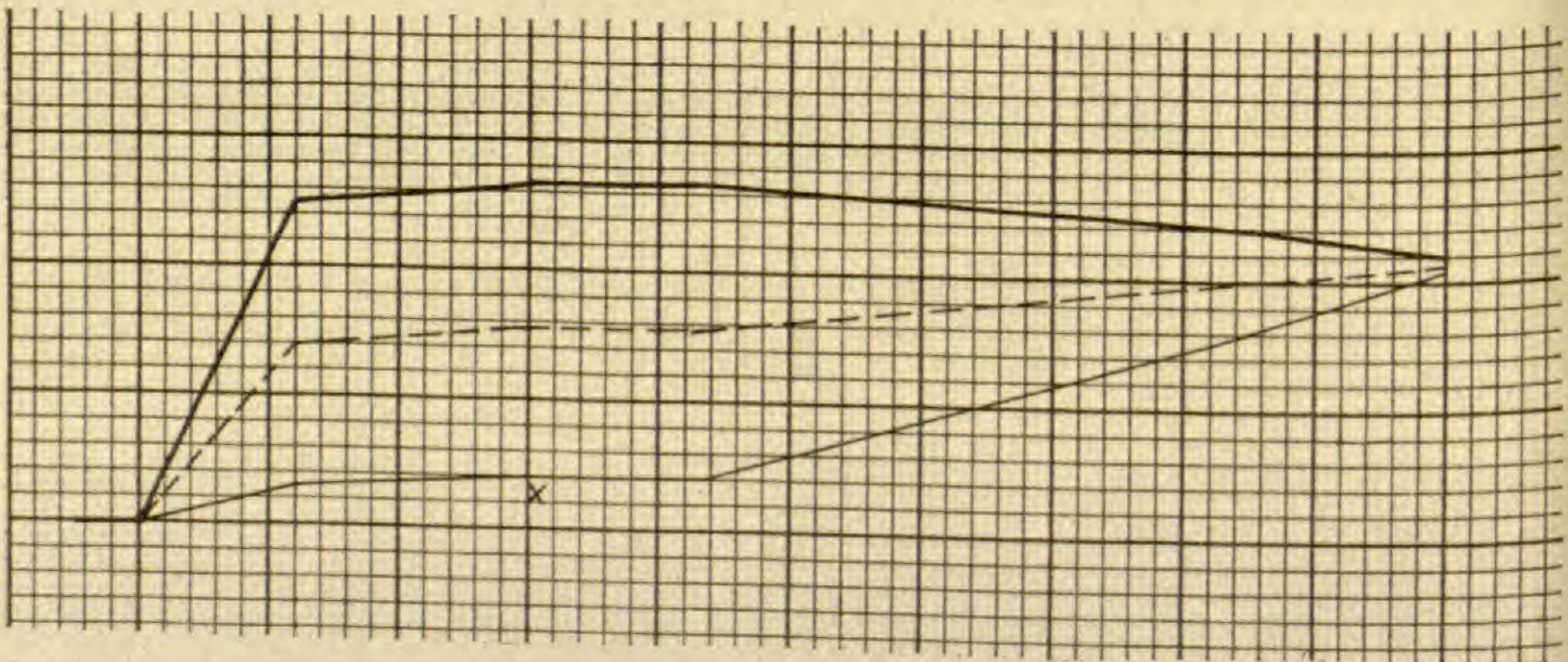

Fig. 10. A graph representing the third reaction of the same tentacle shown in Fig. 9; drawn according to data in Table V, and on the same scale as Fig. 4.

The results of the three successive reactions of this tentacle are summarized in TABLE VI. The increase in length for the three reactions was 0.43 mm., 0.37 mm. and 0.24 mm. The region of most intense growth moved basally. In the first reaction it was in Segments 4 and 5; in the second in Segment 5; and in the third in Segment 6. The ultimate stages of bending in the three reactions are shown in FIG. 11. In each subsequent inflexion

TABLE VI

No. of Segment	Original Length	Length after First Bending	Amt. of Growth	Relative Amt. per Mm.	Length after Second Bending	Amt. of Growth	Relative Amt.	Length after Third Bending	Amt. of Growth	Relative Amt.
1	80	80	0	0	80	0	0	80	0	0
2	47	53	6	13	53	0	0	53	0	0
3	29	34	5	17	36	2	6	39	3	8
4	36	46	10	27	53	7	15	54	1	2
5	43	55	12	28	70	15	27	77	7	10
6	59	69	10	17	82	13	19	95	13	16
Total ...	294	337	43	15	374	37	11	398	24	6

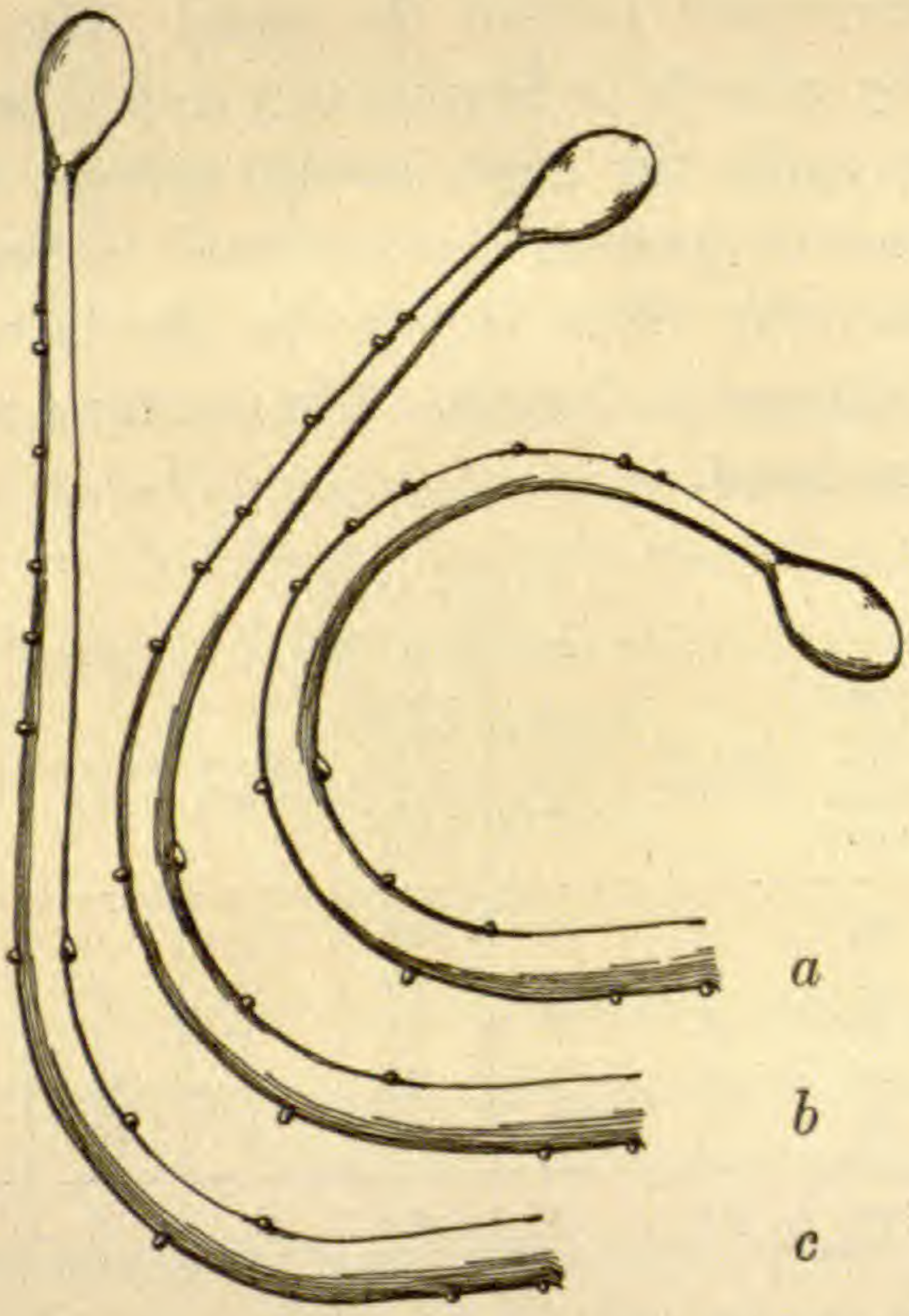

FIG. 11. The ultimate stages in three successive inflexions of the same tentacle, × 22. *a*, at the end of the first inflexion; *b*, at the end of the second inflexion; *e*, at the end of the third inflexion.

the amount of bending decreased, the gland was moved through successively smaller angles and the zone of bending was restricted to shorter and more basal portions of the tentacle.

TABLE VII

No. of Segment	Original Length	Length after First Reaction	Amt. of Growth	Relative Amt. per Mm.	Length after Second Reaction	Amt. of Growth	Relative Amt.	Length after Third Reaction	Amt. of Growth	Relative Amt.
1	23	23	0	0	23	0	0	23	0	0
2	40	40	0	0	40	0	0	40	0	0
3	11	11	0	0	11	0	0	11	0	0
4	22	23	1	5	23	0	0	23	0	0
5	35	34	3	9	41	3	8	41	0	0
6	20	23	3	15	25	2	8	27	2	8
7	21	34	13	62	41	7	21	59	18	44
Total ...	172	192	20	17	204	12	6	224	20	10

TABLE VII shows the growth of another tentacle during three successive reactions. The respective elongations were 0.2 mm., 0.12 mm. and 0.2 mm. During the first reaction Segments 4 to 7 grew. The rate of growth was most intense in the lowest segment and decreased toward the apex. The second reaction was produced by growth in Segments 5 to 7. Segment 4 did not elongate. Here again the most intense growth was at the base. In the third reaction growth was confined to Segments 6 and 7, and was considerably more intense in the latter. Segments 4 and 5 did not increase in length. The tentacle was again stimulated but did not bend.

TABLE VIII

No. of Segment	Original Length	Length After First Reaction	Amt. of Growth	Relative Amt. per Mm.	Length After Second Reaction	Amt. of Growth	Relative Amt.	Length After Third Reaction.	Amt. of Growth	Relative Amt.
1	85	85	0	0	85	0	0	85	0	0
2	52	54	2	4	54	0	0	54	0	0
3	82	88	6	7	89	1	1	89	0	0
4	23	25	2	9	33	8	32	38	5	15
5	36	42	6	17	51	9	21	60	9	18
Total ...	278	294	16	6	312	18	6	326	14	15

A third example of this sort is given in TABLE VIII. The reaction time of the first inflexion was 1 minute, 40 seconds. Segments 2 to 5 increased in length. The rate of growth was greatest in the lowest segment and decreased apically. The second reaction was produced the day following the first. The reaction time was 1 minute, 30 seconds. Growth occurred in Segments 3 to 5. Segment 2 had stopped growing. The third reaction took place two days after the first one. More than an hour elapsed before movement was detected. Growth was confined to Segments 4 and 5. No elongation of Segments 2 and 3 took place. The third unbending of the tentacle was exceedingly slow, and the pedicel did not regain its original position until three days after stimulation. A fourth reaction could not be induced. The elongations accompanying the first, second and third inflexions were nearly constant, being 0.16 mm., 0.18 mm. and 0.14 mm., respectively.

TABLE IX

No. of Segment	Original Length	Length after First Reaction	Amt. of Growth	Relative Amt.	Length after Second Reaction	Amt. of Growth	Relative Amt.
1	80	80	0	0	80	0	0
2	19	20	1	5	20	0	0
3	20	21	1	5	21	0	0
4	16	18	2	13	18	0	0
5	37	43	6	16	44	1	2
6	32	41	9	28	43	2	5
7	34	44	10	29	49	5	11
Total....	238	267	29	12	275	8	3

TABLE IX gives the growth during two successive reactions of a tentacle. The growing region is much more restricted in the second than in the first bending. In both cases the rate of growth increases toward the base of the pedicel.

(*d*) DISCUSSION

i. *Bending*

The bending of a *Drosera* tentacle is produced by an acceleration of the rate of growth, which extends from the convex side through the middle of the tentacle. In some cases the concave side is likewise included, so that the entire cross-section of the pedicel participates. In other cases the region of accelerated growth stops at a so-called neutral line, somewhere between the middle and the concave side. Under such circumstances the concave side becomes shorter, probably as a result of compression. The acceleration is greatest on the convex surface and diminishes toward the concave. This difference in the rate of growth produces the bending when the acceleration extends all the way through the pedicel and includes the concave surface. If a neutral line is present, it presumably serves as a brace against which the elongation of the convex side acts.

The increase in the rate of growth begins in a part of the pedicel at or near its base, whence it moves toward the gland, widening its scope until one to two thirds of the pedicel is involved. The gland and the adjacent portion of the pedicel do not grow. C. Darwin ('08, p. 9) states that the distal half remains straight in all cases; but growth is not always as confined as he indicates, for in one case (TABLE VIII) 70 per cent of the tentacle grew, and in another (TABLE I) 73 per cent. If the place where the reaction begins is not the most basal portion of the pedicel, the acceleration of the rate of growth extends also a short distance in the direction of the leaf-blade (TABLE I). Those regions where the reaction commences have the highest rate of growth and are involved in the reaction for the greatest length of time: consequently they grow most, so that the amount of elongation is greatest at the base and decreases toward the apex. Ordinarily, bending is confined to one place, but in some of the long marginal tentacles the pedicel curves in two places—in the middle and again at the base (cf. C. Darwin, '08, p. 206). This is particularly characteristic of those tentacles which have the gland imbedded on the upper side of the pedicel, instead of at the apex.

The amount of bending is determined by two factors; the difference between the lengths of the convex and concave sides, and the thickness of the bending region. An increase in the former augments, in the latter diminishes the amount of bending. The longest tentacles bend most, since their growing region has the largest dimensions. The gland may be moved through a wide angle, for example 215 degrees as shown in FIG. 2. C. Darwin ('08, p. 9) describes an instance of movement through an angle of 270 degrees. The time required for bending is very variable. It may be nearly six hours (TABLE II, FIG. 5), or only twenty minutes (TABLE III, FIGS. 6, 7 and 8). C. Darwin ('08, p. 23) once saw inflexion finished in 17 minutes, 30 seconds.

In all cases of direct stimulation of the gland, the bending of *Drosera* tentacles is nastic; the inflected gland always points toward the center of the leaf. The stimulus may be contact, heat, injury or some chemical substance in solution.

When a tentacle reacts to a single stimulation, it begins to unbend immediately after the ultimate degree of inflexion has been reached. This is the case when the gland has been irritated by contact with some object for a limited space of time. If the source of stimulation is not removed, as for example when an insect is caught and digested, the tentacle remains inflected for a period varying from one to eleven days, according to C. Darwin ('08, pp. 11, 195). During the interval between bending and unbending the tentacle does not grow in length.

ii. *Unbending*

The unbending of the tentacle is accompanied by an increase in the rate of growth on the concave side and in the median section. The convex side always contracts so that the so-called neutral line exists somewhere between it and the middle of the tentacle. The acceleration of the rate of growth is characterized by a transverse distribution which is exactly opposite that accompanying bending. Its longitudinal distribution is however identical. The increase in the rate of growth commences opposite that basal portion of the convex side which reacted first, and extends as far apically. Growth is most rapid near the base and becomes less intense toward the gland. The contraction of the convex side is usually restricted to a short basal region.

It frequently happens that the concave grows less than the convex side, since the latter is compressed during the expansion of the tentacle. The concave side may undergo a certain amount of compression during the inflexion of the tentacle, so that the two sides grow and contract approximately equal amounts. The unbending proceeds much more slowly than the bending.

In all probability the unbending of *Drosera* tentacles is autotropic (cf. Fitting, '03, p. 612). The stimulus perceived is the inequality of conditions, pressure, tissue-tension, etc., which is produced on the opposite sides of the originally straight tentacle by its bending. The unbending is therefore of a tropic nature, since it is a reaction in response to differences existing on the opposite sides of the tentacle. The inflexion and expansion of a *Drosera* tentacle present a remarkable instance of a practically continuous reaction, produced by a single mechanism, but caused by two stimuli of different nature, so that it is partly nastic and partly tropic.

iii. *Growth and Turgidity*

Since the movement of a *Drosera* tentacle is the result of growth, it is always longer at the end of a reaction than at the beginning. The amount of elongation varies from 0.1 mm. to 0.5 mm. This suggests a simple demonstration to show that the reaction is accompanied by growth. If a single tentacle on a leaf is stimulated, it will project a noticeable distance beyond its fellows after regaining its original position. In the field, a *Drosera* leaf frequently has some tentacles longer than other ones in the same row. These inequalities are the result of growth attendant upon reaction, for all the tentacles in one row remain of equal length if not stimulated. Sometimes a small insect is caught by a single exterior tentacle, which carries it to the center of the leaf. The insect is, however, too minute to cause a sufficient impulse to be conducted from the discal to the other marginal tentacles. They do not bend, so that after the reaction is completed they are not as long as the tentacle which was inflected.

Turgidity does not play a part in the movement of the tentacles. This was proved by plasmolyzing bent tentacles in 20 per cent salt solution. The plasmolyzed tentacles remained bent.

A comparison of FIGS. 4, 5 and 8 with graphs of Fitting, which show the haptotropic reactions of tendrils of *Sicyos angulatus* (Fitting, '02, p. 378), of *Passiflora gracilis* (Fitting, '03, p. 577, *fig. 6*) and of *Pilogyne suavis* (*ibid.*, p. 578, *fig. 7*), shows that the mechanics of movement in tendrils and tentacles are the same. Similar figures are shown by Wiedersheim for photonastic reactions of leaves of *Impatiens parviflora* (Wiedersheim, '04, p. 241, *fig. 1;* p. 242, *fig. 2;* p. 244, *fig. 5*), and for thermonastic reactions of the perianth leaves of the tulip (*ibid.*, p. 250, *fig. 8*) and the crocus (*ibid.*, p. 254, *fig. 10;* p. 255, *fig. 12*). It is clear that all these reactions are produced by the same mechanism; rapid growth on the convex side and in the median section with attendant contraction or a slower rate of growth (*ibid.*, p. 255, *fig. 12*) on the concave side. *Drosera* tentacles are characterized by a contraction of the convex side during expansion; this occurred in one case of a leaf of *Impatiens parviflora* (*ibid.*, p. 242, *fig. 2*).

iv. *Conductivity*

The reaction time represents the interval necessary for the latent period and the conduction of an impulse from the gland to the region where the reaction commences. This region has been shown to be a basal portion of the pedicel, so that the impulse is conducted the entire length of the tentacle. The reaction time usually varies from one to two minutes. C. Darwin ('08, pp. 10, 191) saw movement ten seconds after stimulation. This shows that the rate of conduction can be quite high, for assuming the length of the tentacle (which Darwin does not give) to be 2 mm., the rate of conduction would be 0.2 mm. per second, which is faster than any instance given for the haptotropic reaction of tendrils (Fitting, '04, p. 424). The rate of conduction in tentacles is generally much less (cf. Pfeffer, '06, Vol. III, pp. 93, 94). It should be emphasized that in *Drosera* tentacles stimuli are perceived by cells which are fully grown, and which undergo no further development.

It has not been definitely settled through what tissue impulses are conducted in *Drosera*, but in any case an impulse, in being conducted from the gland to the base of a tentacle, must pass through cells which later react, without producing a response in them. These cells apparently respond only to a secondary impulse released in the basal cells by the impulse conducted directly from the gland. This secondary impulse is conducted in the reverse direction, from the base toward the apex.

v. *Second and Third Reactions*

A tentacle is capable of reacting several times in succession. C. Darwin ('08, pp. 11, 19) observed a leaf inflected three times over insects, and suggested the possibility of more reactions. It is probable, however, that a leaf can clasp insects a greater number of times than any individual tentacle can react, because the capture of such prey does not always necessitate the cooperation of all the tentacles. Those which remain inactive at one time, might bend on a subsequent occasion. However this may be, no tentacle has been observed to react the fourth time.

The second and third reactions of a tentacle are essentially similar to the first. After two reactions a tentacle is much less sensitive than before, as is shown by the increased reaction time. Each subsequent bending takes longer (cf. C. Darwin, '08, p. 19), but the original position is regained in approximately the same time. The amount of growth does not vary according to any definite rule. It depends rather on external conditions and is apparently uninfluenced by the age of the tentacle. If the external conditions are constant, the amount of growth remains the same. In one example (TABLE VIII) this was approximately the case, the increase in length for the first, second and third reactions being 0.16 mm., 0.18 mm. and 0.14 mm. respectively.

The region of growth is however more restricted in each subsequent reaction, and is confined to more basal portions of the tentacle. TABLE VII shows that 57 per cent of the tentacle grew in length during the first inflexion, 50 per cent during the second, and 32 per cent during the third. In another instance (TABLE VIII) the regions of growth were successively 70, 53, and 27 per cent of the length of the tentacle. In each reaction a certain portion of the tentacle becomes fully grown. A *Drosera* tentacle is therefore characterized by intercalary, basipetal growth. Because of this, the number of inflexions which a tentacle can make must necessarily be limited. It is therefore highly probable that a tentacle would bend a fourth time only under very exceptional circumstances.

Since growth is limited to more basal regions, the thickness of the reacting portion is greater at each successive inflexion. Moreover the greatest difference between the lengths of the opposite sides tends to decrease. Both of these factors cooperate in reducing the amount of bending, so that the gland is moved through successively smaller angles, as shown in Fig. 11.

vi. *Nastic reactions*

In all the experiments described, the glands of the marginal tentacles were stimulated directly, but reactions follow likewise in response to impulses received by the discal tentacles and conducted to the marginal ones. The mechanism by which these reactions are carried out is identical with that described above.

Numerous experiments were made to determine if the marginal tentacles bent toward the source of stimulation. The discal tentacles on one side of a leaf were stimulated and most of the marginal tentacles which reacted to the conducted impulse, in bending toward the center of the leaf bent likewise in the direction of the source of excitement. In a number of such cases, however, marginal tentacles were observed to bend toward the center of the leaf in a direction different from the point of excitement. One or two instances in which the tentacles bent slightly in the direction of the source of excitement and not toward the center of the leaf seemed to be purely accidental and due rather to irregularities in the contour of the leaf. Nitschke ('60, p. 240) and C. Darwin ('08, p. 198 and *fig. 10*) noticed that when a gland on one side of the disk was stimulated, "the surrounding tentacles" bent to the point of excitement and not to the center of the leaf. The statement by Darwin together with his figure has generally been understood to include the marginal tentacles. He says, however ('08, p. 200): "It is, perhaps, owing to the exterior pedicels being much flattened that they do not bend quite so accurately to the point of excitement as the more central ones." I am convinced that the peripheral tentacles seldom if ever carry out tropic movements.

vii. *Discal Tentacles*

The discal tentacles differ both anatomically and physiologically from the marginal tentacles. The latter are dorsi-ventral and nastic, the former are radial and tropic. The central tentacles do not bend in response to a direct stimulus, but only to a conducted impulse, and always toward the point of excitement. The method used for investigating the mechanics of the movement of the marginal tentacles is not adapted for studying them in the central tentacles. In all probability, however, their movements are likewise the result of differential growth on opposite sides. The angle of curvature is in any case slight. This and the small diameter of the tentacles indicate that the amount of growth is small. The bending region is confined to a very short basal portion of the pedicel.

Transitions from exterior to central tentacles occur, which exhibit intermediate conditions not only in their structure but also in their behavior. It is probable that some of these tentacles are both nastic and tropic.

8. SUMMARY

1. The red pigment which is found in the leaves and roots of *Drosera rotundifolia* is probably trihydroxymethylnapthoquinone.

2. The rosette habit is conditioned by transpiration.

3. The inflexion of *Drosera* tentacles is produced by an acceleration of the rate of growth on the convex side and in the median section. The unbending is caused by an increase in the rate of growth on the concave side and in the median section, accompanied by compression of the convex side.

4. In both cases the acceleration commences near the base and extends toward the gland. The amount of growth is greatest near the base and decreases apically.

5. A tentacle is capable of reacting three times. During each reaction an apical portion of the bending region becomes fully grown. *Drosera* tentacles have intercalary, basipetal growth.

6. The bending of the exterior tentacles is nastic; of the central tentacles, tropic. The unbending is in all cases owing to autotropism.

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The thermometric movements of tree branches at freezing temperatures*

C. C. TROWBRIDGE

(WITH NINETEEN TEXT FIGURES)

During the winter of 1910, the writer of the present paper noticed that the branches of several linden trees on the grounds of Columbia University in the City of New York changed their position when a fall of temperature below freezing occurred.

FIG. 1. Photograph showing the extent of the change of the position ot a branch of a European linden tree (*Tilia europaea*) between normal and about twenty-two degrees below freezing, Fahrenheit. The lower branch (*M*) has been artificially inserted in the photograph to show extent of movement. Lower branch, at elbow, *M*, 5.33 ft. elevation, temp. + 10° F., February 10, 1912. Upper branch, at elbow, *N*, 6.82 ft. elevation, temp. + 35.6° F., February 28, 1912. This branch is designated as "Branch *A*, Tree No. 1," in the accompanying curves.

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[1] Contributions of the Phoenix Physical Laboratory, No. 34.

The matter was again strikingly called to mind during an exceedingly cold period in the early part of February, 1912. As the phenomenon seemed not to be generally known among botanists, a series of measurements was made to ascertain the extent of the movements, and, if possible, to learn something of their origin.

During the course of the work, two or three papers on the subject came to light, two of which anticipated the observations of the writer with respect to the general phenomena of the thermometric movements of branches of large trees. Since, however, the field of the investigation has been extended in several respects, and because the matter is so little understood, the observations made are published in full in the present paper.

The general facts relating to thermometric movements of branches of large trees as based on the writer's observations are as follows: It appears in the case of certain species, particularly the European linden (*Tilia europaea*), that when the temperature of the air reaches the freezing point of water, 32° F. (0° C.), the branches of the tree, large and small, begin to bend and continue this movement with further reduction of temperature. At the lowest temperature measured, about 0° F. (– 17.5° C.), the ends of the large branches of a particular linden under observation showed depressions as great as from three to five feet below their position at 32° F. The movements of the branches were found in general to correspond closely to the changes in temperature of the surrounding air, as will be shown. The observations made consisted of daily and hourly records of the height of branches of several species of trees with corresponding meteorological data. The work has been supplemented by photographs. The relation of the air temperature and the relative humidity to the observed changes in the branches will be presented in the form of curves.

The subject is an important as well as an interesting one, since frost cracks of the linden have been found by the writer to accompany in no accidental manner the thermometric movements of the branches. Frost cracks have much to do with the injury to various trees by insects and by decay, a matter well known, and at present a subject of investigation by the Bureau of Plant Industry of the Department of Agriculture of the United States.

HISTORICAL

A brief summary of the contents of papers relating to the subject of this paper is given below.

It is a noteworthy fact that comparatively little is to be found in the literature on the thermometric movement of branches of trees. Moreover, references in recent botanical papers to the few contributions on the subject are rare indeed; it is for this reason that the phenomenon is not well known among botanists. The writer was at first unable to find any published account of the gross thermometric movements to be described, but after the observations had been partly completed, his attention was called by Dr. J. T. Grossenbacher, of the Bureau of Plant Industry, Washington, D. C., to two papers on the subject, one by Robert Caspary, and the other by N. Geleznow, which were published in 1866 and 1872 respectively. Dr. Grossenbacher, having observed an abstract of the writer's observations,* published an article chiefly devoted to a discussion of these two early researches.† To quote from a footnote in his paper: "This review of the literature of branch movements and observations grew out of a study of crown-rot of fruit trees and is published separately because it is only indirectly related to the main theme." Owing to the publication of a review of these papers, they are referred to more briefly in the present paper than otherwise would have been the case.

Mr. John Rogers, at Kent, England, was apparently the first to observe the movement of large branches of trees in cold weather. His first observations were made as early as 1838, and a short note on the observations was published a few years later.‡

In 1865, Professor Caspary, of Königsberg, made a series of measurements of the phenomenon observed by Rogers, on a number of species of trees in the Königsberg botanical gardens. The observations were published under the title, "Über die veränderungen der Richtung der Äste holziger Gewächse bewirkt durch niedrige Wärmegrade."§ Caspary found three types of

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* Branch movements of certain trees in freezing temperatures. Torreya **13**: 86–87. 1913.

† Branch movements induced by changes of temperature. Science II. **38**: 201–205. 1913.

‡ Trans. Hort. Soc. London II. **2**: 230. 1842.

§ Internat. Hort. Exhib. Bot. Congress 98–117. 1866.

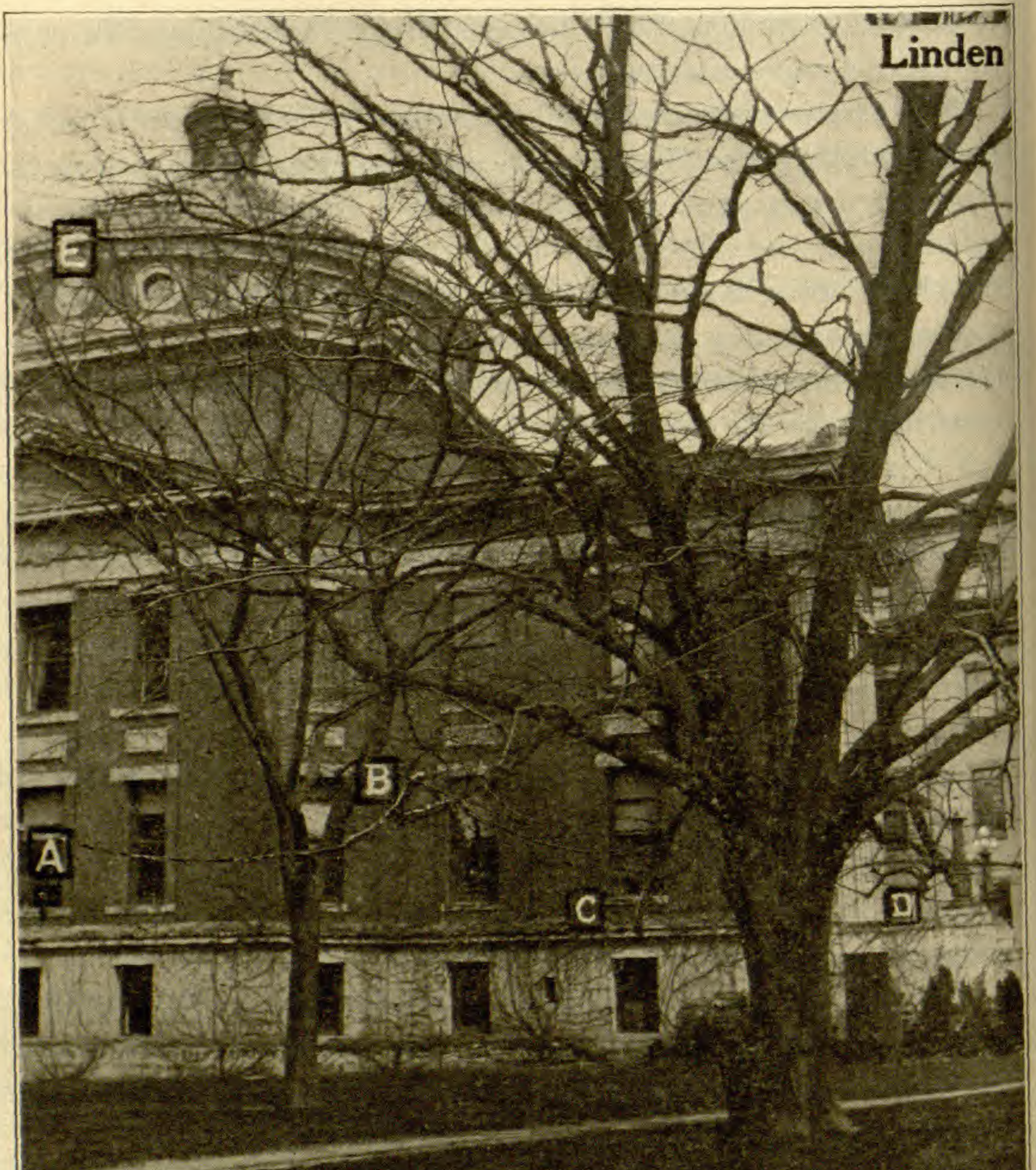

FIG. 2. Photograph of European linden tree No. 1, when the air temperature was + 50° F. Branches at normal level. Note positions of branches at *A*, *B*, *C*, *D* and *E*.

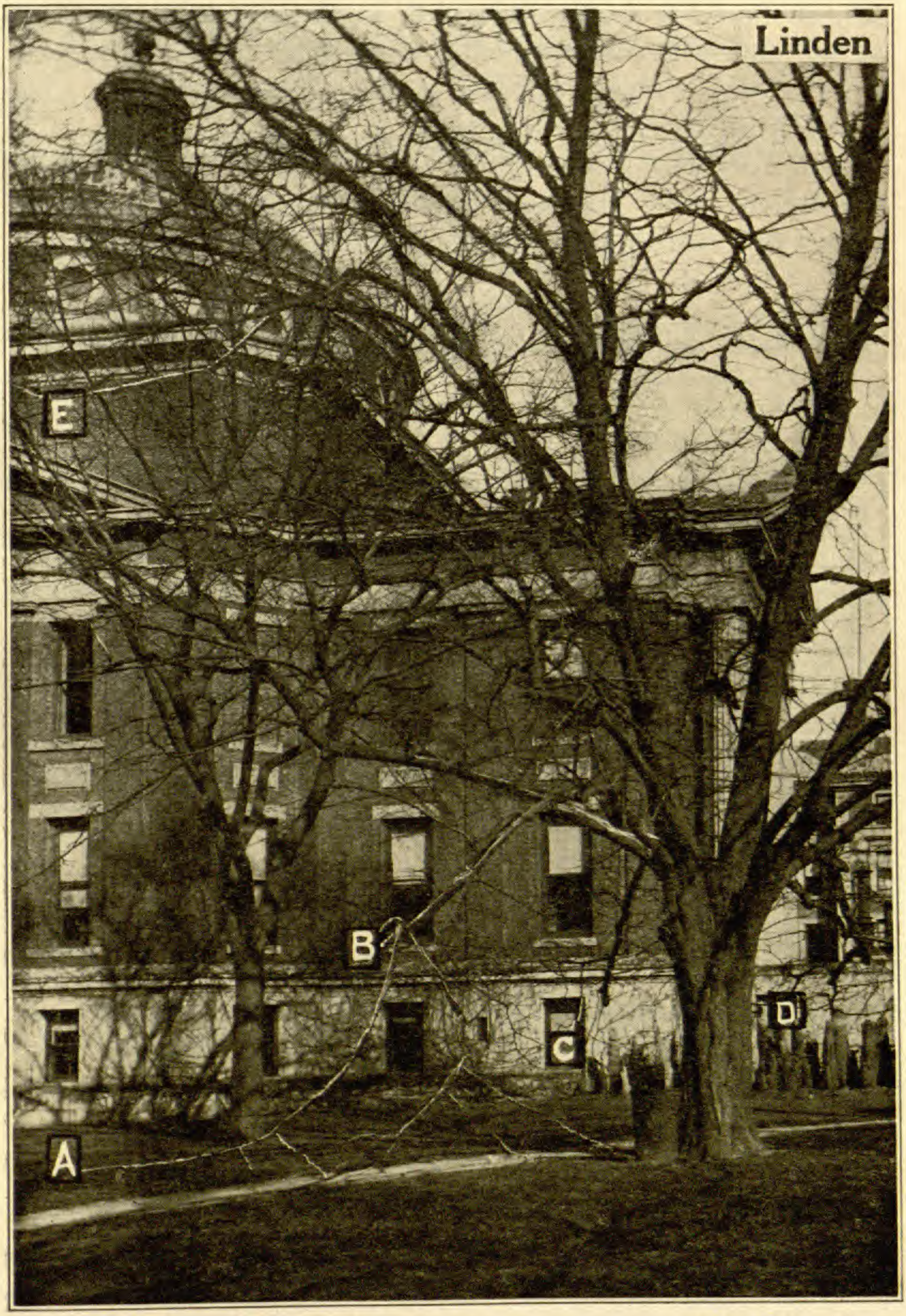

FIG. 3. Photograph of European linden tree No. 1 at + 14° F. (18° below freezing) showing marked depression of branches. See position of branches at *A*, *B*, *C*. *D* and *E*.

movements accompanying a fall of temperature. In one class, (*a*), the branches became depressed; in the second, (*b*), they rose at first, then with continued fall of temperature became depressed; and (*c*) they became elevated without being depressed. The measurements were carefully made on ten species of trees. No definite conclusion, however, as to the cause of the movements was arrived at by Professor Caspary, although he suggested the theory that the movements were caused by a differential expansion between the upper and lower sides of the branches.

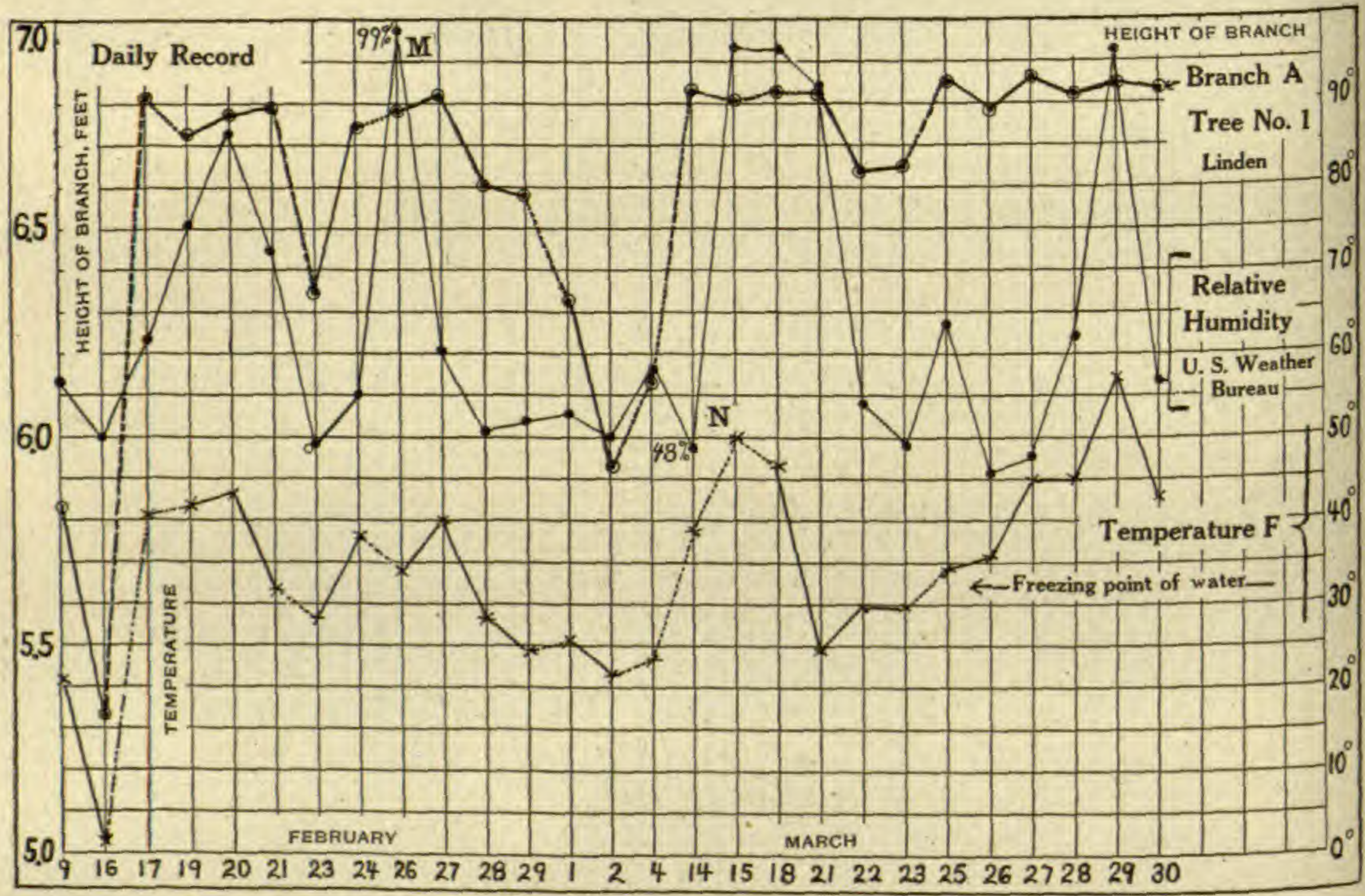

FIG. 4. Daily record of Branch *A*, Tree No. 1 (European linden) during *February* and *March*, 1912. Broken lines indicate where the daily record was not continuous. The branch movements are seen to follow closely the air temperature changes when *below freezing*. The amount of atmospheric moisture present, as shown by the relative humidity record (fine line curve), apparently has little effect on the position of the branch.

Later the following paper appeared: "Recherches sur la quantité et la répartition de l'eau dans la tige des plantes ligneuses," by N. Geleznow.* This contribution deals chiefly with the amount of moisture in the various parts of branches and tree trunks. Observations on the change in the position of branches with change of temperature were also made. Geleznow stated that he had first noted the phenomenon in 1854–5, and experiments made by him in 1864 and 1865 showed that the excentric

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* Bull. Acad. Imp. Sci. St. Petersburg **9**: 667–685. 1873–1877.

position of the medullary canal in some species had a marked influence on the phenomenon, but there were some anomalies which could not be explained. Experiments made in 1865–1867 showed a slight relation of the water content of the branches to the thermometric movement of the branches, but the connection was not at all definite. The work was undertaken largely to find an explanation of Caspary's work at Königsberg, already referred to.

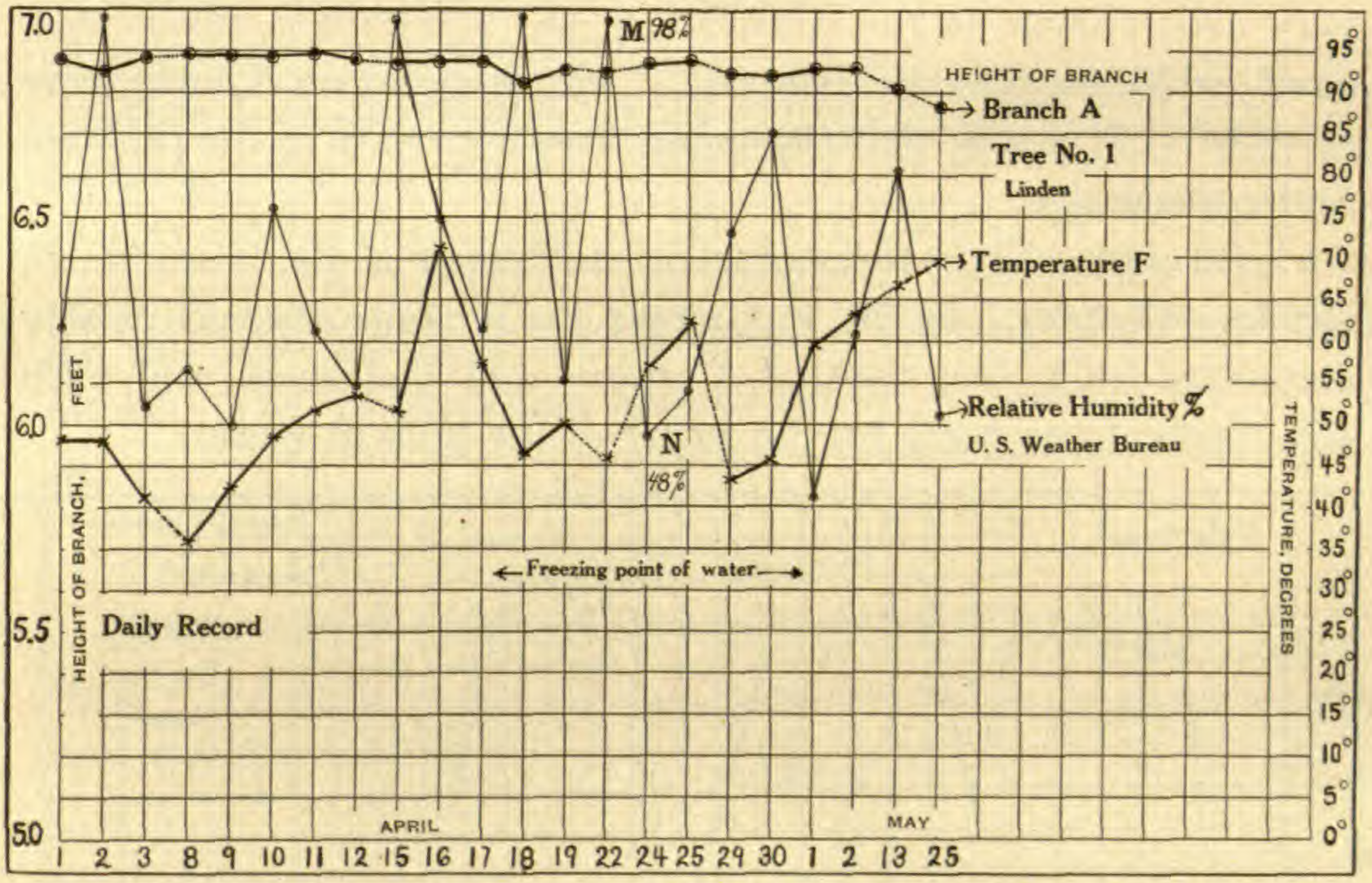

FIG. 5. Daily record of Branch '*A*, Tree No. 1 (European linden) during *April* and *May*, 1912. Little or no movement appears to accompany the large changes of both the air temperatures (all above 32° F.) and the relative humidity. The depression in the branch during *May* is due to the weight of the leaves.

A letter in Nature, entitled, "Position of boughs in summer and winter," by Agnes Fry,* records the height of branches of both a mulberry and a walnut tree in summer and in winter. The measurements show the reduced height in summer due to the weight of the leaves. The changes amounted to one foot or slightly more. This note is not pertinent to the subject under discussion since the movements observed were not thermometric.

In 1898, there appeared a paper of similar character to the last, entitled, "Preliminary observations of the seasonal variation of a branch of a horse chestnut tree," by Miller Christy.†

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* Nature 54: 198. 1896.

† Jour. Linn. Soc. Bot. 33: 501. 1898.

The measurement reported consisted in the change in height of a branch of this species due to the growth and to the fall of the leaves. The height decreased in April and May, coincident with the growth of the leaves. Then followed a period of rest, but in August and September there was a further depression. In October, the branch rose with the fall of the leaves, the maximum variation being about one foot. "During the winter months, very little change in the elevation of the branch was observable, as shown by the observations, etc." No temperature changes were recorded. It is seen that this paper does not relate to the problem under discussion.

"An undescribed thermometric movement of the branches of shrubs and trees," by W. F. Ganong,* is in some respects closely connected with the work of Caspary and Geleznow and with the observations made by the writer of the present paper.

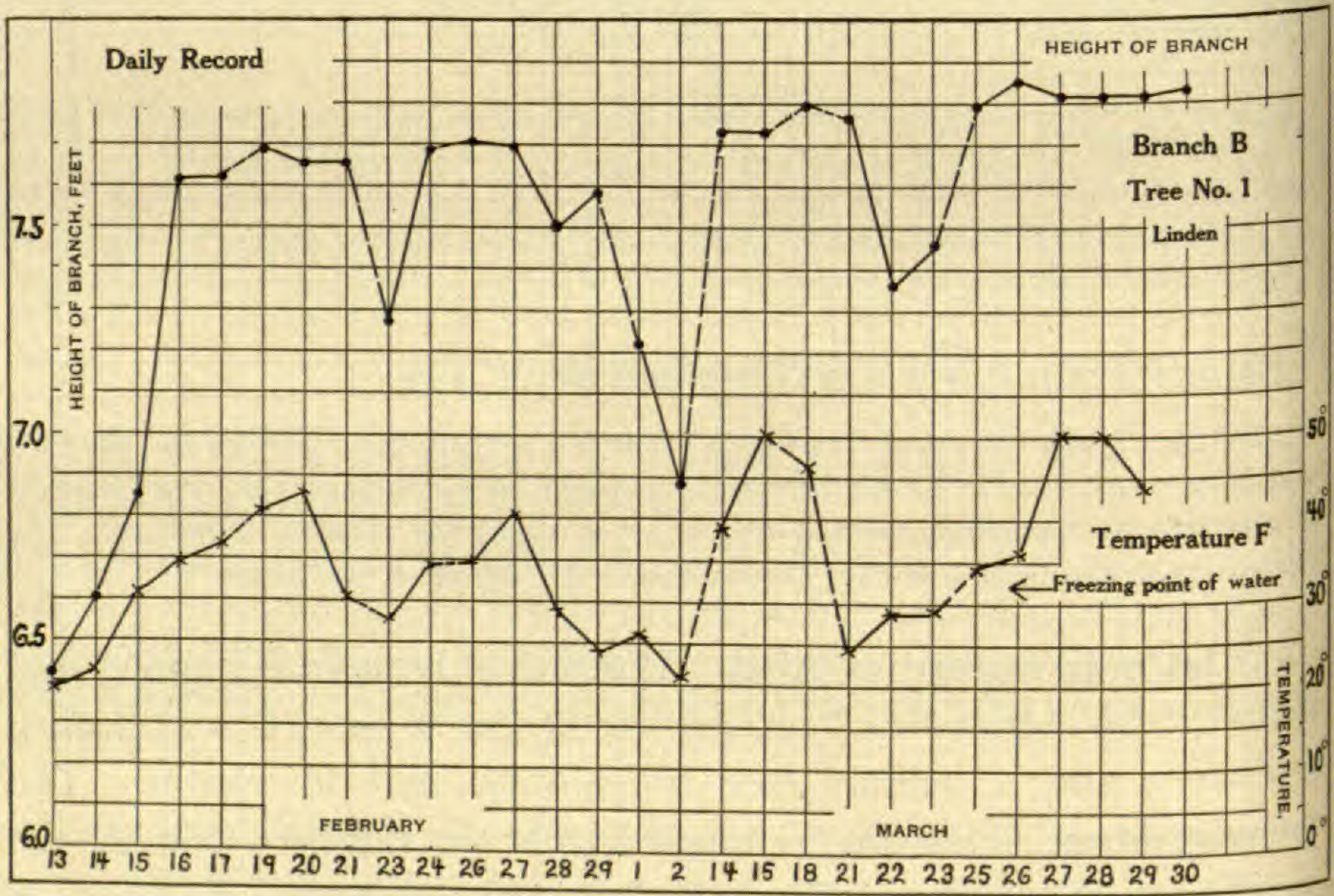

FIG. 6. Daily record of the movements of Branch *B*, Tree No. 1 (European linden) during *February* and *March*, 1912. The movements correspond closely with those of Branch *A*, in FIG. 4, although some of the observations were on different days.

Ganong's observations related mostly to the movements of twigs of shrubs and very small trees, and scarcely exceeded 12 cm. There is no mention, moreover, of the important fact (as

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* Ann. Bot. 18: 631–644. *f. 52–57.* 1904.

in the case of large trees) that the movement begins when the temperature of the air reaches the freezing point of water.

Two movements are described, a gradual seasonal displacement, and a secondary, depending indirectly on thermometric changes. Whether the latter is similar to the one to be described is difficult to ascertain. Ganong has performed some important experiments, and concludes that the secondary movements are correlated with changes in temperature *but that they are not directly caused by temperature.*

Miss Jean Broadhurst * is the author of a note entitled, "The weeping willow in winter," describing the observation that the slender unbranched twigs of this tree (twigs one to two feet long), which in November hang vertically, become curled up during the early winter so that the ends of the twigs are above their origin. The phenomenon appears to be a seasonal one rather than one depending on temporary temperature conditions. A further note on the subject entitled, "Winter changes in the weeping willow," was published later.† It is possible that the

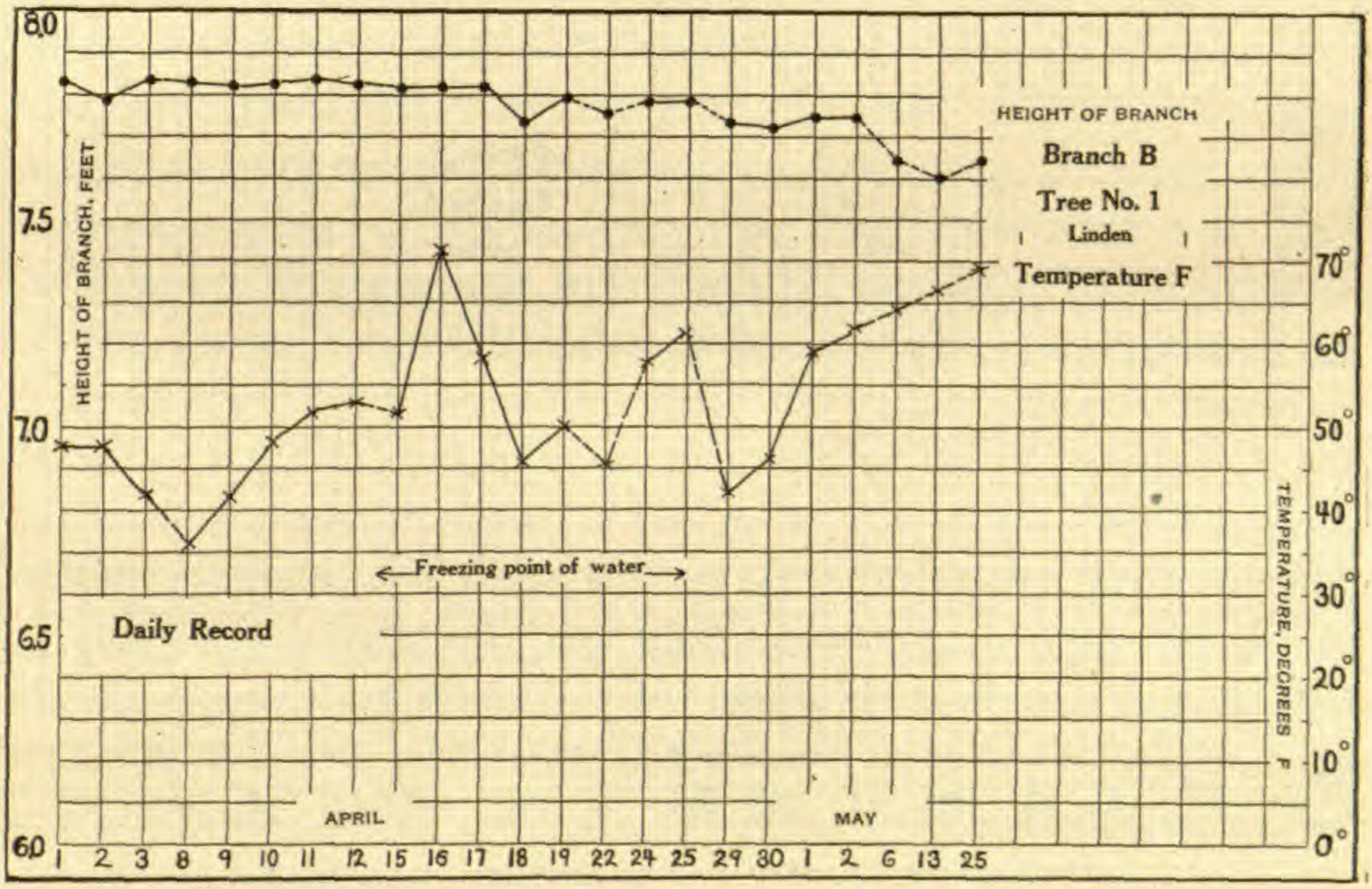

FIG. 7. Daily record of Branch *B*, Tree No. 1 (European linden) in *April* and *May*, in 1912, showing the same effect exhibited by Branch *A*, in FIG. 5, including the drooping in May due to the weight of the leaves.

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* Torreya **10**: 38, 39. 1910.

† Torreya **14**: 31, 32. 1914.

movements here described may be similar to those made on small shrubs by Ganong.

OBSERVATIONS BY THE WRITER IN 1912 AND 1913

The measurements conducted during the early part of 1912, described below, were not made under the most favorable circumstances, because it was near the end of the winter when the striking effects were noted and the measurements begun; also, there were few unusually cold periods during the winter of 1912–13. Enough observations, however, were taken to exhibit some interesting facts. Most of the observations in February, March, April and May, were made with Mr. E. Sweitzer, a special student in Columbia University. The observations during the winters of 1913–14 and 1914–15 were more extended and were made by the writer alone.

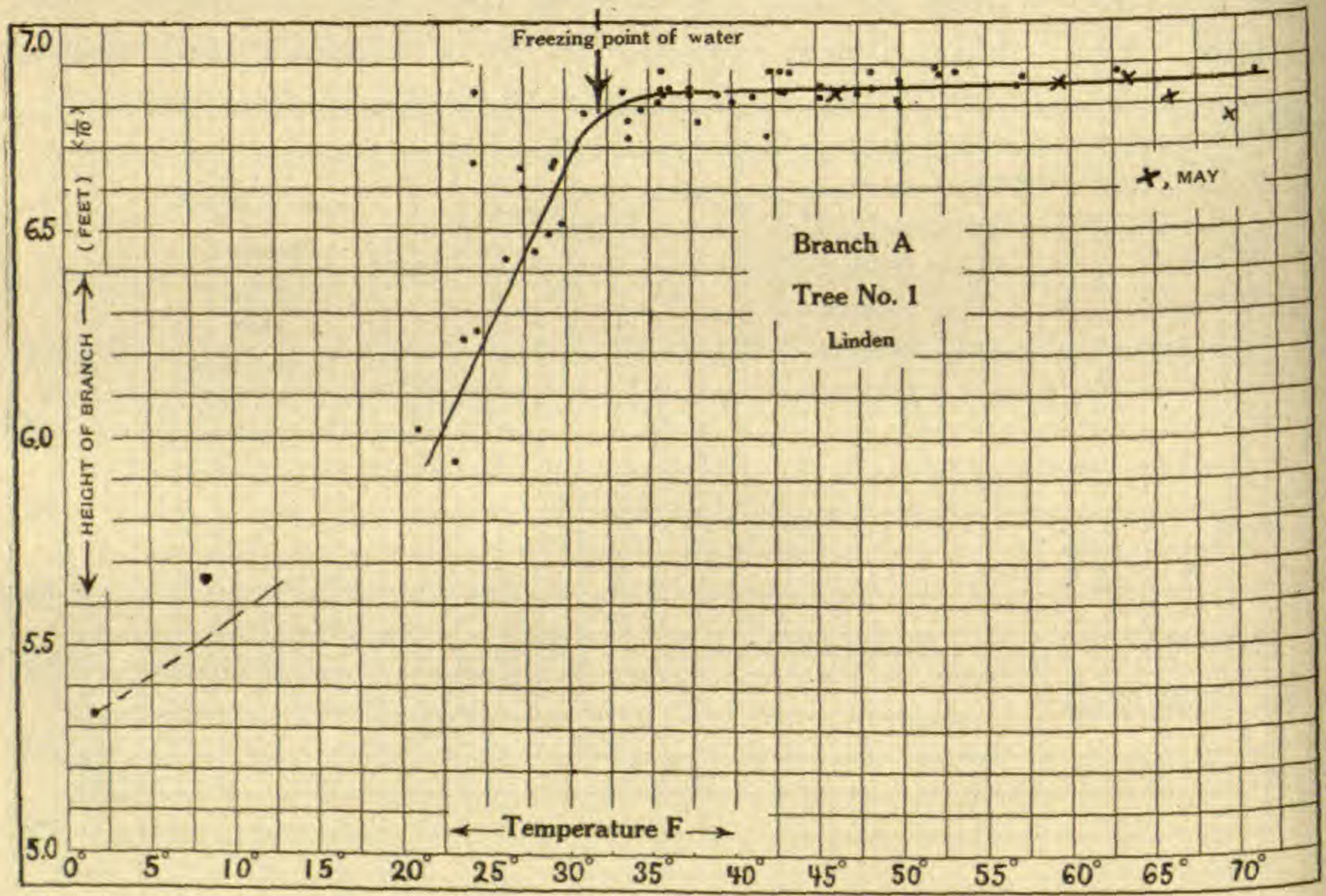

FIG. 8. Curve showing the relation of temperature change to height of branch in the case of Branch *A*, Tree No. 1 (European linden). The curve shows a point of inflection at the freezing point of water. The variation among the observations is due to temperature lag or to strain in the branch as determined by hourly records of the thermometric movements.

A study of movements of the branches of trees under freezing temperature was taken up solely on the physical side of the subject, the problem being to find the atmospheric conditions under which the movements took place, and to determine the extent of the effect produced. To illustrate the interesting phenomenon under discussion, photographs (FIGS. 1–3) have been taken.

In FIG. 1, the extent of movements can be seen at a glance. The photograph has been artificially arranged with the addition of a duplicate photograph of a branch, fitted in according to scale, and is given here solely to show the magnitude of the effect. The upper branch shows the position as it was at 32° F. or above; and the lower one, the same branch as it was at approximately 10° F. This very large movement shown indicates some interesting processes going on within the living portion of the branch.

METHOD OF MEASUREMENT AND SPECIES OF TREES STUDIED

The apparatus used consisted of a specially constructed measuring rod, a steel tape, and thermometers. The linear measurements are given in feet and hundredths of feet. The temperatures are given in Fahrenheit as being more convenient, although many sets were taken in Centigrade. The Fahrenheit scale was used to compare temperatures with temperatures taken from a record of the United States Weather Bureau, which are expressed in Fahrenheit. Also, the temperature curve continually crossed the freezing point of water; hence the use of the Fahrenheit scale avoided the employment of the + and – sign. The heights of four branches from the ground were measured, three species of trees being selected, and also the distance from the point on the branch measured, as indicated by a plumb line, to the trunk of the tree in a horizontal line. The latter measurements are not given in this paper, since they correspond in general to the vertical measurements.

Two similar curved branches of a European linden tree designated as Tree No. 1, were measured; also, a branch of a *Paulownia tomentosa*, designated as Tree No. 2, similar in shape to the branches of Tree No. 1, and a horizontal branch of an oriental plane-tree or sycamore (*Platanus orientalis*) recorded as Tree No. 3.

It was to be regretted that branches of the linden of various shapes were not measured, but the observations that were made absorbed a good deal of time, and the desirability of an extension of the records to branches of different forms was not foreseen.

Temperature and relative humidity observations taken from the United States Weather Bureau have been used in a few cases. The Draper Observatory in Central Park, where these observations were made, is not more than three miles distant from the Columbia University grounds, and since it was shown by the thermometer records at the two places that the temperatures were usually within a degree or so of each other they agree sufficiently in the present case. No relative humidity observations were made, but the Draper Observatory record of the moisture was sufficiently close for the use to which it was put, since large changes in relative humidity appeared to have little or no effect on the position of the branches.

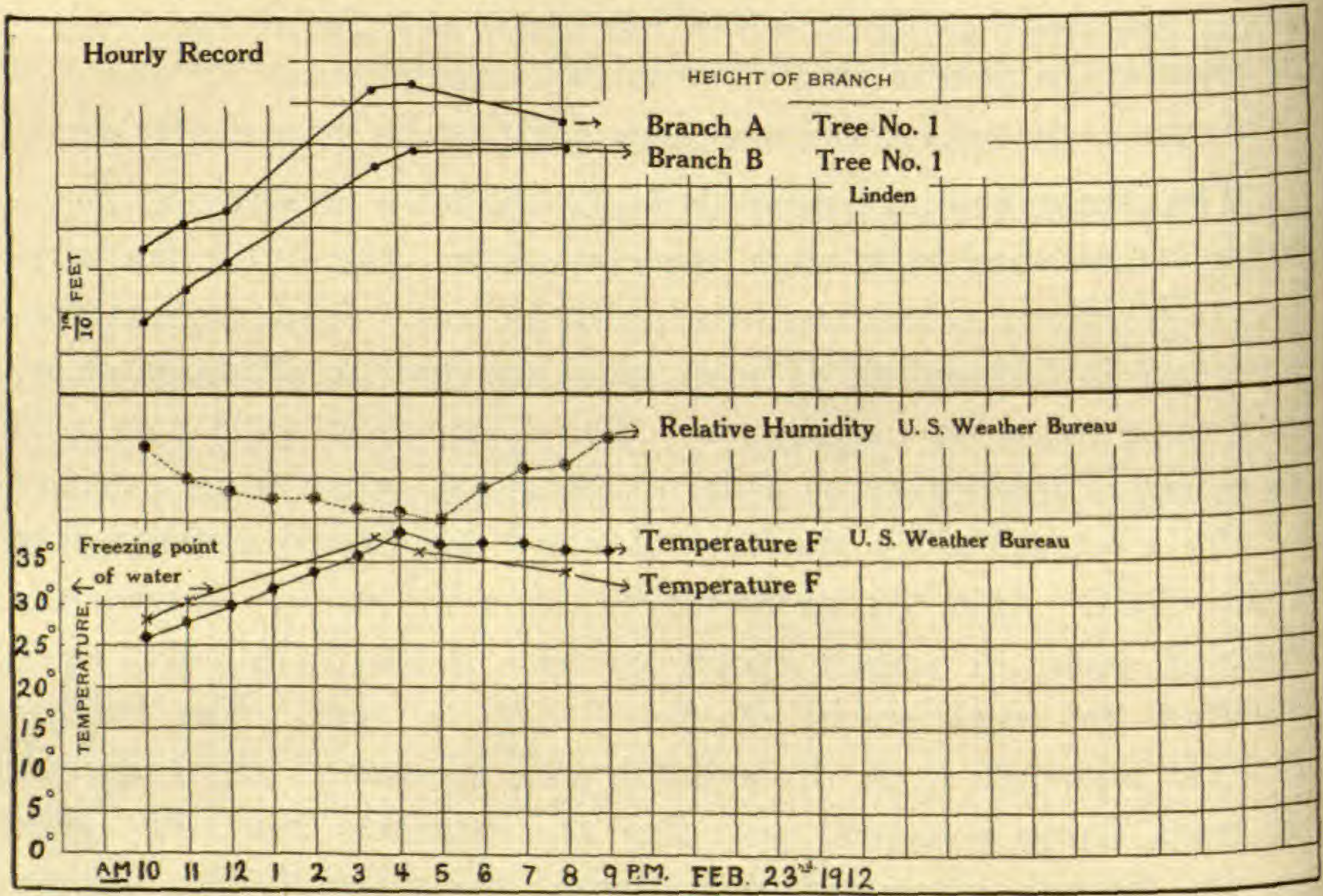

FIG. 9. Hourly record of Branches *A* and *B*, Tree No. 1 (European linden), showing rise of temperature through the freezing point and subsequent fall. Here the branches appear to respond quickly to the changes in temperature and there also appears to be a slight thermometric movement *above freezing*.

DAILY RECORDS AND EXPLANATION OF CURVES SHOWN IN FIGS. 4, 5, 6, 7 AND 8

The daily record of Branch *A*, Tree No. 1 (linden), is given in FIGS. 4 and 5, for February, March, April and May. The facts shown by these curves are as follows:

The temperature when above 32° has little effect on the position of the branch, but whenever the temperature of the air passes below the freezing point of water, an immediate bending of the branches of the tree takes place. Throughout April and for some observations in May, very little change in the position of the branch takes place, except depression of the branch due to the weight of the leaves in May. Notwithstanding the fact that during April and May there was a large variation in temperature, no movement took place because all the temperatures were above 32° Fahrenheit. In regard to the influence of water vapor present in the atmosphere on the movement of the branches, it can be seen by the fine line curve in FIGS. 4 and 5, representing relative humidity, that there is little, if any, effect. This is specially evident at points *M* and *N* in both figures, where the humidity was high and low respectively with apparently little influence on the height of the branch. The curves in FIGS. 6 and 7 made with a different branch show effects similar to those observed in the case of Branch *A*. The curves corresponded very closely

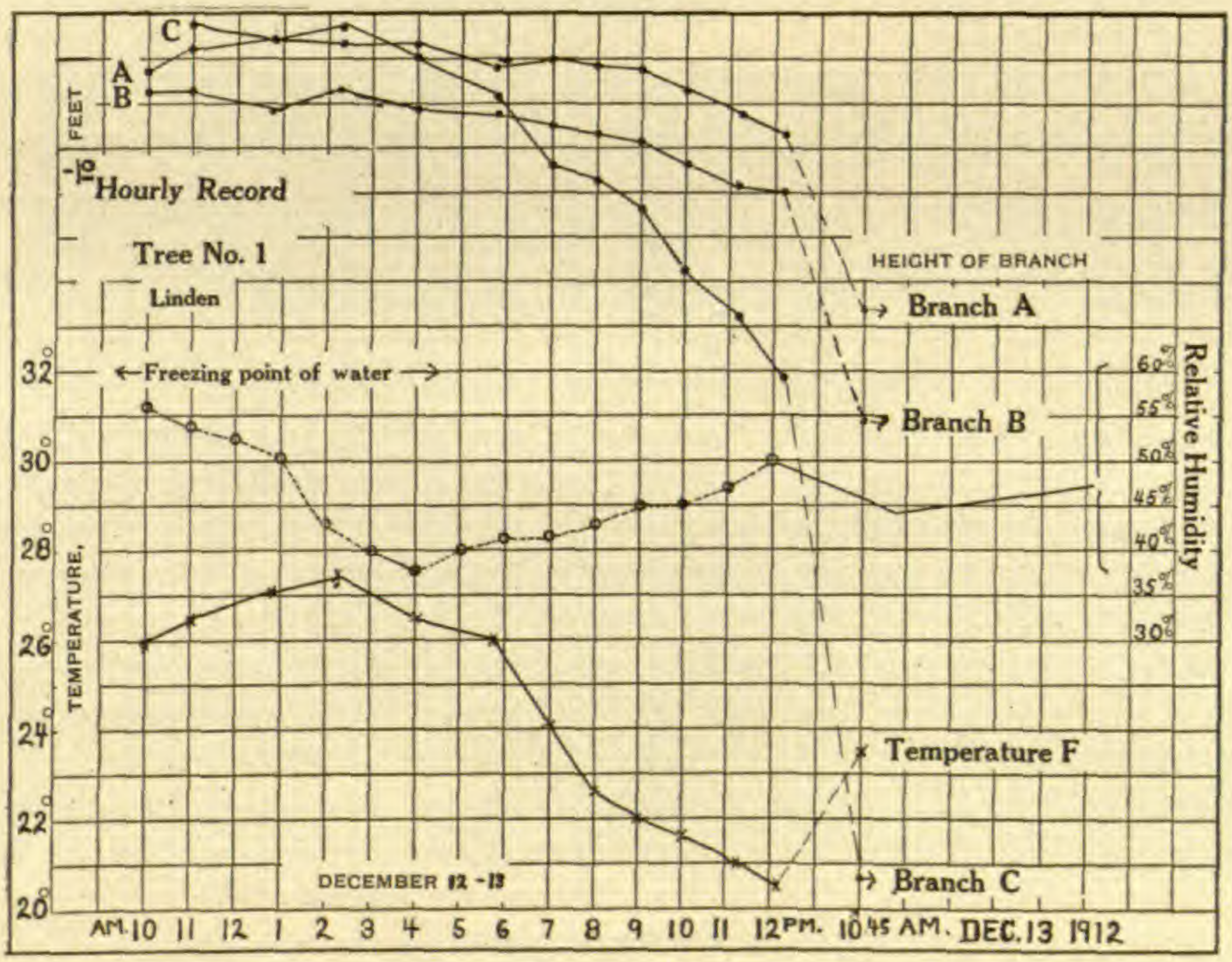

FIG. 10. Hourly record of Branches *A*, *B*, and *C*, Tree No. 1 (European linden). Temperature on a large scale. Branch *C* observations were made at the extremity of a branch. The last reading was taken at 10.45 a.m., the previous observation at 12 midnight preceding.

for Branches *A* and *B*, except that the days of observation were somewhat different. In FIG. 8, the relation of the variation in height of Branch *A* (same as FIGS. 4 and 5) to the variation of temperature is shown. It is seen at once that there is a marked point of inflection of the curve at the freezing point of water. The fact that the observation points do not fall on the curve is significant and will be presently explained. While the major effect of the temperature is below 32° F., there is evidently a minor thermometric effect just above 32°, which, however, is so small as perhaps to be due to a warping of the branch due to internal strains arising from the bending of the branch, caused by below freezing temperatures a short time before the observations at warmer temperatures were made. Thus the behavior of the branch depends somewhat on its immediately previous history.

HOURLY RECORDS AND EXPLANATION OF CURVES IN FIGS. 9, 10 AND 11

In these curves, an hourly record was kept of several of the branches of Tree No. 1 to ascertain how soon the branch responded

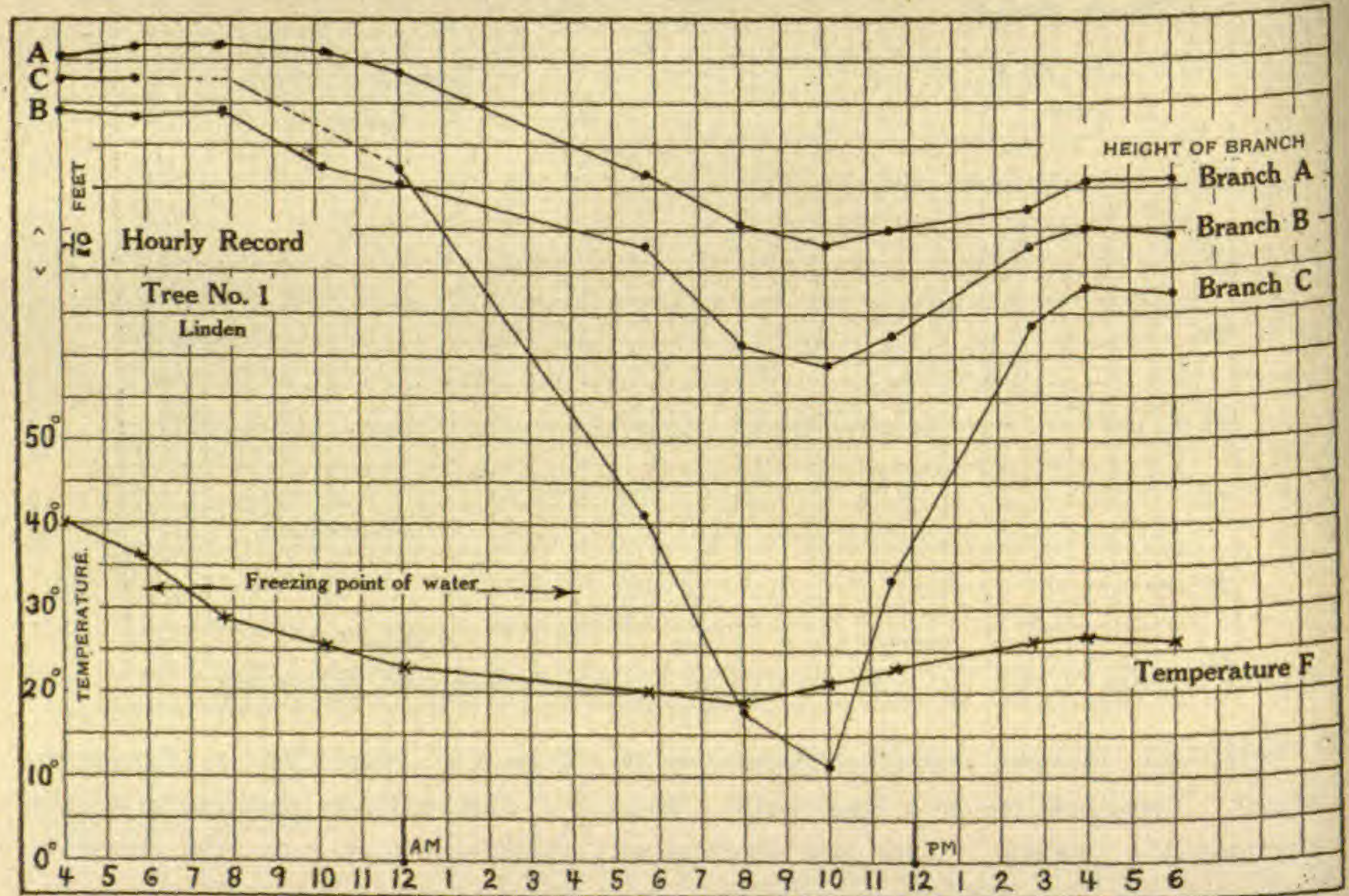

FIG. 11. Hourly record of Branches *A*, *B*, and *C*, Tree No. 1 (European linden), showing the effect of a fall in temperature below freezing and the subsequent rise. Observations of Branch *C* were at the end of the branch. These curves demonstrated the lag in the movements of the branches with fairly rapid changes of temperature and explain the variations among the observations shown in the curve in FIG. 1.

to the changes in the temperature of the air. While observations were not taken every hour, they were frequent enough to obtain the results required. It is seen in FIG. 9, which gives observation where the temperature rises to a maximum just *above the freezing point of water*, that both branches begin to fall with the temperature within a quarter of an hour after the high point of the temperature has been reached and before the temperature passes through the freezing point. This seems to show that there is a very small thermometric effect just above 32° F. The same fact is indicated in other observations. In FIG. 10, three branches were measured and the resulting curves show the effect on the branches when the temperature of the air *rises to a maximum, below the freezing point of water*, and then falls again. C observations in this set were taken at the extremity of the branch and hence show the largest movement.

FIG. 12. Photograph of Branch *A*, Tree No. 2 (*Paulowina tomentosa*). This branch showed little or no thermometric changes. The branch was selected because of its similarity in shape to Branches *A* and *B*, Tree No. 1.

In FIG. 11 the readings of three branches were taken under conditions where the temperature had fallen to about 20° F. and then rose. Here it is clearly shown that there is a lag amounting in time to about two hours before the branches begin to move upward, although a change in the *rate of the depression* is observed to take place as soon as the temperature of the air begins to rise. The effect on the branch of a change of temperature is therefore almost immediate with a lag depending on various conditions. It is probable that the size of the branch is the ruling factor, the very small branches responding almost at once to change in temperature.

EXPLANATION OF CURVES SHOWN IN FIGS. 13 AND 15

In FIG. 13 the daily record from February to May of a *Paulownia* (*P. tomentosa*), Tree No. 2, is shown. The branch measured has the same shape as that of the linden branch shown in FIG. 1. Here it is seen that there is little or no thermometric effect due to the changes of temperature of the air, although the

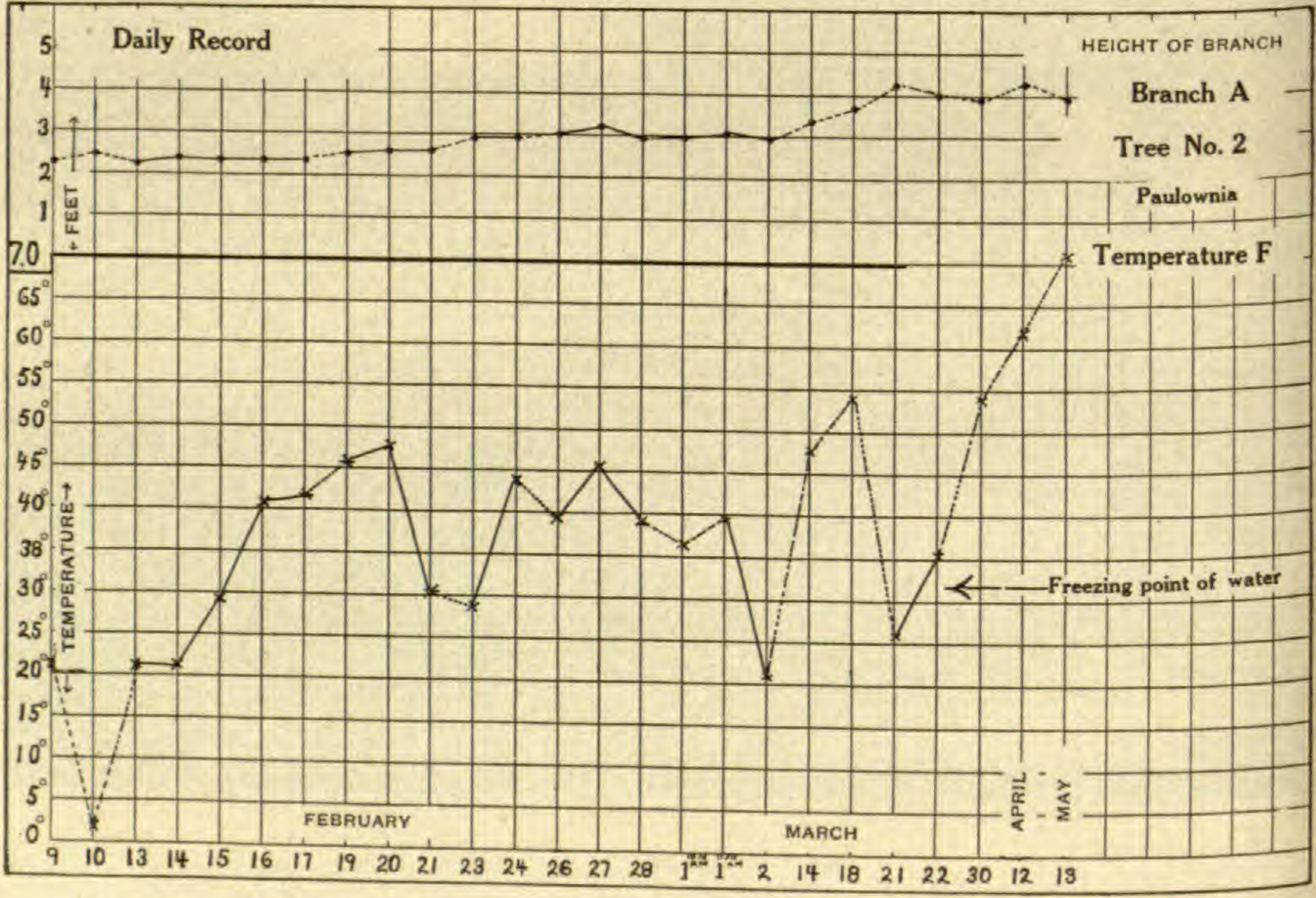

FIG. 13. Daily record of Branch *A*, Tree No. 2 (*Paulownia tomentosa*). Record for *February, March, April* and *May*. No appreciable change is shown which accompanies below freezing temperatures,—but a gradual rise from February to May is evident and a particular response to warm days during that period is apparent.

temperature repeatedly passed through the freezing point of water. There is, however, a continual rise of the branch from early in February till May. This elevation is evidently a response to heat and light of the sun, and being a seasonal change, is an entirely different effect from that observed in the linden.

FIG. 14. Photographs of Branch *A*, Tree No. 3, sycamore (*Platanus orientalis*). Measurements shown in FIG. 15. This branch differed from others measured in being straight and nearly horizontal.

In FIG. 15 an intermittent record of the height of a straight branch of a sycamore tree, *Platanus orientalis*, Tree No. 3, from February to well along in April, is given. Here also no thermometric movement is observed, the gradual rise of the branch recorded being a seasonal change. These observations merely show that in certain trees there is no thermometric movement of the branches.

THE ELASTIC CONSTANT OF BRANCHES ABOVE AND BELOW FREEZING

In FIG. 16 is shown a plot of an experiment which consisted in weighting the branches of both Tree No. 1, the linden, and Tree

No. 2, the *Paulownia*. Sixty-five pounds were added to the branch, five pounds at a time. This experiment was made both at a temperature above freezing, and also at a temperature well below freezing. It is seen that the constant of elasticity has changed in both cases, and the amount of depression per pound has decreased for the branches of both trees at the lower temperature. It would therefore appear as if the change in the modulus of elasticity of the two branches, due to changes in the temperature, had little or nothing to do with the direct temperature effect produced in the case of Tree No. 1, the linden, which showed large thermometric movements.

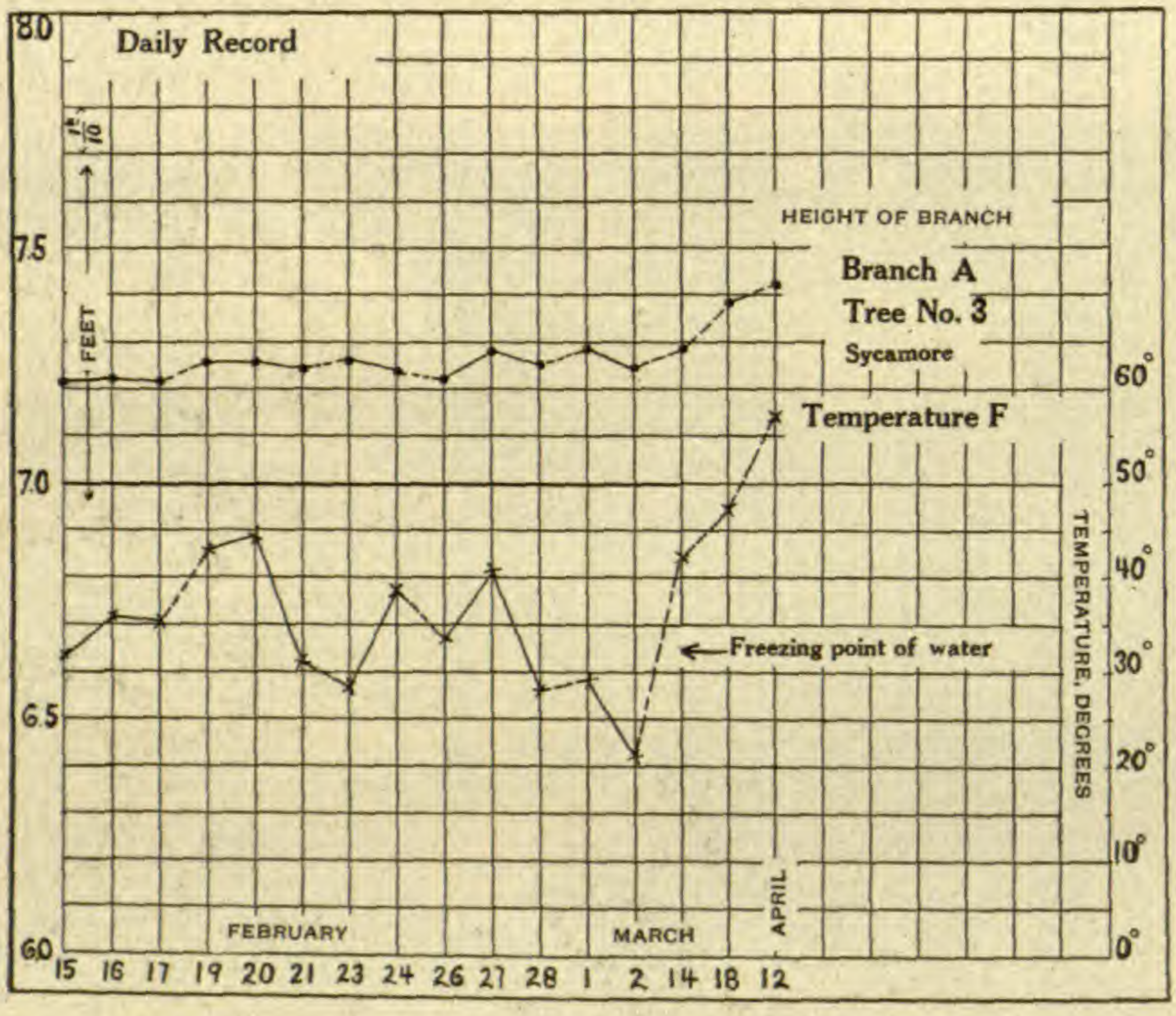

FIG. 15. Daily record of height of Branch *A*, Tree No. 3 (sycamore), during *February*, *March* and *April*, showing no effects due to variation in air temperatures, below freezing, but a rise beginning in February, with a more decided increase in elevation in March and April, especially accentuated on warm days.

From theory it is to be expected that if there is a change in the modulus of elasticity due to temperature, and if a stiffening occurs at low temperature, the branch would not be as much depressed. Such an effect is opposite to the large thermometric movement actually observed. In the case of the weighted cold branches a loss in recovery is noted, which is probably temporary, but explains certain inconsistencies observed on other observations.

The following experiment was tried. A branch curved in form, was cut from the linden and at once artificially cooled to 0° F., in a salt-ice pack, but showed no change of curvature between 0° F. and 40° F. The experiment, however, was not conclusive, since the branch was not longer than about three feet. It was ascertained definitely, however, that certain branches which were curved upward on the linden became more curved when subjected to low temperature. This fact was found by attaching strings to the ends of branches which were curved

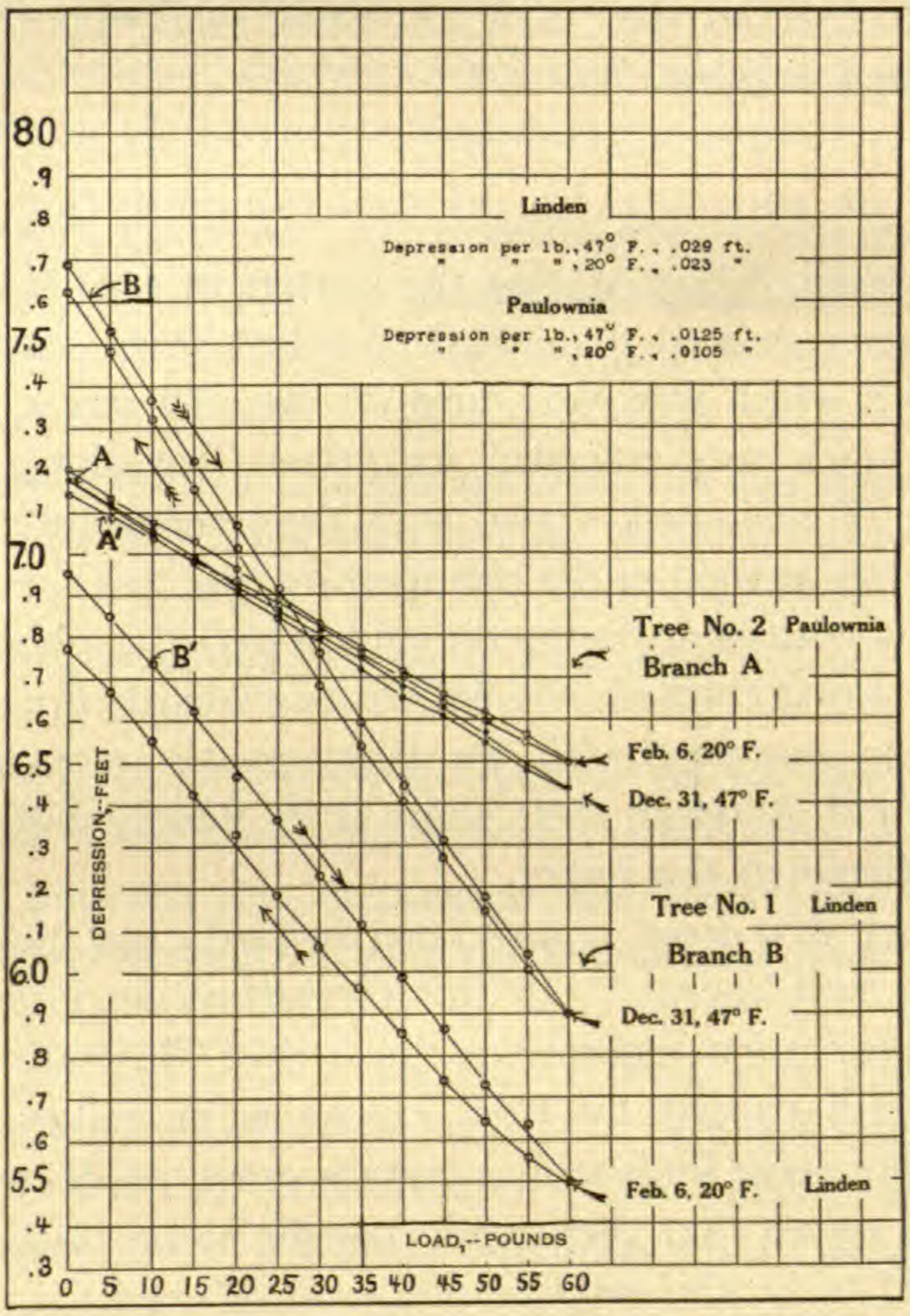

FIG. 16. Effect of loading Branch *B*, Tree No. 1 (European linden), and Branch *A*, Tree No. 2 (*Paulownia tomentosa*), at two differentt emperatures. The modulus of elasticity constant is less in both cases at temperatures below freezing, which is to be expected. A change of the constant, therefore, does not account for any part of the depression of the branches *A*, *B* and *C*, Tree No. 1 (linden), with low temperature since the effect of the change of the modulus is opposite to the thermometric movement observed.

concave upward, and observing the change of the tension on the reduction of temperature. These cords which were taut at 32° F. (or 0° C.), sagged at 15° F., showing an upward movement of branches which were concave upward. This is in agreement with observations made by Geleznow, who cut off branches, inverted them, and observed that their movement was opposite to those in the normal position.

RELATION OF FROST CRACKS TO THE THERMOMETRIC MOVEMENT

It was noticed both during the winters of 1911–2 and 1912–3 that a linden showed a decided so-called frost crack or longitudinal cleft which was wide open during cold snaps, and in one case, the crack was extended for fifteen feet along the trunk. The width of this crack varied with the temperature and closed up completely as soon as the temperature rose to 32° F. This was particularly noticeable during the coldest period of about February 10, 1912. Frost cracks in the linden are evidently due to the same origin as, or connected with, the thermometric movement of the branches, and therefore their study is intimately associated with the main theme of this paper.

The fact that frost cracks open in cold, and close in warm weather is well known.* In this connection an interesting and reliable observation reported to the writer illustrating the well-known noises caused by frost cracks is as follows. In very cold weather some lindens in a certain grove produced such loud and sharp noises that they were thought to be pistol shots, but were found to be the sudden formation of cracks in the lindens which were observed at the time.

In FIG. 17 a frost crack in a linden is shown, which was about three-quarters of an inch broad. Measurements of this crack with curves of the tree temperatures are given in FIGS. 18 and 19.

The facts shown by these curves indicate that the frost crack is not caused by a difference of temperature at successive depths of the tree trunk, but is due rather to a thermometric effect of some sort, not necessarily ordinary thermal expansion, acting on the cells of the tree, and probably those just below the bark.

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* See J. G. Grossenbacher, Science II. **38**: 204. 1913.

In FIG. 18 the frost crack is shown closing rapidly when the "Bark" (one inch deep) and the "Medium" (three inches deep) rise abruptly, while the "Deep" thermometer (five inches deep) remained nearly constant. In FIG. 19 the Deep thermometer is still below 19° F. while the frost crack is nearly closed. Moreover, in both sets of observations, the frost crack appears to close with the rise of temperature of the surface layers of the trunk.

THE ORIGIN OF THE THERMOMETRIC MOVEMENT

While there may not yet be sufficient data on which to formulate a theory for the actual mechanism of the thermometric bending of the branches, there are some salient facts which indicate the origin of the phenomenon. It has been shown, at least so far as the linden is concerned, that the movement begins when the air temperature is at the freezing point of water. The internal temperature of the small branches could not be far from that degree of cold.

In the curves published by Caspary* on the European linden showing the branch movements with temperature, there is correspondence between the temperature and branch positions, which indicates that the depressions of the branches began at the freezing point of water, but there is no mention of this in his text. Owing to the fact that a number of trees were studied, which showed various behavior with change of temperature, the matter might well have been overlooked. This opinion seems to be substantiated by the following quotation from Caspary's paper:

"Der Grad der Kälte, bei welcher ein Sinken eintritt, kann wegen Mangel stündlichen Beobachtungen und Beobachtungen der Kälte des Holzes selbst im Innern nicht sicher angegeben werden."

Besides the linden, measurements of trees of various other species by Caspary show that the movement begins at approximately 32° F. By making hourly observation, not made hitherto, the writer has brought out some important facts; namely, that below freezing the branches respond to the changes in temperature almost immediately. Thus, as shown by the curves in FIG. 11, when the temperature falls to 20° F., and then rises, the branches at once slow up in their downward movement, and shortly after-

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* Loc. cit.

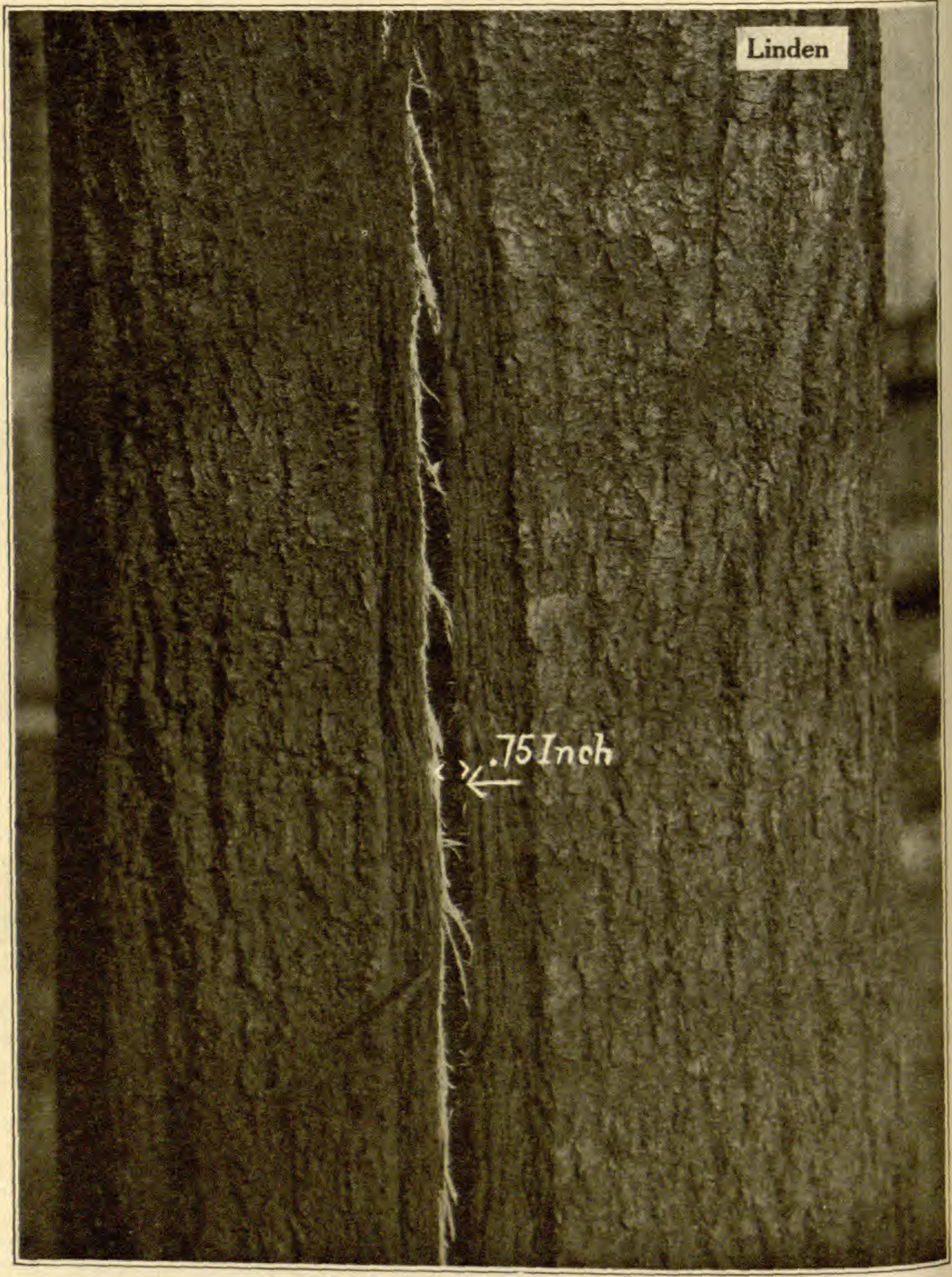

FIG. 17. Frost crack in European linden which opened and shut with changes of temperature and corresponded with movements of the branches. The measurements shown in FIGS. 18 and 19 were made on this tree.

wards move upwards. If the water in the branches was freezing as pure water, then the branches would continue to descend while the temperature remained below freezing, since ice would continue to form at any temperature below freezing. On the other hand, sap from the standpoint of physics is a solution, composed of salts of metals and of dissolved organic substances, and, as such, must freeze fractionally as the temperature is reduced. The sap thus becomes more concentrated as the freezing process continues. On a rise of temperature a fractional melting occurs.

In general, in the case of a solution composed of some salt, a point is reached where the solution will freeze at a definite temperature (in a manner similar to pure water); namely, when the solution reaches a certain degree of concentration. The indications are thus that it is the sap content of the branch rather than the water content which plays the important rôle in the thermometric movements of branches. Geleznow studied the water content of branches with little success in so far as determining the cause of the thermometric movement, and in the light of the explanation given above, negative results should be expected from a study of the water content. The mechanism bringing about the branch movements may well be a process in the living cells where enormous tension is produced in some way from the gradual separation of the ice crystals from the sap, the latter concentrating as the fractional freezing process advances. If this partial explanation is the true one, it should be expected that at some low degree of cold, certain trees would cease to show a thermometric movement of the branches, the sap having reached the so-called cryohydrate concentration where the solution would become solidified. Since the sap is a complex solution, the temperature of complete solidification would probably not be a definite one.

The question of the freezing of the tissues of trees appears not to be a proven question; yet there seems to be evidence that at least a partial freezing of trees at temperatures not far below freezing occurs.

In a paper entitled, "The Maple Sap Flow,"* experiments on

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*C. H. Jones, A. W. Edson and W. J. Morse, Vermont Agric. Exp. Sta., Bull. 103: 41–184. *pl. 1–17* + *f. 1–5*. 1903.

tree temperatures are described and the following statement made: "Casual observations made by one of the writers in mid-winter, showed maples frozen for a depth of an inch and a half in one case, and an inch in another, while both white and yellow birches were

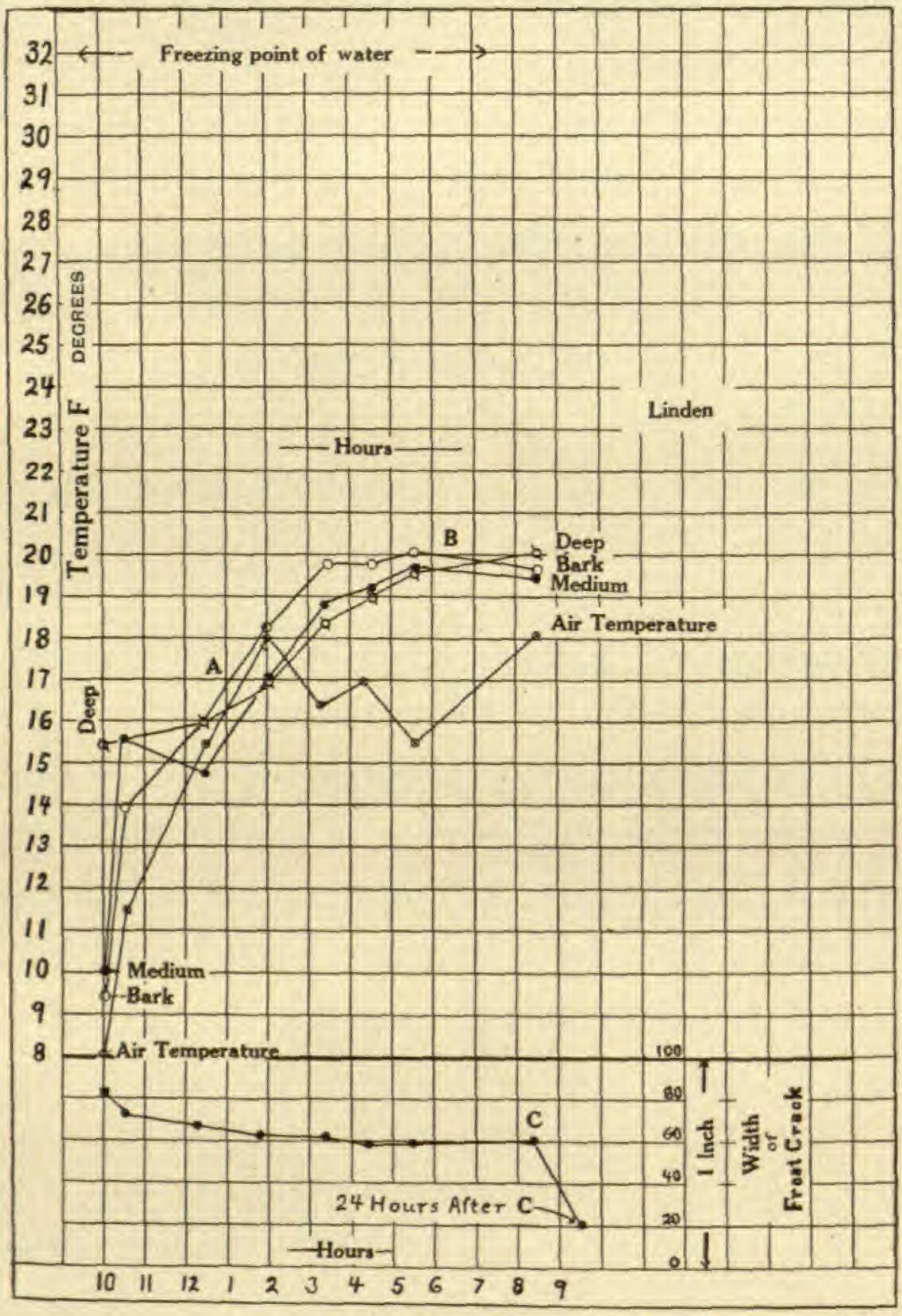

FIG. 18. Curves showing the change of width of frost crack in European linden and change of temperatures of the tree trunk and atmosphere. The bulb of the "Bark" thermometer was one inch below the surface; that of the "Medium" three inches below; that of the "Deep" five inches below. From *A* to *B* on the curves all three tree temperatures were the same. Yet the frost crack decreased in width with the general rise of temperature of the tree trunk. The mean at *A* was 15.4° F., and at *B* 19.6° F.

frozen through, except where the sun was beating upon them. It seems clear that some of the maple tissues are frozen in mid-winter." Also, as a summation, this view is given: "These data and observations lead to the conclusion that in the winter, the temperature of the maple tree tissues is generally below 0° C.

(32° F.), and that it may be considerably lower; that as the sugar season approaches it frequently rises above this point, and during its course is usually above, but occasionally falls below it; and that a part of the sap in the vessels of the outer rings freezes during the winter and may freeze during the sugar season."

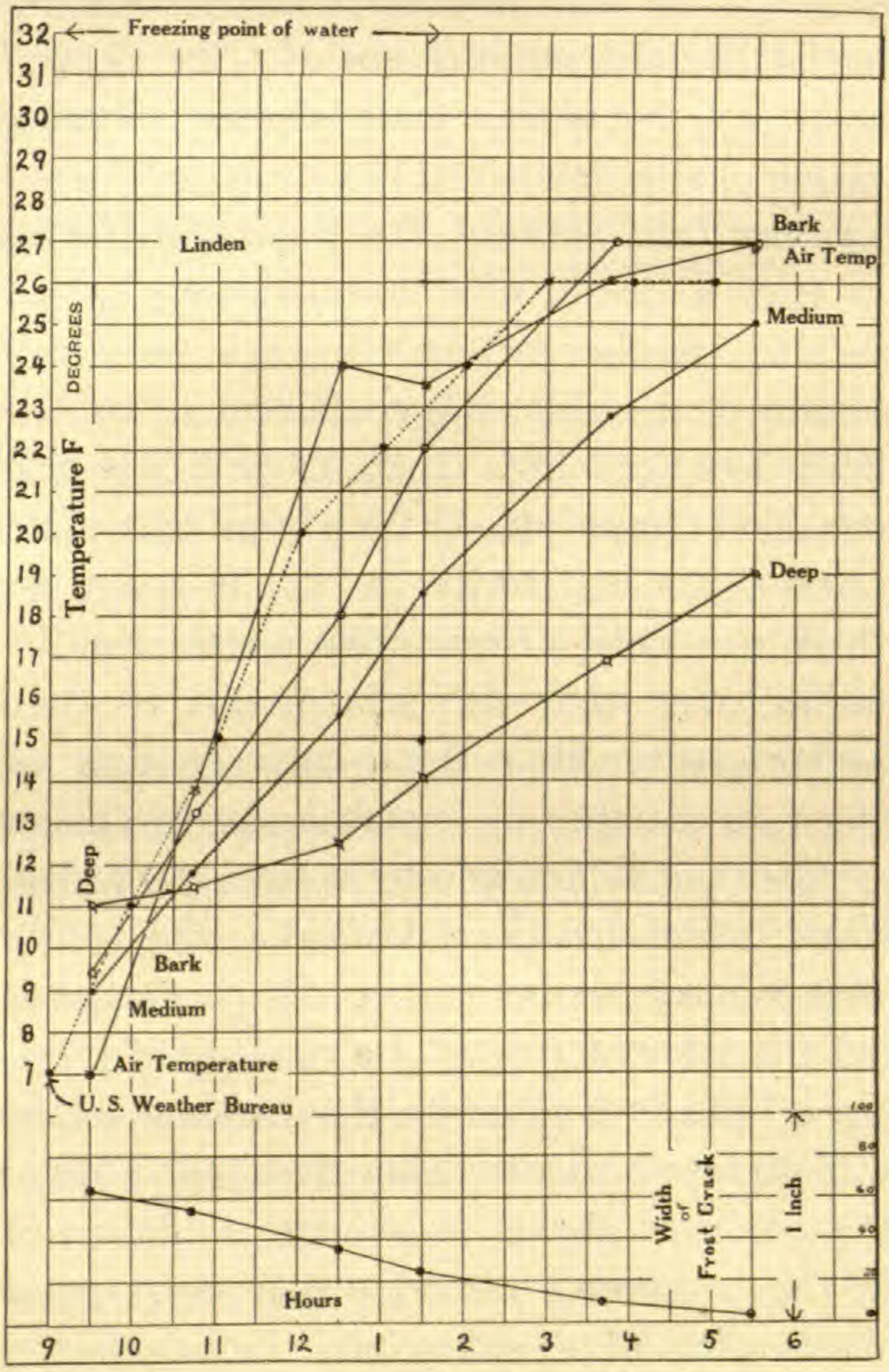

FIG. 19. Curves showing the change in width of frost crack and change of temperature of tree trunk and atmosphere. At *A* the tree trunk was at a uniform temperature to a depth of five inches. From this point on, the frost crack decreased in width consistently with the rise of temperature of the trunk of the tree. At *B*, where the thermometer readings showed the greatest difference of temperature between the successive layers of the tree trunk, the frost crack was nearly closed.

In experiments on certain plants evidence has been presented showing that freezing apparently is arrested by what appears to be a sub-cooling process; i. e., the confines of the liquid content being so small as to prevent solidification. Consequently it is possible that under certain conditions sap does not freeze (even fractionally) until at least at a very low temperature, but the evidence of the thermometric movements of branches and the thermometric opening and closing of frost cracks indicate a change which begins at 32° F. and continues below that point, which must be regarded as evidence in favor of a fractional freezing of the sap. The alternative is that there is some cellular mechanism of the living wood of the tree which begins at 32° F. and continues as the temperature falls without the fractional freezing process, but parallel to such a change of state of the sap.

A considerable number of experiments were performed in order to ascertain, if possible, the coefficient of expansion of the tree trunk just below the bark. It was found that below freezing with the reduction of temperature a very large contraction occurred in the horizontal direction, transverse to the grain; on the other hand, that there was only a very small contraction in the longitudinal direction; also, that this contraction in the transverse direction was far greater than for a corresponding range above 32° F. Owing to a number of uncertainties in the experiments, they have not been published, and have been discarded for a more accurate method, which has been devised. The results indicated correspond with some measurements of Dr. J. G. Grossenbacher,* who measured the circumferences of a number of trees and determined that for a fall of temperature the decrease in circumference per degree was greater below freezing than above that point.

The fact, mentioned above, of greater coefficient of expansion below 32° in the transverse direction also corresponds with the published observation of Caspary who found that the circumference of the bark changed more rapidly than that of the wood cylinder in certain trees.†

General conclusions

In this investigation the mechanics of the thermometric movements of branches has not yet been determined, but the

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* Crown rot of fruit trees; field studies. New York State Agric. Exp. Sta. Tech. Bull. 23. 1912.

† R. Caspary, Neue Untersuchungen über Frostspalten. Bot. Zeit. 15: 329–35; 345–50; 361–71. 1857.

observations described have made an advance in the study of the subject. Some of the facts which have been determined are summarized below; temperatures are given in Fahrenheit for reasons previously stated.

1. The measurements which have been made on the movements of large branches of the European linden (*Tilia europaea*), due to a reduction of the atmospheric temperature seem to show that below 32° F. the movements are thermometric; when the temperature of the air falls below the freezing point of water (32° F.) (or very shortly above that point) the depression of the branches begins, and continues until at least 0° F., the lowest point at which observations were made.

2. There is scarcely any movement *above 32° F.*, the level of a branch at 70° F. being approximately the same as at 32° F. The freezing action of water (the aqueous part of a solution) is therefore the origin of the process which brings about the change in shape of the branch with change of temperature below 32° F. There seems, however, to be a very slight thermometric movement just above 32° F., the data on which is uncertain.

3. By making hourly observations not made hitherto, it has been shown that there may be a lag of one or two hours in the movements of the branches behind the changes of temperature, but if the air temperature is changing, a very slight change in the rate causes an almost immediate modification in the rate of movement of the branch. The observations made thus far indicate that a constant state of temperature for a considerable time, slightly below 32° F., causes a small movement; then the branch remains stationary until the temperature changes. These facts lead to the conclusion that the freezing liquid bringing about the thermometric movements of the branches below freezing temperatures is not pure water, but a solution, namely, the sap.

4. By artificially depressing the branches by means of weights, it was found that strains in the wood cause the branch to become temporarily depressed by a small amount. These strains in the branch, and the effect of lag of position of the branch behind the temperature of the air, explain the fact that in the curves showing the relation of the position of a branch to air temperatures the points are somewhat inconsistent.

5. The degree of moisture in the atmosphere, as shown by relative humidity observations, has apparently a negligible effect on the position of the branch.

6. Modulus of elasticity experiments seem to show that there is a stiffening in the branch below freezing (32° F.); but a stiffening of the branch should produce a less mobility or less depression of the branch whatever the stress; hence the slight effect observed due to a change in the bending constant of the branch arising from a reduction of temperature, taken alone, is in the opposite direction to the gross changes of the level of the branch observed at low temperatures.

7. Observations on frost cracks of the linden have shown that the width of the longitudinal cracks follow the changes in air temperature approximately below 32° F. When the crack first opens it is not thermometric because it is greatly affected by strain conditions, and resistance in the tearing of the wood.

Thermometers placed within the tree trunk at different distances from the surface indicated that the cracks were not caused by an unequal strain between the central core of the tree and the portion of the tree near the surface, arising directly from a difference of temperature, but due rather to excessive tension conditions in the living portion of the tree directly below the surface of the trunk.

All observations made indicate in a general way that the bending of the branches is closely related to the process which produced the longitudinal frost cracks in the linden.

8. Preliminary measurements indicate that the coefficient of expansion in the living linden in the transverse directions of the wood directly below the bark is very large below freezing, while small in the longitudinal direction.

9. Experiments on a *Paulownia* (*Paulownia tomentosa*) and a sycamore tree (*Platanus orientalis*), show scarcely a trace of the thermometric movement as exhibited by the linden.

The writer begs to acknowledge the courtesies shown by Professor Harper and other members of the Department of Botany at Columbia University, who have made many helpful suggestions pertaining to the botanical side of the present investigation.

PHOENIX PHYSICAL LABORATORY,
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INDEX TO AMERICAN BOTANICAL LITERATURE

1916

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 the broadest sense.

Reviews, and papers that 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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Vol. 43 No. 2

BULLETIN

OF THE

TORREY BOTANICAL CLUB

FEBRUARY, 1916

New and rare African mosses, from Mitten's herbarium and other sources

H. N. Dixon

(WITH PLATE I)

It is eminently desirable—if for purposes of reference only—in short and scattered bryological papers, especially where new species are described, to deal separately with separate geographical areas, or at least only with such as can be described in the title of the paper. The practice of some authors, of describing in a paper purporting to deal with one geographical region, single species from quite another part of the globe is, I think, a very unfortunate one, and liable to lead easily to subsequent error. The description in the present paper of new species from as widely diverse localities as Cape Town, Kilimanjaro and Mauritius, is not, I believe, a violation of the above canon. For it is more than ordinarily difficult to draw a line of demarcation between the floristic regions of South and Central Africa. It is an established fact with phanerogams: "One of the most marked facts connected with the flora of this continent is the wide range both in latitude and longitude of many of its species. No less than one fifth of the tropical species are common to east and west; while the range of the trumpet- or pig-lily, from Cape Town to the first cataract of the Nile, is the botanical parallel of the wide latitudinal range of the hippopotamus."*

[The BULLETIN for January (43: 1–62) was issued February 15, 1916.]

* See Boulger, Plant Geography 108. 1912.

This view is amply borne out by the facts of bryological distribution, so far as they have been studied, and is accentuated by some of the records which will be found below. For example, several of Mr. Wager's Transvaal gatherings here referred to are identical with species hitherto known only from the equatorial regions; a further example is that of *Microthamnium saproadelphum* from Mauritius, hitherto known only from a single station in the Cameroons; while *Rigodium dentatum* from Pretoria has at present only one African congener, and that a native of the equatorial zone. The more or less continuous, elevated forest belt connecting these regions, and the absence of any very pronounced geographical barrier, either mountain range, water, or desert, may perhaps help to account for this. The bryological flora of Southeast Africa, especially between the fifth and twenty-fifth parallels of south latitude, is, however, almost unknown, and promises an interesting field of discovery.

The facts above referred to render the description of "geographical species" even more dangerous than in other parts of the world. In describing new species from the Cameroons, for example, it is quite natural to give little heed to species only known from Abyssinia or from Cape Colony, whereas an identity is by no means improbable; and I have no doubt that a comprehensive knowledge of African bryology would lead to a considerable reduction in such species. On the other hand the relationships of African mosses—at least from the equator southwards—with those of other continental areas are much less close than those which obtain in the case of most of the continents, *e.g.*, Europe and North America, Europe and North Africa, Oriental Asia and North America, Australasia and South America; and the number of specific forms common to these parts of Africa and other geographical areas appears to be very small.

LEUCOLOMA HOLSTII Broth.

Kilimanjaro, *Bishop Hannington*, Mitten's herbarium.

A small, slender plant, which agrees exactly with an original specimen of Holst's at Kew, determined by Brotherus, from Usambara, except that the leaves are not markedly secund there, as they are in Hannington's plant.

Campylopus (EU-CAMPYLOPUS § TRICHOPHYLLI) **angolensis** Machado & Dixon, sp. nov.

Sat robustus; caules circa 4 cm. alti, interdum furcati, *densifolii*, superne *olivacei*, infra fusci, per totam fere longitudinem dense rufo-tomentosi, haud intertexti, facile separabiles. Folia valde conferta, sicca suberecta, madida patentia, 5–7 mm. longa, 0.75–1 mm. lata, e basi oblonga *parum concava* cito angustata, marginibus superioribus convolutis, *serrulatis;* inferiora *in pilum breve fuscum subintegrum* desinentia, superiora *pilo longo flexuoso flavido denticulato* aristata. Costa infra $\frac{2}{5}$–$\frac{3}{5}$ folii latitudinem occupans, *optime limitata;* sectione eae *C. flexuosi* Brid. sat similis. Areolatio superior breviter rhomboidea, cellulae supra-alares latae, rectangulares, marginem versus minime angustatae, alares magnae, rubellae, auriculas inflatas pernotatas instruentes.

Flores aggregati, comosi; setae aggregatae; theca leniter asymmetrica, basi parum strumosa; calyptra *fimbriata*.

HABITAT: Gambos, Angola, on the ground at 1,250 m. alt., April, 1915, *Juliano de Carvalho*, communicated by Dr. Ant. Machado.

I do not know any species from Central or South Africa nearly resembling this; nearly all the Angola species as well as those from British East Africa have a very wide nerve. In the present plant the leaf base is almost exactly identical with that of *C. flexuosus* Brid., as is also the nerve section and areolation generally; the hair-point, which at once distinguishes it from that species, is notable in not being hyaline, but yellowish or, in the older leaves, brown, similarly to what obtains in some forms of *C. introflexus* (Hedw.) Mitt., from which however the plant is entirely distinct. *C. æthiops* Welw. & Dub. differs in the black color, entire leaf margin, etc.

FISSIDENS SUBOBTUSATUS C. Müll.

Pretoria, Transvaal, *H. A. Wager*.

This agrees exactly with the description by C. Müller of Wilms's plant (Transvaal, *L. Chriss*). Wilms's specimens were, however, sterile, while Wager's are fruiting, with mature, deoperculate fruit. The terminal seta is short, 1.5–2.5 mm. in length; while the capsule is erect, quite symmetrical, and constricted below the mouth when dry, so as to be markedly urceolate.

DIDYMODON AFER (C. Müll.) Broth.

Trichostomum afrum C. Müll. Hedwigia **38**: 98. 1899.

Near Pretoria, Transvaal, *H. A. Wager 66b.*

This agrees with a specimen, "Transvaal, coll. Wilms, 2475," in the Kew Herbarium. It was mixed with another species of *Didymodon* (*Hydrogonium*), which may be a form of *Trichostomum afro-fontanum* Rehm., but is rather widely different from Rehmann's specimen.

Tortula Eubryum (C. Müll.) Dixon, comb. nov.

Barbula Eubryum C. Müll. Flora **62**: 379. 1879.

Hilly rocks, Pretoria, Transvaal, *H. A. Wager 15;* Barberton, Transvaal, *H. A. Wager 280.*

A very marked and distinct species, which I have no hesitation in referring to *Barbula Eubryum* C. Müll., from Central East Africa (Ukamba, Kitui, *Hildebrandt*, 1877). It is very distinct in the habit, the long, highly undulate, acute leaves with strongly recurved margin, the nerve strongly prominent at back, and shining when dry, excurrent in a short robust mucro or cusp, and in the large, highly developed gemmae in terminal cups or rosettes, as in *T. pagorum* (Milde) De Not. The similarity in this respect, the habit, the lax (very fragile) basal cells, and the upper areolation, leave no doubt, I think, that the proper position of the species is in *Tortula* (*Syntrichia*). Its occurrence in such widely separated stations is a striking fact.

C. Müller described it first as the type of a new section *Bulbibarbula* of *Barbula*, on account of the gemmae which he found at the base of the apical leaves. But, as he explains,* he was not able to confirm their occurrence upon a later reëxamination of the specimen, and therefore to avoid error he subsequently placed the species under a new section *Rhystobarbula* (from the undulate leaves). Mr. Wager's specimens, showing both these characters in a very highly distinct fashion, confirm the accuracy of C. Müller's first observation. In view, however, of the occurrence of somewhat similar gemmae in *T. pagorum*, *T. laevipila* var. *laevipilaeformis* (De Not.) Limpr., etc., the last chosen name

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* Gen. Musc. Frond. 463. 1901.

appears preferable to the former, if the plant be retained in a separate section, in view of the very marked and unusual transverse undulation of the leaves.

TORTULA EXESA (C. Müll.) Broth.

Zoutpansberg District, North Transvaal, *T. Jenkins*, communicated by W. Ingham.

This agrees quite well with the description of *Barbula exesa* C. Müll.* The very highly fragile leaves, of which it is hardly possible to find a perfect specimen, form the most noteworthy feature in this marked species.

TORTULA ERYTHRONEURA Schimp.

Cape of Good Hope, *S. W. Hall*, communicated by L. B. Hall.

This agrees well with "Wilms, 2580," at Kew. Whether it be anything more than a form of *T. ruralis* (L.) Ehrh. may perhaps be doubtful.

OEDIPODIUM AUSTRALE Wager & Dixon

This extremely interesting plant has been described by Wager† but a few additional remarks may be of interest. It is very close to the European species, *Oe. Griffithianum* (Dicks.) Schwaegr., but differs in the non-ciliate, mucronate leaves and smaller cells. The stems also spring from a creeping rhizomatous primary stem, which has not been observed in the northern plant. The gemmae are very remarkable, being perhaps the largest and best developed of any known species of moss. They are large (300 μ in diameter) and lenticular with a thin equatorial ring; while those of *Oe. Griffithianum* are smaller, obovate, and less regular.

The geographical distribution of the two species is also highly remarkable, *Oe. Griffithianum* being confined to a few alpine summits in Great Britain, Scandinavia, Alaska and Greenland, while the stations for *Oe. australe* are confined to low or comparatively low elevations in Natal and the Transvaal.

ANOMOBRYUM PROCERRIMUM Rehm.

Dry earth, Pretoria and Van Reenen, Transvaal, *H. A. Wager;* Estcourt, South Africa, 4,600 ft. alt., *R. C. Wroughton*, March, 1913, communicated by W. R. Sherrin.

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* Hedwigia **38**: 103. 1899.

† Trans. Roy. Soc. South Africa, **4**:3. *pl. 1.*

There is a good deal of confusion about the nomenclature of this plant, which is very near the northern *A. filiforme* (Dicks.) Husn., but which may perhaps be separable on the ground of its slightly pointed leaves and less highly appendiculate cilia.

Rehmann issued his Musci austr.-afr. *214* as *Mielichhoferia procerrima;* this C. Müller gives as a synonym of his *Bryum promontorii.* Paris, Index, Ed. 2, under the latter name gives as a synonym *Mielichhoferia procumbens* Rehm., which is no doubt simply a slip for *procerrima.* A more serious error lies in the fact of his retaining *Bryum promontorii* C. Müll. (with *M. procerrima* Rehm. *214* as a synonym), and at the same time *Anomobryum procerrimum* Rehm. *540*, giving *M. procerrima* Rehm. *219* as a synonym. This would seem to imply that Rehmann's *214* is a different species (and genus) from his *219* and *540*. But Rehmann has himself cited his *214* as a synonym of his *Anomobryum procerrimum* Rehm. *540* (on the label of the latter), and there can be no ground for separating them.

Brotherus cites the plant as "*A*[*nomobryum*] *procerrimum* (C. Müll. als *Bryum*)," but this too appears to be an error. The synonymy should, I believe, stand thus:

ANOMOBRYUM PROCERRIMUM Rehm. Musci austr.-afr. *540*; Brotherus in Engler & Prantl, Nat. Pflanzenfam. 1³: 563. November, 1903*
Mielichhoferia procerrima Rehm. Musci austr-afr. *214*, *219*.
Bryum procerrimum Par. Ind. 206. 1894.
Bryum promontorii C. Müll. Hedwigia **38**: 69. 1899.

Bryum (EUBRYUM § ROSULATA) **canariensiforme** Dixon, sp. nov.

B. canariensi Brid. peraffine; differt statura paullo graciliore, foliis perconcavis, marginibus *erectis nec recurvis*, apicibus *brevius mucronatis*, thecae operculo *breviter conico*, *subobtuso*. Inflorescentia autoica? [FIG. 1.]

HABITAT: Cape of Good Hope, July 25, 1900, *C. H. Hobkirk 928*, communicated by G. Webster. A specimen in the British Museum collection, labelled, "Bry. canariense Schpr. Synops. Süd-Africa", in Breutel's hand, also belongs here.

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* *A. procerrimum* Par. (Ind. Ed. 2, 1: 52) dates from December, 1903.

The differences from *B. canariense* and *B. provinciale* Philib. if not numerous are marked, and, I believe, constant. In these the leaf-margin is distinctly recurved, often all round, the nerve excurrent in a longish cuspidate point; the capsule lid is sharply acuminate, at times almost rostellate; here it is much lower and scarcely acute. *B. polytrichoideum* C. Müll. is described as having the leaves with recurved margins, obsoletely denticulate (here they are sharply toothed above), with the nerve longly excurrent. The nerve in the present species is excurrent in a very short, rather stout, often recurved mucronate point, entire or frequently denticulate.

I have found a terminal male inflorescence on a fruiting stem, but it is possible this may not be the only position in which the antheridia occur, in view of the allied *B. provinciale.*

POGONATUM SIMENSE (B. S. G.) Jaeg.

Van Reenen, Transvaal, 1914, *H. A. Wager 52.*

Another interesting extension of range, the species being hitherto known only from Abyssinia and the Cameroons. It agrees well with Schimper's and Mitten's specimens at Kew. Bruch and Schimper describe the inflorescence as hermaphrodite. It appears to me rather paroicous than synoicous, the antheridia being apparently below the innermost perichaetial bracts.

All the specimens show an occasional very faint rib on the capsule, which leads to a mild plication when dry and empty.

ERPODIUM HANNINGTONII Mitt.

Trees, Kaapmuiden, near Barberton, Transvaal, 1910, *H. A. Wager 258.*

Mrs. Britton has kindly sent me a part of Mitten's type, so that I have been able to establish the identity of Wager's plant with the Lake Nyanza species. It is not recorded from any intermediate station, but I have a strong suspicion that *E. Menyhardtii* C. Müll. from the Zambesi will prove to be the same thing, and if so the geographical gap between the two would be materially bridged over. I have not seen *E. Joannis-Meyeri* C. Müll. from Kilimanjaro; Brotherus, who had specimens of both under his eye, I believe, keeps them separate, and one must suppose that there are some differences. It may be pointed out, however, that C. Müller himself (who had not seen Mitten's plant) describes his species as, "e descr. *E. Hanningtonii* proximum, sed icone ejusdem valde remotum, multo robustius." Now the leaves of *E. Hanningtonii* are, as given by Mitten, 1.5 mm. long, including the hair-point, whereas the drawing by Brotherus of the leaf of *E. Joannis-Meyeri* represents it as almost exactly 1 mm. in actual length. It is difficult to see, therefore, how Müller's plant can be "multo robustius" as described by the author. Probably Mitten's drawing is at fault, for his figure of the species, "natural size",* certainly does not represent a plant with leaves 1.5 mm. long. The difference in size, therefore, the only distinction suggested by C. Müller between the species, falls to the ground.

A further species from Barberton, Transvaal, which is being published by Mr. Wager, throws additional light on the distribution of this interesting genus. Its affinity is with *E. grossirete* C. Müll., from the Zambesi, having large, widely obtuse leaves with lax, smooth areolation, but it presents some differences from that species as described by C. Müller, and must therefore be considered distinct; the only other closely allied species is *E. madagassum* Par. & Ren.

BRAUNIA ELLIOTII† Broth.

Kikuyu, British East Africa, 1910, *A. Allan*, communicated by W. Ingham, *c. fr.*

This agrees quite well with the sterile plant, labelled, "Shire Highlands, December, 1893, *Scott Elliot.*" The fruit has not yet been described. The perichaetium is long, 2–3 mm., the inner bracts erect, short-pointed, seta about 1 cm. long, capsule cylindrical, about 2 mm. long, with a distinct neck, pachydermatous, narrowed at mouth and also slightly constricted below the orifice when dry and empty, somewhat plicate when quite old; lid with a longer or shorter slightly curved rostrate beak; calyptra large, castaneous, cucullate. The branches show a great diversity, a few often, and at times the greater number, being flagelliform.

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* Jour. Linn. Soc. Bot. 22: *pl. 16, f. 4.*

† This is the correct spelling, not *Elliottii* as originally published.

LEUCODON DRACAENAE Vent.

Solai, Mt. Kenya, British East Africa, 1910, *R. Kemp*, communicated by W. R. Sherrin.

This agrees quite well with the specimen (Dendera, Abyssinia, 1862) in the Schimper herbarium, determined by E. S. Salmon as *L. Dracaenae*.

PILOTRICHELLA CONFERTA Ren. & Card.

Barberton, Transvaal, January, 1914, *H. A. Wager 257*.

This agrees quite well with the description of the above species (from Lessonto, South Africa); the only difference I can find being a minor one, viz., that the alar cells which there are described as "plus minus incrassatis et granulatis" are here rather pellucid. It is a distinct species, the short, subdendroid, rather robust and rigid branching being very different from that of most of the African species of the genus.

Thamnium capense Broth. & Dixon, sp. nov.

Caulis *pertenuis*, *flexilis*, elongatus, vage subpinnatim vel bipinnatim ramosus; atroviridis, vix nitidus; rami ramulique complanati, breves, *obtusi*. Folia ramea 2 mm. longa, late ovato-oblonga, superne angustata late acuta, ramulina multo minora, angustiora; omnia concavo-carinata, sicca paullo plicata, marginibus planis, e basi denticulatis, supra grosse regulariter dentatis. Costa valida, subsinuosa, infra summum apicem evanida, dorso prominens, *supra spinuloso-dentata*. Cellulae superiores *pellucidae*, hexagonae, angulatae, 8–12 μ latae, parietibus firmis, *nec incrassatis*, marginem versus majores, elongatae, infra sensim longiores, hexagono-rectangulares, ad infimam basin elongatae, flavidae, parietibus incrassatis. Cetera nulla. [FIG. 2.]

HABITAT: in packing from Cape Town, *710*, communicated by G. Webster.

This species belongs to the small group with the nerve dentate at back above, to which belong the northern *Th. alopecurum* (L.) B. S. G., and *Th. Leibergii* E. G. Britton. The former differs in the more robust, dendroid habit, and smaller, denser, more incrassate cells; the latter in the more rigid habit, more obtusely pointed leaves, and larger cells. *Th. maderense* Kindb. is described as a much larger plant, with the growth of *Th. alopecurum*, the cells rhomboid-oval, the leaves "pauci-dentata," etc. The author describes the nerve as smooth, but Brotherus places the species in the section with nerve toothed at back.

The habit of the species is unusual, the stems being filiform, flexuose and not at all dendroid, but it is quite probable that the scanty material may not represent the true habit altogether correctly. The leaf characters, however, are in any case distinctive.

Entodon brevirameus Dixon, sp. nov.

E. Dregeano peraffinis. Differt caule elongato, sat regulariter pinnatim ramoso, ramis *patentibus brevibus obtusis*, vix 0.5 cm. superantibus, foliis magis decurvatis; foliis perichaetialibus *squarrosis;* columella valde exserta; peristomii dentibus *ubique fere longitudinaliter, ad infimam basin tantum transverse, striolatis,* longioribus, melius evolutis, sporis *laevibus*. [FIG. 3.]

HABITAT: on stones in bed of stream, 2,000–3,000 ft. alt., Pieter Maritzburg, Natal, 1909, *H. A. Wager* 9.

The characters above detailed are, I think, sufficient to separate this plant from *E. Dregeanus* (Hornsch.) C. Müll., which however varies considerably; the perichaetial bracts are usually erect and convolute, but specimens in the national collections in London, apparently correctly named, have the perichaetial bracts squarrose. For the present, however, I am not inclined to lay much stress on this character, nor on the single seta, in view of the small quantity of material available (in *E. Dregeanus* the setae are said to be usually aggregate, but I doubt if this be correct); the habit, branching and peristome characters are, however, probably reliable and of sufficient importance even though the others should prove invalid. In *E. Dregeanus* the peristome teeth are *transversely* striolate in the lower half, they are shorter and less regular, the columella I have not found exserted, the spores are slightly papillose. The inner peristome here is very delicate and adherent to the columella.

TRACHYPHYLLUM GASTRODES (Welw. & Dub.) Gepp

Barberton, Transvaal, *H. A. Wager 265*.

Eight African species have been described of this small genus, all of them are, as Brotherus has remarked, very closely related one to the other, and I should not be surprised if several of them have ultimately to be reduced to *T. fabronioides* (C. Müll.) Gepp.

T. gastrodes however is more marked as a species than some, in the widely spreading leaves, almost at right angles to the stem when moist, very widely cordate-oval, abruptly narrowed to a short but rather fine acumen; the cells are moderately papillose, the alar very numerous, extending half-way up the leaf at the margins. It is probably only known hitherto from the original station in Angola.

STEREOPHYLLUM ODONTOCALYX (C. Müll.) Jaeg.

Trees, Barberton, Transvaal, 1914, *H. A. Wager 261.*

FABRONIA

Sect. **Gymno-ischyrodon** sect. nov.

Planta pro more robusta, dense foliosa. Folia integra; theca gymnostoma, operculo convexo, vix apiculata.

Fabronia Wageri Dixon, sp. nov.

Dioica videtur. Planta *pro more robustiuscula*, sordide viridis, vix nitida; caules elongati, dense intertexti, radiculosi, conferte subpinnatim ramosi, ramis brevibus, suberectis, hic illic ramulosis, obtusis, siccis subteretibus. Folia *conferta, saepe plus minus homomalla*, erecto-patentia, sicca erecta subappressa, vix concava, ovato-lanceolata, *cito breviter acute acuminata,* marginibus omnino planis, *integerrimis*, costa apud medium folium evanida; areolatio foliorum juniorum chlorophyllosa, subobscura, seniorum pellucida, e cellulis alaribus permultis, subquadratis, totam folii basin occupantibus, superioribus *rhomboideis*, circa 10 μ latis, (4–6 × 1), parietibus firmis, angustis, marginalibus serie unica saepe inanibus, instructa.

Fructus e caulibus ramisque enati; perichaetia cylindrica, pallida, foliis, infimis exceptis, truncatis, grosse irregulariter erose dentatis, omnibus pellucidis; vaginula archegoniis paucis praedita. Seta circa 1 cm. alta, pro more *crassiuscula*, pallide rubra, curvata; theca e collo brevi turgide ovalis, 1.5 mm. longa, operculo *convexo, vix apiculato, sicco tantum nonnunquam inconspicue mamillato.* Peristomium *nullum*. Spori parvi, 10–15 μ lati; exothecii cellulae plerumque isodiametricae, parietibus incrassatis valde sinuosis flavidis, apud orificium 5–7 seriebus multo minoribus, valde compressis, transverse rectangularibus, parietibus incrassatis, firmis, rubris. Annulus inconspicuus, persistens. [FIG. 4.]

HABITAT: in Cape Town, on trees, 1910, *H. A. Wager 5.*

This distinct species seems best placed in a new section, characterized by the somewhat robust habit, entire leaves, gymnostomous capsules with plano-convex, scarcely apiculate lid. It is very near the species of the section *Pseudo-ischyrodon* Broth., but they have a peristome and an apiculate lid. *Ischyrodon leptocladus* Rehm. (Musc. austr.-afr. *633*) which, I believe, is an undescribed species is very near it (though more robust and with longer pointed leaves) and may belong to this section. Although labelled "*c. fr.*" there are no capsules to be found on the specimens either at Kew or the British Museum.

I have been unable to find male flowers, though the plants are in abundant fruit, and I think it is certainly dioicous.

LINDBERGIA

The genus *Lindbergia* Kindb. (*Fabroleskea* Best), founded on *Pterogonium brachypterum* Mitt., has been extended by Brotherus to include some half dozen other species, mostly formerly placed in *Leskea*, one (*L. Austini* [Sull.] Broth.) being from North America, two from China, one from the Himalayas, and one from Abyssinia. The genus is almost or entirely based on peristome characters, the processes of the inner peristome being wanting, and the endostome reduced to a very low basal membrane; the outer teeth are usually also densely papillose, with rather weak lamellae, and the spores are large.

The only African species hitherto known is *L. abbreviata* (Schimp.) Broth. (*Leskea abbreviata* Schimp.). It is interesting therefore to find two distinct new species in South Africa. The resemblance of the vegetative characters in the one case to *Pseudoleskea* and in the other to *Haplocladium*—both genera occurring in the same localities with them—is rather remarkable, and I have based the specific names on these resemblances. The fruit, however, serves as a ready method of distinguishing them, the capsules in *Lindbergia* being erect and symmetrical, whereas both in *Pseudoleskea* and *Haplocladium* they are inclined, somewhat asymmetrical and curved, with a much better developed inner peristome.

Lindbergia pseudoleskeoides Dixon, sp. nov.

Autoica; gracilis, repens, irregulariter ramosa, ramis inaequalibus subobtusis, *siccitate teretibus, curvatis.* Folia caulina laxiuscula, *ramea dense conferta*, madida patentia, sicca erecta appressa, late triangulari-ovata, *breviter late acuminata*, acuta vel subobtusa, paullo concava, marginibus planis integerrimis, costa sat valida, infra apicem evanida. Cellulae *rotundo-ovales*, irregulares, parietibus sat incrassatis, *omnino fere laeves, subopacae;* alares transverse elongatae, compressae, permultae, totam basin implentes. Folia perichaetialia externa brevia, lata, subobtusa, raptim brevipungentia, interna multo longiora, erecta, convoluta, *breviter rigide acuminata*, omnia e cellulis elongatis, linearibus, laevissimis, flavo-viridibus instructa. Seta circa 1 cm. alta, pallide rubra, theca erecta, *cylindrica*, pallida, *leptodermata*, operculo *conico, obtuso*. Peristomium (imperfectum) tenue, flavidum; dentes externi dense papillosi, linea media atque articulationes pertenues inconspicuae; peristomii interni membrana brevis, dense papillosa. Spori 22–23 μ. [FIG. 5.]

HABITAT: Buluwayo, South Africa, April 22, 1900, *E. Sadler 3171*, communicated by G. Webster.

Leskea abbreviata Schimp. in all its forms has the leaves with longer points, reflexed when dry, so that the branches are less julaceous; the branches also are not or very rarely curved when dry, the capsule wider, ovate-cylindric, darker and of stouter texture, the lid conico-rostellate. The following species is quite distinct in habit and leaf-form.

In habit and leaf-structure the present plant is almost exactly like some species of *Pseudoleskea*, and without fruit its generic position would be very difficult to determine. The peristomes in the material examined are old and the teeth broken, so that the lower part only could be examined.

Lindbergia haplocladioides Dixon, sp. nov.

Autoica. Olivacea vel aurantiaca, gracilis; caulis vage repens, ramis distantibus, *elongatis, tenuibus, subrigidis.* Folia madida patentia, sicca nonnunquam erecto-appressa, *saepissime autem apice plus minusve fortiter recurvo;* e basi ovata *sensim longe anguste acuminata*, acuta, integerrima; costa *tenuis*, in summo acumine soluta. Cellulae superiores *rhomboideae, elongatae*, incrassatae, in acumine multo angustiores, longiores, alares multae, transverse elongatae, compressae; omnes *laevissimae.*

Perichaetium ei praecedentis sat simile, paullo longius, foliis internis *longius argutius acuminatis;* seta rubra, paullo longior, theca rufescens. Operculum haud visum. Peristomium paullo saturatius flavidum, ceterum simile. Spori paullo minores. [FIG. 6.]

HABITAT: Rydal Mount, Pretoria, South Africa, 1914, *H. A. Wager 29.*

Entirely different in habit, color, leaf-form and areolation from the last; in these respects closely resembling certain species of *Haplocladium,* though differing in the quite smooth cells. The sporophytic characters are almost those of *L. pseudoleskeoides;* the general color only being a little deeper in all the parts.

HAPLOCLADIUM ANGUSTIFOLIUM (Hampe & C. Müll.) Broth.

Macomo's Hoek, South Africa, 1897, *Mrs. Clarke Williams,* communicated by Rev. C. H. Binstead; near Pretoria (on dry earth) and at Van Reenen, Transvaal, *H. A. Wager.*

These plants agree in leaf characters with the specimens in Hampe's herbarium; they manifest some considerable degree of variability, especially in habit and branching, but I believe they all belong to one type, which like its congener, *H. capillatum* (Mitt.) Broth. in southern and eastern Asia, is somewhat polymorphous. I believe that *H. afro-capillatum* Broth. and *H. amplexicaule* (C. Müll.) Broth. are likely to prove forms of the same thing.

PSEUDOLESKEA DISPERSA C. Müll.

Kilimanjaro, *Bishop Hannington,* Mitten's herbarium; Solai, Mt. Kenya, 1911, *R. Kemp,* communicated by W. R. Sherrin.

Although I have not see *P. dispersa* C. Müll., I have no hesitation in referring the above plant to it, from the description given by Brotherus.* The plants of the Cameroons were entirely sterile, and Mitten's specimen is an unnamed, sterile scrap. Kemp's, on the other hand, is in good condition and fruiting, though the capsules are old and deoperculate, with only fragments of peristome showing. The sporophytic characters may be described, so far as shown, as follows:

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* Bot. Jahrb. 24: 282. 1897.

Perichaetium *praelongum*, 5–6 mm. altum, *nitidum*, *foliis profunde plicatis*, longe acuminatis, integris vel tenerrime denticulatis, tenui-nervibus. Seta 2–2.5 cm. longa, rubra, theca circa 3 mm. longa, curvata, asymmetrica, rufo-fusca. Peristomii dentes externi remotiusculi, lanceolati, opaci, transverse striolati, alte trabeculati; endostomii membrana altiuscula, papillosa; processus? Cetera ignota.

Kemp's gathering shows a handsome plant, the young branches bright green, the older part orange-brown. The widely cordate, deeply plicate leaves, intermixed with a dense growth of paraphyllia, give the stems quite a thuidioid appearance. The perichaetia are longer than in any other species with which I am acquainted, and the plant is altogether more robust than any of the species I have seen except *P. denudata* Kindb.

Drepanocladus Hallii Broth. & Dixon, sp. nov.

Caules erecti, 4–5 cm. alti, infra dense intertexti, caespites *compactos*, flavo-virides, *interne pallidos* formantes, *subrigidi*, laxe subpinnatim ramosi, ramis paucis, brevibus, circa .5 cm. longis, substrictis; caulium apices paullo incurvati, vix hamati. Folia caulina sat dense conferta, homomallo-falcata, *parva*, circa 1 mm. longa, e basi ovata vix decurrente *breviter late oblique* acuminata, concaviuscula, *obtusa vel subacuta*, integra; costa tenuiuscula, male definita, circa $\frac{2}{3}$ folii attingens. Areolatio superior *densa*, *opaca*, e cellulis breviusculis incrassatis angustissime linearibus subvermicularibus instructa; cellulis inferioribus sensim laxioribus, basin versus lineari—rhomboideis; alaribus *permultis*, sensim angulos versus majoribus, quadratis et rectangularibus, pellucidis, omnibus subincrassatis. Folia ramea minora, angustiora, brevius acuminata, obtusa, vix falcata.

Dioica. Flores feminei tantum visi, medio caule siti, aggregati; folia perichaetialia interna patentia, caulinis similia sed echlorophyllosa. Cetera ignota. [FIG. 7.]

HABITAT: Cape of Good Hope, 1912, *S. W. Hall 7*, communicated by L. B. Hall.

The affinity of this—for a *Drepanocladus*—well-marked species, is no doubt with *D. aduncus* (Hedw.) Warnst. It is peculiar in the short wide subobtuse acumen, and the numerous enlarged alar cells, which though very conspicuous, and the extreme angular ones rather large and pellucid, do not form well delimited or at all inflated auricles.

MICROTHAMNIUM SAPROADELPHUM C. Müll.

On fallen trees, Ponce, Mauritius, September, 1862, *Dr. Ayres*, Mitten's herbarium, as *M. tenellum* Mitt.

A very slender, delicate plant, with minute, narrow leaves, and very narrow, smooth cells, which does not agree with any of the described species from South Africa or the insular regions, and appeared quite to justify Mitten in considering it a new species. On comparing it, however, with the original of *M. saproadelphum* C. Müll. (Cameroons, *Dusén 499*), I find it identical with that. Mitten's specimen is without capsules, but the setae, perichaetia, etc., are present, and in these and the vegetative characters it agrees exactly with Dusen's plant.

Plagiothecium nitens Dixon, sp. nov.

Dioicum. Caespites perlati, densi, depressi, *argenteo-virides, nitentes.* Caulis repens, sat dense ramosus, ramis complanatis, circa 2 cm. longis, plerumque attenuatis, cum foliis 3 mm. latis. Folia complanato-decurva, illis *P. Mildbraedii* Broth. persimilia, paullo angustiora, asymmetrica, apice integro vel 2–3-denticulato. Cellulae superiores anguste rhomboideae, *10–14 μ latae.*

Folia perichaetialia similia fere, sed *brevius, minus acute acuminata.* Seta *brevis*, 1–1.5 (raro 1.75) cm. longa; theca *suberecta vel erecta, leniter tantum curvata, cylindrica,* sicca paullo striata. [FIG. 8.]

HABITAT: Solai, Mt. Kenya, British East Africa, 1910, *R. Kemp*, communicated by W. R. Sherrin.

This plant is clearly very closely allied to *P. Mildbraedii* Broth.* from the Ruwenzori region, which I have not seen; the vegetative characters indeed seem almost or quite identical (so that I have not thought it necessary to describe them fully). The leaves in that species are figured much wider than they are in this, but the description, "ovato-lanceolata," applies quite well; on the other hand, the cells figured are very similar to those of the present plant, but they are described as "angustissime linearibus," which is not at all applicable here. The fruiting characters, however, appear to present marked differences; the perichaetial bracts are described as "*breviter subulatis*," while here the points are rather wide and scarcely acute; the seta is "2.5–3 cm. alta," or about

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* Wissensch. Ergebn. der Deutsch. Zentral-Afrika-Exped. 2: 169. 1907–8.

twice the length of that of the present plant; the capsule is "horizontalis, asymmetrica, oblonga, laevis," while here it is erect, only very slightly curved and asymmetrical, subcylindric, and lightly plicate when dry.

VESICULARIA SPHAEROCARPA (C. Müll.) Broth.

Barberton, Transvaal, 1914, *H. A. Wager 256, 259.*

I was at first inclined to consider this plant distinct from the insular species, and I understand from Mr. Wager that Dr. Brotherus takes the same view. I have, however, examined a fairly long series of plants of the insular *V. sphaerocarpa*, and I believe that the Transvaal plant may well come within its range. The principal points of difference that I have observed are the slightly wider cells in the present plant, and the usually more shortly pointed leaves. Montagne's specimens, however, show some degree of variation in these respects, and I have found among them some stems with equally short-pointed leaves, while the cells vary a good deal in width, and occasionally quite match those of the Transvaal plant. The leaf apex may be either entire or denticulate.

At the most I think the South African plant can only be looked upon as a slightly divergent regional race. Dr. Brotherus, it may be noted, has recently recorded *V. sphaerocarpa* from Beni, in Central Africa.

Rigodium dentatum Dixon, sp. nov.

Pergracile. *R. gracili* Ren. & Card., et *R. kilimandscharico* Broth. habita simile; caulis primarius longe repens, secundarius erectus, *subdendroideus*, ramis ramulisque numerosis, confertis, *saepius curvatis, filiformibus, rigidis.* Folia caulis primarii subappressa, secundarii patentia, late deltoidea, *sensim longe tenuiacuminata, argute denticulata;* folia ramea minora, concavia, erectopatentia, late ovata, anguste acuminata, *marginibus anguste reflexis*, per totam longitudinem, praecipue superne, *dense argute denticulatis.* Costa foliis caulinis *debilis, circa medium folium attingens, rameis ramulinisque pertenuis, saepe obsoleta.* Cellulae foliorum caulinorum breviter lineares, subsigmoideae, incrassatae, foliorum rameorum subsimiles, breviores, serie unica marginali multo breviores, latiores, limbum denticulatum conspicuum pulchre exhibentes; alares sat numerosae, subquadratae, obscurae. Cetera ignota. [FIG. 9.]

HABITAT: Pretoria, Transvaal, 1914, communicated by Rev. Hilderic Friend.

An interesting addition to the genus, represented in Africa hitherto solely by Brotherus's species cited above, from Kilimanjaro and Usambara. The sharp denticulation of the leaves in the present plant differentiate it from that, and the weak nerve from both that and *R. gracile* Ren. & Card.

RHYNCHOSTEGIELLA HOLSTII (Broth.) Broth.

Chaya, Congo Belge, June 16, 1911, *R. Kemp 14*, communicated by W. R. Sherrin.

This agrees with Holst's Usambara plant at Kew, except that, growing among other mosses, it is a little more lax and straggling, and darker green.

RHYNCHOSTEGIUM VOLKENSII (Broth.) Par.

Chaya, Congo Belge, June 20, 1911, *R. Kemp 19*, communicated by W. R. Sherrin.

I hestitated at first to identify this with Brotherus's plant from Marangse in the Kilimanjaro region, on account of one or two slight discrepancies between it and the original description— the numerous alar cells, which are not mentioned there, the nerve stout just at base, and then narrowed for the greater part of its length ("superne" according to Brotherus), and the capsule, which is described as "fusca, sub ore haud coarctata." The capsules here are blackish when mature, and very slightly contracted below the mouth when dry.

The British Museum specimen, however (*Volkens 447*), agrees exactly in all points with Kemp's plant; it has a single capsule, which agrees in all respects with the present specimens, in color and form, and is certainly not free from a suspicion of being slightly contracted below the mouth.

NORTHAMPTON, ENGLAND

Explanation of plate 1

The type specimen is figured in each case.

FIG. 1. *Bryum canariensiforme* Dixon. *a*, leaf, × 18. *b*, leaf apex, × 45. *c*, capsule, × about 2½.

FIG. 2. *Thamnium capense* Broth. & Dixon. *a*, plant, about natural size. *b*, leaf, × 18. *c*, leaf apex, × 45. *d*, upper cells, × 180.

FIG. 3. *Entodon brevirameus* Dixon. *a*, part of outer peristome, × 180.

FIG. 4. *Fabronia Wageri* Dixon. *a*, stem, about natural size. *b*, leaf, × 18. *c*, upper cells, × 180. *d*, *d′*, capsules, × 4½. *e*, exothecium cells at orifice, × 180.

FIG. 5. *Lindbergia pseudoleskeoides* Dixon. *a*, leaf, × 18. *b*, perichaetium, × 18. *c*, upper cells, × 180.

FIG. 6. *Lindbergia haplocladioides* Dixon. *a*, leaves, × 18. *b*, upper cells, × 180.

FIG. 7. *Drepanocladus Hallii* Broth. & Dixon. *a*, stems, about natural size. *b*, stem-leaf, × 18. *b′*, branch-leaf, × 18. *c*, alar cells, × 90.

FIG. 8. *Plagiothecium nitens* Dixon. *a*, stem, about natural size. *b*, leaf, × 18. *c*, upper cells, × 180.

FIG. 9. *Rigodium dentatum* Dixon. *a*, plant, about natural size. *b*, stem-leaf, × 18. *b′*, branch-leaf, × 18. *c*, upper marginal cells of branch leaf, × 180. *d*, alar cells of stem leaf, × 90.

New species of Opuntia

DAVID GRIFFITHS

(WITH PLATES 2 AND 3)

A living assemblage of 2,400 collection-numbers of *Opuntia* has been established at Chico, California. The majority of the plants have reached fruiting condition. The plantation represents in the largest measure my own field work supplemented by donations, purchases from other collectors, and introductions through the Office of Seed and Plant Introduction of the United States Department of Agriculture. All of the species described below have been propagated vegetatively in this collection, have been studied in their native habitat in all but one instance, and the majority of them have been grown to maturity from seed, either from the type or from previous collections.

Opuntia humistrata sp. nov.

A densely pruinose, prostrate to ascending species, with long radiating, branched, reclining, tangled arms, 30 cm. high, and forming bunches a meter in diameter; joints obovate to elliptical, broadly to sharply rounded above, and stipitate based, or widest at middle, and long, attenuated above and below, commonly 6 × 15 cm., but may be 5 × 18 cm., and again commonly 5 × 10 cm., surface flat, only very slightly raised at areoles even when young, at first dull medium to yellowish green, strongly turgid, with slight tinge of red about areoles of the edges especially, in the main densely pruinose; leaves reddish tinged, circular in section, subulate, cuspidate, 5 mm. long, mostly ascending, and finally curving inwardly; areoles at first tawny with light brown wool, which is soon obliterated by the spicules, subcircular to broadly obovate, 2 mm. in diameter, soon becoming 3 to 4 mm. in diameter; spicules brown, but in places may appear dirty yellowish, 2 to 3 mm. long, and completely filling areole with a compact truncate tuft 3 mm. long; spines none; flowers purplish, similar to those of *Opuntia basilaris* Engelm. & Bigel., but usually smaller; fruit subglobose or more elongate, greenish or white with a blush of red, dry.

This species belongs to the *Opuntia basilaris* group, and it is distinguished from *O. brachyclada* Griffiths by its much wider, different-shaped joints; and from *O. basilaris* by its much smaller as well as different shaped joints. The branching in this species is more truly basilate than in *O. basilaris* when it is young but as the plants increase in size this characteristic is lost in the main branches. Its distribution seems to be confined to the floor of the mountain valleys of the San Bernardino region of California. While in the type the spicules are decidedly brown like those of the majority of *O. basilaris*, they may be entirely yellow. Indeed the species varies in coloration of the entire plant.

The type is preserved under my collection No. 10787, and was collected in the mountain cañons above San Bernardino, California, September 17, 1912. The description was drawn in the main from cultivated plants, grown at Chico, California, July 28, 1914.

Opuntia deltica sp. nov.

A tall, erect, tree-like form, often reaching a height of 2–3 m., with a distinct trunk, rather loose and open branched; joints obovate but often widest at middle, about 17 × 26 cm., light, rather yellowish green, with a little bloom, sharply rounded above and contracted below into a short stipitate base; areoles bright, dark brown, broadly obovate to subcircular, 4–6 mm. long, 2.5–4 cm. apart on sides of joint and 1 cm. on edges; spicules prominent, scattered through entire areole, but more numerous above, the longer 1 cm. in length, unequal, scattered, yellow, formidable; spines yellowish, one to four, mostly two, increasing slightly in age, when two, one erect, other recurved, the upper the larger, flattened, often twisted, not annular, 3 cm. long; flowers yellow, becoming deeper yellow with slight tinge of red only late in the day, 7–8 cm. in diameter when fully opened, slightly greenish tinged within, reddish when closed and bud greenish with only a slight tinge of red in edges of occasional bud scales, filaments greenish, style white, stigma long, five- to seven-parted, very light greenish tinged, almost white; fruit deep purplish red all way through, obovate with wide, nearly flat umbilicus, about 4 × 4.5 cm., areoles large, subcircular, tawny, 3 mm. long and ten to fifteen in number, spicules yellow, 2–3 mm. or even 5 mm. long, but quite distinct from the fugacious spines which may reach extreme length of 2 cm., widely spreading, five to ten in number.

This is another species peculiar to the delta of the Rio Grande. It is not so conspicuously a tree as *O. alta* Griffiths, for it appears to be less woody, more spreading and therefore more easily broken down. Like so many other species, when grown from cuttings it forms a hemispherical shrub, at least for five or six years, and only very remotely suggests a tree form. It is often a low-spreading to hemispherical shrub in its native heath, but when unmolested it assumes the form of a tree. The plants from which our specimens were secured were 3 m. high but have not gotten over 1.5 m. in any of our plantations up to this time after five years of cultivation. The species was secured originally in the vicinity of Brownsville, Texas, in 1908, and has been propagated vegetatively since that time at Brownsville and San Antonio, as well as at Chico, California. The type bears my collection number 10501.

✓ **Opuntia laxiflora** sp. nov.

A hemispherical shrub, 1 m. high and about 2 m. in spread of branch, main arms ascending or resting on edge, and secondary ones erect from them, open, lax in habit of growth; joints long-obovate, mostly rather sharply rounded above, long contracted below into a strong stipitate base, light yellowish green, with some bloom, about 15 × 30 cm., prominently raised, tubercular at areoles for 2 years, with those on the margins very decidedly raised until the margins of the joints often appear notched between the areoles; leaves subulate, cuspidate, 8 mm. long, recurved at tip; areoles brown, subcircular, 4–5 mm. in diameter, 4 cm. apart; spicules yellow, abundant, formidable, unequal, mostly scattered through upper and lateral margins of areole, 7–8 mm. long, continuing to develop the second year, when they are frequently decidedly brown; spines yellow, one to four, mostly two, increasing in age to six, faintly annular, flattened, slightly deeper colored at base, when two, the upper porrect, and lower reflexed, the upper 2 cm. in length; flowers (late in the day), 8 cm. in diameter when fully opened, decidedly purple, the midribs of petals deep orange-red, and the margins purple, exteriorly petals have a strong orange cast also, but purple impression is given of the whole, lax, petals long, obovate, cuspidate, pointed, tapering to almost cuneate below, 5–6 cm. long, eroded-wavy above, light yellowish green with only a tinge of red in the apex of an occasional sepal in the bud, filaments tinged purplish below, style white, stigma light green, with six long linear divisions, ovary obovate, 3–4 cm. in length, its areoles prominent, tawny to gray, with a pronounced protuberance of wool, 1–1.5 mm. high, spicules of same character as on joints, but there are two to seven or eight bristles 1.5 cm.

long identical with spicules, except in size, but are more fugacious even than the spicules; fruit when mature purplish red throughout.

This species is more closely related to *Opuntia cyanella* Griffiths, from which it differs very decidedly in laxness, shape, and tint of flower, color, shape, and character of joints and nature of spination. The flowers are decidedly purplish when they first open at 8 A.M.; but purple coloration exists only toward the base of the petals on the inside of the flower. They turn more purple as the day advances. There are really in each petal when the flower first opens, a small marginal area of purplish red and a larger midrib area of orange-red tint. In sunlight, they are fully opened by ten o'clock, but in the shadow of the joints, the opening is retarded by an hour; or sometimes it may not be fully opened before noon, if shading is heavy.

The type is No. 9915 DG, collected at Loma Alta, near Brownsville, Texas, August 18, 1912. The description was drawn in the main from cultivated plants grown at Chico, California, July 25, 1914. The plants at this place blossomed profusely from cuttings the second year.

Opuntia zuniensis sp. nov.

A low, prostrate, reclining species, 30 cm. high and sometimes 1 m. in diameter, the main branches most commonly resting on edge, or at times prostrate and the secondary ones erect from them, but usually only one or two joints in height; joints ovate obovate, pointed above and below, having a little bloom when young but losing this and becoming decidedly yellowish-green in age, 11–12 × 18–23 cm.; areoles obovate, commonly 6–7 mm. long on edges of joints, shorter and more nearly subcircular on sides, especially toward the base of joint, brown; spicules yellow, 3 mm. long, in a compact crescentic tuft in upper angle of areole, in age filling entire areole and becoming often a cm. in length; spines white but on apex of current year's growth their bases vary from light straw-colored to dark brown, but the general impression given by even these is brown-tawny and even they are more or less white distally, flattened, slightly twisted, seldom even faintly annular, porrect-spreading, usually about six on apex of current year's growth, the lower one about 2 cm.. long and sloping down, the others stouter and varying from 2–5 cm., increasing in both length and numbers in age; flowers yellow, about 7 cm. in diameter when fully opened, having a little red at base of petals when first opened which becomes more prominent later, the whole turning light orange-red as day advances; fruit a dull, light yellowish-red, rind greenish, pulp colorless, areoles small, 1.5 mm. in diameter, gray-tawny, spicules yellow, protruding from wool 1–2 mm.; fugacious spines 5–8 mm. long and two to six in number with a distinct tendency to whitening at complete maturity, and rarely accompanied by an occasional true white spine.

This belongs to the phaeacantha group and differs from previously described species in shape of joints, color of, as well as appendages, of the joints, and nature of flower, fruit and seed. The species was collected near Zuni, New Mexico, August 31, 1911, and the type bears my collection number 10345. It grows commonly in the open sage brush areas of the region, especially eastward and northward, and is probably the most common species of the region. The description applies to one form of the species, the other forms having spines decidedly brown, and the whole plant body, as well as the fruit, darker colored. The description is drawn in the main from plants propagated vegetatively at Chico, California, under field conditions, although it was also grown for a time in a sash house and in field at San Antonio, Texas.

Opuntia flexospina sp. nov.

An erect to ascending bushy species, 50–100 cm. high and having a spread of about 2 m. when fully grown; joints broadly obovate, about 15–16 × 20–22 cm., yellowish green with little or no bloom, raised at areoles, smooth; areoles large, prominent, broadly obovate, 5–6 mm. long on edges of joints, slightly smaller on sides, enlarging in size to subcircular, and often 8–10 mm. in diameter, dark brown; spicules yellow with some brown mottling, scattered throughout the areole, but more numerous above and on edges of areole, giving general impression of being scattered, divergent, 5–7 mm. long, increasing in age to 10 mm. in length and filling entire areole; spines at first porrect but soon bent downward parallel with sides of joint, and commonly tightly recurved on edges, one or two, mostly one on sides and two or three on edges at one year of age, increasing in numbers in age to six to ten, and all sloping down to tightly recurved, 3.5 cm. long at one year old but becoming 5 cm. in age, yellow, with or without brighter brown bases, more or less flattened; flowers deep yellow with blushes of red, filaments greenish below and tinged with red above, style red below and fading upward, stigma dark green, eight- to ten-parted, bud pointed, dull, light reddish, with touches of dull, olive-green; fruit purplish red throughout, bearing light, tawny areoles 2–3 mm. in diameter, and spicules of same nature as those of the stem, 3–5 mm. long, fugacious spines being only slightly longer and consequently scarcely distinguishable from the spicules, umbilicus broad, nearly flat, pulp small in amount, acid, and not palatable, simply obovate to pyriform, about 3–3.5 × 4–5 cm.; seeds small.

The species inhabits the dry, gravelly hills in the vicinity of Laredo, Texas, where it was collected in June, 1911, under my inventory number 10301. It is rather common and easily recognized in vegetative condition by the nature of its spines. The first collections were made in 1908 but the living material of this was lost at both San Antonio and Brownsville, Texas. Mature plants have been grown from the type collection, however, at Chico, California.

Opuntia curvospina sp. nov.

An erect arborescent species, growing into a symmetrical tree form 5–8 feet high, having a distinct cylindrical trunk and a symmetrical, rounded top; joints subcircular, about 8–22 cm. in diameter, smooth, scarcely at all raised at areoles after the first year, glaucous-gray-green, yellowish-green in age; areoles large, prominent, at first light-brown but dark-brown second year, obovate, on edges of joints 5 mm. long, enlarging in age to subcircular and 5–8 mm. in diameter; spicules yellow, irregular in length on edges of joints, about 3 mm. long in upper part and 5–8 mm. on lower edges of areole, making a nearly complete zone around the central, prominent wool, not increasing perceptibly in age for the wool develops rapidly into a columnar structure bounded by the marginal spicules and protrudes often 1 mm. or more above them; spines numerous, formidable, on second year's wood about six, four of which are yellow, often slightly tinted at base, the other two shorter, white or nearly so, diverging or bent in all directions, the four yellow centrals 4–5 cm. long, flattened, annular, twisted, bent, and curving in various directions, in age increasing to eight or more and formidable; flowers yellow, 6–7 cm. in diameter with a little dull red at the bases of the midribs, and developing a little more red in center as the day advances but never becoming prominently red-centered, petals cuneiform, broadly rounded, cuspidate above, filaments yellow, style white, stigma white, large, slightly flattened, nine- or ten-parted, buds light gray-green with blush of red, uniformly distributed in upper portions of sepals; fruit dull red on outside with abundant bloom, rind greenish, and pulp nearly colorless, oval in outline, 3.5–4 × 4.5–5.5 cm., slightly to deeply pitted, areoles tawny, subcircular, with prominent wool 1–2 mm. in diameter, spicules yellow, 1–2 mm. long, fugacious spines, delicate, 10 cm. long. [PLATE 2.]

This species is more closely related to *O. chlorotica* Engelm. & Bigel. (PLATE 3) than any other described, but it is a larger, more robust plant throughout and possesses very different spination. The seeds and the fruits are also quite different. It is apparently quite widely distributed in the California-Nevada-Arizona Desert. The type was collected between Nipton, California, and Searchlight, Nevada, in April, 1912, under my inventory number 10530, when young plants were transferred into cultivation and are still growing, slowly but vigorously.

Opuntia semispinosa sp. nov.

An erect shrub 1–1.5 m. high and having a spread under normal conditions of 2 m. or more, either open or compactly branched, growing mostly in thickets but occasionally isolated individuals; joints obovate, mostly pointed above and below, about 12 × 25 cm., dark green with a little bloom; areoles broadly obovate to subcircular, 5 mm. in length, enlarging to subcircular or even transversely elongated and often 6–8 mm. in diameter, dirty tawny-gray but a lighter tawny with prominent wool when young; leaves subulate, terete, cuspidate, reddish tipped, 8–10 mm. long; spicules yellow, numerous, formidable, occupying one half of areole, very unequal, the upper crescentic, compact, first developed tuft 4 mm. long, the others below more scattering towards center of areole 1 cm. long, continuing to increase with age, especially in numbers; spines white and some of the more central larger ones brownish tinged at base, tips yellowish or simply transluscent-bonelike, some flattened, angular, twisted, at one or two years very faintly when at all annular, usually no trace of annulation; flowers 6–7 cm. in diameter, yellow with tinge of red in the upper part of ribs making them appear a trifle deep-yellow to orange in the upper part of the ribs and lighter-greenish tinged in center, filaments yellow, greenish at very base, style light-red, very large, sometimes 1 cm. in diameter at the largest point, stigma light green, eight- to ten-parted, buds light olive with a tinge of red in the tip, the outer sepals being mostly recurved in bud; fruit purplish red throughout, about 34 × 50 mm., obovate with broad, nearly flat umbilicus, areoles large, 3–4 mm. in diameter with prominent tawny wool; spicules yellow, about 2 mm. long, fugacious spines, conspicuous, numerous, 4–12 mm.

long and often ten to twelve in number, yellow or often with brownish zone toward the apex.

This is a common, conspicuous species in the coastal region of California and is likely to be confused on the one hand with *O. occidentalis* Engelm. & Bigel., which has similar joints but is quite a different plant growing farther inland, and on the other hand with *O. littoralis* (Engelm.) B. & R., which has more subcircular joints and more yellowish translucent spines. The species is very interesting inasmuch as it often has many joints or portions of joints practically destitute of spines, while neighboring areoles are normally spiny. The plant has been in cultivation with me since 1904. The spineless characteristic of a portion of the plant body is exceedingly interesting and it was thought for a time that it might prove of economic value, but vegetative propagation made every year or two since that time has failed to produce any marked change in the degree of spinelessness which the plant bears in nature. In four generations grown vegetatively from single joint cuttings no increase in spineless area was observable at either San Antonio or Brownsville.

Several collections have been made of the species between Santa Barbara and Tija Juana but my inventory number 10353 is designated as the type. It was collected at San Pedro, California, September 22, 1911, and is a plant showing very little of the spineless variation.

Opuntia pyrocarpa sp. nov.

An ascending-spreading, shrubby species 60 cm. high and having a spread of 2 m. or more when full grown, the main branches commonly resting on their edges at base and ascending at their extremities; joints large, nearly as broad as long, about 22 × 25 cm. but contracted below into a very short but mostly evident stipitate base, medium green with considerable bloom; areoles long, obovate, not raised after the first season, about 6 mm. in length, brown, enlarging to subcircular in age; spicules brown, in a compact tuft 4 mm. long occupying the upper two-thirds of the areole and filling it in age; spines porrect, divergent, but mostly sloping down in age, one to three, mostly one or two, yellowish distally and gradually darkening to rather bright, light-brown proximally, the lower one-third of the joint unarmed, flattened, twisted, 3–4 cm. long; flowers 8 cm. in diameter, yellow with light-red centers, filaments yellow, style white, stigma light-green, large, coarse, nine- to ten-parted, buds pointed, light greenish-red with color equally distributed through entire scale but their margins lighter, petals broad, pointed above and below and widest slightly above the middle, about 4 × 5.5 cm., irregularly toothed or even cleft; fruit long, pyriform, burnt carmine with a decidedly purple tinge, same color in interior, spicules brownish but usually with yellowish tips, unequal, surrounded by the end of the gray wool, also having one to three fugacious spines in lower part of areole 5–6 mm. long.

The species is delimited by its large, broad, stipitate joints, long pyriform fruits, large flowers with broad-pointed petals. The type was collected near Marble Falls, Texas, in July, 1908, under my collection number 9392 and has been grown to maturity from cuttings at Chico, California.

Opuntia squarrosa sp. nov.

A bushy, hemispherical shrub 1 m. high and 2 m. in diameter; joints subcircular, raised at areoles even the second year and pronouncedly so the first, deep blue-green with an abundant gray bloom turning more yellowish with age; leaves backward-curved and standing almost at right angles to the surface, subulate, cuspidate, 6 mm. long, slightly flattened; areoles broadly obovate, subcircular in age, dark dull-brown, 6 mm. long, becoming dirty gray-black; spicules very prominent, dark brown, spreading, scattered through nearly the entire areole, their tips slightly yellow, often 8–10 mm. long; spines variable in color, mostly yellowish distally and brown at base, mostly one or two, porrect, 1–2 cm. long, flattened, often twisted; flowers very large and showy, 9–10 cm. in diameter, their centers bright purple fading to yellow at margins, the backs of the petals orange, filaments tinged a little above, apex of style also tinted slightly, stigma light-green, eight-parted; buds light green, pointed with thick, heavy, recurved, prominent outer segments making the bud appear squarrose; fruit purplish red throughout.

The species is frequently met with in the lower Delta region of the Rio Grande in Mexico. It has not been reported from the United States but it probably occurs in the region of Brownsville. It is easily distinguished from other species of the Delta region by its blue-green color, brown spicules and spines, and large, striking flowers. The type was collected under my inventory number 9981 in April, 1910, about 12 leagues south of Matamoros, Mexico.

Opuntia anahuacensis sp. nov.

A glossy, yellowish green, low, reclining to prostrate species, 45–50 cm. high and having a spread of 1.5 m.; joints obovate, thin, 13 × 27 cm., commonly bent over and more or less dished the second year, apex sharply rounded and base more or less stipitate; areoles obovate, at first light brown then dirty gray-black, upper half armed, enlarging in age and becoming subcircular; spicules yellow, in a compact connivent tuft occupying one-half to two-thirds of the upper part of areole, about 2 mm. long, becoming more numerous in age and often 8 mm. in length; spines yellow, becoming white tardily, one or two porrect, 2–3 cm. long, flattened, twisted, the shorter lower two often recurved and only 1 cm. long; flowers canary-yellow, turning slightly darker yellow toward close of day; filaments yellow, style white, stigma white, six-parted; buds light bright-green with only a tinge of red in the upper part of the tardily recurved sepals; fruit deep, dark-purplish-red throughout, pyriform, about 4 × 7.5 cm., deeply pitted; spicules yellow, usually 2 mm. long or less, fugacious spines, mostly merging into the spicules on the one hand and becoming 6–8 mm. long on the other, two to four in number.

The species is characterized by its glossy yellowish green coloration and size and shape of its fruit. It is known to us only from a single collection made by Mr. C. B. Allaire near Anahuac, Texas, at the mouth of the Trinity River in Texas. My inventory number 9217 was assigned to it and it has been grown since at Chico, California, under this same number.

U. S. DEPARTMENT OF AGRICULTURE

Explanation of plates 2 and 3

PLATE 2

OPUNTIA CURVOSPINA Griffiths

Terminal joints and two ripe fruits, a little more than one third natural size, cultivated at Chico, California.

PLATE 3

OPUNTIA CHLOROTICA Engelm. & Bigel.

Terminal joints, about half natural size, three sevenths natural size, cultivated at Chico, California.

Notes on plants of the southern United States—I

FRANCIS W. PENNELL

During two seasons' field-study of the southern species of the group of scrophulariaceous plants termed by the writer the Agalinanae,* including the genera *Agalinis*, *Aureolaria*, *Afzelia* and *Macranthera*, various other plants belonging to many families were incidentally collected. Most of these have proved to be species well known in their respective areas. Others, and some of these, are believed to be of especial interest, and it is the purpose of this series of papers to consider such.

A considerable number of records extend materially the known ranges of certain species. Several species are here first described. For a number of critical groups revisions of southern species, more or less partial, are attempted. Of such groups *Commelina*, "*Nemexia*," *Chamaecrista* and *Lacinaria* are genera to which special attention was given in the field.

The two seasons spent by the writer in the south were those of 1912 and 1913. In 1912, from August 1 to October 18, he was in the southeast, August 2–6 about Atlanta (at Stone Mountain) and Rome, Georgia, after August 8 at various points in the Coastal Plain from the Mississippi River in Louisiana to Wilmington, North Carolina. From Covington, Louisiana, to north of the Savannah River in South Carolina he was in open grassy pine-land, where *Pinus palustris*, if not predominant, is at least an important tree. One week, August 20–26, was spent in West Feliciana Parish, Louisiana, in the region of loess hills just east of the Mississippi River. Here was enjoyed the hospitality of Mr. Edward Butler, and with him all specimens were collected. Near the Georgia coast, and across the portion of South Carolina traversed by the Atlantic Coast Line Railroad the writer was in a region of deeper sand and more scrub, consequently in a region having a flora materially different from that of the open pine-land.

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* Bull. Torrey Club **40**: 119–130, April 7; 401–439. August 13, 1913.

About Wilmington, North Carolina, he was in yet another district of unusual interest, in aspect recalling the open grassy pine-lands further south.

In 1913, from August 22 to October 20, the writer was again in the field, traversing districts inland from, or west of, those visited the year before. In the Mississippi Valley collections were made in Indiana, Illinois, Missouri, especially in the eastern (Cambrian) Ozark region, Arkansas and Oklahoma. Most of September was spent in Texas, through the Black Belt, in the Edwards Plateau northwest of New Braunfels and at Boerne, in the coastal plain eastward from Cuero and Victoria to Rosenberg, and in the pine-land of the southeast. Late September and early October he was in the pine-land of western Louisiana, in Arkansas, in the mountains of northeastern Alabama and eastern Tennessee, and about Stone Mountain, Georgia. Detailed itineraries of the routes of both seasons will be published in the writer's "*Agalinis* and Allies in North America."*

All specimens collected by the writer, unless otherwise specified, are in the herbarium of the University of Pennsylvania. Some of these are represented by duplicates in the herbarium of the New York Botanical Garden, and in other herbaria. In the following lists numbers cited in parentheses are those of the writer's collecting. For groups critically studied specimens are cited from various herbaria indicated by letters as follows:

Academy of Natural Sciences, Philadelphia	(A.)
Biltmore Herbarium, Biltmore, North Carolina	(B.)
Missouri Botanical Garden, St. Louis	(M.)
University of Pennsylvania, Philadelphia	(P.)
United States National Museum, Washington	(U.)
New York Botanical Garden, New York City	(Y.)

To the custodians of all the above herbaria the writer is indebted. In an especial degree he must acknowledge the kindness of Dr. John M. Macfarlane, of the University of Pennsylvania, whose interest made possible the collecting of the specimens recorded as well as much of the opportunity for their study. This study has been conducted at the University of Pennsylvania and at the New York Botanical Garden.

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* It is expected that this paper will soon appear in the Contributions of the Botanical Laboratory of the University of Pennsylvania.

MISCELLANEOUS SPECIES

ADIANTUM PEDATUM L.

Collected in deciduous woodland in the loess hills near Catalpa, West Feliciana Parish, Louisiana, August 21, 1912, *4285* (P.); station previously known to Dr. R. S. Cocks of Tulane University.

ASPLENIUM PYCNOCARPON Spreng.

A. angustifolium Michx.

In a damp ravine in deciduous woodland, Catalpa, Louisiana, August 22, 1912, *4312* (P., Y.); August 23, *4334* (P., Y.). Previously reported in the American Fern Journal **3**: 16. 22 Mr 1913.

SAGITTARIA ANGUSTIFOLIA Lindl.

Edge of small pool in open pine-land, east of Covington, St. Tammany Parish, Louisiana, August 16, 1912, *4243* (P.).

PASPALUM CURTISIANUM Steud.

Open grassy pine-land, north of Abita Springs, St. Tammany Parish, Louisiana, August 14, 1912, *4159* (P.), identified by Mrs. Agnes Chase.

STENOPHYLLUS CILIATIFOLIUS (Ell.) C. Mohr.

Open moist woodland, north of Abita Springs, Louisiana, August 18, 1912, *4264* (P., Y.).

CAREX VERRUCOSA Muhl.

Edge of pool, in pine-land, Abita Springs, Louisiana, August 12, 1912, *4130* (P., Y.).

ARISAEMA QUINATUM (Nutt.) Schott.

Deciduous woodland in loess hills, Catalpa, Louisiana, August 21, 1912, *4286* (P.).

ERIOCAULON DECANGULARE L.

In addition to the typical form, characterized by leaves linear, 3–5 mm. wide, and involucral bracts glabrous, collected at Abita Springs, Louisiana, *4144* (P., Y.), and at Theodore, Mobile County, Alabama, *4472* (P., Y.), there was collected at Theodore, Alabama, a plant differing as follows: leaves broader, 10–15 mm. wide, heads larger, lower involucral bracts broader, outer pubescent. This may possibly be a new species.

ANEILEMA NUDIFLORUM (L.) Kunth, Enum. Pl. 4: 66. 1843

Based upon *Commelina nudiflora* L., citing the second edition of the Species Plantarum, where the species is continued unchanged from the first edition. *Commelina nudiflora* L. (Sp. Pl. 41. 1753), "Habitat in India," is not to be typified by Hermann's plant described by Linnaeus in the Flora Zeylanica 13. 1748, and identified by C. B. Clarke as the species commonly known by this name. In the Species Plantarum Linnaeus's earlier description of this has been modified by the addition of the phrase "involucro nullo" and the adoption of the specific name "*nudiflora*," while from photographs kindly sent me through the courtesy of Mr. B. Daydon Jackson it appears that all specimens of this name in the Linnean herbarium in 1753, and incidentally all subsequently added, belong to *Aneilema*, apparently to this species. The combination *Aneilema nudiflorum* appears not to have been formed by Robert Brown (see Prod. 271. 1810), as it is usually quoted. Collected along streets of Thomasville, Thomas County, Georgia, September 29, 1912, *4737* (P.).

THE GENUS COMMELINA (PLUMIER) L. IN THE UNITED STATES

The following revision of this genus in the United States is provisional, based upon studies in the field and examination of all material in the herbaria of the New York Botanical Garden, the University of Pennsylvania and the Academy of Natural Sciences. It is planned to gather at the Garden a living collection, as complete as possible, of all species inhabiting North America, and for the accomplishment of this the cooperation of all interested is solicited. Mature capsules and seeds, as well as specimens, sent to the writer will be appreciated. Perhaps with living plants for study several proposed species here reduced to synonymy will prove valid. Or, more probably, several here tentatively maintained will be found of varietal rank. At some future date it is hoped to attempt a fuller revision.

Key to the species

Spathes with margins not connate at base.

Two posterior petals blue, anterior much smaller, lanceolate, white. Capsule two-celled, four-seeded (no rudiment of third cell). Annual. Stems decumbent at base, rooting at lower nodes. Leaves lanceolate, 8–12 cm. long. Anthers six. Seeds 3.5–4 mm. long, gray, rugose. 1. *C. communis.*

All three petals blue, anterior slightly smaller, ovate. Capsule three-celled, five-seeded (posterior cell one-seeded, indehiscent). Perennials.

Roots fibrous. Stems creeping, at least at base, rooting at the nodes. Spathes short-peduncled, acute to acuminate, 10–35 mm. long, glabrous or nearly so. Posterior petals long-stalked, 6–8 mm. long. Anthers five (posterior lacking).

Stems soon erect. Leaves lanceolate, 8–10 cm. long. Spathes becoming long-acuminate, 25–35 mm. long. Seeds 2.8–3 mm. long, smooth. 2. *C. caroliniana.*

Stems extensively creeping. Leaves broadly lanceolate, 3–8 cm. long. Spathes acute, 10–25 mm. long. Seeds 2–2.5 mm. long, reticulate. 3. *C. longicaulis.*

Roots tuberous, clustered. Stems erect, not rooting at the nodes. Spathe long-peduncled, caudate, 40–75 mm. long, pubescent. Posterior petals short-stalked, 10–12 mm. long. Anthers six. 4. *C. dianthifolia.*

Spathes with margins connate at base. Perennials. Seeds smooth, farinose.

All three petals blue, equal or nearly so, ovate. Plant strictly erect, relatively stout and broad-leaved. Sheaths ciliate with ferruginous hairs, without evident auricles. Spathes crowded near summit of stem, short-stalked. Two anterior cells of capsule each two-seeded, posterior relatively large but one-seeded and indehiscent. 5. *C. virginica.*

Two posterior petals blue, anterior much smaller, white. Plants often lax or slightly decumbent from base, more slender and narrower-leaved. Sheaths ciliate on rounded auricles with white hairs. Spathes more scattered, both near summit of and in axils along stem, longer-stalked. Cells of capsule all one-seeded, posterior normal, dehiscent, becoming reduced, tardily dehiscent, to even obsolete.

Leaf-blades linear-lanceolate to lanceolate, 8–14 cm. long. Posterior petals 10–25 mm. long. Seeds somewhat flattened. Roots evidently fleshy. Stems green, erect or somewhat diffuse from the base, but not decumbent and rooting at the nodes.

Leaves lanceolate. Posterior petals usually larger, 12–25 mm. long. Seeds mostly more or less oblong. 6. *C. erecta.*

Leaves linear-lanceolate. Posterior petals usually smaller, 10–15(–20) mm. long. Seeds mostly circular.

Spathes 1.5–3 cm. long, with mostly long white hairs near the base. Posterior petals 12–18(–20) mm. long. 7. *C. crispa.*

Spathes 1–2 cm. long, rarely with long white hairs near the base. Posterior petals mostly 10–15(–18) mm. long. 8. *C. angustifolia.*

Leaf-blades lanceolate-ovate to ovate, 5–9 cm. long. Posterior petals 8–11 mm. long. Seeds scarcely flattened. Roots scarcely fleshy. Stems mostly reddish, more or less decumbent at the base and rooting at the lower nodes. 9. *C. elegans.*

1. COMMELINA COMMUNIS L.

Commelina communis L. Sp. Pl. 40. 1753. "Habitat in America." Apparently an erroneous statement of nativity, as the Linnean diagnosis, as well as the fuller description and figure of Dillenius (Hortus Elthamensis 93. *pl. 78.* 1732), appear to apply to this originally East Asian species. All specimens in the Linnean herbarium, from photographs sent me, are evidently the species here described.

Flowers and fruits August to October.

Moist loam or sandy soil, eastern Massachusetts to Virginia and western North Carolina; also in Jackson County, Missouri, and probably in the intervening area. Abundant as a weed eastward. Evidently introduced from eastern Asia.

RHODE ISLAND. Newport:* roadsides near Old Harbor, Block Island, >† September 14, 1913, *M. L. Fernald, B. Long & G. S. Torrey 9137* (A.).

NEW YORK. Bronx: garden, New York Botanical Garden, ≷ September 24, 1915, *F. W. Pennell 6649* (Y.), *6714* (Y.). Richmond: yard, Port Richmond, > September 23, 1915, *F. W. Pennell 6648* (Y.).

NEW JERSEY. Atlantic: Pleasantville, ≷ September 1, 1910, *N. Taylor 2778* (Y.). Burlington: Kinkora, > August 18, 1910, *N. Taylor 2550* (Y.). Camden: Fish House, > August 17, 1910, *B. Long 4512* (A.). Gloucester: Mickleton, > September 10, 1892, *B. Heritage* (A.). Mercer: Trenton, > July, 1889, *F. E. Lloyd* (Y.). Monmouth: Bradley Beach, ≷ September 22, 1915, *F. W. Pennell 6577* (Y.). Ocean: Point Pleasant, ≷ September 22, 1915, *F. W. Pennell 6603* (Y.).

PENNSYLVANIA. Bucks: Bristol, ≷ September 18, 1898, *C. D. Fretz* (A.). Chester: West Chester, > August 24, ——, *W. Darlington* (Y.). Delaware: cultivated soil, Wawa, ≷ August 20, 1906, *F. W. Pennell 1925* (Y.). Lancaster: in sandy places, Tucquan, ≷ August 31, 1899, *A. MacElwee 1217* (A.). Lehigh: roadside, Alburtus, ≷ August 27, 1911, *H. W. Pretz 3893* (A.). Montgomery: Pennsburg, > May 30, 1907, *J. R. Mumbauer 400* (A.). Northampton: waste places, Easton, > August 27,

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* In the following lists one specimen from each county is cited, counties being arranged alphabetically.

† Before dates cited the following signs are used: >, in flower; <, in fruit.

1892, *T. C. Porter* (A.). Perry: Marysville, > August 7, 1888, *J. K. Small* (Y.). Philadelphia: Wissahickon Ravine, > September 2, 1908, *S. S. Van Pelt* (A.).

DELAWARE. Newcastle: ditch banks, Wilmington, < September 10, 1873, *A. Commons* (A.).

MARYLAND. Harford: along shore south of Havre de Grace, > August 1, 1902, *G. H. Shull 143* (Y.). Montgomery: along canal bank, Cabin John, > August 21, 1904, *H. D. House 320* (Y.).

DISTRICT OF COLUMBIA. Moist soil, Chain Bridge, > August 10, 1910, *F. W. Pennell 2544* (Y.).

VIRGINIA. Alexandria: along Potomac River opposite Washington, > July 22, 1910, *F. W. Pennell 2451* (Y.).

NORTH CAROLINA. Cherokee: in damp shady woods, Andrews, > September 5, 1900, *A. M. Huger* (Y.).

MISSOURI. Jackson: along railroad, Independence, > September 24, 1912, *B. F. Bush 6861* (Y.).

2. COMMELINA CAROLINIANA Walt.

Commelina caroliniana Walt. Fl. Carol. 68. 1788. Presumably from Berkeley County, South Carolina. Description apparently of species here considered. There is no type specimen in the Walter herbarium at the British Museum.

Flowers and fruits September to October.

At a few stations through the southern states, South Carolina and Florida to Missouri. Possibly introduced, but more probably native as its collection by Baldwin and other early collectors would suggest.

SOUTH CAROLINA. Charleston: Charleston, ≷ November, 1855, *L. R. Gibbes* (Y.).

FLORIDA. Duval: moist cultivated grounds near Jacksonville, ≷ October 1, 1894, *A. H. Curtiss 5177* (Y.); also *4144, 2992.* Volusia: New Smyrna, *Baldwin* (A.).

ALABAMA. "Ala.," > September, 1839, *S. B. Buckley* (Y.).

MISSISSIPPI. Point St. Martin, < October 13, 1898, *S. M. Tracy 5122* (Y.).

MISSOURI. Jackson: introduced, Sheffield, < September 14, 1905, *B. F. Bush 3332* (Y.). "Missouri," *T. Nuttall* (A.).

3. COMMELINA LONGICAULIS Jacq.

Commelina longicaulis Jacq. Coll. **3**: 234. 1789. ."Ad rivulos & in humidis crescit ad Caracas." Description apparently of species here considered, although leaves unusually narrow. Figured in Jacq., Icon. Pl. Rar. *pl. 294*.

Nephralles parviflora Raf. Fl. Tellur. **3**: 70. 1837. "Kentucky and Tennessee." Type of the genus *Nephralles* Raf. *l. c.* 70. A specimen of Rafinesque's collecting, labeled "Kentucky," and bearing this name, has been seen in the herbarium of Columbia University at the New York Botanical Garden.

Commelina diffusa Burm. f. (Fl. Ind. 18. *pl. 7. f. 2.* 1768) is treated as unidentifiable. While conceivably this, if the plant in both hemispheres be identical, the long pedicels, conventional flowers, and description (apparently contradicted by the figure) "involucro nullo" are not in accord with our plant.

Flowers and fruits, southward throughout the season, northward, late summer and autumn.

Moist loam or sandy soil, along streams, frequently a weed in cultivated ground, from eastern Kentucky and eastern Kansas southward to Bolivia. As usually understood, a widespread species of tropical and subtropical regions. From the few specimens seen the writer is not convinced that the plant of the Old World tropics is conspecific with that of the New. Possibly locally or extensively introduced in the United States.

PENNSYLVANIA. Philadelphia: Old Navy Yard, on ballast, Philadelphia, *I. Burk* (P.).

GEORGIA. Catoosa: along Chickamauga Creek, near Ringgold, > August 6–12, 1895, *J. K. Small* (Y.). Thomas: along streets, Thomasville, > September 29, 1912, *F. W. Pennell 4736* (P.). Wilkes: *A. W. Chapman* (Y.). "Georg.," ricefields, *Leconte*, sub. nom. "*Commelina pestifera* Leconte" (A.).

FLORIDA. Franklin: low grounds, Apalachicola, > July–September, *A. W. Chapman* [Biltmore herbarium *2038a*] (Y.). Gadsden: moist ground, River Junction, > September 11, 1897, *A. H. Curtiss 5991* (Y.). Lee: river bank, Myers, > July–August, 1900, *A. S. Hitchcock 364* (Y.). Leon: Tallahassee, > August 7–9, 1895, *G. V. Nash 2345* (Y.). Manatee: Osprey, > March 3, 1904, *B. H. Smith* (A.). Pinellas: low wet soil, St. Petersburg, ≷ April 3, 1908, *Mrs. C. C. Deam 4062* (Y.). Wakulla: low pine-land, St. Marks, < September 25, 1912, *F. W. Pennell 4700* (P.).

ALABAMA. Covington: cultivated soil, Florala, ≷ September 14, 1912, *F. W. Pennell 4638* (P., Y.). Lee: Auburn, > September 9, 1897, *F. S. Earle & C. F. Baker* (Y.).

MISSISSIPPI. Harrison: Biloxi, September 29, 1899, ≷ *S. M. Tracy 6389* (Y.).

TENNESSEE. Knox: river-banks, Knoxville, > July, 1898, *A. Ruth 134* (Y.).

KENTUCKY. Bell: along Cumberland River, > September, 1893, *T. H. Kearney 590* (Y.). Fayette: damp, near Lexington, > August, 1833, *R. Peter* (A., Y.). Harlan: > July 24, 1888, *F. E. Lloyd* (Y.). Lyon: Kuttawa, > September 27–October 9, 1903, *W. W. Eggleston 5251* (Y.).

MISSOURI. Barry: common, Eagle Rock, > September 18, 1896, *B. F. Bush 356* (Y.). Dunklin: common, Campbell, > August 16, 1895, *B. F. Bush 540* (Y.). St. Louis: wet ground along the Meramec River, Valley Park, > August 27, 1913, *F. W. Pennell 5314* (P.).

KANSAS. Cherokee: rich woods, 1896, *A. S. Hitchcock 841* (Y.). Miami: ≷ July 30, 1882, *J. H. Oyster* (Y.).

ARKANSAS. Pulaski: Little Rock, ≷ August 15, 1885, *H. E. Hasse* (Y.).

OKLAHOMA. Rogers: common, Verdigris, > August 2, ——, *B. F. Bush 583* (Y.).

LOUISIANA. Plaquemines: in wet grounds, common, > June, 1882, *A. B. Langlois 348* (Y.). St. Tammany: low ground, Mandeville, > August 16, 1912, *F. W. Pennell 4241* (P.). Tangipahoa: Tangipahoa, *J. L. Riddell* (A.). West Feliciana: moist cultivated soil, Catalpa, > August 22, 1912, *F. W. Pennell 4294* (P.); also *Pennell 4322* (P.).

TEXAS. Bowie: Texarkana, > May 9, 1891, *E. N. Plank* (Y.).

Also seen from Bermuda, Bahamas, Cuba, Santo Domingo, Jamaica, Porto Rico, Lesser Antilles, Mexico, Guatemala, Nicaragua, Panama, Colombia, British Guiana, Brazil and Bolivia.

4. COMMELINA DIANTHIFOLIA Red.

Commelina dianthifolia Red. Lil. 7: 390. *pl. 390.* 1813. Illustration and description undoubtedly of species here considered, although native country not stated. Name of species probably proposed by Delile.

Flowers late—July to September.

Shady or open places, New Mexico and Arizona to Oaxaca. Northward at elevations of 6,000–9,500 feet.

NEW MEXICO. Bernalillo: sunny rocks, Sandia Mountains, > July 21, ——, *C. C. Ellis 174* (Y.). Dona Ana: Organ Mountains, 6,500 feet alt., > September 17, 1893, *E. O. Wooton* (Y.). Grant: Fort Bayard Watershed, > September 10, 1905, *J. C. Blumer 59* (Y.). Lincoln: White Mountains, 7,000 feet alt., > August 11, 1897, *E. O. Wooton 311* (Y.). San Miguel: Pecos, 7,000 feet alt., > August 21, 1908, *P. C. Standley 5169* (Y.). Sierra: moist shady places, Lookout Mines, 8,500 feet, > August 12, 1904, *O. B. Metcalfe 1212* (Y.). Socorro: rocky places, Mogollon Mountains, > August, 1881, *H. H. Rusby 415* (P., Y.).

ARIZONA. Cochise: rolling andesitic pine-land, recently lumbered, Barfoot Park, Chiricahua Mountains, 8,000–8,250 feet alt., > September 5, 1906, *J. C. Blumer 1354* (Y.). Yavapai: Prescott, > August 15, 1896, *O. Kuntze* (Y.).

Also seen from Chihuahua, Durango, Federal District (of Mexico), and Oaxaca.

5. COMMELINA VIRGINICA L.

Commelina virginica L. Sp. Pl. ed. 2, 61. 1762. "Habitat in Virginia." Description unmistakably of species here considered, although this name has been usually applied to a state of *C. erecta* L.

Commelina longifolia Michx. Fl. Bor. Am. 1: 23. 1803. "Hab. in umbrosis sylvarum Virginiae et Carolinae." Not *C. longifolia* Lam. Tabl. Encyc. 1: 129. 1791. Description unmistakably of species here considered.

Commelina hirtella Vahl, Enum. Pl. 2: 166. 1806. New name for *C. longifolia* Michx.

Ananthopus clandestinus Raf. Fl. Ludov. 21. 1817. "Grows in shady and swampy soils." Louisiana, *C. C. Robin.* Type of genus *Ananthopus* Raf. *l. c.* 20. Description of large leaves would indicate species here considered.

Ananthopus undulatus Raf. Fl. Tellur. 3: 70. 1837. "Alabama, in my herbal." Description of ample, ovate leaves, 5–8 inches long, would indicate species here considered.

Allotria scabra Raf. *l. c.* 70. 1837. "Virginia and Carolina." Type of genus *Allotria* Raf. *l. c.* 70. Description of three subequal petals and of size of plant would indicate species here considered.

Commelina ignorata Kunth, Enum. Pl. 4: 60. 1843. New name for *Ananthopus clandestinus* Raf.

Flowers and fruits mid-July to October.

Moist to wet loam soil, especially alluvial, mostly along riverbanks, southeastern Pennsylvania to northern Florida, inland to mountains of eastern Tennessee, southern Illinois, southern Missouri, and eastern Texas, locally frequent to common.

NEW JERSEY. Camden: Kaighn's Point, > August, ——, *C. E. Smith* (A., Y.).

PENNSYLVANIA. Lancaster: island, Peach Bottom, > September 7, 1863, *J. J. Carter* (A.). Philadelphia: Gray's Ferry above Bartram's Garden, < September, 1862, *A. H. Smith* (A.), probably introduced.

MARYLAND. Baltimore: Baltimore, 1866, *P. V. LeRoy* (Y.). Cecil: moist soil, Conowingo, July 1, 1914, *F. W. Pennell 1565* (A.). Montgomery: along canal below Glen Echo, August 10, 1910, *F. W. Pennell 2549* (Y.).

VIRGINIA. Alexandria: moist soil, Alexander Island, ≷ September 16, 1910, *F. W. Pennell 2670* (Y.); also *Pennell 2450* (Y.). Fairfax: moist soil along Potomac River above Great Falls, < August 7, 1910, *F. W. Pennell 2523* (Y.).

NORTH CAROLINA. Brunswick: west of river, Wilmington, > October 3, 1908, *E. B. Bartram* (A.). Cherokee: meadows, one or two miles east of Andrews, ≷ August 4, 1900, *A. M. Huger* (Y.). Forsyth: Salem, *L. D. von Schweinitz* (A.). Rowan: Faith Post Office, August 14, 1891, *J. K. Small & A. A. Heller 411* (P., Y.). Wake: Raleigh, < August, 1898, *C. W. Hyams* (Y.).

GEORGIA. Bibb: muddy swamp of Ocmulgee River about two miles below Macon, < September 5, 1903, *R. M. Harper*

1969 (Y.). Floyd: moist soil along Coosa River, West Rome, < August 4, 1912, *F. W. Pennell 4081* (P.). Sumter: muddy bank of Muckalee Creek, ⋧ August 9, 1897, *R. M. Harper* (Y.).

FLORIDA. Duval: miry, partially shaded places near Jacksonville, < August 29, 1896, *A. H. Curtiss 5762* (Y.); also *Curtiss 2993* (A., Y.). Franklin: Apalachicola, *A. W. Chapman* (Y.). Leon: near Tallahassee, *N. K. Berg* (Y.).

ALABAMA. Lee: Auburn, > September 8, 1897, *F. S. Earle & C. F. Baker* (Y.). Morgan: low ground, Decatur, > July 18, 1900, *Biltmore Herbarium 2037e* (Y.).

MISSISSIPPI. Oktibbeha: Agricultural College, > August 11–17, 1896, *C. L. Pollard 1279, 1325* (Y.).

TENNESSEE. Cocke: along French Broad River between Paint Rock and Del Rio, ⋧ August 26, 1897, *T. H. Kearney 924* (Y.). Knox: Knoxville, ⋧ July, 1898, *A. Ruth 135* (Y.).

ILLINOIS. Union: Clear Creek, ⋧ August 13, 1900, *F. S. Earle* (Y.).

MISSOURI. Butler: swamps, < October 16, 1905, *B. F. Bush 3717* (Y.). Dunklin: common, sands, Campbell, > August 15, 1895, *B. F. Bush 529* (Y.); also *Bush 6292* (Y.). Jasper: low woods, Neck City, < September 12, 1908, *E. J. Palmer 1288* (Y.). McDonald: bottoms, Noel, > August 10, 1908, *B. F. Bush 5053* (Y.). New Madrid: > September 15, 1893, *B. F. Bush 133* (Y.).

ARKANSAS. Pulaski: Little Rock, > August, 1885, *H. E. Hasse* (Y.).

LOUISIANA. Plaquemines: in low half-shady places, > November, 1880, *A. B. Langlois* (P.). Terrebonne: low moist ground near swamp near Houma, ⋧ October 9, 1913, *E. C. Wurzlow* (Y.). West Feliciana: moist deciduous woodland, Catalpa, > August 21, 1912, *F. W. Pennell 4273* (P.).

TEXAS. Bowie: Texarkana, < October 20, 1894, *Letterman 19* (Y.). Wood: swamps, Mineola, > August 14, 1900, *J. Reverchon 2187* (Y.).

6. COMMELINA ERECTA L.

Commelina erecta L. Sp. Pl. 41. 1753. "Habitat in Virginia." Description unmistakably of species here considered.

Ananthopus cordatus Raf. Fl. Ludov. 22. 1817. "In open fields." Louisiana, *C. C. Robin*. Description indicates this species, or possibly *C. angustifolia* Michx.

Larnalles dichotoma Raf. Fl. Tellur. 3: 71. 1837. "Apalachian mts." Type of genus *Larnalles* Raf. *l. c.* 70. A specimen of Rafinesque's collecting, labeled "Mts. Apalachis, *Larnalles dichotoma* Raf.," has been seen in the herbarium of Columbia University at the New York Botanical Garden.

Larnalles glauca Raf. *l. c.* 71. 1837. "Kentucky, Illinois." Description indicates this species, or possibly *C. crispa* Wooton.

Commelina Rafinesquei Kunth, Enum. Pl. 4: 60. 1843. New name for *Ananthopus cordatus* Raf.

Commelina saxicola Small, Fl. S. E. U. S. 242, 1328. 1903. "Type, Stone Mt., Ga., *Small*, no. 124, in Herb. C. U." *Small 124*, indicated on sheet as type, was collected on Dunn's Mountain, Rowan County, North Carolina, August 18–27, 1894.

Commelina angustifola Michx. and *C. crispa* Wooton, until more fully compared living, are continued as of specific rank. Both are probably better considered as geographic varieties of *C. erecta* L.

Capsules with posterior cell more or less reduced and tardily dehiscent, a state which has been separated as "*Commelina virginica*," are to be found in the same colonies and even upon the same plants with capsules normally developed, three-celled and evenly dehiscent.

Flowers and fruits July to September.

Sandy to loamy, often rocky soil, New York City, New York, to northern Florida, westward to Kansas and Bexar County, Texas; southward below the fall-line only in local heavier soils; locally frequent to common, especially southward. Southward apparently passes into *C. angustifolia* Michx., westward apparently into *C. crispa* Wooton.

NEW YORK. New York: rocks, Inwood, ≷ August 17, 1880, *A. Brown* (Y.); Washington Heights, clefts of rock with *Cheilanthes vestita*, > August, 1867, *W. W. Denslow* (Y.).

NEW JERSEY. Burlington: banks of a ditch near Plattsburgh, > July, 1850 (Y.). Camden: dry sandy ground, Griffith Swamp, *I. Burk* (P.).

PENNSYLVANIA. Lancaster: rocky places along the railroad, Safe Harbor, ≷ September 1, 1899, *A. MacElwee 1238* (A., Y.).

DELAWARE. Sussex: dry sandy soil, Millsboro, > August 15, 1877, *A. Commons* (A.).

MARYLAND. Washington: hillside along railroad, Sandy Hook, ≷ July 17, 1910, *F. W. Pennell 2412, 2413* (Y.). Wicomico: dry sandy soil, Salisbury, < July 27, 1865, *J. J. Carter* (A.).

DISTRICT OF COLUMBIA. Near Georgetown, *Dr. Robbins 154* (Y.).

VIRGINIA. Botecourt: Indian Rock, > June, 1887, *H. E. Wetherill* (P.). Elizabeth City: Old Point Comfort, ≷ September 25, 1895, *N. L. Britton* (Y.). Fairfax: island at Great Falls, < September 2, 1905, *C. S. Williamson* (Y.).

WEST VIRGINIA. Fayette: Nuttallburg, > August 11, 1891, *C. F. Millspaugh 1113* (Y.).

NORTH CAROLINA. Buncombe: in rich soil, Biltmore, ≷ July 19, 1897, *Biltmore Herbarium 2036c* (P., Y.). Forsyth: Salem, *L. D. von Schweinitz* (A.). Polk: light soil, face of White Oak Mountains, near Columbus, > July 5, 1897, *Biltmore Herbarium 2036a* (P., Y.). Rowan: Dunn's Mountain, > August 18–27, 1894, *J. K. Small 124* (Y.), type of *C. saxicola* Small. Swain: sandy soil, 1,700 ft. alt., > July 10, 1891, *H. C. Beardslee & C. A. Kofoid* (Y.).

SOUTH CAROLINA. Oconee: Clemson College, > June 19, 1906, *H. D. House 2403* (Y.). Pickens: sandy places along rivers, > July 9, 1897, *H. D. House 1338* (Y.).

GEORGIA. Cobb: dry rocky woods on Kennesaw Mountain, > July 12, 1900, *R. M. Harper 219* (Y.). DeKalb: light soil on granitic rock, Stone Mountain, August 2, 1912, *F. W. Pennell 4036* (P.). Gwinnett: on the Yellow River near McGuire's Mill, ≷ July 11, 1893, *J. K. Small* (Y.). Rabun: in canyon at Tallulah Falls, April 20, 1893, *J. K. Small* (Y.).

FLORIDA. Lake: hammock land, sand, Eustis, ≷ July 1–15, 1894, *G. V. Nash 1157* (A., Y.). Leon: near Tallahassee, *N. K. Berg* (Y.).

ALABAMA. Covington: cultivated soil, Florala, > September 14, 1912, *F. W. Pennell 4637* (P.). Elmore: Double Bridges, > August 9, 1899, *F. S. Earle 141* (Y.). Etowah: sandy hills, Sand Mount, > July 9, 1898, *H. Eggert* (Y.). Lee: Auburn, > August 8–11, 1897, *F. S. Earle & C. F. Baker 736, 1041* (Y.).

MISSISSIPPI. Clarke: Enterprise, > June 10, 1897, *S. M. Tracy 3278* (Y.). Lowndes: Columbus, > May 3, 1896, *S. M. Tracy 3083* (Y.).

TENNESSEE. Cocke: along French Broad River between Paint Rock and Del Rio, > September 10, 1897, *T. H. Kearney 923* (Y.). Davidson: Nashville, > August 11, 1897, *Biltmore Herbarium 311d* (Y.). Rutherford: crevices of limestone rocks, Fosterville, > August 17, 1897, *Biltmore Herbarium 311c* (Y.).

MISSOURI. Barry: woods, Eagle Rock, > August 12, 1905, *B. F. Bush 3222* (Y.). McDonald: gravelly places, Noel, ⋛ August 7, 1908, *B. F. Bush 4984* (Y.). Shannon: woods, Monteer, > August 5, 1910, *B. F. Bush 6101* (Y.).

KANSAS. Riley: shady places, > July 20, 1895, *J. B. Norton 524* (Y.).

ARKANSAS. Pulaski: Little Rock, > June, 1885, *H. E. Hasse* (Y.).

LOUISIANA. West Feliciana: cultivated soil, Baines, > August 23, 1912, *F. W. Pennell 4323* (P.).

TEXAS. Bexar: San Antonio, *G. Jermy* (Y.). Comal: New Braunfels, > September 14, 1913, *F. W. Pennell 5454* (P.). Travis: Austin, > September 13, 1913, *F. W. Pennell 5432* (P.).

7. COMMELINA CRISPA Wooton

Commelina crispa Wooton, Bull. Torrey Club 25: 451. 13 Au 1898. "Collected at the base of the Organ Mountains, Doña Ana Co., [New Mexico], Sept. 1; altitude 4,800 feet, [Wooton] no. 545." Co-type seen in the herbarium of the New York Botanical Garden.

Flowers and fruits June to September.

Dry sandy soil, woodland or open, dunes, sand-hills, etc., northern Indiana to Colorado south to Texas and eastern Arizona, apparently extending into northern Mexico.

INDIANA. Lake: old sand-dunes, Miller, ⋛ August 23, 1915, *F. W. Pennell 6422* (Y.). Porter: wooded sand-hill, Dune Park, ⋛ August 16, 1897, *A. Chase* (A.).

Illinois. Henderson: sandy barrens near Oquawka, *H. N. Patterson* (Y.).

Nebraska. Cherry: Niobrara Reserve, ≷ July, 1903, *L. Krautter* (P.). Knox: Soldier Creek, > July 18, 1893, *F. E. Clements* (Y.). Lincoln: dry sandhills north of North Platte, > August 18, 1915, *F. W. Pennell 6409* (Y.). Thomas: on Dismal River south of Thedford, > June 17, 1893, *P. A. Rydberg 1345* (Y.).

Missouri. Jasper: dry soil, Prosperity, > June 17, 1909, *E. J. Palmer 2242* (Y.).

Kansas. Geary: Fort Riley, > September, 1892, *E. E. Gayle 565* (Y.). Hamilton: Syracuse, > July 11, 1893, *C. H. Thompson 91* (Y.). Kiowa: near Belvidere, ≷ September 14, 1897, *L. F. Ward* (Y.).

Oklahoma. Payne: sandy woods, etc., very abundant, > July, 1893, *E. W. Olive 122* (Y.). "Arkansas," *T. Nuttall* (A.).

Texas. Coke: Fort Chadbourne, > May 16, 1858, *S. Hayes* (Y.). Concho: Paint Rock, > July 13, ——, *J. M. Bigelow* (Y.). Culberson: dry, rocky ravine, Van Horn's Well, *J. M. Bigelow* (Y.). Duval: San Diego, 1884, *M. B. Croft* (Y.). McLennan: Waco, 1869, *Griffith* (Y.). Mitchell: *G. W. Holstein* (A.).

Colorado. Fremont: Cañon City, > August 8, 1896, *C. L. Shear 3780* (Y.). Yuma: Wray, > July 15, 1909, *G. E. Osterhout 4030* (Y.).

New Mexico. Chaves: sandy plain, twenty miles south of Roswell, ≷ August, 1900, *F. S. & E. S. Earle* (Y.). Doña Ana: Organ Mountains, ≷ September 1, 1897, *E. O. Wooton 545* (Y.). Eddy: junction of Delaware Creek and the Pecos, 1856, *Pope* (Y.). Grant: Dog Springs, ≷ September 16, 1893, *E. A. Mearns 2349* (Y.). Otero: Jarilla Junction, > September 4, 1900, *F. S. & E. S. Earle 523* (Y.).

Arizona. Cochise: Cochise, ≷ October 12, 1900, *D. Griffiths 1902* (Y.).

8. COMMELINA ANGUSTIFOLIA Michx.

Commelina angustifolia Michx. Fl. Bor. Am. 1: 24. 1803. "Hab. in campestribus Carolinae." Type not seen nor verified, but description evidently of species here considered.

Commelina Swingleana Nash, Bull. Torrey Club **22**: 160. 18 Ap 1895. "Collected in the high pine-land region at Umatilla

[Florida] early in August [1894, *G. V. Nash*]." Type, labeled, "vicinity of Eustis, Lake Co., Florida, G. V. Nash 1525," seen in the herbarium of the New York Botanical Garden.

Commelina Nashii Small, Fl. S. E. U. S. 242, 1328. 1903. "Type, Nash, Pl. Fla., no. 2465, in Herb. C. U." Type, collected at "Tampa, Hillsborough County, Florida, August 24, 1895," seen in the herbarium of Columbia University at the New York Botanical Garden.

Flowers and fruits June to October, southward throughout the season.

Sandy soil, pine-land, and fields, dunes, etc., in the Coastal Plain, North Carolina to southern Florida, Cuba and southern Texas.

NORTH CAROLINA. Carteret: sand banks near Beaufort, 1906, *I. F. Lewis 85* (Y.). New Hanover: dry sand, sea beach near Wrightsville, ⋚ September 1, 1900, *C. S. Williamson* (Y.).

SOUTH CAROLINA. Beaufort: Bluffton, *J. H. Mellichamp* (Y.). Berkeley: Summerville, > June, 1850, *L. R. Gibbes* (Y.).

GEORGIA. Chatham: Savannah, *Mrs. Say* (A.). Glynn: sandy pine-land, Brunswick, > October 10, 1912, *F. W. Pennell 4833* (P.). Richmond: dry sandy soil, Augusta, > July 6, 1898, *A. Cuthbert* (Y.).

FLORIDA. Brevard: hammock, Merritt's Island, > September 15, 1895, *A. A. Baldwin 112* (A., P.). Clay: Green Cove, 1881, *M. Treat* (A.). Dade: in pine-lands between Cutler and Longview Camp, > November 9–12, 1903, *J. K. Small & J. J. Carter 992* (A., Y.). Duval: dry fields and woods near Jacksonville, ⋛ June, *A. H. Curtiss 2294* (A., P., Y.). Gadsden: old field near River Junction, > May 3, 1898, *A. H. Curtiss 6339* (Y.). Hillsboro: high pine-land, Tampa, > April 1–15, 1894, *G. V. Nash 387* (Y.). Lake: high pine-land, Eustis, > August, 1894, *G. V. Nash 1644* (A., Y.). Lee: pine forest, Samville, > June 6, 1912, *J. W. Harshberger* (P.). Manatee: Palma Sola, > May 5, 1900, *S. M. Tracy 6756* (Y.). Monroe: shell sand-dunes, Boot Key, > April 7–12, 1909, *N. L. Britton 530* (Y.). Nassau: near St. Mary's, 1817, *Dr. Bacon* (Y.). Pinellas: pine clearing near bay, > April 7, 1908, *Mrs. C. C. Deam 4066* (Y.). St. John: St. Augustine, > April 12, 1897, *J. Crawford* (Y.). St. Lucie: Fort Pierce,

> April 8–9, 1904, *A. B. Burgess 717* (Y.). Santa Rosa: moist sandy soil, Milton, > September 9, 1912, *F. W. Pennell 4577* (P.). Volusia: New Smyrna, *Baldwin* (A.).

ALABAMA. Escambia: Flomaton, > August 24, 1897, *S. M. Tracy 3551* (Y.). Mobile: sandy pine-land, Spring Hill, ≷ September 5, 1912, *F. W. Pennell 4533* (P.).

MISSISSIPPI. Harrison: Biloxi, < July 30, 1897, *S. M. Tracy 3561* (Y.). Jackson: Horn Island, > July 14, 1899, *S. M. Tracy 6388* (Y.).

LOUISIANA. Plaquemines: Breton Island, ≷ August 18, 1900, *S. M. Tracy & F. E. Lloyd 273* (P.).

TEXAS. Bexar: San Antonio, > June, ——, *Blake* (Y.). Brazos: gravelly banks, Bryan, > May 28, 1915, *E. J. Palmer 7793* (Y.). Colorado: dry sandy oak-land, Sheridan, > September 21, 1913, *F. W. Pennell 5524* (P.), *5537* (P., Y.). Galveston: sands, Galveston, > August 8, 1902, *J. Reverchon 3415* (Y.). Harris: sandy soil, Houston, > May 29, 1903, *Biltmore Herbarium 6685a* (Y.). Montgomery: ≷ July 18–21, 1909, *R. A. Dixon 490* (Y.). Nueces: near sea-level, Corpus Christi Bay, > April 9–12, 1894, *A. A. Heller 1555* (Y.). Travis: loose loam soil, Austin, > September 13, 1913, *F. W. Pennell 5433* (P.), *5434* (P.). Victoria: black sandy loam, Victoria, > September 19, 1913, *F. W. Pennell 5503* (P., Y.). Walker: in a pine grove, Huntsville, > July 9–12, 1909, *R. A. Dixon 406* (Y.).

Also in Cuba, where known as *C. hamipila* Wright.

9. COMMELINA ELEGANS HBK.

Commelina elegans HBK. Nov. Gen. et Sp. 1: 259. 1816.

"Crescit in regno Novogranatensi, locis temperatis, umbrosis, ad ripas fluvii Juanambu, alt. 760 hexap." Description apparently of species here considered.

Flowers and fruits throughout the season.

Moist soil, apparently throughout tropical America from southern Florida and southern Texas to Argentina.

FLORIDA. "Chitto River, South Florida," ≷ September, 1878, *A. P. Garber 48* (A., Y.).

TEXAS. Duval: San Diego, 1884, *M. B. Croft 8* (Y.).

Also seen from Bermuda, Bahamas, Cuba, Santo Domingo, Jamaica, Porto Rico, Lesser Antilles, Mexico, Guatemala, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Brazil, Bolivia, Paraguay and Argentina.

NEW YORK BOTANICAL GARDEN

INDEX TO AMERICAN BOTANICAL LITERATURE

1915

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 the broadest sense.

Reviews, and papers that 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.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

Arthur, J. C., & Fromme, F. D. New species of grass rusts. Torreya **15**: 260–265. 30 D 1915.

Includes 7 new species in *Uromyces* (2), *Puccinia* (4), and *Uredo* (1).

Baird, M. M. Anatomy of *Platanus occidentalis.* Kansas Univ. Sci. Bull. **9**: 281–290. *pl. 65–76.* S 1915.

Bartlett, H. H. Mass mutation in *Oenothera pratincola.* Bot. Gaz. **60**: 425–456. *f. 1–15.* 16 D 1915.

Belling, J. Inheritance of length of pod in certain crosses. Jour. Agr. Research **5**: 405–420. *pl. 40.* 6 D 1915.

Bergen, J. Y. Dwarfing effect of trees upon neighboring plants. Bot. Gaz. **60**: 491, 492. 16 D 1915.

Bergen, J. Y. Weed growth and unusual rainfall. Rhodora **17**: 224–227. N 1915.

Börgeson, F. The marine algae of the Danish West Indies—2. Rhodophyceae. Dansk. Bot. Arkiv. **3**: 1–80. *f. 1–86.* 1915.

Boerker, R. H. Some notes on forest ecology and its problems. Proc. Soc. Am. Foresters **10**: 405–422. O 1915.

Bradford, F. C. The pollination of pomaceous fruits. II. Fruit-bud development of the apple. Oregon Agr. Exp. Sta. Bull. 129: 1–16. *pl. 1–6.* My 1915.

Buckner, G. D. Translocation of mineral constituents of seeds and tubers of certain plants during growth. Jour. Agr. Research **5**: 449–458. 13 D 1915.

Burt, E. A. The Thelephoraceae of North America—V. *Tremellodendron*, *Eichleriella*, and *Sebacina*. Ann. Missouri Bot. Gard. **2**: 731–770. *pl. 26, 27.* N 1915.

Includes descriptions of eleven new species.

Cockerell, T. D. A. *Equisetum* in the Florissant Miocene. Torreya **15**: 265–267. *f. 1.* 30 D 1915.

Includes *Equisetum florissantense* n. sp.

Cockerell, T. D. A. Variation in *Oenothera hewetti.* Science II. **42**: 908, 909. 24 D 1915.

Coker, W. C. Observations on the lawns of Chapel Hill. Jour. Elisha Mitchell Sci. Soc. **31**: 113–119. N 1915.

Coker, W. C. Our mountain shrubs. Jour. Elisha Mitchell Sci. Soc. **31**: 91–112. N 1915.

Coulter, J. M. A suggested explanation of "orthogenesis" in plants. Science II. **42**: 859–863. 17 D 1915.

Crabill, C. H. Dimorphism in *Coniothyrium pirinum* Sheldon. Am. Jour. Bot. **2**: 449–467. *f. 1–15.* 16 D 1915.

Davis, A. R. Enzyme action in the marine algae. Ann. Missouri Bot. Gard. **2**: 771–836. N 1915.

Deane, W. Floral changes in a salt marsh during reclamation. Rhodora **17**: 205–222. N 1915.

Detwiler, S. B. White ash. Am. Forestry **21**: 1081–1083. D 1915 [Illust.]

Edgerton, C. W. A new method of selecting tomatoes for resistance to the wilt disease. Science II. **42**: 914, 915. 24 D 1915.

Elmore, C. J. Staminate flowers in *Anemone.* Bot. Gaz. **60**: 492, 493. 16 D 1915.

Fernald, M. L. The identity of *Circaea latifolia* and the Asiatic *C. quadrisulcata.* Rhodora **17**: 222–224. N 1915.

Frye, T. C., Rigg, G. B., & Crandall, W. C. The size of kelps on the Pacific coast of North America. Bot. Gaz. **60**: 473–482. *f. 1, 2.* 16 D 1915.

Gates, R. R. Heredity and mutation as cell phenomena. Am. Jour. Bot. **2**: 519–528. D 1915.

Grover, F. O. Extensions of range. Rhodora **17**: 227, 228. N 1915.

Hasselbring, H., & Hawkins, L. A. Carbohydrate transformations in sweet potatoes. Jour. Agr. Research **5**: 543–560. 27 D 1915.

Hasselbring, H., & Hawkins, L. A. Respiration experiments with sweet potatoes. Jour. Agr. Research **5**: 509–517. 20 D 1915.

Heald, F. D., & Studhalter, R. A. Seasonal duration of ascospore expulsion of *Endothia parasitica*. Am. Jour. Bot. **2**: 429–448. *f. 1–6.* 16 D 1915.

Heald, F. D., & Woolman, H. M. Bunt or stinking smut of wheat. Washington Agr. Exp. Sta. Bull. 126: 1–24. *f. 1–5.* N 1915.

Hoffmann, C. A contribution to the subject of the factors concerned in soil productivity. Kansas Univ. Sci. Bull. **9**: 81–99. *pl. 23–27.* D 1915.

Hotson, J. W. Enemies of the Rhododendron. The Mountaineer **8**: 75–77. D 1915. [Illust.]

House, H. D. Report of the state botanist 1914. N. Y. State Mus. Bull. 179: 1–107. 15 D 1915. [Illust.]

Includes articles by L. H. Pennington and C. H. Kauffman here indexed separately.

Hutchinson, A. H. Fertilization in *Abies balsamea*. Bot. Gaz. **60**: 457–472. *pl. 16–20+f. 1.* 16 D 1915.

Jehle, R. A. El Tizón tardío y la pudrición de la papa. Cuba Estac. Exp. Agron. Circ. 48: 1–6. *f. 1–6.* 1915.

Kauffman, C. H. The fungi of North Elba. N. Y. State Mus. Bull. 179: 80–104. 15 D 1915.

Includes *Boletus rubritubifer* and *Cortinarius chrysolitus*, spp. nov.

Knudson, L. Toxicity of galactose for certain of the higher plants. Ann. Missouri Bot. Gard. **2**: 659–666. *pl. 22.* N 1915.

Kraus, E. J. Somatic segregation. Jour. Heredity **7**: 3–8. *f. 1+frontispiece.* 29 D 1915.

Long, W. H. A honeycomb heart-rot of oaks caused by *Stereum subpileatum*. Jour. Agr. Research **5**: 421–428. *pl. 41.* 6 D 1915.

Lyman, G. R., & Rogers, J. T. The native habitat of *Spongospora subterranea*. Science II. **42**: 940, 941. 31 D 1915.

Mackenzie, K. K. Notes on Carex—IX. Bull. Torrey Club **42**: 603–621. 11 D 1915.

Eight new species are described.

Muenscher, W. L. C. A Study of the relation of transpiration to the size and number of stomata. Am. Jour. Bot. **2**: 487–504. *f. 1–3.* 16 D 1915.

Mulsow, F. W. Differentiation of the oaks by histological methods. Kansas Univ. Sci. Bull. 9: 271–277. *pl. 60–65.* S 1915.

Nieuwland, J. A. Records of adventive plants. Am. Mid. Nat. **4**: 290. N 1915.

Orton, C. R., & Adams, J. F. Collar-blight and related forms of fire-blight. Pennsylvania Agr. Exp. Sta. Bull. 136: 1–23. *f. 1–13.* Au 1915.

Overholts, L. O. Comparative studies in the Polyporaceae. Ann. Missouri Bot. Gard. **2**: 667–730. *pl. 23–25+f. 1–8.* N 1915.

Pennington, L. H. New York species of *Marasmius.* N. Y. State Mus. Bull. 179: 52–79. 15 D 1915.

Pieters, A. J. New species of *Achlya* and of *Saprolegnia.* Bot. Gaz. **60**: 483–490. *pl. 21.* 16 D 1915.

Achlya Klebsiana and *Saprolegnia Kaufmanniana*, spp. nov., are described.

Pieters, A. J. The relation between vegetative vigor and reproduction in some Saprolegniaceae. Am. Jour. Bot. **2**: 529–576. *f. 1, 2.* D 1915.

Pittier, H. On the characters and relationships of the genus *Monopteryx* Spruce. Bull. Torrey Club **42**: 623–627. *f. 1, 2.* 11 D 1915.

Monopteryx Jahnii sp. nov. is described.

Pool, R. J. A brief sketch of the life and work of Charles Edwin Bessey. Am. Jour. Bot. **2**: 505–518. *pl. 18.* D 1915.

Rehder, A. The Bradley bibliography **3**: i–x+1–806. 1915.

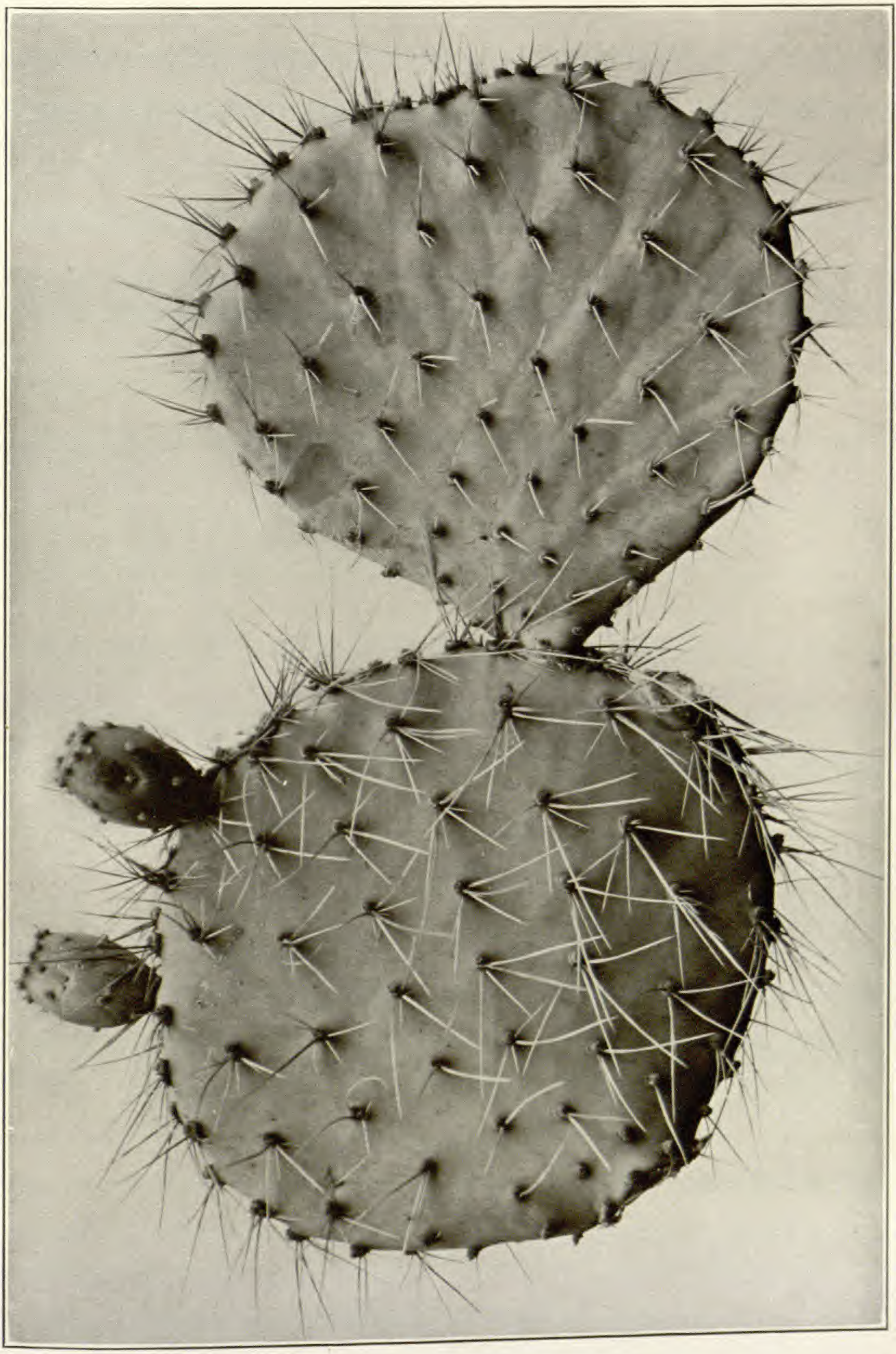
Arboriculture.

Roig y Mesa, J. T. El marabú o Aroma. Cuba Estac. Exp. Agron. Circ. 50: 1–16. *pl. 1–10.* 1915.

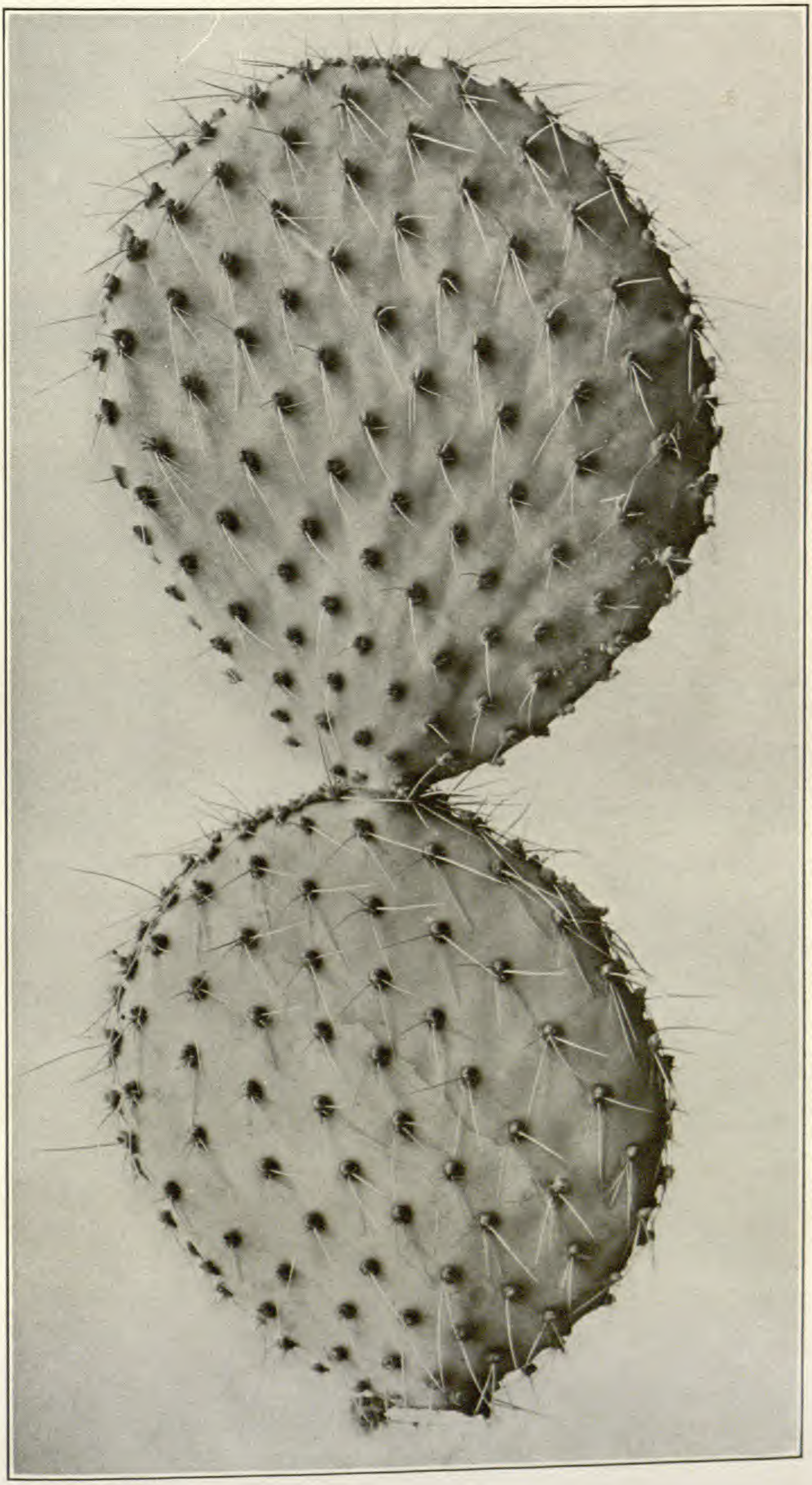
Rydberg, P. A. Phytogeographical notes on the Rocky Mountain region. V. Grasslands of the Subalpine and Montane Zones. Bull. Torrey Club **42**: 629–642. 11 D 1915.

Shedd, O. M. Variations in mineral composition of sap, leaves, and stems of the wild-grape vine and sugar-maple tree. Jour. Agr. Research **5**: 529–542. 20 D 1915.

DIXON: AFRICAN MOSSES



OPUNTIA CURVOSPINA GRIFFITHS



OPUNTIA CHLOROTICA ENGELM. & BIGEL.

Vol. 43 No. 3

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MARCH, 1916

The morphology of Thallocarpus Curtisii

F. McAllister

(WITH PLATE 4)

The first published description of *Thallocarpus Curtisii* (Aust.) Lindb. seems to have been by Austin in 1869 (1). The simple structure of its sporogonium, which is without foot or elaters, naturally pointed toward a relationship to *Riccia*. In the dried material from which his descriptions were made the thallus appeared very like that of *Sphaerocarpos*. This, together with the fact of the spores adhering in fours, led him to believe that it must also be related to *Sphaerocarpos*. He believed it to be a genus intermediate between *Riccia* and *Sphaerocarpos* and gave it the name *Cryptocarpus*, the only species being *C. Curtisii*. The following is his description of genus and species:

> "CRYPTOCARPUS (gen. nov.) Aust. MSS., 1864.
>
> "Frons laxe spongioso-reticulata, irregulariter subpalmatim lobata, tenuis, epidermide hand distincta. Costa nulla. Radices intus non papillosi (ut in *Sphaerocarpo*), longissimi, intertexti. Fructus in frondis substantia immersus (ut in *Riccia*). Sporangia depresso-globosa, singulatim nata, non libera. Calyptra stylo nigro persistente coronata. Sporae 4-jugae (ut in *Sphaerocarpo*), vix solutae, in aspectu singulae et profunde quadrilobae."
>
> "CRYPTOCARPUS CURTISII Aust. MSS. 1864.
>
> "*Riccia Curtisii*, James, in Herb. (fide Curtis).
>
> "Fronde caespitosa valde imbricata fibroso-papulata, laciniis inciso-lobulatis margine crenatis; sporangiis maximis in statu siccati latentibus sed frondes hume-

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[The BULLETIN for January (43: 63–116. *pl. 1–3*) was issued March 11, 1916.]

actae sunt in substantia earum ut maculis nigris apparentibus; sporis fusco-nigris valde muricatis.

"On moist ground, South Carolina, Ravenel (In Herb. Sulliv., 1849). North Carolina, Curtis (l. c., 1853). 'Montand après Marseille' (Herb. Lanning, 'ex Herb. Torrey')."

Somewhat later (10) Lindberg called attention to the fact that the generic name *Cryptocarpus* was already in use, being used as the name of a genus of the Chenopodiaceae as well as for a genus in the Orthotrichiaceae. He proposed the name *Thallocarpus*, which is still in use. He makes no mention of having examined any plants and apparently on the authority of Austin's description places the genus in the Jungermanniaceae, class Cleistocarpae.

In 1877 Trevisan (14) proposed the name *Angiocarpus* as a substitute for *Cryptocarpus*. He placed the genus in the order Ricciaceae, tribe Riccieae, with *Ricciella*, *Riccia* and *Ricciocarpus*.

Austin in 1875 (2) referring to Lindberg's change of the generic name to *Thallocarpus** states that "the plant evidently belongs, with *Sphaerocarpus* (its nearest ally), to the Jungermaniaceae."

Later he refers again to *Thallocarpus* (3) having in the meantime studied fresh living material collected for him by Capt. John Donnell Smith in Florida. From this material he notes the striking similarity to *Riccia* "in which genus" he says "it should probably be included as a subgenus." He states that the adhesion of the spores of the tetrad "appears to be the only character in which it is decidedly different from *Riccia*." It is from this material that he determines the dioecious character of the liverwort.

This seems to be the literature that Schiffner has had access to in his account of *Thallocarpus* in Die natürlichen Pflanzenfamilien (11, p. 50). It is therefore surprising to find that Austin's latest reference to the plant has been overlooked or ignored and this genus placed in the subclass Jungermanniales and family Sphaerocarpoideae; in a family, the sporophyte of which is characterized by the presence of a foot and of sterile, "stärkereiche Nährzellen."

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* Although Lindberg proposed the name *Thallocarpus* he does not seem to have suggested the combination *T. Curtisii*. Austin makes use of this combination in 1875 but does not cite Lindberg as authority.

Stephani (12), under the name *Riccia Curtisii*, has elaborated the description of *Thallocarpus* from material "welche Pastor Curtis in seinem Garten gesammelt hat." He asserts that the plants which he examined were monoecious. In other respects his description does not seem to diverge in any important detail from that of Austin. He, however, insists that material from Austin's herbarium in the possession of Pearson corresponds fully with his description.

Thallocarpus is of common occurrence in the vicinity of Austin, Texas, during late winter and spring, growing most abundantly in sandy soil along with Riccias, *Sphaerocarpos*, and other liverworts. The plant studied corresponds very closely with those described by Austin if we take into account the essential corrections made in his later references to the liverwort. There seems little doubt that it should be regarded as the same species.

Because of the disagreement of Austin and Stephani as to the sex of the thallus of *Thallocarpus* I have examined a large number of thalli with this point in mind. Although a large number of plants of both sexes and of all ages were carefully dissected under a binocular microscope I was unable to find both archegonia and antheridia on any of the plants examined. Realizing the difficulty of detecting and recognizing immature sex organs in dissected material I have carefully examined paraffin sections of about fifty thalli, most of which were female. Part of these plants were sectioned to obtain material for a study of the morphology of the thallus and sporophyte, but special care was taken in each case to mount and stain the entire thallus. No case of the monoecious condition has been found in this material. The evidence seems fairly conclusive that *Thallocarpus*, as it occurs in the vicinity of Austin, is strictly dioecious.

I have accumulated considerable evidence to show that the four spores of the spore ball of *Thallocarpus* give rise to two female plants and two male plants as has been shown to be the case in *Sphaerocarpos texanus* Aust. (*S. californicus* Aust.) (13). I shall, in the near future, publish my results on this phase of the life history of *Thallocarpus*.

Material for this study was collected during the months of March, April, and May of the years 1914 and 1915. Weak

Flemming's solution gave perhaps the most successful fixation though there was no marked difference in the action of the killing solutions used. The gelatinous material of the older sporophytes interfered greatly with the penetration of the reagents, though an air pump was used to hasten the penetration of the liquids.

The thallus of *Thallocarpus* varies greatly in size. Mature sporophytes may be found in thalli with a diameter of but two millimeters, while in late spring sterile thalli may be found which have a diameter as great as fifteen millimeters. The male plants rarely exceed three or four millimeters in diameter, the average diameter being less than three millimeters.

When very young the thallus is distinctly bilobed, having a single distinct growing area. The mature male plants are usually bilobed only. The female thalli usually become symmetrically four-lobed but later the lobing becomes less regular and in the larger thalli there is often a suggestion of palmate lobing with the lobes often crowded and overlapping.

The thallus is very spongy in texture, resembling in this respect the spongy Riccias. Many irregular openings are visible in the upper surface. As is the case with the spongy Riccias the thallus is pale green in color. Superficially it resembles *Riccia crystallina* L.

Cross sections of the thallus show it to be made up, in the upper part of the thallus, of irregular plates of cells, mostly a single layer in thickness. At the upper surface these plates are broadened greatly to form the upper "epidermis" (FIG. 1). The tissue at the base of the thallus is compact with but few intercellular spaces.

The archegonia begin development at the surface of the thallus just back of the growing point. The mother cell of the archegonium elongates and divides transversely, the upper cell being the smaller (FIG. 2). The lower cell divides again by a transverse wall (FIG. 3) which according to Campbell (**6**) also occurs in the development of the archegonium of *Sphaerocarpos* while in *Riccia* this cell remains undivided. The divisions of the upper cell seem to be the same as in *Riccia*. The general structure of the mature archegonium does not present anything new. The neck canal cells seem to number four or five (FIGS. 4, 5).

As the archegonia develop, plates of cells are formed about them in such a manner as to entirely submerge them at maturity.

The antheridia arise back of the growing point of the male thallus in much the same position as the archegonium appears in the female plant. I have not followed the development of the antheridium in detail but there seems to be no noteworthy difference between them and those of *Riccia*. From FIGS. 6 and 7 it will be seen that the early stages of development conform entirely with those of *Riccia*, according to the accounts of Garber, Campbell, and Lewis.

The fertilized egg divides by a wall transverse to the long axis of the archegonium (FIG. 8) as is the case with *Riccia* and the other Marchantiales. The subsequent divisions seem also to be the same as in *Riccia*, forming finally a sphere eight to ten cells across at the longest diameter. Divisions cease in the mass of sporophytic cells when the sporogonium is about half grown (FIG. 10). At this period the cells are all alike, no difference being observable between the cells that are later to form the wall and those that are to form the spore mother cells.

Frequently, however, a number of sporophytic cells adjoining the neck canal, fix and stain differently from the rest of the cells of the sporophyte. They are usually smaller cells with denser protoplasmic content and with nuclei which are smaller and which take the stain more readily than those of the other cells of the sporophyte. From FIGS. 9, 10, 11, and 12 it will be seen that they occur in sporophytes of all ages, except possibly those fully mature. Miss Black (5) has observed bacteria accumulated at the base of the neck canal in *Riccia Frostii* Aust., causing injury to the sporophytic cells of this region. It is possible that the above mentioned cells of the sporophyte of *Thallocarpus* may have been injured by secretions of bacterial origin though I have never observed bacteria-like structures in this region.

The single layer of cells of the venter divides early to form two layers (FIG. 9). These cells enlarge with the division and enlargement of the cells of the sporophyte but do not themselves undergo further division. Their dimensions at the maturity of the sporophyte are at least three times as great as at first (FIGS. 12, 13). The outer layer of venter cells is seen early to be abundantly supplied with chloroplasts while the inner layer lacks them (FIGS. 11, 12). As the spores mature the inner of the two layers of venter cells is crushed and absorbed while the outer layer remains intact, forming a persistent layer about the mass of spores (FIG. 14).

The cells of the sporophyte are probably more than half grown before any difference is perceptible between the cells of the amphithecium and the sporogenous cells (FIG. 9). This difference is first seen in a decrease of the protoplasmic content of the peripheral cells, and a possible increase in the density of the protoplasm of the sporogenous cells (FIG. 10). Later, as the sporogenous cells continue to enlarge, a difference in the size of the cells is apparent. At the time of the rounding up of the spore mother cells before division, the cells of the peripheral layer have a very scanty protoplasmic content and small, degenerate nuclei. The cells are however plump and distended with cell sap and do not show signs of collapse till much later (FIG. 12). Their collapse and disintegration at a later stage greatly enlarges the cavity in which the spores lie (FIG. 13).

Beer (4) has observed similar, large, vacuolate cells making up the amphithecium of *Riccia glauca* L. Garber (7), Campbell (6), and Lewis (9) have, however, described the amphithecium of *Riccia* as made up of flat cells which have dense contents.

The rounding up of the spore mother cells previous to the reduction divisions is accompanied by a swelling and gelatinization of the cell walls (FIG. 12). The gelatinous material accumulates in the spaces between the now rounded spore mother cells (FIG. 13) where it interferes greatly with the penetration of the killing solutions. In fixed material it stains deeply with the violet stain. Garber and Lewis have both observed such gelatinous accumulations in *Riccia* and are of the opinion that it is food material, derived, in part at least, from the surrounding cells, which are believed to be abundantly supplied with food material. In *Thallocarpus* this is not the case. No excess of food is to be identified in the surrounding cells nor is there any marked change in these cells upon the appearance of the gelatinous material. The gelatinization of the walls of the spore mother cells together with the disintegration of the wall layer of cells seems sufficient to account for the amount of gelatin formed.

The gelatinous material persists for some time, disappearing only as the thick common wall is formed around the spore tetrad (FIG. 14). The sporogenous cells all round up to form spore mother cells and all of the spore mother cells undergo division and all of the resulting cells form spores. None become sterile nutritive cells nor elater-like cells.

After the division of the spore mother cell the resulting cells become separated by a thin wall but remain closely attached and finally become surrounded by a thick, papillate common wall (FIGS. 14, 15). These spore walls remain thin and undeveloped until the thick retaining wall of the spore ball is completely formed (FIG. 14). The outer face of the tetrahedral spore is slightly roughened with projections which in cross section appear crenulate (FIG. 16). While thickened to a marked degree the wall of this outer face is not more than half as thick as the retaining wall of the spores of the tetrad. The inner faces of the spore are thickened only slightly.

It will be seen from the above that the structure and the development of the gametophyte and the sporophyte of *Thallocarpus* is practically identical with that of *Riccia*. The adhesion of the spores of the tetrad in a spore ball and the lack of peg-like thickenings in the rhizoids of the former are the only characters upon which a separation of the two genera could be based.

The morphology of the plant is nevertheless that of a *Riccia* rather than of a *Sphaerocarpos*. The adhesion of the spores is certainly very scanty evidence upon which to base relationship to the latter genus, for not all of the *Sphaerocarpos* species have spores remaining attached at the time of their shedding. The spores of *S. cristatus* M. A. Howe separate long before maturity and those of *S. Donellii* Aust. separate as they come to maturity (8).

The occurrence of peg-like rhizoid thickenings throughout the Marchantiales and their lack in the Jungermanniales may be a character of greater phylogenetic significance. While it is probable that this character should receive more consideration than the spore characters, nevertheless, in view of the essential identity of the structure of the gametophyte of *Thallocarpus* with that of *Riccia*, it would seem extreme to remove the genus *Thallocarpus* from the Marchantiales on the grounds of this character alone.

The monoecious plants which Stephani believed he had found may possibly be explained on the ground of the small size of the male plants and the crowded growth of the thalli, which become attached in masses by the rhizoids. The male plants cease growing early and are often entirely overgrown by the female plants. In dry material it would be difficult to separate the plants or even to identify any organic separation. This is often difficult in living material collected early in the season. Two cases of what seemed at first to be monoecious plants in paraffin sections turned out to be distinct plants, the male plant being entirely covered by the female plant. There seems little doubt that the Texas *Thallocarpus*, at least, is dioecious.

SUMMARY

1. *Thallocarpus*, as it occurs in the vicinity of Austin, Texas, seems to be strictly dioecious.

2. The spores of the tetrad adhere after shedding and give upon germination two male and two female plants.

3. The structure of the thallus and the sporophyte is identical with that of the Riccias with the exception of the adhering spore tetrads and the pegless rhizoids.

4. The above mentioned structural differences seem insufficient to exclude *Thallocarpus* from the Marchantiales.

I am indebted to Mr. F. C. Werkenthin, of State College, New Mexico, for valuable aid in preparing sections for this study.

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Explanation of plate 4

The magnification of the figures is about 250 diameters, with the exception of FIG. 1, which is magnified about 30 diameters.

FIG. 1. A portion of a section of a thallus, showing a sporophyte, nearly mature.

FIGS. 2, 3. Early stages in the development of the archegonium.

FIG. 4. Archegonium, not quite mature, becoming submerged by outgrowths of the thallus.

FIG. 5. Archegonium after fertilization of the egg.

FIGS. 6, 7. Early stages in the development of the antheridium.

FIG. 8. A four-celled embryo sporophyte.

FIG. 9. A later stage in the development of the embryo. Venter wall two cell layers in thickness. A group of cells at the apex of the sporophyte separated from the main mass.

FIG. 10. Embryo about half grown. No distinction visible between the peripheral cells and the inner cells of the sporophyte.

FIG. 11. Peripheral cells of sporophyte now easily identified by their scanty protoplasmic content.

FIG. 12. Gelatinization of the cell walls and the rounding up of the spore mother cells. Cells of the amphithecium still plump and intact.

FIG. 13. Spore mother cells fully rounded up and surrounded by the homogeneous gelatinous material. Peripheral layer of cells disintegrated. Venter cells still intact.

FIG. 14. Spores approaching maturity. The papillate retaining wall of the spore ball nearly mature. The spore walls still thin.

FIG. 15. One spore and part of the common retaining wall.

FIG. 16. Section of nearly mature spore, pulled away from spore ball by sectioning knife.

Morphology of the flowers of Zea Mays

PAUL WEATHERWAX

(WITH PLATES 5 AND 6 AND FOUR TEXT FIGURES)

The structure of the maize plant presents a series of problems of a very special nature. Many of these have been thoroughly worked out from a purely morphological point of view, but it need hardly be said that the mass of economic information about corn almost obscures the part that may be considered purely botanical. Of the special morphology of the plant probably no part has received less thorough treatment, in proportion to its importance, than that pertaining to its floral parts. It is true that many studies have dealt in a way with this phase of the subject, but it has almost always been in connection with some more extended study and has, consequently, been superficially treated. The result is that one looks in vain through botanical literature for a complete and well-illustrated discussion of the structure of the maize flower.

The investigations upon which this work is based have extended over a period of almost two years, during which time representatives of all the six subspecies of *Zea Mays* have been under observation to a greater or less extent. The greater part of the work has been done upon different varieties of sweet corn, but the other five types have also been examined, especially where any variation from the sweet corn type of flower was apparent. All the available literature has been consulted, and most of the points made therein have been verified.

It is not intended here to present a group of facts that are entirely new. The available data, widely scattered, have been collected, and some changes and additions have been made, together with an attempt to illustrate fully wherever an illustration will emphasize a point or convey the meaning more clearly.

I desire to express my obligations to Professor D. M. Mottier for valuable suggestions and criticisms pertaining to this work, and to a number of friends who have supplied me with seed of some of the varieties of corn used.

INFLORESCENCE

In the typical case the male and female inflorescences are borne on separate parts of the same maize plant, the former being the tassel and the latter the forerunner of the ear. Exceptions to this separation of the two types of flower sometimes occur and will be discussed later.

The male inflorescence is a broadly expanded panicle, often more than a foot in length, and made up of a central axis and several spreading rachids. Upon each rachis and the central axis the spikelets are arranged in pairs or, more rarely, in groups of three or four; one spikelet of each group is usually pedicelled, while the others are sessile.

The female inflorescence is a thickened spike, later to develop into the ear with its woody cob. Upon the axis of this inflorescence are borne a number of double rows of spikelets, the rows being double because of the pairing of the spikelets, and from these are produced an even number of rows of grains. Normally the minimum number of rows is eight, and it may vary in even numbers from this to twenty-four or more. The whole female inflorescence is enclosed in the husks, which are modified leaf sheaths borne upon the short branch that bears the ear.

It is very probable that the ear has developed from a primitive bisexual inflorescence, which had a structure similar to that of the male inflorescence of the plant at the present time; but Harshberger (1) and Montgomery (2), who have made extensive studies of this, disagree as to how this step actually took place, the one holding that the rachids of the primitive inflorescence united to form the ear, and the other maintaining that it was only the central spike of the tassel that persisted. Good arguments are found to support each view, and some other evidences not mentioned by either of the above, but having an important bearing upon the question, are now under observation and will be made the subject of a future report.

The normal male inflorescence of the plant at the present time is generally believed to have resulted from the suppression of the pistils of the hermaphrodite flowers of the primitive inflorescence.

STAMINATE FLOWER

The male spikelet contains, either functional or in rudimentary form, all the parts of the typical grass spikelet. It is normally two-flowered. A few one-flowered spikelets have been observed, but they usually contain a second flower in an undeveloped condition. At the ends of rachids, spikelets with more than two flowers are sometimes found, but they are probably to be understood as being two or more two-flowered spikelets combined.

Completely enclosing the rest of the spikelet before maturity are the two rather firm, taper-pointed, empty glumes, having a varying number of nerves and thickly beset, as is the rachilla below the glumes, with short, stiff bristles. The lower glume overlaps the edges of the upper and has the lower point of insertion upon the rachilla (FIG. 1). The flower is in the axis of the thin, membranaceous, blunt-pointed, two- to four-nerved lemma or flowering glume, and subtended by the palea, which has a similar structure except that it is regularly two-nerved. No trace of a continuation of the rachilla has been observed between the paleae. On this basis, then, there is no indication that the normal spikelet was ever more than two-flowered. The rachilla is jointed just below the glumes.

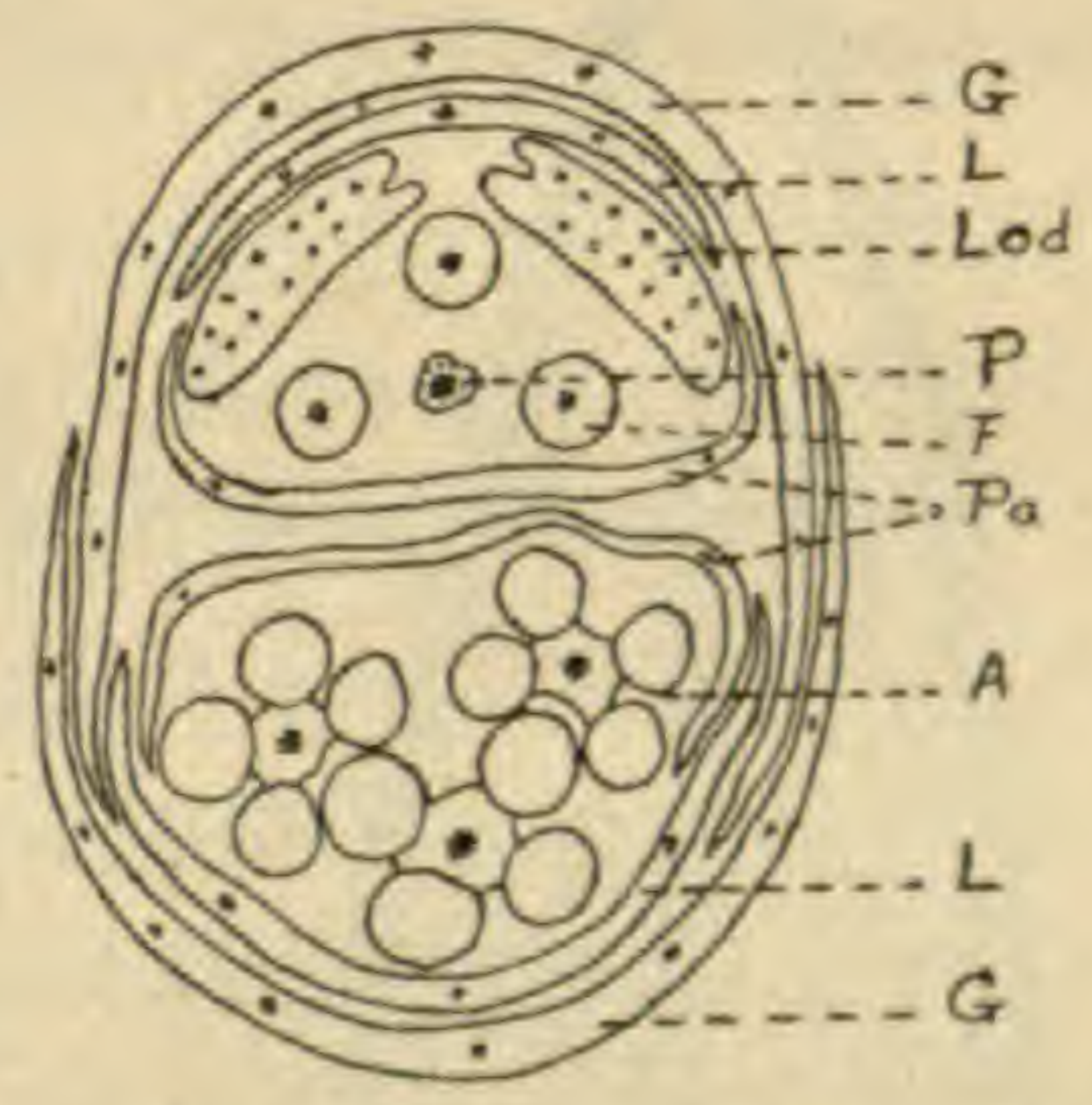

FIG. 1. Transverse section of lower part of staminate spikelet of Country Gentleman sweet corn. ×20. *G*, glumes; *Lod*. lodicule; *F*, filament of a stamen; *A*, anther; *L*, lemma; *P*, rudimentary pistil; *Pa*, palea.

In so far as was observed, the two flowers are identical in structure, but the upper one is the first to mature. During microspore development the anthers of the upper flower are often found with the tetrad stage or with the pollen grains rounded off, while those of the lower flower show resting or synaptic stages; but the pollen grains of the younger flowers are usually rounded off and apparently mature before the older flower puts out its stamens.

The three stamens of each flower are so arranged that their points of attachment form the vertices of a triangle which has one of its bases toward the palea. Midway between the two lateral stamens is the rudiment of a pistil. Next to the lemma, and outside the triangular area to which the stamens and rudimentary pistil are attached, are the lodicules (Fig. 2 and Text fig. 1).

The immature stamens have short, stiff, and rather fleshy filaments, which become long, thin, and flexible in anthesis, allowing the anthers to hang well below the rest of the spikelet (compare Fig. 1 with Fig. 2 and with Text fig. 2). The arrangement of the stamens in the flower seems to have nothing to do with the position that they will occupy in anthesis, all three sometimes falling from one side of the spikelet, or two from one side and one from the other as determined by external conditions. The immature anther has four loculi, which later form two "cells." The anther cells open by short slits and allow the pollen to sift out (Fig. 1).

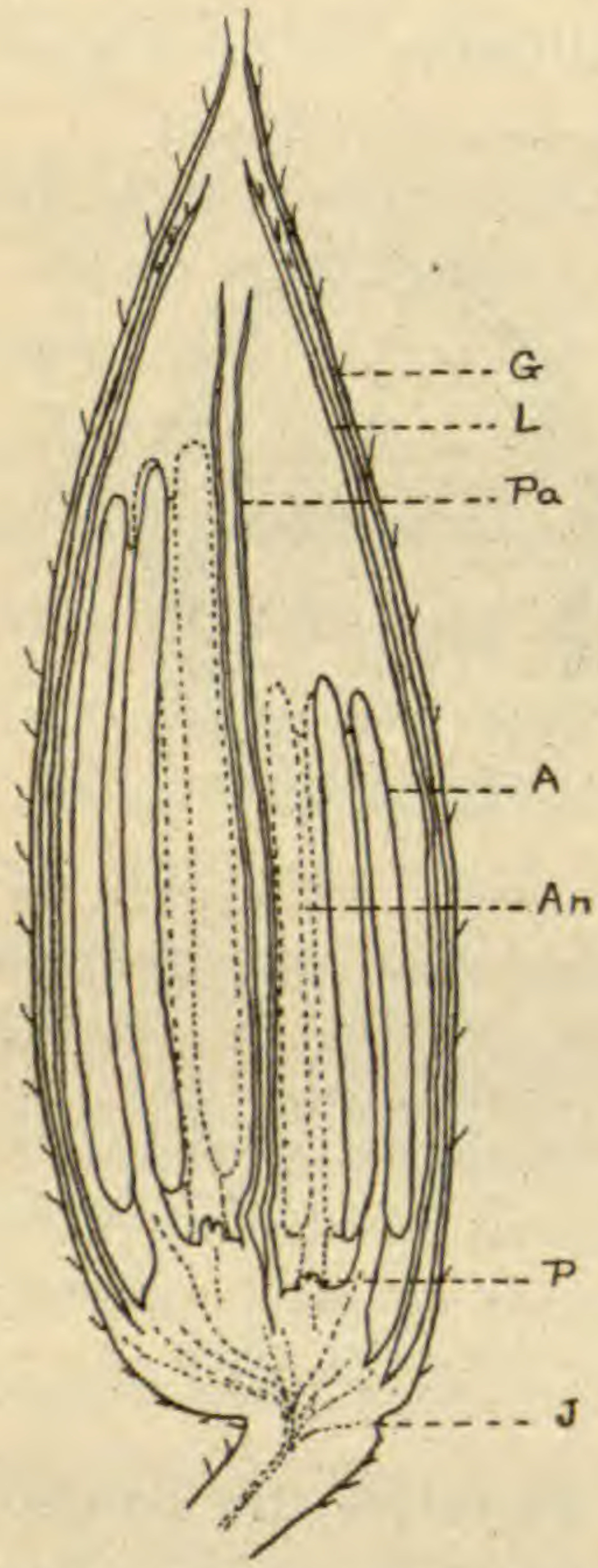

Fig. 2. Longitudinal section of staminate spikelet of Country Gentleman sweet corn, ×15. *G*, glume; *Pa*, palea; *An*, position of one of the lateral anthers; *L*, lemma; *A*, dorsal anther; *P*, rudimentary pistil; *J*, joint of rachilla.

The thick, fleshy lodicules do not show the scale-like structure that often characterizes them in other grasses. Along the top of each there is a deep, rounded groove with irregular sides. The lodicule is well supplied with vascular tissue, transverse sections showing ten or twelve relatively large, well-distributed strands (Text fig. 1). As the flower matures, the lodicules increase in size and push back the lemma and glume, thus opening the spikelet.

In the literature examined, the only mention of a pistil in a male flower is by Baillon (4, p. 325) and Bentham and Hooker (5, p. 1114), both of whom, however, say that it is not present. They treat the normal flower as being wholly staminate in structure as well as in function; but the rudimentary pistil, a very inconspicuous body, to be sure, has been found in every staminate flower that I have examined. Its development has not yet been worked out; but it is known that long before anthesis its growth stops, and, during the greater part of the development of the rest of the flower, the pistil shows evidences of disorganization, especially by its manner of taking stains.

The vascular system of the base of the spikelet has not been thoroughly worked out, but strands have been traced to most of the organs, including a large one to each lodicule and a rudimentary one to the abortive pistil.

PISTILLATE FLOWER

The available descriptions of the female spikelet and flower are much better than those of the homologous parts of the male inflorescence. This is largely due to the fact that several investigators have, in dealing with embryological features, found it necessary to discuss the developing caryopsis in relation to the other parts of the spikelet. However, since much of the work on the structure of the spikelet and flower has been merely incidental to other lines of investigation, many inaccuracies have found their way into the recent works.

The pistillate spikelet is two-flowered, and its parts are, in number and arrangement, similar to those of the staminate spikelet, allowing, of course, for the functioning of a pistil instead of stamens and the abortion of certain other parts.

The empty glumes are rather thick and fleshy and do not completely enclose the other parts, except in pod corn, at any time during the development of the spikelet. The hairs that are present on the glumes of the male spikelet are here represented by similar ones around the edges and by pits scattered over the surface of the glumes. The rachilla is jointed just below the base of the glumes (FIG. 3). The lemma and palea are shorter and thinner than the glumes. These floral bracts cease to develop, in most varieties, about the time of fertilization and remain around the base of the fruit, forming the red or white more or less chaffy covering of the cob. If fertilization is prevented, they may grow to three or four times their normal size. In the pod corns the floral bracts, especially the glumes, become herbaceous and continue to grow after fertilization and are ultimately found completely enclosing the mature fruit.

In most varieties of maize the two flowers of the female spikelet are quite different in function and detailed structure, the lower one being aborted; and the descriptions of the two must be dealt with separately. There are certain important exceptions, however, to this peculiarity of the lower flower, and these will be discussed later.

The functional pistil occupies a normal position between the lemma and palea of the upper flower (TEXT FIG. 3). It is readily seen to consist of two parts, the bulb-shaped lower part, later developing into the caryopsis, and the long "silk" extending beyond the husks.

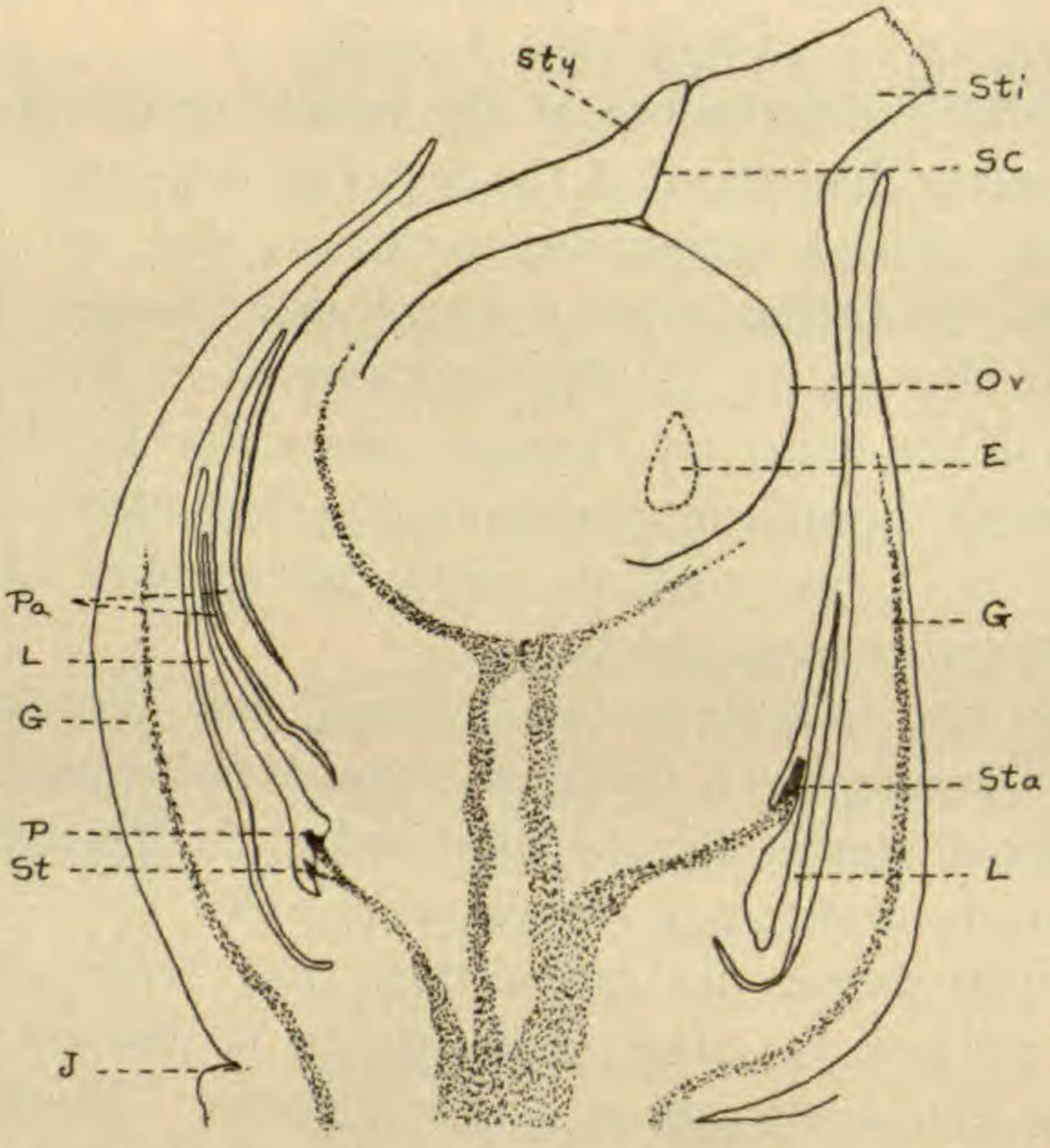

FIG. 3. Longitudinal section of pistillate spikelet of Black Mexican sweet corn, × 25. *Sti*, base of stigma; *Sty*, style; *E*, outline of embryo sac; *L*, lemma; *Pa*, palea; *St*, stamen of aborted flower; *SC*, stylar canal; *Ov*, functional ovule; *G*, glume; *Sta*, rudimentary stamen; *P*, pistil of aborted flower; *J*, joint of rachilla.

The accurate naming of at least one part of the pistil seems to have received little attention from recent writers. Harshberger (1, p. 400) speaks of the silk as a long, hairy style, and later adds that the style is hairy to entrap the round, smooth pollen grains. Hunt (6, p. 146) speaks of it as the "style, commonly known as the 'silk.'" Baillon (4, p. 325) and Bentham and Hooker (5, p. 1114) give similar descriptions and call the silk a style. Only one dissenting opinion has thus far been noted, and that in Wood's (7) text-book, published about 1870. Here (p. 48) he figures the pistil of *Zea* and mentions its long, filamentous *stigma*.

All evidences indicate that the silk is stigmatic, at least in a rudimentary way, even to its base. The hairs are most numerous near the tip but are to be found all along the organ. Crozier (8) has noted that silks that have been repeatedly cut off are still capable of being pollenized, showing that it is not the forked tip alone that is stigmatic. Of course the part of the silk that is protected by the husks does not, under ordinary conditions, become a germinating place for pollen, but continued growth is always exposing parts that were previously covered. How long this might continue is not limited by any visible structural difference, and it is probable that pollen will germinate on any part of the silk. Even those who persistently call it a style admit that the silk catches the pollen grains and furnishes them a place to germinate, and this is by definition the function of a stigma. In cross section the silk has the shape of an asymmetrical figure eight (FIG. 8). This appearance is due to a longitudinal groove extending along both the adaxial and abaxial sides. The abaxial groove is deep and narrow, and the one on the adaxial side is broad and shallow (FIGS. 6–8). Near the tip these two grooves unite, making the silk unequally two-pointed (FIG. 5). A strand of vascular tissue traverses each side of the silk and continues into the tip after the silk divides. In distribution the hairs are limited to the edges and adaxial side (FIGS. 6–8), being more numerous, as has been said, near the distal extremity of the silk. If the two stigmas of the typical grass flower should unite for almost their entire length, the organ formed would be, except for relative length, not unlike a corn silk. It seems wholly consistent, therefore, to consider the corn silk a compound stigma.

Just what course the pollen tube takes with reference to the parts of the pistil is not definitely known, but growth of the tube causes the stigma to dry up. Silks that have been protected from pollen may, however, as Crozier (8) has pointed out, remain fresh for many days and continue to grow in length.

If the silk is to be considered a stigma, then the style is the short protuberance at the top of the ovary, to one side of which the stigma is attached (FIGS. 3 and 4 and TEXT FIG. 3). The style is traversed by a tubular opening leading from the surface to the interior of the ovary (FIGS. 3 and 4 and TEXT FIG. 3.) This canal is especially prominent in young stages of ovarian development and never quite disappears. It has been termed the stylar canal by practically all that have had occasion to mention it, even by some of those that call the silk a style. Whether or not the pollen tube traverses this canal on its way to the ovule has not been determined.

The ovary is thick-walled and contains a single large, anatropous ovule. The embryo-sac is near the upper side, with reference to the cob as an axis, and the embryo is developed on that side of the caryopsis. The detailed structure and development of the ovary properly belongs in another connection and has been worked out by True (**9**, p. 212), Poindexter (**11**, p. 3), Guignard (**10**, p. 2), and others.

Just below the ovary, and somewhat irregularly spaced around the circumference of its support, are three small, rudimentary stamens (FIG. 4 and TEXT FIG. 3). They have a yellowish, wrinkled appearance and stain like disorganizing tissue. Baillon (**4**, p. 325) makes mention of "stamina 3 (in flore foemineo ad staminodia vix conspicua reducta," but Bentham and Hooker (**5**, p. 1114) dismiss the question with "staminodia 0." The other works that I have examined make no mention of these rudimentary stamens.

In the normally functional flower of the female spikelet the lodicules are, in so far as I have observed, entirely lacking. Montgomery (**2**, p. 61) has noted the same fact.

The aborted flower is much more simple in structure than the functional one just described. It is located between the lower lemma and palea, and, because of the suppressed development of its basal parts, it appears to be on the side of the pedicel that supports the functional flower (FIG. 4). In other words, the functional flower appears to terminate the rachilla, while the aborted one seems to be laterally attached; but there is no real evidence that either flower is morphologically at the end of the rachilla.

The male and female parts of this aborted flower make about equal development, the stamens being about as well developed as those of the functional female flower, and the pistil resembling that in the normal male flower. The lodicules are also present and pretty well developed (FIG. 9).

Sturtevant (12) reports that he found on one occasion an ear of pod corn that had the kernels "twinned in the pods." In several ears grown from seed furnished by Professor M. L. Fisher, of Purdue University, I have found a few pods each of which had two grains (FIG. 12). Examination of these shows that both flowers of a spikelet have developed. Kempton (14, pp. 8 and 9) reports the same occurrence in a few spikelets of a variety of corn grown by the Hopi Indians of Arizona and adds that the lower flower in several varieties occasionally develops, sometimes accompanied by the abortion of the upper flower. In the summer of 1914, while preparing material for study, I found that the variety of sweet corn known as Country Gentleman regularly has both flowers of the female spikelet functional. Stewart (13) has recently reported an observation of the same kind.

In this variety, then, two grains are produced where there is only one in most other varieties, and the ear has practically the double number of grains. On account of this the grains are so much crowded that they become long and slender (FIG. 13) and are thrown out of line so as to appear to be no longer arranged in rows (FIG. 14). Kempton (14, p. 8) speaks of one variety of sweet corn that shows an exception to the usual rowed arrangement of the grains, but he attributes the irregularity to an indiscriminate arrangement of the spikelets. The variety is not named, but, even to the "shoe peg" type of grain produced, it might be "Country Gentleman," except for the arrangement of the spikelets. I have found no variety of corn in which the spikelets were not arranged in rows on the cob.

In appearance and structure this functional lower flower of "Country Gentleman" sweet corn is similar to the upper one, but it is often somewhat smaller and slower to mature (TEXT FIG. 4). With reference to their position on the cob as an axis, the arrangement of the parts of this flower is, as might be expected, the exact opposite of that of the upper flower. This causes the stigma to make a sharp bend near its base in order to take its proper direction of growth toward the tip of the ear (Text fig. 4). Because also of this opposite arrangement of parts, the embryo develops on the abaxial side of the grain, and, in following a row, we find the alternate grains with their embryos turned toward the base of the ear, a thing that does not occur in the ordinary ear. This same pairing of the kernels with reference to the position of the embryos is noted in the pod corn that occasionally produces two grains in a pod.

An interesting suggestion as to the probable evolution of this peculiarity in this variety of sweet corn is offered by the fact that in the lower flower rudimentary lodicules are present as in the aborted flower of other kinds of maize. If the spikelet with two functional female flowers is the primitive one from which the other type has been developed by abortion of the lower flower, why should only one of the flowers retain its lodicules? It seems rather more probable that the second functional pistil has resulted from the development of the rudimentary one in the aborted lower flower of the typical female spikelet. In support of this belief may be added the fact that the lodicules of the functional flower

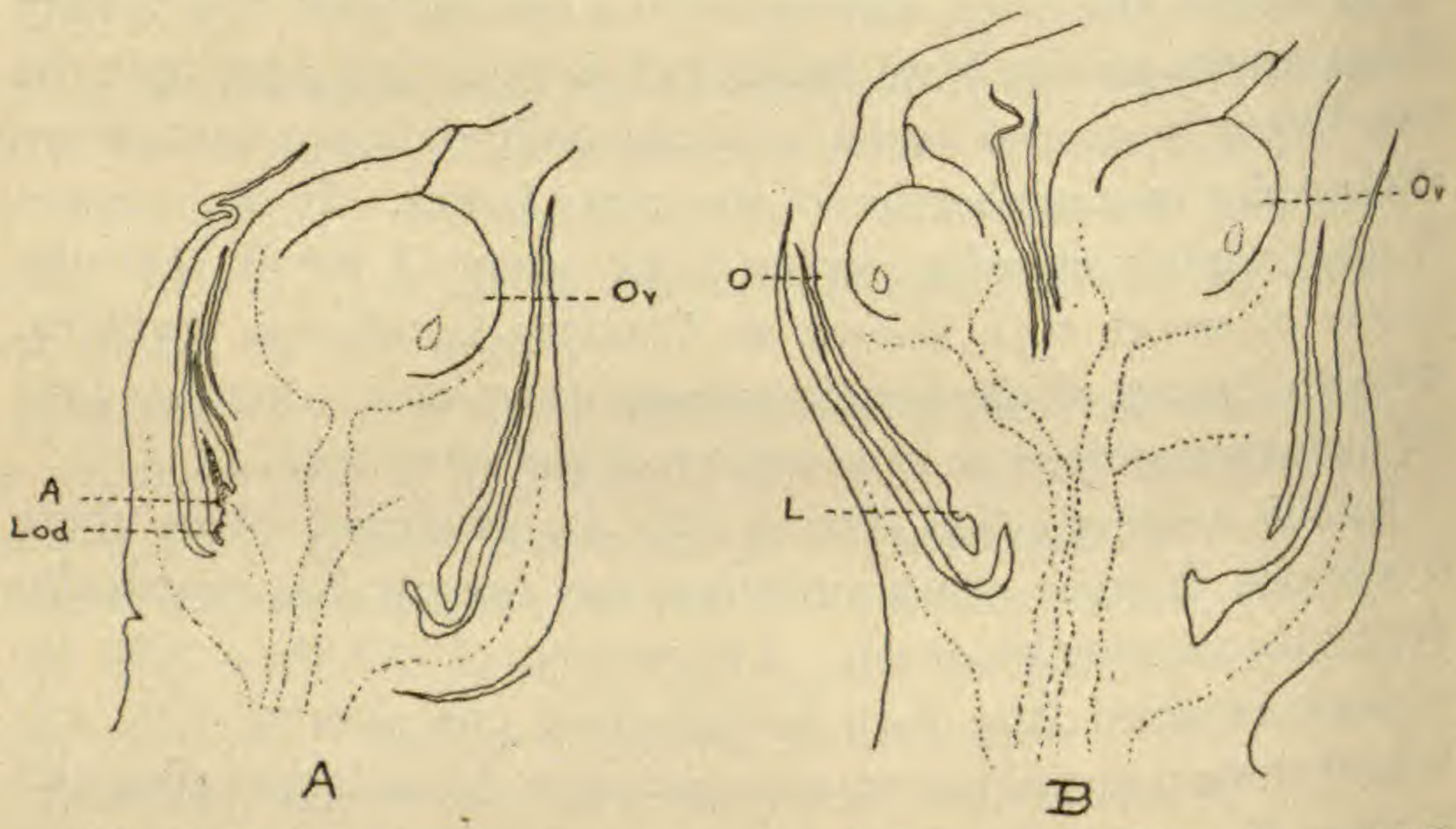

FIG. 4. Longitudinal section of female spikelet of Black Mexican sweet corn (*A*) and of Country Gentleman sweet corn (*B*), × 12. *Ov*, functional ovule; *O*, ovary that usually does not develop, except in Country Gentleman sweet corn; *A*, aborted flower; *Lod*, lodicule. (The lodicules are really lateral organs, but, when rudimentary, they are often sufficiently out of place to show in a median section.)

seem to be smaller and less developed than those of the aborted flower. This question will, however, bear further investigation.

POLLINATION

An unusually large number of interesting correlations are found between structure and function as applied to pollination. Practically the only means of pollen transfer are gravity and the wind. A few insects may work upon one or the other of the inflorescences, but none have been observed that find it profitable to visit both.

The most noticeable correlation, and one that sheds much light upon the probable course followed in the development of monoecism, is in the position of the male inflorescence above the female this tending to render functionless the ovaries in the tassel and the pollen in the lower inflorescence of the primitive ancestor of the maize plant.

The pollen is fine and light and easily carried by the wind. Each individual grain is smooth and dry on the outside and not well adapted to adhering to anything except something of the feathery nature of the stigma. Thus a minimum amount of pollen is lost by adhering to the leaves and stem above the female flowers.

Of course much pollen is lost by any plant that depends upon the wind for pollination, but ample allowance is made for this in maize. Lazenby's estimate for a dent variety shows that about 45,000 pollen grains are produced for every ovule; and Sargent estimates that the ratio is at least 9,000 to 1. These figures are reported by Hunt (**6**, p. 146). In a variety of popcorn that I have examined, the number of male spikelets produced is approximately the same as the number of female spikelets, the variety having an average of three ears to the stalk. But each female spikelet produces one ovule, while the six anthers of a male spikelet produce no less than 15,000 pollen grains. Since most varieties have a larger tassel and a smaller number of ears than this one, it is probable that this ratio of 15,000 pollen grains to 1 ovule is low enough.

The idea is held by many that self-pollination is prevented by the shedding of the pollen before the maturity of the stigmas of the same plant, but such is not the case. Hunt (**6**, p. 146), Harshberger (**1**, p. 401), Collins (**15**, p. 3), and others say that self-pollination is possible, and my own observations are in accord with their conclusions. In securing pure lines for experimental work I have had occasion to self-pollenize individuals of about twenty varieties, and I have, in no case, had to have recourse to any means of pollen preservation. Contrary to the popular idea, I find that the period during which pollen is shed by any one plant extends pretty well over the time between the maturity of its first and last stigmas.

Anthesis in the male inflorescence begins a short distance from the tip of the central axis, and a little later at the tip of each rachis, and the region of maturity of the flowers passes downward along all the axes simultaneously. The period of maturity is further lengthened by the fact that the two flowers in a spikelet do not mature at the same time, and a second wave of maturity and pollen shedding follows the first. Furthermore, the anther does not discharge all its pollen as soon as it is ripe, but lets it sift out slowly. The combined effect of all these conditions is to lengthen the period over which the plant is shedding pollen.

The pistils near the base of the female inflorescence are the first to mature, and their stigmas emerge from the husk and become receptive usually about the time the first pollen is shed by the same plant. Many individuals are found, however, whose stigmas are out before the maturity of the male flowers, and the reverse is also true of many individuals. In most of the kinds commonly cultivated, however, neither of these characteristics seems to be constant for the variety. It is possible that, if the order of maturity of the two inflorescences behaves in true Mendelian fashion, this characteristic has been disregarded in hybridization and selection to such an extent that it has not become fixed for the variety. Self-pollination of an individual is rarely completely prevented in the commoner cultivated varieties by a difference in the time of maturity of the inflorescences.

But, in spite of the fact that self-pollination is possible and actually occurs to a certain extent, it is clear that cross pollination is not only the common occurrence, but is necessary for complete pollination and the production of well-filled ears, as is shown by a comparison of the ears from isolated plants with those that have been produced where a large number of plants near together were shedding pollen at the same time.

Whether or not cross pollination is necessary for the maintenance of the full vigor of a strain is another question, and one that is by no means settled at present. It is not at all impossible that our different agricultural varieties will ultimately be found to differ in this respect. The maize varieties that we now have are the result of much haphazard hybridization, and nothing short of years of work will ever give conclusive results along this line.

FLORAL ABNORMALITIES

It has already been stated that monoecism is the rule, and that the male and female flowers are grouped together in separate inflorescences. But occasionally in probably all types, and often in at least one variety, some of the rudimentary organs are replaced by functional ones, and some usually functional are suppressed. As a result, organs of both sexes may be found in the same inflorescence in any one of three ways or in a combination of these ways:

1. Both sexes may occur in the same inflorescence but not necessarily in the same spikelet.

2. Male and female organs may be found in the same spikelet but not necessarily in the same flower.

3. The flowers may be perfect.

The first type of sex combination is very commonly observed in nearly all varieties of corn. Many writers have mentioned it, and Montgomery (2), especially, has published a number of illustrations of the phenomenon. Its occurrence in the tassel is apparently due to the development of the female instead of the male elements of the spikelets of one or more rachids or, more often, of the central spike. This produces a naked fructification resembling an ear, which Montgomery (2) makes the basis of his theory to account for the evolution of the ear. It has been noted also, as will be more fully discussed later, that some tassel spikelets in pod corn produce only female flowers. In the ear the flowers at the tip are often wholly staminate in structure, although they may never mature pollen. This transposition of sex in the ear is known in nearly all varieties, but Kempton (14, p. 11) is responsible for the statement that it never occurs in pod corn. It sometimes occurs that the staminate portion of the ear is not at the tip but back some distance, as shown in FIG. 16, where the staminate portion resembles the central spike of a tassel. At least one case has been noted also where a double row of spikelets on an ear was replaced for some distance by spikelets that had the structure of those usually found in the tassel.

In the variety of pod corn that I have been growing the tassels of most plants produce female flowers, and at maturity the tassel is bent sharply downward by the weight of the fruit (FIG. 10). Kempton (14, p. 12) and others have noted the same, and the former observed that such plants produced no ears. The same thing was true for a number of my plants also, but most of them produced ears of the podded type. Examination of these tassels shows that many of the spikelets have one male and one female flower.

Bisexual flowers similar to the typical grass flower, except in the structure of the stigma and some minor points, have been found in both the ear and the tassel of pod corn. It is somewhat doubtful whether or not the stamens in the ear spikelets of my plants produced pollen, but they were of the normal size. In the tassel, however, both parts of the perfect flowers were most certainly functional. On account of the increased length of the glumes in these flowers, however, as in almost all flowers of this pod corn, the stamens are not exserted in anthesis. This introduces a special problem of pollination which has not yet been fully investigated.

The presence of these hermaphrodite flowers in pod corn and occasionally in other varieties, and the occurrence of both sexes in the same inflorescence but not in the same flower have provided the basis of the theory generally accepted that the monoecious flowers of the normal maize plant have developed, by the suppression of parts, from hermaphrodite flowers borne in tassel-like inflorescences by some unknown primitive ancestor.

Montgomery (3, p. 349) mentions an ear of dent corn that had three well-developed stamens with each grain and three small ones in the aborted flower. He says further: "This little abortive flower can be found in the embryonic stages of development, and usually all trace of its presence is lost except the extra pair of glumes on the posterior side of the kernel. These little stamens, however, indicate that it at one time might have functioned and give us another clue to some of the evolutionary changes that this interesting plant has gone through."

Contrary to this statement, I find, as previously described, that all traces of the aborted flower are not lost but are present *in every female spikelet*, at least in rudimentary form, at the time of fecundation (FIG. 9). Moreover, if three rudimentary stamens in the spikelets of one particular ear give a clue to evolutionary changes, a much better clue must be given by the development of a normal caryopsis from the lower flower of every female spikelet of Country Gentleman sweet corn (FIG. 14).

The structure of the perfect flowers in pod corn, with reference to the order in which the four flowers of a pair of spikelets lost their staminate elements on becoming ear spikelets, has been worked out by Kempton (14, p. 10). He concludes that the first to change was the upper flower of the sessile spikelet, then the upper flower in the pedicelled spikelet, and then the other two flowers in the same order. Many evidences that I have observed in the tassel of pod corn are in accord with these conclusions, but an occasional spikelet with a functional ovule in the upper flower and the stamens of this one and both pistil and stamens of the lower flower aborted would lead to the belief that the entire lower flower may sometimes have become aborted without a previous loss of function by its stamens. In such spikelet, too, the lodicules of the lower flower are almost normal in appearance, while those of the upper flower are very much reduced in size. This indicates the beginning of the line of evolution that has left rudimentary lodicules in the aborted flower and entirely removed them from the upper flower of the ordinary female spikelet. Moreover, more weight must be attributed to evolutionary evidences from spikelets of the ear, which have passed through the process, than to those from tassel spikelets, which may or may not be giving indications that we are interpreting correctly.

The structure of the stamens of these tassel flowers presents a problem that cannot be solved from the standpoint of gross morphology alone. Guided by size and shape we might select from an ordinary tassel a complete series of stamens represented at one end by a functional organ and at the other by a degree of abortion equal to that which is characteristic of the rudimentary stamens of the normal pistillate flower; and between the two extremes would be possible monstrous forms. It is only when the function of producing mature pollen has been lost that we can say that the flower has ceased to be perfect, and it is probable that, in some cases, this can be determined only cytologically or physiologically.

But the vital point of the whole question, in so far as evolution is concerned, is not the order in which the perfect flowers of a pair of tassel spikelets changed into the present pistillate condition, nor even the occurrence of occasional functional stamens or pistils in flowers of the opposite sex, but in the fact that *every flower of either sex contains either rudimentary or functional elements of the opposite sex.* This is the real indication of primitive hermaphroditism, and the other points only serve to supplement this fact.

SUMMARY

1. Normally the maize plant is monoecious.

2. The male spikelet is two-flowered. Each flower has three stamens, two lodicules, and a rudimentary pistil.

3. The female spikelet is two-flowered, but, in most instances, the lower flower is aborted.

4. In Country Gentleman sweet corn the lower flower of the female spikelet regularly functions the same as the upper one. This same phenomenon has been noted in some spikelets of pod corn.

5. The upper female flower has a pistil and three rudimentary stamens but no lodicules.

6. The lower female flower has a pistil, three rudimentary stamens, and two rudimentary lodicules, whether the flower be aborted or functional.

7. Structurally and functionally the silk is a stigma.

8. Pollination is effected by gravity and the wind. A relatively large amount of pollen is produced. Cross pollination is the more common occurrence, but self-pollination is possible and occurs to a certain extent.

9. In flowers of either sex the rudimentary organs of the opposite sex may be replaced by organs of normal appearance. In many instances these are not functional, but pistils are regularly functional in the tassels of some varieties of pod corn.

10. Except in pod corn the glumes do not enclose the caryopsis as in most grasses.

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Explanation of plates 5 and 6

PLATE 5

FIG. 1. Male spikelet of Red Cob Cory sweet corn with one flower in anthesis, × 12. *G*, glume; *Pa*, palea; *A*, anther of unopened flower; *F*, elongated filament of mature stamen; *O*, opening of anther; *J*, joint of rachilla.

FIG. 2. Male flower of Red Cob Cory sweet corn with its own palea and the other half of the spikelet removed, × 15. G, glume; *Le*, lemma; *F*, short, thick filament of immature stamen; *P*, rudimentary pistil; *Pa*, base of palea that has been removed; *L*, lodicule.

FIG. 3. Female spikelet of Red Cob Cory, × 10. *Sti*, stigma; *SC*, stylar canal; *Sty*, style; *Ov*, ovary; *G*, glumes; *J*, joint of rachilla.

FIG. 4. Female spikelet of Red Cob Cory, with floral bracts removed, × 10. *Sti*, base of stigma; *SC*, stylar canal; *Sty*, style; *Ov*, ovary (functional); *Sta*, rudimentary stamen; *P*, pistil of aborted flower; *Sta*, stamen of aborted flower; *G*, *L*, and *P*, scars left by removal of glumes, lemmae, and paleae, respectively.

FIG. 5. Tip of stigma of Red Cob Cory, showing two points and hairs for catching pollen, × 15.

FIG. 6. Adaxial side of a segment of the stigma a short distance from the style, × 15.

FIG. 7. Same as FIG. 6 but seen from the abaxial side.

FIG. 8. Transverse section of the stigma, × 30; the adaxial side is above. *V*, vascular strands; *H*, place of attachment of hairs.

FIG. 9. Aborted lower flower of female spikelet of Red Cob Cory, × 20. *Sta*, stamen; *P*, pistil; *L*, lodicule; *Pa*, palea; *Le*, scar left by removal of lemma.

PLATE 6

FIG. 10. Tassel of pod corn, bent sharply downward by the weight of the fruits that have developed in it.

FIG. 11. Pairs of spikelets from tassel of pod corn.

FIG. 12. Pairs of spikelets from ear of pod corn. One spikelet in each pair shown has two fruits.

FIG. 13. Grains of Country Gentleman sweet corn (above), and of Stowell's Evergreen (below).

FIG. 14. Ears of sweet corn. Stowell's Evergreen on the left, Country Gentleman on the right.

FIG. 15. Periodic pollination. This ear was bagged after a few silks had come out, and the bag was taken off before all the stigmas had lost their receptivity. The middle portion has no grains because the silks from this part passed their period of receptivity while the ear was protected from pollen.

FIG. 16. Ear of a yellow dent variety. The constricted place back of the tip is staminate in structure.

The Lichens of Bermuda

Lincoln W. Riddle

Our knowledge of the lichens of Bermuda up to the present time has been confined to the Reports of the Challenger Expedition, based on the collections made by H. N. Moseley, who secured in Bermuda only twenty-five species and varieties of lichens. Three successive reports on the lichens of the Challenger Expedition were published. The first was that of Stirton in the Journal of the Linnaean Society for 1875 (**14**: 369–372). Two years later Crombie, with the assistance of Nylander, went over the collection, revised many of Stirton's determinations, and published a report in the journal cited (**16**: 214–217). This report included several "new species and varieties" named by Nylander, but, with one exception noted below, these differed from well-known species in chemical tests only or in such trivial characters that they cannot be considered valid. Finally, in 1885, in the official Report on the Scientific Results of the Voyage of H. M. S. Challenger, Botany, vol. 1, No. 2, Part 1, Hemsley published the list again, his list being practically a reprint of that of Crombie.

Meanwhile, in 1880 and in 1881, Professor W. G. Farlow, of Harvard University, had visited Bermuda and made a small but important collection of lichens. This was turned over to Tuckerman, who named twenty-one species, of which six were new. Tuckerman was then busy with his Synopsis of the North American Lichens and was approaching the end of his life, so that he was unable to publish descriptions of the new species that he named. Duplicates of some of these specimens were sent to the Royal Herbarium at Kew, England, and Hemsley gave a list of thirteen of these in a footnote on page 99 of his report. Descriptions of two of the new species, *Gyalecta Farlowi* and *Verrucaria bermudana*, were published by Nylander in 1890 and 1891, respectively, but the other new species from Professor Farlow's collection have remained undescribed. He has very kindly allowed me to incorporate the results of a study of his specimens in the present paper.

Between 1905 and 1914 a more complete exploration of the flora of Bermuda has been carried on by Dr. and Mrs. N. L. Britton, Dr. F. J. Seaver, and Messrs. Stewardson Brown and Paul Bisset, resulting in the finding of sixty-five species and varieties, of which fifty, including three new species, had not been previously reported.

As a result of these several collections, we now have a total of thirty-six genera, with eighty-six species and varieties of lichens, known to occur in Bermuda. Ten of these species are endemic.

The collection made by the members of the staff of the New York Botanical Garden, in coöperation with the Academy of Natural Sciences of Philadelphia, has formed the chief basis of the following enumeration. All numbers cited refer to these specimens. Since Mrs. Elizabeth G. Britton has collected more numbers than anyone else, the initials only are cited. The names of other collectors are given in full. References are also given to the species collected by Professor Farlow, and to the records of the Challenger Expedition.

1. VERRUCARIA RUPESTRIS Schrad.

On rocks, without definite station, *W. G. Farlow.*

2. VERRUCARIA RUPESTRIS var. RUDERUM DC.

Verrucaria ruderella Nyl.; Crombie, Jour. Linn. Soc. Bot. **16**: 217. 1877.

On rocks, without definite station, *Challenger Expedition.*

3. **Thelidium bermudanum** (Tuck.) Riddle, comb. nov.

Verrucaria bermudana Tuck.; Nylander, Sert. Lich. trop. Labuan et Singapore 43. 1891.

As the original description is not readily accessible, it is given here: "Thallus vix ullus; apothecia pyrenio dimidiato-nigro (latit. circ. 0.25 mm.) convexa; sporae 8nae breviter fusiformes 1-septatae, long. 0.011–12, cr. 0.0035–45 mm., in thecis angustis; paraphyses graciles. Super saxa calcarea in Ins. Bermudis. Affinis *V. albido-atrae* Nyl." South shore; type collected by Professor W. G. Farlow. This species and the next are strictly maritime, growing just at tide-limit.

4. **Thelidium Farlowi** Riddle, sp. nov.

Thallus epilithicus, crustaceus tenuis vel tenuissimus continuus laevigatus plumbeus, in margine linea obscuriore cinctus. Gonidia cystococcoidea. Perithecia partim confluentia, circa 0.5 mm. diam., nigra depresso-hemisphaerica semiimmersa, strato tenuissimo thallode fere ad instar pruinae velata, apice sat late denudato; amphithecio subgloboso completo, basi tenuiore, fusconigro. Paraphyses gelatinam percurrentes. Asci 8-spori. Sporae incolores, oblongae vel ovales, biloculares, 18–20 × 7–9 μ.

On calcareous rocks, south shore, collected by Professor W. G. Farlow, 1881.

Type in the Cryptogamic Herbarium of Harvard University.

This species appears to be related to *Th. pyrenophorum* (Ach.) Koerb., but is distinct in the lead-colored thallus and the confluent perithecia, with the thin thalline covering giving a pruinose effect.

5. PORINA NUCULA Ach.

On bark of orange, Paynter's Vale, *E. G. B. 363*.

6. PORINA PHAEA (Ach.) Muell. Arg.

On *Juniperus*, Harrington House, *Stewardson Brown 560*.

7. PORINA TETRACERAE (Ach.) Muell. Arg.

On coffee trees, Walsingham, *E. G. B. 293*.

8. PYRENULA AURANTIACA Fée.

On *Rhizophora*, Fairy Land, *E. G. B. 193;* also *W. G. Farlow*, who states that it is generally common on *Rhizophora*, but very difficult to cut off.

9. PYRENULA BRACHYSPERMA Muell. Arg.

On *Eugenia*, Hall's Island, *Brown & Britton 885*.

This species was originally published in Mueller-Argau's Revisio Lichenum Eschweilerianum, Flora **67**: 670. 1884. The type came from Brazil. It is exceptional among Pyrenulas in having two-celled spores. Although there has been no material available for comparison, the Bermuda specimen agrees so well with the description that there can be no doubt of its identity.

10. PYRENULA LEUCOPLACA (Wallr.) Koerb.

On decorticated *Juniperus*, north of Hamilton, *E. G. B. 69*, on *Nerium*, Devonshire Marsh, *E. G. B. 165;* on *Rhizophora*, Fairy Land, *E. G. B. 194;* on *Eugenia*, Tucker's Town, *E. G. B. 315;* on *Ficus*, Wreck Hill, *Brown & Britton, 1108;* without definite station, *Brown, Britton & Seaver, 1225.*

11. PYRENULA MAMILLANA (Ach.) Trev.

On *Elaeodendron*, without definite station, *Brown, Britton & Seaver, 1578, 1587.*

12. PYRENULA NITIDA var. NITIDELLA (Flke.) Schaer.

On *Melia*, hillside near Flatts, *E. G. B. 50, 53;* on *Nerium*, Devonshire Marsh, *E. G. B. 164;* on trees, Church Cove, *E. G. B. 1081.* The material shows considerable variability, but on account of the small size of the perithecia appears to belong here.

13. **Anthracothecium tetraspermum** Riddle, sp. nov.

Thallus epiphloeodes crustaceus indeterminatus, sat crassus, continuus sat laevigatus aut subleprosus, olivaceus opacus. Gonidia chroolepoidea. Perithecia dispersa, 0.4 mm. diam., nigra, primum immersa et thallo obducta apice anguste denudato, demum emergentia; amphithecio globoso completo. Paraphyses simplices. Asci constanter 4-spori. Sporae fuscae oblongae murali-divisae, 4-loculares, 2-locellati, 15–20 × 8–10 μ.

On bark of palmetto, Devonshire Marsh, collected by Mrs. E. G. Britton, No. 169 in part.

Distinct from all other species of the genus in the spore-characters.

14. MELANOTHECA AGGREGATA (Fée) Muell. Arg.

On *Elaeodendron*, without definite station, *Brown, Britton & Seaver, 1583.*

15. MELANOTHECA CRUENTA (Mont.) Muell. Arg.

Without definite station, *Challenger Expedition.*

16. PYRGILLUS CUBANUS Nyl.

On bark of palmetto, Devonshire Marsh, *E. G. B. 169* in part. An interesting species known previously only from the original collection made by Charles Wright in the island of Cuba.

17. ARTHONIA CONFERTA (Fée) Nyl.

On tamarisk, Biological Station, *E. G. B. 35;* on *Melia*, hillside near Flatts, *E. G. B. 52;* on *Melia*, Tucker's Town, *E. G. B. 866;* also, on *Melia*, Harrington Sound, *Brown & Britton, 836;* and without definite station, *W. G. Farlow.*

As was pointed out by Willey (Synopsis of the Genus *Arthonia* 12), this is the *Arthonia atrata* of the list in Hemsley's Report, but not of Fée.

18. ARTHONIA POLYMORPHA Ach.

On bark, without definite station, *Challenger Expedition*, under the name *Arthonia polymorphoides* Nyl. apud Crombie (*opus citi*), but the characters are certainly not of specific value, as they were based entirely on the chemical reactions of the hymenium.

19. ARTHONIA RUBELLA (Fée) Nyl.

On bark, Abbot's Cliff, *E. G. B. 924;* Church Cave, *E. G. B. 1082;* without definite station, *Challenger Expedition*, under the name "var. *inferiuscula* Nyl.," but the varietal characters given are not of sufficient importance.

20. ARTHOTHELIUM SPECTABILE (Flot.) Mass.

On *Elaeodendron*, without definite station, *Brown, Britton & Seaver 1585.*

21. OPEGRAPHA ATRA Pers.

On *Cocolobis*, Hungry Bay, *E. G. B. 203* in part, a small form; on *Conocarpus*, without definite station, *Brown, Britton & Seaver, 1211.*

22. OPEGRAPHA BONPLANDI Fée.

On decorticated *Juniperus*, north of Hamilton, *E. G. B. 69* in part; on *Randia*, sand hills near Paget, *E. G. B. 122;* Church Cave, *Brown & Britton, 1085;* on dead *Juniperus*, St. David's Island, *Brown, Britton & Bisset, 2080*, and on *Elaeodendron*, Abbotsford, *Brown, Britton & Bisset, 2110;* on *Juniperus*, without definite station, *Brown, Britton & Seaver, 1210, 1285.*

This species is as variable as it is common. No. 1085, with olive-brown thallus and short apothecia, is the nearest to Fée's original figure (Essai sur les Cryptogames *pl.5, f.4.* 1824). In Nos. 2110, 1210, 1285, the thallus is glaucescent instead of olivaceous. In some of the specimens the spores are somewhat wider than the figures given by Mueller-Argau, but there is nothing else to distinguish these from the typical form.

23. OPEGRAPHA CHEVALIERI var. **incarnata** Riddle, var. nov.

Thallus rimuloso-areolatus, roseo-suffusus vel tandem pallescens et argillaceus.

On calcareous rocks, without definite station, collected by Professor W. G. Farlow, 1880.

Type-specimen in the Cryptogamic Herbarium of Harvard University.

24. **Opegrapha ophites** Tuck. in herb., sp. nov.

Thallus epilithicus crustaceus indeterminatus tenuissimus, atro-griseus et fuligineo tinctus, aut demum evanescens. Lirellae sat graciles elongatae, 1.0–2.5 mm. long, 0.15 mm. latit., sat flexuosae nigrae nitidiusculae simplices aut rariore furcatae laevigatae aut parce transversim diffractae, disco rimiformi. Sporae incolores, 6–8-loculares, circa 22 × 7 μ.

On calcareous rocks, without definite station, collected by Professor W. G. Farlow, 1880.

Type-specimen in the Cryptogamic Herbarium of Harvard University.

25. OPEGRAPHA VULGATA Ach.

On *Eugenia*, without definite station, *Brown, Britton & Seaver, 1288.*

26. GRAPHIS AFZELII Ach.

Without definite station, *Challenger Expedition.*

27. GRAPHIS LINEOLA Ach.

On *Melia*, hillsides near Flatts, *E. G. B. 51.*

28. GRAPHIS PAVONIANA Fée.

On *Ilex*, Devonshire Marsh, *E. G. B. 377a.*

29. GRAPHIS SCRIPTA (L.) Ach.

On *Ilex*, Devonshire Marsh, *E. G. B. 377;* without definite station, *Challenger Expedition.*

30. GRAPHIS SCRIPTA var. SERPENTINA (Ach.) Nyl.

On *Celtis*, Caves, Walsingham, *E. G. B. 291.*

31. GRAPHIS STRIATULA (Ach.) Nyl.

On *Laurocerasus*, Paget Marsh, *E. G. B. 230.*

32. PHAEOGRAPHIS LOBATA (Eschw.) Muell. Arg.

Without definite station, *Challenger Expedition.*

33. GLYPHIS CICATRICOSA Ach.

On *Celtis*, Caves, Walsingham, *E. G. B. 292*, and Church Cave, *E. G. B. 1084;* on *Elaeodendron*, Walsingham, *Brown & Britton 862;* on lemon, Jayces' Dock, *Brown, Britton & Bisset 2104;* also, without definite station, *W. G. Farlow.* Recorded in Hemsley's Report under the synonym *Gl. Achariana* Tuck.

34. CHIODECTON MONTAGNEI Tuck.?

It seems best to place here specimens of sterile thallus collected by Mrs. E. G. Britton, on *Juniperus*, Paynter's Vale, *366;* on *Elaeodendron*, Abbot's Cliff, *941;* and on rocks at Abbot's Cliff, *950.* In the absence of fruit the disposition of these specimens must remain doubtful.

35. SCLEROPHYTON ELEGANS Eschw.

On *Elaeodendron*, without definite station, *Brown, Britton & Seaver 1580.*

36. GYROSTOMUM SCYPHULIFERUM (Ach.) Fr.

On *Celtis*, Walsingham, *E. G. B. 289.*

37. **Leptotrema trypaneoides** (Nyl.) Riddle, comb. nov.

Thelotrema trypaneoides Nyl. Ann. Sci. Nat. IV. **19**: 335. 1863. Type from Cuba.

On *Elaeodendron*, without definite station, *Brown, Britton & Seaver 1581, 1588.*

38. MICROPHIALE LUTEA (Dicks.) Steiner.

On *Melia*, Tucker's Town, *E. G. B.*, a few apothecia mixed with No. 867.

39. GYALECTA FARLOWI Tuck.; Nylander, Lich. Japon. 106. 1890.

The original description reads: "Species concinna affinis *G. hyalinae* Hepp; macula thallina alba vel carneoalba, apotheciis innatis dilute carneoluteis (latit. circ. 0.25 mm.) thelotremoideis; sporae ellipsoidea murales 18–23 × 9.11 μ."

On calcareous rocks, without definite station, *W. G. Farlow*.

LECIDEA.

In the Journal of the Linnaean Society (**14**: 371. 1875), Stirton described three new species of *Lecidea*: *L. euporiza*, *L. semiusta*, and *L. revertens*. These were based on the collections of the Challenger Expedition, and are said by Crombie to be rock-specimens too fragmentary for determination. Indeed, Stirton himself says that one of these was based on a single apothecium!

40. **Biatora fuscorubescens** (Nyl.) Riddle, comb. nov.

Lecidea fuscorubescens Nyl. Bull. Soc. Linn. Norm. II. **7**: 169. 1874.

Without definite station, *Challenger Expedition*.

Said to be related to *Biatora vernalis* (L.) Fr.

41. **Bilimbia Brittoniana** Riddle, sp. nov.

Thallus epiphloeodes crustaceus indeterminatus inaequaliter crassus, omnino granuloso-leprosus, sulphureus. Gonidia cystococcoidea. Apothecia sparsa et dispersa, sat thallo occulta, minuta, 0.2–0.4 mm. diam., plus minusve gyalectiformia, disco primum concavo demum plano pallide carneo, margine crasso integro persistente concolore; intus omnino incolores. Asci 8-spori. Sporae incolores fusiformes, utrinque apices obtusae, 4-loculares, 15–18 × 3 μ.

On exfoliating bark of *Juniperus*, north shore, collected by Mrs. E. G. Britton, August 31–September 20, 1905, no. 77.

This very distinct species has been named in honor of Dr. and Mrs. Britton. It is related to **Bilimbia floridana** (Tuck.) Riddle, comb. nov., but differing in the thallus being entirely made up of sulphury granules, which under the microscope are seen to be glomerules of gonidia with a loose mixture of hyphae. The regular, marginate apothecia, resembling those of *Microphiale lutea*, also distinguish this species from *B. floridana*.

42. **Bilimbia sphaeroides** var. **vacillans** (Nyl.) Riddle, comb. nov.

Lecidea sphaeroides var. *vacillans* Nyl. Lich. Scand. 204. 1861. Without definite station, *Brown, Britton & Seaver, 1279.*

43. BACIDIA FUSCORUBELLA (Hoffm.) Th. Fr.

On *Rhizophora*, Fairy Land, *E. G. B. 194* in part; without definite station, *W. G. Farlow.*

Agrees well with Wright's Lich. Cub. No. 220, in the Tuckerman Herbarium under the synonym *Biatora rubella* var. *spadicea* (Ach.) Tuck.

44. CLADONIA FIMBRIATA var. BORBONICA (Del.) Wainio.

On a roadside banking, Harrington House, *Brown & Britton 852.* Tropical material of the *fimbriata-pityrea* group offers an almost hopeless problem, but this specimen agrees well with Wright's Lich. Cub. No. 31, which is cited by Wainio under his account of this variety.

45. CLADONIA FIMBRIATA var. NEMOXYNA (Ach.) Coem.

According to Wainio, the specimen called "*Cl. fibula* Hoffm." in Crombie's Report belongs here. The specimen listed in the same report as "*Cl. acuminata* var. *hebescens* Nyl." is said by Wainio to be related to *Cl. fimbriata*, but not in condition for determination.

46. CLADONIA FIMBRIATA var. SIMPLEX (Weis.) Flot.

On a stone-wall near St. Mark's Church, *Brown & Britton 496; E. G. B. 1861.*

The squamules of the primary thallus are more compact than in northern material, but there seems to be nothing else to distinguish this.

47. CLADONIA MITRULA Tuck.

On the ground, Hall's Island, *E. G. B. 887* (typical); Paynter's Vale, *Brown & Britton, 980* (reduced); Paget Marsh, *E. G. B. 1862;* without definite station, *Brown, Britton & Seaver 1333;* also *Challenger Expedition.*

48. CLADONIA PITYREA (Flke.) Fr.

On the ground, growing mixed with *Cl. mitrula, Brown, Britton & Seaver, 1333* in part.

49. CLADONIA RANGIFORMIS var. PUNGENS (Ach.) Wainio.

Without definite station, *Challenger Expedition.*

50. **Psorotichia bermudana** Riddle, sp. nov.

Thallus crustaceus effusus indeterminatus crassus (0.3–0.5 mm.) diffracto-areolatus, areolis angulosis 1–2 mm. latis subdispersis, nitidus fusco-niger (madefactus atro-olivaceus), minute crebreque verruculosus vel coralloideo-granulosus; pro maxima parte hyphis tenuibus laxisque constitutis, strato exteriore tenui parenchymatico cellulis 4–10 × 4–6 μ. Gonidia gloeocapsoidea cellulis 4–6 μ diam., in glomerulosas circa 10–15 μ consociatis, tegumento gelatino fuscoluteo. Apothecia primum subimmersa demum superficialia et lecanorina, ad 0.6 mm. diam., disco inaequali fusco-nigro, margine thallino tenui granulato; intus omnino incolores. Sporae incolores simplices ellipsoideae, 14–16 × 8 μ. Spermagonia ovoidea verruculis thallinis immersa. Spermatia oblonga recta, 2–4 × 1 μ.

On calcareous rocks, without definite station, collected by Messrs. Brown, Britton & Seaver, November 29–December 14, 1912, No. 1415.

In habit this species resembles *Psorotichia diffracta* Forssell, as represented in Claudel & Harmand, Lich. Gall. Exsic. 301.

51. OMPHALARIA CUBANA Tuck.

On calcareous rocks, Castle Harbor, *Stewardson Brown 628.*

52. OMPHALARIA LINGULATA Tuck.

On calcareous rocks, Walsingham, *W. G. Farlow,* 1881; in the same region, *Brown, Britton & Seaver 2245.*

Known elsewhere from Cuba and Mona Island.

53. **Collema bermudanum** Tuck. in herb., sp. nov.

Thallus foliaceus laxe adherentis irregulariter crebre laciniatus, siccus rigidus madefactus gelatinosus, lacinulis inciso-crenatis, ad 1 mm. latis, crassiusculis planis scrabiusculis apicibus turgidis adscendentibus imbricatis, in pulvinulos constipatis 5–10 mm. diam., isidiis granulisque destitutus, superne atro-olivaceus subtus nigrescens; strato corticali destitutus. Gonidia nostocacea. Apothecia dispersa primum immersa demum subsuperficialia, ad 0.6 mm. diam., disco badio plano, margine thallino crasso integro persistente. Sporae incolores oblongae 4-loculares, 20–30 × 10–12 μ.

On calcareous rocks, Walsingham, collected by Professor W. G. Farlow, 1880.

Type-specimen in the Cryptogamic Herbarium of Harvard University.

In a letter to Professor Farlow, under date of August 25, 1881, Tuckerman wrote of this species: "*Collema* cum *C. furvo* forsan comparabile sed distincta."

54. COLLEMA FLACCIDUM Ach.

Without definite station, *Brown, Britton & Seaver 1348*.

55. COLLEMA NIGRESCENS (Huds.) Ach.

On *Avicennia*, Walsingham, *W. G. Farlow.*

56. **Collema thamnodes** Tuck. in herb., sp. nov.

Thallus fruticulosus irregulariter ramosus in pulvinulos constipatis 5–10 mm. diam., ramis erectis compressis, circa 3–5 mm. altit., 1.2 mm. latit., 0.5 mm. crassis, partim crebris isidiis, viridi-fuscus vel fusco-niger; strato corticali destitutus. Gonidia nostocacea. Apothecia ignota.

On calcareous rocks, Walsingham, collected by Professor W. G. Farlow, 1880.

Type-specimen in the Cryptogamic Herbarium of Harvard University.

57. LEPTOGIUM MARGINELLUM (Sw.) Mont.

On *Jasminium*, Paynter's Vale, *E. G. B. 368;* on *Juniperus*, without definite station, *Brown, Britton & Seaver, 1410, 1586* (beautiful specimens!).

58. LEPTOGIUM TENUISSIMUM (Dicks.) Koerb.

On the ground, Paynter's Vale, *Brown & Britton 979*.

One would scarcely expect this northern species in Bermuda, and the material being sterile the determination is not certain, but the thalline characters agree with this species.

59. LEPTOGIUM TREMELLOIDES (L. f.) S. F. Gray.

Including *L. diaphanum* (Sw.) Ach. of Crombie's Report.

There are two recognizable phases of the species in Bermuda, although these are not distinct enough to receive names. The following specimens have abundant apothecia and few lobules: on *Juniperus*, Devonshire Marsh, *E. G. B. 39;* on *Elaeodendron*, *847*, and on *Conocarpus*, Castle Harbor, *Brown & Britton 849*. The remaining specimens are sparingly fruited and have the lobes more or less densely fringed with lobules: on various trees, Walsingham, *M. A. Howe;* Castle Harbor, *846*, *848;* Hall's Island, *886*, and Paynter's Vale, *Brown & Britton 992;* St. David's Island, *Brown, Britton & Bisset, 2079*. Also collected by the Challenger Expedition.

60. PERTUSARIA LEIOPLACA (Ach.) Schaer.

P. papillata (Ach.) Nyl. of Crombie's Report.

On orange, Paynter's Vale, *E. G. B. 364;* without definite station, *W. G. Farlow;* also *Challenger Expedition*.

61. PERTUSARIA LUTESCENS (Eschw.) Krempelh. Lichenen-Flora der Südsee-Inseln, Jour. Mus. Godeffroy 1: 104. Hamburg. 1873.

Pertusaria communis var. *lutescens* Eschw.; Martius, Flor. Bras. 1: 118. 1833.

A complete description of the species based on several specimens, including the type, was given in Mueller-Argau's Revisio Lichenum Eschweilerianum, Flora **67**: 672. 1884.

On tamarisk, Biological Station, *E. G. B. 36* in part; and on *Melia*, hillside near Flatts, *E. G. B. 55*.

There has been no authentic specimen of this species for comparison but the material agrees well with Mueller-Argau's description cited above. The species is recorded from Rio Janeiro and Bahia, Brazil, and from Cuba. In the Cryptogamic Herbarium of Harvard University there are specimens from the southern United States, which Tuckerman had labelled under this name with a query.

62. PERTUSARIA MULTIPUNCTA (Turn.) Nyl.

On orange, Walsingham, *E. G. B. 1;* on *Elaeodendron*, Walsingham, *Brown & Britton 863*, and Abbot's Cliff, *Brown & Britton 943*.

63. PERTUSARIA PUSTULATA (Ach.) Nyl.

On bark, Mangrove Creek, *W. G. Farlow;* without definite station, *Challenger Expedition.*

64. PERTUSARIA TUBERCULIFERA Nyl.

On *Celtis*, Walsingham, *E. G. B. 290.*

65. LECANORA BERMUDENSIS Nyl.; Crombie, Jour. Linn. Soc. Bot. **16**: 215. 1877.

Without definite station, *Challenger Expedition.*

Said to be related to *L. Hageni* Ach. I know nothing further of it.

66. LECANORA CINEREOCARNEA (Eschw.) Wainio.

Including *L. chlaronella* Nyl. of Crombie's Report.

Occurring in three well-marked forms:

Forma TYPICA, thallo crassitudine mediocre verruculoso vel verrucoso. On tamarisk, Biological Station, *37b;* on *Melia*, hillside near Flatts, *54;* on decorticated *Juniperus*, north of Hamilton, *68;* on *Rhizophora*, Fairy Land, *192* in part; on cedar posts, Paynter's Vale, *988;* all collected by Mrs. E. G. Britton.

Forma **athallina** Riddle, f. nov., thallo evanescente. On pine fence, Paynter's Vale, *E. G. B. 989, 991a.*

Forma **rugosa** Riddle, f. nov., thallo crasso rugoso. On *Melia*, west end of Causeway, *Brown & Britton, 996.*

67. LECANORA PALLIDA var. CANCRIFORMIS Tuck.

Including *L. glaucomodes* var. *conflectens* Nyl. of Crombie's Report. On *Diospyros*, Warwick Marsh, *E. G. B. 306;* without definite station, *W. G. Farlow;* also *Challenger Expedition.*

68. LECANORA SUBFUSCA (L.) Ach.

On tamarisk, Biological Station, *E. G. B. 37a;* on *Melia*, Tucker's Town, *E. G. B. 867* in part. These specimens appear to belong to the variety *allophana* Ach. In Crombie's Report, there is recorded a var. *sylvestris* Nyl. (Bull. Soc. Bot. France **15**: 188. 1868), but this is a *nomen nudum*.

69. LECANORA VARIA (Hoffm.) Ach.

On *Celtis*, Walsingham, *E. G. B. 288*.

70. LECANORA VARIA var. SYMMICTA Ach.

On *Conocarpus*, without definite station, *Brown, Britton & Seaver, 1211* in part.

71. HAEMATOMMA PUNICEUM (Ach.) Wainio.

On *Diospyros*, Warwick Marsh, *E. G. B. 307;* on *Melia*, Tucker's Town, *E. G. B. 864;* on palmetto, "the commonest habitat," without definite station, *W. G. Farlow*.

72. PARMELIA LATISSIMA var. CRISTIFERA (Tayl.) Hue.

On palmetto, North Shore Road, *E. G. B. 15*.

73. PARMELIA PERLATA (L.) Ach.

Paynter's Vale, *W. G. Farlow;* without definite station, *Challenger Expedition*.

74. PARMELIA TINCTORUM Despr.

On palmetto, Devonshire Marsh, *E. G. B. 167;* without definite station, *Challenger Expedition*.

75. RAMALINA COMPLANATA (Sw.) Ach.

On various trees and shrubs, Abbot's Cliff, *889*, *934*, Fairy Land, *191*, Walsingham, *295*, Serpentine Marsh, *104*, all collected by Mrs. E. G. Britton; also, Tucker's Town, *818*, and Mangrove Pond, *1035*, *Brown & Britton*.

76. BUELLIA CANESCENS (Dicks.) DeNot.

On roadside wall, Devonshire, *E. G. B. 155*.

No fruit has been found so the determination cannot be regarded as certain, but the thalline characters agree exactly with those of the species cited. As this species is entirely unknown in America, the interesting possibility suggests itself of its having been introduced into Bermuda from England, where it is common in just such habitats as the one given.

77. BUELLIA MYRIOCARPA (DC.) Mudd.

On bark of *Melia*, Tucker's Town, *E. G. B. 867* in part; without definite station, *W. G. Farlow*.

78. BUELLIA PARASEMA (Ach.) Th. Fr.

On pine-rail fence, Paynter's Vale, *Brown & Britton 991;* on *Juniperus*, St. David's Island, *Brown, Britton & Bisset 2078*.

The Bermuda material of this species varies considerably from the species as known in the northeastern United States. The thallus is either more distinctly areolate, or, in other specimens, almost absent, the disk of the apothecia is very flat, and the spores of the minimum size for the species. Yet it scarcely seems worth while giving a varietal name in the case of such a polymorphic species.

79. RINODINA INSPERATA (Nyl.) Zahlbr.; Engler & Prantl, Nat. Pflanzenfam. **1**^{1*}: 232. 1907.

Without definite station, *Challenger Expedition*.

This was published originally as *Lecanora insperata* Nyl. Act. Soc. Sci. Fenn. **7**: 443. 1863. Then it was changed to *Lecidea* Nyl.; Crombie, Jour. Linn. Soc. Bot. **16**: 215. 1877. Hue, in his Lichenes Exotici (Nouv. Arch. Mus. d'Hist. Nat. Paris III. **3**: 139. 1891), places it under "Stirps *Lecideae* (*Buelliae*) *myriocarpae*." An examination of an apothecium from an original specimen in Lindig's Lich. Nov. Gran. No. 2616 shows beyond doubt that Zahlbruckner's disposition of the species is correct, in spite of the thalline exciple having disappeared.

80. BLASTENIA FLORIDANA (Tuck.) Zahlbr.

On tamarisk, Biological Station, *E. G. B. 36*, and on *Coccolobis*, north of Hamilton, *E. G. B. 66*.

81. PHYSCIA PICTA (Sw.) Nyl.

On a cliff, Paynter's Vale, *362;* on *Juniperus*, Paynter's Vale, *367;* on stone wall, Harrington House, *853;* on *Melia*, Tucker's Town, *867;* on palmetto, Devonshire Marsh, *169* in part; all collected by Mrs. E. G. Britton.

82. PHYSCIA ALBA (Fée) Muell. Arg.

A small form on *Rhizophora*, Fairy Land, *E. G. B. 192*.

83. PHYSCIA CRISPA (Pers.) Nyl.

On *Avicennia*, Serpentine Marsh, *105;* on rocks, Abbot's Cliff, *937*, *945*, 946, sterile, and *938*, fruiting; on *Celtis*, Abbot's Cliff, *947*, fruiting; all collected by Mrs. E. G. Britton; on *Juniperus*, Abbot's Cliff, *935;* on rocks, Abbot's Cliff, *939*, *940;* on *Avicennia*, west end of Causeway, *995;* all collected by Brown and Britton.

84. PHYSCIA INTEGRATA var. SOREDIOSA Wainio.

Ph. obsessa (Mont.) Nyl. of Crombie's Report.

On *Celtis*, Abbot's Cliff, *E. G. B. 923*, and on bark, Church Cave, *1080* in part, *E. G. B.*

85. PHYSCIA LEANA Tuck.

Without definite station, *Challenger Expedition*.

I give this record on the basis of Crombie's Report, not having seen the specimens, but it seems to me doubtful if the determination is correct.

86. PHYSCIA STELLARIS (L.) Nyl.

On various trees and shrubs, Biological Station, *34;* Serpentine Marsh, *106;* Tucker's Town, *865;* Abbot's Cliff, *922;* Bassett's Caves, *1040;* all collected by Mrs. E. G. Britton; also, Smith's Island, *Brown, Britton & Bisset 2102*, and without definite station, *W. G. Farlow.*

WELLESLEY COLLEGE,
WELLESLEY, MASSACHUSETTS

INDEX TO AMERICAN BOTANICAL LITERATURE

1911-1916

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 the broadest sense.

Reviews, and papers that 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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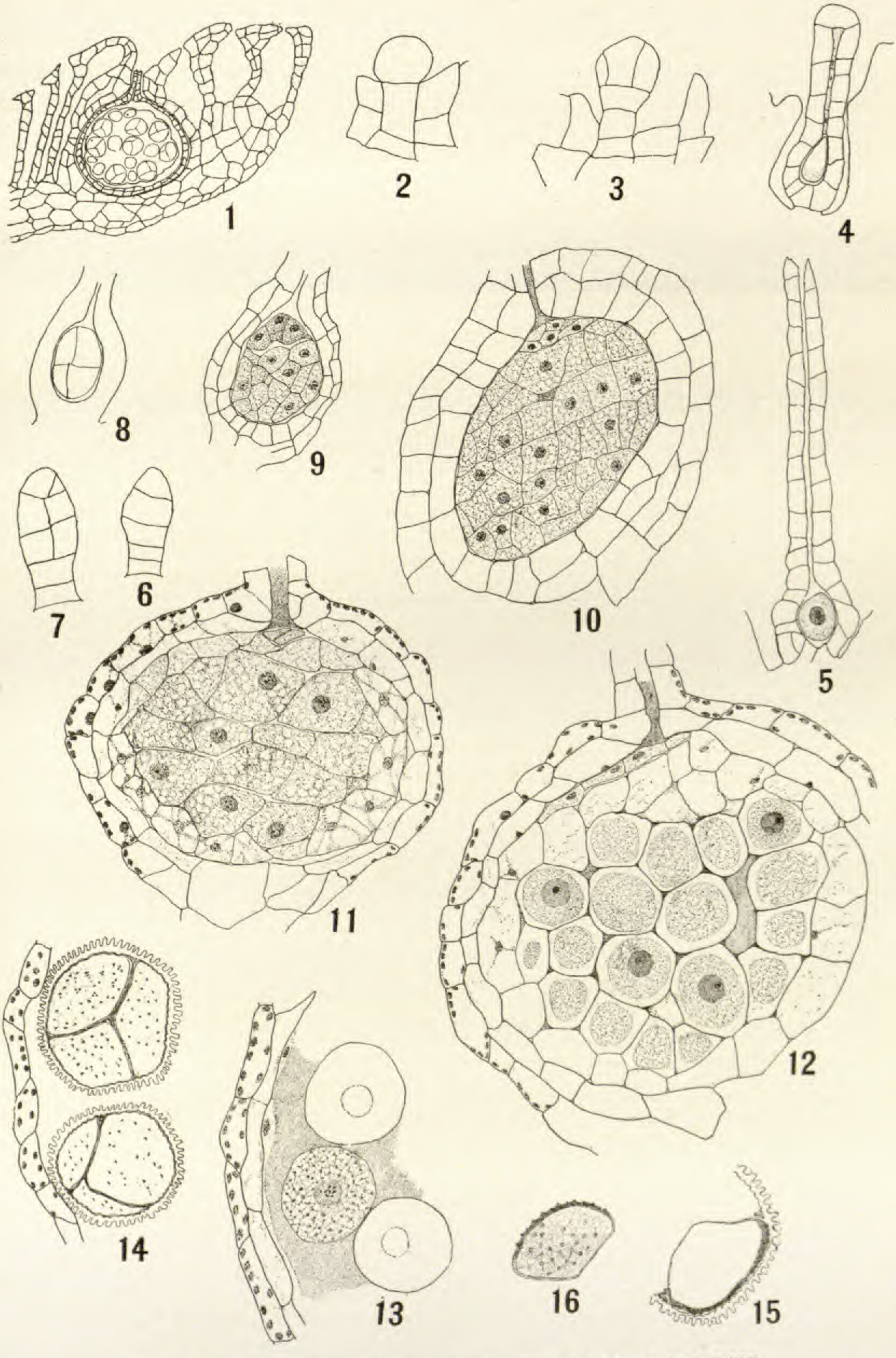

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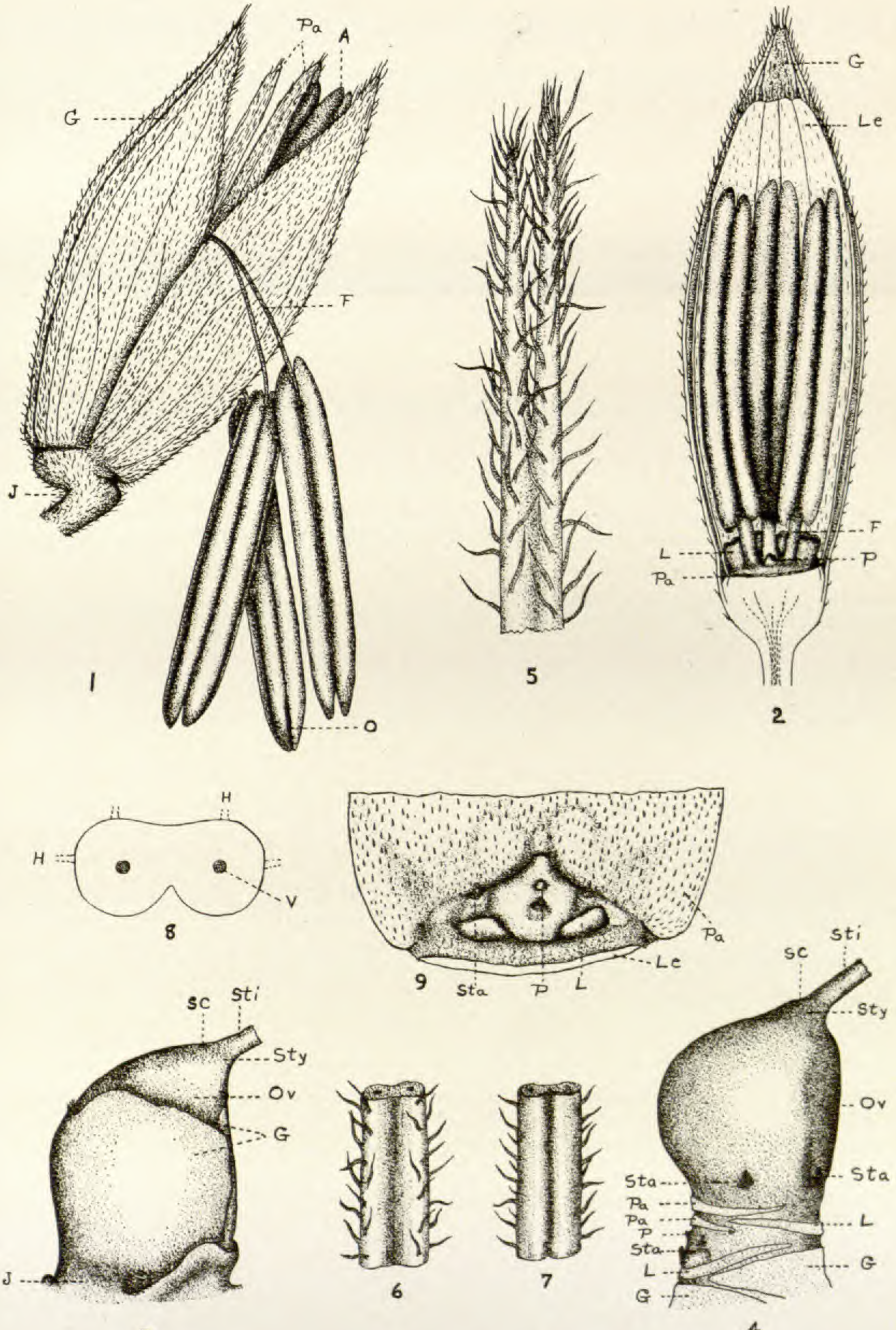

WEATHERWAX: FLOWERS OF ZEA MAYS

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

APRIL, 1916

Notes on species of Halymenia

F. S. Collins and M. A. Howe

In connection with studies of a series of specimens of red algae of the genus *Halymenia* from Bermuda, southern Florida, and North Carolina, we have been forced to recognize as entitled to specific rank four striking and apparently well-defined forms that we are venturing to describe as new. One of these is related to *Halymenia floridana* J. Ag., two find their closest affinity in *H. Floresia* (Clem.) Ag., and the fourth is allied to *H. actinophysa* M. A. Howe. Descriptions follow:

Halymenia bermudensis sp. nov.

Thallo violaceo-rubro, plerumque stipitato; stipite inferne subtereti, superne complanato vel costato-alato, interdum ramoso, plus minusve elongato; fronde membranacea, firma, levi, nec nitente, 60–120 μ crassa, suborbiculari, cordata vel obovata, saepe, interdum repetite, lobata vel prolifera, divisionibus frondi primariae conformibus; margine plana vel plicata, subintegra, crenata, vel interdum irregulariter dentata; medulla frondis subcompacta, inter fila tenuiora filis crassioribus stellatim radiatis frequenter sparsis; strato corticali frondis series 1–3 cellularum minorum monstrante; strato subcorticali series 1–3 cellularum majorum monstrante; tetrasporangiis sparsis; cystocarpiis ignotis.

Species *H. floridanae* J. Ag. proxima, sed differt colore magis saturate violaceo-rubro, minus roseo, fronde magis dissecta, substantia firmiore, cortice crassiore, firmiore, saepe pleiostromatico.

[The Bulletin for March (43: 117–168. *pl. 4–6*) was issued April 14, 1916.]

Ad oras Insularum Bermudensium (typum legit F. S. Collins, Apr. 25, 1912, no. 7074).

Thallus usually stipitate; stipe commonly 2–10 mm. long, 0.45–0.75 mm. thick, subterete below, complanate or costate-alate above, sometimes branched, occasionally more elongate and subrhizomatous; frond membranous, rather firm or slightly gelatinous, 60–120 μ thick, variable in form, suborbicular, cordate, or obovate, attaining a width of 4–30 cm., subentire, or sparingly or copiously lobed or proliferous, the lobes or proliferations conformable or ovate, themselves sometimes once or twice lobed in similar fashion, the proliferations often stipitate, the apices rounded-obtuse, the margins plane or more or less ruffled-plicate, subentire, lightly sinuate-crenate, or now and then irregularly coarsely or obscurely dentate; surface dull or rarely subnitent, smooth; color (dried) violet-red (rosolane-purple to Indian lake*); medulla of stipe compact, sometimes pseudoparenchymatous, 0.15–0.45 mm. thick; cortex of stipe or of its costa very firm, compact, parenchymatous, 8–30 cells thick, its cells in distinct anticlinal rows, cells of subcortex larger and irregularly disposed; medulla of frond moderately compact, its filaments mostly 3–8 μ in diameter, usually interspersed (in older parts at least) with coarser filaments, 6–20 μ in diameter, having more homogeneous refringent contents, such filaments radiating from substellate ganglion-like enlargements 15–65 μ in diameter; cortex of frond parenchymatous or subparenchymatous, 1–3 cells thick, the cells usually firm-walled, subquadrate in section, the superficial cells angular, mostly 5–10 μ in diameter in surface view, their outer walls 2–4 μ thick, protoplasts close (separated 2–3 μ), subcortex 1–3 cells thick, its cells mostly 13–25 μ in diameter; tetrasporangia 12–16 μ × 8–10 μ; cystocarps unknown.

BERMUDA: In shallow water in clefts of rocks and caves and among roots of *Rhizophora; A. F. Kemp*, August, 1856 (as *Rhodymenia palmata*); Walsingham, *W. G. Farlow*, February, 1881; near Hamilton, *M. A. Howe 69*, June 12, 1900; Stokes Bay, Tucker's Town, *M. A. Howe 313*, July 6, 1900; Harrington Sound, *A. B. Hervey*, January 15, 1913; Dingle Bay, *A. B. Hervey*, March 30, 1915; Grasmere, *A. B. Hervey*, March 9, 1914; Old Ferry, *A. B. Hervey*, April 2, 1913; Castle Harbor, *F. S. Collins*, April 25, 1912 (Phyc. Bor.-Am. *2050*), and May 3, 1913.

TYPE: Castle Harbor, near Tucker's Town, April 25, 1912, *F. S. Collins 7074*, in herb. F. S. Collins.

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* Ridgway, R. Color standards and color nomenclature *pl. 26*. 1912.

This species seems to be fairly common in Bermuda. Its favorite habitat is the walls of narrow deep clefts in the shore cliffs, such as are found between Tucker's Town and Walsingham. Here it grows from a little below low-water mark down at least to a depth of two or three meters, usually as single separate plants rather than in dense tufts. It seems to thrive best where much shaded. In an unattached condition it occurs also among mangrove roots, as in the vicinity of Hamilton. These loose fronds are darker in color, firmer in texture, and less adherent to paper when dried under pressure than are the attached forms. There is much variation in the form of the frond; the primary form seems to be orbicular and plane with a slightly developed stipe. Rapid marginal growth of the frond results in ruffles and plications, and when these are well developed the plant has somewhat the aspect of *Porphyra amplissima* in miniature. In color and habit it is often suggestive also of certain conditions of *Callymenia reniformis*, from which, however, it differs markedly in structure. Proliferous growth is common; the proliferations are sometimes sessile but are oftener stipitate, the stipe terete or flattened, in the latter case with or without an obvious costa, which may be continued into the base of the main expansion. In the older plants, under certain conditions of growth, the basal stipe, terete or flattened, may branch and form a matted subrhizomatous complex from which individual fronds arise, these usually orbicular or cuneate, or sometimes cordate from a cuneate base. An important character of this species is the presence, in the medulla, of conspicuous stellate ganglia more or less similar to those exhibited by the type specimen of *Halymenia floridana* J. Ag. and by *Sebdenia heteronema* M. A. Howe.* These may be easily observed through the cortex by transmitted reduced light under low-power lenses without the use of any staining reagents; however, their protoplasts have a peculiar affinity for haematoxylin stains and they may be differentiated with remarkable distinctness by overstaining with preparations of haematoxylin and afterwards partly decolorizing. The nodes of the ganglia are irregularly stellate or subglobose; from each of them radiate three to ten coarse rather rigid and straight tapering filaments with dense homogeneous refringent contents; in the

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* Mem. Torrey Club 15: 163–165. *pl. 58.* 1914.

less developed conditions these radiating arms seem to lose themselves among the ordinary filaments of the medulla, but in older well-developed states some of these radiating arms may be traced directly to other ganglia, which thus form an interconnecting system. When a portion of the thallus is crushed on a glass slide and the other parts are reduced to a confused mass these ganglia and their rays often persist with little change. Septa in these enlarged specialized filaments are distant and irregularly placed. We have seen but few tetraspores and these were apparently not very well developed. Cystocarps have not been observed, although hundreds of specimens have been examined with the hope of finding them. In one lot of material, however, from Grasmere, we found small red spots resembling cystocarps under a hand lens, but these spots were apparently caused by the irritation of some endophyte or through injury by some small animal.

Halymenia bermudensis evidently finds its nearest ally in the little-known *H. floridana* J. Ag.,* with the type of which, as also with the Peruvian *Sebdenia heteronema* M. A. Howe,† it shows more or less agreement in having usually rather conspicuous substellate medullary ganglia. It differs, however, from *H. floridana*, which is now known only from southern Florida and from near Beaufort, North Carolina (*W. D. Hoyt*), in its darker color (rosolane purple rather than pinkish vinaceous), in its commonly more lobed or dissected thallus, in its rather firmer texture, in its thicker, firmer, and less monostromatic cortex, and in its possible loss of sexual reproduction. Although, in a general way, the two species show a similarity in the medullary ganglia and the dimorphous medullary filaments, a critical comparison shows certain points of difference in these organs. The ganglia are less numerous, less conspicuous, and less obviously anastomosing in *H. bermudensis*. The arms on leaving the ganglion commonly taper away gradually, usually without a septum or obvious interruption of the protoplast; in *H. floridana*, the arms usually taper towards the ganglion and usually have a septum or a wide interruption of the protoplast near the place of emergence. As a result of these

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* Anal. Alg. 59. 1892. Howe, Bull. Torrey Club 38: 511. 1911; Mem. Torrey Club 15: 164. 1914.

† Loc. cit.

peculiarities, the outline of the central node or ganglion in *H. bermudensis* is, when viewed through the cortex, more lobed, stellate, or brachiate, and less orbicular or rotate than in *H. floridana*.

J. Agardh founded *Halymenia floridana* on several specimens sent to him from Florida by Mrs. Floretta C. Curtiss, and he appears to have put certain specimens of the same thing, or of the typical thing, in the "*Kallymenia reniformis*" cover in his herbarium. Specimens of it, collected by A. H. Curtiss at Gilbert's Bar, Florida, were distributed by Curtiss with a printed "Algae Floridanae" label under the name "*Kallymenia reniformis* J. Ag.," from which plant it differs greatly in structure. *Halymenia floridana* and *H. bermudensis*, however, differ from typical *Halymenia* (*H. Floresia*) in their firmer subparenchymatous cortex, in their much firmer, non-deliquescent and scarcely gelatinous outer walls of the superficial cells, and in the striking development of the medullary ganglia. It is possible, as has already been hinted by one of us,* that more critical studies, especially of the development of the cystocarps (abundant in *H. floridana*), may furnish adequate grounds for the establishment of a new generic group which would include not only *Halymenia floridana* and *H. bermudensis* but also the Peruvian *Sebdenia heteronema*. J. Agardh placed *Halymenia floridana* in his section *Halarachnion* of the genus *Halymenia*, and De-Toni† has ranged it, with a question mark, under the generic name *Halarachnion*, but the type of *Halarachnion* (*H. ligulatum*) has no medullary ganglia comparable with those of *Halymenia floridana* and it differs also in the structure of the cortex.

Halymenia bermudensis may or may not adhere to paper when dried under pressure.

Halymenia Gelinaria sp. nov.

Thallo roseo-vinaceo vel vinaceo-purpureo, brevi-stipitato; stipite a disco basali orto, inferne subtereti, superne cuneato; fronde plana, levi, nec nitente, membranacea vel subcarnosa, plerumque maxime gelatinosa, 60–600 μ crassa, suborbiculari, oblonga, ovata vel cuneato-obovata, latitudine 5 cm. usque 6 dm.,

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* Howe, Mem. Torrey Club **15**: 165. 1914.

† Syll. Alg. **4**: 1655. 1905.

simplice vel parce subconformiter divisa, margine plana, integra vel irregulariter dentata aut crenulata, nonnunquam fimbriata; medulla frondis laxa vel subvacua, filamentis transversalibus crebris, filis stellatis paucis et inconspicuis; strato subcorticali dense filamentoso, filamentis anastomosantibus, cellulis nodalibus majoribus; strato corticali series 1–4 cellularum monstrante, parietibus cellularum mollissimis, gelatinoso-deliquescentibus; tetrasporangiis decussatim divisis; cystocarpiis numerosis, minutis, ad una pagina frondis plerumque prominulis, massa sporarum turbinata, 120–140 μ diam.

Species colore, habitu, cystocarpiorum forma, *H. floridanae* J. Ag. proxima, sed differt thallo multo magis gelatinoso, plerumque crassiore, cortice manifeste filamentoso, nec pseudoparenchymato, filis stellatis minus evolutis. Structura *H. Floresiae* (Clem.) Ag. similis, habitu differt, fronde latiore integra vel subintegra, nec regulariter pinnata.

Ad oras Floridae et Carolinae Septentrionalis (typum legit M. A. Howe in loco "Jupiter Inlet" dicto ad oras Floridae, Oct, 13, 1902, no. 1252).

Thallus short-stipitate from a small basal disk; stipe 3–5 mm. long, 0.75–1.2 mm. thick, cuneate from a subterete base; frond plane, membranous or carnose-membranous, usually very gelatinous, 60–600* μ thick, suborbicular, oblong, ovate, or cuneate-obovate, attaining a width of 5 cm. to 6 dm., subentire or rather sparingly (usually conformably) parted, lobed, or proliferous, the margins entire or very irregularly lobulate, dentate, erose-crenulate, or occasionally laciniate-fimbriate; surface dull, smooth; color pinkish vinaceous, rocellin-purple, vinaceous purple, or deep hellebore-red;† medulla of stipe 0.45–0.75 mm. thick, moderately compact, gelatinous; cortex of stipe gelatinous, mostly 8–15 cells thick; medulla of frond moderately compact or subvacuous, its filaments mostly 8–14 μ in diameter, many of them obliquely transverse, connecting the opposite subcortical layers, the cells mostly 20–70 μ long, the medulla occasionally showing a few rather inconspicuous stellate ganglia with nodes 20–40 μ in diameter and slender, elongate, rigid, straight or flexuous, now and then tortuous or nodulose, usually long-celled, radiating filaments, these commonly 4–7 μ in diameter, the ganglionic system with

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* The minimum is drawn from the thinner parts of dried specimens, as shown when sections are soaked out with water; the maximum is from the older parts as shown in formalin-preserved material.

† Ridgway, loc. cit. *pl. 27 and 38.*

more homogeneous refringent protoplasts; cortex and subcortex of frond rather distinctly filamentous; subcortex consisting of a close network of anastomosing filaments, the stellately branched nodal cells mostly 13–20 μ in diameter; cortex 1–4 cells thick, the superficial cells (protoplasts) 3–10 μ in diameter in surface view, mostly obtuse and more or less isodiametric, sometimes broader than high, or, 1.5–2 times higher than broad and subacute, often segregated in groups of 2–8, their outer walls very gelatinous and deliquescent; tetrasporangia (protoplasts) 18–26 μ × 13 μ, the spores decussately paired; cystocarps numerous, minute, commonly slightly protuberant on one face, the spore-mass turbinate, 120–240 μ in diameter.

FLORIDA: Unattached, Jupiter Inlet, *Mrs. G. A. Hall*, September 14, 1896 (Phyc. Bor.-Am. *749b* and *749c*, as *H. floridana*); *M. A. Howe 1252–1255*, October 13, 1902; Indian River Inlet, *Mrs. G. A. Hall*, May, 1899 (Phyc. Bor.-Am. *749a*, as *H. floridana*, and *750*, as *H. floridana*, forma *dentata*); Key West, *Mrs. G. A. Hall.*

NORTH CAROLINA: Bogue Beach, Beaufort, *W. D. Hoyt*, August 12 and 16, 1907.

TYPE: Jupiter Inlet, Florida, October 13, 1902, *M. A. Howe 1252*, sheet C, in herb. N. Y. Botanical Garden.

The plant is known locally in the Jupiter Inlet region as the "beefsteak" seaweed. In form and color of the thallus, as well as in size and form of the cystocarps, *Halymenia Gelinaria* bears a remarkable resemblance to *H. floridana;* in fact, for two species that differ so much in the structure of the cortex, the similarity is astonishing. The affinities of *H. Gelinaria* are, however, clearly with *H. Floresia*, a species that it resembles much less in general habit. From *H. Floresia*, it differs chiefly in forming broad, entire or subentire membranes, which may reach a length or width of 60 cm., and in the less often acute, more isodiametric, superficial cells. *H. Floresia*, in typical forms, was found floating with it in Jupiter Inlet (*Howe 1231*) without intergrading conditions. When lobules, proliferations, or teeth occur in *H. Gelinaria*, they are very irregularly disposed, while in *H. Floresia* the branching is manifestly pinnate, or rather, bi-tri-pinnate. The main axes in *H. Floresia* may vary a good deal in width, but we have never seen them any broader than 7 cm. and they are rarely more than

2 or 3 cm. in width. From *Halymenia floridana, H. Gelinaria* differs in the much more gelatinous, often thicker, thallus, in the less firm, obviously filamentous rather than parenchymatous or subparenchymatous cortex, in the deliquescent outer walls of the superficial cells, in the longer cells of the medullary filaments, and in the comparatively rare and inconspicuous and differently shaped medullary ganglia. In *H. floridana* the freely anastomosing medullary ganglia are, with proper illumination or with differential staining* the most conspicuous anatomical feature of the thallus; their radiating branches are coarser than the ordinary medullary filaments and the ganglionic system looks like a sort of skeleton or framework about which the rest of the thallus has been filled in. In *H. Gelinaria*, small stellate cells, with ordinary unspecialized protoplasts are normal elements of the subcortex, but larger specialized stellate ganglia of the medulla with refringent protoplasts are rare or occasional and are not usually obvious without a special search; their radiating branches are commonly more slender than the ordinary medullary filaments among which they make their way; these branches rarely anastomose, commonly showing free ends, and they are, perhaps, rather more suggestive of medullary rhizoids than parts of a primary framework, yet they seem to differ from the medullary rhizoids of the Florideae in general in being straighter and more rigid, and in having denser more homogeneous refringent protoplasts. Medullary ganglia of a somewhat similar sort are of occasional occurrence in *H. Floresia* also. The difference between *H. Gelinaria* and *H. floridana* as to the character of the cortex comes out strongly when a section is made or even when a margin or a fold of the surface is examined microscopically; in *H. Gelinaria*, the dissolving away of the outer walls of the superficial cells leaves these cells more or less isolated and separate, so that the general surface appears minutely papillate, while in *H. floridana* under the same conditions the general surface is covered by a firm cuticle and is perfectly smooth. The cystocarps of *H. floridana* and *H. Gelinaria* appear to be very similar in form, size, and structure, but it is possible that an exhaustive study of the earlier stages of their development might reveal differences as marked

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* See page 171.

as are shown by a microscopic comparison of the vegetative characters of these two superficially similar plants. The cystocarp of *H. floridana*, however, is commonly somewhat protuberant on both faces of the frond, while that of *H. Gelinaria* is commonly protuberant on only one face. In both, the spore-mass or "nucleus" is very dense, turbinate or oblate-spheroid, sometimes apparently two- or three-lobed, and is supported by a short stalk.

In 1900 (Phyc. Bor-Am. 750) the senior author of the present paper used the name "*Halymenia floridana* forma *dentata* (Crouan) Collins" for a dentate-margined condition of the present species, citing *Gelinaria dentata* Crouan in Mazé & Schramm, Algues de Guadeloupe, as a synonym. In doing this he was, in effect, adopting the opinion (expressed *in litt.*) of a distinguished phycologist who was familiar with the Guadeloupe specimens distributed by Mazé & Schramm but knew *Halymenia floridana* J. Ag. from description only. However, the Mazé, Alg. Guad. no. 1602, "Capesterre, Plage du bourg" in the herbarium of the British Museum, is certainly very different, as to species, at least, from either *H. floridana* or *H. Gelinaria*. Whatever may be the relation of other Guadeloupe specimens to these two species, the name *dentata* of Crouan, a "nomen seminudum" at best, can not, under the provisions of the "American Code" at least, be adopted for either, on account of the previously published *Halymenia dentata* Suhr.

Halymenia Gelinaria adheres very firmly to paper when dried under pressure.

Halymenia pseudofloresia sp. nov.

Thallo violaceo-rubro, brevi-stipitata; stipite inferne subtereti, superne cuneato; fronde juvenili membranacea, gelatinosa, aetate provecta firmiore et subcoriacea, 50–450 μ crassa, circumscriptione suborbiculari, ovata, cuneato-obovata, vel nonnunquam valde irregulari, longitudine 7–30 cm., profunde lobata vel prolificationibus stipitatis munita; rachidibus 1–8 cm. latis, lobis et prolificationibus plerumque lanceolatis, serratis vel seriebus loborum etc. secundariorum munitis; superficie haud nitente, plerumque plana, sed aetate provecta minute verruculosa; medulla frondis laxa, subvacua, filamentis sparsis percursa, filamentis transversalibus crebris, filamentis stellatis paucis, inconspicuis; strato subcorticali indistincte filamentoso, cellulis 20–50 μ diam.; strato corticali cellularum minorum 2–6 series monstrante, cellulis superficialibus aetate elongatis, obconicis vel clavato-truncatis, denique diametro plerumque 2–5-plo longioribus, parietibus externalibus gelatinosis, deliquescentibus; tetrasporangiis decussatim divisis; cystocarpiis ignotis.

Ab *H. Floresia* (Clem.) Ag. et *H. Gelinaria* Collins & Howe differt colore magis saturate rubro vel violaceo-rubro, fronde denique firmiore, subcoriacea, nonnunquam verruculosa, cellulis terminalibus filorum corticalium clavato-truncatis. Frons *H. pseudofloresiae* magis divisa est quam *H. Gelinariae*, minus et minus regulariter quam *H. Floresiae.*

Ad oras Insularum Bermudensium (typum legit A. B. Hervey, Jan. 15, 1915).

Thallus short-stipitate; stipe* 5–10 mm. long, 1–2 mm. thick, cuneate from a subterete base; frond membranous and gelatinous in younger parts, becoming firmer and subcoriaceous with age, 50–450 μ thick, suborbicular, ovate, cuneate-obovate, or commonly very irregular in general outline, attaining a length of 7–30 cm., deeply, irregularly, or subpalmately lobed, or often showing cuneate-based substipitate marginal proliferations, the main expansions or axes 1–8 cm. broad, the lobes or proliferations commonly lanceolate, serrate, biserrate, or subpinnately lobulate or bilobulate, the teeth mostly acuminate-deltoid; surface dull, mostly smooth, but often becoming rugose and minutely and copiously verruculose with age; color (when dried) daphne-red, becoming deep hellebore-red or neutral red† in old fronds; medulla of stipe 0.75–1.0 mm. thick, moderately compact; cortex of stipe rather firm, subparenchymatous, mostly 20–40 cells thick; medulla of frond mostly rather loose or subvacuous, its filaments 10–16 μ in diameter, many of them obliquely transverse, connecting the opposite subcortical layers, the cells 25–90 μ long, the medulla or inner subcortex occasionally showing a few inconspicuous stellate ganglia with nodes 20–40 μ in diameter and slender long-celled branches 2–5 μ in diameter; cortex and subcortex rather firm and solid, obscurely filamentous; cells of subcortex ellipsoidal, mostly 20–50 μ in diameter, obscurely anastomosing or concatenate; cortex 2–6 cells thick, the superficial cells (protoplasts) 4–13 μ in diameter in surface view, angular, obtuse, subisodiametric or often broader than high in younger parts, becoming columnar, obtuse, acute, or acuminate, and finally, for the most

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* A well-developed original stipe has been seen in only one case.

† Ridgway, loc. cit., *pl. 38.*

part, obconic or clavate-truncate and 2–5 times higher than broad, their outer walls gelatinous or deliquescent; tetrasporangia (protoplasts) 14–26 $\mu \times$ 12–14 μ, the spores decussately paired; cystocarps unknown.

BERMUDA: *W. G. Farlow*, 1881; Green Bay, *W. S. Wadsworth*, February, 1890; Castle Harbor, near Tucker's Town, *F. S. Collins 7075*, April 25, 1912; Walsingham, *A. B. Hervey*, January 15, 1915 (Phyc. Bor.-Am. *2099*).

TYPE: Walsingham, *A. B. Hervey*, January 15, 1915, in herb. F. S. Collins.

Halymenia pseudofloresia differs from both *H. Floresia* and *H. Gelinaria* in its normally deeper red color, in the firmer subcoriaceous texture and verruculose surface of its older fronds, and in the mostly clavate-truncate and much elongate superficial cells of the older parts of its frond. From *H. Floresia*, which apparently occurs in southern Florida and the West Indies, as well as in the Mediterranean and adjacent regions, it differs also in the less deeply dissected frond, with the teeth or ultimate lobules mostly acuminate-deltoid from a broad base rather than mostly lanceolate, ligulate, or ciliiform from a somewhat constricted base. Lanceolate outgrowths from a narrowed base are of occasional occurrence, but such seem to have more the habit and nature of proliferations than of normal lobes and lobules. From *Halymenia Gelinaria*, *H. pseudofloresia* differs furthermore in its more lobed and dissected and more obviously pinnate frond and in its firmer, less distinctly filamentous cortex.

The older parts of *Halymenia pseudofloresia*, at least as shown in the Walsingham specimens collected by Hervey, are infested by four or five kinds of endophytic algae, and we have sometimes suspected that the small verrucae referred to in our description as occurring on the old fronds might be caused by irritation due to their presence. However, most of these verruculae appear to be free from any endophyte and we have thought best to treat them as more or less normal parts of the old frond. We have not observed any tendency of these verrucae of the general surface to develop into proliferations, even though the marginal proliferations commonly spring from somewhat similar outgrowths. These surface verruculae are dense, dark red, and about 0.2–

0.6 mm. in diameter, and to the naked eye they sometimes look a little as if they might be cystocarps. A filamentous short-celled Rhodophyceous endophyte sometimes forms dense subglobose or irregularly lobed glomeruli in the medulla and these also may have the superficial appearance of being cystocarps of the *Halymenia*.

Halymenia pseudofloresia, like *H. bermudensis*, is commonly found in an unattached condition, and possibly the absence of cystocarps is in some way associated with this fact. The senior author has noted that *Delesseria sinuosa* and certain other membranaceous Rhodophyceae are commonly sterile when found in places where they have apparently been vegetating for some time unattached.

Specimens of *Halymenia pseudofloresia*, with occasional exceptions as to parts of the old fronds, adhere firmly to paper when dried under pressure.

Halymenia echinophysa sp. nov.

Thallo pallido-vinaceo vel lilacino, membranaceo, gelatinoso, 125–200 μ crasso (madefacto), circumscriptione suborbiculari, 10–18 cm. diam., profunde, irregulariter vel subpalmatim lobato, lobis irregulariter obovatis vel suborbicularibus, marginibus sinuato- vel eroso-dentatis; medulla frondis subvacua vel laxe filamentosa, filamentis homogeneis, 10–14 μ diam.; strato corticali gelatinoso translucido, submonostromatico, cellulis superficialibus ovoideis, subglobosis vel ellipsoideis, 4–8 μ diam. max., 5–10 μ inter se distantibus, in membrana communi horizontaliter vel verticaliter positis, parietibus exterioribus (vel membrana superficiali extra-cellulari) 10–18 μ crassis; strato subcorticali 2–4-stromatico, cellulis arcte anastomosantibus, ovoideis, ellipsoideis, vel interdum complanatis, extimis 6–10 μ diam., intimis 25–65 μ diam. max., nonnullis subglobosis, 80–180 μ diam., echinato-stellatis, in medullam protrudentibus, processubus 15–40, subrigidis, subspinescentibus, munitis.

Species *H. actinophysae* M. A. Howe proxima, sed differt thallo minore, crassiore, magis lobato, non-nitente, membrana superficiali communi duplo crassiore, cellulis superficialibus inter se duplo distantioribus, filamentis medullaribus dimidio minus crassis et minus regulariter et minus manifesto capitatis in strato subcorticali abientibus, cellulis intimis strati subcorticalis saepe multum majoribus, magis echinato-stellatis, cum processubus subspinescentibus saepe permultis.

Ad oras Insularum Bermudensium, in profundis (typo in herb. Hort. Reg. Kew., a Exped. "Challenger" lecto et "*Kallymenia reniformis*" denominato).

Frond membranous, gelatinous, 125–200 μ thick (when soaked out), suborbicular in general outline, attaining width of 10–18 cm., deeply, irregularly or subpalmately lobed or divided, the lobes irregularly obovate or suborbicular, mostly 2–6 cm. broad, their margins sinuate- or erose-dentate or sparingly sublobulate; surface dull; color (dried) light grayish vinaceous to Persian lilac;* medulla of frond subvacuous or loosely filamentous, its filaments homogeneous, mostly 10–14 μ in diameter (including gelatinous walls; protoplasts commonly only 1–4 μ); cortex of frond gelatinous, translucent, submonostromatic, the superficial cells (protoplasts) ovoid, subglobose, or ellipsoid, 4–8 μ in maximum diameter, widely spaced (separated 5–10 μ), their longer axes horizontal or vertical, their outer walls ("surface jelly") 10–18 μ thick; subcortex of 2–4 layers of closely anastomosing, ovoid, ellipsoid, or often flattened, thick-walled cells, the outer (protoplasts) granular, 6–10 μ in diameter, the inner mostly 25–65 μ in maximum diameter, some of the inner cells larger, subglobose, 80–180 μ in diameter, echinate-stelliform, projecting into the medullary cavity and showing when detached 15–40 rather rigid subspinescent processes, these mostly 25–60 μ long and 10–20 μ in diameter at base; other parts unknown.

BERMUDA: Dredged in "31 fathoms, off Bermuda" by members of the Challenger Expedition in 1873, and reported as "*Kallymenia reniformis* J. G. Agardh" (Rep. Voy. Challenger, Bot. 1: Bermudas 117. 1884). This is the only specimen known to the present writers.

TYPE: In the herbarium of the Royal Botanic Gardens, Kew, England.

Halymenia echinophysa appears to find its nearest ally in *H. actinophysa* M. A. Howe,† from La Paz, Lower California, but differs in the smaller, thicker, more lobed, non-nitent thallus, with the surface jelly twice as thick, the surface cells twice as widely spaced, the medullary filaments one half as stout, in the less regularly and less obviously capitate terminations of these

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* Ridgway, loc. cit. *pl. 38, 39.*

† Bull. Torrey Club 38: 509. *pl. 34.* 1911.

filaments in the subcortex, and in the often much larger, more numerously and more echinately branched stelliform cells of the inner subcortex.

From *H. bermudensis* Collins & Howe, to certain forms of which it bears a superficial resemblance, it differs in being much more gelatinous, in the much thicker surface jelly or outer walls of the superficial cells (10–18 μ vs. 2–4 μ thick), in the more generally monostromatic cortex, in the more widely spaced (5–10 μ vs. 2–3 μ) protoplasts of the superficial cells, in having a medulla that is filamentous and homogeneous instead of showing a system of substellate ganglia with refringent specialized protoplasts, and in the presence in the inner subcortex of cells that are 80–180 μ in diameter with 15–40 subspinescent processes, while the inner cells of the subcortex of *H. bermudensis* are 13–25 μ in diameter and have no obvious appendages.

When the enlarged echinate-stelliform cells of the inner cortex are detached, some of their numerous sharp-pointed processes show apices that look as if they had been free from all cell connections, but most of them show at the apex traces of a septum to which they have narrowed down and at which point they have been disjoined from their former cell connections. The protoplasts of these large echinate cells are similar to those of their neighbors or are more vacuous, wherein they differ greatly from the substellate medullary ganglia of *H. bermudensis* and *H. floridana*, the protoplasts of which are conspicuously different from those of the ordinary cells in being denser, more homogeneous, and more refringent. As is the case in *H. actinophysa*, the cells of the subcortex of *H. echinophysa* are so gelatinous and translucent that their form and relations can not well be ascertained without resort to staining reagents, such as solutions of haematoxylin.

Of the four species above described, specimens of three, *Halymenia Gelinaria*, *H. pseudofloresia*, and *H. bermudensis*, have already been distributed in the Phycotheca Boreali-Americana of Collins, Holden & Setchell, as indicated. This will, we trust, in a measure atone for the lack of illustrations in the present paper.

Desmopsis, a new genus of Annonaceae

William Edwin Safford

(with plates 7–9 and one text figure)

The genus *Unona* was based by the younger Linnaeus on an American plant, the *peyrico-boom* of Surinam, belonging to the previously established genus *Xylopia*. Its type, *Unona discreta* L. f., is identical with either *Xylopia frutescens* Aubl. or *X. salicifolia* Dunal, and is certainly not congeneric with the Asiatic plants usually referred to the genus *Unona*. Recognizing that *Unona* must become a synonym of *Xylopia* and that the name could no longer be used for any other genus, the writer restored the generic name *Desmos*, established by Loureiro in 1790, for the Asiatic *Unona discolor*, believed by Vahl (1791) to be a congener of the American *U. discreta* but which proved to be identical with Loureiro's *Desmos chinensis*. The type of Loureiro's genus, *Desmos cochinchinensis*, was arbitrarily renamed by Dunal (1817) *Unona Desmos*. The necessity of restoring the generic name *Desmos*[*] in accordance with accepted rules of nomenclature was recognized by Mr. Elmer D. Merrill, in his "Studies on Philippine Annonaceae."[†]

That there are no American species congeneric with *Desmos* (*Unona* Vahl) was recognized by the writer, who in the publication above cited referred *Unona panamensis* Robinson and *U. bibracteata* Robinson to *Unonopsis*, established by Robert E. Fries in 1900. A further study of the genus *Unonopsis*, however, showed that Fries included in it plants differing widely in inflorescence and in the number and arrangement of the ovules. In proposing

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[*] "*Desmos* the proper generic name for the so-called Unonas of the Old World." Bull. Torrey Club **39**: 501–508. 1912.

[†] "Safford has recently conclusively shown that the genus *Unona* Linn. f. was based upon an American species, *Unona discreta* Linn. f., and that Vahl was in error in placing under *Unona* the Asiatic *U. discolor* Vahl, *Desmos chinensis* Lour. The Indo-Malayan material that has by various authors been referred to *Unona* cannot properly be considered under this generic designation, and Safford has correctly taken up the generic appelation *Desmos* for the oriental forms, this genus having been proposed by Loureiro in 1790." Phil. Jour. Sci. Bot. **10**: 234. 1915.

the genus *Unonopsis*, based chiefly upon plants which had been previously included in *Trigyneia*, Fries himself realized that the genus would probably have to be subdivided or even resolved into distinct genera.* This natural division must be made, retaining for the genus *Unonopsis* the typical *Unonopsis angustifolia* (Benth.) Fries, together with *U. Perottetii* (A.DC.) Fries, and *U. rufescens* (Baill.) Fries, with clusters of small globose pisiform long-pedicelled flowers, usually growing from the axils of fallen leaves, on the old wood. Quite distinct from these in the form of flowers and the number and arrangement of the ovules are the two species *Unona panamensis* and *Unona bibracteata* mentioned above, and I here propose for them the generic name *Desmopsis*, which is suggested by their resemblance to the genus *Desmos* of the Old World. To *Desmopsis* must also be referred *Trigyneia Galeottiana* Baill. and an undescribed species recently collected by Mr. William R. Maxon and Professor Henry Pittier in the Republic of Panama.

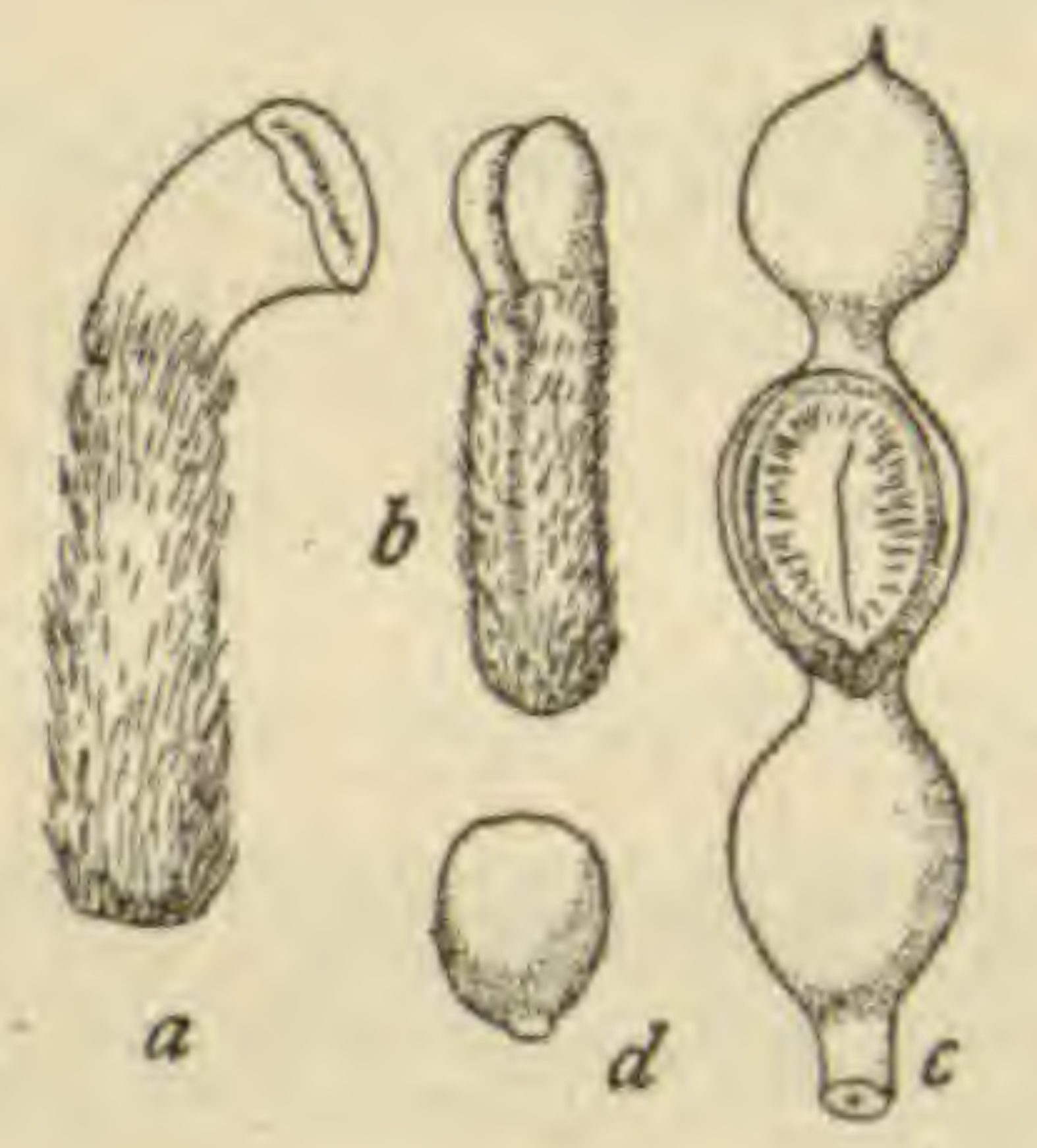

FIG. 1. Pistils, fruit and seed of *Desmos*. *a*, Pistil of *Desmos cochinchinensis* Lour. (*Unona Desmos* Dunal), showing pilose ovary and glabrous style; *b*, pistil of *Desmos chinensis* Lour. (*Unona discolor* Vahl); *c*, *d*, fruit and seed of the same. *a* and *b* enlarged, *c* and *d* natural size.

DESMOPSIS Safford, gen. nov.

Peduncles opposite the leaves or terminal, bearing at the extremity one or two broadly ovate or suborbicular cordate leaf-like bracts, and one or two (rarely three) long slender curved pedicels. Calyx segments three, valvate, broadly ovate or triangular. Petals six, equal or nearly so, lanceolate to linear-oblong, continuing to elongate after anthesis, valvate, in two series, ascending, sometimes incurved at the apex. Stamens numerous, short, cuneate, with the connective broadly expanded into a concave disc above the two pollen sacs. Torus convex or subcylindrical, pilose between the stamens and the carpels. Carpels seven to nineteen. Ovaries pilose. Ovules two to six, two-seriate, parietal, forming a single column. Style depressed-spheroid, densely clothed with short hairs. Fruit a cluster of stipitate

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* Beiträge zur Kenntnis der süd-amerikanischen Anonaceen, Kongl. Svenska Vetensk Akad. Handl. 31: 26. 1900.

subglobose, oval, or oblong one- to six-seeded berries, often more or less constricted between the seeds but never moniliform. Seeds horizontal, discoid, usually with a peripheral groove, the terminal ones depressed-hemispherical, or, if solitary, spheroidal; endosperm ruminate and embryo minute, as in all Annonaceae. Shrubs or small trees with alternate short-petioled entire leaves, and yellowish or greenish solitary or geminate flowers, often very fragrant, on long slender curved pedicels borne by short, bracted, leaf-opposed peduncles, and followed by clusters of pedicelled berries.

TYPE: DESMOPSIS PANAMENSIS (Robinson) Safford.

GEOGRAPHICAL RANGE: From the state of Vera Cruz, Mexico, to the Isthmus of Panama.

This genus differs from the Old World *Desmos* in its peculiar bracted leaf-opposed inflorescence, the pilose indument of the torus between the stamens as well as between the carpels, the depressed-globose hairy styles, and the crowded discoid seeds marked with a peripheral groove, separated from each other by a slight constriction but never enclosed in a moniliform pericarp. In typical species of *Desmos* (*Unona* Vahl) the mature carpels are moniliform (FIG. 1) the seeds devoid of a groove round their periphery, and the styles are not hairy.

Key to the species

Leaves not acuminate, narrowed to an obtuse or rounded apex, oblong-lanceolate or rhomboid, glabrous or nearly so. 4. *D. bibracteata.*
Leaves acuminate.
  Lanceolate-elliptical, often unequal at the base, lower surface hirtellous-tomentose. 2. *D. Galeottiana.*
  Elliptical or oblong, symmetrical at the base.
    Petals incurved at the tips; leaves rufous-pubescent along the midrib and nerves beneath. 1. *D. panamensis.*
    Petals not incurved at the tips; leaves almost quite glabrous beneath. 3. *D. Maxonii.*

1. **Desmopsis panamensis** (Robinson) Safford

Unona panamensis Robinson, Am. Jour. Sci. III. 50: 175. 1895.

A small symmetrical tree 5–8 m. high with horizontal limbs and a straight trunk covered with brownish gray bark. Branches brown with lighter colored lenticels; young growth finely rufous-tomentose with simple hairs. Leaves short-petioled, oblong or elliptic, shortly acuminate, narrowed or cuneate at the base, entire, 10–20 cm. long and 4.5–8 cm. broad, glabrous above, when young covered beneath with an appressed rufous silky pubescence, at length pubescent beneath only upon the nerves. Flowers greenish yellow; peduncle short (5–10 mm. long), bearing at the summit a suborbicular cordate bract about 1 cm. in diameter (rarely larger and more like the leaves, rarely absent) and one or two elongated pedicels (4–9 cm. long), slightly thickened near their summits, these rarely bearing a small clasping suborbicular bract about 4 mm. broad below the middle. Calyx three-parted, with the segments ovate-triangular, 2–3 mm. long; petals six, equal, lance-linear, 15–25 mm. long, never widely spreading, the tips incurved and the edges revolute, finely pubescent on the outside and covered with minute yellowish green granules on the inner surface; torus convex or depressed-hemispherical, thickly covered with short straight fulvous hairs and bearing numerous closely crowded stamens surrounding the gynoecium; stamens 1.5 mm. long, with the brown connective broadly expanded above the two parallel pale straw-colored pollen sacs into a concave thickish disk; carpels seven to fifteen, ovaries 2 mm. long, clothed with fulvous hairs, containing two to eight ovules in a single vertical column and bearing a subglobose brown stigma clothed with short erect hairs; maturing carpels five to twelve, stipitate, oval to oblong, 14–18 mm. long and 10–14 mm. in diameter, very slightly constricted between the seeds, and rounded at each end; stipe (carpophore) 8–10 mm. long and 1.5–2 mm. thick; seeds two to six, disk-shaped, with an impressed line around the periphery, those at the ends depressed hemispherical. [PLATE 7.]

Type in the Gray Herbarium of Harvard University, collected by Sutton Hayes in "woods near Gatún Station on the old Panama Railway, January 30, 1860." Specimen of type collection in United States National Herbarium bearing same data (sheet No. 314144).

DISTRIBUTION: Known only from the Panama Canal Zone.

SPECIMENS EXAMINED

PANAMA: Type as cited; same locality and data (type collection) in United States National Herbarium (sheet No. 314144); in forest, railroad relocation Caimito and New Frijoles, Canal Zone, altitude 10–50 m., "5 to 8 m., fls. yellow," January 7, 1911, *Pittier 2269;* hills around the Agua Clara Reservoir, near Gatún, Canal Zone, altitude 20–30 m., "a little tree with straight trunk 4 meters high, flowers greenish yellow," February 5, 1911, *Pittier 2660.*

This interesting species, hitherto known only from the type collection, was collected by Professor Henry Pittier during his recent botanical exploration of Panama very nearly on the exact spot where Dr. Sutton Hayes found it. Professor Pittier reports it as "a small tree 5 to 8 meters high and regularly shaped. The straight trunk, covered with a brownish gray bark, is not divided but sends out radiating horizontal limbs, the extremities of which are slightly pendulous, and which are shorter toward the top, so as to form a pyramidal crown."

2. **Desmopsis Galeottiana** (Baill.) Safford

Trigyneia Galeottiana Baill. Adansonia **8**: 181. 1868.

A shrub or small tree with slender branches, at length glabrate. Young growth hirtellous-tomentose with simple yellowish hairs. Leaves short-petioled, elliptic-lanceolate, shortly acuminate, obtuse at the tip and usually unsymmetrically cuneate at the base, above bright green, glabrate except along the impressed midrib, beneath fulvous tomentose-hirtellous especially along the prominent midrib and the primary nerves. Flowers green (according to Galeotti), borne on long slender curved pedicels, these solitary or in pairs (rarely in three's) growing from a short peduncle and subtended by a leaf-like elliptical or cordate bract with nerves and indument like the leaves; peduncle terminal or opposite a leaf, about 8 mm. long, at length woody and branch-like; pedicels recurved, 40–50 mm. long, at first filiform and hirtellous and bearing a small ovate clasping bract below the middle, at length glabrate and bractless. Calyx three-parted, the divisions short and usually acute, pubescent on the outside. Petals six, equal or nearly so, valvate, in two series, ovate-lanceolate, rather thick, usually acute at the apex, puberulous on the outside. Stamens numerous, borne on a convex torus, with the connective expanded above the linear pollen sacs into a broad more or less concave disk. Carpels (in specimens examined) seven to eleven; ovary oblong, tomentose, bearing the subglobose blackish style, the latter articulated at the base and easily detached. Ovules two to six in each ovary, arranged in a single vertical row. Fruit a cluster of several stipitate berries (mature carpels) radiating from the indurated receptacle (torus), these oblong or subglobose, puberulent at first, at length glabrate; stipes 4–6 mm. long and 1.5 mm. thick, straight or curving slightly upward; seeds one to four, discoid, or if solitary subglobose, endosperm ruminate as in all Annonaceae.

Type in Herbarium of Copenhagen, "Anonac. Mexic. Liebm. No. 153," collected at Palanque, state of Vera Cruz, Mexico, in March, 1841, by Liebmann (No. 7); cotypes in Paris Museum and

Herbarium Delessert, collected at Jalapa, altitude 2000 feet, by Galeotti (Nos. 4066 and 7083).

DISTRIBUTION: Known only from the *tierra templada* of the state of Vera Cruz, Mexico.

SPECIMEN EXAMINED:

MEXICO: Near Orizaba, 1500 feet, July, *Dr. C. Sartorius*, in United States National Herbarium, Sheet No. 2571; and the following sheets belonging to the Copenhagen Herbarium: Palanque, *Liebmann 7* (type, as cited, with duplicate bearing the same data); Colipa, *Liebmann 5, 6, 9;* Mirador, *Liebmann 4, 19;* between Mirador and Jalapa, *Liebmann 1;* San Pablo, *Liebmann 10.*

For the opportnnity of examining the Liebmann material I am indebted to Dr. C. H. Ostenfeld, Director of the Copenhagen Herbarium. Since specimens from several localities are cited by Baillon in the original description of this species, and it is possible that differences may subsequently be found between plants growing remote from one another, it becomes necessary to designate one specimen as the type. I have therefore selected as the type Liebmann's No. 7 (sheet No. 153), including leaves, flowers, and mature fruit, since this number represents the species more completely than any of the others. This speciman therefore becomes the type of *Desmopsis Galeottiana;* and Palanque, near Colipa, in the state of Vera Cruz, Mexico, must be designated as its type locality.

3. **Desmopsis Maxonii** sp. nov.

A small tree 5–7 m. high. Branches slender, brown with numerous lenticels; young growth clothed with appressed pale fulvous hairs. Leaves broadly elliptical to elliptical-oblong or lanceolate acuminate, narrowed at the base into the short petiole, the smaller ones about 10 cm. long and 3.8 cm. broad, gradually acuminate, the larger ones 12–14 cm. long and 6–8 cm. broad, abruptly acuminate, with the petiole about 5 mm. long, relatively thick and grooved above, with the acute base of the blade decurrent upon it, glabrous above, covered beneath when young with pale fulvous silky hairs, at length quite glabrous. Flowers straw-colored, or pale yellow, fragrant with the odor of banana; peduncle 7–14 mm. long, opposite a leaf, or apparently terminating a branchlet, normally bearing at the summit a suborbicular or broadly ovate clasping leaf-like bract 7–15 mm. broad and (in the specimens observed) a solitary elongated very slender recurved pedicel 3.5–6 cm. long, thickened at the summit, clothed when very young with a few minute sparse appressed pale fulvous hairs, soon becoming quite glabrous, bearing a minute clasping bract below the middle and often a similar bract at the base adjacent to the much larger bract terminating the peduncle. Calyx-segments broadly triangular, 4 mm. long; petals equal, elongating after anthesis, linear-oblong, 13–18 mm. long, 4–5 mm. broad, obtuse at the apex, pubescent on the outside with minute appressed grayish hairs, dark brown (in dried specimens) on the inside. Stamens numerous, resembling those of *Desmopsis panamensis* in size and form, their closely crowded concave expanded connectives forming, before anthesis, a tight domelike pavement over the androecium, protecting the pollen until the pollen sacs are ready to open. Gynoecium composed of a cluster of ten to fifteen carpels, with the ovaries, about 2 mm. long, clothed densely with silky hairs, at first dirty white, at length olivaceous, ovaries in a single ovary two to five, stigmas depressed-globose, covered with short hairs, adhering together in a dark brown mass after pollination and soon falling off. Fruit a cluster of short-stiped or nearly sessile one- to three-seeded spheroid or ovoid berries, scarcely at all constricted between the seeds, about 8 mm. in diameter, seeds discoid, horizontal, forming a single column. Stipes 1–3 mm. long (in the type) and 1.5–2 mm. in thickness. [PLATE 8.]

Type in the United States National Herbarium (sheet No. 677550), collected by Henry Pittier in the forest near El Boquete, Chiriquí, Republic of Panama, at an altitude of 1,000 to 1,300 meters, March 16, 1911 (No. 3154). Cotype (with flowers only) collected by William R. Maxon in the humid forest along the upper Caldera River, near Camp I, Holcomb's trail, above El Boquete, Chiriquí, altitude 1,450–1,650 meters, March 22–24, 1911 (No. 5564).

DISTRIBUTION: Known only from the vicinity of El Boquete, Chiriquí, Republic of Panama.

SPECIMENS EXAMINED

Type as cited and two additional sheets of type collection; cotype, as cited, with flowers only.

This species, like *Desmopsis bibracteata*, is remarkable for the banana-like fragrance of its flowers. It is easily distinguished from that species by its much broader, acuminate leaves, the much shorter and thicker stipes of the fruit, and the absence of constrictions between the seeds.

4. **Desmopsis bibracteata** (Robinson) Safford

Unona bibracteata Robinson, Am. Jour. Sci. III. 50: 175. 1895.

A shrub or small tree with slender branches. Very young branchlets minutely hirtellous, soon glabrous or nearly so. Leaves not acuminate, oblong-lanceolate or rhomboid, sometimes slightly falcate, narrowed to an obtuse or rounded apex, connected below to a very short thickish petiole, when very young clothed beneath with fulvous hairs, at length green and glabrous on both surfaces, 5.5–14 cm. long, 2.5–4 cm. broad, firm but not coriaceous in texture. Flowers light yellow, very fragrant, borne on very slender wiry recurved pedicels about 2.5 cm. long, subtended by a suborbicular cordate bract about 1.3 cm. in diameter and sometimes bearing a minute clasping bract below the middle, rarely a second flower growing from the axil of the basal bract; peduncle opposite a leaf, very short (2–5 mm. long). Calyx three-parted, the segments broadly ovate, rounded at the apex, to 5 mm. long. Petals increasing in length after anthesis, at first broadly ovate, densely clothed on the outside with pale grayish brown hairs, at length linear-oblong, about 18 mm. long and 5–6 mm. broad, obtuse or rounded at the tips, and glabrous or nearly so, with the edges usually revolute. Stamens numerous, about 1.5 mm. long, broadly cuneate, the brown connective expanded above the pale yellow pollen sacs in the form of a thick concave saucer-shaped disk. Carpels fourteen to twenty, sessile at first, ovaries oblong, clothed with whitish or pale yellowish ascending hairs and bearing a depressed-spheroid glandular hairy brown style, styles constricted at the base, adhering together after pollination, and soon falling off in a mass. Fruit a cluster of slender-pedicelled two- or three-seeded berries, red when fresh, at length turning brown, covered with appressed hairs when young, at length glabrate, pericarp thin, constricted between the seeds, these arranged in a vertical row, disk-shaped, 5–7 mm. in diameter, marked with a groove around the periphery, the end one depressed-hemispherical or convex on one side; stipes (carpophores) slender and wire-like, 5–8 mm. long, 1 mm. thick. [PLATE 9.]

Type in the Gray Herbarium of Harvard University, collected by Charles Wright in Nicaragua, on the North Pacific Exploring Expedition under Commanders Ringgold and Rodgers in 1855 (No. 1), bearing the label "*Unona violacea* Dun. aff." Duplicate of the type bearing the same data in the United States National Herbarium (sheet No. 2517).

DISTRIBUTION: From Nicaragua to Chiriquí, Republic of Panama.

SPECIMENS EXAMINED

NICARAGUA: Type and duplicate of type as cited.

COSTA RICA: "Terrenos incultos, Nuestro Amo, alt. 500 metros, arbusto de flores olorosas, nom. vulg. 'guineo,'" March, 1912, *Otón Jiménez 416*, in United States National Herbarium.

PANAMA: Vicinity of David, Chiriquí, altitude 30–80 m., small tree, flowers sulphur yellow, fruit red, March 25, 1911, *H. Pittier 3367;* vicinity of San Feliz, eastern Chiriquí, altitude 0–120 m., tree about 3 m. high, flowers yellow, having the fragrance of a banana, and hence called "flor de guineo," *H. Pittier 5747*, in United States National Herbarium.

ADDENDUM

After receiving the proof of the above descriptions the writer came upon an additional species of *Desmopsis* among the Annonaceae of the Copenhagen Herbarium lent him for study. This species I have named in honor of its collector.

5. **Desmopsis Oerstedii** sp. nov.

A shrub or small tree with the young growth, petioles, midrib beneath, peduncles, and pedicels densely fulvous-hirtellous with soft simple hairs projecting outward. Leaves short-petioled, the blade resembling that of *D. panamensis* in shape, elliptic or elliptic-oblong, shortly acuminate at the apex and narrowed or acute at the base, 10–13 cm. long, 4–5 cm. broad. Flowers not observed. Fruiting peduncle (normally terminating in a small leaf-like bract) leaf-opposed, 1 cm. long; pedicels (solitary in type material) 2–4 cm. long, clothed with persistent spreading fulvous hairs; bract separating the peduncle from the pedicel broadly cordate, 5 mm. long, sessile, sometimes missing. Maturing carpels usually about seven, subglobose to oval, 12–24 mm. long and 10–12 mm. in diameter, not constricted between the seeds, rounded at the apex, and narrowed at the base into a short stipe 5–7 mm. long and 2–3 mm. thick. Seeds four to six, horizontal, discoid and circular, 9–10 mm. in diameter, or surfaces beveled at an acute angle and more or less semicircular in outline, those of the two rows overlapping alternately, the testa light brown, thin, wrinkled by the inclosed ruminate endosperm, and marked by an impressed line around the periphery.

Type in the Botanical Museum of Copenhagen, collected by Anders Sandöe Oersted on Mount Aguacate, Costa Rica, in November, 1847, Plantae Centro-Americanae Oersted No. 148, bearing the generic name "*Guatteria*."

DISTRIBUTION: known only from the province of Alajuela, Costa Rica.

SPECIMENS EXAMINED

COSTA RICA: Type material, as cited (three sheets); also *Oersted 149*, collected "in Monte Jaris, Nov. 1846." Common name, "Guinea."

The common name applied to this plant in Costa Rica is the same as that applied to *Desmopsis bibracteata*, as quoted by Jiménez, except it has a feminine instead of a masculine ending. It is undoubtedly derived from the banana ("guineo") odor of the flowers. In the specimens examined fruits only were observed. These differ from the fruits of all the other species observed in their larger size, and the alternate arrangement of the seeds, somewhat after the manner of the seeds of Asimina and Sapranthus. The leaves differ from those of *D. panamensis* in the indument of the midrib beneath, which is densely fulvous-hirtellous; and the species is easily distinguished from *D. Maxonii* by its much shorter floral pedicels. From *D. bibracteata* it is at once distinguished by the shape of the leaves.

This species and *D. bibracteata* would be desirable additions to the cultivated shrubs of the warmer parts of the United States on account of the fragrance of their flowers. Those of the latter species are much used by Spanish Americans in decorating their altars.

BUREAU OF PLANT INDUSTRY,
UNITED STATES DEPARTMENT OF AGRICULTURE

Explanation of plates 7–9

PLATE 7

DESMOPSIS PANAMENSIS (Robinson) Safford

Showing flowers, fruit and essential parts. *a*, Short peduncle terminating in leaf-like bract; *b*, elongated pedicels; *c*, torus devoid of stamens and bearing cluster of young carpels; *d*, stamen, showing concave connective expanded above pollen sacs; *e*, ovary bearing depressed spheroid hairy style; *f*, cluster of mature stiped carpels; *g*, carpel, showing column of discoid seeds; *h*, seed, lateral view; *i*, terminal seed, showing convex surface; *d*, *e*, enlarged; remaining parts natural size. Drawn by Theodore Bolton from the type specimen.

PLATE 8

DESMOPSIS MAXONII Safford

a, Short peduncle terminating in leaf-like bract; *b*, elongated pedicel bearing small bracts at its base and below its middle; *c*, essential parts, showing cluster of carpels tipped with hairy styles surrounded by the stamens; *d*, stamen; *e*, cluster of young carpels from which styles have become detached; *f*, fruit, showing short-stiped carpels (nearly mature); *g*, a fruit (berry) with part of pericarp removed so as to show the seeds. Branches with flower, fruit and leaves, natural size; *c* and *d* enlarged. Drawn by Mrs. R. E. Gamble from the type specimen.

PLATE 9

DESMOPSIS BIBRACTEATA (Robinson) Safford

a, Cluster of fruit; *b*, seeds. Natural size. Drawn by Theodore Bolton from type material in the United States National Herbarium.

Observations on the fern rust Hyalopsora Polypodii

E. T. BARTHOLOMEW

(WITH THREE TEXT FIGURES)

A study of this rust on *Cystopteris fragilis* (L.) Bernh. was undertaken in order if possible to bring together the somewhat widely varying statements of different writers with reference to its life history.

Lindau* states that *Hyalopsora Polypodii* (Pers.) Magn. has teliospores and uredinia, but no aecia, and that the uredinia have no peridia. Grove† describes teliospores and uredinia but no aecia; the uredinia, with no peridium, containing yellow, sessile spores of two kinds, respectively thick- and thin-walled, both repeatedly found in the same sorus. In his artificial infection experiments, Dietel‡ found that the first uredinia contained only thin-walled spores; later, however, thick-walled spores also were found among the thin-walled spores and in many of the uredinia formed still later, the majority of the spores were thick-walled. Arthur§ describes the two kinds of yellow spores, which for convenience he considers respectively aeciospores and urediniospores, as being in separate sori; the aecia, containing the thick-walled spores, being without a peridium, and the uredinia, containing the thin-walled spores, having only a very delicate peridium; both kinds of spores borne singly on pedicels.

The observations recorded in the present paper were obtained in two ways; by a study of fresh material both in the field and in the greenhouse, and by that of fixed and sectioned material. In both field and greenhouse considerable difference was noted between the appearances of the sori produced in cloudy weather and of those produced during a period of sunshine. Several times during the months of May and June there were periods of cloudy weather

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* Kryptogamenflora für Anfänger 2. Berlin. 1912.

† The British Rust Fungi 375. Cambridge. 1913.

‡ Ueber einige Kulturversuche mit *Hyalopsora Polypodii* (Pers.) Magn. Ann. Mycol. 9: 530–533. 1911.

§ No. Am. Flora 7: 112. 1907.

lasting from three or four days to a week or more. During these periods the sori remained pale gray, but within twenty-four hours after the sun appeared they assumed a bright orange color. In contrast to this history, the sori that developed during the bright periods began to take on the yellow color even while they were quite small. Often a marked difference could also be noticed between the sori on shaded and on unshaded fronds—those on the former remaining gray for a considerable length of time, while the sori on the latter began to turn yellow almost as soon as they were noticeable.

It is not difficult to dissect an infected pinna in such a manner that large masses of the mycelium may be obtained free from the host tissues. To do this most effectively, it was found best to soak the pinnae in Flemming's weak fixing fluid for two or three hours, then to wash them in water for about the same length of time and afterward to dehydrate them by running them through a series of progressively stronger solutions of alcohol up to 95 per cent. A sorus was then cut from a pinna and dissected under a binocular microscope. Not only could mats of the mycelium be easily obtained in this manner, but in some cases rust spores remained attached to the hyphae. Often among the separated spores one was found with its short stalk still attached. This made it plain that the spores are not sessile as stated by Grove, but that, as Arthur says, they are borne on short stalks. This observation was verified by the study of sectioned and stained preparations (FIG. 1).

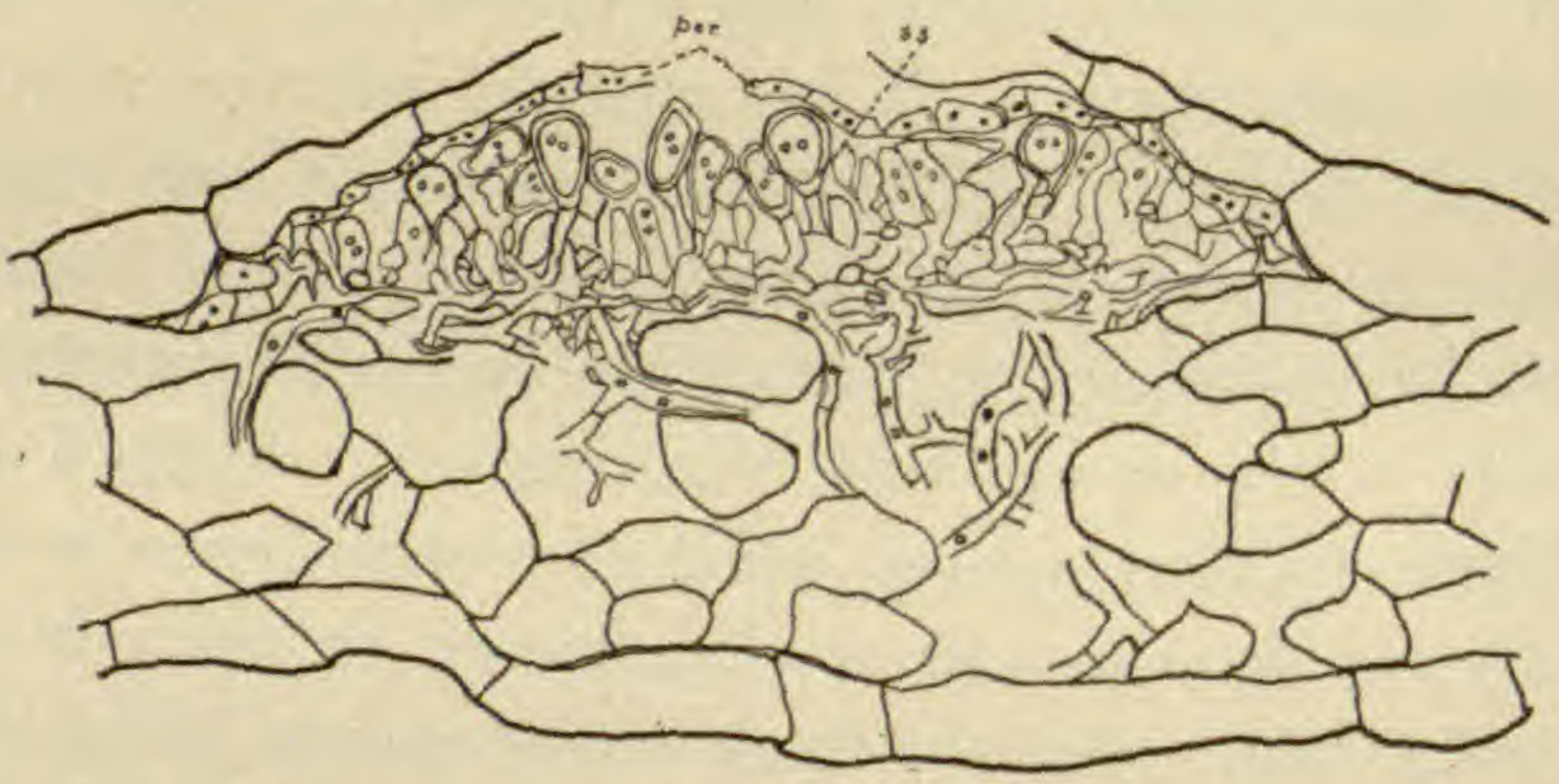

FIG. 1. Section through fixed and stained sorus, showing the peridium (*per*) and stalked spores (*ss*), × about 390. Camera lucida drawing.

In studying stained sections of a very large number of sori which had not yet broken open, not one was found without a peridium. FIG. 1 shows a typical sorus just as it is breaking open. Ordinarily, though not always, by the time the sorus has become erumpent, the peridial cells have distintegrated to such an extent that they are scarcely noticeable. In the material which was dissected with needles the peridial cells could easily be distinguished.

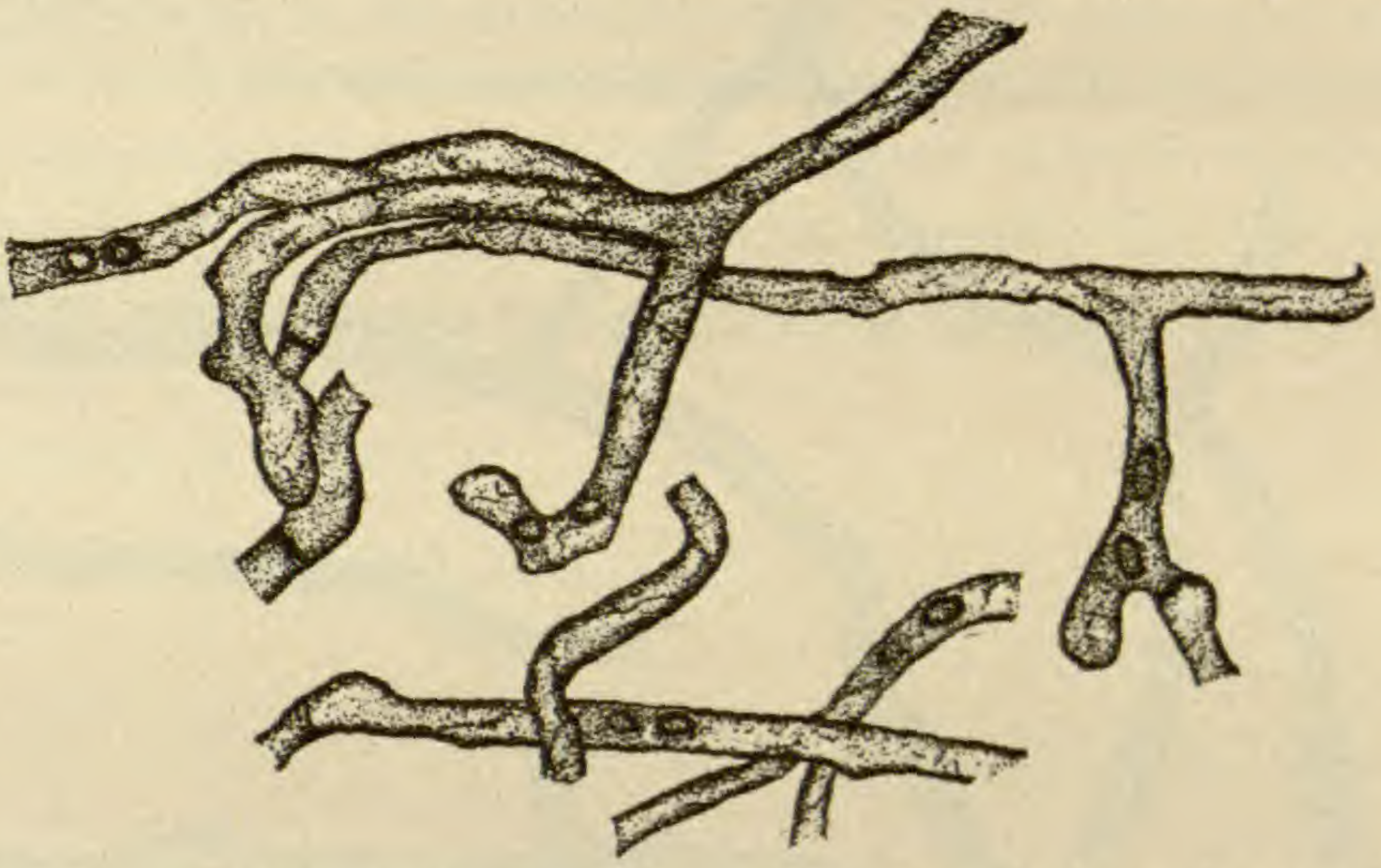

FIG. 2. Fragments of binucleate hyphae taken from the base of a sorus in which most of the spores were thick-walled, × about 700. Camera lucida drawing.

Perhaps the most interesting part of the results of this investigation concerned the nuclear condition of the hyphae. The mats of mycelium which had been freed from the host tissues were transferred to separate slides and stained *in toto*. Without exception the cells of these hyphae were found to be binucleate. This was true of hyphae taken from the bases of sori in which the majority of the spores were thick-walled, as well as of those taken from the bases of sori containing mostly thin-walled spores. Small fragments of the mycelium are shown in FIGS. 2 and 3. Sectioned material shows the same facts as to the binucleate condition of the hyphae.

From these observations it would seem that there can no longer be any basis for calling the thick-walled spores aeciospores and the thin-walled spores urediniospores. This conclusion would indicate that there must be an aecial host for this rust, and although Bubak* has been unsuccessful in his attempts to inoculate species

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* Infektionsversuche mit einigen Uredineen. Centralb. Bakt. Zweite Abt. 12: 411–426. 1904; 16: 150–159. 1906.

of *Abies* and *Pinus* with *Hyalopsora*, future workers will probably find the aecial host of *Hyalopsora* as has been done for different species of *Uredinopsis*.

An explanation for the production of two kinds of urediniospores at the present time may be at least suggested.* Of the groups of plants which now serve as hosts to the various rusts, the pteridophytes are the oldest. This gives some ground for assuming that the fern rusts are the most ancient of the rusts now living. Following the pteridophytes came the gymnosperms, and it is upon the conifers of this group that, as far as is now known, the aecial stage of the fern rusts appears. We may suppose, then, that some of the conifers became susceptible to infection by one stage of the rusts already parasitic upon the pteridophytes. It follows that one of the present spore forms of the fern rusts is a

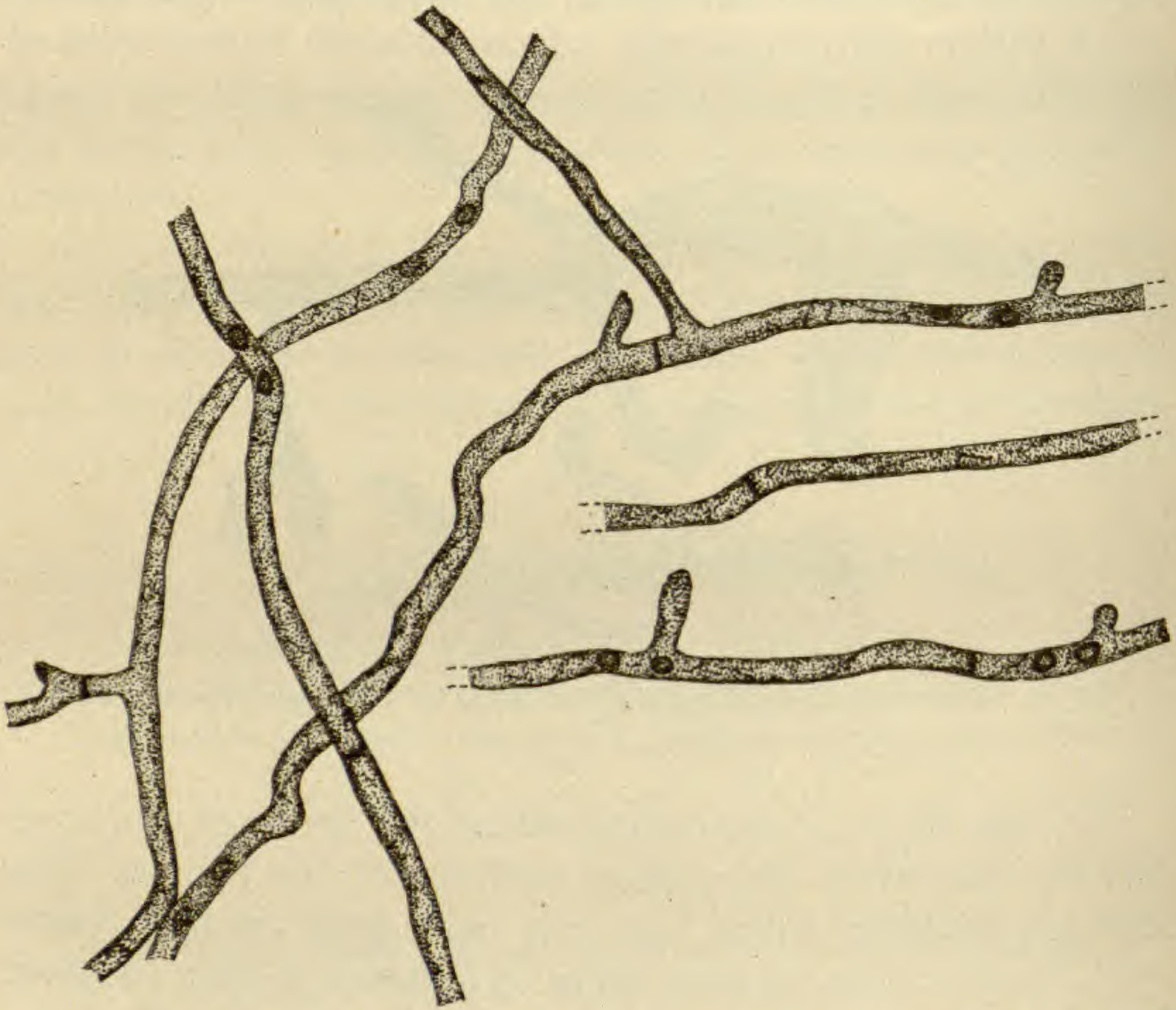

FIG. 3. Fragments of binucleate hyphae taken from the base of a sorus in which most of the spores were thin-walled, × about 680. Camera lucida drawing.

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* This suggestion was first made to the writer by Dr. J. J. Davis of this laboratory.

relic of an autoecious condition which prevailed in connection with a uninucleate mycelium that developed from a sporidial infection. As a result of the passing of the aecial stage to the conifers, only binucleate mycelial stages are now found in the ferns. From the persistence of the primitive spore form under the changed conditions, one may infer that the autoecious condition in the history of these rusts existed for a long period of time. While not germane to the question as to the spore forms of the fern rusts, it may not be amiss to carry the speculation a little further with the suggestion that the angiosperms upon their appearance became infected by aeciospores from conifers, and that consequently the most primitive rusts of phanerogams bear their aecia upon coniferous hosts.

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INDEX TO AMERICAN BOTANICAL LITERATURE

1907-1916

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 the broadest sense.

Reviews, and papers that 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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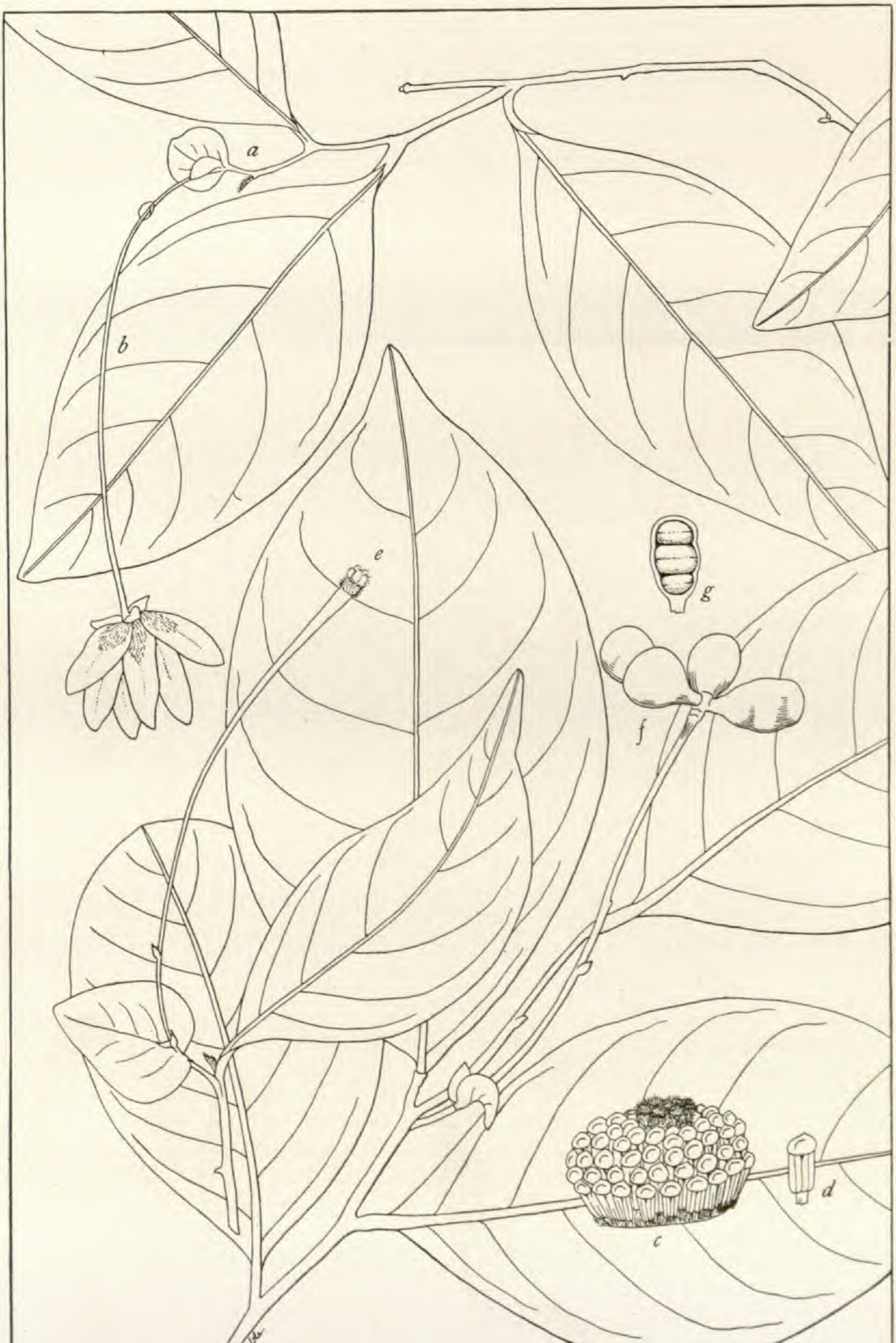
DESMOPSIS PANAMENSIS (ROBINSON) SAFFORD



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DESMOPSIS BIBRACTEATA (ROBINSON) SAFFORD

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The origin of new varieties of Nephrolepis by orthogenetic saltation

I. Progressive variations

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(WITH PLATES 10–15)

A. Introduction

1. *Definition and scope of paper*

The title, "The origin of new varieties in *Nephrolepis* by orthogenetic saltation," was selected to emphasize two points: first, that the variations to be described are discontinuous and of considerable magnitude, *i.e.* jumps or saltations; second, that these variations occur in definite series along a few limited lines, *i.e.* they are orthogenetic. I purposely beg the question as to whether they are mutations or not because I do not know. The exact application of the term, mutation, seems at present to be in a state of some uncertainty, and in any event, there may be considerable question about classifying these vegetative fern sports in the same category with the forms of *Oenothera*, among which, surely, orthodox mutations must exist.

Nephrolepis is a genus of tropical ferns, several species of which have been cultivated. Nearly all these species have shown some variation under cultivation, but one of them, *N. exaltata*, through its variety, the so-called "Boston fern," *N. exaltata bostoniensis*, has been especially prolific of new forms. From this variety there have arisen in about fifteen years at least sixty

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named horticultural forms besides a probably equally large number which have never gained horticultural recognition. The present account is concerned only with a portion of these Boston fern varieties, the basis of selection being indicated below.

Reproduction in the Boston fern and its varieties, as indeed in the varieties of the other species of *Nephrolepis*, is almost exclusively vegetative. The varieties with a few possible exceptions have arisen strictly by bud variation, the explanation being found in the fact that almost all the forms, the wild species being excepted, produce imperfect sori with mostly abortive sporangia. As indicated, there are a few varieties reputed to have been raised from spores and there is nothing impossible in this connection, but there is also no question that the great majority of forms have developed from bud sports. Their study is therefore untroubled by questions of pure line or hybridization, nor does it readily allow these valuable analytical methods of attack, but calls mainly for an accurate determination of the origin and parentage of each form and an adequate description of its characters.

The large number of varieties mentioned includes a multiplicity of forms, some of which have arisen by progressive, some by regressive, variation. A complete description of all these at present would involve considerable difficulties in the way of preparation and presentation. The scope of this paper is therefore limited to deal mainly with the more pronounced lines of progressive variation. The terms "progressive," "regressive," and "reversion," are used here with only their ordinary non-technical connotation. Progressive variations as understood are those which show less resemblance to var. *bostoniensis* than do their parent forms. It must be understood here that the variations from var. *bostoniensis* include series of forms with as many as six successive intensifications of a given character by which the first of the series diverged from var. *bostoniensis*. Such a series is considered progressive (see PLATE 10). Regressive variations or reversions, on the other hand, are understood to be those which show something of a return in characters toward var. *bostoniensis*. This classification is largely one of convenience, and the separation of the two types of forms may not always be justified as made. It will, however, furnish a good basis for a description and discussion of these forms.

As preliminary to such description, it will be appropriate to consider some of the significant features of these variations, and to compare them with other variations of possibly similar nature. This discussion will be dealt with under two headings: viz., Earlier studies of orthogenesis; Conditions under which *Nephrolepis* varieties have originated.

2. *Earlier studies of orthogenesis*

The term "orthogenesis" was proposed by Haacke to characterize what the zoölogist, Eimer, had been calling "bestimmt gerichtete Entwicklung," *i.e.* "definitely directed evolution" as translated by T. J. McCormack.* It appears that the botanist, Nägeli, had expressed views similar to those of Eimer at a somewhat earlier date. The evidence upon which these writers built their conclusions was systematic, and dealt with groups of living species showing close relationship. An orthogenetic series for Eimer was, for example, a group of related butterflies, the relationships between which was traced by gradations in the markings which varied from one extreme to another, but were connected by intervening forms. Evolution was postulated as progressive in one direction or the other.

Later writers, such as Cope, Hyatt, Grabau, and Osborn, have considered orthogenesis in connection with groups of organisms in geologic series. Grabau, for example, has illustrated orthogenesis in gastropods† by series of fossils from successive strata, which show gradual but definite progressive variation in the sculpture of the shells.

A third line of orthogenetic study is illustrated by Coulter's recent discussion of orthogenesis in gymnosperms.‡ This, of course, is similar to that of Grabau, Hyatt, etc., in that it deals with extinct forms, but differs in being applied to a much longer period of variation and to less closely related forms, and it differs further in that it deals with the evolution of *organs* as such, the egg, proembryo, seed, etc., rather than with the phylogeny of *organisms*.

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* Eimer. On orthogenesis. Chicago. 1898.

† Studies in Gastropoda III. Am. Nat. **41**: 607–651. 1907.

‡ Science II. **42**: 859–863. 1915.

The conclusions reached by the writers specified above are like those of any similar morphologic or systematic research, but differ in the use of the term "orthogenesis," instead of "tendency to vary," "trends of variation," or some similar expression. This difference is of interest, however, because it lays emphasis on the belief that the evolution of the present-day organic world has not been by chance fluctuation, but has proceeded in an orderly fashion in a law-conforming way. According to orthogenetic theory, evolution proceeds, at least in part, by the progressive intensification of characters in any series of forms, regardless of considerations of adaptation or utility. In the long run, of course, only such forms as possess useful characters will survive.

In the present case, the lines of variation do not appear to be in the interests of utility. The new forms produced are not as adaptable to natural conditions as the original species from which they all originated. Proof of this is found in the fact that the various new varieties are, in general, more difficult of cultivation than the original form, and further proof is contained in the fact that none of the varieties of *N. exaltata bostoniensis* have been found wild in the tropics. It may appear then that these fern varieties, produced so artificially and unnaturally, are poor forms to cite as illustrations of orthogenesis. This would be true were it not for the fact that the same types of variation appear everywhere among ferns as distinctive of recognized species or even genera. That is, fern species *have* differentiated naturally by the same manner and degree of variation as is shown by these horticultural varieties. On this basis, these Boston fern sports may be considered as unsuccessful variations, either premature or normal, perhaps called forth or at least perpetuated by the unusual cultural conditions. Like wild forms in other genera in the degree of their variation, they are unlike them in having developed no means of maintaining themselves under natural conditions, and if put to the test of competition, would soon be disposed of by natural selection. They may be said to indicate potentialities of variation in *Nephrolepis*. It is worth while noting that variations of similar type *but of spore origin*, have appeared in other fern genera, notably *Polypodium* and *Polystichum*.

3. *Conditions under which Nephrolepis varieties have originated*

It is suggested in the preceding paragraph that cultural conditions may be responsible in some degree for the development or preservation of so many new varieties. Two points are of special interest in connection with the cultural conditions: first, the fact that these are probably generally the optimum for these ferns; second, the very large numbers of individual plants raised each year.

For soil, the florist uses a good loam or leaf mould with at least one half to equal amounts of rotted manure. In one case the mixture used consists of one part sand to five parts rotted manure, leaf mould, and humus. New plants are propagated from stock plants which are planted out in long benches in shallow soil. A single stock plant may produce nearly one hundred runners, as the young plants are called, in a single year. These new plants develop from slender stolons which spring from the parent plant close to or connected with the leaf bases, and penetrate the soil in all directions. Each runner may produce a considerable number of buds as well as roots. It is worthy of present note that these stolons serve not only for reproduction but also as agents in the nourishment of the parent plant, at least until the secondary plants have attained some size. The main point to be noted in connection with the methods of propagation aside from the quality of the soil, etc., is the freedom of growth which is given the stock plants and their progeny in the early stages. The plants after potting are sometimes further fed with liquid fertilizer of some sort. They are grown in low-roofed houses with absence of draft, and usually with no other kinds of plants which might desire slightly different conditions. If variation is in any way connected with vigorous growth, there is every reason why these ferns should vary.

With respect to the number of plants grown per annum, it is hard to estimate in what will appear a conservative manner. I have talked with two growers who claimed to sell three and four hundred thousand small plants every year and there seemed to be no reason why they should be exaggerating. There are undoubtedly half a dozen florists in the eastern states who raise over one hundred thousand plants each year, and a larger number who produce fifty thousand. The number who grow fifteen to twenty thousand is of course much larger still. Some deduction from the total thus indicated must be made in connection with smaller growers because of the fact that many buy part or all of their stock of ferns each year as small plants to raise to larger sizes. A single plant may thus be sold twice at wholesale, and once at retail, and the non-growing jobber may come in to make a third wholesale transfer. Taking everything into consideration, however, it seems safe to put the total number of plants raised every twelve months at not less than one million, and probably nearer two. As will readily be seen, this immense number offers large possibilities for the occurrence of variation.

A third factor connected with the selection and preservation of new varieties of these ferns is found in the fact that some of these varieties have been the means of large profits to their producers. The first good two-pinnate sport of var. *bostoniensis* created a furor in the florist trade, and was awarded gold medals and other insignia which no other new plant has ever received. The regular price for a small plant of a standard variety from a two and a half inch pot is five cents in hundred lots. New forms of merit now sell at introduction for twenty-five cents apiece, and some new forms have sold as high as one dollar per plant. In the past this has led to the exercise of great watchfulness for new forms of possible merit, and has thus aided in the discovery and development of new varieties. So many forms have now been developed, however, that there appears to be a reaction from the interest in new forms.

The figure as to the number of plants grown per year suggests the possibility of determining an approximate coefficient of variation, but this seems to be an almost impossible problem. For one variety about which I have made inquiry, the number indicated is at least one in three thousand. For another variety which is appearing rather frequently in different establishments at present, the coefficient is undoubtedly higher, perhaps one in one thousand. For yet another variety a figure of one in a million is probably too high an estimate. It should be added that these figures are for progressive variations only. Reversions or regressive variations appear much more frequently as a rule.

Two conclusions are evident from the foregoing: (1) the coefficient of variation differs with different varieties; (2) the coefficient of variation is never high for progressive variations.

4. *Methods of study*

One method of study of the Boston fern problem is indicated by the above facts as almost obligatory, viz., frequent visits to florists' establishments for purposes of observation. During the last two years I have visited nearly all the leading fern growers in the eastern states. Visits have been made to the greenhouses of the growers in Massachusetts, New York, New Jersey, Pennsylvania, and Ohio, who have produced practically all the new forms of *Nephrolepis* raised east of the Mississippi. These visits are being continued, and arrangements have been made for experimental work through the coöperation of some of the growers.

A second method of study has been connected with the assembling of a living collection of all obtainable varieties of these ferns at the Brooklyn Botanic Garden. These collections now number at least seventy-five varieties, nearly all obtained directly from their original producers, and orders are now in the hands of English and French growers for foreign varieties which will raise the total number to over one hundred. Requests have also been sent to a number of stations in the tropics for the collection of wild forms with a view to obtain a good representation of both horticultural and natural forms.

Still a third method which is really a combination of the other two has consisted in the introduction to florists all over the country of varieties with which they were not familiar. A large number of small plants have been sent out in this way. The benefit to the investigation will come in connection with future visits when a much larger number of varieties will be available for observation. A considerable number of new forms have also been obtained in this way by exchange.

It will be noted that there is little opportunity for the experimental production of new progressive variations in connection with the Botanic Garden collection. Not enough plants can be grown. In the florists' establishments, the number of plants may be large enough but it is not always possible to control all conditions or to find sufficient time for regular and thorough observation.

The greatest difficulty which inheres in the study of the known forms of these ferns is connected with the possible inaccuracy of the growers. For the facts as to the origin and parentage of each variety it is necessary to rely almost wholly on the statement of the florist who produced it. With every desire for accuracy, the grower may easily be mistaken with respect to the relationship of any given form, even if it has been under his eye since its first appearance. Plants of various forms are often grown together in stock beds, and the stolons may spread two or three feet in all directions with consequent mixing of the runners. When a form is discovered by one florist and sold for development and introduction to another, there is still greater chance for inaccuracy.

In general, however, there is every reason for believing that the statements which follow regarding the origin and relationship of the varieties are in the main accurate. Many of them, nearly all, in fact, are established beyond the possibility of any reasonable doubt. A few are definitely indicated as open to possible question.

It is a pleasure to acknowledge indebtedness to the numerous florists who have contributed to the living collections which have been built up almost exclusively by their gifts of plants. A nearly complete list of the contributing florists is given at the end of this paper in connection with an index of the varieties. To Mr. W. R. Maxon, of the United States National Museum, my thanks are due for valuable information regarding his collections and observations of these ferns in the tropics. For the opportunities at the Brooklyn Botanic Garden, without which complete data could not have been accumulated, I am glad to make grateful acknowledgment to Dr. C. Stuart Gager, the director. To Dr. O. E. White of the same institution I am indebted for a reading of my manuscript and a number of suggestions. Finally the study has been aided by a grant of one hundred dollars from the American Association for the Advancement of Science, made at the Columbus meeting, which will be applied to the expenses incident to the visits to florists. Only a small part of this has so far been used, most of the visits to date having been made at private expense.

B. ORIGIN AND DESCRIPTION OF THE VARIETIES IN NEPHROLEPIS

1. *N. exaltata and N. exaltata bostoniensis*

Nephrolepis exaltata, or rather its variety *bostoniensis*, has been named as the form from which the variations under consideration have all originated. As already noted, a number of other species in the genus have also given rise under horticultural conditions to variations similar to those of *N. exaltata*, but none of the other species has received as extensive cultivation, and there has, therefore, been less opportunity for variation. It may be noted here that all the wild species forms of *Nephrolepis* are once-pinnate. This is significant in consideration of the fact that among the varieties of *N. exaltata bostoniensis* are two-, three-, four-, and even five-pinnate forms. So far as I have been able to discover, only two partial aberrations from the once-pinnate type have been found wild; one, *N. biserrata* ("*davallioides*") *furcans*, with dichotomously divided pinnae, the so-called "fish-tail" form of the florists (see PLATE 12, FIG. 3, for illustration of this type of variation in the variety *falcata*); and the other, the anomalous form known as *N. Duffii* from New Zealand, referred by Goebel to *N. cordifolia* as a variety.

N. exaltata is a species of common and general occurrence in tropical America, and of somewhat scattered distribution in the Old World tropics. As I have it from Porto Rico, it appears as a plant with narrow erect leaves with sharply acute pinnae (PLATE 13, FIG. 1), well deserving its common name of "sword fern."* The sori are well developed and large with many fully formed sporangia. Presumably this form has been in cultivation in America for over fifty years, although the source and exact character of the original introduction are uncertain. It seems to have been first introduced into cultivation in 1793, at Kew, and came from Jamaica. The date of its American introduction I have not yet been able to discover, although this is a matter of consider-

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* There is a great deal of confusion in the trade use of the names "sword fern," "Boston fern," and *Nephrolepis exaltata*. In Florida, Dr. J. K. Small tells me the wild species, *N. exaltata*, is called "Boston fern," and the term "sword fern" is applied to the other Florida species, *N. biserrata*, a very different thing. Several florists, at least, list as *N. exaltata*, the dissimilar *N. cordifolia*, a further element of confusion.

able interest, especially with respect to the origin of the variety *bostoniensis*. Between 1890 and 1895 florists discovered that there were in cultivation under the name of sword fern two distinct forms, the one as above described, the other (see PLATE 13, FIG. 2) laxer, with broader leaves, upon which the sori and sporangia were small and abortive. The second form was also more rapid in growth.

There are two versions of the origin and discovery of this second form which afterward came to be known as the "Boston fern," or "Boston sword fern." According to one version, the variety was first discovered among a lot of two hundred small plants shipped as plain sword fern by the Robert Craig Company, of Philadelphia, to F. C. Becker, of Cambridge, Massachusetts. It is certain that the latter florist was among the first to recognize the importance of the second form which he at first identified as *N. davallioides*. Under this name a considerable number of plants were sold. This identification was later challenged by G. W. Oliver, of Washington, who finally convinced Becker after a considerable exchange of opinion in the Florists' Exchange* that the fern in question was at least not *N. davallioides*, or, as it should be called, *N. biserrata*. The dispute ended according to the citations referred to by September 12, 1896. Becker stated that the plant had been submitted to a fern expert by the Nomenclature Commission of the Society of American Florists, and his advertisement was changed so that the fern was listed henceforth as *N. exaltata bostoniensis*.

The other version has recently received a convincing statement in the Florists' Exchange† by F. W. Fletcher, of Auburndale, Massachusetts. According to this version, the Boston fern, when attention was first directed to it, was in the hands of several growers, particularly about Boston. Many of these growers were of the opinion that they were the discoverers of it, but there seemed to be no way of determining its real origin. At any rate it was referred to the Nomenclature Commission of the Society of American Florists as stated above, and by them submitted first to Kew, and later to G. W. Davenport. The latter is said

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* **8**: 23; 57; 92; 122; 814; 858. 1896.

† **40**: 1134, 1135. 20 N 1915.

to have been responsible for its identification as a variety of *N. exaltata*, and the assignment of the varietal name *bostoniensis*, because of its prevalence in the neighborhood of Boston. Supporting this statement, there is a single, small, and immature, leaf of var. *bostoniensis* preserved in the Gray Herbarium with Davenport named as collector and dated in 1896.

It may be noted that the second account does not preclude the possibility that a single florist, perhaps Becker, may have been originally responsible for the discovery of the new form. It is generally admitted that he had much to do with its exploitation and dissemination. It should be added, however, that some florists are of the opinion that the form has been in existence as long as forty years. A factor of great present uncertainty lies in the possibility of errors in identification on the part of florists. At present a number of florists are offering as *N. exaltata* a very different form, the species, *N. cordifolia* or *N. tuberosa*. Absolute nomenclatorial accuracy seems still to be beyond the abilities of botanists, even systematists, so that florists may be forgiven for occasional lapses, but the occurrence of such lapses indicates that the origin of var. *bostoniensis* may necessarily remain in the category of unsolved mysteries.

The study of tropical collections of *Nephrolepis*, both living and herbarium, may throw some light on this mystery. Another source of possible enlightenment lies in a study of the sources from which this species was introduced into cultivation. The possibilities of variation in a species so widely distributed as *N. exaltata* are too great to be overlooked. It is not impossible that the variety *bostoniensis* may have had a direct importation from the tropics.

2. *Sports from var. bostoniensis*

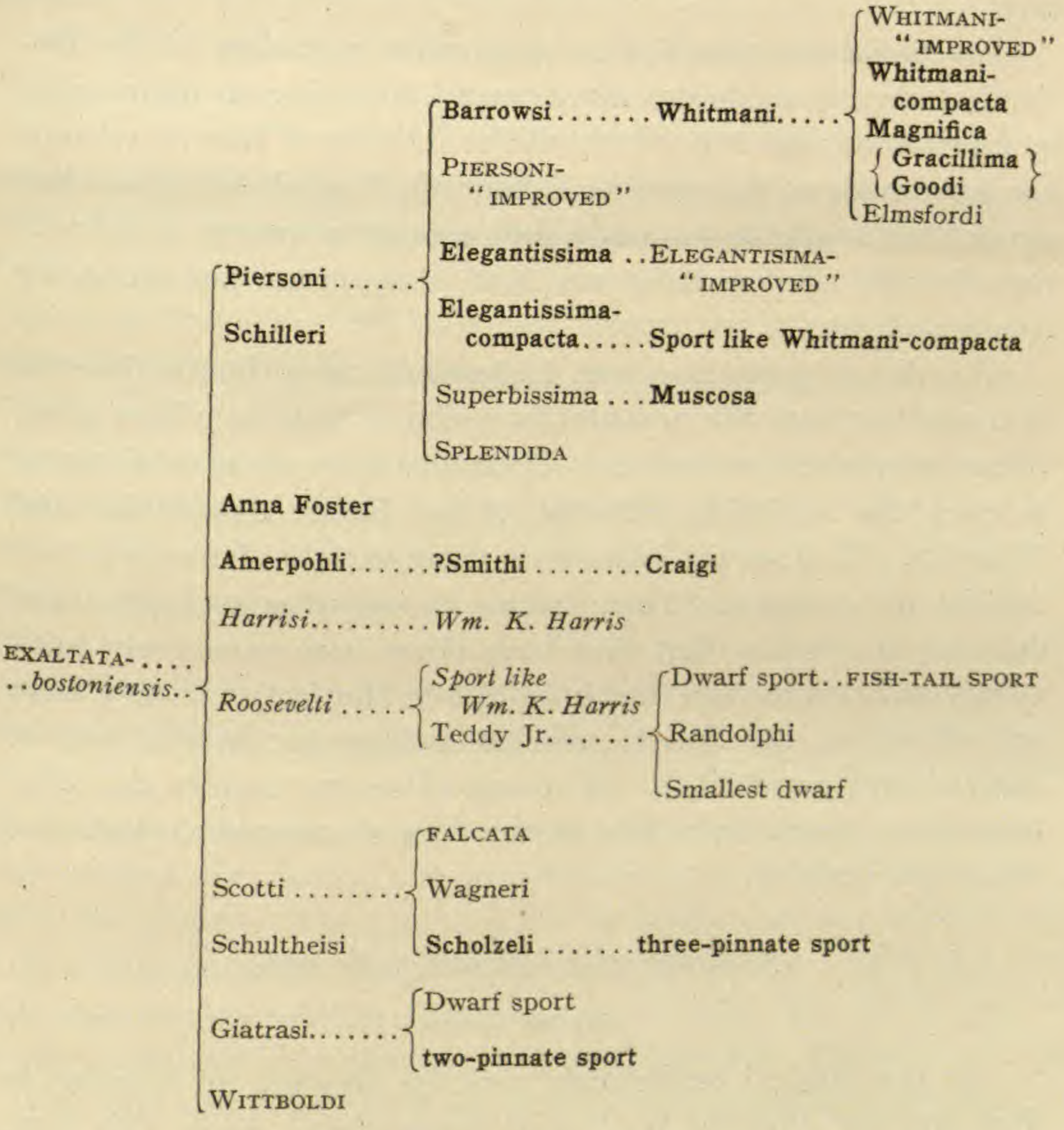
No matter what may be the uncertainty regarding the ancestry of var. *bostoniensis*, there is little or no uncertainty regarding its progeny. In the course of less than twenty years, it has given rise, directly and indirectly, to at least one hundred different forms. Its known first generation descendants probably number no more than twelve. The remaining ninety odd represent third, fourth, fifth, or even later generation sports of vegetative origin.

The forms which are claimed as direct sports from var. *bostoniensis* are as follows: *Piersoni* (PLATE 10, FIG. 2; PLATE 11, FIG. 2), *Schilleri*, *Anna Foster*, *Amerpohli* (PLATE 11, FIG. 7), *Harrisi* (PLATE 13, FIG. 3), *Roosevelti* (PLATE 13, FIG. 3), *Scotti* (PLATE 14, FIG. 2, 5), *Schultheisi*, *Giatrasi* (PLATE 15, FIG. 2) and *Wittboldi*. These forms do not represent ten diverse lines of variation, but three, or at most four or five. *Piersoni*, *Schilleri*, *Anna Foster*, and *Amerpohli* show an increase in leaf division from the once-pinnate type of var. *bostoniensis*. *Schilleri* seems to be an approximation of the form shown by *Piersoni*, which appeared more than ten years earlier. Both are twice-pinnate, as is *Anna Foster*, but the latter shows further differences in the shape and size of the ultimate segments, and other features. *Amerpohli* is thrice-pinnate, and, if directly descended from *bostoniensis*, represents a skipping of the twice-pinnate stage.

Scotti (PLATE 14, FIG. 2, 5), *Schultheisi*, and *Giatrasi* (PLATE 15, FIG. 2) are dwarf sports of var. *bostoniensis*. *Schultheisi* seems to be an approximate repetition of *Scotti*, ten years afterward. *Giatrasi* is well distinguished from the other two dwarfs in characters of growth habits, leaf form, etc., so that there may be said to be at least two distinct kinds of dwarf sports.

Harrisi and *Roosevelti* (see PLATE 13, FIG. 3) are almost exactly alike in respect to the leaf characters, but both differ from var. *bostoniensis* in having the pinnae more wavy or undulate, due to an increase in the parenchymatous part of the pinnae especially along the margin. *Wittboldi*, for which a spore origin is claimed, was originally described as "twice as wide as var. *bostoniensis*, and with wavy pinnae." As yet I have no surely authentic plants, and so cannot speak with certainty. The original introducers do not have the plant in stock now, but the material at hand named *Wittboldi* indicates that var. *bostoniensis* was probably not the parent form. The new form may have arisen as a chance sporeling, the result of the accidental introduction of some entirely different form, a very frequent occurrence in greenhouses. Herbarium specimens from Florida indicate that there may also be a "fish-tail" sport of var. *bostoniensis*, not included in the list of sports named above. There have probably been a few other variations of var. *bostoniensis*, either like those already named, or so unsatisfactory from the florists' point of view that they have not been preserved.

Eliminating the last two mentioned types, *Wittboldi* and the "fish-tail" form, there remain then three main lines of variation from var. *bostoniensis*, namely: a line showing increased division in the leaf, a line showing increased waviness or ruffling of the



GENEALOGICAL CHART OF PROGRESSIVE SPORTS OF *bostoniensis*

Black face type indicates division sports.
Italics indicate sports showing ruffling.
Plain Roman type indicates dwarfing.
SMALL CAPITALS INDICATE OTHER KINDS OF VARIATION.

pinnae, and a line showing dwarfing. These types of variations are referred to as "lines of variation" because they represent the beginning of the orthogenetic series already mentioned, series in which these three kinds of variation are repeated in intensified form in one or more further vegetative generations. In these three lines occur all the illustrations of progressive orthogenetic variation about which this paper is mainly concerned. Reversion or regressive variation is also common, but need not be considered here.

The variations classified as progressive according to the distinction already made are all arranged according to their origin in the chart on page 219. It should be understood that no attempt has been made at this time to include the English forms, as they are not yet available for study, but enough is known to indicate that they do not represent any kind of variation not shown by American forms.

The direct sports from var. *bostoniensis* are of further interest in connection with the present discussion only as they have given rise to progressive variations. Upon this basis we may eliminate at once the varieties, *Schilleri*, *Anna Foster*, *Schultheisi*, and *Wittboldi*. It does not follow that these varieties have no potentialities of variation. Their failure to vary has probably been due only to the fact that they have never been extensively cultivated, and this in turn, has been due to the fact that they have not offered to the florist sufficient inducement in the way of horticultural possibilities. It remains then to consider the other *bostoniensis* sports according to the lines of progressive variation which they exhibit.

3. *Progressive division of the leaf*

(PLATES 10–12)

Of the original *bostoniensis* varieties showing an increase in leaf division, *Piersoni* is of most importance. From this form have come three or possibly four types of sports, viz., varieties showing further increase in division, *Barrowsi*, *elegantissima*, and *elegantissima-compacta*: varieties showing dwarfing, *superbissima;* a variety with forked pinnae, *splendida;* and a so-called "improved" form, *Piersoni* "improved."

Piersoni represents a twice-pinnate sport from the once-pinnate var. *bostoniensis*. *Barrowsi* shows a slight increase in the lobing of the pinnulae, that is, it is twice-pinnate pinnatifid. *Elegan-*

tissima (PLATE 12, FIG. 1) and *elegantissima-compacta* (PLATE 12, FIG. 2) are, however, more divided, in some leaves as much as thrice-pinnate. *Elegantissima-compacta* is of further interest because it is also a dwarf, thus combining two lines of variation at once.

Piersoni "improved" illustrates a type of variation which is of special interest to florists, and to which they seem generally to apply the name "improved," as, for example, *elegantissima* "improved" and *Whitmani* "improved." All the forms in the division series revert more or less, that is, throw once-pinnate leaves, and sometimes runners, *i.e.* plants which revert as a whole. The florist objects to these mixed plants and selects for greater stability. When he obtains stock showing less reversion, he is likely to call it "improved." There is great variation in the matter of reversion. Some kinds are relatively stable from their first appearance, others may produce as many reverting leaves as of the new type. Usually in order to keep stock true to type, a florist must exercise care in the selection of the runners which are used as stock plants.

Another illustration of dwarfing from *Piersoni* apparently of a brachyotic nature is represented by the variety *superbissima* (PLATE 12, FIG. 4), which is much less than half as long as its parent form. The dwarfing has been achieved mainly by a radical shortening of the rachis, with proportionately less decrease in the size of the pinnae. The resulting leaf is dense, stiff and twisted, of no particular grace, but interesting as an oddity. Like *Piersoni*, *superbissima* exhibits considerable reversion, and as yet no certain "improved" or non-reverting form has been obtained.

The sixth sport of *Piersoni* which may be classed as progressive, exhibits the kinds of variation prevalent though not common throughout the fern order, that is, the forking or dichotomy of the leaf apex or of the segments. In this form, called *splendida* (PLATE 12, FIG. 3), the pinnae show the forking, and a single plant may bear at one time several kinds of leaves, once-pinnate, twice-pinnate, and forking.

Referring again to the form *superbissima*, it may be noted here that from this there has come, as from *Piersoni* itself, a further sport showing progressive increase in the division of the leaf.

This variety is called *mucosa* (PLATE 12, FIG. 6) because of the dense, finely divided condition of the leaf. It seems to represent the same amount of division of leaf as is seen in the forms *elegantissima* and *elegantissima-compacta*, that is, it is thrice-pinnate. Tracing the ancestry of *muscosa*, we find the four forms, *bostoniensis—Piersoni—superbissima—muscosa*, which are, respectively, one-pinnate, two-pinnate, dwarf, and three-pinnate.

Two generalizations are suggested by the facts shown in the preceding series, and borne out by others to be shown later, which, if thoroughly understood, will simplify the description and explanation of the remaining forms. They rest not only on these few examples, but, as will appear, are true in the case of nearly all the variations considered in this paper.

1. Progressive variation takes place naturally along the three lines already described, viz., increase in leaf division, increase in ruffling or crisping, and dwarfing.

2. Any form which has not reached the limits of possibility in variation along the first and last mentioned lines, may be expected to give rise to new forms showing further progressive variation in one or both of them.

To particularize, we may say that any once-pinnate form may be expected to give rise to a twice-pinnate variety. A twice-pinnate variety may be expected to give rise to a thrice-pinnate form. The most highly divided form which has so far appeared is five times pinnate (see PLATE 10, FIG. 5; PLATE 11, FIG. 6), and there appear to be constitutional physiological reasons why further division is unlikely. As is the case in the progressive division in the leaf, so also with dwarfing or pumilism. Any large form whether once- or twice-pinnate, may be expected to give rise to a dwarf variety, as *superbissima* was derived from *Piersoni*, and as dwarf forms have occurred in the other series to be described below. With respect to progressive increase in ruffling, it is uncertain whether the second generalization applies to this line of variation or not. It may be that it does not apply in this line at all, or it may be that in the division series, a change in the degree of waviness would be too relative to admit of exact determination. It is certain that dwarfing occurs in all three lines, and that increase in division occurs also in the dwarfing series. Whether increase in division also occurs in the frilled or ruffled series is yet to be determined.

Of all the varieties of *Piersoni*, *Barrowsi* is perhaps of greatest interest because it has given rise to at least two further generations (vegetative) of division sports. From *Barrowsi* has come *Whitmani*, a clear increase in division, and from *Whitmani* have come several sports showing still more division.

Of the sports of *Whitmani* (PLATE 10, FIG. 3; PLATE 11, FIG. 3) named on the chart, *Whitmani* "improved" represents a more stable form, *i.e.* less given to reversion. *Whitmani-compacta* is a trifle smaller than its parent form, and has a fuller leaf with more expanded segments. *Goodi* and *Gracillima* (PLATE 11, FIG. 4; PLATE 12, FIG. 5) are apparently separate occurrences of the same variety, entirely thrice-pinnate, and with smaller segments than *Whitmani*. It may represent a dwarfing. *Magnifica* (PLATE 10, FIG. 4; PLATE 11, FIG. 5) is clearly four times pinnate, and represents the greatest amount of division which can be definitely stated to have been evolved in this particular series. *Elmsfordi* (PLATE 12, FIG. 7), a reputed spore sport, looks much like a miniature *Whitmani*, being less than half its size. It is different in another particular, in that it produces a much greater number of leaves to each crown, and in a given size pot. A plant grown to full size in a four-inch pot may show as many as a hundred leaves. In a twelve-inch pan, an estimate of a thousand leaves appeared conservative.

The other progressive sports in the *Piersoni* line are sufficiently described for the present by the typography of the chart and by the figures in plates 10–12.

The other reputed *bostoniensis* sport from which further progressive variations in the line of division are believed to have come is *Amerpohli*, a thrice-pinnate variety. *Amerpohli* in leaf division is very like *magnifica*, and in growth habit and carriage of the leaf it is also similar. Because of this close resemblance it is more than reasonable to suggest that it may really have come from *Whitmani* as a sport and that its reputed origin from var. *bostoniensis* may be an error. From *Amerpohli*, the four times pinnate form, *Smithi*, is said to have come. There is some question as to the correctness of this assertion but none regarding the fact that from

Smithi a five times pinnate form, *Craigi* (PLATE 10, FIG. 5; PLATE 11, FIG. 6), has come. This form is particularly interesting as exemplifying what is at present the highest amount of leaf division that has been attained by these forms. *Craigi* is illustrated in the plate with *Piersoni* not as necessarily derived from this but in order to complete the possible series of division forms. In that plate *Barrowsi* has been omitted because I have not yet been able to get a mature leaf of it.

As appears most noticeably on the plates illustrating these division forms, the increase in pinnation seems generally to be accompanied by a striking decrease in the size of the leaf, that is, in the total area. It is probable, however, that the actual leaf surface area remains the same, the apparent decrease being compensated for by the multiplication of the segments which may even expose more actual surface.

4. *Progressive increase in ruffling of the leaf*

(PLATE 13)

The series showing progressive increase in ruffling or crisping of the leaf begins with the original species, *N. exaltata* (PLATE 13, FIG. 1), because one of the characters in which var. *bostoniensis* (PLATE 13, FIG. 2) departs from the typical *N. exaltata* is in this feature. From var. *bostoniensis* there have been two more ruffled sports, *Harrisi* and *Roosevelti*, almost duplicating each other in appearance, but well distinguished as regards their progeny. PLATE 13, FIG. 3, may represent either *Harrisi* or *Roosevelti*, and PLATE 13, FIG. 4, may represent the variety *Wm. K. Harris*, or a coördinate form of similar appearance derived from *Roosevelti* but unnamed. Both are alike in leaf characters including crisping of pinnae, and both represent the highest development of this character which has been obtained in a direct progressive series. It will be noted that with the increase in crisping there has come also a tendency to develop auricles on the pinnae. This is of interest because it is a feature characteristic of wild varieties of other fern species.

The form described above represents the final sport so far obtained from the *Harrisi* line. From the *Roosevelti* line, however, two additional generations have appeared, showing progressive dwarfing. The first, called *Teddy Jr.* (PLATE 13, FIG. 5), has the characteristics appropriate to the principles of its namesake, as it appears to be the most prolific in producing new progressive variations of any *Nephrolepis* form. These new variations have appeared in three forms, but the interesting feature about them is that they are apparently common wherever *Teddy Jr.* is grown. In other words, *Teddy Jr.* shows a high frequency of variation.

Teddy Jr. is about half the size of the parent form *Roosevelti*. The three new forms are further dwarfs as shown in PLATE 13, FIGS. 6–8, respectively, the last being the smallest of the three and perhaps brachyotic. Only one, the middle-sized one, has been named as yet, being called *Randolphi* (FIG. 7) or "Baby Randolph." The smallest form may come directly from *Teddy Jr.* or it may also, according to report, arise as a sport from the largest of the three *Teddy Jr.* dwarfs.

It will be noted that the illustrations indicate that the amount of frilling continues to increase in the successively smaller forms. This increase, however, is probably to be correlated with the dwarfing, and should not be interpreted as in the line of progressive increase in ruffling.

From the largest of the three dwarf sports from *Teddy Jr.* there has just come to my attention a fish-tail sport, a form of variation apparently possible in all ferns.

5. *Progressive dwarfing*

(PLATES 14 AND 15)

Finally we have the series showing progressive dwarfing directly from var. *bostoniensis*. This seems to have occurred in three separate instances. The forms *Scotti* (PLATE 14, FIGS. 2, 5) and *Schultheisi* appear to be very similar, but independently derived. Of these *Scotti* is particularly interesting because it has given rise to other sports. *Giatrasi* (PLATE 15, FIG. 2) is also interesting for the same reason, and because it has distinctive features of its own. Neither of these dwarfs seems to be brachyotic.

Scotti (PLATE 14, FIGS. 2, 5) differs from var. *bostoniensis* not only in being smaller, but also in having blunter more wavy pinnae, and in having both leaves and pinnae more or less arched. From *Scotti* have come dwarf and division sports, as well as a fish-tail form. The further dwarf is called *Wagneri* (PLATE 14, FIGS. 3, 6), and seems to represent merely a foreshortening of the *Scotti* form with an intensification of the arching.

The division sport of *Scotti* is called *Scholzeli* (PLATE 14, FIG. 7), and is practically a miniature *Piersoni* in the type of division, shape of pinnae, et al. From *Scholzeli*, a two-pinnate form, has come a three-pinnate sport (PLATE 14, FIG. 8) to which no separate name has been given. It has been sold as *Scholzeli*. It corresponds to *Whitmani* in the division series proper, and like this would undoubtedly give rise to a four-pinnate form if grown in sufficient numbers.

Giatrasi (PLATE 15, FIG. 2) is little more than half as large as *Scotti*, and differs further in being slower growing, in producing a larger number of leaves per crown, and in the characteristics of individual leaves as well. These are thinner, have undulating rachides, and the pinnae are shorter and blunter. Because of its slower habits of growth, it appears to have found favor only with its introducer, George Giatras, in whose establishment some five to ten thousand plants are grown each year. Under these conditions it has given rise to two further sports, both as yet unnamed. One of these is a further dwarf (PLATE 15, FIG. 3), and the other is twice-pinnate (PLATE 15, FIG. 4). These new forms seem to partake of the slower growth habits of *Giatrasi*, and are therefore unlikely ever to be grown in quantity. This is unfortunate from a scientific point of view, as their further development and possible sports would be of considerable interest.

C. GENERAL CONSIDERATIONS

Some general considerations suggest themselves as a result of the foregoing descriptions; for example, the character and significance of the reversions, the possibilities of spore reproduction and segregation of forms, the possible results of morphological and cytological studies, etc. Nothing, however, is to be gained by speculation along these lines in the absence of additional facts. The reversions are under observation, and I hope that another growing season may allow the accumulation of sufficient information to make possible a description of these forms. Furthermore, the forms which have been so incompletely described in the preceding pages are worthy of a more careful and detailed study and description. I hope also to start spore cultures within a few weeks, using not only material known to be spore-fertile, but also forms presumably spore-sterile in the hope that apospory may result. There are indications that this phenomenon may occur.

Before concluding the present consideration, there are, however, two or three phases of the topic to which attention should be directed, by way of emphasis upon the significance of the variations which have been described.

First, further emphasis should be laid upon the separateness of the forms inter se. They are entirely discrete and distinct, and in this respect, are in accord with the characteristics ascribed to mutations. The individuals of a given variety show great uniformity under any given conditions of cultivations, and do not pass by imperceptible differences into related varieties. The fact that reversion takes place does not alter the separateness of the different varieties. In fact the reversions themselves furnish the best possible evidence of the distinctiveness and lack of continuity between even closely related varieties. The truth of this statement is established by the fact that the reversions are rarely if ever complete. A twice-pinnate variety may show some once-pinnate leaves and may give rise to new plants with once-pinnate leaves, but these once-pinnate leaves do not show a complete return to the form, size, etc., of the leaves of the original once-pinnate variety. The leaves of the reverted plant tend always to retain something of the character of the twice-pinnate plant. It appears then that the process by which the twice-pinnate form was produced from the original once-pinnate form must represent a protoplasmic change which is retained to some extent, even in the reversion. I cannot say that reversion may never be complete, but I have not yet found any cases where it is. This fact, however, that in any given progressive variation, a constitutional change is effected so pronounced that it can rarely if ever be completely reversed, is striking evidence that the varieties formed by progressive variation are distinct and discontinuous.

One of the interesting morphological possibilities is found in a problem under study, to determine whether new bud sports do not always appear first in the form of a variant leaf on the parent plant, this leaf showing the line of variation which the new form afterward fulfills. The solution of this problem depends on the possibility of determining whether each leaf has a subtending runner, and whether all the new plants from a given runner are alike and partake of the characteristics of the connected leaf. The problem, stated in other words, is to determine whether the actual process of variation takes place first in the cells of the leaf and is repeated in the runner and its sports, or whether the variation may not take place in the runner itself.

The fact that varieties in the division series do not always differ *inter se* merely by division, but also sometimes in the size and shape of the segments et al., and the further fact that other variations occur, such as dwarfing and ruffling, are in opposition to the conclusions reached by R. G. Leavitt,* who suggested that the appearance of varieties showing an increase in division was due merely to a translocation of the ability to divide from the whole leaf to the pinnae, a phenomenon to which he applied Bateson's term of homoeosis. To accept the hypothesis of such a translocation, it would be necessary to find that the twice-pinnate form differs from the once-pinnate form, from which it arose, merely in the amount of division, a supposition which is hardly supported by facts.

A further argument for the hypothesis of homoeosis adduced by Leavitt, and applied not only to these ferns but also, for example, to the horse-chestnut, lay in the fact that the new forms possessed no utilitarian advantage over their parents. The fact that the horse-chestnut leaf cuts off each pinna by a distinct callus as well as its petiole base, and that this double *decision* appears to have no adaptive value, was advanced as confirmatory of the homoeosis thesis. This is interesting, but will hardly be accepted as an argument in view of modern objections to teleological explanations. It may be noted that Eimer, twenty and more years ago, made a most determined stand against the belief that adaptability was a prime necessity in the appearance of new characters and the evolution of new forms.

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* Bot. Gaz. 47: 30–68. Ja 1909.

With respect to the present group of horticulturally produced forms, it appears evident that the lack of adaptability to natural conditions shown by most of them would prevent their establishment if they were to be introduced. This statement is probably true for the original sports of var. *bostoniensis* as well as for the forms of later vegetative generations, and this fact in itself is an adequate explanation of the non-occurrence of any of these forms wild. On this assumption they represent new forms produced in the course of evolution, most of which would be eliminated by the discriminating agency of natural selection. They differ therefore from wild forms showing the same types of variation, only in their non-adaptability. Certainly the three lines of variation along which these forms of *Nephrolepis* have been differentiated, and especially the lines of increase in division and dwarfing, can be paralleled by similar lines of variation among wild forms which have succeeded better because provided with the means to meet natural conditions of competition, etc. Certainly also the forms described in this paper comprise, within their extremes of variation, greater differences than are required for the differentiation for many natural species. For example, differentiation of species and even genera on the basis of leaf division is too common, not only among ferns but also among flowering plants, to require more than mention.

As possible corollaries to the statements of the preceding paragraphs, two points are of interest and may be indicated in the form of questions. Is the rapidity of evolution of these *Nephrolepis* varieties, fifty or more in fifteen years, any indication of the speed of evolution of wild forms of similar distinctiveness? Or does the fact, that nearly all if not all of these forms would lose out in the struggle for existence, indicate that, while the appearance of ill-adapted variations may be common, the appearance of successful variations is most uncommon?

In the preceding paragraphs it has been assumed that the variations of these cultivated ferns are homologous with similar variations occurring among wild species. If this is true, (that the two lines of variations are homologous) it is not improbable that the causes may be similar. These causes may be sought by experimental methods, by the cultivation of a variety which shows a relatively high coefficient of variability, as for example, *Teddy Jr.* They may be sought by cytological study of similar variations, as is shown by the production of dwarfs in many widely separated lines, or by the reversions. The cytological method would only show some possibly correlated facts of cell structure. The experimental method might show some connection between cultural methods and the appearance of new forms. In this connection it may be noted that Eimer and Coulter, perhaps the earliest and the latest to discuss the possible causes of orthogenetic variation, have both professed the opinion that climate is the probable causative agency.

The query has been expressed as to whether a hybrid origin might not account for these variations of *bostoniensis*. With this possibility in mind, one species of *Nephrolepis*, *N. biserrata*, which is co-extensive with *N. exaltata* in distribution, would seem to be worthy of investigation. It is hard to imagine, however, how the combination of any two twice-pinnate species of *Nephrolepis*, or indeed of any more dissimilar species, could account for the appearance not only of the three lines of variation but of the progressive intensification of these lines thereafter. The sterility of these forms is apparently the only feature these forms have in common with most hybrids, and this must presumably be accounted for in some other way.

For the present, all that can be said as to the genesis of these forms is they apparently proceed from some internal cause. It may be added that similar variations have occurred as a result of spore sporting, and also that similar variations are common wild. These forms may therefore be considered as indicating how species, showing similar differences, have arisen, that is, by what lines of variation. The evidence offered along this line by the progressive forms alone is most incomplete, however, without an understanding of the regressive variations as well.

D. SUMMARY OF FACTS AND CONCLUSIONS

1. *Nephrolepis*, a genus of once-pinnate tropical ferns, includes several species which are cultivated. Nearly all of these cultivated species show variation by bud sports, but *N. exaltata* through its variety *bostoniensis* is most prolific, having given rise

to more than one hundred different forms in less than fifteen years.

2. Cultural conditions are such as to favor the appearance and preservation of variations, because the soil and other environmental conditions are probably practically perfect, and because very large numbers of plants, one to two million, are grown per annum in the United States alone.

3. The variations may be classified under two headings, progressive, and regressive or reversive. Progressive varieties are defined as those which show less resemblance to var. *bostoniensis* than their parent forms. Regressive varieties are defined as those which show something of a return in characters toward var. *bostoniensis*.

4. Progressive variations have appeared along three main lines, viz., those showing increased division of the leaf; those showing increased ruffling of the pinnae; those showing dwarfing. Variations showing dichotomy of the pinnae and leaf tips also occur.

5. Progressive increase in division has gone through five vegetative generations, each succeeding step being an intensification of the preceding, the forms varying from once to five times pinnate. Progressive increase in ruffling has gone through three vegetative generations. Progressive dwarfing has gone through three vegetative generations.

6. The dwarfing seems to be clearly of two sorts: first, brachyotic or unilinear; and second, normal in all dimensions. More than one type of division sport is also indicated.

7. Progressive increase in leaf division and progressive dwarfing may be expected in any form which has not reached the limits of variation along these lines.

8. Regressive variations rarely if ever show complete return to their parent forms or to var. *bostoniensis*.

9. The indicated coefficient of variation for progressive variations is very low; probably between one in one million and one in one thousand. Regressive variation is much more common.

10. The variations are all discrete or discontinuous, not proceeding by imperceptible differences.

11. The progressive variations in their differences actually

parallel the differences existing between many wild species of ferns and flowering plants.

12. The main difference between these variations and those shown by wild forms lies in the fact that these horticultural forms do not possess adaptability to natural conditions. In most cases, with the variation, has come decreased vigor of growth.

13. The cause or causes of these variations are undetermined. They proceed as if from internal stimulation. The improved cultural conditions do not appear as causes, but rather as a means of preserving forms which, under wild conditions, would be eliminated by natural selection.

E. INDEX OF THE SPORTS DESCRIBED ABOVE

VARIETIES SHOWING INCREASE IN LEAF DIVISION

Name	Producer
Anna Foster	Lucias Foster, Dorchester, Mass.
Barrowsi	Henry Barrows, Whitman, Mass.
Amerpohli	Edward Amerpohl, Janesville, Wis.
Elegantissima	F. R. Pierson, Tarrytown, N. Y.
Elegantissima-compacta	F. R. Pierson, Tarrytown, N. Y.
Elegantissima "improved"	F. R. Pierson, Tarrytown, N. Y.
Giatrasi	George Giatras, West Hoboken, N. J.
Goodi	Good & Reese, Springfield, Ohio.
Gracillima	Henry Barrows, Whitman, Mass.
Craigi	Robert Craig, Philadelphia, Penn.
Magnifica	Henry Barrows, Whitman, Mass.
Muscosa	F. R. Pierson, Tarrytown, N. Y.
Piersoni	F. R. Pierson, Tarrytown, N. Y.
Schilleri	J. L. Schiller, Toledo, Ohio.
Scholzeli	Herman Scholzel, New Durham, N. J.
Scholzeli, three-pinnate sport	Herman Scholzel, New Durham, N. J.
Smithi	John Clark, Washington Botanic Garden, Washington, D. C.
Whitmani	Henry Barrows, Whitman, Mass.
Whitmani compacta	Henry Barrows, Whitman, Mass.
Whitmani "improved"	Henry Barrows, Whitman, Mass.
Elegantissima sport, like Whitmani compacta	George Giatras, West Hoboken, N. J.

VARIETIES SHOWING PROGRESSIVE RUFFLING

Name	Producer
Var. bostoniensis	?F. C. Becker, Cambridge, Mass.
Harrisi	Wm. K. Harris, Philadelphia, Pa.
Wm. K. Harris	Wm. K. Harris, Philadelphia, Pa.

Roosevelti	American Rose & Plant Co., Springfield, Ohio.
Roosevelti sport, like Wm. K. Harris	American Rose & Plant Co., Springfield, Ohio.

VARIETIES SHOWING PROGRESSIVE DWARFING

Name	Producer
Elegantissima-compacta	F. R. Pierson, Tarrytown, N. Y.
Elmsfordi	Scott Bros., Elmsford, N. Y.
Giatrasi	George Giatras, West Hoboken, N. J.
Giatrasi, dwarf sport of	George Giatras, West Hoboken, N. J.
Schultheisi	Anton Schultheis, College Point, N. Y.
Scotti	John Scott, Brooklyn, N. Y.
Superbissima	F. R. Pierson, Tarrytown, N. Y.
Wagneri	Peter Wagner, Brooklyn, N. Y.

VARIETIES SHOWING DICHOTOMY OF PINNAE

Name	Producer
Falcata	Peter Wagner, Brooklyn, N. Y.
Splendida	Good & Reese, Springfield, Ohio.

VARIETY OF UNCERTAIN CHARACTER

Name	Producer
Wittboldi	Wittbold, Chicago, Ill.

Explanation of plates 10-15

All photographs made to about the same scale except on Plates 11 and 14.

PLATE 10

Leaves illustrating a division series. Fig. 1. Var. *bostoniensis*. Fig. 2. *Piersoni*. Fig. 3. *Whitmani*. Fig. 4. *Magnifica*. Fig. 5. *Craigi*.

PLATE 11

Pinnae illustrating a division series. Fig. 1. Var. *bostoniensis*. Fig. 2. *Piersoni*. Fig. 3. *Whitmani*. Fig. 4. *Goodi* (or *gracillima*). Fig. 5. *Magnifica*. Fig. 6. *Craigi*. Fig. 7. *Amerpohli*.

PLATE 12

Illustrating one secondary and four direct sports of *Piersoni*. Fig. 1. *Elegantissima*. Fig. 2. *Elegantissima-compacta*. Fig. 3. *Splendida*. Fig. 4. *Superbissima* (small leaf). Fig. 5. *Goodi* (or *gracillima*). Fig. 6. *Muscosa*. Fig. 7. *Elmsfordi*.

PLATE 13

Illustrating variations in ruffling and dwarfing. Fig. 1. *Nephrolepis exaltata*. Fig. 2. Var. *bostoniensis*. Fig. 3. *Harrisi* (or *Roosevelti*). Fig. 4. *Wm. K. Harris* (or new sport of *Roosevelti*). Fig. 5. *Teddy Jr*. Figs. 6–8. Dwarf sports of *Teddy Jr*. Fig. 7. *Randolphi*.

PLATE 14

Pinnae illustrating dwarfing and sports of *Scotti*. FIG. 1. Var. *bostoniensis*. FIG. 2. *Scotti*. FIG. 3. *Wagneri*. FIG. 4. *Falcata*. FIG. 5. *Scotti*. FIG. 6. *Wagneri*. FIG. 7. *Scholzeli*. FIG. 8. Three-pinnate sport of *Scholzeli*.

PLATE 15

Illustrating dwarfing and sports of *Giatrasi*. FIG. 1. Var. *bostoniensis*. FIG. 2. *Giatrasi*. FIG. 3. Dwarf sport of *Giatrasi*. FIG. 4. Two-pinnate sport of *Giatrasi*.

The vegetation of Connecticut

V. Plant societies along rivers and streams*

GEORGE E. NICHOLS

(WITH ELEVEN TEXT FIGURES)

In the present series of papers on the vegetation of Connecticut, the principle of succession has been adopted as the most satisfactory basis for classifying plant associations. This scheme of classification, it may here again be remarked, treats vegetation both from a genetic and a dynamic standpoint. It recognizes the fact that plant societies, or associations, as they exist today, are the product not alone of contemporaneous conditions, but of past conditions as well. It also emphasizes the fact that the plant associations of today are not necessarily permanent, but are liable to change through the influence of various factors.

In the third and fourth papers of the series,† attention was directed to the plant associations of uplands and of lowlands. There the changes in vegetation, and therefore the succession of plant associations, are influenced primarily by plant and animal agencies—in other words, by biotic factors. There remain to be considered, then, successions which are associated not only with biotic factors but with topographic factors as well. Succession of this sort has been termed TOPOGRAPHIC SUCCESSION. Topographic succession is seen principally along rivers and streams and along the coast. The present paper deals with plant societies along rivers and streams. Some of these societies might almost equally well have been treated along with the societies of uplands and of lowlands; yet, on the whole, so marked may be the impress of a stream on the vegetation at its margin, and so closely linked may be the development of the one with that of the other that the two cannot well be treated separately.

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* Contribution from the Osborn Botanical Laboratory.

† Torreya 14: 167–194. 1914; Bull. Torrey Club 42: 169–217. 1915.

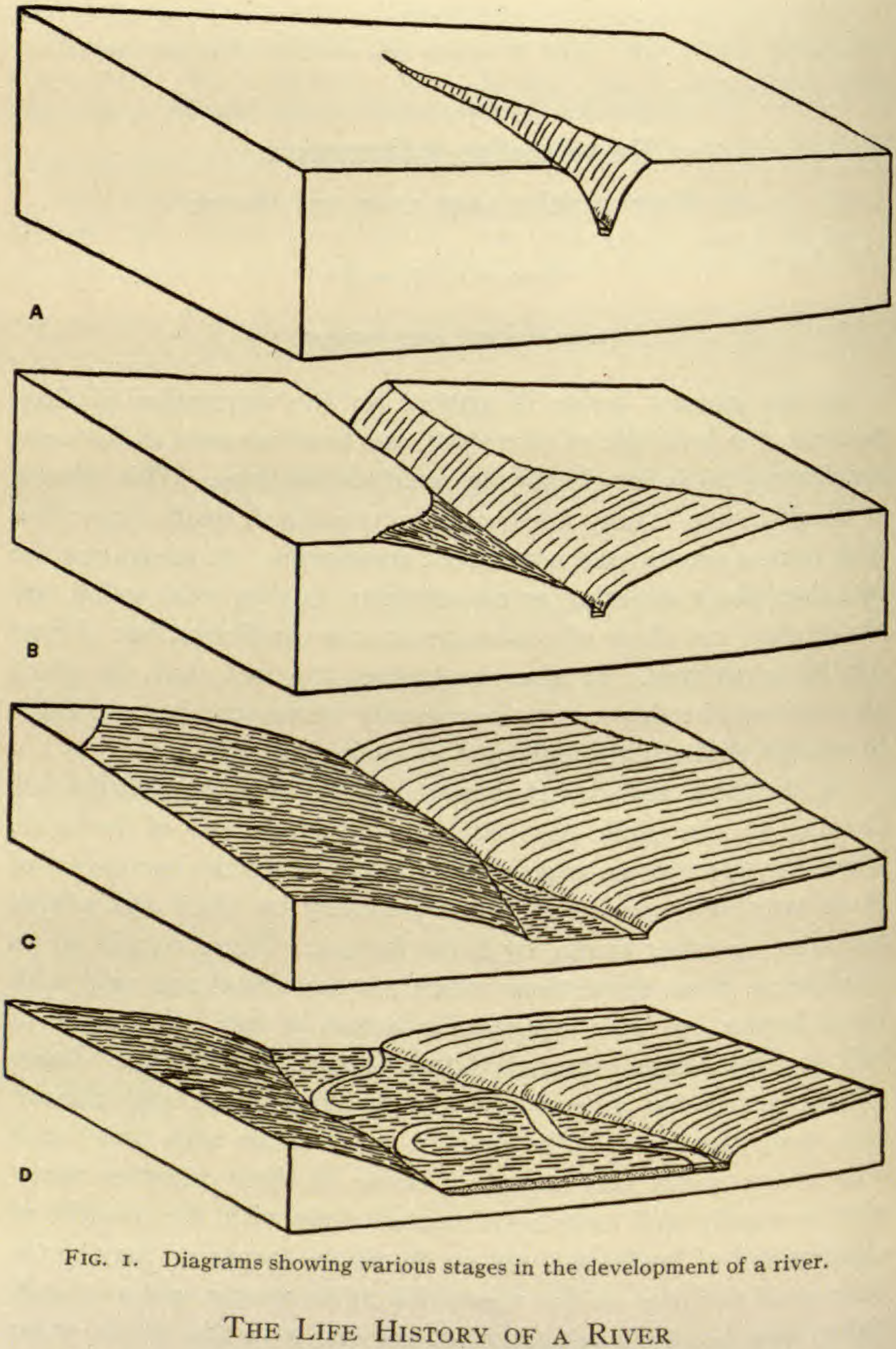

FIG. 1. Diagrams showing various stages in the development of a river.

THE LIFE HISTORY OF A RIVER

Various stages in the life history of a river are graphically represented in FIG. 1. In a young stream the current is swift and wears away the floor and sides of its channel. Vertical erosion, however, is greater than lateral, so that the stream may gradually intrench itself in a narrow ravine or canyon. At this stage of stream development vegetation is largely confined to the flanks of the ravine. During the course of time, as the channel is cut deeper and deeper, downward erosion proceeds more and more slowly, ultimately ceasing altogether, while lateral erosion becomes correspondingly more pronounced; so that, as the stream approaches maturity, it comes to occupy a broad valley which it has carved out for itself. Vegetation covers both the bordering bluffs and the floor of the valley. As the level of the stream approaches the level of the water at its mouth, the current becomes sluggish and aggradation largely succeeds degradation. An old age river meanders about in broad, sweeping curves on the flood plain which it has built up out of sediment derived from younger parts of its system. A very distinctive type of vegetation is developed on flood plains.

Of course, the rate at which the topographic changes outlined in the preceding paragraph are effected varies widely according to the nature of the rock formations concerned. The scouring out of a ravine in clay or gravel, for example, may proceed with comparative rapidity, but the erosion of a ravine in rock is extremely slow. Ravines in glacial till and outwash have been developed since the retreat of the glaciers, and may even now be observed in the process of active formation. In most rock ravines, on the other hand, the topographic changes since the ice age have been practically negligible. The bearing of these facts on the nature of the vegetation will be referred to in later paragraphs (pp. 245, 249).

ROCK RAVINES

Occurrence and General Features.—Throughout the region under discussion the rock ravine is the common type. It abounds in the highland districts, and in the Central Lowland is frequent along the trap ranges and elsewhere. Owing mainly to the nature of the rocks concerned, canyons with overhanging or perpendicular walls are absent. The predominant type of rock ravine (FIG. 2) is somewhat V-shaped in cross section, often narrow and precipitous below but broadening out above. Toward the bottom the vegetation may be restricted to such forms as can cling to the rock face or maintain a foothold in crevices, but higher up the sides are usually forested.

There are, of course, all sorts and sizes of ravines. In the remarks on the nature of ravine vegetation which follow, the writer has in mind a number of unusually good examples, such as Sage's Ravine and the Wolf Den in Salisbury, the Glen along Spruce Brook at Beacon Falls, Wintergreen Falls ravine in

FIG. 2. Precipitous rocky slopes along stream in Sage's Ravine, Salisbury. The cliffs in the foreground are covered with mosses and liverworts.

Hamden, Woodbridge Glen in Woodbridge, Roaring Brook ravine in Cheshire, Devil's Gulch in Branford, and Ninevah Falls ravine in Killingworth. Most of these are ravines of considerable depth and have a good-sized brook at the bottom. To shallower, less well-developed ravines the remarks naturally may not be equally applicable.

The Bryophytic Flora of Rock Ravines.—Perhaps the most striking feature of the vegetation near the bottom of a ravine (FIG. 2) is the rich display of mosses and liverworts. In the stream itself, attached to rocks but always submerged, grow various aquatic forms, such as *Fontinalis*. Other more or less hydrophytic species cover the low-lying, wet and frequently submerged rocks along the margin and in the bed of the stream, mantle the spray-dashed rocks at the foot of waterfalls, and form extensive mats even in rapids and similar precarious situations. The following more or less hydrophytic species may be looked for in such places:

Chiloscyphus rivularis
Scapania undulata
Porella pinnata
Fontinalis dalecarlica
Fontinalis gigantea
Fontinalis Lescurii
Oxyrrhynchium rusciforme
Amblystegium fluviatile
Amblystegium irriguum
Hygrohypnum dilatatum
Hygrohypnum eugyrium
Hygrohypnum ochraceum

Growing on periodically inundated rock surfaces, either in the bed of the stream or along its sides, are such forms as *Fissidens incurvus*, *Grimmia apocarpa*, *Racomitrium aciculare*, and *Brachythecium plumosum*. Along with these, but usually on springy banks or on continuously moist rock surfaces, where they may or may not be submerged during flood time, may occur:

Conocephalum conicum
Pellia epiphylla
Plagiochila asplenioides
Lophocolea bidentata
Jubula pennsylvanica
Anthoceros laevis
Fissidens adiantoides
Mnium hornum
Mnium punctatum
Philonotis fontana
Thuidium delicatulum
Brachythecium rivulare
Climacium americanum
Catharinaea undulata

Higher up on the slopes, numerous species thrive in the crevices or plaster the faces of overhanging cliffs and precipitous rocks. The following are fairly characteristic of wet or moist cliffs:

Marsupella emarginata
Plagiochila asplenioides
Scapania nemorosa
Radula complanata
Lejeunea cavifolia
Hymenostylium curvirostre
Didymodon rubellus
Anoectangium Mougeotii
Plagiopus Oederi
Plagiothecium denticulatum
Hylocomium brevirostre
Thamnium alleghaniense

Inhabiting the drier cliffs, either in crevices or on the rock face, are such forms as:

Metzgeria conjugata
Cephaloziella Hampeana
Porella platyphylloidea
Leucolejeunea clypeata
Frullania Asagrayana
Rhabdoweisia denticulata
Grimmia conferta
Ulota americana
Bartramia pomiformis
Hedwigia albicans
Neckera pennata
Haplohymenium triste
Anomodon attenuatus
Anomodon rostratus

The Influence of the Chemical Nature of Rocks on the Distribution of Bryophytes.—In earlier papers of this series[*] brief reference has been made to the influence of the chemical composition of the substratum on vegetation. In glaciated regions like Connecticut, where most soils are transported and residual soils are rare, this influence is nowhere seen to better advantage than in ravines and similar localities where there are exposures of bare rock. In Connecticut, the problem as to the effect of the chemical nature of the substratum on vegetation concerns chiefly calcareous versus potassic rocks. The granites, gneisses, schists and sandstones, which comprise the bed rock over much of this state, are for the most part rich in potassium, which is one of the principal constituents of orthoclase feldspar and of mica (muscovite and biotite). Calcium also, as one of the components of plagioclase feldspar, hornblende, and certain other minerals, is present in some of these rocks, and in the sedimentary formations—the sandstones and shales—small amounts of calcium carbonate may be included in the cementing material. But, except locally, the amount of lime in these rocks, in so far as it affects vegetation, appears relatively insignificant. The important lime-bearing formations of Connecticut are trap and marble. The former contains potassium in small amount, one or two per cent.; the latter con-

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[*] See Torreya **13**: 109, 110. 1913; **14**: 185. 1914.

tains none. Trap outcrops (diabase and basalt) occur chiefly in the Central Lowland. The marble (sometimes referred to as a limestone or dolomite) forms extensive deposits in the western part of the state, particularly in the upper Housatonic Valley.

Owing to their frequently intimate association with rock surfaces, no group of plants, with the possible exception of the lichens, is better qualified to demonstrate the influence of the chemical composition of the substratum on vegetation than the bryophytes. To be sure, many mosses and liverworts apparently flourish indiscriminately on any sort of rock substratum, provided only that requisite conditions of moisture and shade are present. But a large number of species undoubtedly "prefer" either calcareous or potassic rocks, and some are confined to such substrata. A list is given below of local species which favor calcareous rocks. Nearly all of these are commonest in the marble areas of western Connecticut, and several of them have been collected only there. Some, however, occur also along the trap ranges, while a few are known from other scattered localities.

Grimaldia fragrans
Preissia quadrata
Pellia Fabroniana
Lophozia badensis
Lophocolea minor
Cololejeunea Biddlecomiae
Frullania riparia
Saelania glaucescens
Fissidens cristatus
Cratoneuron filicinum
Hymenostylium curvirostre
Tortella tortuosa
Encalypta contorta
Mnium orthorrhynchum
Plagiopus Oederi
Myurella julacea
Amblystegiella confervoides
Amblystegium noterophilum

The species cited in the next list are reputedly calciphobous (i.e. "lime-avoiding"), and are for the most part restricted to potassic rocks.

Marsupella emarginata
Sphenolobus exsectus
Scapania nemorosa
Scapania undulata
Radula obconica
Andreaea petrophila
Andreaea Rothii
Rhabdoweisia denticulata
Dicranum fulvum
Glyphomitrium incurvum
Racomitrium aciculare
Ulota americana
Pterigynandrum filiforme
Brachythecium plumosum
Sematophyllum carolinianum
Hygrohypnum dilatatum
Hygrohypnum eugyrium

The Mesophytism of the Flora in Rock Ravines.—A rock ravine, more than any other sort of habitat, affords environmental conditions congenial to pronounced mesophytic plants. Seepage water is usually abundant along the sides, there is protection from sun and wind, and the humidity of the air, as compared with the surrounding upland, is high. Certain mosses and liverworts are practically confined to such habitats. In a more arid region than Connecticut the same observation might be made with regard to many of the higher plants, but while it is a familiar fact that in this region as elsewhere the flora of rock ravines includes many of the most extreme shade- and moisture-loving ferns and flowering plants, most of the species present are equally representative of other habitats. Species intolerant of shade are largely excluded. The majority of the forms cited in earlier papers as typical of the climax forest of this region are to be found here, and not a few of the common plants of rock ravines thrive elsewhere in wooded swamps. The following list includes a number of ferns and herbaceous flowering plants which may be considered characteristic of rock ravines, though by no means peculiar to them.

Polypodium vulgare
Phegopteris polypodioides
Asplenium Trichomanes
Asplenium acrostichoides
Aspidium spinulosum
Cystopteris bulbifera
Cystopteris fragilis
Lycopodium lucidulum
Arisaema triphyllum
Smilacina racemosa
Streptopus roseus
Trillium erectum
Laportea canadensis
Pilea pumila
Solidago latifolia
Asarum canadense
Actaea rubra
Caulophyllum thalictroides
Chrysosplenium americanum
Impatiens pallida
Viola cucullata
Viola blanda
Viola rotundifolia
Circaea alpina
Aralia racemosa
Sanicula gregaria
Hydrocotyle americana
Cryptotaenia canadensis
Collinsonia canadensis

The Ravine Forest.—The intense mesophytism of a rock ravine is further accentuated by the nature of the ravine forest (Fig. 3). As a rule the hemlock and yellow birch are prominent, and more often than not they predominate. Along with them commonly occur the sugar maple and others of the trees elsewhere cited as characteristic of the climax forest in this region. The woody undergrowth usually includes *Hamamelis virginiana*, *Kalmia latifolia*, and *Viburnum acerifolium*, while forms such as *Carpinus caroliniana*, *Alnus rugosa* and *Benzoin aestivale*, which one ordinarily associates with swamps, frequently grow along the stream at the bottom. On the whole, ravine forests almost invariably are more mesophytic, and approximate more closely the climax

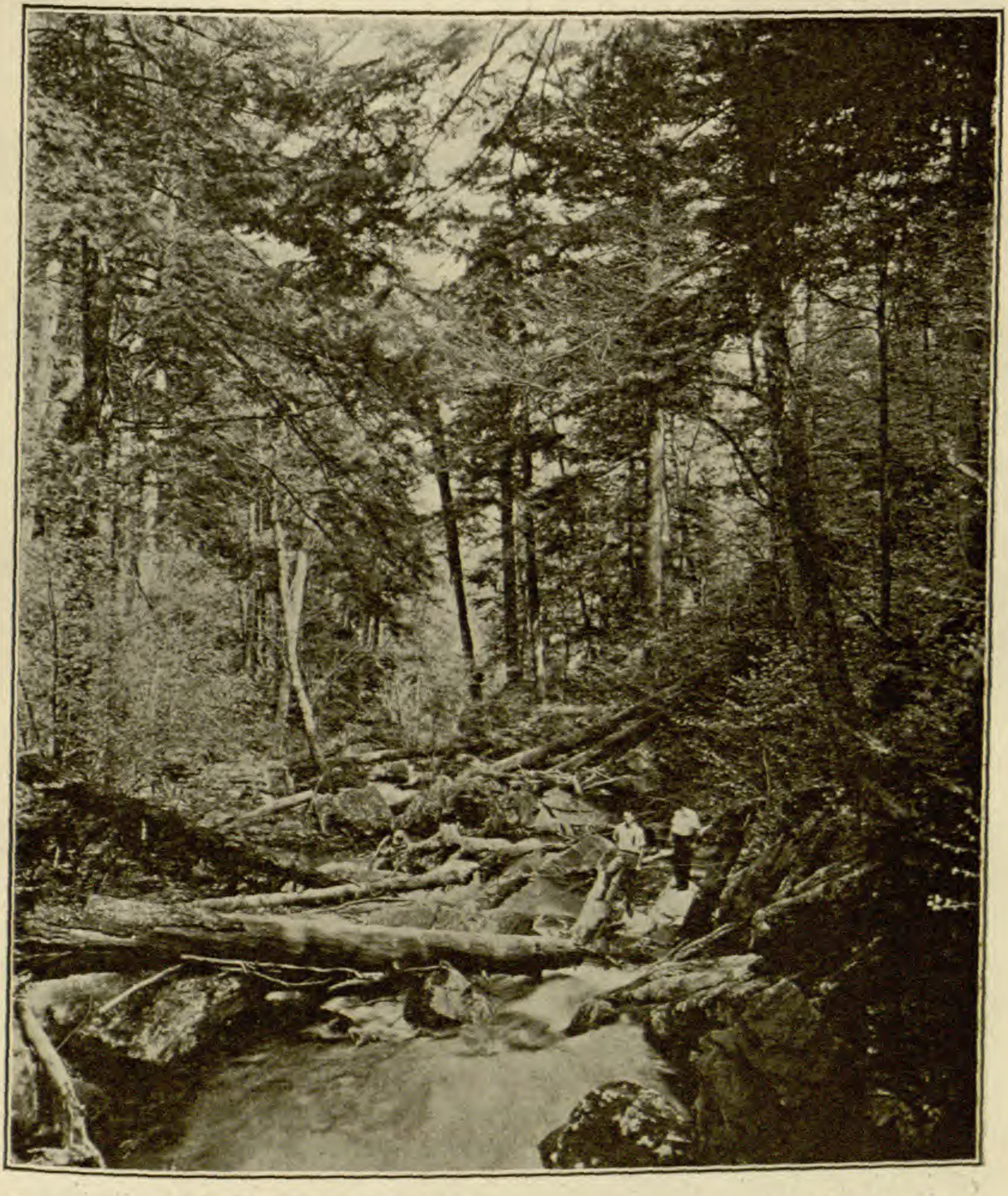

FIG. 3. Primeval forest in Sage's Ravine. Hemlock and yellow birch the common trees.

formation of this region than do the forests on the adjoining uplands. In a large measure this fact of course is due to the exceptionally favorable conditions of environment under which they have been developed. But there are other contributory causes which, while they have nothing to do with the development of these forests, may at least be partly responsible for their perpetuation. Thus, on account of their comparative topographic isolation, ravine forests may be largely immune from the fires which frequently devastate the surrounding uplands, while by reason of the difficulty in removing the timber they offer little temptation to the lumberman.

The Boreal Aspect of the Vegetation in Rock Ravines.—A few locally rare Canadian plants, such as *Lophozia alpestris*, *Lophozia attenuata*, *Gymnostomum rupestre*, *Polytrichum alpinum*, *Lycopodium Selago*, *Streptopus amplexifolius*, and *Viola Selkirkii* have been collected only in rock ravines. From an ecological standpoint, however, it is the mass-effect of the vegetation rather than the occurrence of isolated species which is significant. Many of the bryophytes, which have already been referred to as being largely restricted to rock ravines in Connecticut, are much more generally distributed farther north. But even if these rock-face and crevice forms are ignored, the stamp of the north on the vegetation here is unmistakable. The predominant trees of ravine forests are usually species of northward range. The bryophytic flora of these forests—the mossy carpet of *Bazzania trilobata*, *Hylocomium splendens*, *Ptilium Crista-castrensis* and *Hypnum Schreberi* which frequently covers the forest floor—likewise is strongly suggestive of the north. In Sage's Ravine, and doubtless elsewhere, masses of *Sphagnum* grow high up on the slopes—a common phenomenon in the Maritime Provinces of eastern Canada. Moreover, in Connecticut, many vascular plants characteristic of the north woods, while by no means confined to this sort of habitat, attain their optimum development in rock ravines. As representative of this latter group of species may be cited:

Phegopteris polypodioides
Taxus canadensis
Streptopus roseus
Actaea rubra
Oxalis acetosella
Acer pennsylvanicum
Acer spicatum
Viola rotundifolia
Lonicera canadensis
Aster acuminatus

On the whole, the display of Canadian plants in rock ravines is noticeably richer than in any other sort of habitat, with the exception of bogs. Various explanations for this fact may be suggested. In the first place, the atmospheric conditions here are congenial to northern plants. As compared with less protected habitats, the air is more humid, while, especially in summer, the temperature is uniformly lower and less subject to extremes. Moreover, the length of the growing season is presumably shorter than in more open situations. In a Connecticut rock ravine there may thus be reproduced in miniature a type of climate similar to that which in the Canadian Zone prevails over vast areas. In the second place, geological factors are of undoubted significance. As has already been remarked, most rock ravines have remained practically unaltered since glacial times; they represent very ancient plant habitats. It seems probable, therefore, that boreal plants which today are confined to rock ravines may formerly have been much more widely distributed, and that they have been able to persist in their present habitats because of the unusually favorable environmental conditions there afforded. In the same way it is conceivable that the present boreal aspect of the vegetation in rock ravines may be reminiscent of a one-time much more universal aspect of vegetation in this region.

RAVINES IN UNCONSOLIDATED ROCKS

The unconsolidated stony materials which form so considerable a portion of the superficial crust of the earth are not commonly designated as rocks. "Yet no line of separation can be drawn between such solid rocks as those into which the sands and muds of distant geological ages have been transformed and the semi-consolidated deposits of more recent times, or the sediments now accumulating."* In the present paper, the term UNCONSOLIDATED ROCK embraces any uncompacted rock formation, such as sand, gravel, and clay. For the sake of convenience, the word ROCK itself, written without a qualifying adjective, is used in its popular sense to include only consolidated rock formations.

Distribution, Character, and Vegetation of Ravines in Unconsolidated Rocks.—In Connecticut, ravines of this description are by

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* Barrell, J. & Loughlin, G. F., Conn. State Geol. and Nat. History Survey, Bull. 13: 17. 1910.

no means uncommon. They are developed along streams throughout the Central Lowland, while in the Highlands they may occur wherever there are deposits of glacial drift. More often than not they are relatively small and correspondingly unimpressive; but in some cases, particularly in the northern half of the Central Lowland, they may assume considerable size and importance.

One of the best examples which the writer has examined of a ravine in unconsolidated rock is located in the town of Windsor. It has been scoured out to a depth of perhaps thirty feet from a coarse, sandy substratum through the activity of a small brook which flows into the Farmington River from the north. The slopes of the ravine, forested with hemlock, yellow birch, sugar maple, beech, white ash and tulip, contrast sharply with the surrounding upland which is largely overgrown with white pine, oaks, and chestnut. The undergrowth includes many of the herbaceous and shrubby species which have been listed as characteristic of rock ravines. But along with these grow *Lycopodium obscurum*, *Oakesia sessilifolia*, *Corylus americana*, *Geranium maculatum*, *Chimaphila umbellata*, *Pyrola rotundifolia*, and *Erigeron pulchellus*—all plants of relatively dry, open woods. As might be anticipated, the bryophytic flora is poorly represented. The rock-face and crevice mosses and liverworts, which constitute such a striking feature of the vegetation in rock ravines, are absent. Along the wet, sandy banks of the stream are a few species, such as *Pellia epiphylla*, *Conocephalum conicum*, *Mnium hornum*, and *Catharinaea undulata;* but aside from these about the only bryophytes present are a few forms which grow on rotten wood or humus, such as *Mnium cuspidatum*, *Stereodon cupressiformis* and *Georgia pellucida*.

Ravines in unconsolidated rock compare neither in scenic nor botanic interest with rock ravines. To be sure, all gradations are found between extremely shallow and scarcely perceptible depressions, which ordinarily would hardly be classed as ravines, and ravines of considerable depth, with fairly steep sides, like the one at Windsor. As a result of the diversity in environments which it is obvious may thus be afforded by different ravines, all stages of transition may be found between the vegetation of swamps and uplands on the one hand and that of typical ravines on the other. On the average, however, ravines in unconsolidated rock are smaller in size and are relatively broader and shallower than rock ravines. In consequence, the atmospheric conditions are seldom as favorable as those of rock ravines, and the vegetation rarely equals that of rock ravines in the high degree of mesophytism attained. Soil moisture, as a rule, would seem to be more important here in its effect on vegetation than atmospheric humidity. The boreal tone which characterizes the vegetation of rock ravines is likewise lacking. This would naturally be expected, not only on account of the less congenial environmental relations but also because of the comparative recency with which ravines in glacial deposits have been developed.

Spring Brooks.—As Cowles* has remarked, "springs and spring brooks may be classed with ravine streams, but differ from them in the relative absence of erosion phenomena." They might equally well, if not better, be classed with spring swamps,† with which they are usually associated. Spring brooks are common throughout Connecticut. Perhaps their most familiar floristic feature is the fringe of alders (*Alnus rugosa*, *Alnus incana*) which almost invariably lines their banks. Aside from these, the brookside flora may include any of the species elsewhere cited as characteristic of spring swamps.

The Succession of Vegetation during the Development of Ravines in Unconsolidated Rocks.—In his treatment of the plant societies of the Chicago region, Cowles‡ has described the development of clay ravines and the concomitant sequence of plant associations. The following observations are quoted from this work: "Wherever there is an elevated stretch of land adjoining a body of water, such as a lake bluff, one is apt to find excellent examples of the beginning of a ravine. *Fig. 1* [reproduced in this paper as FIG. 4] shows an embryonic ravine of a type which may frequently be seen along the clay bluffs. . . . A ravine of this type is essentially a desert, so far as plant life is concerned. The exposure to wind and to alternations of temperature and moisture is excessive. The lack of vegetation, however, is due chiefly to the instability of the soil; this instability is particularly great in the case of clay bluffs, where the seepage of water causes extensive landslide action.

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* The physiographic ecology of Chicago and vicinity. Bot. Gaz. 31: 98. 1901.

† See Bull. Torrey Club 42: 192, 193. 1915.

‡ *Op. cit.*, pp. 86–88.

No plants can yet get a foothold in such a place, unless it be a few species that may be able to make their appearance between periods of landslide action; among these plants annuals particularly predominate. The perennials that may be found in such places are almost entirely plants which have slid down the bank. Ravines of a similar type may be seen in many places inland, and wherever found the poverty of vegetation on the slopes is the most striking character.

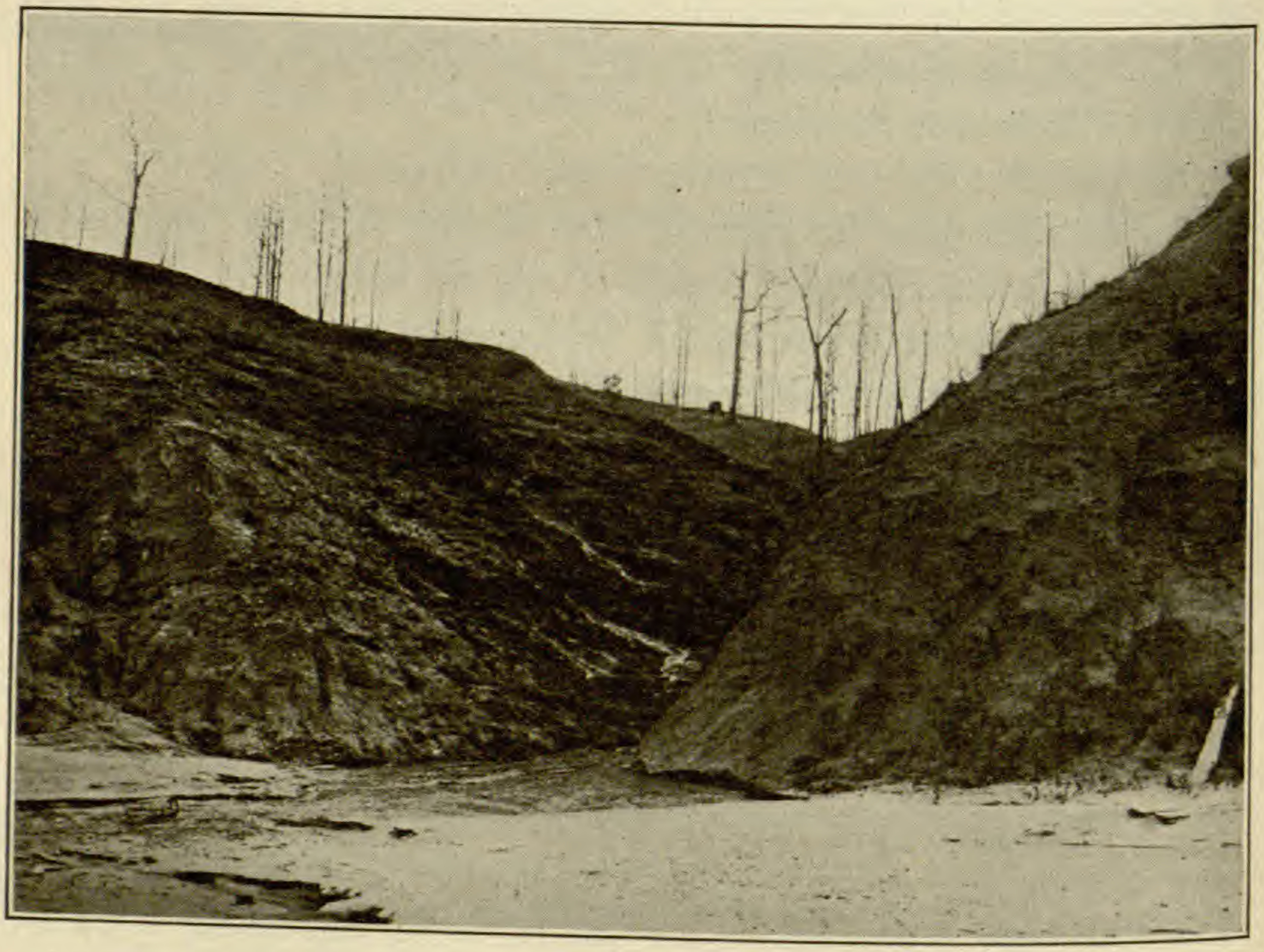

FIG. 4. An embryonic ravine in a clay bluff along the western shore of Lake Michigan. Vegetation entirely absent on the unstable clay slopes, except for shrubs and grasses which have slid down from the top. (After Cowles, Physiographic ecology of Chicago and vicinity; photograph furnished by H. C. Cowles.)

"As the ravine extends itself inland the conditions outlined above may be always seen about its head, but toward the mouth of the ravine the slopes are less precipitous. Torrents cut down the bed of the ravine until a depth is reached approaching the water level at its mouth. From this time on the slopes become reduced and the ravine widens more than it deepens, by reason of lateral cutting, landslide action, and side gullies. After a time a sufficient stability is reached to permit a considerable growth of vegetation.

If the erosion is slight enough to allow a vegetation carpet to develop, a high degree of luxuriance may be attained. In fact, ravine conditions are usually extremely favorable for plants, after the initial stages have passed. In a comparatively few years the vegetation leaps, as it were, by bounds through the herbaceous and shrubby stages into a mesophytic forest, ... Nothing shows as well as this the brief period necessary for a vegetation cycle in a favored situation as compared with an erosion cycle."

In Connecticut, clay ravines are much less frequent than are those in rock. They exist on a small scale in many parts of the Central Lowland, especially along the Connecticut River from Glastonbury to Windsor Locks, but elsewhere they are rare. Nowhere in this state are the successive changes in vegetation which accompany the development of a clay ravine so clearly shown as in the area described by Cowles, an area which the writer has visited on several occasions. So far as it has been possible to compare, however, the observations recorded in the Chicago region seem quite applicable to conditions in Connecticut.

PRE-EROSION TOPOGRAPHY AND ITS BEARING ON THE PHENOMENA OF SUCCESSION IN ROCK RAVINES

"From the standpoint of dynamic plant geography our land areas are divided into two well-marked categories: on the one hand is the erosion topography which is characteristic of the eroding and depositing phases of present streams and shores, and on the other hand is the preërosion topography which is characteristic of those areas that have not as yet been invaded by erosive forces."* To this latter category, speaking from the standpoint of the succession of plant associations, belong rock ravines. For while it is conceivable that, just as in the case of clay ravines, the topographic changes which accompany the development of rock ravines might react on the vegetation, yet such changes are brought about with such extreme slowness that their effect on plant life may be regarded as practically negligible. Whatever changes in the nature of ravine vegetation may have taken place in the past have probably been associated not only with topographic changes but with climatic changes as well; and the same will very likely

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* Cowles, H. C. Bot. Gaz. 51: 172, 173. 1911.

hold true in the future. From a standpoint of present-day plant geography, therefore, the climax vegetation of rock ravines may be looked upon as practically permanent.

Although the fact cannot be overlooked that ordinarily the plant societies of rock ravines are associated with a definite phase of stream development, it should also be recognized that while very commonly the formation of a ravine has been due to the activity of streams which are still operative, this is by no means always the case. There are many rock ravines whose formation cannot be accounted for by contemporaneous factors at all. Often, as in the Devil's Gulch, the streams now present in such ravines can have played little part in their formation. Many streams have been superposed, so to speak, on the topography. They have found rather than made their channels. Not infrequently, as in the Wolf Den, ravines have been developed in other ways than by stream erosion. It is largely due to the prevalence of this preërosion type of topography, which has been moulded by physiographic forces of the geologic past, that rock ravines are so much more highly developed in the Highlands than in the Lowland.

RIVER AND STREAM BLUFFS

The later phases in river activity may be observed along most of the larger streams throughout the state. As the result of lateral cutting, the ravine once present has been replaced by a broad valley. As a ravine widens out, the exposure to wind, sun, and changes of temperature increases, and the moisture content of the slopes is appreciably modified. The effect of these environmental changes on vegetation can be seen by comparing the flora of a river valley with that of a ravine. In a general way, the vegetation of stream valleys can be treated under two heads: BLUFFS and FLOOD PLAINS. The term Bluff, as used here, includes not only the relatively steep slopes which frequently demarcate the valley from the upland, but also the gentler slopes which commonly occupy most of the intervening valley floor. In other words, it embraces all parts of the valley which, in contrast to flood plains, have been formed by erosion rather than by deposition.

The Vegetation of Bluffs in Unconsolidated Rocks.—In the

Chicago region,* the increased exposure which follows the widening out of a clay ravine may have a disastrous effect on the ravine flora.

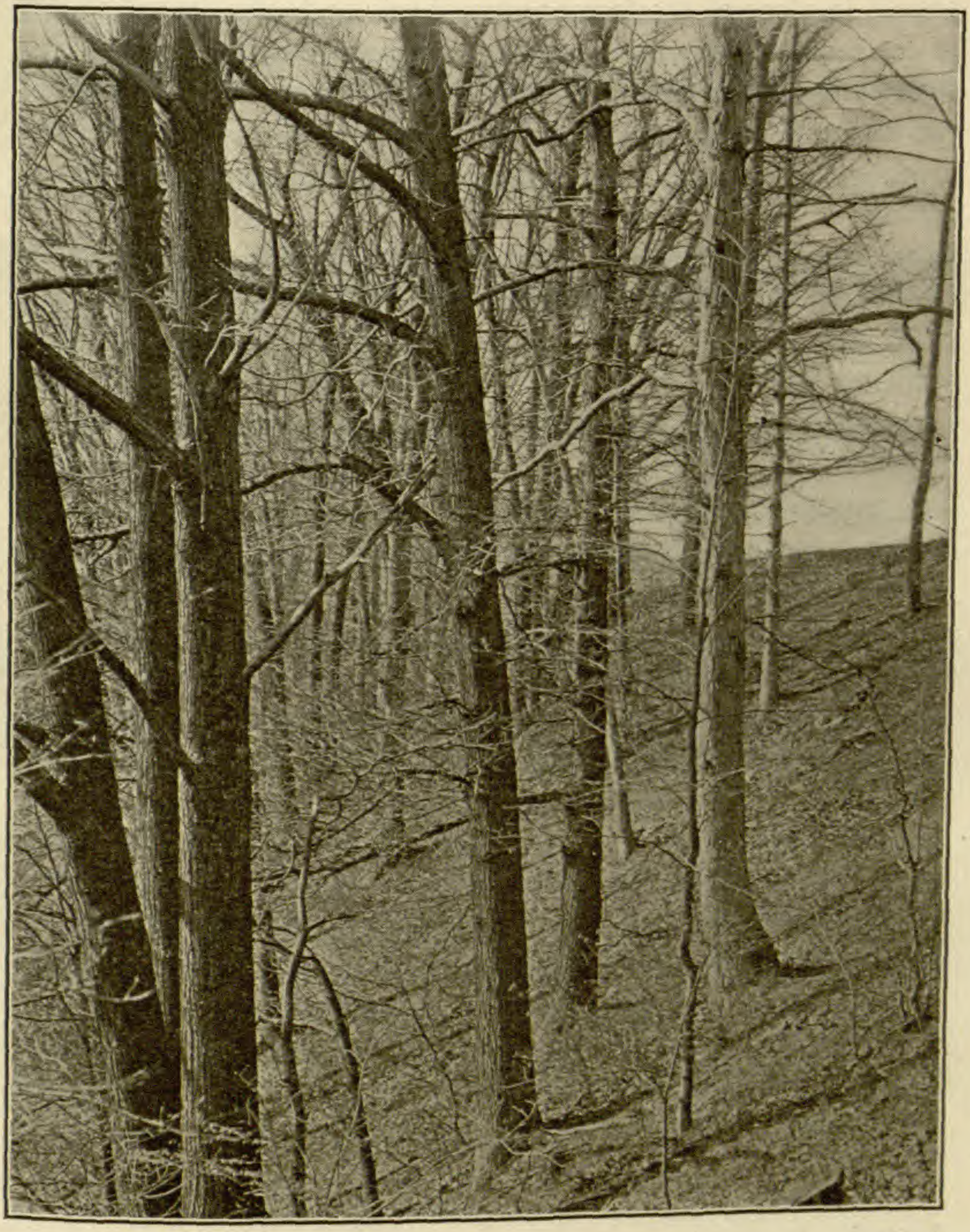

FIG. 5. Forest of chestnut, white oak, red oak, etc., along a sandy bluff bordering West River, New Haven. Elsewhere along the bluff, hemlock, beech and basswood are more or less abundant.

"The rich mesophytic herbs, including the liverworts and mosses, dry up and die, . . . and a xerophytic undergrowth comes in. . . .

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* See Cowles, H. C., 1901, *op. cit.*, pp. 90–93.

After a few years have passed, xerophytic shrubs appear, . . . and it is not long until xerophytic or semi-xerophytic thickets prevail in place of the former mesophytic undershrubs. The last of the mesophytes to die are trees, because they are longer-lived than herbs and shrubs, and also because their roots reach down to the moisture"; but eventually these too give way to relatively xerophytic species. In Connecticut, the changes are not so radical; in fact, a bluff forest may be scarcely less mesophytic than a ravine forest. This is not surprising when it is considered that the climax formation in this region (that is, the most mesophytic type of vegetation which is capable of development on uplands) is very nearly as mesophytic as the climax association (termed by Cowles a "temporary climax") of ravines. In the Chicago region, on the other hand, the contrast between the mesophytic ravine forests and the xero-mesophytic climax forests on uplands is very pronounced.

The most striking difference between a bluff forest (FIG. 5) and a ravine forest is seen in the greater abundance of relatively intolerant trees. The undergrowth also, while it may contain any of the characteristic ravine species, includes many forms which ordinarily do not thrive under the shadier ravine conditions. On bluffs in unconsolidated rock, especially on clay and till, the soil moisture relations usually favor the continuance of a mesophytic flora. Near the mouth of the Windsor ravine, to select a concrete example, along the bluffs which border the Farmington Valley, common trees are *Juglans cinerea*, *Tilia americana*, *Betula alba papyrifera*, *Ulmus americana*, *Platanus occidentalis*, *Carya cordiformis*, *Quercus rubra*, *Ostrya virginiana*, and *Carpinus caroliniana*. Along with these occur the trees of the ravine forest—the sugar maple, white ash, tulip and yellow birch, and to a less extent the hemlock.

The undergrowth of moist valley forests is particularly rich in spring-flowering species. Among the herbaceous plants characteristic of such habitats may be mentioned the following:

Aspidium noveboracense
Asplenium Filix-femina
Adiantum pedatum
Osmunda Claytoniana
Botrychium virginianum
Oakesia sessilifolia
Allium tricoccum
Erythronium americanum

Asarum canadense
Claytonia virginica
Thalictrum dioicum
Anemonella thalictroides
Smilacina racemosa
Polygonatum biflorum
Medeola virginiana
Trillium erectum
Hepatica triloba
Anemone quinquefolia
Caulophyllum thalictroides
Sanguinaria canadensis
Dicentra cucullaria
Dentaria diphylla
Dentaria laciniata
Viola pubescens

The Vegetation of Rock Bluffs.—In comparing rock bluffs with rock ravines, one striking dissimilarity concerns the bryophytic flora. Species inhabiting the rock-face or the crevices, together with certain of the forest-floor species, may be well represented, but most of the others are absent. Under favorable circumstances a rock bluff may support a highly mesophytic vegetation; much apparently depends on exposure and on ground-water relations. Along the Connecticut River, south of Middletown, the north-facing bluffs are (or were) well forested; most of the vascular plants already cited as characteristic of rock ravines grow luxuriantly; *Acer pennsylvanicum* is common, attaining a height of more than thirty feet; and the mesophytic ravine mosses are well represented. The vegetation on the south-facing bluffs across the river, however, especially as regards the herbaceous flora, is much less mesophytic. In general, north- or east-facing bluffs are more mesophytic than those which face south or west. As might be expected, the highest degree of mesophytism prevails toward the bottom of a bluff; toward the top the vegetation is more xerophytic. In some cases, where the water supply is insufficient, mesophytes may be virtually lacking and xerophytes predominate from top to bottom. On the whole, the vegetation of the rock bluffs which border stream valleys throughout the state resembles that which has been described elsewhere* as characteristic of talus slopes.

FLOOD PLAINS

The topographic changes which take place during the building up of a flood-plain are accompanied by a fairly definite succession of plant associations. In the earlier stages of flood plain develop-

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* See Torreya 14: 181–184. 1914.

ment, the surface of the ground is so low that it is covered with water at all seasons of the year. Here the vegetation consists of aquatic or semi-aquatic plants. As the surface is built up higher, it reaches a level where it is exposed to the air during summer, the period of low water, and here aquatic plants are replaced by terrestrial herbs. As the constructive process continues, the surface is built up to a height where it is out of water much of the year, and finally it may attain an elevation where it is out of reach of all but the highest floods. On these older flood plains grow shrubs and trees.

Flood Plain Associations along the Connecticut River.—Flood plains are formed to some extent along every sizable stream. In Connecticut, as might be expected, they are developed on the largest scale along the Connecticut River. Here, on the higher flood plains from Middletown northward, the rich alluvial soil furnishes the most fertile farm-lands in the state. As the result of agriculture, much of the primitive vegetation has been obliterated,* but it may still be seen to advantage on various flood plain islands (FIG. 6) and elsewhere. On an island at Windsor, in particular, the natural vegetation has never been disturbed. Whether or not it is true, as old residents maintain, that this island —now about three-quarters of a mile long, perhaps a hundred yards wide, and rising to a height of more than a dozen feet above low water level—has been developed entirely within the last thirty years, it is certain that it is growing rapidly at the present time, having increased several hundred feet in length at the lower end since it first came under the writer's observation in 1910. The following notes on the vegetation of the Connecticut River flood plains are based partly on the study of this island, partly on studies made at Middletown, Haddam and other points along the river.

As compared with a lake-swamp succession, free-floating aquatics, for obvious reasons, are rarely represented in a flood

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* Many of the grassy meadows along the Connecticut date back to pre-colonial days. It is recorded that when the first settlers arrived these areas were open and under cultivation by the Indians, who were accustomed to burn them over annually. But from the fact that today trees occur along the sloughs and scattered through the grassland, wherever they are permitted to grow, it would seem probable that these meadows were formerly forested, and that, if left to themselves, they would soon revert to their original condition.

plain succession. The pond-lilies also are usually absent. Commonly the first forms to appear are submersed species, such as the pondweeds (*Potamogeton* sp.), *Vallisneria spiralis* and *Elodea canadensis*, which may grow in water four or even more feet in depth. In shallow water various aquatics with aerial foliage are ordinarily conspicuous. Of these, the following species are perhaps the most noteworthy:*

FIG. 6. Flood plain island in the Connecticut River, at Haddam. The plant in the foreground is the wild rice (*Zizania palustris*).

Equisetum fluviatile
Typha latifolia
Sagittaria latifolia
Zizania palustris
Scirpus americanus
Scirpus validus
Peltandra virginica
Orontium aquaticum
Pontederia cordata
Polygonum Muhlenbergii

While the number of species present at this early stage of flood plain development is relatively small, any lack of variety is more than counterbalanced by the luxuriance with which these

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* From this and the two following lists have purposely been omitted a number of species which, while peculiar to the Connecticut River flood plains, seem too rare or too local to be of importance in the present connection. The majority of such species, so far as known, have already been mentioned elsewhere (Torreya 13: 106. 1913).

few forms often grow. Fringing zones of pickerel weed and the like are quite as characteristic of flood plains as of lake shores, while marshy swamps, predominated by wild rice (FIG. 7) and other grass-like plants, are a prominent feature of many low flood plains, particularly toward the mouth of the river. Here, within the sphere of tidal influence, the ground occupied by these plants may be submerged at high tide and bare at low tide.

FIG. 7. Wild rice along banks of the Quinnipiac River, North Haven. Some idea of the height of this grass is suggested by the bow of the canoe in the foreground.

The second phase of flood plain development may well be designated the Strand Stage (FIG. 8). The surface of the ground is exposed for a longer or shorter period during summer, but is covered with water during winter. Certain algae, such as *Vaucheria* and *Botrydium*, are common here, as are also ephemeral bryophytes, such as *Riccia*, *Ephemerum*, and *Physcomitrium immersum*. The predominant vascular plants are either annuals or herbaceous perennials (or biennials)—forms which are able to develop between successive periods of submergence. On the lower, muddier parts of the strand, species with more or less pronounced amphibious proclivities may be well represented: such, for example, as *Echinochloa Walteri*, *Eleocharis aciculare*, *Penthorum sedoides*, and *Ludvigia palustris*. A list of other species characteristic of the strand stage is here given.

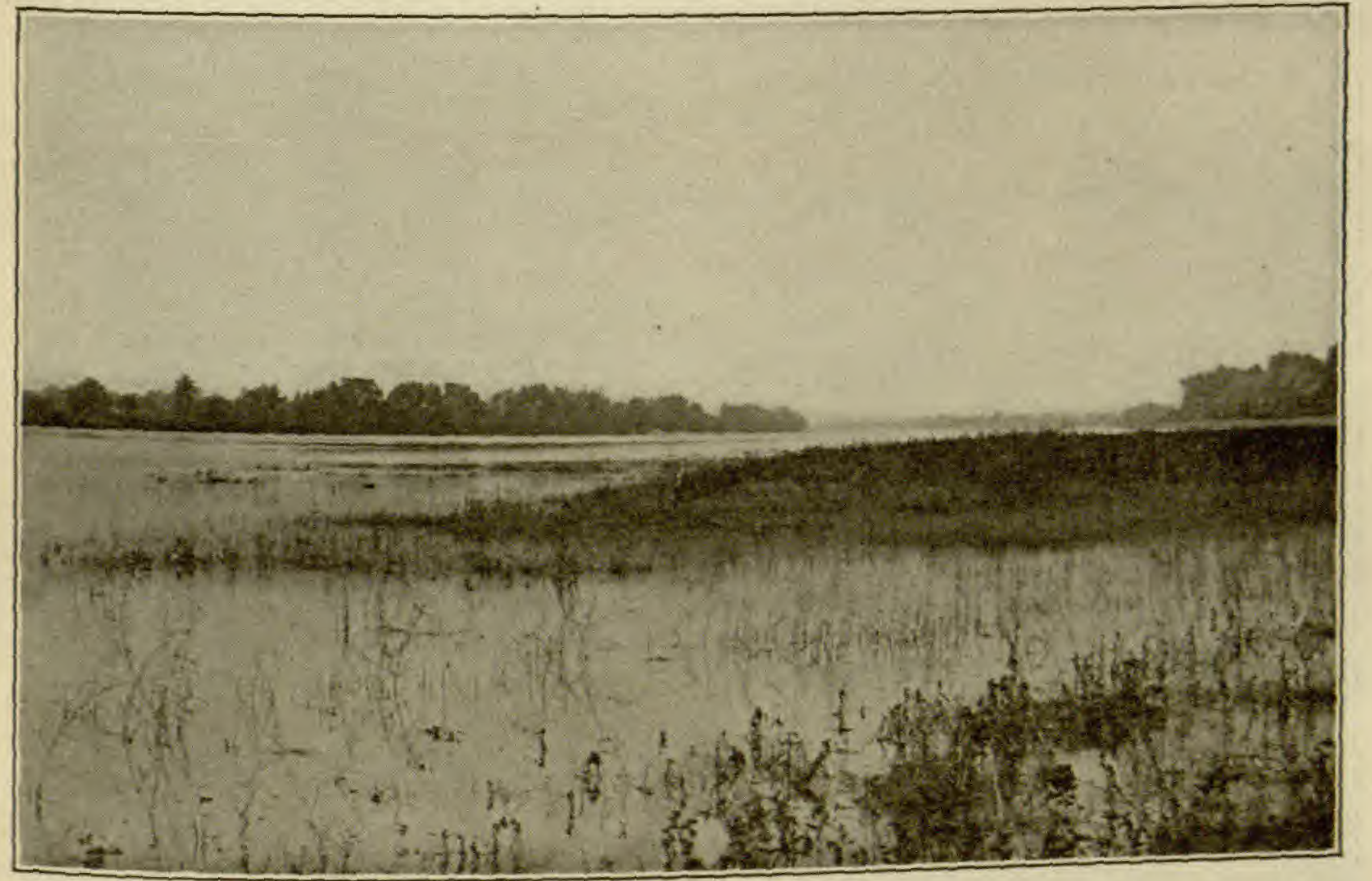

FIG. 8. A typical, low, flood plain strand along the Connecticut River, at East Windsor. Vegetation mostly herbaceous, but seedlings of willow and cottonwood abundant.

Equisetum arvense
Panicum agrostoides
Leersia virginica
Cyperus strigosus
Juncus effusus
Rumex crispus
Polygonum pennsylvanicum
Radicula palustris
Gnaphalium uliginosum
Ambrosia trifida
Xanthium echinatum
Bidens vulgatum

Woody plants are seldom wholly absent from the strand stage of a flood plain; commonly, seedlings of willow and cottonwood are abundant. Indeed, certain species of willow, such as *Salix cordata* and *Salix longifolia*, occur here which are usually lacking on older flood plains. But woody plants are rarely well developed; for even if they are able to withstand submergence in winter, trees and shrubs of any size are liable to be badly battered or else uprooted and carried away by the ice when it breaks up in spring. As soon, however, as the surface has been built up to such a height that it is beyond the reach of the winter ice, trees become the controlling element of the vegetation and ultimately a luxuriant forest may be developed. The boundary between the wooded part of a flood plain and the strand area is often marked by a distinct shelf or step—the result of ice-shove in winter.

FIG. 9. Nearly pure growth of willow (*Salix nigra*) near southern extremity of flood plain island in Connecticut River, Windsor.

One of the first trees to establish itself on the flood plain is the black willow (*Salix nigra*). The willow is essentially a pioneer. Young flood plain forests (FIG. 9) may be composed almost wholly of this tree, while a zone of willow almost invariably fringes the shoreward margin of older forests. Closely following the willow, in fact often appearing simultaneously with it, are other trees, such as the sycamore (*Platanus occidentalis*) and the cottonwood (*Populus deltoides*), particularly the latter. As the surface of the ground continues to be built up higher, the soil becomes relatively drier and better aerated, so that conditions rapidly become less hydrophytic and more mesophytic. Under the changing conditions of soil and light, the willow gradually assumes a position of less and less importance, while the cottonwood comes to occupy a more and more prominent place in the rising forest (FIG. 10).

FIG. 10. Cottonwood forest with luxuriant herbaceous undergrowth (*Laportea*, etc.) on flood plain island at Windsor.

For while, like the willow, the cottonwood is relatively intolerant of shade, it grows more rapidly and to a much larger size, so that it tends to overtop and shade out the willow. Meanwhile other trees make their appearance. In addition to the species already enumerated, common trees on the Connecticut River flood plains are the elm (*Ulmus americana*), silver maple (*Acer saccharinum*), basswood (*Tilia americana*), white ash (*Fraxinus americana*) and red ash (*Fraxinus pennsylvanica*). Without exception, all of these last-named trees are more tolerant of shade than their predecessors. Springing up in the light shade which the cottonwood and willow produce, these more tolerant species become increasingly abundant until ultimately they dominate the forest. And while today the cottonwood and willow are perhaps the most conspicuous trees of the Connecticut River flood plains, there is little doubt that the forests which originally clothed the higher flood plains were made up largely of elm, silver maple, basswood, and ash.

A striking feature of the vegetation in flood plain forests is the wealth of lianas. Woody forms, such as *Rhus Toxicodendron*, *Vitis vulpina*, and *Psedera quinquefolia*, ascend the trunks of trees and hang in graceful festoons from the branches. A few herbaceous lianas also, notably *Sicyos angulatus* and *Echinocystis lobata*, clamber the trees, while numerous less vigorous species, *e.g.* *Polygonum scandens*, *Amphicarpa monoica*, *Convolvulus sepium*, *Solanum Dulcamara*, and *Clematis virginiana*, twine about or cling to any available support. The parasitic *Cuscuta obtusiflora* is a common form on the Windsor flood plain. Shrubs are usually few and scattered, about the only forms ordinarily present being *Cornus Amomum* and *Sambucus canadensis*.

The herbaceous undergrowth in such a forest is rank and luxuriant; some idea of its character is conveyed by FIG. 10. Tall, broad-, thin-leaved mesophytic plants predominate. The giant ragweed (*Ambrosia trifida*) commonly reaches a height of from ten to twelve feet, and the ostrich fern (*Onoclea Struthiopteris*), largest of the native ferns, a height of more than six feet. The nettles (*Laportea canadensis* and species of *Urtica*), growing more than waist-high, are uncomfortably abundant. Other characteristic herbaceous species worthy of mention are the following:

Asplenium Filix-femina
Onoclea sensibilis
Leersia virginica
Muhlenbergia mexicana
Cinna arundinacea
Bromus altissimus
Elymus canadensis
Pilea pumila
Boehmeria cylindrica
Thalictrum polygamum
Impatiens biflora
Viola cucullata
Circaea lutetiana
Verbena hastata
Eupatorium purpureum
Eupatorium urticaefolium
Solidago serotina
Aster paniculatus
Helenium autumnale

Flood Plain Associations along Other Streams.—The conditions described in the preceding paragraphs are found not only along the Connecticut, but also along the Housatonic and to a considerable extent along others of the larger rivers. But even along these rivers, there is a more or less noticeable variation in the aspect of flood plain associations, while along the smaller streams the departure from the described conditions may be very pronounced. On gravelly or stony flood plains, such as occur along swift streams, the pioneer forms of vegetation may be scraggly willows, alders,

FIG. 11. Cat-tail (*Typha latifolia*) marsh along Muddy River, North Haven. In the background is a flood plain forest of elm, pin oak, etc.

and red-osier dogwood, along with which may grow a few herbaceous plants. Along many of the smaller streams throughout the state, during the building up of a flood plain, a sequence of plant associations is commonly encountered which is essentially similar to what has been described in an earlier paper* as characteristic of lakes and swamps. With the exception of the free-floating forms, any of the aquatic plants there mentioned may occur here. Of the species with aerial photosynthetic organs, the cat-tail (*Typha latifolia*) is especially conspicuous along many slow streams, frequently monopolizing wet, swampy tracts to the exclusion of practically everything else (FIG. 11). Marshes and meadows are quite as frequently developed along streams as along lake margins, and in general the aspect of the vegetation is similar in either case.† *Phalaris arundinacea* and *Leersia oryzoides*, however, might be mentioned as being more common in alluvial swamps than in other habitats. All of the shrubs and trees listed as characteristic of lake swamps are likewise found on flood plains along streams. Typical flood plain forests are best developed in areas which are subject to inundation only in spring. Here the soil relations are essentially those of a periodic swamp. Prominent trees in these forests along most streams are *Quercus bicolor* and *Quercus palustris*, species which are at least very infrequent in similar situations along the Connecticut. Except along the larger rivers, on the other hand, the cottonwood is practically absent and the silver maple is scarce. In addition to the two oaks already mentioned, the following trees are commonly represented in flood plain forests.

Carya cordifolia
Carpinus caroliniana
Ulmus americana
Liriodendron tulipifera
Acer rubrum
Tilia americana
Nyssa sylvatica
Platanus occidentalis

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* Bull. Torrey Club 42: 176–194. 1915.

† Regarding the vegetation of Connecticut meadows in general it should be remarked here that while in the case of many wet meadows there seems to be no doubt that the present vegetation represents the original type, this is probably not true of all present-day meadow-lands. There is reason to believe that most of the less wet areas now occupied by meadow associations were formerly forested, and that their present vegetation has been developed only as a result of human interference with the original conditions. See footnote on p. 254.

Fraxinus americana	*Fraxinus pennsylvanica*
Fraxinus nigra	

The Temporary Nature of Flood Plain Forests.—It has been shown in the preceding pages that during the development of a flood plain the vegetation becomes less hydrophytic and more mesophytic, culminating in the formation of a mesophytic forest. Such a forest is to be regarded as the climax association of flood plains. But it can easily be seen that, owing to the activity of the river, this forest may be relatively short lived; in other words, it may represent only a temporary climax. For as the river meanders about on its flood plain in serpentine curves, it is constantly wearing away its banks on the outer, concave side of each bend, while at the same time deposition is usually taking place on the opposite, convex shores. In this way "a river may swing quite across its flood plain, destroying all that it has built, including the mesophytic forest."* Changes of this sort take place with appreciable speed and may be observed along almost any depositing stream.

Ox-bow Ponds.—In this connection should also be mentioned the crescent-shaped curves, or ox-bows, which are a characteristic feature of old-age streams. Frequently the meandering river shifts its course, abandoning a loop-like channel for a more direct route. The loop then becomes an ox-bow pond (FIG. 1, D), and as such its vegetation can best be treated with that of ponds and swamps.†

The Subsequent History of Flood Plains.—One other phase of river activity may be briefly sketched. It has already been shown that while deposition is the main feature of old-age streams, erosion is not wholly absent. In the course of time, for various causes, downward cutting may be renewed, the flood plains become terraces, and new flood plains may ultimately be formed at lower levels. The resultant topography is well illustrated along the Connecticut and others of the larger streams. The low flood plains of today are comparatively recent in origin. The more ancient flood plains are represented by sandy terraces, of which

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* Cowles, H. C., 1901, *op. cit.*, p. 107.

† See Bull. Torrey Club 42: 171. 1915. *Fig. 1* of this paper pictures a typical ox-bow pond.

there may be one or more. These have attained their present condition through the downcutting of the rivers into the deep fill of glacial drift and outwash.* The effect of the changed topographic relations on these former flood plains as habitats for plants is readily comprehended. With the lowering of the river they must gradually have become more and more xerophytic and thus less and less tenable for the flood plain mesophytes. The actual effect of these changes on vegetation can only be conjectured. For, just as has been pointed out in the case of rock ravines, the period of time involved has been so great that oscillations in climate as well as changes in topography must presumably be taken into account. At the present day the vegetation of river and stream terraces is perhaps best treated with that of uplands, since the river has long since ceased to act as a dynamic factor in its development.

ACKNOWLEDGMENTS

For suggestions in connection with the preparation of this paper, the writer is greatly indebted to Professor Joseph Barrell, of the Geological Faculty, and Professor A. W. Evans, of the Botanical Faculty of Yale University, and to Mr. C. A. Weatherby, of East Hartford.

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* In this connection, see Rice, W. N., & Gregory, H. E., Manual of the Geology of Connecticut. Conn. State Geol. and Nat. Hist. Surv. Bull. 6: 35, 36. 1906.

The ferns and flowering plants of Nantucket—XVII

EUGENE P. BICKNELL

COMPOSITAE—*continued*

BACCHARIS HALIMIFOLIA L.

Very local, and confined to the eastern side of the island. As long ago as 1849 it was rather numerous on Coskaty, according to Mrs. Owen, and it is abundant there today. It occurs also on Coatue, and extends sparingly from Polpis southeasterly towards Siasconset, well away from any direct saline influence. A single small plant was seen in one of the higher bogs on Saul's Hills, and a shrub nearly seven feet tall in Gibb's Swamp. In 1904 a large clump grew in dry open ground about a mile northwest of Siasconset. Not yet in bloom September 6, 1904; in full flower September 17, 1899.

PLUCHEA CAMPHORATA (L.) DC.

Common about pools and mud flats in tidal marshes, blooming in August and September.

ANTENNARIA PLANTAGINIFOLIA (L.) Richards.

Found everywhere throughout the island, along roadsides, on banks and in pine groves, in damp meadows with *A. neglecta* and on dry hills with *A. neodioica*, on the plains and commons and on dry lichen-clothed levels in the poorest soils. In full flower May 31, 1909, except in the shade of pines where only the most forward plants were in bloom; mostly gone to seed by June 15, 1910.

Exceedingly variable, forms with broad rounded leaves, and forms with narrowly oblanceolate leaves on elongated petioles (var. *petiolata* Fernald) often growing side by side. A small form having narrow and acute leaves, collected in the Miacomet pines, is especially noteworthy by reason of reddish glandular hairs scattered along the stems, these being rather numerous in some examples. More noteworthy still is a very small form found also among the Miacomet pines. It is at once set apart from reduced examples of true *A. plantaginifolia* by perfectly white instead of purple styles, and is further well characterized by very small, orbicular to obovate, short-petioled basal leaves, often in a close rosette, their blades only 0.75–1.5 cm. broad; the cauline leaves are mostly blunt or rounded at the apex, their upper surface invested with a minute appressed tomentum quite different from the loosely arachnoid pubescence characteristic of the attenuate-tipped cauline leaves of true *A. plantaginifolia*. Not any of the pistillate plants were taller than 10–15 cm., and the few staminate plants found were only 3–5 cm. high; in several of them a few of the involucral bracts were bright rose color. Altogether the plant possesses a combination of striking characters that give it quite the aspect of a most distinct species. But certain Nantucket specimens of *A. plantaginifolia* show a tendency to develop somewhat similar characters, thus making it doubtful whether the smaller plant is other than a localized variety of the common species.

*ANTENNARIA FALLAX Greene.

On Prospect Hill in the western outskirts of the town, also on a dry slope at Capaum Pond, only a few plants at each station. In full flower June 10, 1909; flowers passing, June 5, 1911. A stout form of the species, becoming 4 dm. high, the acute leaves 2–3 cm. broad, pubescent on the upper surface; some stems with a few purplish glandular hairs below the rather close corymb.

*ANTENNARIA NEODIOICA Greene.

Rather common locally, but wanting in many parts of the island; perhaps most frequent on the rolling commons westward from the town; Madequet, Shawkemo, Siasconset. In full bloom, but also much of it only just in flower May 30, 1909, some heads mature by June 6.

Much of the Nantucket plant appeared to be somewhat aberrant, and specimens sent to Professor Fernald proved to be his var. *attenuata* (Proc. Bost. Soc. Nat. Hist. **28**: 245. 1898). My collections seem to show that this variety is more common on Nantucket than the typical plant. Professor Fernald writes me that it appears to be more common than the type in the Canadian zone.

*ANTENNARIA NEGLECTA Greene.

In damp fields and open places, rather scarce and found mainly on the western side of the island. In full flower May 31, 1909; mature heads June 7, 1908.

*ANTENNARIA PETALOIDEA Fernald.

An extensive colony of this interesting plant overspreads many rods of a sterile hilltop field southwest of Capaum Pond, an extreme southern outpost of the species. On May 30, 1909, in fullest bloom, it was far more conspicuous in the whiteness of its inflorescence than any of our more familiar Antennarias, appearing like snow drifted along the hilltop with outlying patches down the slope. I had never before met with the species nor understood just how it differed from *A. neglecta*, but the eye needed no closer inquiry to approve it instantly as a beautifully distinct plant. Professor Fernald, who has kindly examined my specimens, writes me that they are typical of his var. *subcorymbosa* (Rhodora **16**: 133. 1914) not known hitherto from south of Mt. Desert, whence it extends locally along the coast to Prince Edward's Island and eastern Nova Scotia, there very common, and further eastward to Newfoundland.

ANAPHALIS MARGARITACEA (L.) Benth. & Hook.

Not an abundant plant, but widely scattered over the island. It is frequent in close patches among the mixed growths of herbs and low woody plants that like miniature thickets are scattered over the plains and rolling upland, and is common in more open colonies on parts of Great Neck. Corymbs white, but no open flowers, July 10, 1912; in full flower through August and September.

The close groups or patches, often far distant from each other, that are natural to its habit of growth in poor soils, are noticeable early in the season before the stems appear, from the whitish green color of the basal leaves; by midsummer it has become a conspicuous plant from the snowy whiteness of its flowering corymbs.

GNAPHALIUM OBTUSIFOLIUM L.

Common in dry soils, often in white sand among the beech grass. Plants very small up to late June; in full flower in August and September.

GNAPHALIUM ULIGINOSUM L.

Locally common in damp fields and cartways and occasional in the town streets. First flowers June 17, 1910; blooming through September.

GNAPHALIUM PURPUREUM L.

On sandy levels about most of the ponds along the south side of the island, especially Nobadeer and Madequecham Ponds, sometimes in great abundance. Collected by Miss Gardner at Sachacha Pond. Reddened flower heads June 7, 1909; plants still small but in full flower July 9, 1912; flowers passing September 13, 1907.

*INULA HELENIUM L.

Sparingly established in a meadow near the Springfield House and in a low field at the southern end of the town. In full flower August 4, 1906; out of bloom August 27, 1904.

RUDBECKIA HIRTA L.

Frequent or rather common in many parts of the island. According to Mrs. Owen its first appearance on Nantucket was probably about 1878 and ten years later it was rather common at Siasconset and becoming so elsewhere.

HELIANTHUS DIVARICATUS L.

Common on the plains and moorland towards Siasconset, and local throughout the eastern third of the island, not seen on the western two thirds. In exposed places on poor soils it is often much dwarfed, with unusually narrow leaves and few flowering heads or only a single one. In full bloom August 6, 1904; mostly passed flowering September 17, 1907.

HELIANTHUS STRUMOSUS L.

Locally common in the northeastern quarter of the island in dry soil about the borders of thickets; not seen west of Swain's Neck. No flowers up to August 3, 1906; in full bloom September 17, 1907.

*HELIANTHUS ANNUUS L.

Occasional in waste ground and in old fields. In full flower August 11, 1906.

*HELIANTHUS SCABERRIMUS Ell.

A casual waif. A single small flowering plant in an old field September 15, 1899; one plant past flowering September 20, 1907, in waste spot west of the town; a few small plants near Crooked Lane June, 1908.

HELIANTHUS TUBEROSUS L.

Yards and waste places and by roadsides, mainly near the town, growing in close colonies and not coming into full bloom until late in the season. Plants a few inches high June 3, 1909; a precocious flowering head September 11, 1904; earliest flower September 14, 1907.

BIDENS CERNUA L.

Frequent in wet places and locally abundant, as at Watt's Run and along ditches west of the town. Just in flower August 30, 1904; in full bloom September 14, 1907. Stout forms, having closely serrate leaves becoming 4 cm. broad, correspond with specimens in the herbarium of the New York Botanical Garden labeled var. *elliptica* by Dr. Wiegand (Bull. Torr. Club, **26**: 417–418).

BIDENS CONNATA Muhl.

Everywhere in low grounds, in bogs and along pond shores. At Maxcy's Pond five feet tall, with leaves as deeply lobed as in the smaller forms. No flowers up to August 15, 1906; just in flower at the end of August, 1904; blooming through September.

*BIDENS PETIOLATA Nutt.

Collected only in low grounds west of the town. Freshly in bloom September 21, 1899.

A plant of wet woods and thickets rather than of open bogs, and apparently not a common species on the immediate coast. I used to find it an abundant and characteristic plant of low open woods and shaded swamps in the lower Hudson River region where *Bidens connata* was of such rarity, if it occurred at all, that I never met with it. When first coming to know this plant in its coastal bogs I could not doubt that it was distinct from the Hudson Valley species, and my observation of the two plants for many years has only confirmed that view.

*BIDENS FRONDOSA L.

Frequent in low grounds and waste places about the town; sometimes on pond shores. In early flower at the end of August, 1904; in full flower September 10, 1907.

*BIDENS VULGATA Greene.

Frequent in yards and waste places and by streetsides in the town; Shawkemo. Just in flower in early September, 1904; in full flower September 16, 1907.

*Galinsoga aristulata sp. nov.

Galinsoga parviflora var. *hispida* DC. not *G. hispida* Benth.

A few plants on Easton Street in full flower September 13, 1907; Fair Street, September 19, 1914; specimen in herbarium of Miss Grace B. Gardner.

This now widespread weed wherever I have met with it has not failed to prove itself always readily distinguishable from the true *G. parviflora* Cav., even without reference to the constant and pronounced differences in the pappus scales. Nevertheless I do not discover that it has ever received an available specific name. In some European gardens of today it is evidently known as *G. brachystephana* Regel, since it has been grown at the New York Botanical Garden from seeds received from Europe under that name. There are before me specimens raised from such seeds that, noting their similarity to our plant known as *G. parviflora* var. *hispida*, I took from the herbaceous beds at the garden September 11, 1898. Although the close counterpart of these specimens has not been found in any example of our common weed met with since that time their divergencies, however obvious, are not greater than might well be expected to mark a long established garden form of so variable a plant. In any case, however, there need be no doubt that the name *G. brachystephana* in its use for this plant has been mistakenly applied. I have not been able to consult the rare pamphlet (Ind. Sem. Hort. Turic, 1846) that contains the original description of *G. brachystephana*, which species, if we may so understand its history, came from seeds received in Europe about the year 1846, from what country does not appear. Nor do I find any descriptive text in the different issues of that period of Index Seminum Hortus Botanicus Imperialis Petropolitanus wherein the name appears. But a description, presumably a transcript of the original, is found in Walper's Repertorium (**6**: 722. 1846–7). Therein we read, "*ligulae amoene roseae*." The correlation is thus evidently with *G. caracasana* (DC.) Sch. Bip. and not with our white-rayed species. Another name requiring to be considered is *Wiborgia urticaefolia* H. B. K. (*G. urticaefolia* Benth.). An excellent illustration of this plant accompanying its description (Nov. Gen. et Sp. **4**: 257. *pl. 389.* 1820) shows that it is closely related to our species but differs by larger rays and the absence of a pappus. *G. Humboldtii* Heiron. (Bot. Jahrb. **28**: 618. 1899–1900) based on a variety of *G. urticaefolia*, which is cited as a synonym, differs in having a short coroniform pappus, thus excluding our plant with elongated attenuate or aristulate pappus scales. In some respects the characterization of *G. quadriradiata* Ruiz & Pav. (Syst. Veg. 198. 1798) might seem to refer to our plant but, as a whole, it is more descriptive of, and clearly applicable to, a mere form of *G. parviflora* Cav. (*G. quinquiradiata* Ruiz & Pav. *l. c.*), as was long ago determined by De Candolle.

ACHILLEA MILLEFOLIUM L.

Fields and roadsides, flowering from early June until October. In its best developed state it is often only slightly pubescent, and is branched above the middle to form an ample compound corymb, the heads having rays 2.5–3.5 mm. broad. Reduced and more pubescent forms of poorer soils have more contracted leaves and are unbranched, bearing a single terminal corymb of somewhat smaller heads.

Dr. Rydberg, who has examined my Nantucket collections of *Achillea*, finds that certain specimens are quite clearly referable to the plant recognized in Europe as *A. asplenifolia* Vent. (*A. rosea* Desf.), in which the flowers are prevailingly rose color to magenta, and the ultimate subdivisions of the leaves finally thickened and callous at the ends below the cartilaginous pointed tip. The status of this plant, however, seems not to be very clear, and the question of its formal recognition may well await a better understanding of its relationship to *A. Millefolium*.

*ACHILLEA OCCIDENTALE Raf.

Specimens of this have been determined by Dr. Rydberg who points out to me that its more obvious differences from *A. Millefolium* are smaller rays, 1.5–2 mm. wide, more delicately dissected leaves with narrower unmargined or but slightly margined midrib, and more arachnoid pubescence, the crowded heads commonly with more cylindric involucres and narrower and paler or more stramineous bracts. This yarrow seems to be not uncommon on Martha's Vineyard, where I have collected very typical examples, and also on Long Island and near New York. When last on Nantucket I did not well enough distinguish it from *A. Millefolium* to learn its real status there, although noting that a yarrow having very small rays, now presumably this, was not at all an uncommon plant.

*ACHILLEA PANNONICA Scheele, Linnaea **18**: 471. 1835.

A. lanata Spreng, Cat. Fl. Hal. 1799, not Lam. 1778.

This yarrow of southeastern Europe, not before, I think, reported from America, occurs in scattered growth on the dry plains towards the south shore of Nantucket especially near Madequecham Pond. In full flower July 9, 1912.

A very distinct appearing plant as compared with our common forms, densely white woolly throughout and with congested rounded or convex corymbs, and small rays 1–1.5 mm. wide. The numerous densely lanose-pubescent cauline leaves are narrow and ascending or erect, their short segments and subdivisions more or less incurved and closely crowded together. Dr. Rydberg, who has determined the identity of my specimens, has called my attention to the marked characters by which this plant differs from *A. lanulosa* Nutt. which in some respects it resembles.

ANTHEMIS COTULA L.

Mainly in and about the town and suburbs, but also in fields and waste places. A precocious flower June 18, 1910; first flowers June 27, 1912; blooming until late autumn.

CHRYSANTHEMUM LEUCANTHEMUM L.

Abundant throughout the island, whitening the fields in June. Sometimes growing in close groups in pure sand among the beach grass. First flowers May 30, 1909; in full flower June 7, 1908. All presumably the var. *pinnatifidum* Lecoq & Lamotte.

CHRYSANTHEMUM PARTHENIUM (L.) Pers.

Occasionally spontaneous by streetsides and in waste places. Not yet in flower June 14, 1908; in full flower June 27, 1912.

The more common form of this plant seen in old gardens and as an escape, has a broad pale yellow disk and short rays and would appear to be the var. *breviradiatum* Rouy (Fl. de France **8**: 263). On this understanding the less usual plant, with us, having a smaller bright yellow disk and longer rays would be the typical form. This was found growing sparingly in a barnyard west of the town in full flower September 17, 1899, and in two instances by streetsides in the town.

*CHRYSANTHEMUM BALSAMITA L.

A casual estray from cultivation, and at a few stations persistent and spreading in abandoned grounds. Large flower heads August 29, 1904; heads yellow but not actually in flower September 11, 1907.

TANACETUM VULGARE L.

Frequent near old barns and farm houses and in abandoned grounds usually growing in close masses and appearing as if a survival of cultivation. The var. *crispum* DC. is perhaps more frequent than the typical form. Begins to bloom in August and continues in full flower through September.

ARTEMISIA CAUDATA Michx.

A characteristic plant of the commons and open sandy places and often growing in pure sand among the beach grass. No heads visible June 27, 1910; inflorescence appearing June 20, 1908; not quite in bloom July 13, 1912.

ARTEMISIA VULGARIS L.

An infrequent weed, seen only about the wharves. In full flower September 5, 1904.

*ARTEMISIA BIENNIS Willd.

A single stout plant near the wharves just in flower September 5, 1904; one plant back of the beach at Wauwinet, June 20, 1910, the heads very immature.

*ARTEMISIA ANNUA L.

Collected near the Springfield House in 1901 and, more recently west of the town, by Mrs. Flynn; Main Street, September 14, 1914, Walter Burdick, specimen in herbarium of Miss Gardner.

*ARTEMISIA ABSINTHIUM L.

In full flower about a remote abandoned dwelling in Squam September 1, 1904; streetside in the town 1912.

*ARTEMISIA PONTICA L.

Casually persistent and spreading as a survival of cultivation, not seen in flower. It is more frequent on Martha's Vineyard, but only as a relic or an estray from old gardens.

*ARTEMISIA STELLERIANA Bess.

A characteristic plant of the sea beaches, mainly on the north side of the island, growing in dense confluent patches on the white sand beyond the reach of the tides; rarely seen away from the immediate shore, but becoming established in spots among the beach grass above the highest bluffs. Nearly in flower May 30, 1909, June 7, 1911; earliest flowers June 17, 1910; past its height of bloom June 27, 1912; continuing to produce some flowering stems during the summer and sometimes into September.

ERECHTITES HIERACIFOLIA (L.) Raf.

Very common, especially among the open groups of mixed woody and herbaceous vegetation that are scattered over the plains, this being the first predominating plant that springs up after these growths have been laid waste by fires. It is even more abundant among the windrows of shore refuse back of the beaches around Sachacha Pond where it becomes unusually stout and hairy and develops much purplish coloring in its upper parts. Plants a few inches high June 19, 1910, June 27, 1912; in full flower during September.

SENECIO VULGARIS L.

Streets and alleys in the town and outlying waste places, also in cultivated fields at the Cabot farm in Shimmo and on the Appleton farm at Miacomet Pond. Mature seeding heads before the end of May, but continuing to bloom throughout the season, doubtless until frost.

ARCTIUM MINUS Schk.

Infrequent; neglected places and about farm buildings near the town; Quaise; Shawkemo; Great Neck. Blooms from August through September.

*ARCTIUM TOMENTOSUM (Lam.) Schk.

The common burdock of Nantucket, inhabiting barnyards and waste places all over the island. Often with very large cottony heads and otherwise strongly typical but sometimes with the heads smaller and only thinly arachnoid, more like those of *A. minus.* Occasional forms appear to approach *A. Lappa* L. which has not yet been detected on the island. In bloom from August through September.

CIRSIUM LANCEOLATUM (L.) Hill.

Roadsides and open places in all parts of the island but nowhere in abundance. Basal leaves only June 15, 1910; first flower July 14, 1912; blooming through September.

CIRSIUM DISCOLOR (Muhl.) Spreng.

Locally common in the northeastern quarter of the island from Shawkemo to Polpis, Pocomo and, especially, in Squam. Most frequent about thickets near the shore. Comes into bloom the latest of the thistles. First flowers September 11, 1907.

CIRSIUM ODORATUM (Muhl.) Britton.

Along roadsides, and widely scattered over the downs and commons. It is often strongly developed, and plants were observed bearing as many as nine flowering heads besides several not yet in bloom. First flowers June 20, 1910, June 27, 1912; mostly past flowering in August, but flowering heads are not unusual late in the month and even in September. Heads of palest pink are frequent; occasionally they are pure white.

CIRSIUM HORRIDULUM Michx.

Common, mainly in brackish soil or in low grounds near the shore, but found as well in damp places in all parts of the island, and not infrequently in dry sandy soil, even among open growths of pine. The flowering heads, normally of a yellowish color, are often deep reddish purple medially or, rarely, throughout. First flowers June 2, 1909, June 7, 1908, June 7, 1911; some plants past flowering by June 25, 1910; mostly out of bloom by the middle of July or earlier; rarely a flowering head is produced in September.

CIRSIUM ARVENSE (L.) Scop.

Frequent near the town, and occasional elsewhere, but not much of it anywhere. First flowers July 1, 1912.

*CENTAUREA CYANUS L.

Transient in and near the town. First flowers on strayed plants June 6, 1911, June 21, 1910; flowering earlier in gardens.

*CENTAUREA MELITENSIS L.

Waste ground near Surfside, July 9, 1912, a few plants in earliest flower.

During the publication of this series further exploration on Nantucket, both by myself and by others, has brought to light a considerable number of plants not before discovered there. These later additions to the flora will be recorded in an appendix.

INDEX TO AMERICAN BOTANICAL LITERATURE

1909-1916

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 the broadest sense.

Reviews, and papers that 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.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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BENEDICT: VARIETIES OF NEPHROLEPIS

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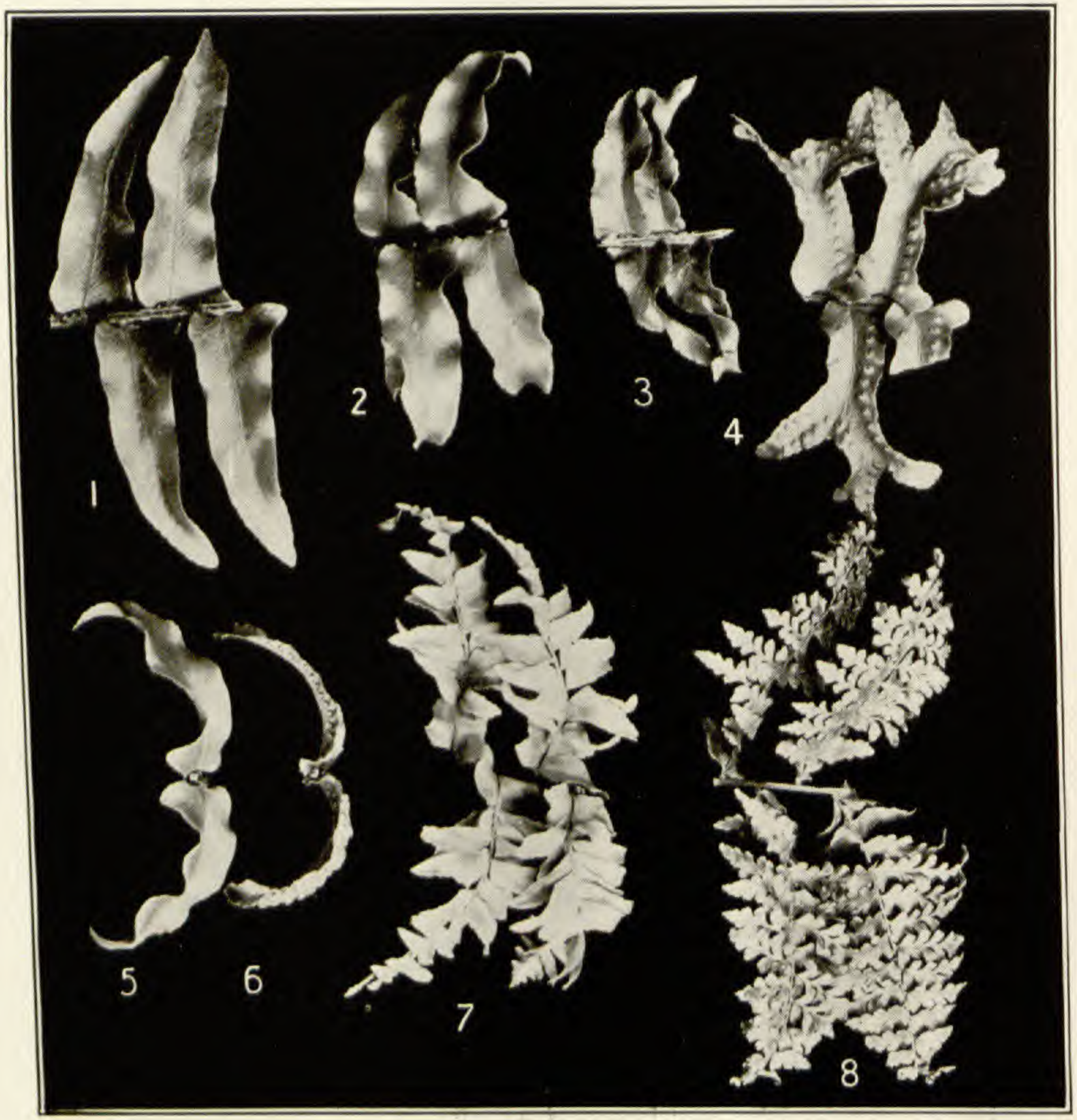

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TORREY BOTANICAL CLUB

JUNE, 1916

Contributions to the Mesozoic flora of the Atlantic coastal plain, XI.—Tennessee *

Edward Wilber Berry

(with plate 16)

Tennessee west of the river of that name is physiographically and geologically a part of the Atlantic Coastal Plain. The Upper Cretaceous deposits of Tennessee outcrop in a belt of considerable width which extends across the state from north to south immediately west of the Tennessee River. In McNairy and Hardin counties on the south this belt is about sixty-eight miles in width, but the beds become thinner or are overlapped by the Eocene to the northward so that in Henry County on the northern boundary the Cretaceous belt is only about ten miles in width.

The Upper Cretaceous of Tennessee when compared with that of Alabama and Mississippi is seen to be much thinner. According to the nomenclature adopted for Tennessee† the sequence from the top downward is as follows:

Ripley formation.... { McNairy sand member
Unnamed member

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* The last previous contribution of this series appeared in the Bull. Torrey Club 40: 295–300. 1914.

† Stephenson, L. W. U. S. Dept. Int. Geol. Surv. Professional Paper 81. 1914.

[The Bulletin for May (43: 207–282. *pl. 10–15*) was issued June 16, 1916.]

Selma chalk	Representing a tongue of chalky material extending northward from about the middle of the Selma chalk of western Alabama
Eutaw formation....	Coffee sand member
Tuscaloosa formation.	

No fossil plants have been recorded from these beds in Tennessee except *Salex eutawensis* Berry, which is recorded from the Coffee sand near Parsons, Decatur County, Tennessee. While the materials are prevailingly littoral or sublittoral in character with numerous small clay lenses, the bulk of the deposits are sands, and while these are often lignitic or contain petrified wood, determinable fossil plants are rare. The apparent scarcity of fossil plants is due in a measure to lack of exploration, since this area has not yet been surveyed as thoroughly as the balance of the Cretaceous of the Eastern Gulf area. The country is thinly settled, and is for the most part without large towns, railroads or good wagon roads.

That eventually a considerable flora will be known from the Cretaceous of Tennessee is indicated by the results of a single season's detailed work in McNairy and Hardin Counties by Mr. Bruce Wade, a student of the Johns Hopkins University, working under the auspices of the Tennessee Geological Survey.

Determinable plants were obtained by him during the summer of 1915 at two horizons. The first of these is in the McNairy sand member of the Ripley formation and comes from two localities—one in the big cut on the Southern Railway west of Cypress and the other two and one half miles southwest of the town of Selmer, both in McNairy County. The second is in the Coffee sand member of the Eutaw formation and comes from the classic outcrop of the Upper Cretaceous at Coffee Bluff on the Tennessee River in Hardin County, first described by Safford in 1864.*

The flora collected by Mr. Wade is too limited to warrant a botanical analysis but it is of considerable interest stratigraphically and it possesses an especial botanical interest since hardly any-

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* Safford, J. M. Am. Jour. Sci. II. 37: 360–372. 1864.

thing is known of the later Upper Cretaceous floras of the Atlantic Coastal Plain. The forms identified with their geographical and geological ranges are shown in the following table:

	Coffee Sand, Tennessee	McNairy Sand, Tennessee	Lower Eutaw, Alabama, Georgia	Cusseta Sand	Black Creek Formation	Magothy Formation	Woodbine Formation	Tuscaloosa Formation	Dakota Formation	Raritan Formation	Emscherian of Europe	Turonian of Europe	Colorado Group	Montana Group
Phragmites Prattii	×	...	×	...	×	...	...	...	...	...	...	...	...	...
Sabalites sp.	...	×	...	...	...	...	...	...	...	...	...	...	...	...
Myrica ripleyensis	...	×	...	...	...	...	...	...	...	...	...	...	...	...
Salix eutawensis	×	...	×	...	×	...	...	...	...	...	...	...	...	...
Dryophyllum gracile	...	×	...	...	...	...	...	...	...	...	×	...	...	...
Ficus crassipes	×	...	×	...	×	×	...	×	×	...	...	...	...	...
Ficus Krausiana	×	...	×	...	×	×	...	×	×	...	...	×	...	...
Ficus ovatifolia	×	...	×	...	×	×	...	×	...	×	...	...	...	...
Dewalquea Smithi	×	...	...	...	×	...	...	×	...	...	...	...	...	...
Cissites crispus	...	×	...	...	...	...	...	...	...	...	×	...	...	...
Bauhinia ripleyensis	...	×	...	×	...	...	...	...	...	...	...	...	...	...
Manihotites georgiana	×	×	×	×	×	...	...	...	...	...	...	...	...	...
Sterculia Snowii tennesseensis	...	×	...	...	...	...	...	...	...	...	...	...	...	...
Pterospermites carolinensis	×	...	...	...	×	...	...	×	...	...	...	...	...	...
Laurophyllum elegans	×	...	...	...	×	×	...	...	×	...	...	...	...	...
Cinnamomum Heerii	×	...	×	...	×	×	×	×	×	...	...	...	...	...
Cinnamomum sp.	...	×	...	...	...	...	...	...	...	...	...	...	...	...
Malapoenna horrellensis	...	×	×	...	×	...	...	...	...	...	...	...	...	...
Myrcia havanensis	...	×	×	...	...	...	...	...	...	...	...	...	...	...
Eugenia (?) anceps	...	×	...	...	...	...	...	...	...	...	...	...	...	...
Andromeda Wardiana	×	...	×	...	...	...	...	...	×	...	...	...	...	...
Andromeda novae-caesareae	×	...	...	×	×	×	×	×	...	×	...	...	...	...
Diospyros primaeva	×	...	×	...	×	×	×	×	×	×	...	×	...	...
Halymenites major	×	×	...	...	...	...	...	...	...	...	...	...	×	×

This flora as at present known comprises twenty-four forms, of which *Sabalites* sp., *Cinnamomum* sp., and *Eugenia* (?) *anceps* are poorly characterized. *Halymenites major* is probably not a plant but it is a very characteristic object common in the western United States in the Colorado and Montana series.

The Tennessee Cretaceous flora is remarkable in not showing any traces of ferns or gymnosperms. When the prevailing coarseness of the sediments is considered the absence of ferns is not to be wondered at, but such sediments usually contain an abundance of coniferous twigs and with further exploration these should be discovered. The presence of considerable amber both in the Coffee sand and in the McNairy sand is a sure indication of conifers, and the petrified wood found at Coffee Bluff is also coniferous and represents an undetermined species of *Cupressinoxylon. Araucaria bladenensis*, which is so common in the Black Creek and Lower Eutaw and ranges upward into the Cusseta sand, has not been discovered in Tennessee.

If the two Tennessee horizons be considered separately it will be noted that the Coffee sand flora as at present known consists of fourteen named species and an unidentified *Cupressinoxylon*. None of these are new. It is contrasted with the McNairy sand flora by having but one common species (*Manihotites georgiana*) and by a considerable number of forms that come up from older horizons. Thus it has four species that originate in the Raritan, although none of these are characteristic of the Raritan but of slightly younger horizons. It has three species common to the Woodbine sand, five to the Dakota sandstone, seven to the Magothy formation, and eight to the Tuscaloosa formation. Nine of the Coffee sand forms are common to the basal Eutaw and twelve of the fourteen species are found in the Black Creek formation of the Carolinas. The Coffee sand has not yielded an invertebrate fauna, although on stratigraphic grounds Stephenson refers it to the *Exogyra ponderosa* zone. The present collections unquestionably confirm this reference. Its exact position in this zone is not directly determinable since the possible equivalents of the Coffee sand in Mississippi and Alabama are strictly marine formations without fossil plants, so that we have the familiar but much involved problem of comparing a section in one area with plants and without invertebrates, with a section in an adjoining area containing invertebrates but no plants. While the interpretations resulting from the two classes of evidence are in substantial agreement the paleobotanical evidence would seem to indicate that the Coffee sand may be slightly older than Stephenson (*op. cit.*) postulates, unless we are to assume that 86 per cent. of the Coffee sand flora comes up from older horizons and then becomes extinct in the relatively short interval between the Coffee and the McNairy sand. This is of course possible and future work may demonstrate its truth, but in the present state of our knowledge it seems improbable. Two of the Coffee sand species, *Ficus Krausiana* and *Diospyros primaeva*, occur in both the Cenomanian and Turonian of Europe.

The McNairy sand flora consists of eleven species, five of which are new and peculiar to this horizon. Only one is common to the Coffee sand, although two additional are found in the basal Eutaw of Alabama or Georgia. Two are common to the Cusseta sand and two occur in the Black Creek formation. The distinctness of the McNairy sand flora is further emphasized by the total absence of any Raritan, Woodbine, Tuscaloosa, Dakota or Magothy species. Singularly enough it has no known elements in common with the Cretaceous floras of the Rocky mountain or Great Plains provinces. Compared with European Upper Cretaceous floras it has two species, *Dryophyllum gracile* and *Cissites crispus*, common to the Emscherian of Prussia and Bohemia and not found elsewhere. While this is not sufficient evidence upon which to base intercontinental correlation it is not without significance, especially in view of the fact that the McNairy sand has not yet furnished any elements common to the fairly abundant floras of the Campanian and Maestrichtian of Europe.

POALES

POACEAE

PHRAGMITES Trinius

PHRAGMITES PRATTII Berry

Phragmites sp., Berry, Bull. Torrey Club **34**: 190. *pl. 11, f. 5.* 1907.

Phragmites Prattii Berry, Bull. Torrey Club **37**: 191. 1910; U. S. Dept. Int. Geol. Surv. Professional Paper 84: 28, 109. 1914.

Grasslike leaf fragments referred to this species have been described from several localities in the Black Creek formation of the Carolinas and from the lower Eutaw of Georgia. Identical remains occur in the Upper Eutaw of Tennessee.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

ARECALES

PALMAE

SABALITES Saporta

SABALITES sp.

Fragments of leaves of a large fan palm are present in the basal Ripley beds of Benton County, and in the McNairy sand of McNairy County, Tennessee. They indicate large flabellate leaves with numerous rays 1.5–2 cm. broad with an illy-defined midrib and closeset parallel lateral veins. The texture is coriaceous.

The material is very fragmentary and is altogether insufficient for specific diagnosis. It is in my judgment distinct from the so-called *Sabalites Grayanus* Lesquereux of the Montana Group, *Sabalites magothiensis* Berry of the Magothy formation or *Sabalites carolinensis* Berry of the Middendorf beds of South Carolina.

OCCURRENCE: RIPLEY FORMATION, MCNAIRY SAND MEMBER. One half mile from Camden, Benton County; two and one half miles southwest of Selmer, McNairy County, Tennessee.

MYRICALES

MYRICACEAE

MYRICA Linné

Myrica ripleyensis sp. nov.

Leaves of medium size, linear-lanceolate in outline with a gradually cuneate base. Length about 13 cm. Maximum width, in the middle part of the leaf, about 1.75 cm. Margins conspicuously serrate-toothed, the teeth somewhat irregular in size and disposition; distad they are reduced and close-set. They increase in size proximad until in the median and basal part of the leaf, they are large and triangular the intervening sharp sinuses reaching nearly to the midrib and closely simulating our recent *Comptonia* in character. Texture coriaceous. Petiole not preserved, presumably short and stout. Midrib stout, flexuous. Secondaries numerous, diverging from the midrib at wide angles.

about 70 degrees, every third or fourth one straighter than the rest and running to a marginal tooth, the intervening ones somewhat more curved and camptodrome.

This is an exceedingly well marked species, quite distinct from previously described forms and resembles closely some of the leaves of our existing *Comptonia peregrina* (Linné) Coulter. It is also much like some of the European Tertiary forms about which so much controversy raged in times past as to whether they were myricaceous or proteaceous.* For example some of the forms of *Comptonia vindobonensis* (Ettingshausen) Berry are close to the present species. A somewhat similar form is described by Velenovsky from the Bohemian Cretaceous as *Dryandra cretacea*,† and another by Unger from the Cretaceous of Transylvania as *Comptonites antiquus*.‡ These are both generically distinct from the present species as shown by their characteristic habit.

OCCURRENCE: RIPLEY FORMATION, MCNAIRY SAND MEMBER. Camden-Paris Road, thirteen miles northwest of Camden, Benton County; two and one half miles southwest of Selmer, McNairy County, Tennessee.

SALICALES

SALICACEAE

SALIX Linné

SALIX EUTAWENSIS Berry

Salix eutawensis Berry, Bull. Torrey Club **37**: 193. *pl. 22, f. 1–11.* 1910; U. S. Dept. Int. Geol. Surv. Professional Paper 84: 109. *pl. 19, f. 3.* 1914.

This very characteristic willow, represented by both leaves and fruits in North Carolina is also found in Georgia. It is

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* The reader who wishes additional information on this point should consult my paper on Living and Fossil Species of *Comptonia*. Amer. Nat. **40**: 485–520. *pl. 1–4.* 1906.

† Velenovsky. Fl. Böhm. Kreidef. **2**: 1. *pl. 1. f. 1–5.* 1883.

‡ Unger. Ueber einige fossile Pflanzenreste aus Siebenbürgen und Ungarn. Sitz. K. Akad. Wiss. Wien **51**: 2. *pl. 1, f. 1.* 1865.

not present in the material collected by Mr. Wade but was collected some years ago by Mr. Stephenson at the following locality.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Cut on The North Carolina and St. Louis Railway, east of Parsons, Decatur County, Tennessee.

FAGALES

FAGACEAE

DRYOPHYLLUM Debey

DRYOPHYLLUM GRACILE Debey

Dryophyllum gracile Debey, Feuilles querciformes d'Aix-la-Chapelle. Compte rendu Congres bot. et hort. Brussels 10. *f. 10, 11.* 1881.

Quercus pseudodrymeja Velenovsky, Fl. Böhm. Kreidef. 2: 17. *pl. 2, f. 21, 22.* 1883; 4: 13. *pl. 7, f. 10.* 1885. Bayer, Sitz. k. Böhm. Gesell. Wiss. 1896: 10. Fric, Archiv. Naturw. Landes. Böhm. 10: 75. *pl. 100.* 1897.

Leaves oblonglanceolate in outline, with a cuneate base and a gradually narrowed tip. Length about 12 cm. Maximum width, in median part of leaf, ranging from 1.75 cm. to 2.5 cm. Petiole missing. Texture subcoriaceous. Margin with regularly spaced, fairly prominent, nearly straight-serrate teeth. Midrib stout, prominent on the lower surface of the leaf. Secondaries thin, regularly spaced, about fifteen craspedodrome pairs, branching from the midrib at angles of forty-five degrees or more, curving regularly upward, subparallel, terminating in the marginal teeth. Tertiaries thin, partly percurrent and partially alternating, joined midway between adjacent secondaries by a zigzag tertiary. [FIG. 6.]

This well-marked species is represented by five specimens in the small collection from the Cretaceous of Tennessee. None of these are complete, each showing about two thirds of a leaf, enough to demonstrate the identity with the European form. The type material came from the Emscherian where it is recorded from Aachen, Rhenish Prussia; Tannenberg, Bohemia and Kieslingswalde, Silesia, all at about the same horizon, probably representing the Santonian substage of the Emscherian.

OCCURRENCE: RIPLEY FORMATION, MCNAIRY SAND MEMBER. Big Cut on Southern Railway near Cypress, two and one half miles southwest of Selmer, McNairy County, Tennessee.

URTICALES

MORACEAE

FICUS Linné

FICUS CRASSIPES (Heer) Heer

Proteoides crassipes Heer, Fl. Foss. Arct. 3^2: 110. *pl. 31, f. 6–8.* 1874.

Ficus crassipes Heer, *Ibid.* 6^2: 70. *pl. 17, f. 9a; pl. 24, f. 1, 2.* 1882; Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 37, 110. *pl. 10, f. 12; pl. 12, f. 8–10.* 1914.

The leaves of this species as they occur in the southern Coastal Plain are narrowly lanceolate with gradually narrowed apex and base, about 15 centimeters in length by 2.5 centimeters in greatest width, and resemble *Ficus atavina* Heer in outline but are relatively narrower. The texture is coriaceous and the midrib and petiole are extraordinarily stout in many specimens. The secondary venation when seen is of the usual camptodrome type with relatively long, ascending, curved secondaries.

This species was described originally from the Atane beds of western Greenland, the first rather fragmentary specimens collected having suggested the genus *Proteoides*. It was subsequently recorded from the Dakota sandstone of Kansas by Lesquereux. In the Atlantic Coastal Plain it is found in the Magothy and Black Creek formations, including the Middendorf member of the latter, and it is especially common in clays of the Tuscaloosa formation of Alabama. It occurs in the basal beds of the Eutaw formation in Georgia and the present occurrence extends its range upward to near the top of the latter formation.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

FICUS KRAUSIANA Heer

Ficus Krausiana Heer, Neue Denks. Schw. Gesell. 23: 15. *pl. 5, f. 3–6.* 1869; Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 38, 110. *pl. 11, f. 4–7; pl. 19, f. 4.* 1914.

Leaves of large size, ovate lanceolate in outline, broadest at or below the middle. Apex and base acutely pointed, the apex often extended and attenuated. Petiole and midrib stout Secondaries regular, open, thin, ascending, camptodrome, branching from the midrib at angles of forty-five degrees or more. Texture coriaceous or subcoriaceous. Length about 17 cm. Greatest width about 4 cm.

This species was described by Heer from Moletein in Moravia (Cenomanian), and it has been subsequently identified from a large number of American localities. In the West it occurs in the Dakota sandstone of Kansas and Colorado; in the East it is common from Martha's Vineyard and Block Island to Alabama and is present between these limits in Maryland, North Carolina and South Carolina. It occurs in the lower Eutaw of Georgia and the present record extends its range upward to near the top of the Eutaw.

Associated with this species at the type locality in Moravia are similar leaves which were described by Professor Heer as a different species, *Ficus Mohliana*. These are somewhat larger with a more sparse secondary venation. It seems probable that these merely represent the somewhat larger leaves of *Ficus Krausiana*, but they are not united with it in view of the lack of positive evidence, because *Ficus Mohliana* has priority and this would involve the change of name of this well-known type and horizon marker. In both North and South Carolina fruits are found associated with this species, but whether they are related to it or to some of the other rather numerous species of *Ficus* which occur at the same localities can not be determined.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

FICUS OVATIFOLIA Berry

Ficus ovata Newberry, Mon. U. S. Geol. Surv. **26**: 70. *pl. 24, f. 1–3*. 1896. Not Don, 1802–3.

Ficus ovatifolia Berry, Bull. Torrey Club **36**: 253. 1909.

Leaves ovate in outline, extended above into a narrow, usually pointed apex. Length 8–12 cm. Greatest width, which is in the basal part of the leaf, 4–7 cm. Base broadly rounded and in many specimens slightly decurrent. Margins entire. Primaries, three from the base, the midrib somewhat stouter than the lateral primaries. Secondaries camptodrome.

This species is closely allied to the Raritan species *Ficus Woolsoni* Newberry, differing primarily in its greater elongation and in the tendency of the former to a cordate outline. *Ficus ovatifolia* was described originally from the Raritan formation of New Jersey. It is present in the Black Creek formation of North Carolina and in the lower part of the Eutaw formation in Georgia.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

RANALES

RANUNCULACEAE (?)

DEWALQUEA Saporta & Marion

DEWALQUEA SMITHI Berry

Dewalquea Smithi Berry, Torreya **10**: 36. *f. 1.* 1910; U. S. Dept. Int. Geol. Surv. Professional Paper 84: 41. *pl. 8, f. 3–9.* 1914.

Leaves palmately decompound, the petiole dividing into three principal branches, the angle of divergence varying from twenty to sixty degrees, and the two lateral branches forking at an acute angle 1–2 cm. above their base. The middle leaflet lanceolate in outline, being widest in its central part and tapering almost equally to the acute apex and base. Length 7.5–16 cm. Greatest width 1–4 cm. Margin entire or serrate, usually entire below and serrate in the apical three-fourths, sometimes with large aqualine-serrate teeth. Midrib stout. Secondaries regular, subopposite, parallel; about twenty pairs, branching from the midrib at angles varying from forty-five to seventy degrees, usually about fifty degrees, curving upward and running to the marginal teeth, or camptodrome. The base of the leaflet extends downward to within 2 or 3 mm. of the forks of the petiole. Lateral leaflets more or less inequilateral, usually somewhat smaller than the middle leaflet. The internal lateral leaflet is lanceolate, the outer lamina starting at or very near the point where the lateral branch of the petiole forks. The inner lamina, however, extends downward almost to the base of the lateral branch, making the base markedly inequilateral. In general outline, marginal and venation characters, it is identical with the middle leaflet. The outer lateral leaflet is also somewhat inequilateral, but less so than the internal lateral leaflet, the internal lamina starting at or near the fork and its outer lamina extending more or less below the fork. Marginal and venation characters as in the other leaflets.

This handsome species is abundantly represented in the Middendorf formation of South Carolina, mostly by terminal leaflets. It is common in the Upper Tuscaloosa of Alabama where nearly complete leaves have been collected. It is markedly distinct from the American species of *Dewalquea* previously described, all of which were apparently tripartite. Among the European forms it is quite similar to the Senonian species *Dewalquea insignis* Hos. & v. d. Marck, which is, however, entirely distinct.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

ROSALES

CAESALPINIACEAE

BAUHINIA Linné

Bauhinia ripleyensis sp. nov.

Leaves of medium size, more or less bilobate, but much less deeply divided than in the preceding species, obovate in general outline. Length along the midrib 4.5 cm. From apex of lobes to base 6.7 cm. Width across upper part of the leaf 5.5 cm. Apical sinus open, extending about one fourth of the distance toward the base of the leaf, its margins at the tip of the midrib forming an angle of about 90°, curving slightly upward and then conspicuously outward to the pointed tips of the lobes which are directly laterally. Outer margins of the leaf full and rounded, becoming straight toward the broadly cuneate base. Midrib of medium size. Lateral primaries branching from the base at angles with the midrib of about 25 degrees, of medium size, curved upward and then outward, and running to the tips of the lobes. They give off four or five camptodrome secondaries on the outside and two or three on the inside. The midrib, in its upper half, also gives off one or two secondaries on each side. Leaf substance somewhat coriaceous. [FIG. 1.]

This species, which is sparingly represented in the argillaceous greensand marls along Cowikee Creek in Alabama, associated with shallow water or estuarine mollusks of the Ripley formation, and in the McNairy sand of Tennessee, is markedly distinct from any described species of *Bauhinia*. It is much smaller and less deeply divided than *Bauhinia gigantea* Newberry or *Bauhinia alabamensis* Berry, and is much less ornate in character. It is, on the other hand, much larger than *Bauhinia marylandicus* Berry of the Magothy formation in the Maryland area. It differs from all of these American Cretaceous species in its pointed, outwardly-directed lobes, but is not unlike a number of existing species of this genus.

OCCURRENCE: RIPLEY FORMATION. Right bank of Cowikee Creek, one-eighth of a mile above mouth, Barbour County, Alabama. MCNAIRY SAND MEMBER. Two and one half miles southwest of Selmer, McNairy County, Tennessee.

GERANIALES

EUPHORBIACEAE

MANIHOTITES Berry

MANIHOTITES GEORGIANA Berry

Manihotites georgiana Berry, Bull. Torrey Club 37: 507. *f. 1, 2.* 1910; U. S. Dept. Int. Geol. Surv. Professional Paper 84: 114. *pl. 22; pl. 23; pl. 24, f. 4, 5.* 1914.

This remarkable large-leafed species has been somewhat fully described and figured recently. The type was based on nearly perfect material from the Lower Eutaw of McBrides Ford, Georgia. This species has also been recorded from the Cusseta sand member of the Ripley formation at Buena Vista, Georgia. It is present in the Black Creek formation of North Carolina and Mr. Wade's recent collections contain fragmentary but characteristic specimens from both the Eutaw and Ripley formations of Tennessee.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County. RIPLEY FORMATION, MCNAIRY SAND MEMBER. Two and one half miles southwest of Selmer, McNairy County, Tennessee.

RHAMNALES

VITACEAE

CISSITES Heer

CISSITES CRISPUS Velenovsky

Cissites crispus Velenovsky, Fl. Böhm. Kreidef. 4: 12. *pl. 4, f. 6* 1885. Not Newberry, 1896, Berry, 1906, 1911.

The present species was identified from the Raritan of New Jersey by Newberry and from the Magothy by Berry but neither occurrence represents the European form so that recently I made them the basis of a new species, *Cissites Newberryi*.*

A perfectly distinct small-leafed form which appears to be identical with the Bohemian type is present in the Ripley of Tennessee. It differs from *Cissites Newberryi* in its relatively shorter and broader form, its crenate instead of serrate or dentate teeth, its less ascending secondaries and its cordate base.

The type and only other known occurrence of *Cissites crispus* is the Chlomeker beds (Emscherian) of Bohemia.

OCCURRENCE: RIPLEY FORMATION, MCNAIRY SAND MEMBER. Two and one half miles southwest of Selmer, McNairy County, Tennessee.

MALVALES

STERCULIACEAE

STERCULIA Linné

Sterculia Snowii tennesseensis var. nov.

Leaf bilobate with a bluntly pointed base and gradually narrowed acuminate recurved apical lobes. Length about 11 cm. Width of entire basal part of leaf 2.5–2.75 cm. Width of lobes 1.1–1.6 cm. Margins entire. Texture subcoriaceous. Sinus extending half way to base or less, open, narrowly rounded. Midrib stout, flexuous. Lateral primary stout, diverging from midrib at an acute angle about 3 cm. above the base. Secondaries thin, largely immersed, diverging from primaries at wide angles at regular intervals, arching in a camptodrome manner near the margins. [FIG. 5.]

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* Berry, E. W. Md. Geol. Surv. Upper Cret. 856. 1916.

This striking form is unfortunately represented by only two specimens both of which are bilobate, although it, like so many fossil and existing species of *Sterculia*, may well have varied from entire to trilobate. Among previously described fossil forms it may be compared with the Magothy species *Sterculia minima* Berry, a smaller more variable form, or with the Dakota sandstone species *Sterculia mucronata* Lesquereux and *Sterculia Snowii* Lesquereux. The latter while often much larger and at times with five lobes is extremely variable. Two named varieties have already been recognized and the general character and venation of the Tennessee form leads me to conclude that it represents another variety of this protean species.

OCCURRENCE: RIPLEY FORMATION, MCNAIRY SAND MEMBER. Two and one half miles southwest of Selmer, McNairy County, Tennessee.

PTEROSPERMITES Heer

PTEROSPERMITES CAROLINENSIS Berry

Pterospermites carolinensis Berry, Bull. Torrey Club **34**: 198. *pl. 14, f. 2.* 1907.

This characteristic species, which was described from the Black Creek formation of North Carolina, is also not uncommon in the Tuscaloosa formation of Alabama. The present collections extend its range upward to the Coffee Sand Member of the Eutaw formation in which it occurs at Coffee Bluff, Hardin County, Tennessee.

THYMELEALES

LAURACEAE

LAUROPHYLLUM Goeppert

LAUROPHYLLUM ELEGANS Hollick

Laurophyllum elegans Hollick, Mon. U. S. Geol. Surv. **50**: 81. *pl. 27, f. 1–5.* 1907; Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 53. *pl. 12, f. 6.* 1914.

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 and petiole stout. Secondaries numerous, usually less close and somewhat coarser than in *Laurophyllum nervillosum*, 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.

The species is certainly known from the upper Raritan at South Amboy, New Jersey, and is common in the Magothy formation of Maryland. It is sparsely represented in the Black Creek beds of North Carolina and is not uncommon in the Middendorf beds of South Carolina.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

CINNAMOMUM Sprengel

CINNAMOMUM HEERII Lesquereux

Cinnamomum Heerii Lesquereux, Cretaceous Flora 84. *pl. 28, f. 11*. 1874; Mon. U. S. Geol. Surv. **17**: 105. *pl. 15, f. 1*. 1892; Newberry, Mon. U. S. Geol. Surv. **35**: 100. *pl. 17, f. 1–3*. 1898; Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 118. *pl. 21, f. 8*. 1914.

Leaves coriaceous, entire, ovate in outline, more or less attenuated apically. Base broadly rounded. Primaries three, stout, suprabasilar. Secondaries camptodrome.

The exact status of this species is made out with difficulty. In typical specimens it is clearly distinct from *Cinnamomum Newberryi* Berry in its more regular outline and venation, broader form, more rounded base, and stouter suprabasilar primaries. Other remains have been referred to *Cinnamomum Heerii* which are not typical in some of these distinctive characters, and the well-known variation of the leaves of *Cinnamomum* renders a satisfactory solution of the problem difficult. It does, however, characterize the somewhat younger beds represented in the west by the Dakota sandstone and the Woodbine sand and in the Coastal Plain by the Magothy formation of the north and the Black Creek and Tuscaloosa formations of the south. In the lower Eutaw of Georgia it is represented by fragments showing the coriaceous texture, broad base, and suprabasilar primaries of the species.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

CINNAMOMUM sp.

A characteristic *Cinnamomum* of uncertain specific identity occurs in the McNairy sand member of the Ripley formation at the locality two and one half miles southwest of Selmer in McNairy County, Tennessee.

MALAPOENNA Adanson

MALAPOENNA HORRELLENSIS Berry

Malapoenna horrellensis Berry, Bull. Torrey Bot. Club 37: 198. *pl. 24, f. 1–9.* 1910; U. S. Dept. Int. Geol. Surv. Professional Paper 84: 118. 1914.

Leaves ovate-lanceolate, about 8 cm. long by 2.5 cm. in greatest width; broadest at the evenly rounded or slightly acute base, narrowing gradually upward, the apex narrow and extended but obtusely pointed. Leaf substance thin but persistent, evidently coriaceous in life, as these leaves occur abundantly at a locality where all the vegetable remains were thoroughly macerated before entombment. Secondaries four to six pairs, subopposite, curved upward, camptodrome, branching from the midrib at an acute angle, the lowest pair branching from the top of the petiole and extending upward halfway to the apex or farther, giving the leaf a triple-veined appearance. Perhaps they should be termed lateral primaries, although they are much finer than the fairly stout midrib. The next pair of secondaries branch at a less acute angle, a considerable distance above the base, one third to one half the distance to the apex. Tertiary venation typically lauraceous.

The present species may possibly be confused with *Cinnamomum Heerii* when only the basal part of the leaf is found, but the general proportions and characters of the whole leaf are perfectly distinct.

The genus *Malapoenna* has more than one hundred existing species, chiefly of the Oriental tropics, and is well represented in the fossil state from the Dakota and Magothy formations upward. It is especially well represented in the Paleocene of Europe and in the Shoshone group of America. Of the two species in the Dakota sandstone of the West, one occurs in the Tuscaloosa formation at Cottondale, Alabama, and the other in the Magothy formation of New Jersey.

OCCURRENCE: RIPLEY FORMATION, MCNAIRY SAND MEMBER. Near Cypress and two and one half miles southwest of Selmer, McNairy County, Tennessee.

MYRTALES

MYRTACEAE

MYRCIA DeCandolle

Myrcia havanensis sp. nov.

Leaves linear-lanceolate in outline, falcate, about 9 cm. in length by 1 cm. in maximum width, which is in the lower half of the leaf. Margins entire. Apex gradually narrowed, acuminate. Base narrowly pointed, decurrent. Petiole very stout, tapering upward, 1.75 cm. in length. Midrib stout, curved. Secondaries numerous, thin, somewhat irregularly spaced, 2–6 mm. apart, branching from the midrib at angles of about forty degrees, running with but slight curvature to the well-marked and nearly straight longitudinal vein which forms a marginal hem less than one half a millimeter from the margin. Texture coriaceous.

The present species is very close to some of the numerous forms which have been from time to time referred to *Eucalyptus Geinitzi* (Heer) Heer. It is, however, distinct from the latter, especially when compared with Heer's type or with the more typical American material. In general it is a smaller leaf with a larger and longer petiole, an outline less inclined toward ovate, and relatively much more produced apically. It is typically *Myrcia*-like in all of its characters. It is found in both the Ripley and Eutaw formations in Alabama and Tennessee.

OCCURRENCE: EUTAW FORMATION. Two miles south of Havana, Hale County, Alabama. RIPLEY FORMATION, MCNAIRY SAND MEMBER. Two and one half miles southwest of Selmer, Big Cut on Southern Railway near Cypress, McNairy County; Camden, Benton County, Tennessee.

EUGENIA Linné

Eugenia (?) **anceps** sp. nov.

Coriaceous leaves of variable size and form, lanceolate or oblong lanceolate. Base and apex equally acuminate or apex somewhat more attenuated. Margins entire. Length 7.75–10 cm. Maximum width, midway between the apex and the base, 11–18 mm. Petiole enlarged, short and stout, 3–4 mm. in length. Midrib stout. Secondaries thin, immersed in the leaf substance. [FIGS. 2–4.]

This species is referred with much doubt to *Eugenia*. The material is abundant but poorly preserved and these leaves resemble a variety of forms referred to such genera as *Salix*, *Laurophyllum*, etc.

Eugenia has a species in the Tuscaloosa formation of Alabama, another in the Dakota sandstone, and is not uncommon in the Eocene of the Mississippi embayment area.

OCCURRENCE: RIPLEY FORMATION, MCNAIRY SAND MEMBER. Two and one half miles southwest of Selmer, McNairy County, Tennessee.

ERICALES

ERICACEAE

ANDROMEDA Linné

ANDROMEDA NOVAE-CAESAREAE Hollick

Andromeda novae-caesareae Hollick; Newberry, Mon. U. S. Geol. Surv. **26**: 121. *pl. 42, f. 9–12, 28–31*. 1896; Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 58, 120. *pl. 14, f. 5, 6; pl. 24, f. 1*. 1914.

Leaves small, thick, and entire, with stout petioles and midribs and obscure secondary venation which is immersed in the thick lamina. Length 2.5–5.0 cm. Width varying from 0.9–1.3 cm. Venation, where visible, showing numerous parallel, camptodrome, relatively long and thin secondaries which branch from the midrib at acute angles. While the majority of these leaves are equally acuminate at both ends there is considerable variation in this respect, and a well-marked tendency is shown in a considerable number of specimens which are relatively broader, especially in the upper half, toward an obtusely rounded apex, the termination of the midrib showing as a small mucronate point. The base in these forms gradually narrows to the stout petiole.

This species is found as early as the uppermost Raritan in the New Jersey area and is also common in the overlying Magothy. It is exceedingly common throughout the Black Creek formation of the Carolinas and has also been recorded from the Cusseta sand member of the Ripley formation in Georgia. It occurs also in the Woodbine of Texas and the Tuscaloosa of Alabama so that it is apparently a form with a wide stratigraphic range.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

ANDROMEDA WARDIANA Lesquereux

Andromeda Wardiana Lesquereux, Mon. U. S. Geol. Surv. 17: 119. *pl. 64, f. 17.* 1892; Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 120. *pl. 24, f. 3.* 1914.

Leaf elliptical in outline, entire. Apex and base equally narrowed but the apex bluntly rounded. Length 5.3 cm. Greatest width, which is halfway between the apex and the base, 2.3 cm. Midrib thin. Secondaries not made out. In the type they are thin, diverging at an angle of about forty degrees and camptodrome.

The type material came from the Dakota sandstone of Ellsworth County, Kansas. The Georgia material which came from the basal beds of the Eutaw formation shows a leaf which is a trifle larger but which in its general proportions and outline is identical with the western form, and there can be no doubt of their identity.

It is quite possible, in fact probable, that this species is not distinct from *Andromeda tenuinervis* Lesquereux, which, if the form referred to it by Hollick is correctly identified, approaches it closely in size. The two differ somewhat in texture and in the degree of acuteness of the apex, but whether these features are of specific value or not is an open question. The Tennessee material extends the range of this species to the upper part of the Eutaw formation.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

EBENALES

EBENACEAE

DIOSPYROS Linné

DIOSPYROS PRIMAEVA Heer

Diospyros primaeva Heer, Phyll. Crét. d. Nebr. 19. *pl. 1, f. 6, 7.* 1866; Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 61. *pl. 11, f. 3; pl. 14, f. 12, 13.* 1914.

Leaves oblong-ovate in outline, variable according to age, ranging from 3–15 cm. in length, by 1.3–5 cm. in greatest width, which is in the middle part of the leaf. Apex acute or obtuse. Base cuneate. Margins entire. Petiole rather long and very stout. Midrib also stout. Secondaries branching from the midrib at usually acute angles, subopposite or alternate, parallel, camptodrome. Tertiaries forming polygonal areoles whose relative prominence is one of the features of this species.

This species, which is quite suggestive of the modern *Diospyros virginiana* Linné, was described by Heer from the Dakota group of Nebraska nearly half a century ago. It has proved to be a most wide-ranging form, having been identified at both the Atane and Patoot horizons in Greenland; in the Cenomanian of Saxony and the Turonian of Bohemia; from various localities within the Dakota group, including its southern extension, the Woodbine formation of Texas; and with the exception of the fragments from Marthas Vineyard and Long Island, which are of questionable identity, it is present in either the Raritan, or Magothy, or homotaxial formations from New Jersey to Alabama. Its most marked character is the prominence of its tertiary areolation.

OCCURRENCE: EUTAW FORMATION, COFFEE SAND MEMBER. Coffee Bluff, Hardin County, Tennessee.

INCERTAE SEDIS

HALYMENITES MAJOR Lesquereux

Halymenites major Lesquereux, Tertiary Flora 38. *pl. 1, f. 7, 8.* 1878.

These very common objects, frequently considered as fucoids, are abundant in the western United States in sandy beds ranging in age from the Colorado group to the Eocene. They were long considered typical of the Fox Hills horizon but are now known from both older and younger beds and characterize sandy ferruginous sediments. Typical material is abundant in the Coffee sand member of the Eutaw formation at Coffee Bluff, Hardin County, Tennessee, and this is the first record of these objects in the coastal plain. It occurs also in sands of the Lower Ripley and in the McNairy sand of McNairy County, but in a very friable condition and these last horizons are not represented by collected material.

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Explanation of plate 15

FIG. 1. *Bauhinia ripleyensis* Berry. More perfect specimen from Ripley, Barbour County, Alabama, to illustrate McNairy sand species.

FIGS. 2–4. *Eugenia* (?) *anceps* Berry. McNairy sand two and one half miles southwest of Selmer, Tennessee.

FIG. 5. *Sterculia Snowii tennesseensis* Berry. McNairy sand, two and one half miles southwest of Selmer, Tennessee.

FIG. 6. *Dryophyllum gracile* Debey. McNairy sand, near Cypress, Tennessee.

Plants from southern Patagonia collected by Charles Wellington Furlong

W. W. Rowlee

Introduction

During the summer of 1907–1908 (November to March), Mr. Furlong collected a very interesting set of specimens representing the vegetation of southern Patagonia. The plants for the most part grew in the vicinity of the southern shore of Lake Argentine. Some, however, were secured in the journey overland from the mouth of the Gallegos river. Mr. Furlong was working primarily on problems of ethnology and the story of his journey is told in Harper's Magazine for June, 1910, and May, 1911.

The vegetation of the southern end of South America has been a subject for investigation for many years. One of Darwin's most valuable works is his account of his voyage to South America. He ascended the Santa Cruz River, the outlet of Lake Argentine, far enough to see the Andes, but not far enough to discover the Lake. Before Darwin's time, however, collections had been made especially along the Straits of Magellan; many have collected in the same region more recently. Few travellers, however, even up to the present time have explored the inland region of southern Patagonia.

If we except the so-called Antarctic Continent of the ice bound south polar region, it is the most southerly continental land. The plants inhabiting it have long been known to show affinity with the flora of Australia, New Zealand, and other Antarctic islands. This relation has led to the belief that there once existed a continent in the Southern Hemisphere which connected more or less completely these southern land masses. The results of antarctic explorations in recent years have tended to confirm this theory. Fossil remains of various gymnosperms and angiosperms have been discovered which represent the ancestral forms of closely related species now widely separated geographically.

Lake Argentine is located in southern Patagonia about latitude 51 degrees. Its latitude and longitude south correspond almost exactly to the latitude and longitude north of Lake Mistassinica in southern Labrador. The continents of North America and South America have generally speaking the same shape. Their configuration in relation to the tropics, however, is reversed. South America narrows southward until in the latitude of the region under discussion, it is about 200 miles wide; on the other hand North America widens towards the north until in the latitude of southern Labrador, it stretches out to more than three thousand miles. Arboreal vegetation extends as far south in South America as it does north in North America. In fact the climate of corresponding latitudes south seems to be less detrimental to plant-life than corresponding latitudes in North America. This is probably due to the influence of the oceans.

It has long been known that the only strip of deciduous forest in the southern continent is along the east side of the Andes in temperate South America. In the north temperate zone deciduous forests form a very dominating feature in the vegetation of both hemispheres. This type of vegetation is restricted in the Southern Hemisphere to a very limited area extending from subtropical Argentina and Chile southward and across the Fuegia Peninsula. In striking contrast to the northern deciduous forest the southern one is composed of a single generic type the so-called southern beeches (*Nothofagus antarctica* and its congeners). The west side of Patagonia and Fuegia has an evergreen rain-forest. One of the most abundant elements in that forest is the evergreen species of this same genus, *Nothofagus*. This reminds one in a way of the oaks of North America which are represented by both deciduous and evergreen species. The rain-forest area comprises the westerly slope and summit of the Cordilleras of the Andes. This is a region of perpetual rain and fog. The easterly part of Patagonia and Fuegia presents the other extreme of climate in that it is arid and wind-swept with a comparatively small rainfall. It is the pampas region and supports a distinctly desert vegetation. Lying between these two extremes is the narrow belt of deciduous forest extending over about fifteen degrees of longitude, that is, from southern Fuegia to the Rio

Negro. This corresponds in distance from Central Labrador to Washington, or from Sitka to San Francisco. It seldom exceeds fifty miles in width and is confined to the easterly base of the Andes. Like most other regions lying between two extremes, this transitional region supports a vegetation that is unique and diversified.

Dusén made a special study of the vegetation of Fuegia and reports that few species (not more than four) represent the vegetation of the forest floor in the transitional region in Fuegia. Other travelers speak of the absence or scarcity of vegetation in the beech groves of Patagonia. Whether this is due to the intense shade of the beeches or to historical reasons or to both can only be conjectured. There seems to have been no type of vegetation in this southern region corresponding to the rich spring flora of the forest floor in the north temperate zone.

Lake Argentina is the most southerly of several large lakes in the easterly foothills of the Patagonia Andes. It is a large lake some forty miles long and fifteen miles wide and with long arms at the westerly end, one extending north and the other south for thirty or forty miles. Both of these arms have large glaciers flowing into them. The outlet of the lake is Santa Cruz River which flows eastward into the Atlantic Ocean. The western end of the lake and particularly the north and south arms are filled with icebergs for the greater part of the year. The northern shore rises abruptly into an elevated table land which has been explored only to a very limited extent and that principally along the Leona river which comes down from Lake Veidma some twenty-five miles away and empties into Santa Cruz River near Lake Argentina. The southern shore of the lake is more hospitable and a few sheep ranchers inhabit the region. Between Lake Argentina and its southwesterly arm the region is known as the Burmeister peninsula. There are two mountains on this peninsula, the westerly one Mt. Buenos Aires and the easterly one Mt. Frias. It was from this peninsula and the slopes of these mountains that the principal part of Mr. Furlong's collections were made. South of the Burmeister Peninsula there is a range of mountains, the Baguales, of considerable elevation which extends easterly into the Patagonia high pampas region. These mountains are rough, covered with volcanic rock and present a formidable barrier to travel to the south. The lake Argentine valley is therefore a vast amphitheater in the east side of the main Cordilleras and apparently affords more favorable conditions for vegetation than any place south or immediately north of it.

The collections from which the descriptions of Patagonia plants have been made are very widely separated. Collections in herbaria in the United States are meager and often imperfectly named. The national herbaria of Chile and of Argentina contain a large amount of the material. The other principal collections are in the Kew Herbarium at London and the National Herbarium at Stockholm, Sweden. This makes it difficult to identify species with absolute certainty. The only works dealing with the flora in a synoptical way are Hooker's Flora Antarctica, Macloskie's Flora of Patagonia, and Reiche's Flora of Chile. Many monographs and lists, however, have appeared.

One of the most recent is a list of plants based on a collection of plants made by Pritchard and published by Rendle in the Journal of Botany in 1904. This collection was also made principally on the Burmeister Peninsula. Rendle's list contains about 150 species of flowering plants, 18 of which are described as new species. Our list contains 166 species of flowering plants. We have refrained from describing as new any of our plants at the present time, but have instead associated each specimen with a name already published. Further study and particularly opportunity to compare our specimens with authentic specimens may warrant recognition of novelties in the collection.

LIST OF SPECIES COLLECTED

LICHENS

1. CLADONIA COCCIFERA (L.) Willd.

2. STICTA ENDOCHRYSEA Delise.

3. NEPHROMA ANTARCTICUM (Wulf.) Nyl.

Very closely related to *N. arcticum* (L.) E. Fr.

MOSSES

(Determined by A. LeR. Andrews)

4. BARTRAMIA POMIFORMIS (L.) Hedw. var. CRISPA B. & S.

5. WEYMOUTHIA MOLLIS (Hedw.) Broth.
6. POLYTRICHADELPHUS MAGELLANICUS (L.) Mitt.

LYCOPODIACEAE

7. LYCOPODIUM MAGELLANICUM Sw. Syn. Fil. 13. 1806.

POLYPODIACEAE

8. ASPIDIUM MOHRIOIDES Bory, Mém. Soc. Linn. Paris 4: 597. 1826.
9. CYSTOPTERIS FRAGILIS (L.) Bernh. Schrad. Neues Jour. Bot. 1^2: 27. *pl. 2, f. 9.* 1806.
10. ASPLENIUM MAGELLANICUM Kaulf. Enum. Fil. 175. 1824.

OPHIOGLOSSACEAE

11. BOTRYCHIUM LUNARIA (L.) Sw. Schrad. Jour. Bot. 1800^2: 110. 1801.

GRAMINEAE

12. DESCHAMPSIA FLEXUOSA (L.) Trin. Bull. Acad. Sc. St. Petersburg 1: 66. 1836.

Aira flexuosa L. Sp. Plant. 96. 1753.

13. CORTADERIA PILOSA (D'Urv.) Hack.; Dusén, Svenska Exped. till Magell. 3: 222. 1900.

Arundo pilosa D'Urv. Mém. Soc. Linn. Paris 4: 600. 1826.

The best known of this genus is Pampas Grass, *C. argentea* (Nees) Stapf. Our species is the only one in the Magellan region. The genus is confined to South America.

14. BROMUS COLORATUS Steud. Syn. Pl. Gram. 429. 1855.
15. POA FUEGIANUS (Hook. f.) Hack.; Dusén, Svenska Exped. till Magell. 3 : 225. 1900. Macloskie, Rep. Princeton Univ. Exp. Pat. 8: 235. *f. 42.* 1905.

Festuca fuegianus Hook. f. Fl. Ant. 2: 380. *pl. 141.* 1847.

This is the "forma *vivipara*" depicted in Hooker's illustration.

16. FESTUCA GRACILLIMA Hook. f. Fl. Ant. 2: 383. 1847.

The specimens have no flowers and their determination is uncertain. Mr. Furlong says: "Grass from the pampas of Patagonia, vicinity of foot-hills of the Andes between the source of the Gallegos and Santa Cruz Rivers. It is upon this grass that the great herds of Patagonian sheep feed."

17. FESTUCA PURPURASCENS Banks & Sol.; Hooker, Fl. Ant. **2**: 383. *pl. 140.* 1847.

18. POA PRITCHARDI Rendle, Jour. Bot. **42**: 324. 1904.

From Mt. Buenos Aires, the locality where the type was collected.

19. POA ARGENTINA Speg. Rev. Agron. i Vet. La Plata 1897: 584.

The type was collected at Lake Argentine. It belongs to the sect. *Dioicopoa* of Hackel (Engler & Prantl, Nat. Pflanzenfam. **2**^{2}: 73. 1888). Only the staminate plant appears in this collection.

20. POLYPOGON INTERRUPTUS H. B. K. Nov. Gen. & Sp. **1**: 109. *pl. 44.* 1815.

Awns longer and spike more compact than is represented in the original figures.

21. STIPA POGONATHERA Desv.; C. Gay, Fl. Chil. **6**: 277. 1853.

CYPERACEAE

22. CAREX BANKSII Boott, Trans. Linn. Soc. **20**: 119. 1846.

23. CAREX INCONSPICUA Steud. Syn. Pl. Cyp. 221. 1855.

Culms 25 cm. high.

JUNCACEAE

24. LUZULA CHILENSIS Nees & Meyen; Kunth, Enum. Pl. **3**: 312. 1841.

LILIACEAE

25. LUZURIAGA MARGINATA (Banks & Sol.) Benth. & Hook. Gen. Pl. **3**: 768. 1883.

Enargea marginata Banks & Sol.; Gaertner, De Fruct. **1**: 283. *pl. 59. f. 3.* 1788.

AMARYLLIDACEAE

26. ALSTROEMERIA NANA Rendle, Jour. Bot. **42**: 325. 1904.

IRIDACEAE

27. SISYRINCHIUM CHILENSE Hook. Curt. Bot. Mag. *pl. 2786.* 1827.

28. S. JUNCEUM E. Meyer; Presl, Rel. Haenk. 1: 118. 1830.

29. S. STRIATUM Sm. Icon. Pict. *pl. 9.* 1789.

30. S. IRIDIFOLIUM H. B. K. Nov. Gen. & Sp. 1: 324. 1815.

31. SOLENOMELUS SISYRINCHIUM (Griseb.) Pax; Engler & Prantl, Nat. Pflanzenfam. 2^5: 152. 1888.

Lechlera Sisyrinchium Griseb.; Lechler, Pl. Chil. Exsic. *2966.* 1853–1855.

Having every appearance of a *Sisyrinchium* except the elongated ovary.

32. SYMPHYOSTEMON BIFLORUS (Thunb.) Dusén, Svenska Exped. till Magell. 3: 203. 1900.

Gladiolus biflorus Thunb. Diss. Glad. 10. 1784.

33. S. LYCKHOLMI Dusén, Svenska Exped. till Magell. 3: 204. *pl. 10, f. 4–7.* 1900.

BURMANNIACEAE

34. ARACHNITES UNIFLORA Phil. Bot. Zeit. 28: 217. 1864.

This is the only plant of this family growing outside tropical or subtropical regions except the species of *Thismia* discovered recently by Pfeiffer* near Chicago. Our plant, furthermore, is the only vascular saprophyte in south temperate South America. It was first found by Philippi in the Province of Valdivia, Chile, in 1864. In transmitting it to Professor Schlechtendahl, Dr. Phillippi made the following observation: "*Arachnites uniflora* Ph. A new orchid genus from Valdivia. A few weeks ago, in my property in S. Juan, my son discovered a wonderful (to me at least) orchid, a few hundred paces from the dwelling, and under the shade of a macqui-bush (*Aristotelia Macqui*). Unfortunately the large number of specimens which had been collected were destroyed in the fire which on November second laid my possessions in ashes in a half-hour. Only through a lucky accident a few escaped, and these have not been well enough preserved to allow me to make out distinctly the structure of the gynostemium,

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* Bot. Gaz. 57: 122. 1914.

which, at all events, is very anomalous." The next year he sent to the editor of Verh. d. zoologisch-botanischen Gesellschaft the following letter:

> "S. JUAN IN THE PROVINCE OF VALDIVIA,
> "February 5th, 1865.
>
> "Dear Sir:
>
> "About a year ago I received from Professor von Schlechtendal a report on a remarkable orchid (?) which my eldest son had discovered here in several places on the same unlucky day in which the whole of my possessions were burned. I called this plant *Arachnites uniflora*. I had not been able to recognize with certainty the pistil and stamens in the small, dried specimens which I possessed. However, there appeared to me to be present six stamens of the usual form. In the latter part of November, my son, in spite of the great amount of labor that the management and rebuilding of the estate involved, again found this plant and studied and portrayed it. I herewith share with you his drawings and descriptions so that you may convince yourself that this plant must unquestionably found a distinct family.
>
> "*Arachnites* occurs not infrequently in the neighborhood of my house, always in the shade of *Aristotelia Macqui* and other trees, which usually will not suffer other vegetation beneath them. It appears to be a wound (?) parasite. In height it varies from between a foot and a foot and a half. All specimens, without exception, are one-flowered."

It has been found in several places along the Andes south from Valdivia to somewhat south of Lake Argentine. It grows in peaty humus in the shade of various trees.

ORCHIDACEAE

35. CHLORAEA KINGII (Hook. f.) Wildeman, Rés. Voy. Belgica, Bot. Phan. 72. 1905.

Asarca Kingii Hook. f. Fl. Ant. **2**: 351. 1847.

36. C. PLEISTODACTYLA Kraenzl. & Speg. Anal. Mus. Nac. Buenos Aires **7**: 167. 1902.

This species is closely related to, if not identical with, *Asarca arauacana* Phil. Linnaea **29**: 56. 1857–1858.

37. C. MAGELLANICA Hook. f. Fl. Ant. **2**: 350. 1847.

A beautiful and striking plant on account of dark veins of the bracts and the perianth.

38. CODONORCHIS LESSONII (D'Urv.) Lindl. Gen. & Sp. Orch. 411. 1830–1840.

Pogonia tetraphylla Poepp. & Endl. Nov. Gen. & Sp. Pl. **2**: 16. *pl. 122.* 1838.

FAGACEAE

39. NOTHOFAGUS ANTARCTICA (Forst.) Oerst. Vidensk. Selsk. Skr. V. **9**: 354. 1873.

Fagus antarctica Forst. Comm. Soc. Gotting. **9**: 24. 1789.

Young leaves just developing from the scaly buds.

URTICACEAE

40. URTICA MAGELLANICA Juss.; Poiret, Encycl. Meth. Suppl. **4**: 223. 1815.

PROTEACEAE

41. EMBOTHRIUM COCCINEUM Forst. Char. Gen. Plant. 16. *pl. 8.* 1776.

MYZODENDRACEAE

42. MYZODENDRON QUADRIFLORUM DC. Coll. Mém. **6**: *pl. 12, f. 2*, 1830; Skottsberg, Engler, Pflanzenreich 4^{58}: 12. 1914.

43. M. LINEARIFOLIUM DC. Prodr. **4**: 671. 1830; Skottsberg, *l. c.* 11.

44. M. PUNCTULATUM Banks; Solander in Forster, Comm. Soc. Gotting. **9**: 45. 1789 (*nomen nudum*); De Candolle, Prodr. **4**: 286. 1830; Skottsberg, *l. c.* 15.

SANTALACEAE

45. ARJONA PUSILLA Hook. f. Fl. Ant. **2**: 342. 1847.

46. A. TUBEROSA Cav. Icon. Pl. **4**: 57. *pl. 383.* 1797.

47. MYOSCHILOS OBLONGUM Ruiz & Pavon, Syst. Veg. 73. 1798; Fl. Peruv. & Chilen. **3**: 20. *pl. 242.* 1802.

48. QUINCHAMALIUM PROCUMBENS Ruiz & Pavon, Fl. Peruv. & Chilen. **2**: 1. *pl. 107b.* 1799.

CHENOPODIACEAE

49. CHENOPODIUM ALBUM L. Sp. Plant. 219. 1753.

50. C. ANTARCTICUM (Hook. f.) Benth. & Hook. f. Gen. Pl. **3**: 52. 1880.

Blitum antarcticum Hook. f. Fl. Ant. **2**: 549. 1847.

CARYOPHYLLACEAE

51. CERASTIUM ARVENSE L. Sp. Pl. 438. 1753.

52. MELANDRIUM MAGELLANICUM (Lam.) Fenzl; Rohrbach, Linnaea **36**: 224. 1869–70.

Lychnis magellanica Lam. Encycl. Méth. **3**: 641. 1784.

53. M. ALPESTRE Dusén, Ark. f. Bot. 7^2: 15. 1907.

54. STELLARIA DEBILIS Urv. Mém. Soc. Linn. Paris **4**: 618. 1826.

55. ARENARIA SERPYLLOIDES C. Gay var. ANDICOLA (Gill.), Reiche, Fl. Chil. **1**: 192. 1896.

Arenaria andicola Gill.; Hook. Bot. Misc. **3**: 148. 1833.

RANUNCULACEAE

56. ANEMONE MULTIFIDA Poir. var. GRANDIFLORA Rendle, Jour. Bot. **62**: 328. 1904.

57. RANUNCULUS PEDUNCULARIS Sm. var. PATAGONICUS Poepp. Frag. Syn. Phaner. 20. 1833.

58. R. CYMBALARIA Pursh, Fl. Am. Sept. 392. 1814.

BERBERIDACEAE

59. BERBERIS EMPETRIFOLIA Lam. Tab. Encyc. Bot. Illustr. Gen. **2**: 391. 1793.

60. B. ILICIFOLIA Linn. f. Suppl. Plant. 210. 1781.

61. B. MICROPHYLLA Forst. Comm. Soc. Gotting. **9**: 29. 1789.

CRUCIFERAE

62. CARDAMINE HIRSUTA L. var. MAGELLANICA Phil. Anal. Univ. Chil. 666. 1872.

63. THLASPI MAGELLANICUM Pers. Syn. Plant. **2**: 189. 1805.

64. CORONOPUS AUSTRALIS (Hook. f.) Macloskie, Rep. Princeton Univ. Exp. Pat. **8**: 428. 1905.

Senebiera australis Hook. f. Fl. Ant. **2**: 241. 1847.

MAGNOLIACEAE

65. DRIMYS WINTERI Forst. Char. Gen. Plant. 84. *pl. 42.* 1776.

SAXIFRAGACEAE

66. ESCALLONIA RUBRA Pers. Syn. Plant. **2**: 235. 1805.

This is called by the English colonists the "Elserly Bush." The presence of resin dots on the lower surface of the leaves distinguishes it from the next species.

67. E. BRITTENIANA Rendle, Jour. Bot. **42**: 330. 1904.

68. RIBES CUCULLATUM Hook. & Arn.; Hooker, Bot. Misc. **3**: 340. 1833.

69. SAXIFRAGA CORDILLERARUM Presl, Rel. Haenk **2**: 55. 1835–36.

70. S. CORDILLERARUM Presl var. BREVISCAPA (Hook. f.) Macloskie, Rep. Princeton Univ. Exp. Pat. **8**: 459. 1905.
S. exarata Vill. var. *breviscapa* Hook. f. Fl. Ant. **2**: 280. 1847.

ROSACEAE

71. ACAENA MAGELLANICA Vahl var. VENULOSA (Griseb.) Bitter, Biblist. Bot. **74**: 168. 1911.
A. venulosa Griseb. Goett. Abh. **6**: 118. 1854.

72. A. PLATYACANTHA Speg. Rev. Agron. i Vet. La Plata **1897**: 515.

73. A. PHILIPPI Dusén, Svenska Exp. till Magell. **3**: 167. 1900.
A. sericea Phil. Anal. Univ. Chil. **84**: 621. 1893. Not *A. sericea* Jacq.

74. A. MULTIFIDA Hook. f. Fl. Ant. 265. 1844.

75. GEUM MAGELLANICUM Comm.; Persoon, Syn. Plant. **2**: 57. 1807.

76. POTENTILLA ANSERINA L. Sp. Plant. 495. 1753.

LEGUMINOSAE

77. ADESMIA BORONOIDES Hook. f. Fl. Ant. 257. 1844.

78. A. SALICORNIOIDES Speg. Anal. Soc. Cien. **53**: 31. 1901.

79. **A. glandulifera** (Rendle) comb. nov.
Patagonium glanduliferum Rendle, Jour. Bot. **42**: 332. 1904.

80. **A. campestris** (Rendle) comb. nov.
Patagonium campestre Rendle, Jour. Bot. **42**: 332. *pl. 465*. 1904.

81. A. PARVIFOLIA Phil. Linnaea **28**: 683. 1856.

82. A. PUMILA Hook. f. Fl. Ant. 255. 1844.

83. A. VILLOSA Hook. f. Fl. Ant. 256. 1844.

84. ANARTHROPHYLLUM PRITCHARDI Rendle, Jour. Bot. **42**: 331. 1904.

85. **Astragalus Dusenii** nom. nov.
A. brevicaulis Dusén, Svenska Exped. till. Magell. **3**: 158. 1900. Not *A. brevicaulis* A. Nelson, Bull. Torrey Club **26**: 9. 1899.

86. A. PATAGONICUS (Phil.) Dusén, Svenska Exped. till Magell. 3: 256. 1900.

Phaca patagonica Phil. Anal. Univ. Chil. 84; 20. 1893.

87. LATHYRUS MAGELLANICUS Lam. Encycl. Méth. 2: 708. 1806.

88. VICIA SERICELLA Speg. Anal. Soc. ci Argent. 47: 278. 1899.

89. V. MAGELLANICA Hook. f. Fl. Ant. 2: 257. 1847.

90. ERODIUM CICUTARIUM L'Hérit.; Aiton, Hort. Kew., ed. 1, 2: 414. 1789.

91. GERANIUM SESSILIFLORUM Cav. Icon. Plant. 4: 198. *pl. 77, f. 2.* 1797.

Standley (Contr. U. S. Nat. Herb. 18: 111. 1916) has described a closely related species, *G. confertum*, collected by Pittier from the Central Cordillera of Colombia at altitudes of 3,000 to 3,600 meters.

92. G. MAGELLANICUM Hook. f. Fl. Ant. 251. 1844.

OXALIDACEAE

93. OXALIS PATAGONICA Speg. Rev. Agron. i Vet. La Plata 1897: 501.

EUPHORBIACEAE

94. EUPHORBIA PORTULACOIDES L. Sp. Plant. 456. 1753.

CELASTRACEAE

95. MAYTENUS MAGELLANICUS (Lam.) Hook. f. Fl. Ant. 254. *pl. 130.* 1844.

CASSINE MAGELLANICA Lam. Encycl. Méth. 10: 130. 1811.

RHAMNACEAE

96. DISCARIA DISCOLOR (Hook. f.) Reiche, Fl. Chil. 16. 1898.

Colletia discolor Hook. f. Icon. Plant. *pl. 538.* 1838.

VIOLACEAE

97. VIOLA MACULATA Cav. Icon. Plant. 6: 20. *pl. 539.* 1793.

"Throughout islands of Terra del Fuego. Vega regions." *C. W. F.*

LOASACEAE

98. LOASA VOLUBILIS Juss. Ann. Mus. Paris **5**: 26. *pl. 5, f. 1.* 1804.

99. L. ARGENTINA Urb. & Gilg, Nov. Act. Nat. Cur. **76**: 186. 1900.

ONAGRACEAE

100. EPILOBIUM PATAGONICUM Rendle, Jour. Bot. **42**: 367. 1904.

101. FUCHSIA MAGELLANICA Lam. Encycl. Méth. **2**: 564. 1783.

102. OENOTHERA ODORATA Jacq. Icon. Plant. Rar. **3**: 3. *pl. 456.* 1786–93.

103. PSEUDOPANAX LAETEVIRENS (C. Gay) Franchet, Miss. Sci. Cap. Horn 339. *pl. 1.* 1889.

Aralia laetevirens C. Gay, Fl. Chil. **3**: 151. 1847.

UMBELLIFERAE

104. AZORELLA TRIFURCATA (Gaertn.) Pers. Syn. **1**: 303. Hook. f. Icon. Plant. **6**: *pl. 539.* 1843.

Chamitis trifurcata Gaertn. De Fruct. **1**: 95. *pl. 22. f. 4.* 1788.

105. A. TRIFOLOLIATA Clos; C. Gay, Fl. Chil. **3**: 85. *pl. 30, f. 2.* 1847.

Leaflets less distinctly lobed than indicated in Gay's illustration.

106. CONIUM MACULATUM L. Sp. Plant. 243. 1753.

107. MULINUM SPINOSUM Pers. Syn. Plant. **1**: 309. 1805.

108. OREOMYRRHIS ANDICOLA Endl. Gen. Pl. 787. 1839.

109. OSMORHIZA BERTERII DC. Prodr. **4**: 232. 1830.

110. PERNETTYA MUCRONATA (Linn. f.) Gaud. Ann. Sci. Nat. Bot. I. **5**: 102. 1825.

Arbutus mucronata Linn. f. Suppl. Plant. 239. 1781.

PRIMULACEAE

111. SAMOLUS SPATHULATUS (Cav.) Duby; DeCandolle, Prodr. **8**: 74. 1844.

Androsace spathulata Cav. Icon. Plant. **5**: 56. *pl. 484. f. 1.* 1799.

PLUMBAGINACEAE

112. ARMERIA CHILENSIS Boiss. var. MAGELLANICA Boiss.; De Candolle, Prodr. **12**: 682. 1848.

GENTIANACEAE

113. GENTIANA PATAGONICA Griseb. Gen. Spec. Gent. 237. 1839.

POLEMONIACEAE

114. COLLOMIA COCCINEA Lehm.; Bentham, Bot. Reg. *pl. 1622.* 1833.

Phlox linearis Cav. Icon. Plant. **6**: 17. *pl. 527.* 1801.

115. C. GRACILIS Dougl.; Hooker, Bot. Mag. *pl. 2924.* 1829 (as synonym); Bentham, Bot. Reg. *pl. 1622.* 1833.

Gilia gracilis Hook. Bot. Mag. *pl. 2924.* 1829.

HYDROPHYLLACEAE

116. PHACELIA CIRCINATA Jacq. f. Eclog. Am. Plant. **1**: 135. *pl. 1.* 1811–16.

SCROPHULARIACEAE

117. CALCEOLARIA BIFLORA Lam. Encycl. Méth. **1**: 556. 1783.

C. plantaginea Smith, Plant. Icon. 1: 2. *pl. 2.* 1789.

118. C. TENELLA Poepp. & Endl. Nov. Gen. Sp. Plant. **3**: 76. *pl. 287.* 1845.

A delicate species. Leaves nearly orbicular, about 5 mm. in diameter, the flower about 1 cm. in length and breadth.

119. C. UNIFLORA Lam. Tab. Encycl. Méth. **1**: 52. 1791.

120. **C. Pritchardi** (Rendle) comb. nov.

Fagelia Prichardi Rendle, Jour. Bot. **42**: 371. 1904.

121. EUPHRASIA ANTARCTICA Benth.; DeCandolle, Prodr. **10**: 555. 1846.

122. OURISIA RUELLOIDES (Linn. f.) Gaertn. f. De Fruct. **3**: *pl. 185.* 1805–07.

Chelone ruelloides Linn. f. Suppl. Plant. 271. 1781.

Ourisia magellanica Gaertn. f. De Fruct. **3**: 44. *pl. 185.* 1805–07.

BORAGINACEAE

123. AMSINCKIA ANGUSTIFOLIA Lehm. Del. Sem. Hort. Hamb. 7. 1831.

124. ERITRICHIUM DIFFUSUM Phil. Plant. Chil. 191. 1894.

VERBENACEAE

125. VERBENA PRITCHARDI Rendle, Jour. Bot. **43**: 33. 1905.

126. V. CARROO Speg. Anal. Soc. Cient. Argent. **15**: 112. 1883.

127. SATUREIA DARWINII (Benth.) Briquet; Engler & Prantl, Nat. Pflanzenfam. 4^{3a}: 300. 1897.
Micromeria Darwinii Benth.; DeCandolle, Prodr. **12**: 222. 1848.

PLANTAGINACEAE

128. PLANTAGO MARITIMA L. Sp. Plant. 114. 1753.

RUBIACEAE

129. CRUCKSHANKSIA GLACIALIS Poepp. & Endl. Nov. Gen. Sp. Plant. **3**: 31. *pl. 236.* 1845.
Oreopolus citrinus Schlecht. Linnaea **28**: 493. 1856.

130. RELBUNIUM PUSILLIUM (Gill.) K. Schum.; Martius, Fl. Bras. 6^{6}: 117. 1888.
Rubia pusilla Gill.; Hooker & Arnott, Bot. Misc. **3**: 363. 1833.

131. GALIUM APARINE L. Sp. Plant. 108. 1753.

VALERIANACEAE

132. VALERIANA CARNOSA Smith, Pl. Icon. Ined. **3**: *pl. 52.* 1791.

133. V. LAPATHIFOLIA Vahl, Enum. Plant. **2**: 11. 1806.

CALYCERACEAE

134. MOSCHOPSIS SPATHULATA Dusén, Ark. f. Bot. 7^{2}: 41. *pl. 5, f. 7; pl. 8, f. 13, 15.* 1908.

The specimens were collected near Cerro Sepulchro on a divide in the Baguales Mountains, at an altitude of 1,800 meters. They do not agree in all respects with the incomplete descriptions and figures given by Dusén but are more like that species than any other we have found described.

COMPOSITAE

135. BACCHARIS DARWINII Hook. & Arn. Jour. Bot. **3**: 34. 1841.

136. B. PATAGONICA Hook. & Arn. *l. c.* **3**: 29. 1841.

137. B. MAGELLANICA (Lam.) Pers. Syn. Plant. **2**: 425. 1807.
Conyza magellanica Lam. Encycl. Méth. **2**: 91. 1806.

138. CHILIOTRICHIUM DIFFUSUM (Forst.) Dusén Svenska Exped. till Magell. 3: 99. 1900.

Amellus diffusus Forst. Comm. Soc. Gotting. 9: 39. 1789.

139. CULCITIUM MAGELLANICUM (Hook. & Arn.) Hombr. & Jacquem.; Decaisne, Bot. Voy. Astrol. et Zél. 45. 1853.

Senecio magellanicus Hook. & Arn. Jour. Bot. 3: 343. 1841.

140. ERIGERON ALPINUS L. Sp. Plant. 864. 1753.

There is a great variation in size in the specimens. The largest are 25 cm. high. The smallest are nearly acaulescent and about 4 cm. high.

141. E. SPICULOSUS Hook. & Arn. Bot. Beech. Voy. 1: 32. 1841.

142. HIERACIUM TRISTE Willd.; Sprengel in Linnaeus, Syst. Veg. ed. 16, 3: 640. 1826.

143. H. AUSTRO-AMERICANUM Dahlst.; Dusén, Ark. f. Bot. 7^2: 51. 1907.

144. HYPOCHOERIS ARENARIA Gaud. Ann. Sci. Nat. Bot. I. 5: 103. 1825.

145. ANTENNARIA MAGELLANICA Sch. Bip. Flora 38: 117. 1855.

146. A. CHILENSIS Remy; C. Gay, Fl. Chil. 4: 235. 1849.

147. GNAPHALIUM PURPUREUM L. Sp. Plant. 854. 1753.

148. G. SPICATUM Lam. Encycl. Méth. 2: 757. 1806.

149. LAGENOPHORA HIRSUTA Poepp.; Lessing, Linnaea 6: 131. 1831.

150. LEUCERIA LANIGERA O. Hoffm.; Dusén, Svenska Exped. till Magell. 3: 115. 1900.

151. L. PATAGONICA Speg. Rev. Agron. i Vet. La Plata 1897: 538.

152. L. MULTIFIDA (DC.) S. Moore; Rendle, Jour. Bot. 42: 376. 1904.

Chabraea multifida DC. Prodr. 7: 60. 1838.

153. L. PURPUREA (Vahl) O. Hoffm.; Dusén, Svenska Exp. till Magell. 3: 118. 1900.

Chabraea purpurea DC. Ann. Mus. Paris 19: 65, 71. *pl. 19.* 1812.

154. L. RUNCIANATA Gill. & D. Don, Phil. Mag. 1832: 389.

Chabraea rosea DC.; Delessert, Icon. Sel. Plant. 4. *pl. 90.* 1820.

155. MADIA SATIVA Molina, Sagg. Chile 136. 1782.
The specimens vary from 40 cm. to only 4 cm. high.

156. NARDOPHYLLUM HUMILE (Hook. f.) A. Gray, Proc. Amer. Acad. 5: 123. 1862.
Chiliotrichium humile Hook. f. Fl. Ant. 304. 1844.

157. NASSAUVIA DARWINII (Hook. & Arn.) O. Hoffm.; Dusén, Svenska Exped. till Magell. 3: 112. 1900.
Panargyrus Darwinii Hook. & Arn. Comp. Bot. Mag. **2**: 43. 1836.

158. N. PYGMAEA Hook. f. F. Ant. **2**: 319. 1847.

159. N. REVOLUTA D. Don, Phil. Mag. **11**: 390. 1832.

160. N. SUBSPINOSA (Phil.) Wildeman, Rés. Voy. Belgica, Bot. Phan. 177. 1905.
Panargyrum subspinosum Phil. Anal. Univ. Chil. 85: 98. 1894.

161. PEREZIA RECURVATA (Vahl) Lag. Amen. Nat. Esp. 31. 1811.

162. P. LINEARIS Less. Syn. Gen. Comp. 412. 1832.

163. SENECIO ACANTHIFOLIUS Hombr. & Jacquem.; Decaisne, Voy. Astrol. et Zél. 46. *pl. 115.* 1853.

164. S. HATCHERIANUS Hoffm.; Macloskie, Rep. Princeton Univ. Exp. Pat. **8**: 847. 1905.

165. S. PATAGONICUS Hook. & Arn. Jour. Bot. 3: 344. 1841.

166. S. DARWINII Hook. & Arn. *l. c.* 3: 333. 1841.

167. S. FALKLANDICUS Hook. f. Fl. Ant. 316. *pl. 110.* 1844.

168. S. KINGII Hook. f. *l. c.* 314. 1844.

169. S. LONGIPES Hook. f. *l. c.* 314. 1844.

170. S. PAENINSULARIS S. Moore; Rendle, Jour. Bot. 42: 374. 1904.

171. S. SERICEO-NITENS Speg. Rev. Agron. i Vet. La Plata 1897: 537.

172. S. TRIFURCATUS Less. Syn. Comp. 392. 1832.

173. TARAXACUM LAEVIGATUM DC. Cat. Hort. Monsp. 149. 1813.

174. ACHYROPHORUS TENUIFOLIUS DC. Prodr. 7: 94. 1838.

175. ASTER VAHLII Hook. & Arn. Comp. Bot. Mag. 2: 49. 1836.

176. MATRICARIA CHAMOMILLA L. Sp. Plant. 891. 1753.

177. ADENOCAULON CHILENSE Less. Linnaea 6: 107. 1831.

CORNELL UNIVERSITY

Peruvian mosses

R. S. WILLIAMS

(WITH PLATES 17–20)

The following list is made up of two collections. The first, obtained by Harry Ward Foote, on the Yale Peruvian Expedition of 1911, was kindly forwarded by Dr. A. W. Evans of Yale. It consisted of forty-eight packets and contained thirty-seven species among which appear to be two novelties, also two species known before only from Patagonia. The specimens are from localities varying from about 900 to 3,300 meters in altitude. They were without number, and I have accordingly rearranged and numbered them from 1 to 48.

The second collection consisted of forty-three packets, obtained by Messrs. Cook and Gilbert, with the exception of three species by Hiram Bingham, while on the Yale University-National Geographic Society Peruvian Expedition in 1915. In this second collection four species are apparently new to science. I may say that it was through the coöperation of the United States Department of Agriculture that Messrs. Cook and Gilbert were detailed to accompany this expedition and the specimens were forwarded to me by Mr. William R. Maxon of the United States National Museum. The altitude at which this second collection was obtained varies from 1,800 to 4,100 meters, and there are thirty-three species not in the first collection, making seventy species in this list. The type specimens of the new species are deposited in the herbarium of the New York Botanical Garden.

DICRANUM MITTENII C. Müll.

Above Arma Valley, July, 1915, *H. Bingham 2063*.

I have not been able to find any publication of this species except that by Brotherus in Engler & Prantl's Nat. Pflanzenfam. (1: 328), under subgenus 4. It is a plant of medium size with the ovate leaf-base quickly narrowed to a long, subulate and serrulate point; the alar cells are numerous, those above in the broader part of the leaf narrow and elongate with pitted walls. The collection is scanty and sterile.

CAMPYLOPUS LEUCOGNODES (C. Müll.) Paris.

Lucumayo Valley, 3,600 m., June, 1915, *Cook & Gilbert 1264a.*

FISSIDENS ASPLENIOIDES (Sw.) Hedw.

San Miguel, on rock, 1,820 m., September, 1911, *Foote 1.*

FISSIDENS CRISPUS Mont.

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 754.*

FISSIDENS RIGIDULUS Hook. f. & Wils.

Ollantaytambo, on rock, about 3,000 m., May, 1915, *Cook & Gilbert 670.*

TRICHOSTOMUM BRACHYDONTIUM Bruch.

Cuzco, on dry rock, about 3,500 m., July, 1911, *Foote 2;* these Cuzco specimens have leaves shorter and broader than in typical specimens and possibly should not be referred here, but they seem to be only a stunted form of the species; Lucma, on dead wood, 2130 m., August, 1911, *Foote 15a.*

TRICHOSTOMUM SEMIVAGINATUM Schimp.

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 501a.*

Leptodontium integrifolium sp. nov.

Dioecious, the male plants about like the fertile, the flowers with outer leaves similar to those of the stem, the inner broadly oblong, rounded obtuse, scarcely one third the length of the outer, costate, of mostly golden-brown, elongate, smooth cells enclosing five or six antheridia and numerous, longer, filiform paraphyses: fertile plants simple or slightly branched, the stems 3–4 cm. long with scattered, loose tufts of radicles and leaves, when dry rather loosely imbricate and incurved-flexuous, when moist spreading-recurved; stem-leaves 3–3.5 mm. long, ovate-lanceolate, the entire margins strongly recurved from a little below the apex to near the base and papillose; costa stout, papillose on the back, excurrent into a serrulate point sometimes 0.5 mm. long; cells of the upper part of leaf rather obscure, scarcely elongate, 8–9 μ in diameter, densely papillose on both sides, in the lower fourth of leaf, elongate, narrowly rectangular, smooth, except near the margin and costa; perichaetial leaves about 6 mm. long, convolute, with a subulate, abruptly spreading, serrulate point; fruit unknown. (PLATE 17, FIGS. 1–7.)

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 704a.*

Growing with *Thuidium peruvianum.*

Globulina peruviana sp. nov.

Inflorescence unknown: plants in rather compact mats with simple stems 1–4 mm. high, bearing radicles at the base and imbricate-appressed leaves rather uniformly placed along the stem or somewhat clustered at the apex and forming a globose bud about 0.5 mm. in diameter; stem in cross-section about 200 μ in diameter with cells of outer walls not differentiated and with a distinct central strand; leaves rotundate or slightly oblong, about 0.5 mm. long, more or less cucullate, the flat margins crenulate half way down or more; costa vanishing abruptly a little below the apex, rather weak in the lower part, widest near the apex, slightly rough on the back and papillose on the inner face, in cross-section showing two rows of medium-sized, thick-walled cells on the dorsal side and a single row of much larger cells on the ventral side; cells mostly gradually smaller from the base to the apex of the leaf, more or less shortly rectangular below, 12–16 μ by 16–30 μ, toward the apex square to rhomboidal, with sides 6–8 μ long, finely papillose on both sides about the upper half of the costa, the marginal cells smooth; fruit unknown. (PLATE 17, FIGS. 8–15.)

Araranca, south side of Roya Pass, about 4,100 m., April, 1915, *Cook & Gilbert 177a.*

Growing apparently on dry soil with *Pogonatum polycarpum*, at the highest elevation given for any of the collections.

BARBULA COSTATA Mitt.

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 610b.*

A small amount of what is apparently this species occurred, with immature fruit, growing with *Bryum argenteum.* What appears to be this also was found sterile, mixed with *Leskea gracillima*, at the same locality by these collectors, *663a.*

BARBULA PRUINOSA (Mitt.) Jacq.

Cuzco, on dry rock, 3,500 m., July, 1911, *Foote 3.*

BARBULA REPLICATA Tayl.

Cuzco, on dry rock, 3,500 m., July, 1911, *Foote 4;* Ollantaytambo, about 3,000 m., on soil, May, 1915, *Cook & Gilbert 610a.*

Mitten was correct, I believe, in thinking *B. apiculata* Hampe not distinct from this species.

BARBULA SUBULATULA C. Müll.

Urubamba, on damp earth, 2,900 m., July, 1911, *Foote 5*.

TORTULA AFFINIS Hampe.

Sicuani, Vilcanota Valley, on stone, about 3,600 m., April, 1915, *Cook & Gilbert 157;* Ollantaytambo, on rock, about 3,000 m., May, 1915, *Cook & Gilbert 612;* Urubamba, on rock, 2,900 m., July, 1911, *Foote 6*.

Tortula bipedicellata Besch. and *T. confusa* Card., I believe, do not differ from *T. affinis*, which in turn is very close to *T. pichinchensis* (Tayl.) Mitt., differing chiefly in having a low basal membrane of the peristome, the cell structure of which also varies. In *T. pichinchensis* the cells are often as high as broad, and somewhat rhomboidal in slightly oblique rows; in *T. affinis* the cells are low, mostly two or three times broader than high.

TORTULA ANDICOLA Mont.

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 771*.

Tortula lacerifolia sp. nov.

Dioecious: plants with stems (in this small collection scattered through cushions of *Fabronia andina*) mostly simple, 6–8 mm. high, with radicles at the base and leaves more or less aggregate toward the apex; stem-leaves twisting incurved when dry, erect-spreading when moist, oblong, mostly 2–2.5 mm. long, the margins usually deeply incised in the upper half into readily separating, narrow, irregular segments, often 0.25 mm. long and twisted part way round or inflexed or reflexed, the margins of the lower leaf being entire and recurved; costa golden-brown, stout, near the base 80 μ wide, smooth on the back, more or less papillose on the upper side, excurrent into a thorn-like spine, in cross-section showing two large guide-cells, a large band of stereid cells on the dorsal side, with two medium-sized cells on the ventral side; cells throughout upper leaf rather obscure, mostly hexagonal, mamillose and covered on both sides with small often C-shaped papillae, those of lower leaf pale, with few or no papillae and mostly short-rectangular, up to about 18 μ wide by 40–50 μ long; outer perichaetial leaves like those of the stem, the inner small, pale, more or less deeply cleft into numerous segments, the archegonia numerous, with few paraphyses; fruit unknown. (PLATE 18, FIGS. 1–6.)

Ollantaytambo, about 3,000 m., July, 1911, *Foote 7*.

GRIMMIA MICRO-OVATA C. Müll.

Temple of Viracocha near Tinta, on rock, about 3,500 m., April, 1915, *Cook & Gilbert 206;* Ollantaytambo, on rock, about 3,000 m., May, 1915, *Cook & Gilbert 609*.

GRIMMIA OVATA Web. & Mohr.

Cuzco, on dry rock, about 3,500 m., 1911, *Foote 8*.

Grimmia rivulariopsis sp. nov.

Dioecious, the male plant rather more slender than the fertile with often 2–3 flowers scattered along the stem; the inner perigonial leaves small, ovate, ecostate, or faintly costate, enclosing rather numerous, fusiform antheridia about 0.5 mm. long, without paraphyses: fruiting-plants abundantly branching, 2–3 cm. high, without radicles and bearing slightly secund leaves, erect-spreading when moist, mostly somewhat incurved-appressed when dry; stem-leaves oblong-ovate, about 2 mm. long, rather abruptly narrowed to an acute, serrulate apex, the margins entire, of a double thickness of cells and recurved from a little below the apex to near the base; costa stout, percurrent, smooth on both sides and flat or convex on the ventral side in the upper part; cells of stem-leaves distinct, smooth, with slightly thickened, scarcely or not sinuous walls, the median mostly 6 μ wide by 6–8 μ long, the basal more or less rectangular, 8 μ wide by 16–22 μ long; perichaetial leaves larger than those of the stem, about 3.5 mm. long, the costa of the inner leaves rather faint below, widest toward the apex, not quite percurrent, the cells of the lower half of leaf narrowly rectangular or linear with slightly thickened, straight walls; capsule ovate, immersed, about 1.5 mm. high, without stomata, a band of five or six rows of small, transversely elongate cells about the rim, the median exothecal cells scarcely or not elongate, rather irregular with scarcely thickened or sinuous walls, up to 25 μ in diameter; seta erect, scarcely one half the capsule in height; peristome-teeth lanceolate, about 120 μ wide at the base and 400 μ high, red, papillose, entire or often split at the apex or along the median line and slightly lacunose; annulus none; lid convex, obliquely apiculate; calyptra little more than covering the apiculus, the base cleft into several lobes. (PLATE 19.)

Ollantaytambo, about 3,000 m., on rock in stream bed, May, 1915, *Cook & Gilbert 753;* and on rock, same place and collectors, *561*.

Most closely related to *G. amblyophylla* C. Müll. of the South American species, but the apex of the leaf is very different, the cells of the stem-leaves much smaller, with thinner, scarcely sinuous walls and the inner perichaetial leaves have much longer, narrower cells throughout the lower leaf.

RHACOMITRIUM CRISPIPILUM (Tayl.) Jacq.

Lucumayo Valley, 3,000 m., June, 1915, *Cook & Gilbert 1264.*

FUNARIA CALVESCENS Schwaegr.

Ollantaytambo, about 3,000 m., on wet soil, May, *Cook & Gilbert 669;* Manchu Picchu, about 2,100 m., May, *Cook & Gilbert 996.*

MIELICHHOFERIA ANDINA Sull.

Araranca, south side of La Roya Pass, about 4,100 m., on earth wall, April, 1915, *Cook & Gilbert 182a.*

MIELICHHOFERIA BOGOTENSIS Hampe.

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 705.*

LEPTOBRYUM WILSONI (Mitt.) Broth.

Arequipa, on wet rock, 2,300 m., June, 1911, *Foote 9.*

ANOMOBRYUM FILIFORME (Dicks.) Husn.

Santa Rosa, on dry hillside, 3,960 m., July, 1911, *Foote 10.*

BRYUM ANDICOLA Hook.

Above San Miguel, on rocks, 1,830 m., September, 1911, *Foote 11.*

BRYUM ARGENTEUM L.

Cuzco, on dry rock, 3,500 m., 1911, *Foote 12;* Ollantaytambo, on soil, about 3,000 m., May, 1915, *Cook & Gilbert 610.*

Bryum biforme sp. nov.

Pseudoautoicous, the male plants minute, 1–2 mm. high, attached by radicles to the tomentum of the fertile stems, each plant bearing one or two flowers containing two or three antheridia, with few, somewhat longer paraphyses; the outer antheridial leaves broadly ovate-lanceolate, scarcely serrulate, with costa vanishing well below the apex: fertile plants with more or less branching, tomentose stems 3–4 cm. high, the short branches often bearing at the apex abundant, filiform flagella, 3–4 mm. long and covered with minute scale-like leaves; stem-leaves widely spreading when moist, somewhat spreading-flexuous and twisted when dry, serrulate above, rather broadly ovate, acute, slightly decurrent, 3–3.5 mm. long, the margins flat above, recurved below with a border of elongate, narrow, pale cells most distinct half way down the leaf where it becomes four or five cells wide; costa not quite percurrent, from a broad, reddish brown base, tapering gradually to the slender apex; cells in upper leaf rhomboidal or hexagonal, in lower leaf larger and more or less rectangular, all with somewhat thickened walls distinctly pitted, at least in the lower leaf; the median cells about 16 μ wide and 40–50 μ long; outer perichaetial leaves about the length of the stem-leaves, from a broad base, oblong, acute, serrulate and with costa vanishing a little below the apex; seta about 2 cm. long; capsule pendent with sporangium rather narrowly ovate and tapering into a neck about one half the length of the sporangium, the median exothecal cells irregularly elongate with evenly thickened, mostly slightly curving walls, the stomata abundant in the neck, about 40 μ long; annulus large; peristome-teeth lanceolate, about 100 μ wide at the base and 600 μ high, with hyaline borders and the outer plates finely punctate, mostly one and one half to two times wider than high, the inner lamellae without cross-walls; inner segments about the height of the teeth, keeled and solid along the median line, very slender-pointed with mostly two long, slender cilia between them, sometimes distinctly appendiculate; spores rough, up to 20 μ in diameter; lid highly convex-apiculate. (PLATE 20.)

Torontoy, Urubamba Valley, about 3,600 m., May, 1915, *Hiram Bingham 730*.

This is, I believe, the only *Bryum* known having inflorescence as above described; the flagella also are unusual.

BRYUM DENSIFOLIUM Brid.

Urubamba, on damp earth, 2,900 m., July, 1911, *Foote 13;* Santa Anna, 912 m., August, 1911, *Foote 14*.

MNIUM LIGULATUM C. Müll.

Lucma, on dead wood, 2,130 m., Aug. 1911, *Foote 15*, growing mixed with *Cyclodictyon aeruginosum* (Mitt.) Broth. and *Trichostomum brachydontium* Bruch.; Urubamba, on wet earth, 2,900 m., July, 1911, *Foote 16*.

ANACOLIA SUBSESSILIS (Tayl.) Broth.

Urubamba, on loose earth and rocks, 2,900 m., July, 1911, *Foote 17;* Ollantaytambo, about 3,000 m., *Cook & Gilbert*, May, 1915, *504, 749, 771a*.

BREUTELIA BRYOCARPA Herzog.

Lucumayo Valley, 1,800–3,600 m., June, 1915, *Cook & Gilbert, 1320a*.

A few stems with one capsule were found mixed in with *Breutelia tomentosa*. This is evidently the same species as that collected by Weddell in Peru and named, apparently in manuscript only, *Bartramia nutans* by Montagne. It is also the same as my Bolivian collection, No. 2825, referred to *Breutelia nutans* (Mont.).

BREUTELIA TOMENTOSA (Sw.) Schimp.

San Miguel, Urubamba Valley, about 1,800 m., May, 1915, *Cook & Gilbert 988;* Lucumayo Valley, 1,800–3,600 m., June, 1915, *Cook & Gilbert 1320.*

POGONATUM CAMPYLOCARPUM C. Müll.

Lucumayo Valley, 1,800–3,600 m., June, 1915, *Cook & Gilbert 1322.*

POGONATUM POLYCARPUM (Schimp.) Broth.

Araranca, south side of La Roya Pass, about 4,100 m., April, 1915, *Cook & Gilbert 177 and 182.*

POLYTRICHUM ANTILLARUM Rich.

Torontoy, Urubamba Valley, about 2,400 m., June, 1915, *Cook & Gilbert 1194;* Lucumayo Valley, 1,800–3,600 m., on wet earth, June, 1915, *Cook & Gilbert 1318.*

HEDWIGIA ALBICANS (Web.) Lindb.

Temple of Viracocha, near Tinta, about 3,500 m., April, 1915, *Cook & Gilbert 204;* Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 501.*

HEDWIGIDIUM IMBERBE (Sm.) B.S.G.

Urubamba, on rocks, 2,900 m., July, 1911, *Foote 18;* Ollantaytambo, 2,750 m., July, 1911, *Foote 19;* Temple of Viracocha, near Tinta, about 3,500 m., April, 1915, *Cook & Gilbert 204a.*

BRAUNIA CANESCENS Schimp.

Near Calca, on rock, April, 1915, *Cook & Gilbert 245;* Ollantaytambo, about 3,000 m., April and May, 1915, *Cook & Gilbert 473, 502, and 503.* This species has been considered scarcely distinct from *B. cirrifolia* (Wils.) Jaeg., but it seems to me to be a rather smaller species with more closely imbricate leaves. The leaves also, below the apex of the stem, are broader in the upper part, often slightly obovate, and more abruptly narrowed to the pale apex of blade and hair point. *B. cirrifolia* has leaves rather lanceolate and gradually narrowed to a yellowish apex and flexuous hair point. *Braunia argentinica* C. Müll. and *B. cirriolia* var. *falcatula* Herzog belong, I should say, under *B. canescens*.

PRIONODON BOLIVIANUS C. Müll.

Torontoy, Urubamba Valley, about 3,600 m., May, 1915, *Hiram Bingham 729.*

SQUAMIDIUM ROTUNDIFOLIUM (Mitt.) Broth.

Above San Miguel, 1,830 m., September, 1911, *Foote 20.*

PILOTRICHELLA VIRIDIS (C. Müll.) Jacq.

San Miguel, Urubamba Valley, 1,800 m., May, 1915, *Cook & Gilbert 919.*

PAPILLARIA IMPONDEROSA (Tayl.) Broth.

Above San Miguel, on moist earth, 1,830 m., September, 1911, *Foote 21.*

METEORIOPSIS REMOTIFOLIA (Hornsch.) Broth.

San Miguel, 1,500–1,830 m., July, 1911, *Foote 22.*

NECKERA EUCARPA Schimp.

Urubamba, on bark, 2,900 m., July, 1911, *Foote 23;* Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 763.*

NECKERA JAMESONI Tayl.

Ollantaytambo, about 3,000 m., on *Alnus*, May, 1915, *Cook & Gilbert 763a.*

NECKERA LINDIGII Hampe.

Lucma, on dead wood, 2,130 m., August, 1911, *Foote 24;* Urubamba, on bark, with *N. eucarpa*, 2,900 m., July, 1911, *Foote 23a.*

POROTRICHUM VALDIVIAE C. Müll.

Ollantaytambo, about 3,000 m., on trunks, May, 1915, *Cook & Gilbert 762a;* apparently the farthest northern station for this species.

ENTODON PLATYGYRIOIDES C. Müll.

Above San Miguel, on rock, 1,830 m., September, 1911, *Foote 25.*

ERYTHRODONTIUM SQUARROSUM (C. Müll.) Par.

Santa Ana, on rock, 912 m., August, 1911, *Foote 26.*

FABRONIA ANDINA Mitt.

Ollantaytambo, on rock, about 3,000 m., May, 1915, *Cook & Gilbert 662;* Urubamba, 2,900 m., July, 1911, *Foote 27;* Ollantaytambo, 2,750 m., July, 1911, *Foote 28.*

FABRONIA POLYCARPA Hook.

Santa Ana, 912 m., August, 1911, *Foote 29.*

CYCLODICTYON AERUGINOSUM (Mitt.) Broth.

Lucma, on dead wood, 2,130 m., August, 1911, *Foote 30.*

RHACOPILUM TOMENTOSUM (Hedw.) Mitt.

Santa Ana, on dead wood, 912 m., August, 1911, *Foote 31, 32;* San Miguel, 1,525 m., September, 1911, *Foote 33.*

LESKEA GRACILLIMA Tayl.

Urubamba, 2,900 m., July, 1911, *Foote 34,* on bark, *35* on rock; Ollantaytambo, on rock, about 3,000 m., May, 1915, *Cook & Gilbert 609a, 663.*

THUIDIUM PERUVIANUM Mitt.

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 704, 748.*

HYGROAMBLYSTEGIUM IRRIGUUM (Wils.) Loeske.

Urubamba, on rock, 2,900 m., July, 1911, *Foote 36.* Apparently not before reported for South America. The next nearest known location is, I believe, Guatemala.

Drepanocladus longifolius (Wils.) comb. nov.

Amblystegium longifolium Wils.; Mitten; Jour. Linn. Soc. Bot. 12: 571. 1869.

Temple of Viracocha, near Tinta, about 3,500 m., in a spring, April, 1915, *Cook & Gilbert 216.*

These sterile specimens seem to belong under this species although only known from Patagonia up to the present time.

Hygrohypnum peruviense sp. nov.

Inflorescence unknown: growing in loose mats with irregularly branching stems without radicles, 2–3 cm. long and about 200 μ in diameter, in cross-section showing a distinct central strand and outer walls of about three rows of smaller, thick-walled cells; leaves loosely erect-spreading, more or less secund, rather broadly ovate-acute, somewhat cymbiform, 1.5–2 mm. long, and nearly or quite entire; costa stout, 80 μ wide or more at the base, simple and extending about three fourths up the leaf or shorter and dividing into two to five branches; leaf-cells all elongate, prosenchymatose and mostly slightly sinuous, with rather thin walls, the median 5–6 μ wide and 40–60 μ long, the alar usually forming a distinct cluster of broad, short cells either greenish or finally reddish-brown; fruit not found. (PLATE 18, FIGS. 7–12.)

A variety evidently of the above, growing in flowing water, has elongate, hispid, wiry stems, 10–15 cm. long, without leaves below and in habit like *H. Bestii*, except much more slender.

Cuzco, on wet rock, 3,500 m., July, 1911, *Foote 37* (type); Ollantaytambo, about 3,000 m., on rock under spring, May, 1915, *Cook & Gilbert 666* (the variety).

CTENIDIUM MALACODES Mitt.

Ollantaytambo, about 3,000 m., on trunks, May, 1915, *Cook & Gilbert 762b.*

MITTENOTHAMNIUM ANDICOLA (Hook.) Card.

Ollantaytambo, about 3,000 m., on trunks, May, 1915, *Cook & Gilbert 762.*

MITTENOTHAMNIUM OXYSTEGUM (Spruce) Card.

Santa Ana, on rock, 912 m., August, 1911, *Foote 38.*

HYPNUM SCHREBERI Willd.

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 748a.*

ECTROPOTHECIUM AERUGINOSUM (C. Müll.) Mitt.

Santa Ana, 912 m., on dead wood, August, 1911, *Foote 39.*

PALAMOCLADIUM LESKEOIDES (Hook.) E. G. Britton.

San Miguel, on rock, 1,830 m., September, 1911, *Foote 40.*

BRACHYTHECIUM ASPERULUM (Hampe) Jaeg.

Ollantaytambo, about 3,000 m., May, 1915, *Cook & Gilbert 753a.*

BRACHYTHECIUM FLACCUM C. Müll.

Huadquinia, on wet earth, 1,530 m., August, 1911, *Foote 41;* Ollantaytambo, about 3,000 m., on trunks, May, 1915, *Cook & Gilbert 762c.*

BRACHYTHECIUM SERICEOVIRENS (C. Müll.) Par.

Ollantaytambo, on rock, 2,750 m., July, 1911, *Foote 42.* Known previously only from Patagonia.

BRACHYTHECIUM STEREOPOMA (Spruce) Jaeg.

San Miguel, on live wood, 1,830 m., July, 1911, *Foote 48.*

RHYNCHOSTEGIUM AQUATICUM (Hampe) Jaeg.

Urubamba, in water, 2,900 m., July, 1911, *Foote 43;* Arequipa, in water, June, 1911, *Foote 44;* Cuzco, on wet rocks, July, 1911, *Foote 45.*

RHYNCHOSTEGIUM CONOPHYLLUM (Tayl.) Jaeg.

Urubamba, on rock, 2,900 m., July, 1911, *Foote 46;* San Miguel, on live wood, 1,830 m., July, 1911, *Foote 47.*

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Explanation of plates 17–20

PLATE 17

Leptodontium integrifolium. 1. Plant about natural size. 2. Perichaetium, × 7. 3. Stem-leaf, × 15. 4. One side of base of leaf, × 115. 5. Median cells of leaf, × 240. 6. Apex of leaf, × 50. 7. Cross-section of leaf, × 150.

Globulina peruviana. 8. Plant about natural size. 9. Plant, × 10. 10. Stem-leaf, × 45. 11. Apex of costa and leaf, × 230. 12. Median cells of leaf, × 230. 13. Basal cells on one side of costa, × 230. 14. Cross-section of stem, × 230. 15. Cross-section of leaf, × 230.

PLATE 18

Tortula lacerifolia. 1. Plant about natural size. 2. Perichaetial leaf, × 25. 3. Upper stem-leaf, × 25. 4. A segment from the leaf-margin, × 130. 5. Base of leaf on one side of costa, × 180. 6. Cross-section of leaf, × 180.

Hygrohypnum peruviense. 7. Plant about natural size. 8. Cross-section of stem, × 130. 9. Basal leaf-cells on one side of costa, × 270. 10, 11. Stem-leaves, × 25. 12. Median leaf-cells, × 270.

PLATE 19

Grimmia rivulariopsis. 1. Fertile and male plant about natural size. 2. Capsule, seta and perichaetial leaf, × 20. 3. Calyptra, × 20. 4. Lid, × 20. 5. Part of peristome and rim of capsule, × 110. 6. Antheridia with leaf, × 20. 7. Upper part of stem leaf, × 180. 8. Stem-leaf, × 18. 9. Median cells of leaf, × 180. 10. Cells in lower part of perichaetial leaf, × 180. 11. Perichaetial leaf, × 18. 12. Median exothecal cells, × 180. 13. Cross-section of stem-leaf, × 180.

PLATE 20

Bryum biforme. 1. Fertile and male plant about natural size. 2. Male plants, × 20. 3. Capsule, moistened, × 8. 4. Upper stem-leaf, × 16. 5. Outer perichaetial leaf, × 16. 6. Upper part of stem-leaf, × 135. 7. Border of leaf and adjoining cells about half way down, × 135. 8. Inner perichaetial leaf, × 16. 9. Stoma, × 135. 10. Median exothecal cells, × 135. 11. Part of peristome, annulus and rim of capsule, × 100.

INDEX TO AMERICAN BOTANICAL LITERATURE

1910-1916

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 the broadest sense.

Reviews, and papers that 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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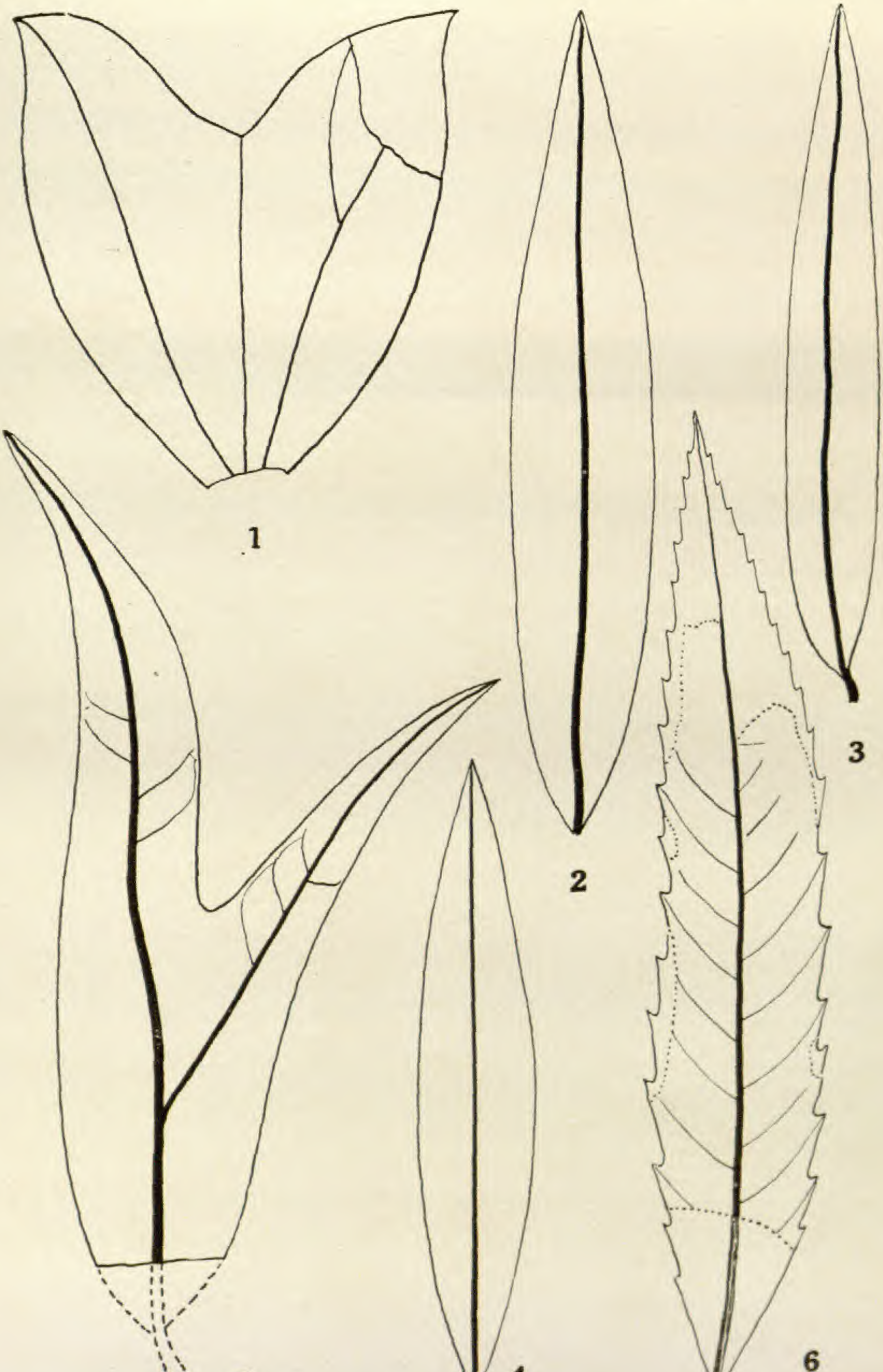
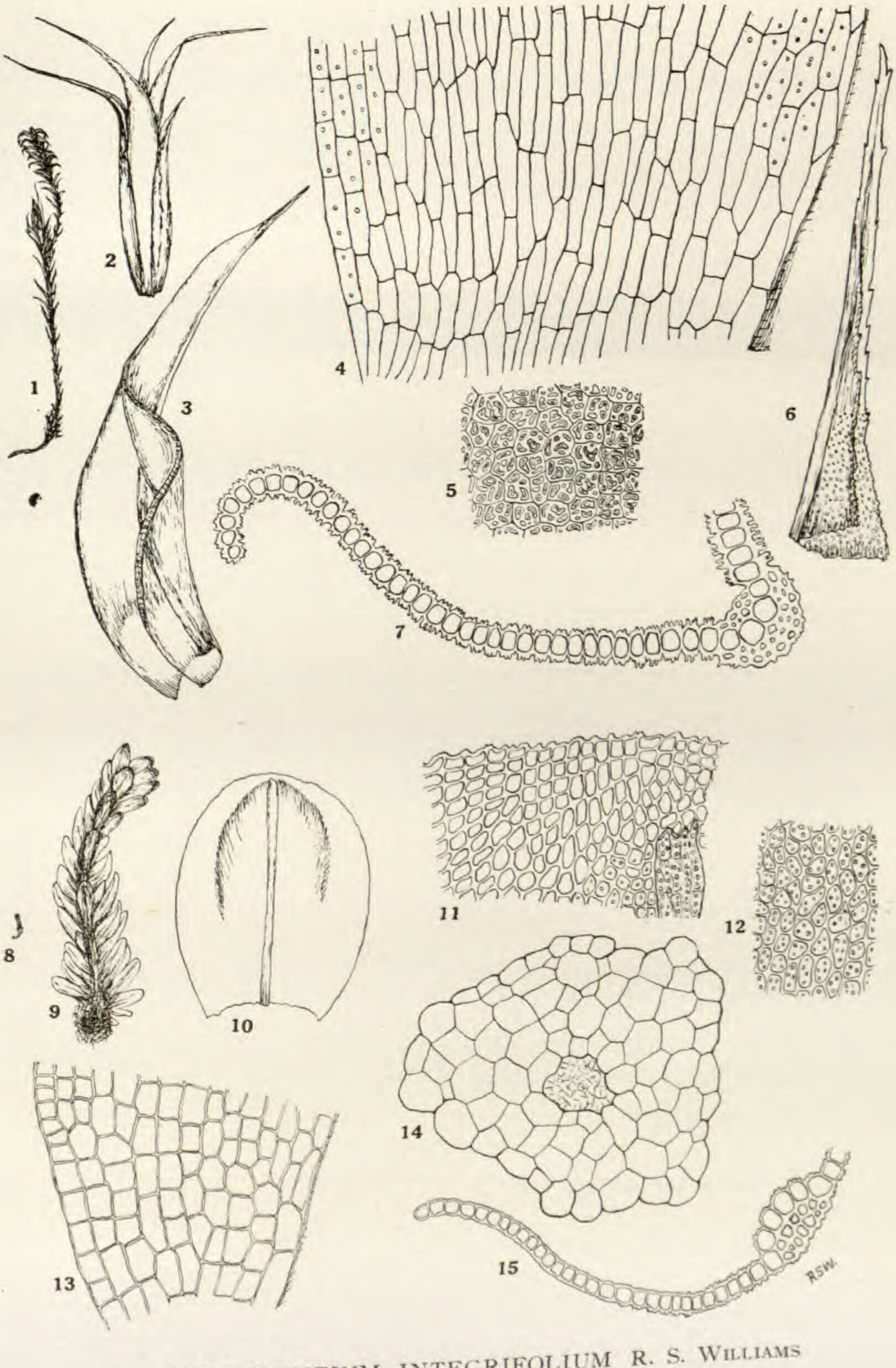
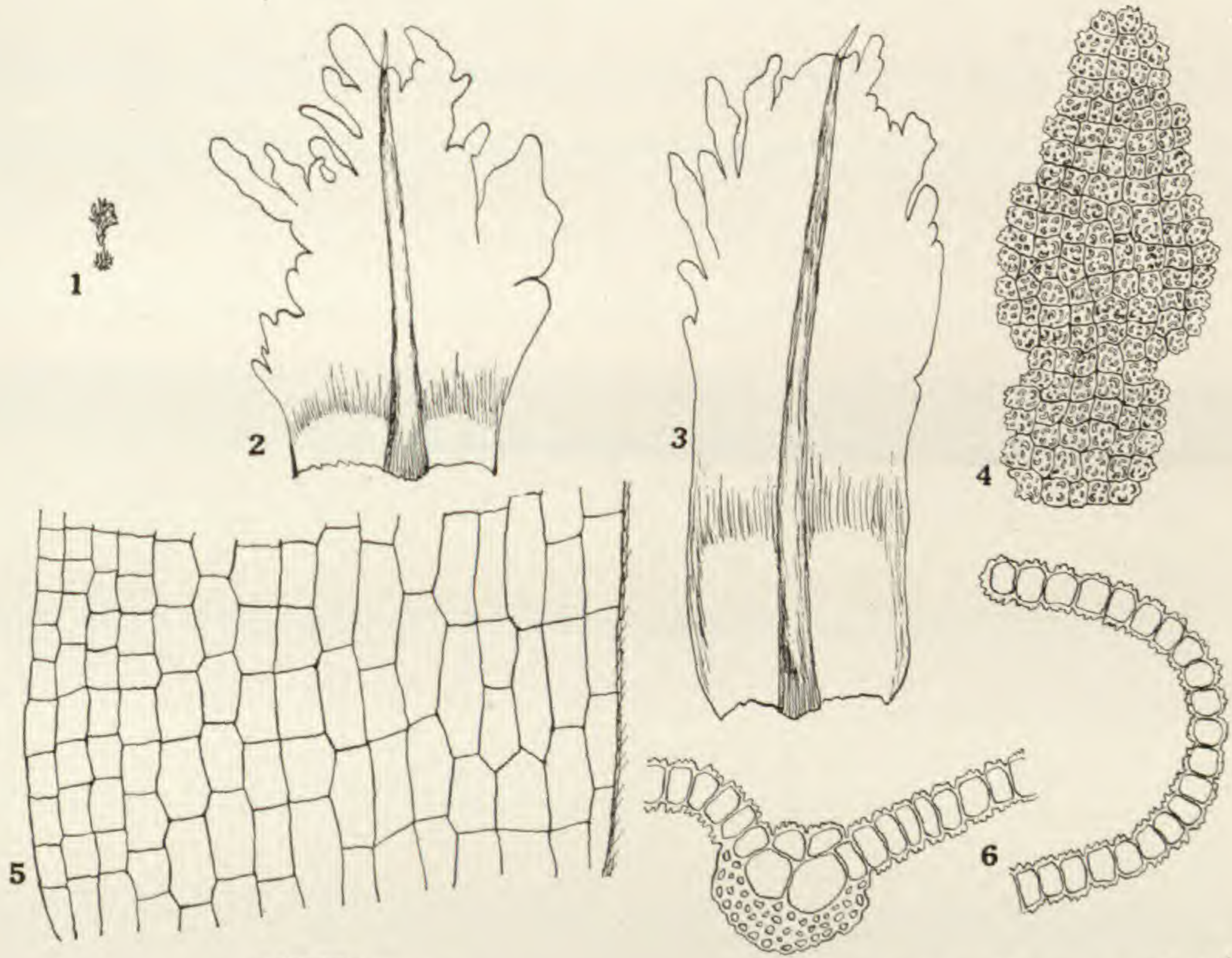
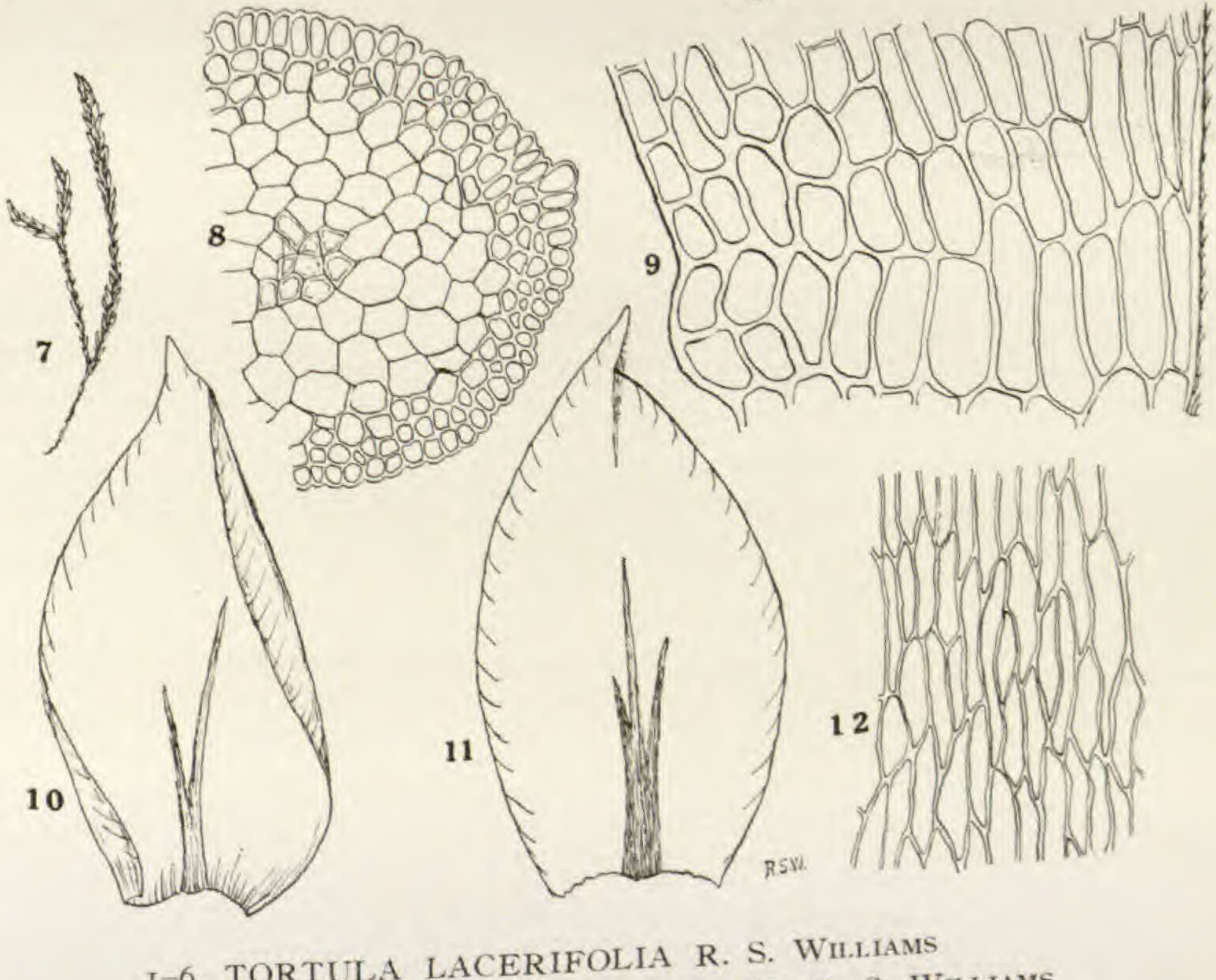


1. BAUHINIA RIPLEYENSIS BERRY
2–4. EUGENIA (?) ANCEPS BERRY
5. STERCULIA SNOWII TENNESSEENSIS BERRY
6. DRYOPHYLLUM GRACILE DEBEY

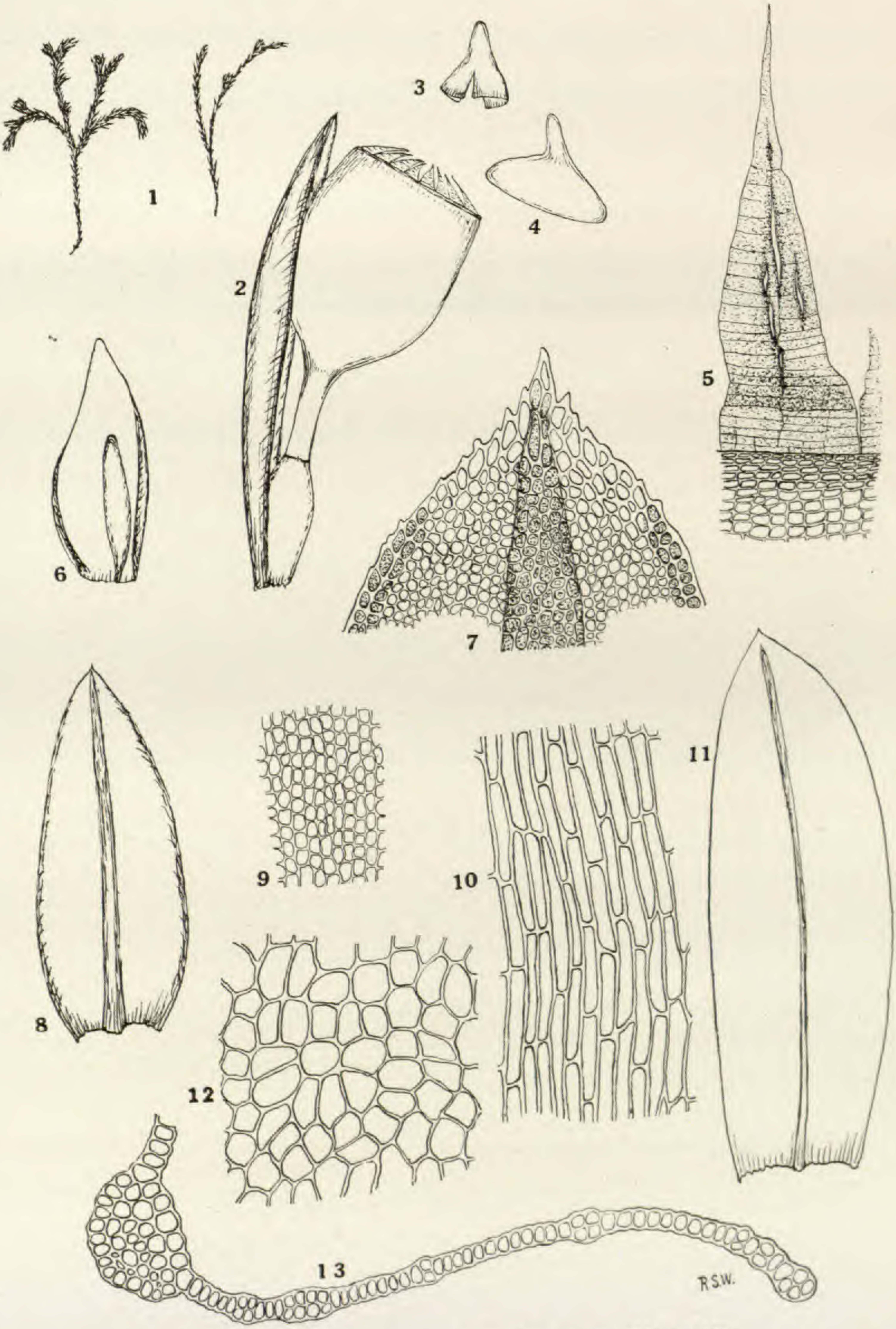


1–7. LEPTODONTIUM INTEGRIFOLIUM R. S. WILLIAMS
8–15. GLOBULINA PERUVIANA R. S. WILLIAMS

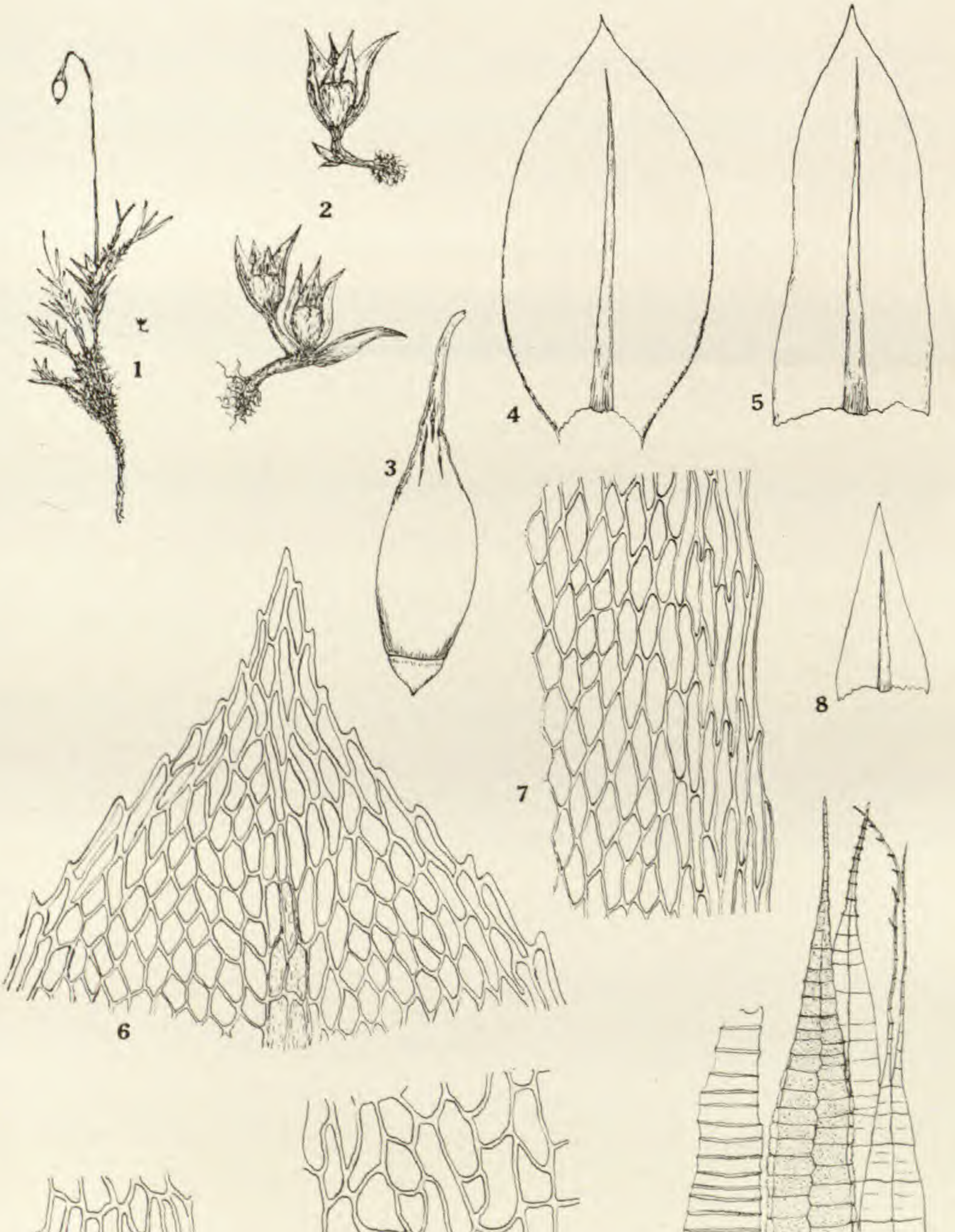




1–6. TORTULA LACERIFOLIA R. S. WILLIAMS
7–12. HYGROHYPNUM PERUVIENSE R. S. WILLIAMS



GRIMMIA RIVULARIOPSIS R. S. WILLIAMS



BRYUM BIFORME R. S. WILLIAMS

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

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Phytogeographical notes on the Rocky Mountain region
VI. Distribution of the subalpine plants

P. A. Rydberg

I have already pointed out in a paper entitled "Vegetative Life Zones of the Rocky Mountains," read at the twentieth anniversary of the New York Botanical Garden, that the Subalpine and Montane Zones of the Rockies are very different from those zones in the eastern part of North America, although the Hudsonian and Canadian Zones extend west to the foot of the Rockies from the headwaters of the Athabasca River northward. Also, I showed that the aspen was the only one among the ecologically important trees, common to the eastern and central (Rocky Mountain) provinces, that the Subalpine and Montane Zones of the central and western (Pacific) provinces merge in the north, and that many species have emigrated from either of these provinces to the other. These statements were largely based on the most conspicuous element of these zones, namely, the forest trees. Now it is to be shown whether or not these statements apply to the secondary species of the forests, to the grasslands and other herbaceous formations, and to the coppice.

The subalpine flora may be divided into the following categories:—I. The transcontinental element, many members of which are also found in the Old World; II. Plants common to the Rockies and either of the other provinces; III. The endemic element. To the first belong the larger proportion of the plants common to the alpine-arctic zone.

[The Bulletin for June (43: 283–342. *pl. 16–20*) was issued June 29, 1916.]

Some of the plants of the first category may have a range limited in the Middle Province to the Canadian Rockies alone; others may extend throughout the Northern Rockies, but not be found in the Southern; while still others may extend throughout the Rocky Mountain system. Of the second category, some plants may be common to the Rockies and the Hudsonian Zone of the east, some others common to the Rockies and the Pacific mountains, or to the Sierra Madre in Mexico, or to the Alaskan mountains, or to the arctic coast. Some might have their home in the Rockies and spread to other regions, and others might be immigrants into the Rocky Mountain system. Among the plants of the third category, many are distributed throughout the Rockies, others have a distribution limited to either the Northern or the Southern Rockies, or to certain parts of either, while still others are purely local.

The strictly subalpine element of the flora of the Rockies is in fact very small, the plants consisting mostly of species that are found also in the Montane Zone, especially the upper part thereof, and of alpine-arctic species, running down in the swales, along the streams, or along the wind-swept hog-backs. In fact some plants, especially aquatics and hydrophytes, are common to three or more zones. In the following lists the plants common to the alpine-arctic zone are designated by a dagger (†). No attempt is made to designate those common to the Montane Zone, as they would probably constitute 90 per cent. of the remaining species.

I

1. TRANSCONTINENTAL SPECIES RANGING THROUGHOUT THE ROCKIES

This element is represented among the trees by the quaking aspen, *Populus tremuloides*,* but this tree is not one of the characteristic trees of the Subalpine or Subarctic Zone either of the east or of the Rockies, nor is it limited to the subalpine regions. One should therefore not lay too much stress upon this tree and its

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* It is true that some botanists, such as Tidestrom, Wooton and Standley, regard the Rocky Mountain aspen as a distinct species, *Populus aurea*, differing in smaller, thicker, less toothed leaves and different colored anthers and bark, but as the distribution of this species has not been worked out, it is better here to ignore the same and include it in *P. tremuloides*.

distribution when considering the resemblances of and distinctions between the Hudsonian flora and the subalpine flora of the Rockies. Looking over the following two lists we find that they are mostly made up of either aquatic plants and hydrophytes or plants from dense or open woods or copses, requiring a good deal of moisture.

Trees

Populus tremuloides

Shrubs

Salix chlorophylla
Betula glandulosa
Lepargyrea canadensis
Vaccinium caespitosum
Linnaea americana
Distegia involucrata

Herbs

Sparganium minimum
“ *angustifolium*
Potamogeton natans
“ *alpinus*
“ *heterophyllus*
“ *Richardsonii*
“ *pectinatus*
“ *filiformis*
Triglochin palustris
“ *maritima*
Scheuchzeria palustris
Savastana odorata
Muhlenbergia racemosa
Phleum pratense
“ *alpinum*
Alopecurus aristulatus
“ *occidentalis*
Agrostis hiemalis
“ *canina*
Calamagrostis Langsdorfii
“ *canadensis*
“ *purpurascens*
Deschampsia caespitosa
“ *atropurpurea*
Avena striata
Danthonia intermedia
Trisetum subspicatum
Phragmites Phragmites
†*Catabrosa aquatica*
Bromus ciliatus
Poa pratensis
† “ *alpina*
“ *crocata*
†*Festuca curtifolia*
Panicularia nervata
Hordeum jubatum
Agropyron violaceum
Eriophorum angustifolium
†*Carex Hepburnii*
“ *leptalea*
† “ *obtusata*
† “ *gynocrates*
“ *siccata*
“ *interior*
“ *canescens*
“ *brunnescens*
“ *Rossii*
“ *aurea*

†*Carex capillaris*
" *misandra*
" *Halleri*
† " *atrata*
" *rostrata*
Lemna minor
†*Juncus triglumis*
† " *castaneus*
Juncoides parviflorum
† " *spicatum*
" *intermedium*
†*Lloydia serotina*
Vagnera stellata
Lysiella obtusata
Peramium ophioides
†*Cytherea bulbosa*
†*Oxyria digyna*
†*Bistorta vivipara*
Alsine longifolia
" *laeta*
" *crassifolia*
" *borealis*
Moehringia macrophylla
" *lateriflora*
Sagina saginoides
†*Silene acaulis*
Anemone parviflora
Pulsatilla ludoviciana
†*Thalictrum alpinum*
Batrachium confervoides
†*Draba crassifolia*
† " *fladnizensis*
† " *aurea*
†*Chrysosplenium tetrandrum*
†*Saxifraga cernua*
Leptasea Hirculus
†*Sibbaldia procumbens*
†*Potentilla quinquefolia*
† " *nivea*
† " *uniflora*
Dasiphora fruticosa
Geum rivale
Tium alpinum
Epilobium alpinum
" *Hornemannii*
† " *anagallidifolium*
Chamaenerion angustifolium
† " *latifolium*
Hippurus vulgaris
Moneses uniflora
Pyrola uliginosa
" *chlorantha*
" *minor*
" *secunda*
Menyanthes trifoliata
Veronica americana
" *Wormskioldii*
" *serpyllifolia*
†*Elephantella groenlandica*
Utricularia vulgaris
" *minor*
Campanula petiolata
Erigeron jucundus
" *compositus*
Artemisia spithamaea

2. TRANSCONTINENTAL SPECIES CONFINED TO THE NORTHERN ROCKIES

The number of transcontinental plants found in the Northern Rockies, but not in the Southern, is much smaller, and of these a larger percentage are arctic-alpine, descending into the Subalpine Zone. Among these plants there are no trees and only a few low shrubs.

Shrubs

†*Salix pseudomyrsinites*
Ribes hudsonianum
Andromeda polifolia
Chiogenes hispidula
Vaccinium uliginosum

Herbs

†*Eriophorum Chamissonis*
†*Scirpus pauciflorus*
† “ *caespitosus*
†*Carex capitata*
“ *aenea*
“ *Heleonastes*
† “ *supina*
“ *deflexa*
“ *Hassei*
“ *livida*
“ *vaginata*
“ *atratiformis*
“ *miliaris*
“ *scirpoidea*
†*Juncoides hyperboreum*
Cypripedium passerinum
†*Ranunculus hyperboreus*
Drosera rotundifolia
Parnassia palustris
† “ *Kotzebuei*
†*Saxifraga rivularis*
Anthiphylla oppositifolia
Comarum palustre
Mertensia paniculata
Veronica scutellata
†*Pinguicula vulgaris*
Valeriana septentrionalis
Erigeron alpinus
“ *unalaschkensis*
“ *purpureum*
Senecio pauciflorus

3. TRANSCONTINENTAL SPECIES LIMITED TO THE CANADIAN ROCKIES

Some of the transcontinental subarctic plants have not spread at all south in the mountains and are found in the Rockies only at an altitude where the Subarctic Zone covers the lowlands. In other words, they are found only in the Canadian Rockies. These plants are also found north of the arctic timberline. They are:

Shrubs

†*Rubus acaulis*
† “ *Chamaemorus*
†*Ledum groenlandicum*
†*Cassiope tetragona*
†*Vaccinum Vitis-Idaea*
†*Oxycoccus Oxycoccus*

Herbs

†*Eriophorum Scheucheri*
† " *alpinum*
†*Juncoides arcticum*
† " *arcuatum*
†*Orchis rotundifolia*
†*Arenaria norvegica*
†*Drosera longifolia*
†*Condrosea Aizoon*
†*Leptasea tricuspidata*

II

1. SPECIES NEARLY EQUALLY DISTRIBUTED IN THE ROCKIES AND THE PACIFIC MOUNTAINS

There are many species which seem equally at home both in the Rocky Mountains, the Sierra Nevada and the Cascade Mountains. The larger part of these are more or less xerophytic plants growing in the drier part of the subarctic zone, especially on southern exposures. Nearly all of the plants listed below are also equally distributed in the Montane and the Subalpine Zones. To these belong four of the conifers, *Pseudotsuga mucronata*, *Pinus Murrayana*, *P. flexilis* and *P. albicaulis*. Of these the last mentioned is the only one which is not better represented in the Montane Zone. Its distribution is also more extensive in the Pacific mountains, and it is not found in the Southern Rockies. It has therefore been placed among the immigrants, though its original home might be the Northern Rockies. *Pseudotsuga mucronata* is also found in the mountains of northern Mexico. All extend north in the Rockies to about latitude 55 degrees, except *Pinus Murrayana*, which grows much further north in the Yukon Valley, at latitude 65 degrees.

Trees

Pseudotsuga mucronata
Pinus Murrayana
Pinus flexilis

Shrubs

Salix glaucops
Ribes montigenum
Pachystima myrsinites
Phyllodoce empetriformis
Ledum glandulosum
Kalmia microphylla
Gaultheria humifusa

Herbs

Muhlenbergia comata
Agrostis asperifolia
" *variabilis*
Danthonia californica
Graphephorum muticum
Poa longiligula
" *Fendleriana*
Bromus polyanthus
Panicularia pauciflora
Elymus glaucus
†*Carex nigricans*
" *Douglasii*
" *illota*
" *athrostachya*
" *phaeocephala*
" *festivella*
" *Reynoldsii*
" *nova*
Lemna gibba
Veratrum speciosum
†*Juncus Drummondii*
† " *Parryi*
" *Mertensianus*
Eriogonum umbellatum
†*Bistorta bistortoides*
Alsine bailcalensis
" *calycantha*
†*Cerastium beeringianum*
Alsinopsis Nuttallii
Nymphaea polysepala
Anemone globosa
Ranunculus Eschscholtzii
Aconitum columbianum
Cardamine umbellata
*Draba nitida**
† " *oligosperma*
†*Rhodiola integrifolia*
Parnassia fimbriata
Pectianthia pentandra
Micranthes arguta
Ivesia Gordonii
Potentilla diversifolia
Fragaria bracteata
Gayophytum racemosum
Amarella strictiflora
" *plebeia*
Leptodactylon Nuttallii
Phacelia heterophylla
Pentstemon procerus
Mimulus Langsdorfii
Pedicularis racemosa
" *bracteata*
Erigeron simplex
" *Coulteri*
" *salsuginosus*
†*Antennaria media*
" *rosea*
Dugaldia Hoopesii‡
Achillea lanulosa
Arnica pedunculata
" *cordifolia*

2. SPECIES COMMON TO THE ROCKIES AND THE MOUNTAINS OF THE GREAT BASIN

A few plants are distributed through a larger or smaller part of the Southern Rockies (especially the Wasatch Mountains of Utah

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* Lacking in Colorado.

‡ In the Southern Rockies only.

and the Bear River Mountains of Idaho) and of the higher mountains of the Great Basin extending to the eastern slopes of the Sierra Nevada. These plants are very few in the Subalpine Zone, more in the Montane, and still more in the Submontane and Upper Sonoran. Some of these are listed under the endemic element of the Rockies, as it is very hard to tell whether their original homes are in the Rockies or in the Basin mountains. To this element belongs one tree, *Pinus aristata*, growing on dry southern slopes from Colorado west to eastern California. It is perhaps more frequently met with in Colorado, but it might have originated on the eastern slopes of the Sierra Nevada, as its only close relative, *P. Balfouriana*, is also found there. The following is a partial list of the plants of this category:

Tree

Pinus aristata

Herbs

†*Erigeron Kingii*
†*Draba pectinata*
Ivesia utahensis
Drymocallis pumila
Kentrophyta tegetaria
Macronema discoidea
Senecio seridophyllus

3. SPECIES COMMON TO THE NORTHERN ROCKIES AND THE CASCADE MOUNTAINS

As the Northern Rockies and the Cascades are connected by several mountain chains in British Columbia, it is very hard to decide where these common plants should be counted, to the Rocky Mountain flora or to the flora of the Cascades. It is probable that to the former should be counted those which are generally distributed in the main chain of the Rockies in Alberta and Montana, especially if their range extends south into the Yellowstone Park. I would even include in the Rocky Mountain flora such species as *Larix Lyallii* (although very local), which crosses the main range at a few places, while I would count *Tsuga Mertensiana*, which extends east only to the Bitter Root and Selkirk Mountains, to the Cascade element.

a. Rocky Mountain Element

Tree

Larix Lyallii

Shrubs

Ribes petiolaris

†*Phyllodoce glanduliflora*

Herbs

Carex Tolmiei
Tofieldia intermedia
Erythronium grandiflorum
Eriogonum Piperi
" *polyphyllum*
†*Draba lonchocarpa*
Ozomelis trifida
Heuchera ovalifolia
Drymocallis pseudorupestris

Atragallus spicatus
Hedysarum sulphurescens
Amarella anisopetala
Pentstemon crassifolium
Castilleja lutea
" *pallescens*
Erigeron pedatus
Antennaria corymbosa
†*Senecio Fremontii*

b. Cascade Element

Tree

Tsuga Mertensiana

Shrubs

Salix Barclayi
" *subcaerulea*
Alnus sinuata

Rubus nivalis
Azaliastrum albiflorum
Gaultheria ovatifolia

Herbs

Carex laeviculmis
" *stenochlaena*
" *Mertensii*
Juncoides glabratum
Alnus sinuata
Silene oregana
†*Ranunculus Suksdorfii*
Aquilegia columbiana

†*Smelowskia ovalis*
Arabis Lyallii
Hemieva ranunculifolia
†*Lutkea pectinata*
Viola adunca
Osmorrhiza Leibergii
Pentstemon fruticosus
Synthyris reniformis

Most of these extend to the western slopes of the Rockies in British Columbia or northern Montana, but *Tsuga Mertensiana*, *Osmorrhiza Leibergii* and *Synthyris reniformis* are restricted to the western slopes of the Bitter Root Mountains in Idaho.

4. Western immigrants from the Sierra Nevada and the Cascades, which have invaded the Northern Rockies

There are a number of species which are common to the Pacific mountains and the Rockies, but have a wider distribution in the former than in the latter. Their home may therefore be regarded as being on the west coast, and they may be regarded as immigrants into the Rocky Mountains. Those of the following list are common to the Sierra Nevada and the Cascades, and their range extends into the Northern Rockies. Some of these are found in the Bitter Root or the Selkirk Mountains only, and are without doubt immigrants. Others extend into the main Rockies of Alberta and Montana and even as far south as northern Wyoming. Whether these are immigrants or endemics to the Rockies is more doubtful. A very few reach the Wasatch Mountains in northern Utah. There are no immigrants from the Sierras to the southern Rockies. It is true that there are a few subalpine endemics common to the Sierra Nevada and the Southern Rockies, but these are plants characteristic of the mountains of the Great Basin, and limited to the eastern slope of the Sierra Nevada and the western slope of the Rockies.

Trees

Pinus albicaulis
Salix sitchensis

Shrubs

†*Salix cascadensis*
Ribes laxiflorum
Ribes glandulosum
Cassiope Mertensiana
Vaccinium occidentale
Linnaea longiflora

Herbs

Stipa oregonensis
Poa Cusickii
Carex spectabilis
Xerophyllum tenax

Juncus Regelii
" *nevadensis*
Cytherea occidentalis
†*Eriogonum pyrolaefolium*
Naiocrene parvifolia
†*Arenaria salmonensis*
Anemone Drummondii
Pulsatilla occidentalis
Ranunculus alismellus
Aquilegia formosa
Thlaspi californicum
Dentaria rupicola
Draba eurocarpa
Pectianthia Breweri
Heuchera glabra
Potentilla flabellifolia
Epilobium oregonense
" *luteum*
†*Dasystephana calycosa*
Romanzoffia sitchensis
Adenostegia ramosa
†*Pedicularis contorta*

Of these *Eriogonum pyrolaefolium, Draba eurocarpa, Potentilla flabellifolia* and *Linnaea longiflora* are limited to the Bitter Root-Selkirk region, while *Pinus albicaulis* and *Stipa oregonensis* extend south to Wyoming, and *Vaccinium occidentale* to northern Utah.

5. Immigrants from Alaska and the arctic coast

The following are mostly arctic, a few being subarctic plants from near the arctic timber line, which extend farther south in the Rockies and are there found in the subalpine as well as the alpine zone. Of these *Silene repens, Micranthes Lyallii, Dasystephana glauca* and *Euphrasia mollis* extend as far south as Montana; the others are limited to the Canadian Rockies.

Shrubs

†*Salix myrtillifolia*
† " *alaxensis*
† " *Barrattiana*
† " *Seemanii*
" *Drummondiana*
Salix arbusculoides
" *desertorum*
" *saskatchewana*
†*Arctous erythrocarpa*

Herbs

Carex venustula
" *physocarpa*
" *MacCallae*
Silene repens
†*Anemone Richardsonii*
Aconitum delphinifolium
Sophia sophioides
Pilosella Richardsoniana
Arabis ambigua
Micranthes Lyallii

Micranthes aestivalis
Spathularia Brunnoniana
" *ferruginea*
Argentina subarctica
†*Hedysarum Mackenzii*
Moneses reticulata
*Androsace septentrionalis**
†*Amarella propinqua*
†*Dasystephana glauca*
†*Castilleja pallida*
Euphrasia mollis
Valeriana sitchensis
†*Campanula heterodoxa*
Erigeron grandiflorum
Erigeron lanatus
†*Antennaria monocephala*
†*Artemisia Richardsoniana*
Petasites frigida
" *corymbosa*
Senecio lugens

6. IMMIGRANTS FROM THE SOUTH

Immigrants from the south are almost unknown in the Subalpine Zone; they are more frequent in the Montane and Submontane Zone and are very common in the Sonoran. The following are the only ones found in the subalpine zone:

Pseudocymopterus purpureus
Blepharineuron tricholepis

III

1. ENDEMIC SPECIES, WHICH ALSO HAVE EMIGRATED INTO THE CASCADE MOUNTAINS

The endemic element of the Rocky Mountains is by far the largest. As the Rockies and the Cascades are connected through several mountain chains it is natural that many of the endemic Rocky Mountain species should have emigrated into the Cascade Mountains. Let us treat these species first.

The dominant tree in the Subalpine Zone is, as already stated in a previous article,† the Engelmann spruce, *Picea Engelmannii*. Often associated with it is found the subalpine fir, *Abies lasiocarpa*. Both extend throughout the Rockies from about latitude 55 degrees southward to the higher mountains of New Mexico and Arizona. They are also found in the northern portion of the western or Pacific province, i.e. throughout the Cascades, but not in the Sierra Nevada region. They are not found in the eastern province but are represented there by *Picea canadensis*, *P. mariana*, and *Abies balsamea*. Although the two species of *Picea* have been reported

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* Also in Europe.

† See Bull. Torrey Club 42: 11. Ja 1915.

from Alberta and Montana, all specimens referred to these and seen by me have turned out to belong to *Picea albertiana*. *Picea Engelmannii* and *Abies lasiocarpa* may be regarded as endemic Rocky Mountain species, which have emigrated into the Cascades. In the Northern Rockies there could be added to these *Larix Lyallii*, which has also emigrated into the northern part of the Cascades. In the very lowest part of the Subalpine Zone there are sometimes found intermixed trees of *Pseudotsuga mucronata* belonging really to the Montane Zone. It has about the same distribution in the Rockies as the spruce and fir mentioned above, but is also equally common though in the Pacific province and extends south into the Sierra Madre of Mexico. It is hard to tell if its original home was in the Rockies or on the Pacific coast.

The two species, *Picea Engelmannii* and *Abies lasiocarpa*, are not restricted to the Subalpine Zone, however, for both run down into the Montane Zone on northern slopes and along streams. The element of the Rocky Mountain flora, which has the same distribution as these, is, as stated before, not large and it contains no other woody plants.

Trees

Picea Engelmannii
Abies lasiocarpa

Herbs

Trisetum majus
Poa reflexa
" *leptocoma*
" *Paddensis*
" *nevadensis*
† " *rupicola*
†*Festuca saximontana*
Carex Engelmannii
" *pyrenaica**
" *petasata*
" *Geyeri*
Juncus balticus montanus
Ophrys nephrophylla
Trollius albiflorus
Cardamine acuminata
Arabis rupestris
" *Drummondii*
Lithophragma bulbifera
Ozomelis stauropetala
Leptasea austromontana
†*Sieversia ciliata*
Epilobium Drummondii
†*Phlox caespitosa*
Macronema grindelifolium
Aster apricus
Anaphalis subalpina
Antennaria umbrinella
" *anaphaloides*
Arnica Parryi
" *Rydbergii*

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* Also in Europe and Asia.

2. ENDEMIC SPECIES, COMMON TO THE NORTHERN AND SOUTHERN ROCKIES

The endemic element, which extends over the whole Rockies, but has not invaded the Cascades, is much larger, but it does not include any of the forest trees and only a few shrubs. It consists of the following species:

Shrubs

†*Salix petrophila*
† “ *saximontana*
“ *brachycarpa*
Ribes parvulum
†*Vaccinium oreophilum*
“ *scoparium*

Herbs

Potamogeton interior
Stipa Tweedyi
“ *minor*
“ *Nelsonii*
Deschampsia curtifolia
Poa Olneyi
“ *Buckleyana*
“ *epilis*
“ *laevigata*
Bromus Porteri
“ *Pumpellianus*
Festuca ingrata
Agropyrum andinum
“ *Scribneri*
Carex pseudoscirpoidea
† “ *albonigra*
† “ *chalciolepis*
† “ *scopulorum*
† “ *chimaphila*
Allium brevistylum
*Disporum trachycarpum**
Ophrys borealis
Eriogonum flavum
Bistorta linearifolia
†*Claytonia megarrhiza*
†*Oreobroma pygmaea*
Alsine strictiflora‡
Cerastium scopulorum
“ *strictum*
†*Alsinopsis propinqua*
† “ *obtusiloba*
Silene Douglasii
“ *Menziesii*
†*Anemone zephyra*
Thalictrum venulosum
Atragene tenuiloba
†*Ranunculus affinis*
† “ *eximius*
“ *alpeophilus*
Aquilegia caerulea
Thlaspi glaucum
†*Smelowskia americana*
Radicula alpina
†*Draba andina*
“ *crassa*
†*Clementsia rhodantha*
Heuchera parviflora
†*Saxifraga debilis*

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* East to Manitoba and the Black Hills.

‡ East to Quebec.

†*Muscaria adscendens**
" *delicatula*
†*Micranthes rhomboidea*
" *arnoglossa*
†*Spathularia Vreelandii*
Potentilla filipes
" *glaucophylla*
" *divisa*
† " *saximontana*
" *arachnoidea*
Fragaria glauca
†*Acomastylis turbinata*
Lupinus parviflorus
" *caespitosus*
†*Trifolium nanum*
Atelephragma elegans
Aragallus deflexus
†*Epilobium clavatum*
" *wyomingense*
Osmorrhiza obtusa
†*Vaccinium oreophilum*
" *scoparium*
†*Primula Parryi*
†*Androsace carinata*
" *subumbellata*
" *filiformis*
Anthropogon elegans
†*Dasystephana Romanzovii*
† " *affinis*
Pleurogyne fontana
Swertia scopulina
† " *congesta*
Leptodactylon pungens
†*Phlox depressa*
Phlox Kelseyi
" *alyssoides*
†*Phacelia sericea*
† " *ciliosa*
†*Eritrichum elongatum*
*Myosotis alpestris**
Besseya gymnocarpa
Castilleja rhexifolia
" *lanata*
" *lancifolia*
† " *occidentalis*
Valeriana edulis
Solidago scopulorum
† " *ciliosa*
" *oreophila*
Chrysopsis pumila
†*Aster alpinus**
" *Fremontii*
†*Erigeron trifidus*
" *glabellus*
" *flagellaris*
Antennaria microphylla
" *sedoides*
" *aprica*
Chaenactis alpina
†*Rydbergia grandiflora*
Achillea subalpina
†*Artemisia scopulorum*
Arnica subplumosa
" *rhizomata*
" *pumila*
†*Senecio Purshianus*
" *cymbalarioides*
" *pseudaureus*

3. ENDEMIC SPECIES LIMITED TO THE NORTHERN ROCKIES

The following endemics are not merely local but are practically limited to the Northern Rockies:

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* Also in Europe.

Shrubs

†*Salix Tweedyi*
Salix Fernaldii

Herbs

*Alopecurus caespitosus**
Agrostis idahoensis
Poa nervosa
" *confusa*
Sitanion rigidum
Agropyron latiglume
Xerophyllum Douglasii
Erythronium obtusum
Eriogonum caespitosum
" *heracleoides*
Spraguea multiceps
†*Alsine americana*
Arenaria lithophila
†*Silene Lyallii*
" *multicaulis*
Anemone tetonensis
" *lithophila*
Ranunculus saxicola
" *Helleri*
†*Caltha leptosepala*
†*Aquilegia Jonesii*
†*Smelowskia lobata*
†*Draba densiflora*
Arabis oreophila
" *exilis*
Coniomitella Williamsii
Heuchera flabellifolia
" *grossularifolia*
†*Telesonix heucheriformis*
†*Muscaria monticola*
†*Micranthes Rydbergii*
" *occidentalis*
† " *saximontana*
Potentilla glomerata
" *perdissecta*
" *Macounii*
" *ovina*
†*Acomastylis sericea*
Lupinus pulcherrimus
" *monticola*
Trifolium Haydeni
† " *montanense*
Cystium platytropus‡
Atelophagma Forwoodii
" *debilis*
Homalobus Bourgovii
†*Aragallus foliolosus*
† " *alpicola*
† " *viscidus*
† " *viscidulus*
Viola flavovirens
Epilobium latiusculum
" *saximontanum*
Ligusticum filicinum
Pseudoreoxys bipinnata
Angelica Roseana
Bupleurum americanum
" *purpureum*
Vaccinium globularis
†*Douglasia montana*
†*Dasystephana monticola*
Polemonium pulcherrimum
† " *viscosum*
†*Collomia debilis*
†*Phlox costata*
† " *diapensioides*

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* Canadian Rockies only.
‡ Also in Nevada.

Phacelia alpina
† " *Lyallii*
Mertensia stenoloba
† " *Tweedyi*
Pentstemon Lyallii
† " *montanus*
" *aridus*
" *pseudohumilus*
" *Tweedyi*
Synthyris laciniata
" *dissecta*
†*Castilleja Tweedyi*
† " *pulchella*
†*Pedicularis ctenophora*
† " *cystopteridifolia*
Oreostemma Haydeni
†*Erigeron radicatus*
Hulsea carnosa
Senecio sphaerocephalus
† " *alpicola*
" *megacephalus*

Some of these endemics of the Northern Rockies extend south into the Wasatch Mountains of Utah. As I have already stated, the exchange of species between the Northern and Southern Rockies does not take place along the continental divide in Wyoming, but between the Wasatch and Teton Mountains, through the Bear River Mountains in southeastern Idaho. This exchange is more evident in the Montane Zone, but the following northern endemics have crossed the line and their range extends into Utah:

Eriogonum heracleoides
Arabis oreophila
Anemone tetonensis
Potentilla Macounii
Ligusticum filicinum
Angelica Roseana
Vaccinium globulare
Polemonium viscosum
Collomia debilis
Synthyris laciniata

A few of the northern endemics extend eastwards into the Black Hills of South Dakota such as:
Atelephragma Forwoodii
Epilobium saximontanum

4. ENDEMIC SPECIES RESTRICTED TO THE SOUTHERN ROCKIES

The endemics are more numerous in the Southern Rockies than in the Northern. The more widely distributed are the following:

Shrubs

Salix pseudolapponum
" *Wolfii*
Ribes coloradensis
Ribes Wolfii
Sambucus microbotrys

Herbs

Muhlenbergia Wolfii
" *subalpina*
" *filiculmis*
" *gracilis*
†*Deschampsia alpicola*
†*Avena Mortoniana*
Trisetum montanum
Graphephorum Wolfii
†*Poa alpicola*
" *Vaseyana*
" *occidentalis*
" *lucida*
" *aperta*
" *longipedunculata*
" *Sheldoni*
† " *Pattersoni*
" *Traceyi*
† " *Grayana*
† " *Lettermanii*
Festuca arizonica
" *Thurberi*
† " *minutiflora*
Elymus simplex
Carex elynoides
" *occidentalis*
" *Egglestonii*
" *eburnea*
" *Nelsonii*
† " *bella*
Veratrum tenuipetalum
Anticlea coloradensis
Juncus Hallii
" *parous*
Juncoides subapetalum
Erythronium parviflorum
Sisyrinchium alpestre
Limnorchis purpurascens
Eriogonum arcuatum
" *chloranthum*
" *neglectum*
†*Paronychia pulvinata*
Cerastium Earlei
" *variabile*
" *oreophilum*
Alsinopsis macrantha
Arenaria confusa
" *Tweedyi*
" *Fendleri*
Silene Hallii
†*Wahlbergella montana*
Ranunculus alismaefolius[*]
" *Macauleyi*
" *micropetalus*
† " *adoneus*
† " *stenolobus*
†*Caltha rotundifolia*
†*Aquilegia saximontana*
" *elegantula*
" *oreophila*
Aconitum Bakeri
" *insigne*
Delphinium occidentale
" *Barbeyi*
†*Thlaspi coloradense*
† " *purpurascens*
†*Smelowskia lineariloba*
Lesquerella parvula
" *montana*
Sophia purpurascens
Cheirinia oblanceolata
" *nivalis*
† " *radicata*
† " *amoena*
†*Draba Parryi*

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[*] North to Wyoming.

Draba chrysantha
" *graminea*
" *streptocarpa*
" *spectabilis*
" *luteola*
" *aureformis*
†*Rhodiola polygama*
Ozomelis stenopetala
" *Parryi*
Heuchera flavescens
†*Telesonix Jamesii*
†*Saxifraga simulata*
†*Micranthes brachypus*
†*Leptasea chrysantha*
Potentilla modesta
" *viridior*
" *decurrens*
Drymocallis fissa
†*Trifolium stenolobum*
† " *lividum*
† " *dasyphyllum*
" *Brandegei*
† " *Parryi*
Homalobus humilis
Aragallus oreophilus
" *Parryi*
Lathyrus arizonicus
Geranium Pattersonii
Viola neomexicana
" *bellidifolia*
Epilobium ovatifolium
" *stramineum*
Ligusticum Porteri
Ligusticella Eastwoodiae
†*Oreoxis humilis*
† " *Bakeri*
† " *alpina*
Pseudocymopterus montanus
Pseudocymopterus sylvaticus
† " *Tidestromii*
Pseudopteryxia anisata
" *longiloba*
Oxypolis Fendleri
†*Angelica Grayi*
Conioselinum scopulorum
" *coloradense*
†*Primula angustifolia*
Androsace pinetorum
†*Anthropogon barbellatum*
†*Amarella monantha*
†*Condrophora Fremontii*
† " *americana*
Dasystephana Parryi
Ploemonium delicatum
" *foliosissimum*
† " *confertum*
" *miletum*
† " *Brandegei*
Gilia globularis
†*Phlox condensata*
Phacelia nervosa
†*Eritrichium argenteum*
Mertensia polyphylla
† " *lateriflora*
† " *Bakeri*
† " *nivalis*
† " *viridula*
† " *Parryi*
† " *alpina*
†*Pentstemon Hallii*
† " *stenosepalus*
† " *Harbourii*
† " *caespitosus*
Chionophila Jamesii
†*Besseya alpina*
" *plantaginea*

Besseya Ritteriana
Castilleja brunnescens
" *confusa*
† " *puberula*
†*Pedicularis Parryi*
" *Grayi*
† " *scopulorum*
Valeriana acutiloba
Campanula Parryi
Coleosanthus umbellatus
Solidago decumbens
†*Tonestus pygmaeus*
Oreochrysum Parryi
Chrysopsis alpicola
" *asprella*
Pyrrocoma Clementis
Townsendia grandiflora
Aster Canbyi
†*Erigeron pinnatisectus*
† " *melanocephalus*
† " *leiomeris*
" *glandulosus*
" *elatior*
" *superbus*
" *formosissimum*
Hymenopappus cinereus
†*Rydbergia Brandegei*
†*Artemisia Pattersonii*
†*Artemisia saxicola*
Arnica macilenta
" *ovata*
Senecio chloranthus
" *pudicus*
† " *amplectens*
" *pagosanus*
† " *Holmii*
† " *taraxacoides*
" *Soldanella*
" *carthamoides*
" *invenustus*
" *admirabilis*
" *lapathifolium*
" *crassulus*
" *perplexans*
" *anacletus*
" *atratus*
" *foliosus*
† " *Harbourii*
" *Nelsonii*
" *crocatus*
" *Jonesii*
† " *petrocallis*
" *pentadontus*
† " *werneriaefolius*
" *ambrosioides*
" *multicapitatus*

5. LOCAL ENDEMIC SPECIES

The following are rare and local species which have been collected at only one or two localities within the Canadian Rockies or the states mentioned below:

Canadian Rockies

†*Wahlbergella attenuata*
†*Cassiope saximontana*
†*Douglasia nivalis*
†*Mertensia Drummondii*
†*Antennaria chlorantha*
" *acuta*

Montana

†*Potentilla Vreelandii*
Dodecatheon uniflorum
Pedicularis Canbyi

Idaho

Allium simillisimum
Romanzoffia Leibergii
†*Tonestus laceratus*

Wyoming

†*Oreobroma minima*
Aconitum ramosum
†*Draba ventrosa*
†*Muscaria micropetala*
Potentilla wyomingensis
" *virgultata*
" *Nelsonii*
†*Pedicularis Hallii*
" *lunata*
†*Trifolium scariosum*
Mertensia viridis
Aquilegia larimiensis
†*Erigeron flabellifolius*
Arnica tenuis

Utah

†*Wahlbergella Kingii*
Aquilegia scopulorum
Delphinium attenuatum
Capnorchis brachycarpum
Lesquerella Wardii
†*Draba sobolifera*
" *brachystylis*
Gormannia debilis
Edwinia macrocalyx
Potentilla paucijuga
†*Synthyris pinnatifida*
Castilleja viscida
" *parvula*

Colorado

Poa callicroa
" *pudica*
" *tricholepis*
Allium Pikeanum
Alsine polygonoides
Radicula curvipes
Radicula Underwoodii
Arabis oblanceolata
†*Potentilla tenerrima*
† " *minutifolia*
†*Trifolium bracteolatum*
†*Trifolium attenuatum*
†*Aragallus Hallii*
†*Polemonium Grayanum*
Besseya reflexa
Chaenactis peduncularia

One of the strangest distributions is that of *Viola biflora*, a European species, which has been collected in America only at a few places in Colorado and in Alaska.

SUMMARY

The subalpine flora contains over eight hundred species. Of these about 30 per cent. are also found above the timberline and about 60 per cent. are also found in the Montane Zone or pine belt. This leaves only about 10 per cent., which are restricted to the Subalpine Zone. The percentage of characteristic subalpine species is, however, larger, probably 25 per cent. or 30 per cent. of the number, for the 30 per cent. growing above the timberline is divided into two categories, alpine plants descending below the timberline, and subalpine species ascending above the same. So are also some of the plants which are common to the Subalpine and Montane Zones, essentially subalpine, though they descend into the upper part of the Montane Zone. A small proportion is even common to the three zones, and a few, as for instance *Poa crocata*, range from the plains to the alpine regions.

Of the eight hundred species, over 20 per cent. are transcontinental plants, and of these the larger part, about 15 per cent. of the whole number, extend as far south as Colorado and scarcely 2 per cent. are confined to the Canadian Rockies. About one hundred species are common to the old world. Besides the transcontinental element nearly 20 per cent. more are common to some part of the Rocky Mountain region and some part of the Pacific mountains. Of these about 5 per cent. are equally distributed throughout both provinces and 6 per cent. limited to the northern part of both. The remainder is about equally divided between Rocky Mountain plants which have invaded the Cascades and Pacific plants found in the Northern Rockies.

The strictly endemic species constitute nearly 60 per cent., and if those which have invaded the Pacific mountains are added the endemic element comprises about 70 per cent. of the flora. Of the 60 per cent. of strictly endemic plants fully one half are restricted to the Southern Rockies, fully one fourth common to both, and less than one fourth restricted to the Northern.

Of the trees and shrubs found in the Subalpine Zone, eighteen are transcontinental, eighteen are common to the Pacific mountains or emigrants from them, nine are immigrants into the Canadian Rockies from arctic regions, and eighteen are endemics, five of which have invaded the Cascades. Of the endemics, eight are common to both the northern and the southern Rockies, and five are limited to each region; none of them are strictly local.

NEW YORK BOTANICAL GARDEN

Branched prothallia in the Polypodiaceae*

ELIZABETH D. WUIST

(WITH FIFTEEN TEXT FIGURES)

INTRODUCTION

Branching in the early stages of the gametophytes of the Polypodiaceae has received little attention in the literature. Branching in older prothallia by means of adventitious outgrowths arising from any part of the prothallium has been described for various genera by Wiegand ('49), Hofmeister ('51), Kny ('70), Goebel ('77), De Bary ('78), Bauke ('78), Dodel-Port ('80), Klebs ('93), Heim ('96), Lagerburg ('06), Pace ('10), Heilbronn ('10), Fischer ('11), Schlumberger ('11), Wuist ('13), Pickett ('14), and Black ('15). Few cases have been cited where branching took place at an early period in the development of the gametophyte, except in the case of *Vittaria* which has been described and figured by Britton and Taylor ('02). As it is characteristic of the prothallia of that genus to branch extensively, resembling in this respect the gametophytes of the Hymenophyllaceae, no examples will be cited. Among the other genera of the Polypodiaceae the following cases of branching, while the prothallia were still in the filamentous stage, have been noted. Beck ('80) described branched prothallia of *Scolopendrium vulgare* Sm., while Klebs ('93) by means of weak light obtained, in *Polypodium aureum* L., branched prothallia with adventitious outgrowths. Atkinson ('94) observed "in *Adiantum cuneatum* . . . some curious forms of starved prothallia," and added: "In one case, first noted by a student, the protonemal thread forked a short distance from the spore, and the branches extended at right angles to the primary thread like the arms of the letter T, each arm bearing a prothallium. In another case observed the young prothallium produced nearly colourless protonemal threads from marginal cells. Each of these threads bore a prothallium, and in turn produced marginal threads

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* Contribution from the Osborn Botanical Laboratory.

bearing other prothallia." Lagerburg ('06) figured a slightly branched filamentous male gametophyte of *Pteridium aquilinum* (L.) Kuhn. Pace ('10) described branched filamentous prothallia of an unknown genus, and Black ('15) observed extensive branching among the filamentous prothallia of *Onoclea sensibilis* L. which had grown in a submerged condition in cultures of distilled water.

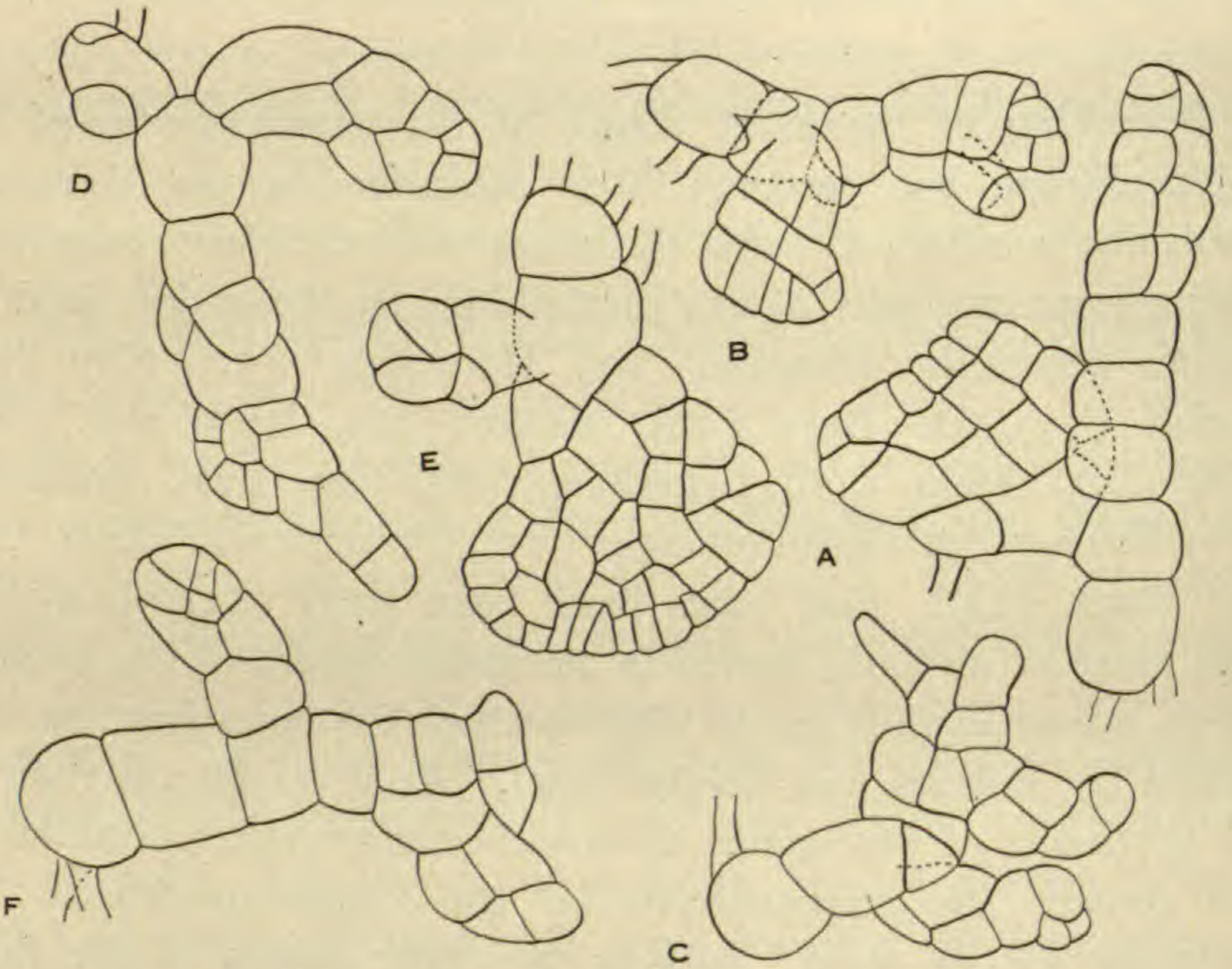

FIG. 1. Branched prothallia of *Onoclea sensibilis* L., × 125.

MATERIAL

The branched prothallia described in this paper occurred in cultures which had been made for the study of the comparative length of the filamentous stage in various genera of the Polypodiaceae. The genera which showed a tendency to branch were the following: *Adiantum*, *Asplenium*, *Camptosorus*, *Onoclea*, *Phegopteris*, *Polypodium*, *Pteridium*, *Scolopendrium*, *Woodsia* and *Woodwardia*. The spores of these various genera were obtained from several sources. Those of *Adiantum* were secured from the greenhouse of the botanical department, Cornell University, and those of *Phegopteris* came from a lawn in Ithaca, New York. The spores of *Camptosorus* and *Scolopendrium* were collected in eastern New York by Mr. Ten Eyck Burr; while those of *Asplenium*, *Onoclea*, *Pteridium* and *Woodsia* were obtained from the wild botanical gardens of Minneapolis, Minnesota, through the courtesy of Miss Eloise Butler. The spores of *Woodwardia* were collected near Ann Arbor, Michigan.

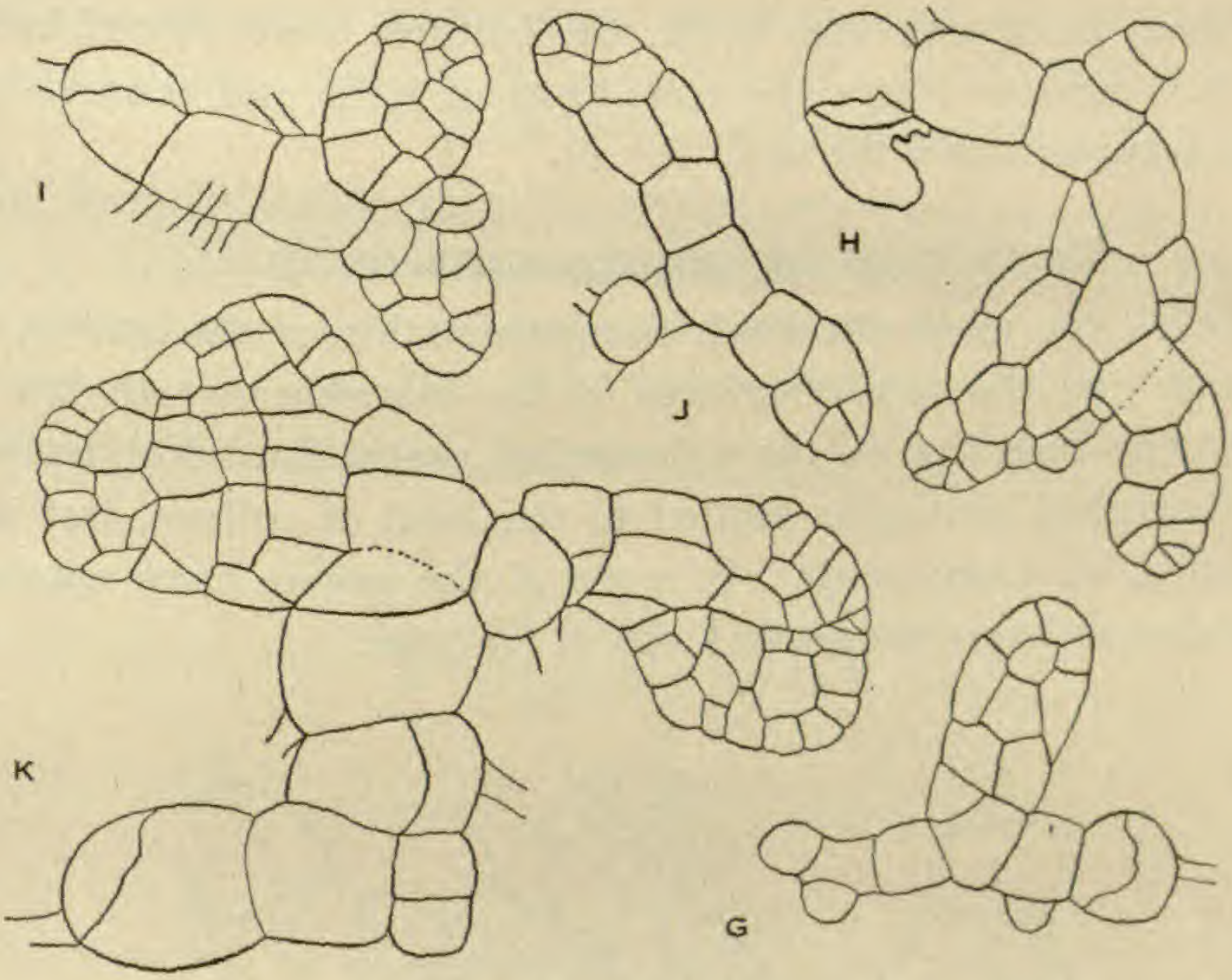

FIG. 2. Branched prothallia of *Onoclea sensibilis* L., × 125.

Cultures of these genera were made by sowing the spores on distilled water and on soil. A series of cultures of *Camptosorus*, *Phegopteris*, *Pteridium*, *Onoclea*, *Scolopendrium*, and *Woodwardia* were made by sowing the spores on Knop's and Prantl's full solutions and on certain modifications of these solutions.

The formulas used in making up Knop's and Prantl's ('81) nutrient solutions are as follows:

Knop's Solution	
$MgSO_4$	0.25 g.
$Ca(NO_3)_2$	1.00 g.
K_2HPO_4	0.25 g.
KCl	0.12 g.
$FeCl_3$	trace

Prantl's Solution	
K_2SO_4	0.7 g.
$NaCl$	0.23 g.
$CaSO_4$	0.7 g.
$MgSO_4$	0.5 g.
Na_3PO_4	0.5 g.
NH_4NO_3 solution, 0.064 per cent.	20 c.c.

The modifications employed were the following:

Knop's Solution
- (*a*) $Ca(NO_3)_2$ omitted

Prantl's Solution
- (*a*) NH_4NO_3 omitted
- (*b*) NaCl and Na_3PO_4 omitted
- (*c*) NaCl omitted
- (*d*) Na_3PO_4 omitted
- (*e*) $CaSO_4$ omitted

After the spores were sown, the cultures were placed before an east window where the conditions of light and temperature were approximately the same for all.

DESCRIPTION OF THE BRANCHED PROTHALLIA

In all the cases observed, the germination of the spores, the manner and the rate of growth in the branching prothallia did not differ from that of the unbranched prothallia. Neither were the branched prothallia limited to one kind of culture, but were found in all three kinds. In some of the genera they appeared simultaneosluiyn the three kinds of cultures.

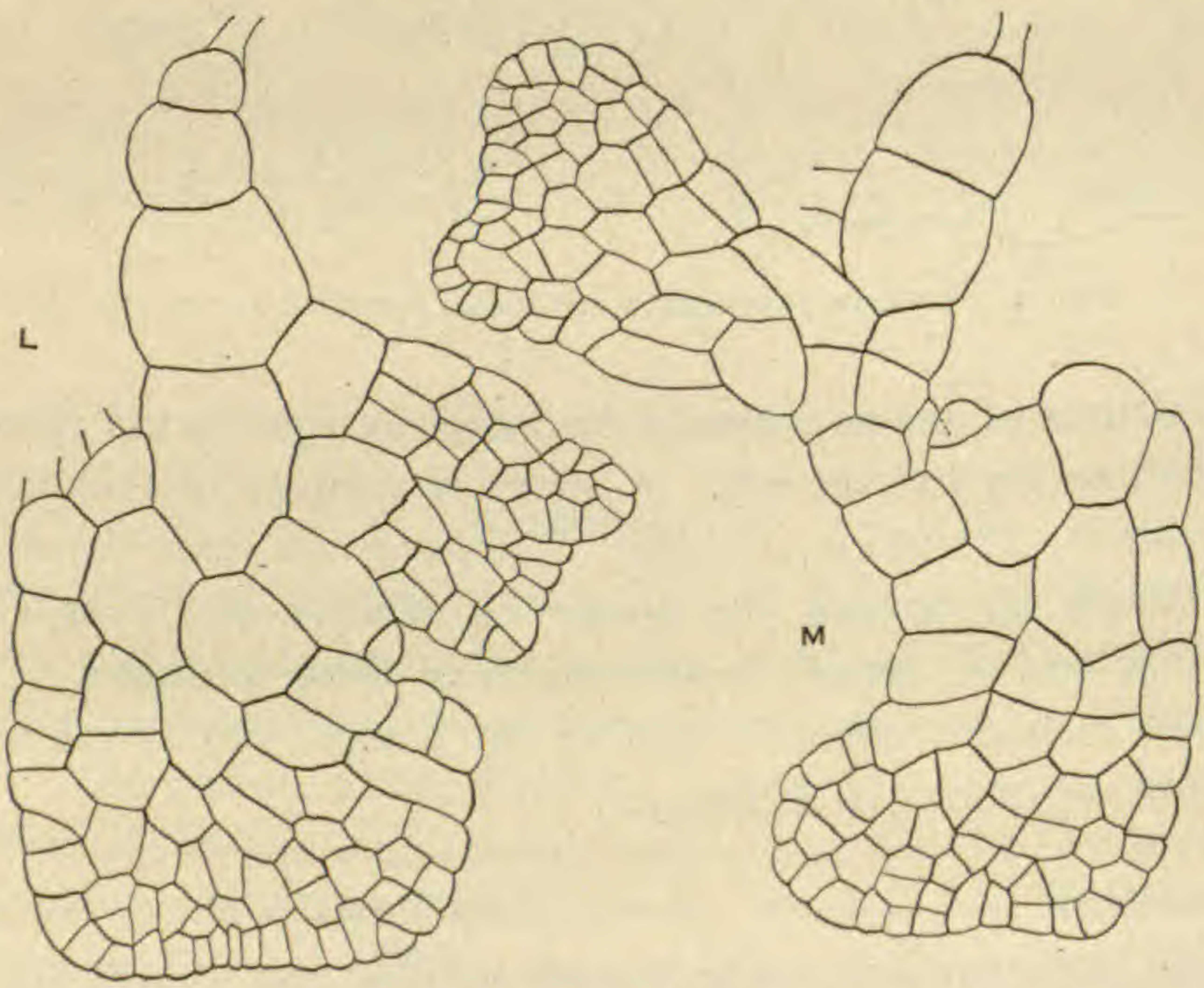

FIG. 3. Branched prothallia of *Onoclea sensibilis* L., × 75.

Onoclea sensibilis L.—The prothallia of this species both on the distilled water and the soil cultures showed a decided tendency to branch. Likewise, the branches showed a great diversity of origin and form, and the beginnings of apical cells or more advanced apical growth was present in all of them. The branched prothallia shown in FIGS. 1, A–F; 2, G–J; 4, N–Q; and 5, R–T, developed on the distilled water cultures, while those in FIGS. 2, K; 3, L, M; and 5, U, developed close to the inner pot wall on the soil cultures. FIG. 1, A, D, shows branched prothallia whose branches originated in the second cell of the filament. In these prothallia the branches tended to form immediately a plate of cells, while the cells of the filaments continued to divide transversely until three and five cells were formed before they developed an expanded region. In FIG. 1, B, C, while the first branches developed from the second cell of the filament, later branches were given off by the expanded portions of the prothallia. FIG. 1, D, shows not only the development of a branch from the second cell of the filament but also

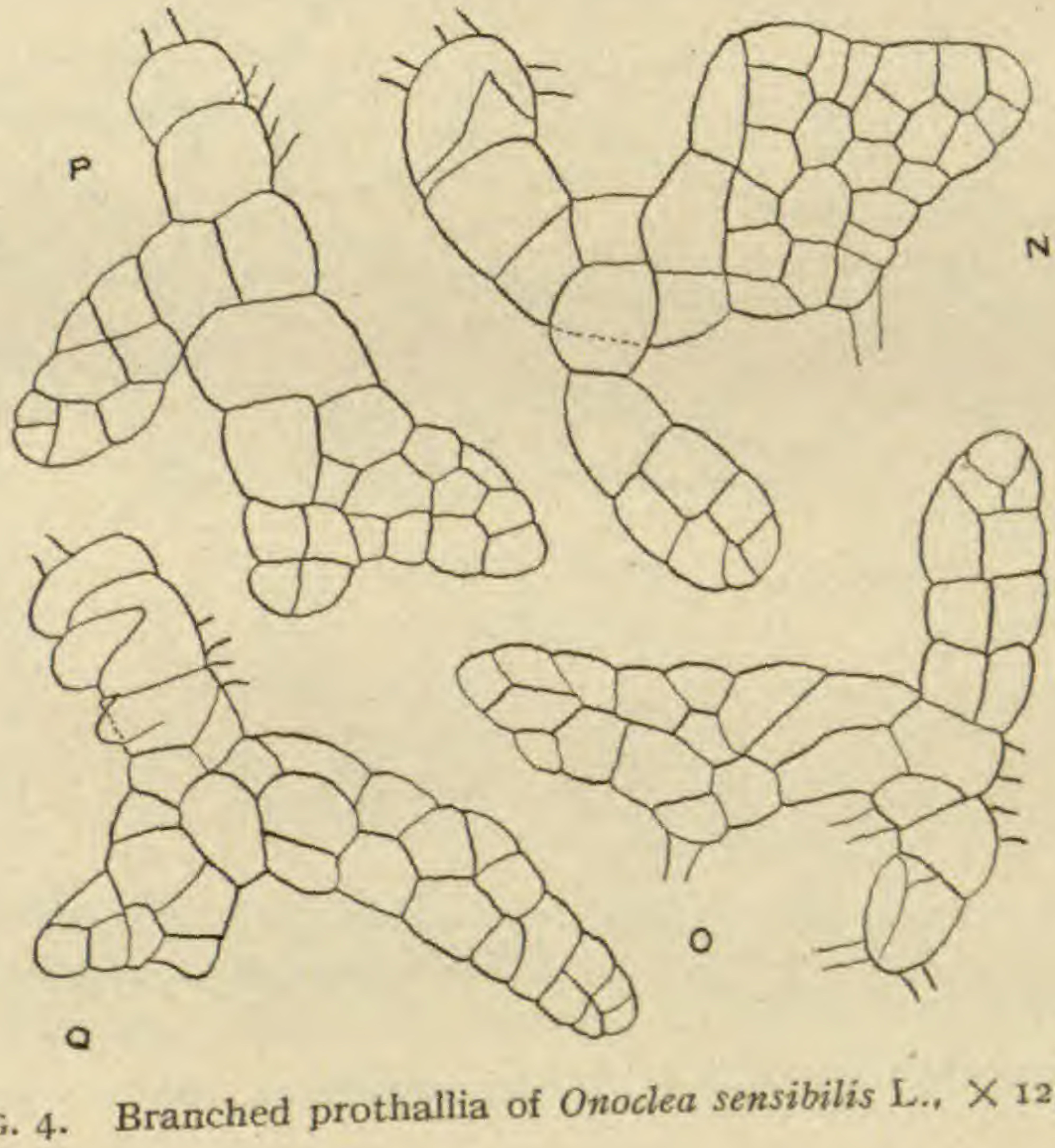

FIG. 4. Branched prothallia of *Onoclea sensibilis* L., × 125.

the tendency of the prothallium to revert to a filamentous stage after a small plate of cells has been formed, if the nutrition is not sufficient to meet its needs. In FIGS. 1, F; and 2, G, H, it seems characteristic for the first branch to originate in the third cell of the filament. However, other branches developed from the more expanded portion of the prothallia. FIG. 2, I, J, shows pronounced cases of dichotomous branching which occurred where the filament usually gave rise to the expanded portion of the prothallium. In both of these cases the branches originated in the third cell of the filament. In FIG. 2, J, the group of cells at the apex between the branches indicate that there will be a continuation of the main growth of the prothallium. In FIGS. 2, K, and 3, L, M, dichotomous branching developed at a slightly later stage after the first divisions of the expanded portion of the prothallia had been formed. FIG. 4, N–Q, show single lateral branches which appear to have originated at about the same period in the development of the prothallia as the dichotomous branches shown in FIGS. 2, K, and 3, L, M. FIG. 5, R, S, shows branches developed from the expanded portions of the prothallia. In FIG. 5, R, the branch formed a plate of cells while in FIG. 5, S, it tended to assume a filamentous character. FIG. 5, T, shows another case of dichotomous branching but at a later stage in the development of the prothallium. Here it occurred at the apex of the expanded region of the young prothallium. FIG. 5, U, is unique in that the branch appears to have originated in the first, second and third cells of the filament.

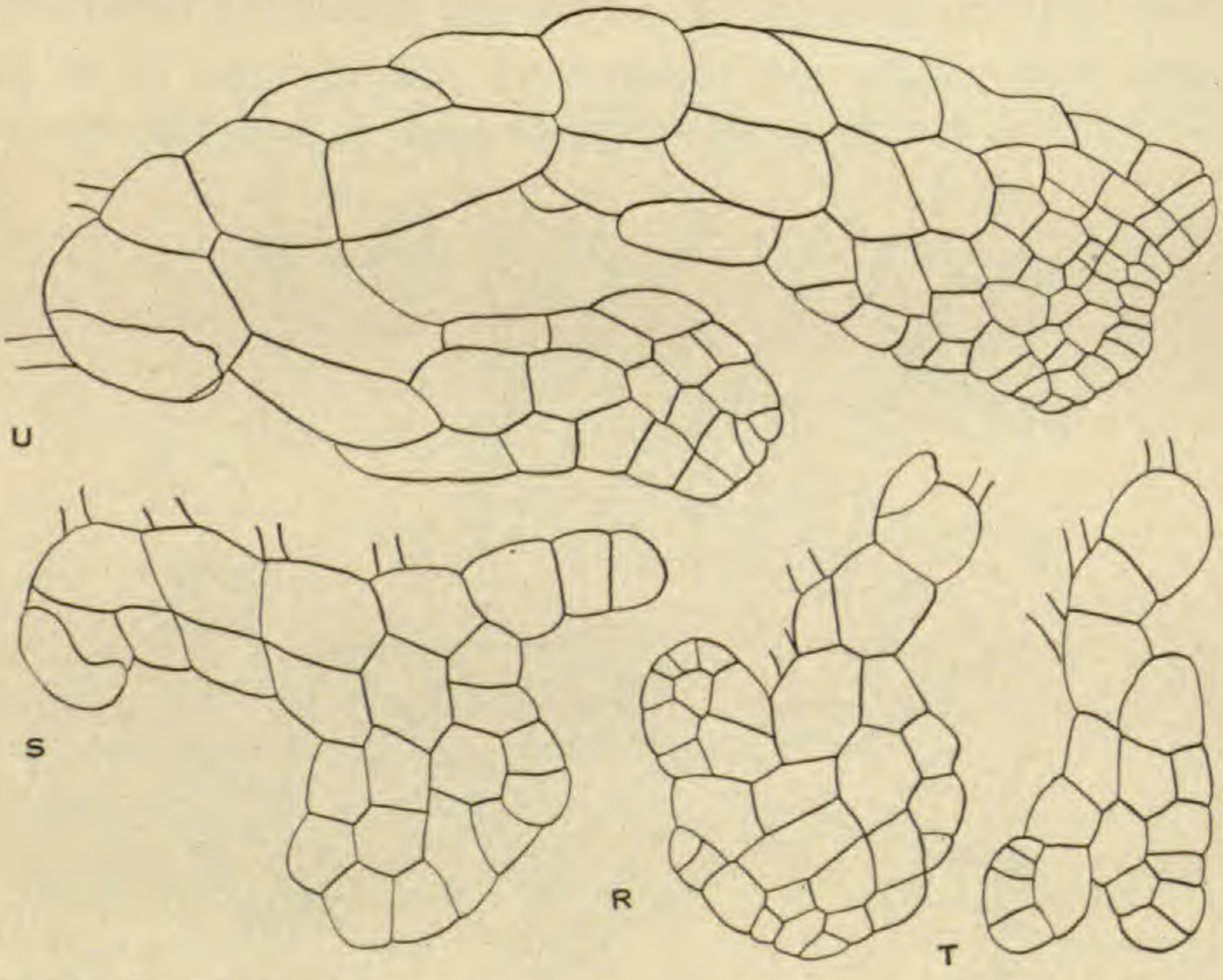

FIG. 5. Branched prothallia of *Onoclea sensibilis* L. R–T, × 125; U, × 75.

Adiantum bellum Moore.—Branched prothallia in the various species of *Adiantum* studied occurred only on the distilled water cultures. In FIG. 6, A, is shown the only case of branching which was observed *in A. bellum.* Here the filamentous branch originated in the first cell of the filament.

Adiantum Capillus-Veneris L.—Examples of branching among the prothallia of this species were frequently observed. In all cases the branching was monopodial and in the majority of cases, as shown in FIG. 6, B–G, the branches developed from the second cell of the filament. FIG. 6, C–E, shows the manner of development of the branch and likewise the continued growth of the main filament. In FIG. 6, F, no filament had been developed; the second cell divided to form the beginnings of the expanded portion of the prothallium. From this expanded region the branch was given off.

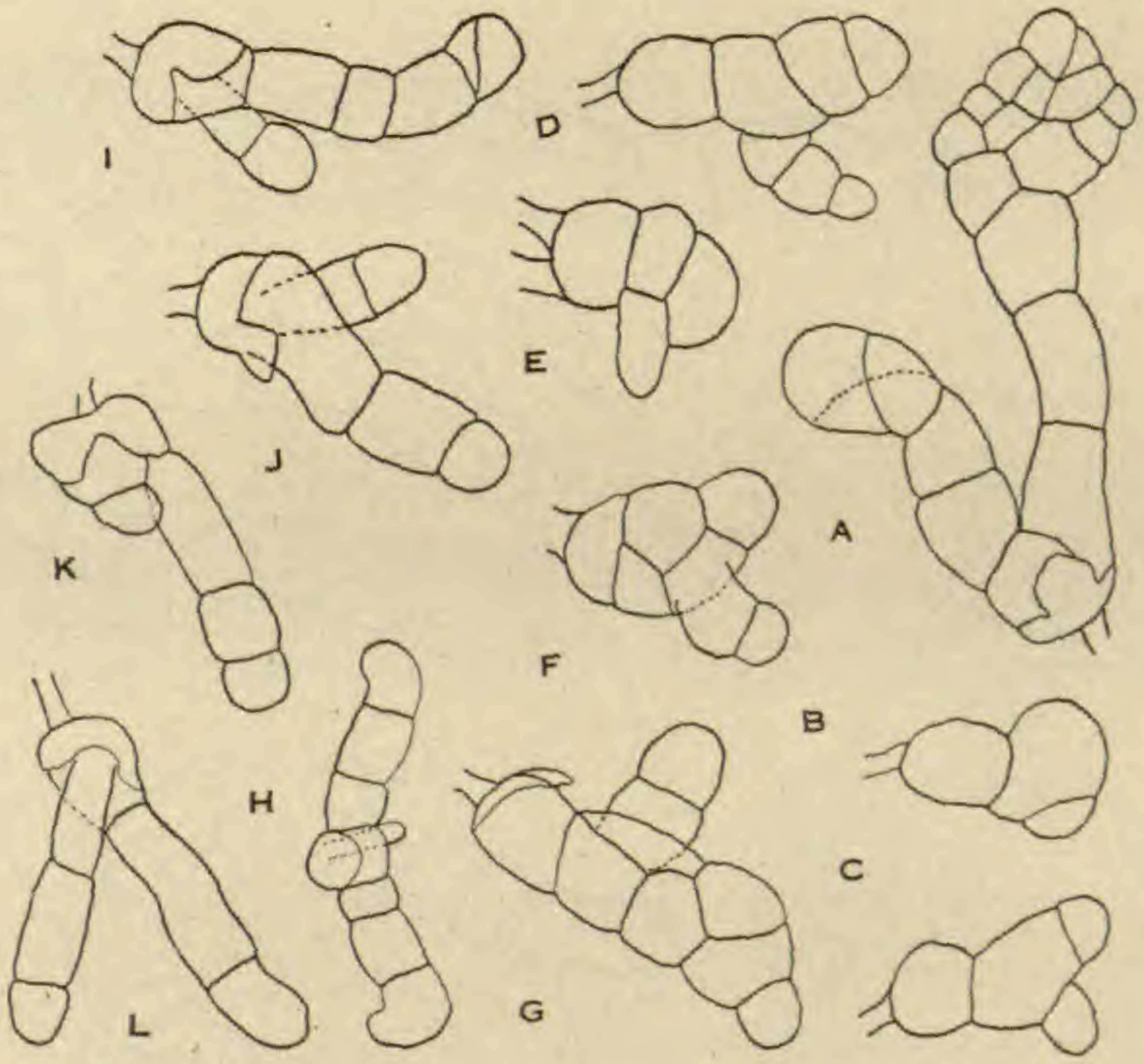

FIG. 6. A. Branched prothallium of *Adiantum bellum* Moore, × 175. B–G. Branched prothallia of *A. Capillus-Veneris* L., × 125. H. Branched prothallium of *A. cardiochloena* Kunze, × 125. I–L. Branched prothallia of *A. cuneatum* Langsd. & Fisch., × 125.

Adiantum cardiochloena Kunze.—FIG. 6, H. Here the branch developed from the cell which was cut off by the formation of a vertical wall in the second cell of the filament.

Adiantum cuneatum Langsd. & Fisch.—FIG. 6, I–L. Branching in this species occurred at an early stage in the development of the prothallia. The branches originated in the first cell of the filament and the growth in all cases was very rapid. In FIG. 6, L, is shown a prothallium with a branch as long as the main filament.

Adiantum trapeziforme L.—FIG. 7, A–G, represents branched prothallia of this species. Here branching was both dichotomous and monopodial. In FIG. 7, E, is shown an unusual case of dichotomous branching where both branches tended to grow in the same direction.

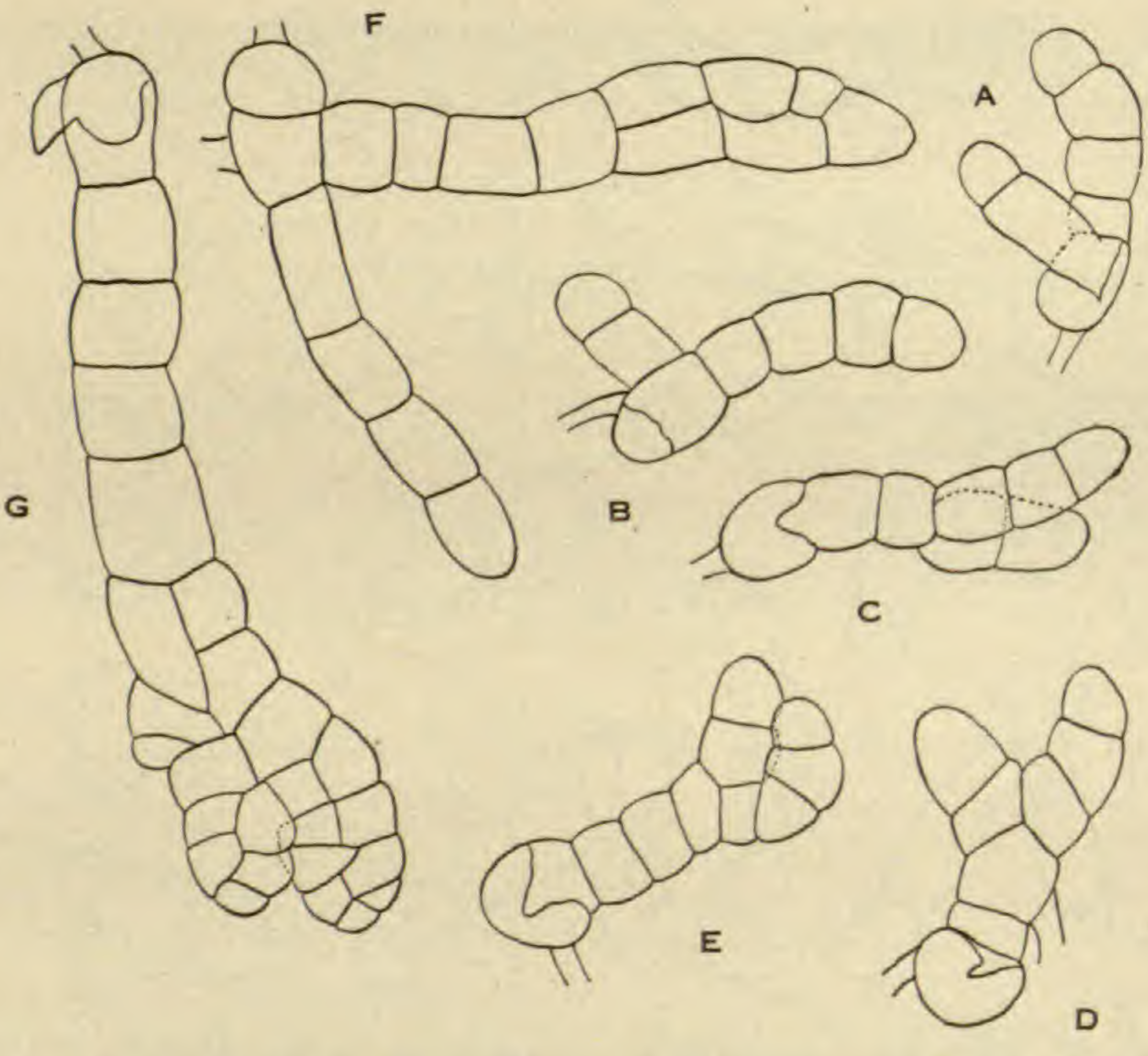

FIG. 7. Branched prothallia of *A. trapeziforme* L., × 125.

Camptosorus rhizophyllus (L.) Link.—FIG. 8, A–D, shows branched prothallia of this species which developed on the distilled water cultures, while FIG. 8, E, shows a prothallium which developed on the inner surface of the pot wall of the soil cultures. FIG. 8, A–D, shows the beginnings of branching in very young prothallia. Branching in two of the cases was dichotomous and in the other two cases monopodial. A few days after the spores were sown on the distilled water, germination took place in the normal manner. In FIG. 8, A, the first prothallial cell instead of dividing by a transverse wall to form a filament of two cells, cut off by two oblique longitudinal walls, a branch cell on either side. FIG. 8, B, C, shows similar cases, however in FIG. 8, B, the second instead of the first prothallial gave rise to the branches. In FIG. 8, C, both the second and third cell each gave rise to a branch while the third cell of the filament continued the growth of the prothallium. In FIG. 8, D, the branch cell which developed from the first prothallial cell divided immediately to form the beginning of a plate of cells. The branched prothallium shown in FIG. 8, E, is in a much more

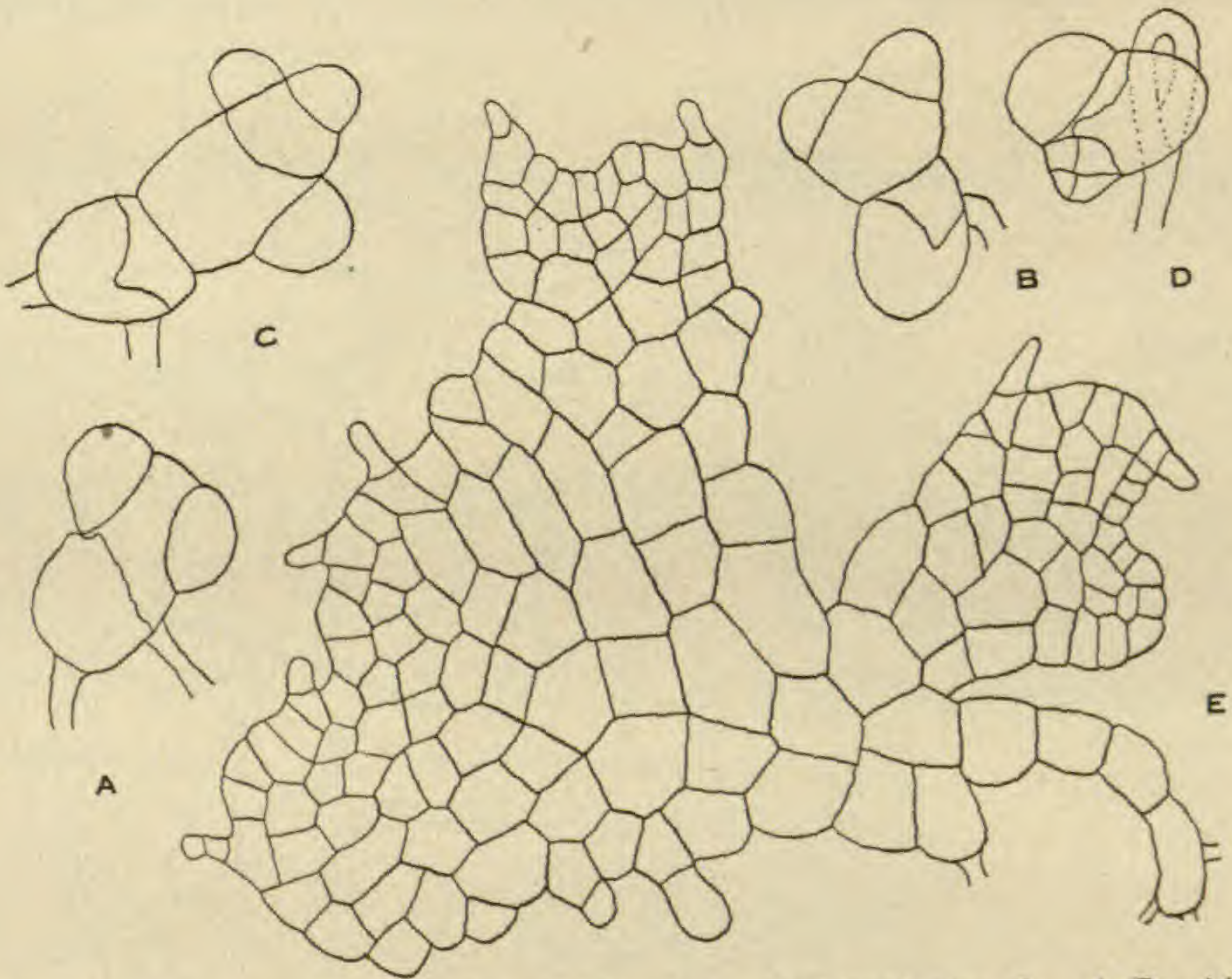

FIG. 8. Branched prothallia of *Camptosorus rhizophyllus* L. A–D, × 125; E, × 75.

advanced stage of development. Here a filament of four cells was formed, then a plate of cells developed. From this plate, early in its development, a lateral branch was cut off which in turn formed an expanded prothallium. The original plate of cells continued its growth into a broad prothallium which showed a decided tendency to branch at its apex.

Asplenium Filix-femina (L.) Bernh.—The branched prothallia of *A. Filix-femina* were observed on both the soil and distilled water cultures. FIG. 9, A, B, developed on the distilled water cultures and FIG. 9, C, on the inner surface of the pot wall where the light conditions were good and the prothallium was not crowded by other prothallia. FIG. 9, A, shows a young branched prothallium of about twenty cells, which had formed a filament of three cells in the usual manner before the expanded portion of the prothallium developed. The second cell of this filament gave rise to a filamentous branch of three cells; the terminal one of which divided by two oblique longitudinal walls to form the beginnings of an apical cell. From the first cell of the branch was cut off laterally a cell which would later develop into another branch. The expanded portion of the prothallium also gave rise to a short filamentous branch of two cells.

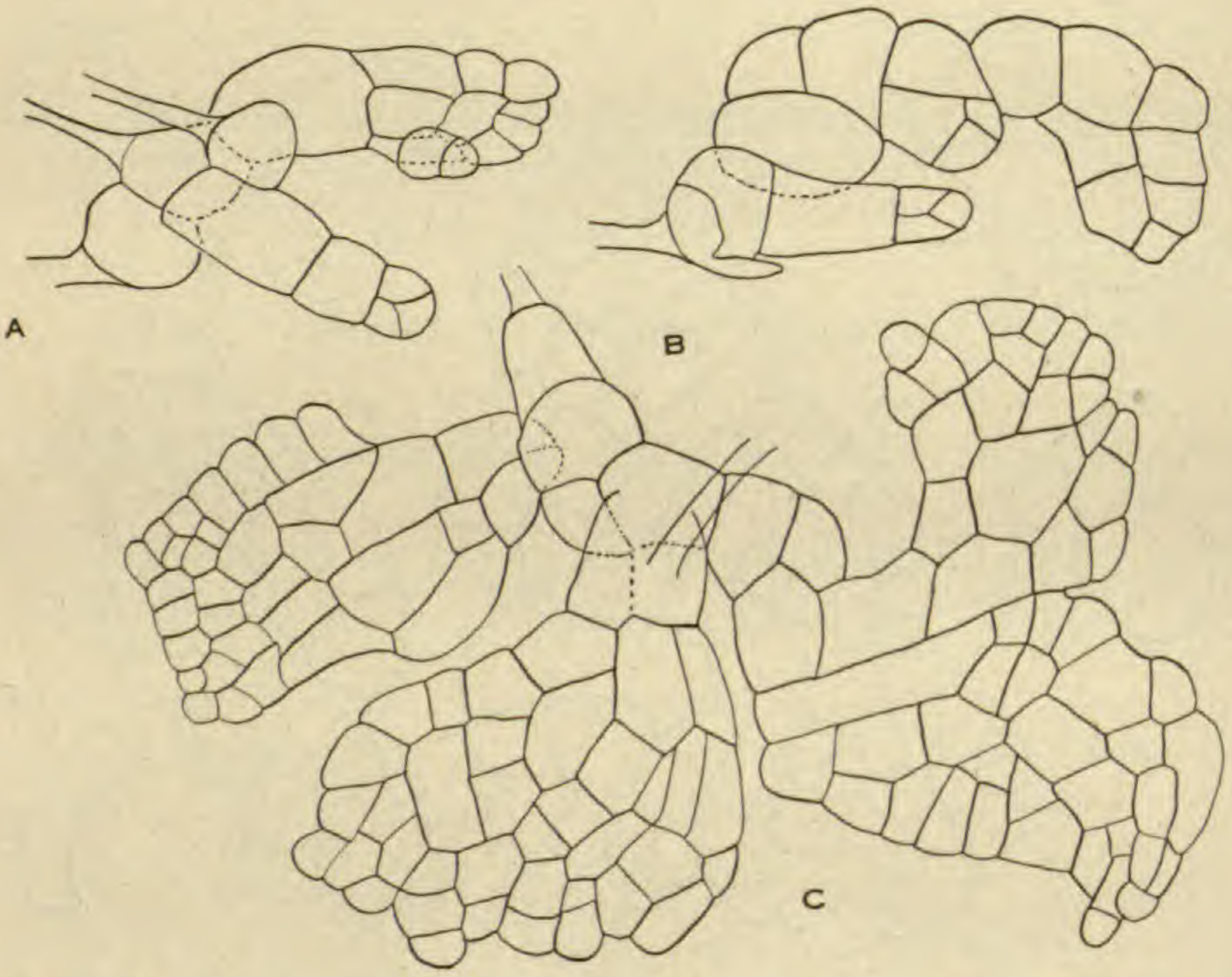

FIG. 9. Branched prothallia of *Asplenium Filix-femina* (L.) Bernh., × 75.

In FIG. 9, B, a short filament of three cells was first formed by transverse divisions, then the third cell divided in such a manner as to form the beginnings of an apical cell. In the meantime a cell was cut off laterally from the first cell of the filament. By transverse and longitudinal divisions this branch developed becoming two cells in width and forming at the apex the beginnings of an apical cell. An extreme case of branching is shown in FIG. 9, C. A filament of three cells formed in the usual manner. From the second cell there was cut off laterally a cell which developed immediately by longitudinal and transverse divisions into an expanded branch with a definite growing region at the apex. The third cell of the original filament divided by a longitudinal division into two cells, a larger and a smaller one. From the larger of these two cells a branch developed which formed another expanded prothallium whose growing point was not definitely marked. In the meantime the growth of the primary prothallium had continued and an expanded part was formed showing a decided tendency to branch dichotomously at the apex.

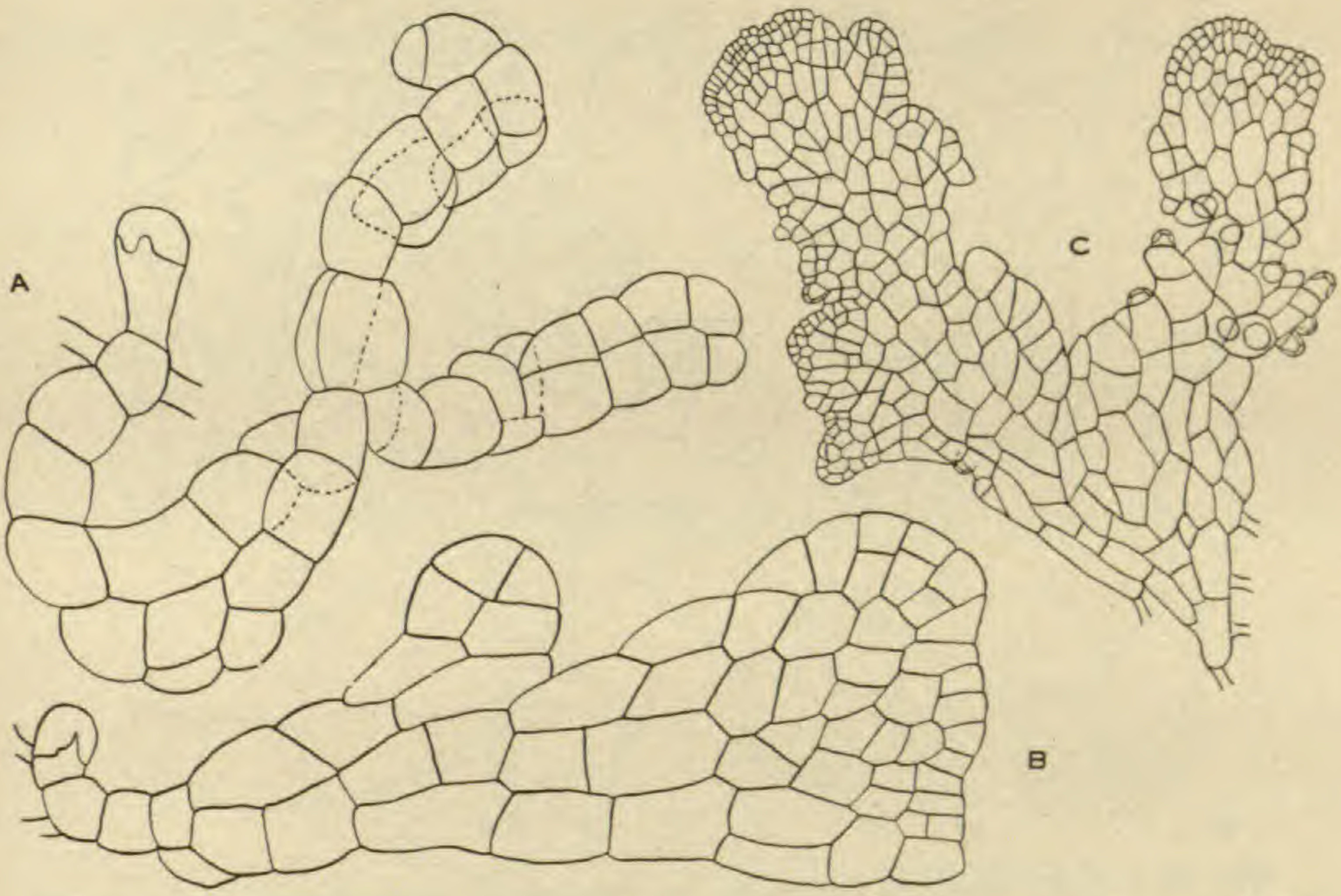

FIG. 10. A, B. Branched prothallia of *Asplenium bulbiferum* Forst., × 75. C. Branched prothallium of *Asplenium platyneuron* (L.) Oakes, × 75.

Asplenium platyneuron (L.) Oakes.—FIG. 10, C, shows a prothallium of this species which developed in a crowded region on a soil culture. In this case branching occurred at a later period in the development of the prothallia. No filament was formed in the early development of the prothallium, but the second cell by division gave rise immediately to the beginnings of an expanded cell plate which during development branched dichotomously. Each branch in turn formed a distinct growing region at its apex.

Asplenium bulbiferum Forst.—The two examples of branched prothallia which are shown in FIG. 10, A, B, developed on the distilled water culture. In both cases the branches originated after the expanded portion of the prothallia had been formed. In FIG. 10, A, the branching was dichotomous. This example is especially interesting as showing the tendency of the prothallium to revert to a filamentous condition at the time of the formation of the filamentous branch. In FIG. 10, B, branching was monopodial and the branch tended to form immediately a plate of cells.

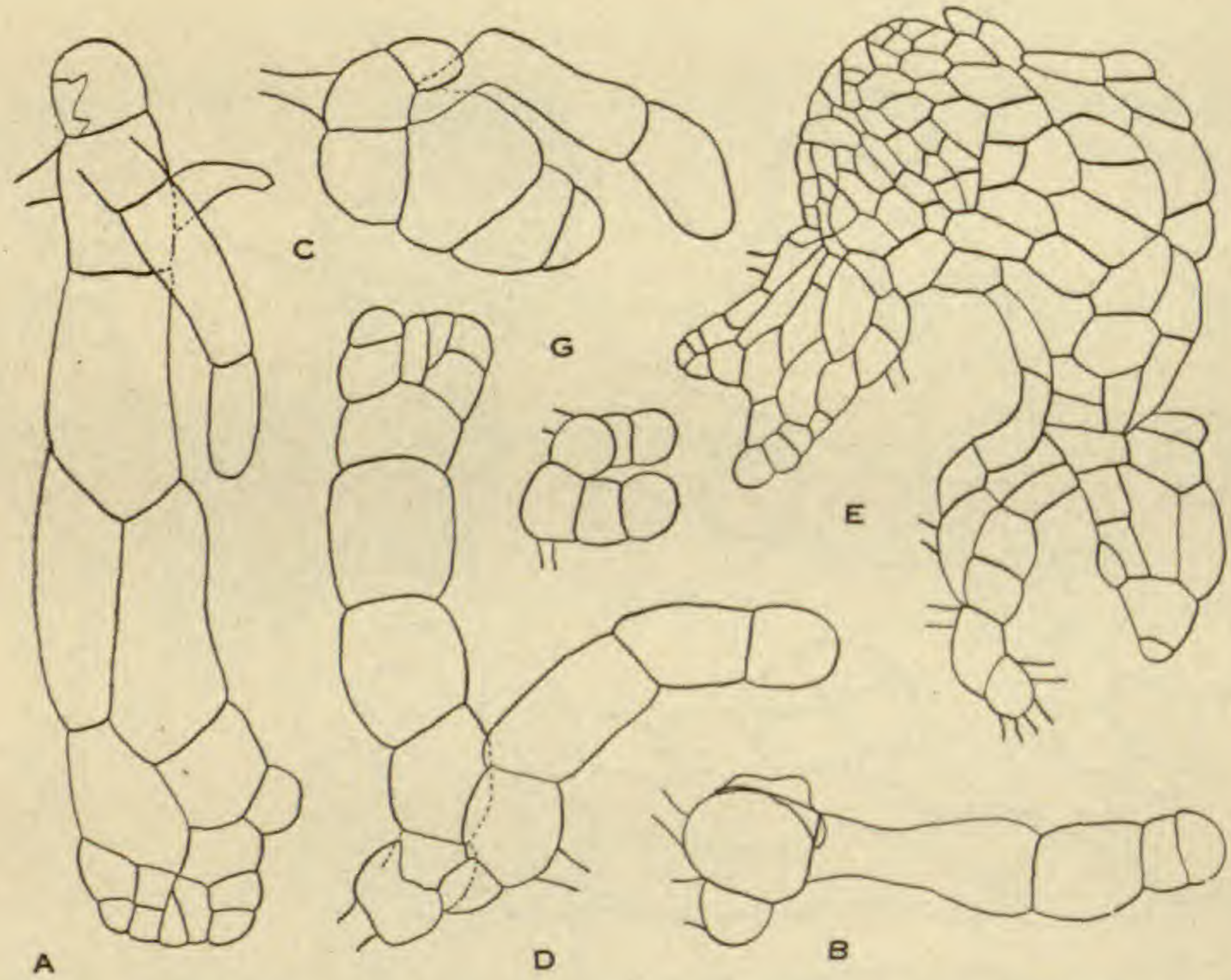

FIG. 11. A–E. Branched prothallia of *Phegopteris polypodioides* Fée, × 125. G. Branched prothallium of *Polypodium aureum* L., × 125.

Phegopteris polypodioides Fée.—The branched prothallium which is shown in FIG. 11, A, occurred in an uncrowded region of the soil culture while those shown in FIGS. 11, B–E, and 12, F, developed in modified Prantl's solutions. FIG. 11, B–D, was found in the Prantl's solution with K_2SO_4 omitted, while FIGS. 11, E, and 12, E, occurred in Prantl's solution from which $CaSO_4$ had been omitted. In all cases observed the branching was monopodial. In FIG. 11, A, the branch was filamentous in form and originated in the second cell of the filament. FIG. 11, B, shows the origin of the branch from the first cell of the filament and FIG. 11, D, shows the further development of this branch into a filament of five cells. In FIG. 11, C, is shown an interesting example of branching. Here the first prothallial cell instead of dividing by a transverse wall into two cells, divided by means of a longitudinal wall, thus forming two cells side by side. One of these cells by growth and transverse division continued the growth of the filament while the other gave rise to two branches. One formed a filament of two cells, the first of which was extremely long. In FIGS. 11, E, and 12, the branches were not formed until the expanded portion of the prothallia had begun to develop. In FIG. 12, the expanded portion later showed a decided tendency to branch monopodially at its apex.

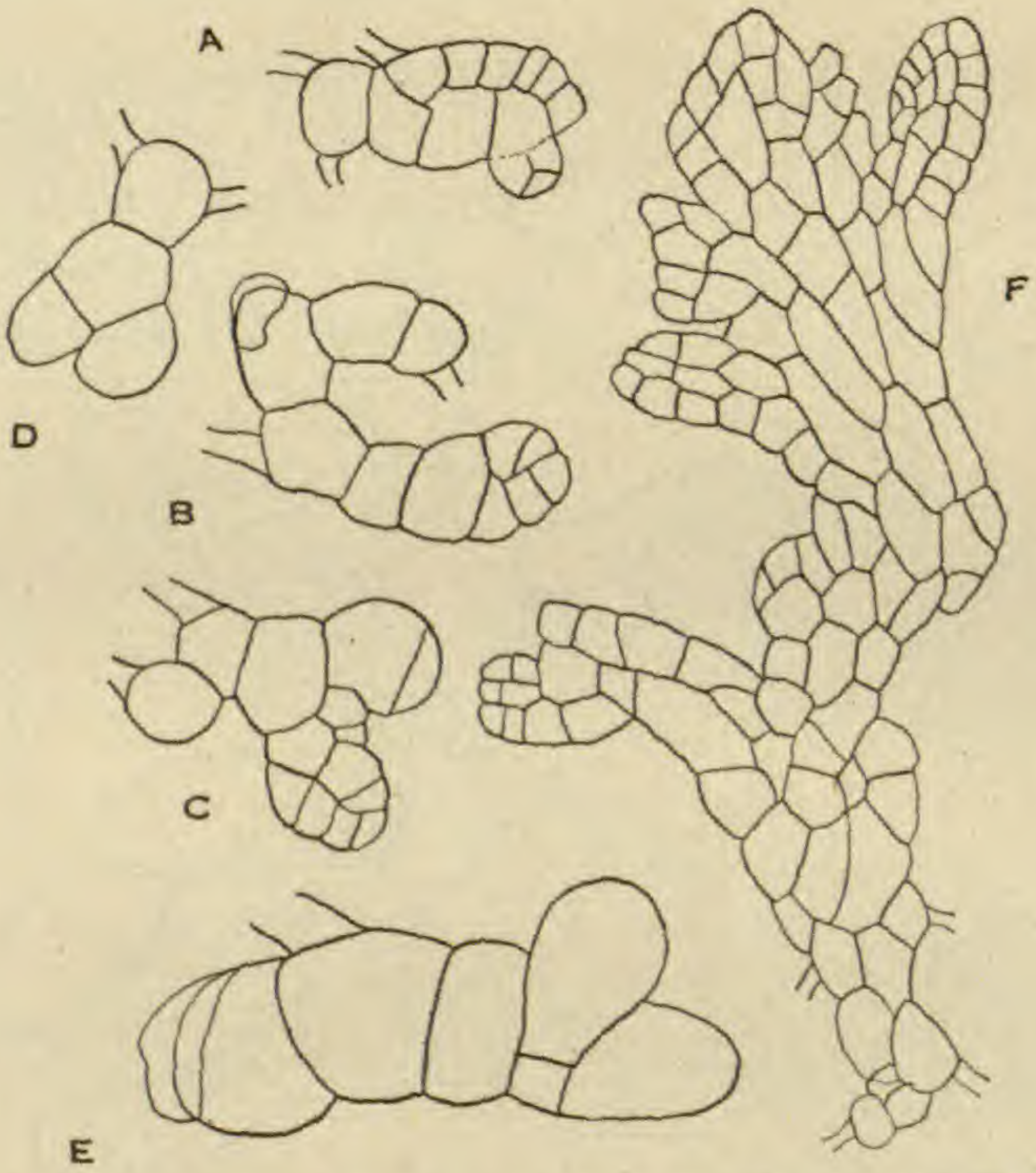

FIG. 12. A–E. Branched prothallia of *Woodsia obtusa* (Spreng.) Torr., × 125. F. Branched prothallium of *Phegopteris polypodioides* Fée, × 75.

Polypodium aureum L.—Only one case of branching was observed in this species and it developed on the distilled water culture. As shown in FIG. 11, G, the branch originated in the first prothallial cell. The rate of growth was the same for both the main filament and the branch.

Woodsia obtusa (Spreng.) Torr.—All the cases of branched prothallia of *Woodsia obtusa* were observed on distilled water cultures; in two cases branching was dichotomous while in the other three cases it was monopodial. FIG. 12, B, shows the branch originated from the first cell of the filament. In FIG. 12, A, the branch originated from the slightly developed cell plate. FIG. 12, C, D, shows different stages in the development of the dichotomous branches. FIG. 12, E, was an interesting case of branching. Here the wall which cuts off the branch from the main filament did not form at the usual place, but formed almost in the center of the filament cell which gave rise to the branch.

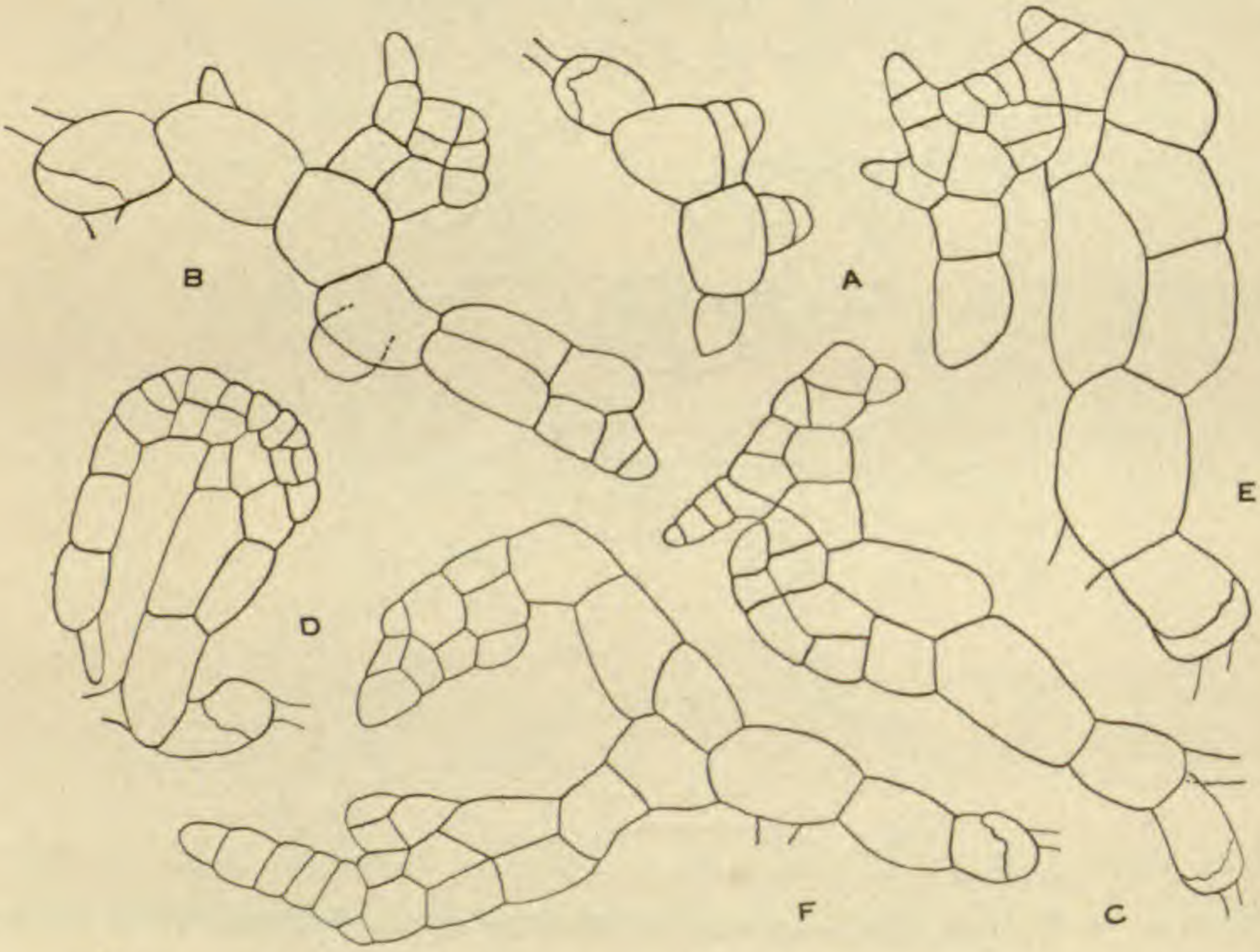

FIG. 13. Branched prothallia of *Scolopendrium vulgare* Sm., × 125.

Scolopendrium vulgare Sm.—All cases of branching in this genus were observed on Prantl's solution with $CaSO_4$ omitted. FIG. 13, A–E, shows typical examples of the types of branching found in these cultures. FIG. 13, A, is interesting as showing the tendency of both the second and third cells of the filament to form monopodial branches with very short cells. In FIG. 13, B, the branch which originated from the third cell of the filament formed immediately a plate of cells which in turn showed a tendency to branch at one side of the apex. FIG. 13, C, shows the origin of a branch from the apex of the expanded portion of the prothallium, while FIG. 13, D, E, shows further development of such a branch. These branches formed a small plate of cells, two rows in width, then tended to revert to a filamentous condition, at the same time growing downward, thus giving the appearance of two young prothallia attached by their apexes. FIG. 13, F, shows the only case of dichotomous branching which was observed. One of the branches reverted from a plate of cells to a filament four cells in length.

Woodwardia virginica (L.) Sm.—The branched prothallia of *Woodwardia virginica* varied in size and shape and showed a decided tendency to branch dichotomously. Those shown in FIG. 14, A–D, and 15, E, F, developed on the inner surface of the pot wall of the soil culture. They were not crowded by other prothallia and were well lighted. FIG. 15, G, developed on Prantl's nutrient solution with $CaSO_4$ omitted. In FIG. 14, A, B, branching took place from the first and second cells of the filament. In FIG. 14, C, D, and 15, G, branching took place after the plate of

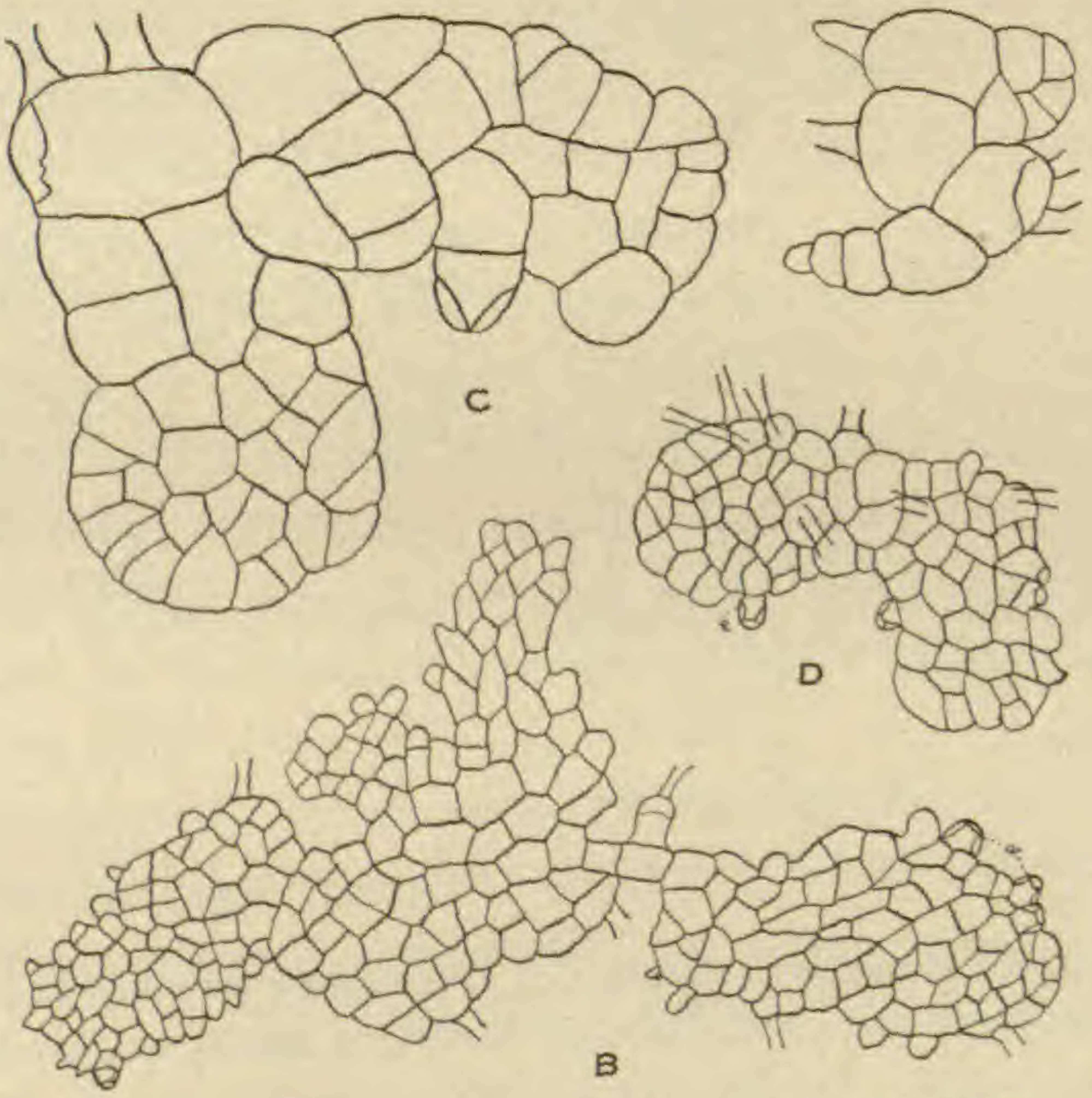

FIG. 14. Branched prothallia of *Woodwardia virginica* (L.) Sm. A, D, × 125; B, C, × 75.

cells had begun to develop, while in FIG. 15, E, F, branching occurred much later in the development of the prothallia.

Pteridium aquilinum (L.) Kuhn.—The only example of branching observed in this species was on Prantl's full solution (FIG. 15, H). Here the branch developed from the second cell of the filament and seemed to show a more vigorous growth than the main filament. The branch formed a short filament of two cells, then developed the beginnings of an expanded region while the main filament developed three cells of irregular length before cutting off the beginnings of an apical cell. This slowness in growth and the irregularity of length of the cells of the filament would seem to indicate a poorly nourished condition of the main filament.

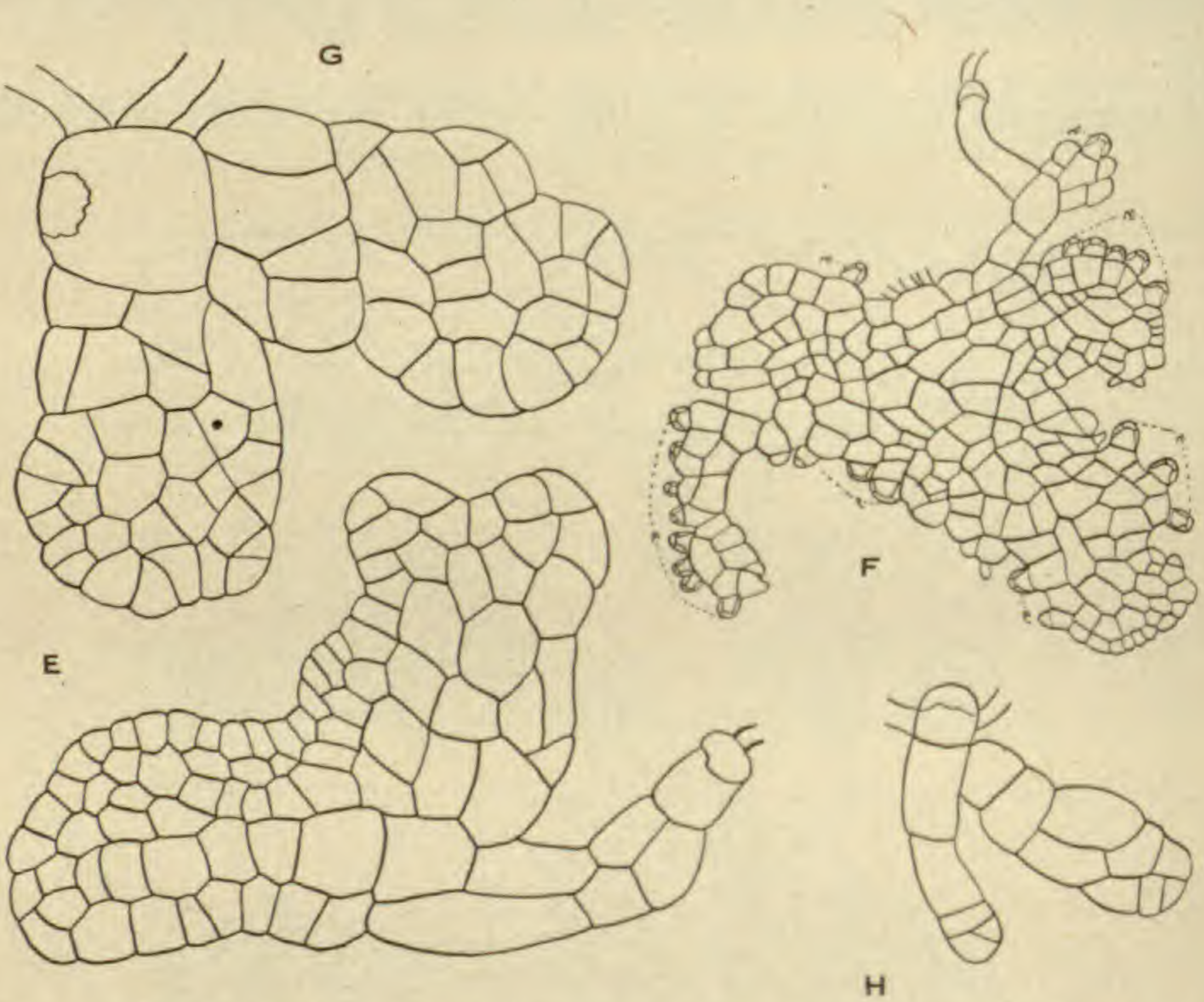

FIG. 15. E–G. Branched prothallia of *Woodwardia virginica* (L.) Sm., × 75; *a*, antheridia. H. Branched prothallium of *Pteridium aquilinum* (L.) Kuhn, × 125.

DISCUSSION

A comparison of the previously described branched prothallia with those found by other writers would seem to indicate that whatever factor, or set of factors, working separately or together, may have been the determining ones, the development of branches was associated with conditions of the environment. In Klebs's experiment weak light seemed to have been the cause of branching. Light may be the determining factor in branching where the prothallia are crowded and therefore shaded by other prothallia, but it can not be considered the determining factor in all the cases described in this paper, for the majority of these branched prothallia occurred in uncrowded regions of the cultures under good light conditions. However, all the branched prothallia except one developed on cultures of distilled water or nutrient solutions, from which some chemical element had been omitted; while all but two of the branched prothallia on the soil cultures were found on the inner surface of the pot wall. This is especially interesting as indicating that other factors than light entered into the problem. Atkinson designates the branched prothallia of *Adiantum* as "starved prothallia," which would seem to indicate that they had developed under poor nutritive conditions. Miss Black suggested the possibility of a lack of oxygen as the determining factor in the production of the branched prothallia in her cultures. This explanation would not hold good for the present cases, as all three cultures, distilled water, soil, and nutrient solution, were covered with loosely fitting glass plates and, since the prothallia were not submerged in the nutrient solution or distilled water they received a sufficient supply of oxygen.

As branching was not observed in the nutrient solution cultures, where all the chemical elements necessary for growth were present in sufficient quantities to meet the needs of the prothallia; as few cases of branching were observed among the prothallia of the soil cultures, in positions which appeared favorable for nutrition, it would seem as if there was an intimate connection between nutrition and branching, that poor nutritive conditions accelerated the stimulus of branching, and that good nutritive conditions weakened the stimulus. However, it is impossible to say just what factor of nutrition was the determining one; for even by cultivating prothallia on nutrient solutions whose chemical formula are known, we do not know the physiological effect from the chemical reactions due to the presence or absence of various chemical elements.

SUMMARY

1. Branched prothallia occurred in cultures of *Adiantum bellum*, *A. Capillus-Veneris*, *A. cardiochlaena*, *A. cuneatum*, *A. trapeziforme*, *Asplenium bulbiferum*, *A. Filix-femina*, *A. platyneuron*, *Camptosorus rhizophyllis*, *Onoclea sensibilis*, *Phegopteris polypodioides*, *Pteridium aquilinum*, *Scolopendrium vulgare*, *Woodsia obtusa*, and *Woodwardia virginica*.

2. Branched prothallia were not confined to one type of culture medium, but developed on distilled water, on soil and on nutrient solutions.

3. Branches were not developed at any definite period in the life history of the prothallia, but were formed: (*a*) by any cell of the filament; (*b*) by divisions of the last cell of the filament; (*c*) from the margin and apex of the expanded portion of the prothallium.

4. Branching was both dichotomous and monopodial.

5. A definite relation seemed to exist between branching and nutrition.

In conclusion I wish to express my thanks to Professor Alexander W. Evans of Yale University and to Dr. C. H. Kauffman of the University of Michigan, to both of whom I am indebted for valuable suggestions in the preparation of this paper.

YALE UNIVERSITY

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A new species of Pritchardia

Joseph F. Rock

(WITH PLATE 21 AND ONE TEXT FIGURE)

The genus of palms, *Pritchardia*, is represented in the Hawaiian Islands by eleven species, including the new species treated in this paper. Originally, there were only two species known from these islands, *Pritchardia Gaudichaudii* Wendl. and *Pritchardia Martii* Wendl.

For several years I have carried on, on all the islands of this group, thorough botanical explorations; these have brought to light several new species of *Pritchardia*, most of which have been described by O. Beccari. Kauai has furnished two species; *P. minor* and *P. eriophora;* Maui, one species, *P. arecina;* Oahu, one species, *P. Rockiana;* and Hawaii, two species, *P. eriostachya* and *P. Beccariana*, the last (which is the handsomest of all) being here described for the first time. Beccari had described previously *P. Hillebrandii* from Molokai, *P. lanigera* from the Kohala Mountains, on Hawaii, and *P. remota* from Bird Island (Moku Manu), northwest of Kauai.

During a sojourn at the Volcano of Kilauea with my friend, M. L. Copeland, whom I take this opportunity to thank for his kind assistance, we discovered this handsome species in the humid forests of Glenwood. I was at once struck by the extraordinary size of this palm, its peculiar inflorescence and large globose fruits. We felled one tree and thus obtained complete specimens, some of which I forwarded to my friend, Dr. O. Beccari, with whom I had had long and interesting discussions of our Hawaiian palms while in Florence less than two years ago. He pronounced the palm a very distinct species but asked me, as he was occupied with other work, to describe it. With his consent I have taken the liberty of naming this beautiful species in his honor.

I believe that the Hawaiian Islands still harbor other species of *Pritchardia*, especially Lanai and the Island of Oahu; future explorations will doubtless increase our knowledge of this beautiful genus of palms.

Pritchardia Beccariana Rock, sp. nov.

Trunk 20–25 m. tall, about 40 cm. in diameter at the base, cylindrical, grayish, smooth, about 30 cm. in diameter breast-high, with more or less distant rings, showing the attachment of the leaves, the crown of leaves forming perfect globose heads of large dimensions; leaves large, suborbicular, measuring 1.5 m. or more from the ligule to the apex of the median segment, the ligule rotundate and prolonged in the middle to a distinct point; petioles 3 m. long in young fronds, 1.5–2 m. in mature fronds, stout, and covered on the under side with a fawn-colored squamaceous tomentum; segments about sixty, each segment 4–4.5 cm. wide, and subdivided again for 30 cm. into linear-acuminate lobes, with filaments 15–25 cm. long in the bifurcations, the lower surface of the leaves, especially near the petiole and costae covered with a squamaceous, flaky tomentum, upper surface glabrous; spadix 2–3 m. long including a main peduncle of 1 m., the spadix branching into three to five large open panicles at intervals of 3–4 dm.; the terete peduncle 2 cm. in diameter, enclosed by various, tubulose spathes 70–80 cm. long; panicles compressed, loose, the first two or three open and loosely branched, the last two nearest the leaf-axil short and densely branched, the branchlets short and spirally twisted; the former bearing abortive flowers only, the latter, or often only the last panicle producing fertile flowers and mature fruits; each panicle enclosed in several, reddish brown spathes, 30–40 cm., long covered with a squamaceous tomentum on the outside; flowers subsessile, on the more or less tortuous branchlets of the compound panicle, those bearing fertile flowers spirally twisted; calyx 5 mm. long, tubular-cylindrical, truncate at base and apex, with three very short teeth; petals (?); staminal cup much longer than the calyx, exserted 3 mm., and terminating into six, somewhat compressed, filaments, 2 mm. long; anthers acute at the apex, obtuse and slightly notched at the base, 3.5 mm. long, attached at about the middle to the filament; style columnar, triquetrous, with three punctiform stigmas at the apex; mature fruits large, subglobose; black, shining, 4 cm. in diameter, slightly flattened on one side, with a short conical apex; epicarp black, thin, fragile at the maturity of the fruit and exposing the thick, fibrous mesocarp, 5–6 mm. thick at the base, thinner at the apex; endocarp ligneous, 1 mm. thick; cavity of the endocarp circular, slightly flattened at the base, 2.75 cm. in diameter, not situated exactly in the middle of the fruit, but a little nearer to the apex;

seed globose, base slightly broader, dark, brownish black, albumen horny, snow-white, hilum orbicular, embryo situated immediately above the hilum. [PLATE 21 and TEXT FIG. 1.]

ISLAND OF HAWAII: in the rain forests in the neighborhood of Glenwood at an elevation of 3,200 feet; collected flowering and fruiting, December 23, 1914. The type specimen is preserved in the herbarium of the College of Hawaii.

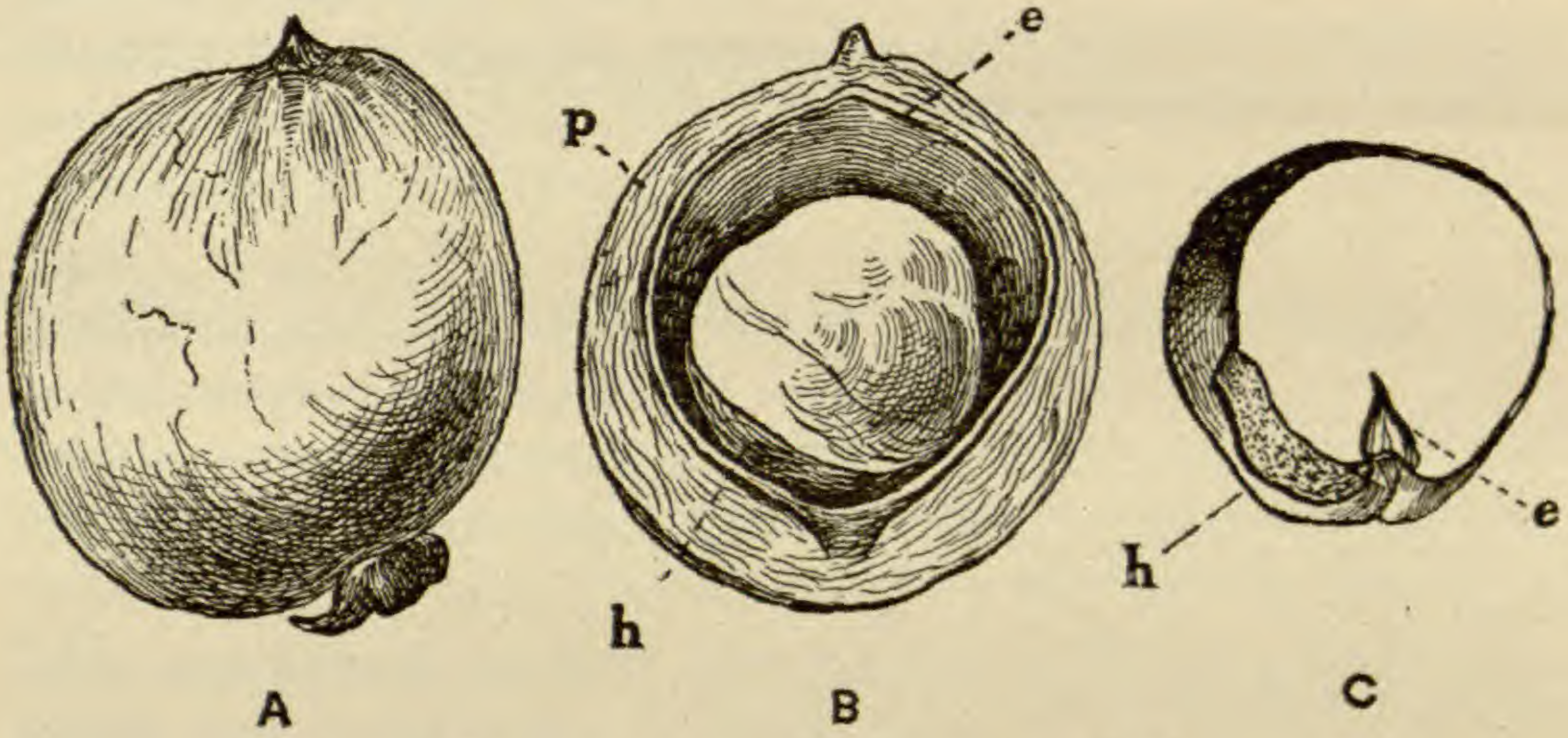

FIG. 1. PRITCHARDIA BECCARIANA Rock

A. Mature fruit, slightly reduced. B. Mature fruit cut in half, showing whole seed, slightly reduced: *p*, pericarp; *e*, endocarp; *h*, hilum. C. Seed cut in half, slightly reduced: *h*, hilum; *e*, embryo.

This exceedingly distinct species is one of the handsomest and tallest of the genus *Pritchardia*. It forms large groves throughout the forest in the vicinity of Glenwood, several hundred feet below the volcano of Kilauea, growing in company with *Metrosideros polymorpha*, *Cibotium Chamissoi*, *Cibotium Menziesii*, etc., towering as high as the tallest *Metrosideros* (Ohia Lehua) trees.

This species differs from all other species of *Pritchardia* mainly in the enormous inflorescence, which branches into five distinct spadices; in the large globose fruits; and in the large dimensions of the plant in general.

COLLEGE OF HAWAII,
HONOLULU, HAWAIIAN ISLANDS

Description of plate 21

Stand of *Pritchardia Beccariana* Rock, growing in the humid forest near Glenwood, Olaa, Hawaii, at an elevation of 3,200 feet. Ferns in the foreground, *Cibotium Chamissoi* and *C. Menziesii;* trees in the background, *Metrosideros polymorpha*.

Botanical work of Dr. E W. Hilgard

ROLAND M. HARPER

Dr. Eugene Woldemar Hilgard, who was born in Zweibrücken, Bavaria, January 5, 1833, and died in Berkeley, California, three days after his eighty-third birthday, was a shining example of a versatile type of scientist, common in the nineteenth century but becoming scarce in these days of increasing specialization. He was best known as a soil investigator and agronomist, but also ranked high as a geologist and chemist, and was pretty well versed in systematic and geographical botany. He was one of the pioneers in the correlation of soils with vegetation in America, and always emphasized the importance of native vegetation as an indicator of the productivity of soils. The fact that the scientific study of soils is almost inseparable from that of plant ecology was more fully appreciated by him than by most American soil investigators now living (some of whom seem to have little or no botanical training, if one may judge by their writings).

His first contribution to botanical science was his 415-page report on the geology and agriculture of Mississippi, published in 1860. In that the soils and vegetation of the several geographical divisions of the state (except the alluvium of the Mississippi River) were described in considerable detail, and it was at the time and for years afterward the best account of Mississippi vegetation in existence. As it was written before the publication of Chapman's Flora of the Southern United States, when there were no very satisfactory manuals for that part of the country (the best available being Darby's), some of the plants were wrongly identified, but a reader familiar with the southern flora can easily make the necessary corrections for himself.

A somewhat similar treatment was employed in a 44-page pamphlet on a geological reconnaissance of Louisiana, published in New Orleans in 1869, and in his descriptions of Mississippi, Louisiana and California, in the fifth and sixth volumes of the Tenth Census (1884), which have never received the attention from botanists that they deserve.

In Garden and Forest for March 7 and June 13, 1888, he had short papers on California forest trees; and a longer account of the weeds of that state by him appeared in the California Experiment Station Report for 1890 (pp. 238–252) and, almost simultaneously, in several numbers of Garden and Forest during the second half of 1891. His paper on the *cienagas* of southern California, published in the Bulletin of the Geological Society of America in 1892 and in the California Experiment Station Report for 1892–1894, is of some botanical interest, as are several papers on deserts and alkali lands in various publications. His review of Fernald's "Soil preferences of alpine plants," in Science for January 24, 1908, shows an intimate knowledge of ecological principles.

His text-book on Soils, with 620 pages and numerous illustrations, published in 1906, is practically a summary of all his researches, and contains much that is of interest and value to botanists.* He contributed many papers on cultivated plants to the reports and bulletins of the California Experiment Station (of which he was director from 1888 to 1904), which it is hardly worth while to enumerate separately.

In the line of botanical discoveries, he is credited by Chapman (Fl. So. U. S. ed. 2, 658. 1883) with being the first to find *Eriocaulon septangulare* in the South.† During his geographical explorations for the "Northern Transcontinental Survey" in Montana and Washington in 1882 he collected a few plants, at least one of which turned out to be undescribed; this was named *Oenothera Hilgardi* by Greene (Bull. Torrey Club **10**: 41. 1883) and afterwards transferred to *Sphaerostigma* by Small (see Piper, Contr. U. S. Nat. Herb. **11**: 18, 406. 1906).

The writer, after corresponding with Dr. Hilgard for several

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* See review in Torreya **7**: 170–175. Aug. 1907; and comments in Bull. Torrey Club **40**: 377 *et seq.* Aug. 1913.

† The plant so determined, if collected on his trip to southeastern Mississippi in the spring or early summer of 1859, as seems most likely, may have been another species, perhaps *E. lineare* Small, which was not distinguished until 1903 (see Bull. Torrey Club **32**: 461–463; **33**: 527). For *E. septangulare* grows mostly on sandy shores of lakes and ponds, and blooms in late summer, while *E. lineare* is a typical pine-barren plant, and blooms in April and May. The only southern stations for *E. septangulare* known to the writer are in Lowndes County, Georgia, and Leon, Walton and Santa Rosa Counties, Florida. In Small's Flora it is said to range west to Texas, but this statement lacks verification.

years, had the pleasure of meeting him at his home in Berkeley at the time of the A. A. A. S. meetings last summer, and found him somewhat enfeebled by age but wide-awake mentally. He always wrote for publication in plain simple language, as free as possible from technicalities, and was very modest, sincere and unaffected, as befits a great scientist.

Accounts of his life and work by two of his California colleagues were published in Science for March 31, 1916, and reprinted with some additions, two portraits, and a bibliography of over 250 titles, in the University of California Chronicle, vol. 18, no. 2 (this also issued in June as a separately paged pamphlet with 50 pages). Other recent biographical sketches are in the Experiment Station Record (Washington) for March, 1916, and the Geographical Review (New York) for May. The last contains references to a few earlier ones.

COLLEGE POINT, NEW YORK

INDEX TO AMERICAN BOTANICAL LITERATURE

1915-1916

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 the broadest sense.

Reviews, and papers that 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.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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PRITCHARDIA BECCARIANA Rock

Vol. 43 No. 8

BULLETIN

OF THE

TORREY BOTANICAL CLUB

AUGUST, 1916

The development of the embryo sac and embryo of Cooperia Drummondii*

MARGARET B. CHURCH

(WITH PLATES 22 AND 23)

The following study of the embryo sac and embryo of *Cooperia Drummondii* was undertaken with the idea that a further knowledge of the embryo sac of the Amaryllidaceae would doubtless be of value and interest, since little or no work of this kind has been attempted recently in connection with this family.

The geographical range of *Cooperia Drummondii* extends from the prairies of southern Kansas southwest into northern Mexico and as far west as New Mexico. The leaves of a mature plant are glabrous, the very narrow grass-like blades arising from coated, subglobose bulbs which are six to eight inches below the surface of the ground. The roots are coarse and unbranched except when injured at the tip. The flower scape varies from pale green at the base to yellow at the perianth. Its veins are a distinct rose color. The flower at the time of opening is creamy white with the tips of the lobes of the salverform perianth sometimes rose-colored. It becomes pure white when in full bloom and on withering gradually changes to deep dull rose. No difficulty was encountered in obtaining seed in the greenhouse from self-pollinated flowers.

Cooperia Drummondii is popularly known as "Rain Lily," because the flower scapes shoot up and bear blooms very rapidly

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[The BULLETIN for July (43: 343–396. *pl. 21*) was issued August 12, 1916.]

* Contribution from the Botanical Laboratory of Brown University.

after a heavy shower of rain. In contrast it is worth noting that *Habranthus* [*Zephyranthes*] *gracilifolius β Boothianus* breaks the sheath three days before the flower opens (Lindley, 7). The flowering period of *Cooperia Drummondii* in the vicinity of Austin, Texas, usually includes the last week in April and the first week in May.

The material for the study of the development of the embryo sac was furnished to the writer by Professor H. H. York, who collected it on the campus of the University of Texas. For the study of the development of the embryo, bulbs were secured from the above mentioned place, and were grown in the greenhouse at Brown University. Flemming's weaker and stronger solutions, chromo-acetic acid, alcoholic and aqueous picro-acetic acid were used in general for killing and fixation. Aqueous picro-acetic gave the best results in the case of the embryo sac and the mature embryo. The following additional solutions were tried in an attempt to prevent the shrinking of the immature embryo during the process of killing and fixation: (1) 2 c.c. of a one per cent. aqueous solution of acetic acid, 11 c.c. of a one per cent. aqueous solution of osmic acid and 11 c.c. of water for fifteen minutes; (2) a one per cent. aqueous solution of osmic acid for fifteen minutes; (3) a one per cent. aqueous solution of osmic acid for three minutes, followed by twenty-four hours in Schaffner's chromo-acetic; (4) a solution of osmic acid and acetic acid in the proportions mentioned above for three minutes, followed by Schaffner's chromo-acetic for twenty-four hours; and (5) a two per cent. aqueous solution of acetic acid for twenty-four hours. The two per cent. aqueous solution of acetic acid proved to be a perfect fixing agent for the immature embryos, especially if the individual ovules were dissected out from the ovary immediately before fixing. Dehydration and imbedding were carried on in the usual way, except in the case of embryos large enough to be dissected out of the ovule. Here the laying of the material in a certain position in order that sectioning might be in the right plane was facilitated by staining the embryos *in toto* by means of a dip into erythrosin before dehydration was completed, and the subsequent use of the binocular microscope and substage illumination as will be described. The binocular microscope was unscrewed from its stand and placed upon a ground glass plate below which in a convenient compartment was an electric light bulb. A glass plate, bearing the imbedding ells, was placed on the arms of the stage. The light from the electric bulb readily made visible the gross structure of the embryo, so that the orientation of the object could be positively determined. Care was taken not to overheat the lenses of the binocular by leaving the electric bulb lighted for too long a period. The imbedding was done therefore quite rapidly. Serial sections 10–12 μ in thickness were cut. Delafield's hematoxylin; Haidenhain's iron-alum haematoxylin with fuchsin, erythrosin or Orange G; thionin with erythrosin; and Flemming's triple stain were used. The last gave the best results.

Very early in the development of the ovule, the primitive archesporial cell, which is hypodermal in origin, may be distinguished from the surrounding somatic tissue by its size, its granular content and its prominent nucleus (FIG. 1). Two hypodermal cells in one ovule were noted in five examples out of one hundred and forty-six ovules examined (FIG. 2). It was not possible to follow the subsequent development. Guignard (4) reported this condition in *Ornithogalum pyrenaicum*, and similar instances have been found in an increasing number of the Liliaceae. See Coulter and Chamberlain (1), Lechmere (6), and McAllister (8, 9). At this time the integuments of the ovule are not visible. The archesporial cell develops at the expense of the surrounding nucellus into a large oblong cell, which stands with its longer axis parallel to that of the ovule (FIG. 3). No tapetal cells were observed. The absence of a parietal tissue occurs among some of the close relatives of the Amaryllidaceae, as in *Allium, Hemerocallis, Lilium,* and *Erythronium* of the Liliaceae; and in *Sisyrinchium iridifolium* and *Iris stylosa* of the Iridaceae (Coulter and Chamberlain, 1).

Megaspore formation takes place in the way usual for the Liliaceae. The archesporial cell becomes directly the one-celled stage of the embryo sac (FIG. 3). It was not possible to follow out the behavior of the chromosomes in any of the divisions of the embryo sac nuclei. Since the mode of development of the embryo sac of *Cooperia Drummondii* is similar to that of *Ery-*

thronium (Schaffner, 11), *Lilium* and *Tulipa Gesneriana* (Treub and Mellink, 12) and other Liliaceae, we may for the present assume that the reduction division occurs with the division of the one-celled stage and is completed when the four-nucleate embryo sac is formed (FIGS. 4, 5). By a division of the four nuclei the eight-nucleate sac results (FIG. 6).

At the time of fertilization the two polar nuclei are in the chalazal half of the sac, the antipodals near the chalaza, and the egg cell and the synergids opposite the micropyle (FIG. 6). The polar nuclei have a very thin protoplasmic content, although their nucleoli stain heavily. The three antipodals are at first arranged in a pyramid whose apex points toward the micropyle. Just before fertilization they become rearranged in a row, parallel with the longitudinal axis of the chalazal end of the embryo sac; while after fertilization they generally move again, this time to form a pyramid with its apex directed toward the chalaza. The antipodals stained very deeply in all of the combinations of stains that were used. This may be indicative of disintegration. The synergids have dense but vacuolated protoplasm. The egg cell is large and pear-shaped with a large round nucleus. It is directly in front of the micropyle. The dense protoplasm of the egg is less vacuolated than that of the synergids.

The nucellus at the time of fertilization has been largely absorbed or digested except for a thin layer of cells about the micropylar portion of the sac and a small mass of cells located at the chalaza and almost wholly deprived of protoplasm. The antipodals show a marked tendency to enlarge, and in numerous instances increase so as to almost equal the egg cell in size. This tendency toward enlargement persists even after fertilization, when the partial development of the embryo has taken place. Ordinarily, however, the antipodals have almost disintegrated when the embryo has become two-celled. The two polar nuclei, which are in close contact at maturation, fuse at the time of fertilization. A few examples of triple fusion were observed (FIG. 8). Ernst (2) has observed this condition in *Paris quadrifolia*. Further, it has been observed in other Liliaceae: as in *Trillium grandifolium;* in species of *Lilium*, of *Fritillaria*, and of *Tulipa;* and in *Endymion nutans* (Coulter and Chamberlain, 1). The synergids disappear at fertilization.

Following fertilization the endosperm nucleus divides, and by subsequent mitotic divisions a number of free nuclei, apparently without nuclear walls, are formed (FIG. 17), which are imbedded in the cytoplasm lining the wall of the sac and surrounding the embryo. Free nuclei are found in *Alisma Plantago* (Schaffner, 10), *Leucojum vernum* (Hofmeister, 5), and *Xyris indica* (Weinzieher, 13). Eventually these nuclei become separated by cell walls, which are at first laid down so as to include several nuclei in each lumen (FIG. 18). Later these multinucleate cells divide in such a manner that a single nucleus becomes enclosed within a lumen. The cells divide by amitosis after the walls are laid down. Several cases have been noted where endosperm formation was lacking. In connection with endosperm development in *Cooperia Drummondii* the description of endosperm formation in *Leucojum vernum* as given by Hofmeister (5) is of interest: ". . . the kernels in the inner fluid of the embryo sac increase in size and number; most of them lie now against the wall of the embryo sac; . . . they unite with the cells which fill up the space of the embryo sac. The lower part of the nucellus is pressed continually outward by the growing endosperm as the seed ripens."

At first it was impossible to kill and fix the early stages of the embryo. This difficulty was due to the fact that a suitable killing and fixing agent which would not cause great shrinkage of the protoplasm in these particular stages was not known. Therefore free hand sections or sections cut on a freezing microtome were used. The working out of the anatomical details of the developing embryo becomes possible with the use of a two per cent. acetic acid in water solution as a killing and fixing agent.

After fertilization the oöspore continues to occupy the same position as the oösphere. It enlarges (FIG. 7) and soon divides by a transverse wall (FIG. 9). Soon after the first division of the oöspore, the two-celled proembryo is in contact with the nucellus at the micropylar end of the embryo sac, and a little later is firmly attached at the same point. The basal cell of the proembryo develops into a suspensor, while the free terminal cell gives rise to the embryo proper (FIG. 10). The second cell division of the proembryo occurs in the basal cell, resulting in the formation of a two-celled suspensor. Further cell divisions in the suspensor have not been observed. A number of examples were found where the suspensor consisted of but a single cell. Following the division of the basal cell, the free terminal cell divides first in a plane parallel with the longitudinal axis of the proembryo, forming the two-celled embryo (FIG. 11). The four-celled stage results from radial walls perpendicular to the first (FIG. 12).

From the four-celled stage by repeated division arises a spherical mass of cells (FIGS. 13, 14), on one side of which develops a niche or indentation (FIG. 15). This niche is the point where the shoot primordium will arise, while the cotyledon differentiates off from the rounded top, and the hypocotyl from the cells just above the suspensor of this immature embryo. In one instance this niche in an early stage was covered with a thin cell-like transparent membrane (FIG. 16). Later stages are shown in FIGS. 19 and 20.

The structure of the mature embryo may be seen in FIGS. 22 and 23. In relief a scarcely protruding pocket protects the leaf primordia by surrounding their outer surface as they lie against the base of the cotyledon. This is the "cotylar" sheath, corresponding to the sheath of a monocotyledonous leaf. This sheath has no vascular system and is very simple in structure. The long spindle-shaped cotyledon is succulent and projects into the mass of the endosperm (FIG. 21), where like a haustorium it absorbs food for the development of the embryo by means of a thin-walled row of parenchymatous cells running parallel with the longitudinal axis of the embryo. This strong development of the cotyledon is assumed to be in itself indicative of richness of endosperm development, and is, according to Goebel (3), characteristic of plants such as *Leucojum* and *Narcissus*.

The suspensor, varying in the number and arrangement of its cells, still holds the embryo in position at maturity.

The number of leaf primordia developed at the time the seed is ripe depends on the individual embryo, influenced as it is by various conditions of internal and external factors. No cases have been noted where the first leaf is undeveloped at the end of the same period, but the development and size attained by such leaf primordia in a mature embryo is not at all constant. The leaf base of *Cooperia Drummondii*, like that of *Leucojum* and *Narcissus* (Goebel, 3), is closed. The primary root arises from the base of the hypocotyl and developing downward is protected by a well-developed root cap even as early as at the maturity of the seed.

In conclusion it may be of interest to contrast Hofmeister's description (5) of embryo sac and embryo development in *Amaryllis longiflora* with that of *Cooperia Drummondii*. They are almost entirely dissimilar. Hofmeister states that *A. longiflora* (*Hippeastrum solandriflorum*) is the only member of the Amaryllidaceae having irregular megasporangium formation. Just what he had in mind the writer does not dare to say, as no figures are given and his interpretation of the embryo sac was not that of present-day botanists. In regard to *Cooperia Drummondii* the statement may again be made that the embryo-sac development is without doubt regular, as compared with its near relatives.

In *Amaryllis longiflora* endosperm formation is sparing. The endosperm cells are displaced by the embryo before they become united into a compact tissue; while *Cooperia Drummondii*, as has been shown, has a firm, abundant and well-developed endosperm tissue. The embryo of *Amaryllis longiflora* is spindle-shaped in the region of the root and plumule but the cotyledon is bent and consequently knee-shaped, where that of *Cooperia Drummondii* grows straight upward forming a regular, spindle-shaped body except in individual instances where too much externalpres sure is exerted by earlier developed or more rapidly growing ovules.

This paper represents in part work undertaken by the author during the years 1912–1914 for the degree of Master of Arts at Brown University. The writer begs to acknowledge the assistance given by Professor Harlan H. York, of the Botanical Deaprtment of Brown University, and the courtesies of all others who may have made any helpful suggestions whatsoever.

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Explanation of plates 22 and 23

All figures except where noted are Zeiss camera lucida drawings from microtome sections. A Leitz compound microscope was used for all drawings. In some cases the scale of magnification is designated; in other cases the ocular and objective combinations are given.

FIG. 1. Archesporial cell, × 310.

FIG. 2. Ovule with two archesporial cells, × 300.

FIG. 3. Uninucleate embryo sac, × 310.

FIG. 4. Two-nucleate embryo sac, × 200.

FIG. 5. Four-nucleate embryo sac, × 110.

FIG. 6. Eight-nucleate embryo sac, × 150.

FIG. 7. Fertilized egg and pollen tube nucleus from fresh material; 1 ocular, 7 objective.

FIG. 8. Fused polar nuclei and pollen tube nucleus, × 600.

FIG. 9. Proembryo, two-celled and as yet unattached; 4 ocular, 7 objective

FIG. 10. One-celled embryo with suspensor and endosperm, from free-hand section of fresh material; 4 ocular, 7 objective.

FIG. 11. Two-celled embryo, from fresh material cut on freezing microtome, × 310.

FIG. 12. Four-celled embryo, from fresh material cut on freezing microtome, × 130.

FIG. 13. Longitudinal section through young embryo, from fresh material cut on freezing microtome, × 150.

FIG. 14. Outline of young embryo and suspensor with endosperm at one side, from free-hand section of fresh material; 4 ocular, 7 objective.

FIG. 15. Outline of embryo with suspensor, showing niche where growing point is developing, from free-hand section of fresh material; 4 ocular, 7 objective.

FIG. 16. Outline of embryo with suspensor, showing further differentiation of a growing point over which is a transparent cell-like membrane; 4 ocular, 7 objective.

FIG. 17. Free nucleus from endosperm; cytoplasm in which nucleus is imbedded not shown in drawing. Oil immersion.

FIG. 18. Cell walls being laid down between free nuclei of endosperm; walls warped by plasmolysis; diagrammatic, × 60.

FIG. 19. Outline of embryo, showing differentiation of root, sheath, plumule, and cotyledon regions, × 70.

FIG. 20. Outline of immature embryo, × 60.

FIG. 21. Diagram of mature seed, showing seed coats, endosperm, and embryo fitting loosely in the endosperm.

FIG. 22. Mature embryo, dissected out of ovule; 2 ocular, 1 inch Beck objective.

FIG. 23. Longitudinal section through mature embryo, × 150.

Notes on plants of the southern United States—II

Francis W. Pennell

In the first series of these notes, published in the February Bulletin of this year, there was given a tentative revision of the genus *Commelina*. The treatment of species there presented differed widely from current treatments and should probably have been preceded by a fuller introductory statement. A summary of the conclusions reached may therefore be in place.

Commelina communis L. is the common introduced weed of the northeastern states. Both *Commelina longicaulis* Jacq. and the little-known *C. caroliniana* Walt. have passed as *C. nudiflora* L., but, as is shown on page 96, the latter specific name must be retained for a plant of another genus, *Aneilema nudiflorum* (L.) Kunth. Strangely enough the Linnean *Commelina nudiflora* had been perpetuated in the names of two species belonging to different genera. Linnaeus's description of his *Commelina virginica* is clear and diagnostic, and leaves no doubt that the plant he was considering is that we have been calling *C. hirtella* Vahl. But the plant which has been separated in recent floras, by reason of having its capsule three-celled, as *C. virginica*, is but a state or condition of *C. erecta* L. *C. crispa* Wooton and *C. angustifolia* Michx. are continued as species but are very near, possibly not distinct from, *C. erecta*. *Commelina elegans* HBK. is a widespread species of tropical America.

In the present paper further noteworthy records, based upon my southern collections of 1912 and 1913, are given, and revisions are made of a portion of the genus *Schoenocaulon*, and of the *Nemexia* subgenus of the genus *Smilax*.

MISCELLANEOUS SPECIES

Carex glaucescens Ell.

This species was listed in the first series of these Notes (p. 95) as *C. verrucosa* Muhl., a later name. See Mackenzie; Small, Fl. SE. U. S. ed. 2, 1324. 1915.

PLEEA TENUIFOLIA Michx.

Moist sandy soil in pine-land, Winter Park near Wilmington, New Hanover County, North Carolina, October 16, 1912, *4917*.

YUCCA GLAUCA Nutt.?

As compared with the prevalent growth of this widespread species, plants collected near Dallas, Texas (*Reverchon 4029, 4029A, F. W. Pennell 5407*), apparently differ as follows:

Leaves thickened, rigid, usually conspicuously fibrillose. Upper bracts ovate, acute, pale, with broad white margins. Capsule 50–60 mm. long, oblong, not or scarcely constricted. Seeds flat, 9–10 mm. long. 1. *Y. glauca* Nutt.

Leaves thinner, shorter, dull-green, weak-tipped, short-fibrillose above, more fibrillose at base. Upper bracts broadly lanceolate, acuminate, brown, with narrower white margins. Capsule 30 mm. long, oblong-ovoid, evidently constricted about the middle Seeds more turgid, 6 mm. long. 2. *Y.* sp.

Full identification of the doubtful plant is left for someone more conversant with this group.

GYROTHECA TINCTORIA (Walt.) Salisb.

Moist open pine-land, north of Abita Springs, St. Tammany Parish, Louisiana, > August 14, 1912, *4196*.

BLEPHARIGLOTTIS CONSPICUA (Nash) Small.

Moist sandy open pine-land, Pass Christian, Harrison County, Mississippi, > August 27, 1912, *4364*.

IBIDIUM BECKII (Lindl.) House.

Moist deciduous woodland, Catalpa, West Feliciana Parish, Louisiana, > August 21, 1912, *4282*.

SCHOENOCAULON A. GRAY IN SOUTHERN TEXAS

Two species of this genus, hitherto confused, may be distinguished as follows:

Base of stem scarcely or not fibrous-coated. Leaves 3–5 mm. wide, slightly or not glaucous, shorter than the scape. Scape stout. Inflorescence 15–20 mm. thick. Bracts rounded. Perianth-segments oblong-ovate, nearly membranous, with broad scarious margins, crenulate. Filaments stout, much dilated, 5–7 mm. long. Styles 1–2 mm. long. Flowering in autumn. 1. *S. Drummondii.*

Base of stem densely fibrous-coated. Leaves 1.5–4 mm. wide, glaucous, mostly equaling the scape. Scape slender. Inflorescence 9–15 mm. thick. Bracts acutish to acute. Perianth-segments linear-oblong, thickened, not scarious-margined, entire. Filaments slender, not dilated, 3–4 mm. long. Styles less than 1 mm. long. Flowering in spring. 2. *S. texanum.*

1. SCHOENOCAULON DRUMMONDII A. Gray; Torrey, Bot. Mex. Bound. Surv. 222. 1858–9. "This species was first discovered by Drummond, and is No. 284 of his third Texan collection." Co-type seen in the herbarium of Columbia University at the New York Botanical Garden.

Texas. In the lower coastal plain. Flowers late-September to early-October.

TEXAS. Colorado: sandy soil, three miles east of Alleyton, > September 22, 1913, *F. W. Pennell 5557* (P, Y). Dewitt: roadside near Yorktown, > October 6, 1857, *A. Schott* (Y).

2. SCHOENOCAULON TEXANUM Scheele, Linnaea 25: 262. 1852. "Gesellschaftlich auf trockner Prairie, deren sehr nahe Unterlage Kalkfelsen ist, bei Neubraunfels: *Lindheimer*, April 1846." *Lindheimer 1221*, seen in the herbaria of the New York Botanical Garden, the Academy of Natural Sciences at Philadelphia and the University of Pennsylvania, is probably from the type-locality.

Texas to Chihuahua and San Luis Potosi. Edwards Plateau and southwestward. Flowers April to June.

TEXAS. Hays: San Marcos > Spring, 1898, *S. W. Stanfield* (Y). Kendall: Rocky bluffs, > June, 1885, *J. Reverchon 1607* (P, Y). Kerr: Kerrville > April to June, 1894, *A. A. Heller 1626* (A, Y). Travis: hills, Austin, > May 13, 1872, *E. Hall 644* (Y).

SMILAX, SUBGENUS NEMEXIA (RAF.), IN THE EASTERN UNITED STATES

The subgenus or section of *Smilax* containing the herbaceous-stemmed vines, frequently with beautiful foliage and bearing umbels of lurid green, mostly malodorous flowers—a group of plants commonly known as the carrion-flowers—is one which has long been of especial difficulty to taxonomists. Various writers have held nearly the entire group of species here presented, as well as certain East Asian allies, in one species, *Smilax herbacea*, while others have attempted segregations based upon the shape of the branchlets, the length of the peduncles, the number of primary veins, and other characters which field-study proves too variable for certain use. But it has gradually become apparent that a number of species may be distinguished upon features at first thought of little moment.

Linnaeus in the first edition of the Species Plantarum recognized two species, *Smilax herbacea* and *S. Pseudo China.* The types of these show that they are identical, and that the widespread glaucous- and glabrous-leaved species of the east is properly called *S. herbacea. Smilax tamnifolia* and *S. pulverulenta*, two surprisingly distinct species considering how poorly our books have described them, were added by Michaux. *Smilax lasioneuron* was described by Hooker in 1840 from the Saskatchewan region, and the main innovation of this present revision is the extension of this species eastward to embrace a plant widespread through the Mississippi Valley states. Hooker and his followers have laid emphasis upon the short-peduncled cymes of *S. lasioneuron*, but it requires but slight inspection of a series of any species of this group to show how undependable this character is; indeed, that peduncles should be shortened in specimens of western more arid regions seems natural. Two southern species have been added by Dr. Small, and the present writer describes one species, believed new to science, from Georgia.

The carrion-flowers are here continued as a subgenus of *Smilax*, in deference to the opinion of Mr. John B. Norton, of the United States Department of Agriculture, who is engaged in a study of the entire genus *Smilax*. To him I am indebted for valuable criticism.

My interest in this group extends from 1908, and my collections include most of the species, although several critical southern species have not been obtained.

Anthers about equaling the filaments. Leaves lanceolate to triangular-ovate, usually more or less hastate-lobed at base. Leaves slightly paler and glabrous beneath. Peduncles frequently several in an axil.
  Perianth-segments 1.5–2.5 mm. long. Peduncles and pedicels relatively short, the latter less than 10 mm. long. 1. *S. tamnifolia.*
  Perianth-segments 4 mm. long. Peduncles and pedicels longer, the latter about 20 mm. long. 2. *S. leptanthera.*
Anthers shorter than the filaments. Leaves ovate to cordate, not hastate-lobed at base.
  Mature leaves pale beneath, relatively short-acuminate. Berries dark-blue, glaucous. Perianth-segments broadly lanceolate, 2–5 mm. long.

Leaves glabrous beneath. Bracts on stem below leaves appressed.

Stem 3–5 dm. tall, erect, without tendrils. Leaves all clustered near summit of stem, oblong-ovate, acute. Perianth-segments 2–3 mm. long. Seeds 4.5–5 mm. long, maturing two to a berry. 3. *S. biltmoreana.*

Stem elongated, climbing, with tendrils. Leaves on adult stems all alternate, cordate to ovate, acuminate. Perianth-segments 3–4 mm. long. Seeds 3.5–4 mm. long, maturing three to five to a berry. 4. *S. herbacea.*

Leaves puberulent to pubescent beneath. Bracts on stem below leaves more or less spreading.

Stem elongated, climbing, with numerous tendrils. Peduncles all in the axils of normal leaves. Leaves puberulent to pubescent beneath, acuminate. Seeds maturing three to five to a berry.

Perianth-segments 3.5–4.5 mm. long. Leaves ovate to cordate. 5. *S. lasioneuron.*

Perianth-segments 2–2.5 mm. long. Leaves triangular-ovate. 6. *S. tenuis.*

Stem not or slightly elongated, not climbing, with few to no tendrils. Peduncles, at least in part, in the axils of bracts below the leaves. Leaves pubescent beneath.

Perianth-segments 4–5 mm. long. Seeds maturing three to five to a berry. Leaves acuminate, paler beneath. Stems frequently somewhat elongated and with tendrils. 7. *S. ecirrhata.*

Perianth-segments 2.5–3 mm. long. Seeds maturing two to three to a berry. Leaves acute to mucronate, whitened beneath. Stems not elongated, very rarely with tendrils. 8. *S. Hugeri.*

Mature leaves shining-green beneath, strongly acuminate. Berries black, not or scarcely glaucous. Seeds maturing three to five to a berry. Perianth-segments lanceolate, 4–6 mm. long. 9. *S. pulverulenta.*

1. SMILAX TAMNIFOLIA Michx.

Smilax tamnifolia Michx. Fl. Bor. Am. **2**: 238. 1803. "Hab. in Carolina." Description of leaves as "rotundato-obtusis" apparently applies to this. Type not verified.

Coprosmanthus tamnifolius Kunth, Enum. Pl. **5**: 267. 1850.

Nemexia tamnifolia Small, Fl. SE. U. S. 281. 1903.

Moist sandy soil near streams, in the Coastal Plain; Long Island to South Carolina.

Flowers after the other species, in northern New Jersey and on Long Island in late-June and early-July.

NEW YORK. Nassau: Rockville Center, *E. P. Bicknell* > June 27 (Y).

NEW JERSEY. Atlantic: Egg Harbor, *J. B. Brinton* > June 21 (P). Burlington: Atsion, *B. Long 6217* > July 19 (A). Camden: Parkdale, *G. W. Bassett 66* > June 14 (A). Cape May: Court House, *F. W. Pennell 3984* > July 15 (A). Cumberland: Beaver Dam, *B. Long 4943* (A). Gloucester: Repaupo, *E. B. Bartram* > June 23 (A). Middlesex: near Milltown, *N. Williamson* > August (Y). Monmouth: Farmingdale, *N. Taylor 2148* > July 4 (Y). Ocean: Barnegat, *B. Long 5296* < September 29 (A). Salem: Yorktown, *B. Long 4137* (A).

PENNSYLVANIA. Delaware: Tinicum, *T. C. Porter* (Y).

DELAWARE. Sussex: Laurel, *A. Commons* > June 18 (A).

MARYLAND. Dorchester: near Sharptown, *J. P. Otis* (A). Kent: Chestertown, *E. G. Vanatta* < August 3 (A). Prince Georges: Hyattsville, *F. H. Knowlton* > June 27 (U).

DISTRICT OF COLUMBIA. Terra Cotta, *C. S. Pollard 606* (U).

VIRGINIA. Nansemond: Suffolk, *A. A. Heller 925* > June 8–13 (P, U, Y), a large-leaved form.

SOUTH CAROLINA. Aiken: Graniteville, *H. Eggert* > May 21 (M). Clarendon: Manning, *W. Stone 245* > May 21 (A).

2. **Smilax leptanthera** Pennell, sp. nov.

Stem striate, glabrous. Leaves alternate; petioles slender, rounded, narrowly channeled above, 6–7 cm. long; blades triangular-ovate, cordate at base, acuminate at apex, dull-green above, slightly glaucous beneath, glabrous above and beneath. Tendrils about 7 cm. long, stouter than in *S. tamnifolia*, two to an axil. Staminate inflorescence: peduncles 12–15 cm. long; umbels thirty-five- to forty-flowered; pedicels filiform, 18–22 mm. long; sepals six, lanceolate, yellowish green, one-nerved, 4 mm. long, spreading to reflexed-spreading; filaments six, 1.2 mm. long, glabrous; anthers linear, recurved-coiled, 1–1.2 mm. long. Pistillate inflorescence not seen.

TYPE: Warm Springs, Meriwether County, Georgia, collected in flower May 22, 1905, *S. M. Tracy 9257*, in the herbarium of the New York Botanical Garden.

Piedmont Region of central Georgia, known only from the original collection.

Species closely allied to *S. tamnifolia*.

3. **Smilax biltmoreana** (Small) J. B. Norton, comb. nov.

Nemexia biltmoreana Small, Fl. SE. U. S. 281, 1328. 1903.

"Type, Biltmore Herbarium, no. 906b, in Herb. N. Y. B. G." Type seen.

Woodlands; highlands of North Carolina and upper South Carolina.

Flowers in May, fruits in August.

NORTH CAROLINA. Buncombe: Biltmore, *Biltmore Herbarium 906, 906b* > May 4 (B, Y). Cleveland: Kings Mountain, *Biltmore Herbarium 14954 p. p.* (B). Henderson: Flat Rock, *Dr. Shoolbred* (Y). Rutherford: Hickory Nut Gap, *J. K. Small & A. M. Huger* < October 3 (Y).

SOUTH CAROLINA. Greenville: Caesars Head, *L. M. Bragg 3637* < August 26 (S).*

4. SMILAX HERBACEA L.

Smilax herbacea L. Sp. Pl. 1030. 1753. "Habitat in Virginia, Marilandia." Type, a specimen in the Linnaean herbarium, obtained evidently from Gronovius and labeled by him "Smilax annua inermis caule fusco purpureo glabro claviculis plurimis teneris vestito. Ex alis foliorum oritur pedunculus teres glaber semipedalis gerens flores in capitulos globos, collectos." This is evidently a duplicate of Clayton's No. 541 from Virginia, identified both in the Linnaean and Gronovian herbaria as the plant here considered.

Smilax Pseudo China L. *l. c.* 1031. 1753. "Habitat in Virginia, Jamaica." Species clearly aggregate, represented in the Linnean herbarium by specimens written up by Linnaeus as follows, according to a letter of B. D. Jackson: "three sheets pinned together; the first is '11 K Pseudo China,' it is a barren branch, the leaves leathery: the second sheet is written up '11' and seems quite the same plant as the former, but has one berry, the third sheet is of a West Indian species, coll. by Patrick Browne in Jamaica, probably *S. celastroides.*" From the wording of the Linnaean description none of these can be considered the type of *S. Pseudo China*, but this would be

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* Specimens from the Charleston Museum, Charleston, South Carolina, are indicated by "S."

rather a specimen of Gronovius, also studied by Linnaeus, now in the Gronovian herbarium in the British Museum. The description of Linnaeus is word for word from Gronovius, except for the addition of the phrase "racemis ovato-oblongis," inappropriate for any *Smilax* whatever. "Smilax caule tereti inermi: foliis inermibus, caulinis cordatis, ramorum lanceolatis; pedunculis longissimis," Gronovius, Fl. Virg. 156. 1742, citing Clayton's Nos. 541, 561 and 630, is represented in the herbarium by Nos. 561 and 630 (for No. 541 see above note under *S. herbacea*). These two numbers are identified by Dr. A. B. Rendle as both the same as No. 541, that is, as genuine *Smilax herbacea* L. For the verification of these two Linnaean types I am indebted to Dr. B. Dayden Jackson, of the Linnaean Society of London, and to Dr. A. B. Rendle, of the British Museum.

Smilax inermis Walt. Fl. Carol. 244. 1788. Type, presumably from Berkeley County, South Carolina, not verified.

Smilax peduncularis Muhl.; Willdenow, in Linnaeus, Sp. Pl., ed. 4, 4: 786. 1806. "Habitat in Canada, Pensylvania." Type not verified.

Nemexia nigra Raf. Neogenyt. 3. 1825. New name for *S. herbacea* L., but apparently intended for the black-fruited *S. pulverulenta* Michx.

Nemexia cerulea Raf. *l. c.* 3. 1825. New name for *S. peduncularis* Muhl.

Coprosmanthus peduncularis Kunth, Enum. Pl. 5: 264. 1850.

Coprosmanthus herbaceus Kunth, *l. c.* 265. 1850.

Smilax herbacea α Simsii A. DC. Monogr. Phan. 1: 51. 1878. "*S. herbacea* Sims, Bot. Mag. *pl. 1920*." From figure and description evidently a narrow-leaved form of *S. herbacea.*

Smilax herbacea β peduncularis A. DC. *l. c.* 51. 1878.

Nemexia herbacea Small, Fl. SE. U. S. 280. 1903.

Smilax herbacea crispifolia Pennell, Proc. Acad. Nat. Sci. Phila. 62: 559. 1910. "Type.—Serpentine, Mineral Hill, Delaware County, Penna., F. W. Pennell 594, coll. Sept. 6, 1908, in Herb. Acad. Nat. Sci. Phila." A narrow, rigid-leaved form of dry soils, probably identical with *S. herbacea Simsii.*

Most woodlands, spring-heads, and near streams; more rarely, in dry soils, thickets, or open barrens; under the latter circumstances, usually as forma *crispifolia*: New Brunswick to Alabama, west to Indiana and Nebraska.

Flowers in eastern Pennsylvania, New Jersey and southeastern New York late-May to early-June, fruits September to November.

NEW BRUNSWICK. York: Fredericton, *J. Fowler* (U).

ONTARIO. York: Toronto, *Biltmore Herbarium 902b* > June (B).

MAINE. Penobscot: Oldtown, *L. H. Harvey 1014* (U).

NEW HAMPSHIRE. Grafton: Lisbon, *F. Blanchard* (M).

VERMONT. Caledonia: Barnet, *F. Blanchard* (M).

MASSACHUSETTS. Berkshire: Great Barrington, *C. L. Pollard* (U). Bristol: Nonquitt, *E. L. Sturtevant* (M). Essex: Ipswich, *T. Morong* > June 23 (M, Y). Plymouth: Marion, *A. M. Vail* > July (Y).

RHODE ISLAND. Newport: Crescent Beach, Block Island, *Fernald, Long & Torrey 9249* (A).

CONNECTICUT. Fairfield: Greens Farms, *C. L. Pollard 36* > June 7 (U). New Haven: Mt. Carmel, *W. E. Safford 137* > June 5 (U).

NEW YORK. Bronx: east of Van Cortlandt Park, *F. W. Pennell 7039* > June 14 (Y). Delaware: Arkville, *E. N. Harvey* > August (P). Essex: Westport, *N. L. Britton* (Y). Greene: New Baltimore, *N. Taylor 1375* < August 19 (Y). Oneida: Sylvan Beach, *W. R. Maxon 554* (U). Onondaga: Syracuse, *L. M. Underwood* > June (Y). Orange: Guymarch, *F. W. Pennell 6919* (Y). Queens: College Point, *J. Schrenk* > June 3 (Y). Richmond: near Garretson, *A. M. Vail* < October 24 (Y). Rockland: Spring Valley, *P. Wilson* (Y). Sullivan: Mongaup, *F. W. Pennell 6820* (Y). Tioga: Apalachin, *F. E. Fenno 402* > July 27 (Y). Tompkins: Fall Creek, *W. Trelease* > June 13 (M). Ulster: Cragsmoor, *E. M. Farr* (P). Washington: *S. H. Burnham* > July 18 (B). Westchester: Tarrytown Heights, *F. W. Pennell 7001* > June 13 (Y).

NEW JERSEY. Bergen: Alpine, *F. W. Pennell 5729* < September 12 (Y). Burlington: Bordentown, *B. Long 3086* (A). Cape May: Court House, *F. W. Pennell 2601* < August 30 (Y). Essex: Montclair, *J. F. Poggenburg* < September 5 (Y). Gloucester: Woodbury, *C. S. Williamson* > May 25 (A). Middlesex: Milltown, *A. M. Vail* (Y). Monmouth: Farmingdale, *B. Long &*

S. Brown 3545 > May 28–30 (A). Ocean: New Egypt, *J. H. Grove 285** > May 31 (A). Sussex: Andover, *N. L. Britton* < September 28 (Y).

PENNSYLVANIA. Bucks: Penn Valley, *J. Crawford* (U). Chester: Sugartown, *F. W. Pennell 821** < September 23 (A). Delaware: Wawa, *F. W. Pennell 3648*, 3649** > June 9 (A). Fayette: Ohio Pyle, *Brown, Crawford & Van Pelt 29* (A). Lancaster: Pleasant Grove, *J. J. Carter* < August 22 (Y). Lehigh: Slatington, *C. C. Bachman 2413* > June 8 (A). Montgomery: Ashbourne, *B. Long 5835, 5836* > May 28 (A). Northampton: Bangor, *C. S. Williamson* > May 30 (A). Philadelphia: Germantown, *T. Meehan** < September 24 (A). Westmoreland: *P. E. Pierron* > June 10 (U). York: McCalls Ferry, *N. L. Britton* (Y).

DELAWARE. Newcastle: Townsend, *J. B. Brinton* > May 30 (A).

MARYLAND. Allegany: Cumberland, *H. Shriver* (Y). Garrett: Oakland, *F. W. Pennell 6729* (Y). Kent: Chestertown, *E. G. Vanatta* (A).

VIRGINIA. Fairfax: Great Falls, *F. W. Pennell* (Y). Page: Stony Man Mountain, *E. S. & Mrs. Steele 176* < September 1 (B, M, U, Y). Pulaski: Peak Mountain, *J. K. Small* (B, M, U). Rockingham: Mt. Crawford, *A. A. Heller* > May 5–13 (A). Tazewell: Tazewell Peak, *A. H. Howell 437* (U).

NORTH CAROLINA. Guilford: High Point, *Biltmore Herbarium 902c* (B). Haywood: Eagle's Nest, *P. C. Standley 5489* < September 4 (U). Iredell: Statesville, *Biltmore Herbarium 902d* > May 19 (B). Watauga: Blowing Rock, *A. M. Huger* (Y).

SOUTH CAROLINA. Anderson: Pendleton, *L. M. Bragg 3897* (S). Greenville: Paris Mount, *J. K. Small* (Y). Oconee: Clemson College, *H. D. House 2119* (U).

GEORGIA. DeKalb: *H. Eggert* > May 23 (M).

ALABAMA. Lee: Auburn, *F. S. Earle* (Y).

OHIO. Licking: *W. W. Stockberger 902* > June 1 (B).

INDIANA. Steuben: Clear Lake, *C. C. Deam* (U). Wells: Twin Bridges, *C. C. Deam* > June 12 (B).

ILLINOIS. Clinton: Carlyle, *N. M. Glatfelter* (M). Stark: Wady Petra, *V. H. Chase* > May 28 (U).

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* Forma *crispifolia*.

NEBRASKA. Lancaster: Lincoln, *H. J. Webber* (Y).

MISSOURI. Greene: Springfield, *P. C. Standley 9745* < September 2 (U).

5. SMILAX LASIONEURON Hook.

Smilax lasioneuron Hook. Fl. Bor. Amer. **2**: 173. *pl. 187, A.* 1840. "Hab. Carlton House Fort on the Saskatchawan, *Dr. Richardson.*" Type not verified, but evidently plant here considered.

Coprosmanthus lasioneuron Kunth, Enum. Pl. **5**: 265. 1850.

Smilax herbacea γ *lasioneuron* A. DC. Monogr. Phan. **1**: 52. 1878.

(?) *Smilax diversifolia* Small, Bull. Torrey Club **25**: 607. 1898. "The original specimens were collected by the writer along the Flint River near Albany, Georgia, May 24–28, 1895." Type, in immature fruit, seen in the herbarium of Columbia University at the New York Botanical Garden. Needs to be studied in flower and mature fruit.

(?) *Nemexia diversifolia* Small, Fl. SE. U. S. 281. 1903.

Nemexia herbacea melica A. Nels. Proc. Biol. Soc. Wash. **17**: 175. 1904. "I take as type Mr. Andrews' specimens from Boulder Cañon [Colorado],—fruit in 1903, flowers (staminate and pistillate) in 1904." Type not seen, but evidently plant here considered.

Nemexia lasioneuron Rydb. Bull. Torrey Club **32**: 610. 1905.

Moist soil, thickets, and along streams; southwestern Ontario and Ohio to Georgia, Alabama, Colorado and Wyoming. Intergrades with *S. herbacea* and with *S. ecirrhata*. Through the Mississippi Valley this species grows much larger and frequently bears peduncles much longer than does the typical form of drier western regions.

ONTARIO. Huron: Wingham, *J. A. Morton 5971* > June 25 (A, Y).

GEORGIA. Dougherty: Albany, *J. K. Small* (Y), type of *S. diversifolia* Small.

ALABAMA. Bullock: Union Springs, *Biltmore Herbarium 14675a* (B).

KENTUCKY. Warren: near Green River, *S. F. Price* (M).

OHIO. Hamilton: Cincinnati, *C. G. Lloyd* > May 23 (M).

INDIANA. Allen: Fort Wayne, *F. W. Pennell 5301* (P). Wells: Bluffton, *C. C. Deam 14* (M, U).

ILLINOIS. Cook: Chicago, *W. C. Ohlendorf* > May 15 (B). Dupage: Naperville, *L. M. Umbach* (U). Kane: Elgin, *E. E. Sherff* < September 14 (M). Lasalle: Starved Rock, *Greenman, Lansing & Dixon 118* (Y). St. Clair: *H. Eggert* > June 14 (M). Stark: Wady Petra, *V. H. Chase* > May 28 (A).

WISCONSIN. Milwaukee: Milwaukee, *H. E. Hasse* (Y).

MINNESOTA. Winona: Stockton, *J. M. Holzinger* < September (U).

NORTH DAKOTA. Benson: Lake Ibsen, *J. Lunell* (Y). McHenry: Towner, *J. Lunell* < September 10 (Y).

SOUTH DAKOTA. Fall River: Hot Springs, *P. A. Rydberg 1052* > June 19 (U, Y). Lawrence: Deadwood, *W. P. Carr 154* (Y). Mellette: White River, *E. J. Wallace* (Y). Washabaugh: *S. S. Visher 2280* < August 22.

IOWA. Decatur: *J. P. Anderson* (M). Johnson: Iowa City, *A. S. Hitchcock* (U).

NEBRASKA. Cedar: St. James, *F. Clements 2609* (U). Lancaster: Lincoln, *G. G. Hedgcock* > May 22 (M). Lincoln: Hershey, *C. D. Mell 41* > May 15 (U). Thomas: Halsey, *L. Krautter* > May 29 (P).

MISSOURI. Barry: Monett, *F. W. Pennell 5359* (P). Cass: *G. C. Broadhead* > June 17 (M). Greene: Springfield, *P. C. Standley 8397* < August 29 (U). Jackson: Independence, *B. F. Bush 529* > June 7 (M). Jasper: Webb City, *E. J. Palmer 473* > June 20 (M). Jefferson: Sulphur Springs, *W. Trelease* < October 23 (M). St. Louis: Valley Park, *F. W. Pennell 5315* (P). Shannon: *B. F. Bush 68* > June 8 (U).

ARKANSAS. Benton: Sulphur Springs, *F. W. Pennell 5364, 5366* < September 3 (P).

OKLAHOMA. Creek: Sapulpa, *F. W. Pennell 5379* < September 7 (P). Kay: *M. White* (Y).

WYOMING. Crook: Sundance Mountain, *A. Nelson 2139* > July 3 (B, M, Y). Fremont: Wind River, *T. A. Williams* (Y). Sheridan: Dayton, *F. Tweedy 2277* < September (Y).

COLORADO. Boulder: Boulder, *F. Daniels 224* (M). El Paso: Colorado Springs, *M. E. Jones 997* > June 18 (U, Y). Larimer: Horsetooth Mountain, *F. W. Pennell 5850* (Y).

6. SMILAX TENUIS Small

Smilax tenuis Small, Bull. Torrey Club 25: 607. 16 D 1898. "The original specimens were collected by Dr. Hale, many years ago in Louisiana." Type seen in the herbarium of Columbia University at the New York Botanical Garden.

Nemexia tenuis Small, Fl. SE. U. S. 281, 1329. 1903. Woods, Louisiana and eastern Texas.

LOUISIANA. *Dr. Hale* > April (Y).

TEXAS. San Augustine: San Augustine, *G. L. Corbett* (U).

7. SMILAX ECIRRHATA (Engelm.) S. Wats.

Smilax herbacea ε ecirrhata Engelm.; A. DeCandolle, Monogr. Phan. 1: 52. 1878. "Prope Saint-Louis Americae bor. (Engelm.) . . . in h. ber. fol. 89 . . . et in h. Boiss." Type not seen nor verified.

Smilax ecirrhata S. Wats.; A. Gray, Man. ed. 6, 520. 1890.

Coprosmanthus ecirrhatus Chapm. Fl. S. U. S. ed. 3, 504. 1897.

Nemexia ecirrhata Small, Fl. SE. U. S. 280. 1903.

Woodlands; southwestern Ontario to Tennessee, Minnesota and Missouri.

ONTARIO. Huron: Wingham, *J. A. Morton 2283* > June 14 (M, U).

TENNESSEE. Franklin: Cowan, *H. Eggert* > May 7 (M). Knox: Knoxville, *Biltmore Herbarium 906d* > May 1 (B).

KENTUCKY. Bell: Pineville, *Biltmore Herbarium 906c* > May 7 (B). Estill: Irvine, *Biltmore Herbarium 14826* (B).

OHIO. Erie: Groton, *E. L. Moseley* < October 23 (U). Lorain: Amherst, *A. E. Ricksecker* > May 12 (U).

INDIANA. Huntingdon: *C. C. Deam 1953* (Deam). Tippecanoe: Lafayette, *F. W. Pennell 5310* (P). Wells: Bluffton, *C. C. Deam* > May 12 (M, U).

ILLINOIS. Cook: West Pullman, *L. M. Umbach* > May 21 (U). Hancock: —— > May 21 (M). McLean: Bloomington, *G. Vasey* (U). St. Clair: French Village, *H. Eggert* > May 8 (M, Y).

MICHIGAN. Gratiot: Alma, *C. A. Davis* > May 15 (U).

WISCONSIN. Grant: Boscobel, *C. H. Sylvester* > June (Y).

Minnesota. Chippewa: Montevideo, *L. R. Moyer* > May 30 (B). Winona: Winona, *J. M. Holzinger* > June (U).

Iowa. Fayette: *B. Fink 614* > June (U). Harrison: *R. Burgess* (Y). Johnson: *T. J. & M. F. L. Fitzpatrick* > May 13 (U).

Missouri. Clark: Dumas, *B. F. Bush* (M). Jackson: Courtney, *B. F. Bush* (M). Jefferson: Victoria, *H. Eggert* < August 24 (M, Y).

√ 8. **Smilax Hugeri** (Small) J. B. Norton, comb. nov.

Nemexia Hugeri Small, Fl. SE. U. S. 280, 1328. 1903. "Type, Stone Mt., Ga., *Small,* May 1–18, 1895 (fl.); Hickory Nut Gap, N. C., *Small & Huger,* Oct. 3, 1901, in Herb. N. Y. B. G." Type, "Stone Mt., De Kalb Co., Georgia, J. K. Small, May 1–18, 1895," seen in the herbarium of the New York Botanical Garden. Fruiting specimen cited is *S. biltmoreana.*

Woodlands, Piedmont and upper coastal plain of South Carolina to Alabama.

South Carolina. Aiken: Graniteville, *H. Eggert* (M). Berkeley: Santee Canal, *H. W. Ravenel* > April (S). Eutaw: Nelson's Ferry Road, *L. M. Bragg* (S).

Georgia. Clarke: Athens, *Biltmore Herbarium 14826* < July 22 (B). Dekalb: Stone Mountain, *J. K. Small* > May 1–18 (Y), type. Marion: Buena Vista, *R. M. Harper 1409* (M, U, Y).

Florida. Gadsden: *A. W. Chapman* (Y).

Alabama. Lee: Auburn, *F. S. Earle & C. F. Baker* < September 8 (Y). Tallapoosa: Dadeville, *C. L. Pollard & W. R. Maxon 138* (U, Y). Tuscaloosa: Tuscaloosa, *E. A. Smith* > April (M).

9. SMILAX PULVERULENTA Michx.

Smilax pulverulenta Michx. Fl. Bor. Amer. **2**: 238. 1803. "Hab. in Canada et Pensylvania." Type not verified, but a specimen of this plant of Michaux's collecting, "No. 29," seen in the herbarium of the Academy of Natural Sciences of Philadelphia, is probably a co-type.

Smilax herbacea var. *pulverulenta* A. Gray.

Nemexia pulverulenta Small, Fl. SE. U. S. 281. 1903.

Rich woods; southeastern New York to North Carolina and

Tennessee; also in southern Missouri. Frequent in the Piedmont region of southeastern Pennsylvania.

Flowers in New Jersey and southeastern Pennsylvania early- to late-May, two weeks to ten days before *S. herbacea;* fruits September to November.

NEW YORK. Bronx: east of Van Cortlandt Park, *F. W. Pennell 7070* (Y).

NEW JERSEY. Bergen: Fort Lee, *F. W. Pennell 7061* (Y). Cape May: Cold Spring, *O. H. Brown* (A). Gloucester: Swedesboro, *C. D. Lippincott* > May 22 (A). Mercer: near Trenton, *A. R. Slack* (P).

PENNSYLVANIA. Bucks: Nockamixon, *A. MacElwee* > May 28 (A). Chester: New Garden Station, *F. W. Pennell 4995* (A). Delaware: Cheyney, *F. W. Pennell 1986* < September 17 (Y). Franklin: Mercersburg, *Detwileer* > June 12 (A). Lancaster: Haines Station, *J. J. Carter* > May 16 (Y). Montgomery: Ashbourne, *B. Long 5824, 5828* > May 21 (A). Northampton: Easton, *T. Seal* > June 2 (A). Philadelphia: Cobbs Creek, *T. S. Githens* > May 14 (A). York: *J. Crawford* (A).

DELAWARE. Newcastle: Stanton, *W. M. Canby* > June 13 (B).

MARYLAND. Cecil: Conowingo, *S. S. Van Pelt & B. Long* > May 21 (A). Montgomery: High Island, *C. L. Pollard 254* > May 19 (U).

DISTRICT OF COLUMBIA. Rock Creek Park, *H. D. House 716* > May 13 (U).

VIRGINIA. Alexandria: Rosslyn, *C. L. Pollard* > May 6 (U). Smyth: Marion, *N. L. Britton & others* > May 22 (Y).

WEST VIRGINIA. Fayette: Thurmond, *Biltmore Herbarium 902e* (B).

NORTH CAROLINA. Buncombe: Biltmore, —— > May 8 (B). Forsyth: Salem, *L. D. von Schweinitz* (A). Halifax: Weldon, *E. B. Bartram* > April 19 (A).

TENNESSEE. Knox: Knoxville, *A. Ruth 154* > May (Y).

MISSOURI. Greene: Gates, *P. C. Standley 9377* < August 26 (U). Howell: Willow Springs, *F. W. Pennell 5339* (P). Jasper: Webb City, *E. J. Palmer 487* (M). Shannon: Monteer, *B. F. Bush 2787* > May 11 (M).

NEW YORK BOTANICAL GARDEN.

Notes on Carex—X

KENNETH KENT MACKENZIE

CAREX ROSEA SCHK. AND ITS ALLIES

Schkuhr's original illustration of *Carex rosea* in the Riedgräser (*pl. ZZZ, f. 179*) is drawn with his usual care and accuracy. Two culms in mature condition are shown. One has four spikes having respectively (commencing with the lowest) eight, seven, five, and five perigynia; and the other has five spikes having respectively eight, eleven, seven, six, and six perigynia. The detailed illustrations of the perigynia show that the body of the perigynium tapers or is but little contracted into the beak, and also that the perigynia are light green in color and are not conspicuously white-hyaline at the orifice. It is further to be especially noticed that the stigmas are slender and not twisted and that the exserted portion is about one third the length of the perigynium at flowering time.

The plant so illustrated is a slender plant with leaf-blades averaging about 1.5 mm. in width. The lower spikes usually have from five to eight perigynia, but the number varies between three and twelve. The most distinctive features, however, are to be found in the shape of the stigmas, slender and not twisted, and in their light reddish brown color. This plant, the genuine *Carex rosea*, is not the plant usually so treated in the manuals, but is the plant which is the basis of many records of *Carex rosea* var. *radiata*. The only work known to me where the distinctive stigmas are alluded to is Boott's Illustrations of the Genus Carex (**2**: 81), where the plant under discussion is treated as var. *minor* Boott of *Carex rosea* and briefly described and figured (*pl. 224*). It is a widely distributed species, ranging from Maine and Quebec, westward to North Dakota and southward to Georgia, Alabama, Mississippi and Louisiana. It flowers late in April or in May, is mature late in May or in June, and in July can be found only in very poor condition.

The plant which has usually been taken for *Carex rosea* is a much stouter plant of a deeper green color. The leaf-blades average nearly 2.5 mm. in width, and the lower spikes usually have from nine to twelve perigynia, although the number varies between six and twenty. The stigmas are short, thickish and twisted and are dark brownish red in color. The perigynium is abruptly contracted into the beak, is deep green in color, and is conspicuously white-hyaline at the orifice. Like *Carex rosea*, this is a widely distributed plant, ranging from Maine to Manitoba and southward to Alabama, Tennessee and Missouri; and like it, it matures in late May or June. For this species, which is apparently nameless, the name *Carex convoluta* is here proposed.

A third plant of much more restricted range remains for consideration. This is a very slender plant, in which the leaf-blades average little more than 1 mm. in width. The perigynia are very small, mostly 2.5–3 mm. in length, and are ascending or but little spreading. Each spike has but two to six perigynia, and the bract of the lowest spike is as conspicuous as the bract in *Carex trisperma*. In fact, the general aspect of the plant is very much like that of *Carex trisperma*. The stigmas are short and twisted, as in *Carex convoluta*, and the perigynium is abruptly contracted into the beak, as in that species. The perigynia, however, are rather lighter green in color, and less conspicuously white-hyaline at the orifice.

This is a later maturing plant than either of the other two. It blooms late in May or in June, and can be found in good condition in July and August. It is Alleghenian in its distribution and I have seen specimens showing a range from Maine and New York southward to North Carolina and Tennessee. It is the plant treated by Dr. Small (Fl. SE. U. S. 218) as *Carex radiata* and also the plant treated by Dewey (Am. Jour. Arts and Sciences, **10**: 276) and also by Boott (Ill. Car. **2**: 81. *pl. 225*) as *Carex rosea* var. *radiata*. The name "*radiata*," however, goes back to a plant described by Wahlenberg (Kongl. Vet. Akad. Handl. [II.] **24**: 147) under *Carex stellulata*, as *β radiata*, and collected in North America by Rev. Hultgren. As pointed out by Boott (*l. c.* 81) the description of this plant agrees best with *Carex trisperma* or some species of the *C. stellulata* group. Schkuhr referred it as a synonym to his *Carex rosea* (*l. c.* 15), and Dewey, as stated above, referred it to the plant now under discussion. In the absence of opportunity to examine the original specimen, I am not changing the application of the name. Tuckerman's *Carex neglecta* (Enum. Method. 19) is the oldest specific name for the species, but the name "*neglecta*" had previously been used by other authors for other species. It is interesting to note that both Tuckerman and Wahlenberg (if his name is correctly applied) erroneously placed this species among those with the staminate flowers below the pistillate.

The best characters to separate the three species in question may be contrasted as follows:

- Stigmas slender, not twisted, elongated, light brownish red; perigynium tapering or but little contracted into beak, inconspicuously white-hyaline at the orifice. *C. rosea.*
- Stigmas stouter, twisted, short, deep brownish red; perigynium contracted into beak, conspicuously white-hyaline at the orifice.
  - Leaf-blades averaging 2.5 mm. wide; spikes usually with nine to twelve perigynia; perigynia 3.25–4.5 mm. long, widely radiating. *C. convoluta.*
  - Leaf-blades averaging little more than 1 mm. wide; spikes usually with two to six perigynia; perigynia 2.5–3 mm. long, more ascending. *C. radiata.*

CAREX ROSEA Schk.; Willdenow, in Linnaeus, Sp. Pl. ed. 4, 4: 237. 1805; Riedgr. Nachtr. 15. *pl. zzz, f. 179.* 1806

Carex rosea var. *minor* Boott, Ill. Car. 2: 81. *pl. 224.* 1860.

Carex rosea var. *staminata* Peck; E. C. Howe, Rep. New York State Mus. Nat. Hist. 48: 132. 1895.

Densely cespitose, the culms 2–5 dm. high, slender, 1–1.75 mm. wide at base, aphyllopodic, smooth or slightly serrulate on the angles above, usually exceeding but at times equalled by the leaves, light brownish tinged and fibrillose at base. Leaves with well-developed blades three to six (usually four or five) to a culm, on lower fourth, but not bunched, the blades erect-ascending, 1–2 mm. wide, 3 dm. long or less, light green, flat, strongly minutely serrulate on the margins and on the veins towards the apex, the sheaths tight, not septate-nodulose. Spikes four to eight, androgynous, in an elongate terminal head, 5 cm. long or less, 5–8 mm. wide, the lower three to five separate, the upper three or four aggregated. Staminate flowers apical, inconspicuous, with the four to twelve ascending or at maturity widely radiating perigynia below. Bracts bristle-form, that of the lowest spike conspicuous, 10 cm. long or less, those of the upper spikes much smaller and often rudimentary. Scales triangular-ovate, greenish hyaline, thin, the midrib not strong, green, the scales obtusish, about width of and half length of body of perigynium. Perigynia soon widely spreading, plano-convex with slightly raised margins ventrally, light green, nerveless or obscurely nerved, roughened on margins above, 3–3.5 mm. long, 1.5 mm. wide, spongy and rounded at base, tapering or somewhat contracted into a bidentate beak, one fourth length of body, inconspicuously hyaline between teeth. Achenes lenticular, broadly obovate, filling perigynia, 1.75 mm. long, 1.25 mm. wide. Style enlarged at base, deciduous. Stigmas two, elongate, slender, usually not twisted, light reddish brown.

SPECIMENS EXAMINED

QUEBEC: Montmorency Falls, *Macoun 67755*, June 28, 1905 (N. Y.).

MAINE: Veazie, *Knight*, June 10, 1905 (K. M.).

NEW HAMPSHIRE: Orange, *Briggs*, 1900 (N. Y.).

MASSACHUSETTS: Chapman herbarium (C.).

NEW YORK: Staten Island, *Britton*, May 25, 1889 (C., P.); New York City, *Morong*, May 28, 1893 (C.); Penn Yan, *Sartwell 25* (C.); Oneida County, *Vasey* (C., P.); Oneida, *Maxon 4552*, July 8, 1909 (N. Y., K. M.); Cooperstown Junction, *Peck*, June, var. *staminata* Peck; Apalachin, *Fenno 491*, May 30, 1898 (N. Y.).

NEW JERSEY: Closter, Bergen County, *Mackenzie 5427*, June 8, 1913 (K. M.); Summit, Union County, *Mackenzie 161*, May 30, 1903 (K. M.); Eagle Rock, Essex County, *Mackenzie 143*, May 17, 1903 (K. M.); Berkeley Heights, Union County, *Mackenzie 2031*, May 30, 1906 (K. M.); Landisville, *Gross*, June, 1878 (P.); Mickleton, *Brinton*, June 15, 1890 (P.); Salem County, *Heritage*, May 28, 1892 (P.); New Egypt, *Grove*, May 21, 1905 (P.); Swedesboro, *Lippencott*, May 20, 1892, June 7, 1893 (P.); Kinkora, *Long 12245*, May 27, 1915 (P.); Vincentown, *Long 12214*, May 25, 1915 (P.); Edgewater Park, *Long 12018*, May 18, 1915 (P.).

PENNSYLVANIA: Easton, *Porter*, June 3, 1890 (C.); New Texas, *Carter*, May 20, 1909 (N. Y.); York Furnace, *Brinton*, May 30, 1892 (P.); Glenolden, *Keller*, June 9, 1895 (P.); Delaware County, *Smith*, May 30, 1898 (P.); Bartram's Garden, *Crawford*, June 3, 1892 (P.); Byberry, *Martindale*, June, 1863 (P.); Haverford, *Smith*, June 11, 1897 (P.); Penn Valley, *Crawford*, June 1, 1899 (P.); Germantown, *Wister*, June 17, 1862 (P.); Philadelphia

County, *Van Pelt*, June 10, 1908 (P.); West Park, *MacElwee*, May 27, 1892 (P.); Wawa, *MacElwee*, June 5, 1892 (P.); Bethlehem, *Schweinitz* (P.); Sellersville, *Fretz*, June, 1883 (P.); Lafayette, *Saunders*, May 28, 1898 (P.); Ryets, *Long*, June 15, 1909 (P.); Penllyn, *Long 915*, June 12, 1909 (P.); Fort Washington, *Long 913, 914*, June 11, 1909 (P.); Bear Hill, *Pennell 3956*, June 28, 1912 (P.); Brookfield, *Pennell 3688*, June 12, 1912 (P.); Bartram's Garden, *Crawford*, June 3, 1892 (P.); Wawa, *Pennell 2083, 2091*, May, 1909 (P.); Phoenixville, *Brinton*, May 25, 1890 (P.); Mt. Bethel, *Bartram*, May 30, 1908 (P.); Slatington, *Bachman 2408*, June 7, 1912 (P.); Mountainville, *Pretz 5325, 5335, 5336*, May 18, 1913 (P.); Allentown, *Pretz 5491*, June 17, 1913 (P.); Hosensack, *Pretz 5407*, May 30, 1913 (P.); Jordan, *Pretz 5512, 5532, 5542*, June 21, 1913 (P.); Bletzel, *Pretz 1775*, May 11, 1909 (P.); Allentown, *Pretz 380*, June 8, 1907 (P.); Mt. Cuba, *Keller*, May 30, 1895 (P.); Lowhill, *Pretz 4659*, June 23, 1912 (P.); Lanark, *Pretz 4475*, June 1, 1912 (P.); Henningville, *Pretz 6532*, May 30, 1914 (P.); Emaus, *Pretz 6595, 6611*, June, 1914 (P.); Bethlehem, *Schweinitz* (P.); Long Pond, *Crawford*, July 3, 1893 (P.); Fulton County, *Stone 242*, June 6, 1905 (P.).

DELAWARE. Belleview, *Commons*, June 2, 1897 (P.); Greenbank, *Commons*, June 4, 1882 (P.).

DISTRICT OF COLUMBIA: *House 792*, May 23, 1905 (N. Y.); *Steele*, May 21, 1898 (K. M.).

NORTH CAROLINA: Chapel Hill, *Ashe*, April (N. Y.); Salem, *Schweinitz* (P.).

SOUTH CAROLINA: Oconee County, *House 2131*, May 13, 1906 (N. Y.).

GEORGIA: Bear Creek, Whitfield County, *Harper 248*, July 18, 1900 (N. Y.); Chokee Creek, Sumter County, *Harper 1116*, July 25, 1901 (N. Y.).

ALABAMA: Auburn, *Earle*, June 2, 1901 (N. Y.).

MISSISSIPPI: Starkville, *Tracy*, April 15, 1888 (C.).

TENNESSEE: Knoxville, *Ruth 927*, June, 1895 (N. Y.).

KENTUCKY: Lexington, *Short*, 1836 (C.).

OHIO: Akron, *Foltz*, May 19, 1889 (N. Y.); Strongsville, *Watson*, May 10, 1896 (K. M.).

ONTARIO: Walpole Island, *Dodge*, May 24, 1910 (K. M.).

MICHIGAN: Agricultural College, *Wheeler*, May 2, 1895 (C.); Mayville, *Dodge*, June 16, 1910 (K. M.); Port Huron, *Dodge*, May and June, 1911, and June, 1915 (K. M.); Long Lake, Lapeer County, *Dodge*, June 2, 1911 (K. M.); Detroit, *Billington*, 1915 (K. M.).

INDIANA: *Clapp* (C.); Helmsburg, *Deam 11168*, June 16 1912 (N. Y.); Vermilion County, *Deam 5791*, May 8, 1910 (K. M.); Decatur County, *Mrs. Deam 8148*, May 13, 1911 (K. M.); Brown County, *Deam 6406, 11168*, May 21, 1910, June 16, 1912 (K. M.); Greene County, *Deam 10723*, May 26, 1912 (K. M.); Ripley County, *Deam 10563*, May 19, 1912 (K. M.); Allen County, *Deam 14244*, May 31, 1914 (K. M.); Wells County, *Deam 14175*, May 17, 1914 (K. M.); Marion County, *Deam 8524, 12905*, May 30, 1911, May 22, 1913 (K. M.); Posey County, *Deam 8347*, May 24, 1911 (K. M.); Martin County, *Deam 12845*, May 21, 1913 (K. M.).

ILLINOIS: Cook County, *Chase*, May 31, 1897 (P.); Decatur, *Clokey*, June 2, 1899 (K. M.); Macon County, *Clokey*, June 4, 1915 (K. M.); "Illinois," *Vasey* (P.).

WISCONSIN: Milwaukee, *Hasse*, June (N. Y.).

MINNESOTA: Chaska, *Ballard*, June, 1891 (C.).

NORTH DAKOTA: Fargo, *Waldron*, June 2, 1900 (N. Y.); Towner, McHenry County, *Lunell*, June 12, 1913 (K. M.).

MISSOURI: Independence, *Bush 717*, June 2, 1895 (C.); St. Louis, *Riehl 394*, June, 1843 (C.); Butler County, *Bush 2659*, May 1, 1905 (K. M., N. Y.); Courtney, *Bush 6751*, May 31, 1912 (K. M., N. Y.); St. Louis, *Glatfelter*, May 15, 1894 (K. M.); Adams, *Mackenzie*, May 23, 1897 (K. M.); Clay County, *Mackenzie 820*, April 27, 1895 (K. M.); Sibley, *Mackenzie 66*, May 29, 1898 (K. M.); Thornton, *Mackenzie 121*, June 5, 1898 (K. M.); Courtney, *Bush 6825*, June 18, 1912 (K. M.); Buckner, *Bush 6785*, June 5, 1912 (K. M.); Cockrell, *Bush 6717*, May 21, 1912 (N. Y., K. M.).

ARKANSAS: Moark, *Bush 2575*, May 1, 1905 (K. M.).

LOUISIANA: *Leavenworth* (C.).

Carex convoluta sp. nov.

"*Carex rosea* Schk." Boott, Ill. Car. **2**: 81 *pl. 223*. 1860.

Carex rosea var. *pusilla* Peck; E. C. Howe, Rep. New York State Mus. Nat. Hist. 48. 132. 1895.

Densely cespitose, the culms 3–6 dm. high, strict, 2.5 mm. wide at base, aphyllopodic, roughened above, equalling leaves, light brownish tinged and fibrillose at base. Leaves with well-developed blades four to six to a fertile culm, on lower fourth, but not bunched, the sheaths tight, somewhat septate-nodulose, the blades flat, 1.5–3 mm. wide, deep green. Spikes four to seven, androgynous, the upper closely contiguous, the lower strongly separate, with six to twenty perigynia, the staminate flowers few and inconspicuous; lowest bract setaceous, prolonged and often overtopping the culm, the others less developed. Scales broadly ovate, obtuse, thin, white-hyaline with green midvein, about width of and half length of body of perigynium. Perigynia soon widely spreading, plano-convex with slightly raised margins ventrally, deep green, nerveless or obscurely nerved, roughened on margins above, 3.25–4.5 mm. long, 1.75 mm. wide, spongy and rounding at base, abruptly contracted into a bidentate beak, one third length of body, conspicuously hyaline between teeth. Achenes lenticular, orbicular-obovate, filling perigynia, 2 mm. long, 1.6 mm. wide. Style enlarged at base, deciduous. Stigmas two, short, thickish, twisted, dark brown.

My No. 2088 collected June 10, 1906, at Budd's Lake, New Jersey, and preserved in my herbarium may be taken as the type.

SPECIMENS EXAMINED

MAINE: Veazie, *Knight*, June 10, 1905 (K. M.).

NEW HAMPSHIRE: *Blake* (C.).

MASSACHUSETTS: Great Barrington, *Brown*, June 3, 1894 (C., P.); Cambridge, *Fernald*, May 30, 1891 (C.); Dedham, *Forbes*, June 27, 1903 (K. M.); "Mass." *Dewey* (P.).

RHODE ISLAND: North Kingstown, May, 1872 (N. Y.); *Olney*, June (N. Y., P.); Lime Rock, *Batchelder*, June 4, 1913 (P.).

CONNECTICUT: Trumbull, *Eames*, May 20, 1903 (K. M.).

NEW YORK: *Torrey* (C.); Penn Yan, *Sartwell 24* (C.); High Bridge, *Bicknell*, July 5, 1890 (C.); Lake George, *Kemp*, June 1901 (N. Y.); Binghampton, *Clute*, 1895 (N. Y.); Apalachin, *Fenno 492, 500*, May 1898 (N. Y.); Portage, *Peck*, var. *pusilla* Peck (N. Y.).

NEW JERSEY: Budd's Lake, *Mackenzie 2088*, June 10, 1906 (K. M.); Cranberry Lake, *Mackenzie 732, 1295*, June 12, 1904, May 30, 1905 (K. M.); Mickleton, *Heritage*, May 18, 1892 (P.); Mickleton, *Brinton*, June 15, 1890 (P.); Glassboro, *Long 3419*, May 16, 1910 (P.); Farmingdale, *Long & Brown 3702*, May 28, 1910 (P.); Bordentown, *Long 12468*, June 11, 1915 (P.); Mullica Hill, *Long 12390*, June 4, 1915 (P.); Sharptown, *Long 12354*, June 1, 1915 (P.).

PENNSYLVANIA: York County, *Glatfelter*, June, 1895 (K. M.); Llewellyn Mills, *Pennell 5065*, July 16, 1913 (P.); Byberry, *Martindale*, June, 1865 (P.); Rock Hill, *Keller*, June 19, 1892 (P.); Lafayette, *Keller*, June 2, 1895 (P.); Spring Mount, *Van Pelt*, June 12, 1908 (P.); Gwynedd, *MacElwee 2322*, June 8, 1902 (P.); Green Lane, *Allebach*, May, 1911 (P.); Wernersville, *Lightfoot*, July 6, 1892 (P.); Easton, *Porter*, May 28, 1895 (P.); Rock Hill, *Saunders*, May 30, 1898 (P.); Chestnut Hill, *Porter*, June 14, 1898 (P.); Lancaster, *Long*, June 22, 1909 (P.); Revere, *Long*, July 6, 1909 (P.); Churchtown, *Long*, June 17, 1909 (P.); Bustleton, *Long*, June 15, 1909 (P.); Willow Grove, *Long 3778*, June 1, 1910 (P.); Chester Heights, *Pennell 5045*, June 21, 1913 (P.); Montgomery County, *Long 8274*, May 18, 1913 (P.); Limeport, *Pretz 5646, 5709*, June and July, 1913 (P.); Locust Valley, *Pretz 5675*, July 4, 1913 (P.); Mill Hill, *Pretz 5431*, May 30, 1913 (P.); Mountainville, *Pretz 1855, 5342, 6650, 6776*, May 29, 1909, May 18, 1913, June, 1914 (P.); Jordan, *Pretz 5545*, June 21, 1913 (P.); Jordan Creek, *Pretz 5566*, June 22, 1913 (P.); Vera Cruz, *Pretz 3472a, 5621*, June 4, 1911, June 29, 1913 (P.); Hosensack, *Pretz 4828B*, July 21, 1912 (P.); Treichler, *Pretz 4583*, June 22, 1912 (P.); Dillinger, *Pretz 3487*, June 4, 1911 (P.); Emaus, *Pretz 6583*, June 6, 1914 (P.); Spring Valley, *Pretz 4535*, June 9, 1912 (P.); Fleetwood, *Long 12603*, June 27, 1915 (P.); Laurel Hill, Somerset County, *Brown & Saunders*, May 30, 1899 (P.); Tannersville, *Brown*, July 4, 1901 (P.); Easton, *Porter*, 1891 and 1895 (C.); Conewago, *Small*, May 28, 1889 (C.).

DELAWARE: Mt. Cuba, *Brinton*, June 22, 1890 (P.); Greenbank, *Commons*, June 17, 1882 (P.).

DISTRICT OF COLUMBIA: *Steele*, May 15, 1896 (K. M.); *Williams*, May 30, 1899 (K. M.).

VIRGINIA: Smyth County, *Britton & others*, May, 1892 (C., P.); June 1, 1892 (C., K. M.); Wytheville, *Shriver*, 1874 (P.).

NORTH CAROLINA: *Hunter* (C.); Biltmore, *Biltmore Herbarium 263a*, June 3, 1896 (N. Y.).

SOUTH CAROLINA: Clemson, *House 3389*, May 22, 1907 (N. Y.).

ALABAMA: *Buckley*, May, 1841 (C.); Point Clear, Baldwin County, *Mohr*, April 29, 1879 (N. Y.).

TENNESSEE: Franklin County, *Eggert*, June 8, 1897 (N. Y.); Prospect, *Gattinger*, May 18, 1883 (N. Y.).

KENTUCKY: *Short*, in 1842 (C., N. Y.); Lexington, *Peter*, May, 1834 (P.).

OHIO: *Frank 55*, 1835 (C., N. Y.).

ONTARIO: Guelph, *Klugh*, July 9, 1905 (K. M.); Ontario, *J. M. Macoun*, June 12, 1891 (C.).

MICHIGAN: Cassapolis, *Wheeler 22*, June 2, 1890 (C.); Agricultural College, *Wheeler*, May 6, 1895 (C.); Olivet, *McClatchie*, June 3, 1887 (N. Y.); Flint, *Clarke* (P.); Tuscola County, *Dodge*, June 20, 1910 (K. M.): Mackinack County, *Dodge*, July 1, 1912 (K. M.); Port Huron, *Dodge*, June 6, 1911 (K. M.); Lapeer County, *Dodge*, June 2, 1911 (K. M.).

INDIANA: Greencastle, *Underwood*, June, 1893 (N. Y.); Laporte County, *Deam 8745*, June 17, 1911 (K. M.); Noble County, *Deam 6786*, June 20, 1910 (K. M.); Putnam County, *Deam 6506* (K. M.); Clarke County, *Deam 6476*, May 25, 1910 (K. M.); Vermilion County, *Deam 5841*, *5841a*, *5842*, May 8, 1910 (K. M.); Wells County, *Deam 14181*, May 17, 1914 (K. M.); Ripley County, *Deam 10588*, *10606*, May 19, 1912 (K. M.); Hendricks County, *Deam 10885*, June 1, 1912 (K. M.); Elkhart County, *Deam 10998*, June 4, 1912 (K. M.); Howard County, *Deam 5913*, *5950*, May 15, 1910 (K. M.); Brown County, *Deam 6560*, June 5, 1910 (K. M.); Wayne County, *Deam 13146*, June 4, 1913 (K. M.); Jackson County, *Deam 12719*, May 11, 1913 (K. M.); Johnson County, *Deam 11082*, June 8, 1912 (K. M.); Hamilton County, *Mrs. Deam 10540*, May 19, 1912 (K. M.); Lagrange County, *Deam 15945*, June 5, 1915 (K. M.).

WISCONSIN: Milwaukee, *Hasse*, June 1, 1880 (N. Y.); Madison, *Hale* (P.).

ILLINOIS: Mt. Carmel, *Schneck*, May 15, 1880 (C.); Peoria, *McDonald*, June, 1903 (N. Y.); Lasalle County, *Greenman & others. 59*, June, 1909 (N. Y.).

MINNESOTA: Center City, *Taylor*, June, 1892 (C.).

IOWA: Ames, *Ball 15*, June 4, 1898 (N. Y.); Charles City, *Arthur*, May 16, 1875 (N. Y.); Fayette, *Fink*, June, 1895 (N. Y.); Iowa Lake, *Cratty*, June 8, 1881 (N. Y.); Armstrong, *Cratty*, June 22, 1898 (N. Y.); Marshalltown, *Pammel 384*, May 1, 1897 (K. M.).

MISSOURI: Monteer, *Bush 4673*, *4689*, May 24, 1907 (K. M.); Swan, *Bush 4513*, *4513a*, May 17, 1907 (K. M.); Martin City, *Mackenzie*, June 13, 1900 (K. M.); Monteer, *Bush 2802*, *2870*, May, 1905 (K. M.); Burge Park, *Mackenzie*, May 16, 1896 (K. M.); Courtney, *Mackenzie*, May 23, 1896 (K. M.); Courtney, *Bush*, May 18, 1891 (C., P.), and *6810*, June 10, 1912 (K. M., N. Y.); Swan, *Bush 2914*, May 19, 1905 (K. M., N. Y.).

KANSAS: Leavenworth County, *Hitchcock 867*, 1896 (N. Y.); Quindaro, *Mackenzie*, May 30, 1897 (K. M.).

NEBRASKA: Ponca, *Clements 2557*, June 15, 1893 (C.); Lincoln, *Webber*, June, 1886 (C.); Ashland, *Williams*, 1890 (K. M.).

SOUTH DAKOTA: Bigstone, *Williams*, June, 1895 (K. M.).

MANITOBA: Portage la Prairie, *Macoun 72775*, June 9, 1906 (N. Y.).

CAREX RADIATA (Wahl.) Small, Fl. SE. U. S. 218. 1903

Carex stellulata β. C. radiata Wahl. Kongl. Vet. Akad. Handl. (II.) 24: 147. 1803.

Carex rosea β. radiata Dewey, Am. Jour. Sci. 10: 276. 1826.

Carex neglecta Tuckerman, Enum. Method. 19. 1843.

"*Carex disperma* Dewey" Kunze, Riedgr. Suppl. 131. *pl. 33*. 1840–50.

Densely cespitose, the culms 2.5–5 dm. high, very slender, 1.5 mm. thick at base, weak, aphyllopodic, roughened above, equalling leaves, light brownish tinged and fibrillose at base. Leaves with well-developed blades four to six to a fertile culm on lower fourth, but not bunched, the sheaths tight, not septate-nodulose, the blades flat, 1–1.75 mm. wide, light green. Spikes mostly four, androgynous, the two upper closely contiguous, the lower strongly separate, with two to six perigynia, the staminate flowers few and inconspicuous; lowest bract setaceous, erect, prolonged and often overtopping the culm; the others less developed. Scales ovate, obtuse, thin, white-hyaline with green midvein, about width of but shorter than body of perigynium. Perigynia at first erect, at maturity more or less strongly spreading, plano-convex with slightly raised margins ventrally, deep green, nerveless or obscurely nerved, roughened on margins above, 2.25–3 mm. long, 1.5 mm. wide, somewhat spongy and rounding at base, abruptly contracted into a bidentate beak, half length of body, hyaline between teeth. Achenes lenticular, orbicular-obovate, filling perigynia, 1.5 mm. long, nearly as wide. Style enlarged at base, deciduous. Stigmas two, short, twisted, dark reddish brown.

SPECIMENS EXAMINED

MAINE: Orono, *Briggs*, June, 1892 (N. Y.); Orono, *Fernald*, July 1, 1891 (C.).

NEW HAMPSHIRE: East Andover, *Briggs*, 1900 (N. Y.).

VERMONT: Middlebury, *Brainerd*, June 20, 1880 (P.).

MASSACHUSETTS: Plainfield, *Porter* (C.); Ashfield, *Forbes*, August 19, 1904 (K. M.); North Adams, *Fernald & Long 9017*, June 23, 1913 (P.); "Mass." *Nuttall* (P.).

RHODE ISLAND: *Olney* (N. Y., K. M.).

CONNECTICUT: *Barratt* (N. Y.); West Goshen, *Underwood*, June 29, 1891 (C.).

NEW YORK: Oneida County, *Vasey* (N. Y., K. M., P.); Hunter, Catskill Mountains, *Britton*, August 1, 1898 (N. Y.); Tannersville, *Vail*, July 16, 1892 (C.); Preston, *Coville*, June 28, 1886 (K. M.).

NEW JERSEY: Water Gap, *Mackenzie 5306*, September 28, 1912 (K. M.); Moe, Passaic County, *Mackenzie 6005*, July 5, 1914 (K. M.).

PENNSYLVANIA: Pike County, *Brown & Saunders*, July 9, 1899 (P.); Nockamixon, *MacElwee*, May 28, 1893 (P.); Rockdale, *Krout*, June, 1877 (P.); New Jerusalem Church, Lehigh County, *Hamm 839*, August 14, 1911 (P.); Rockdale, *Van Pelt*, July 25, 1909 (P.); Hoffman, *Pretz 7752*, August 8, 1915 (P.); Rockdale, *Pretz 2019*, July 25, 1909 (P.); Bethlehem, *Schweinitz* (P.); Tobyhanna, *Brown*, July 2–4, 1893 (P.); Ararat, Susquehanna County, *Saunders*, July 8–20, 1900 (P.).

VIRGINIA: Peaks of Otter, *Curtiss*, June 28, 1871 (N. Y.), *Brown & others*, May and June, 1890 (C., P.); Smyth County, *Britton & others*, June, 1892 (C.); Grayson County, *Britton & others*, June 15, 1892 (C., K. M.); Mountain Lake, *Britton & others*, June 1, 1890 (C.); Pond Mountain, *Small*, June 11, 1892 (C.); Luray, *Steele*, August 11, 1901 (N. Y.).

KENTUCKY: Big Black Mountain, Harlan County, *Kearney 156*, August, 1893 (C.).

TENNESSEE: Thunderhead Mountain, 6711 ft. alt., *Ruth 928*, July, 1894 (N. Y.), and *30*, June, 1894 (K. M.).

NORTH CAROLINA: Mt. Mitchell, *Biltmore Herbarium 206b*, June 18, 1898 (N. Y.); Craggy Mountain, *Biltmore Herbarium 206a*, July 9, 1897 (N. Y.); Macon County, *Buckley* (C.); Swain County, *Beardsley & others*, July, 1891 (C.); Watauga County, *Small & Heller 265*, June 24, 1891 (C., P.); Mt. Mitchell, *Biltmore Herbarium 4974c*, June 20, 1898 (N. Y.).

INDEX TO AMERICAN BOTANICAL LITERATURE

1909-1916

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 the broadest sense.

Reviews, and papers that 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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Britton, E. G. Wild plants needing protection—10. "Liver-leaf" (*Hepatica Hepatica* (L.) Karst.). Jour. N. Y. Bot. Garden **17**: 55, 56. *pl. 170.* Ap 1916.

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Contains a chapter on the fauna and flora of the region.

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A North American plant.

CHURCH: COOPERIA DRUMMONDII


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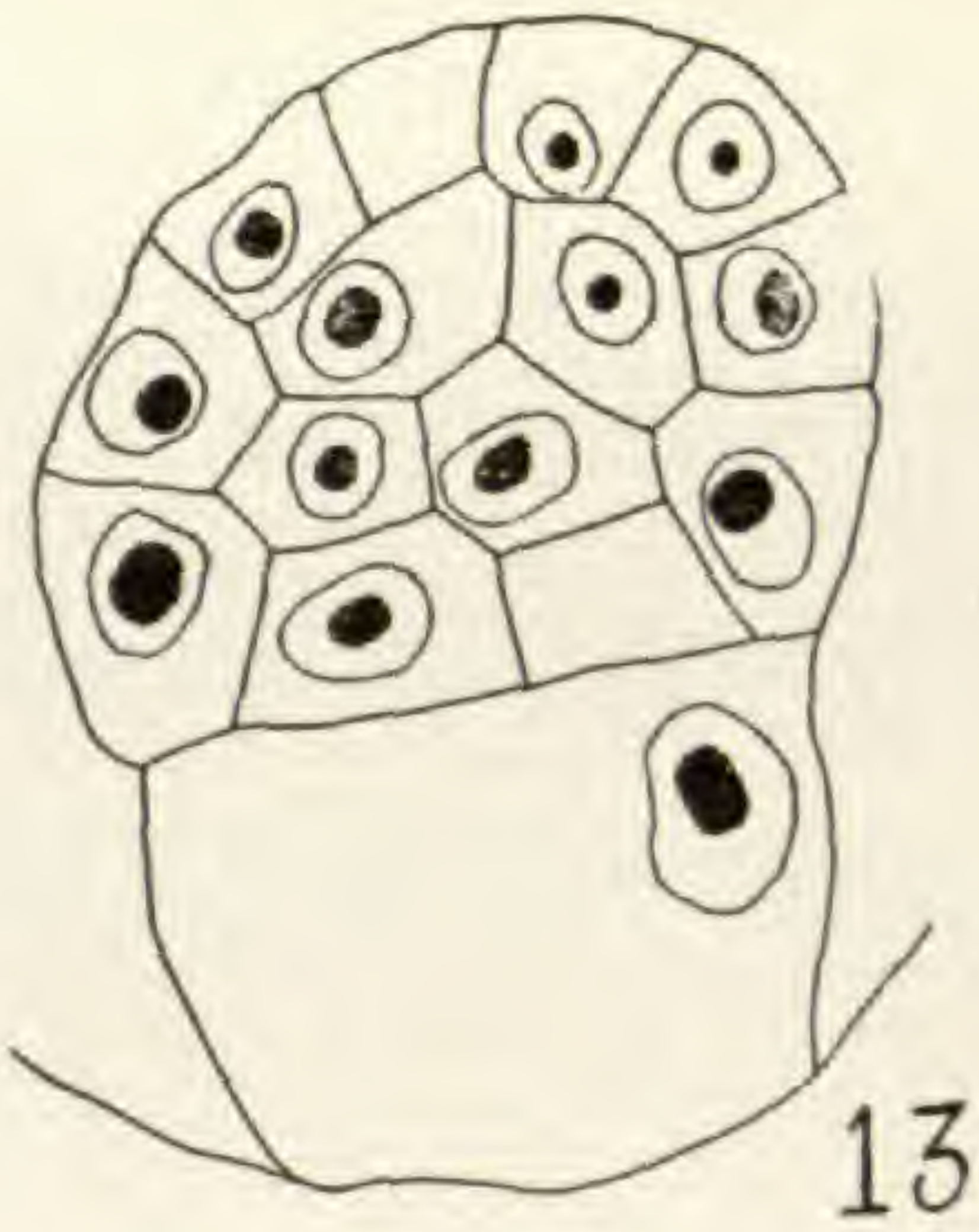
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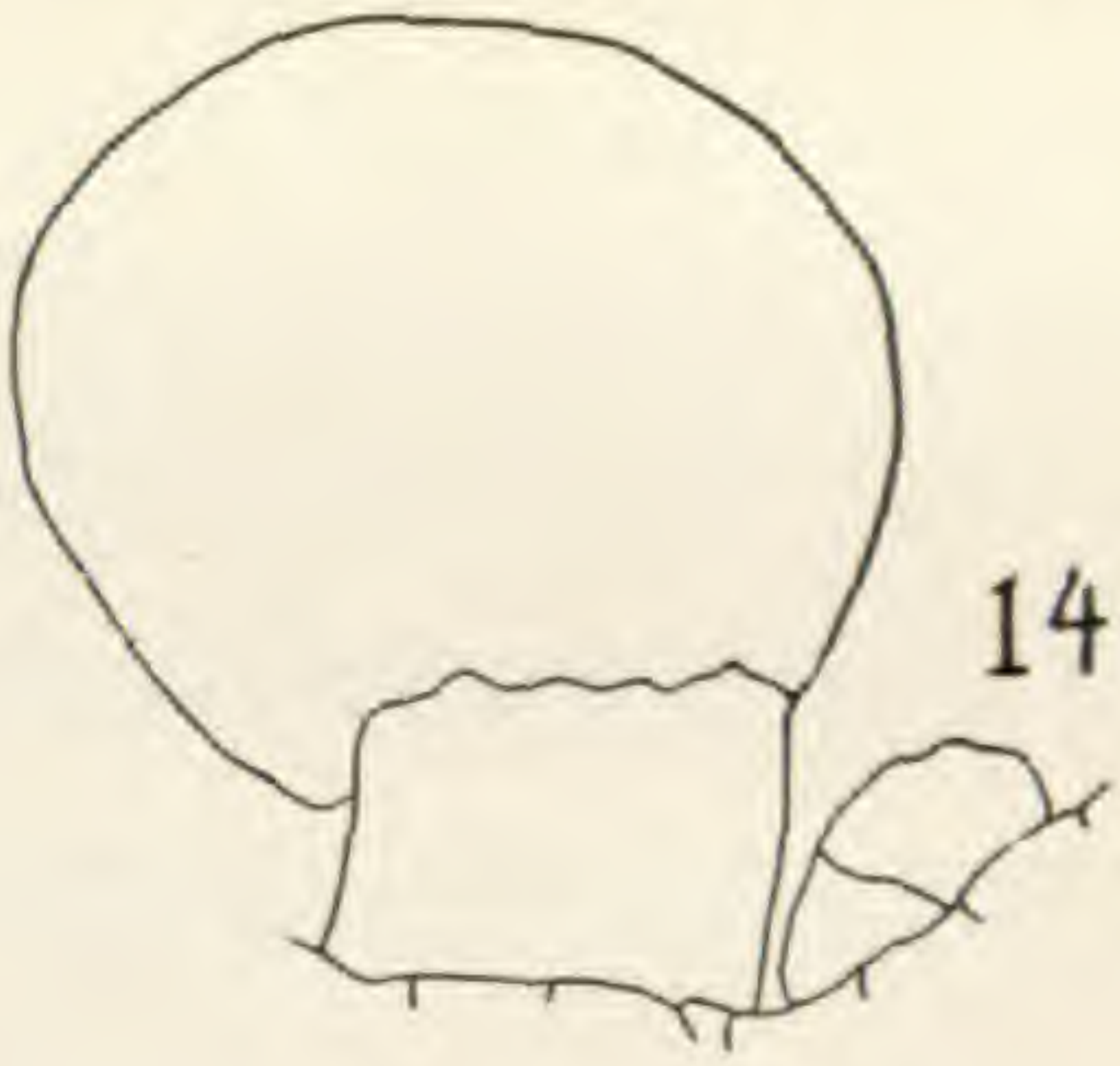
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CHURCH: COOPERIA DRUMMONDII

Vol. 43 No. 9

BULLETIN

OF THE

TORREY BOTANICAL CLUB

SEPTEMBER, 1916

Studies of West Indian plants—VIII

Nathaniel Lord Britton

44. FURTHER RECORDS OF JAMAICA SEDGES*

Cyperus fugax Liebm. Vid. Selks. Skr. V. 2: 196. 1851

Savanna, Belle Vue, near Spanish Town (*Harris 12183*).
Distribution: Mexico and Guatemala.

Cyperus cyperoides (L.) Kuntze, Rev. Gen. Pl. 3^2: 333. 1898

Scirpus cyperoides L. Mant. 181. 1771.
Mariscus Sieberianus Nees, Linnaea 9: 286. 1834.
Mariscus cyperoides Urban, Symb. Ant. 2: 164. 1900. Not *M. cyperoides* A. Dietr.

Belle Vue, near Spanish Town, in wet hollows in pastures (*Harris 12045*); previously collected in Jamaica by Hart and by Wullschlaegel.

Distribution: Trinidad. Native of the Old World tropics.

Cyperus nanus Willd.

In Bull. Dept. Agric. Jamaica 5: Suppl. 1, 9, I noted Mr. C. B. Clarke's record of this species from Jamaica, as based on the same specimen (*March 13*) as his record of *Mariscus gracilis* Vahl (*Cyperus granularis* [Desf.] Britton), and I subsequently ascertained that this specimen preserved in the Kew herbarium is

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* Bull. Dept. Agric. Jamaica 5: Suppl. 1. 1907. Bull. Torrey Club 35: 568, 569. 1909. *Ibid.* 41: 1, 2. 1914.

[The Bulletin for August (43: 397–440. *pl. 22, 23*) was issued August 22, 1916.]

C. granularis. It would therefore appear that *C. nanus* was entered as Jamaican by Mr. Clarke in error. *C. granularis* on the other hand is now known to me to inhabit dry soil at Long Acre Point near Black River (*Britton 1383*).

Cyperus ignotus sp. nov.

Perennial, glabrous; culm rather stout, smooth, bluntly 3-angled, about 5 dm. high. Basal leaves as long as the culm or longer, smooth, 2.5–4 mm. wide, those of the involucre similar, much longer than the inflorescence, sometimes 3 dm. long; umbel compound, its primary rays 8 cm. long or less; spikelets compressed, capitate, 6–8-flowered, the heads numerous, 8–10 mm. in diameter; rachis wingless; scales ovate-lanceolate, mucronulate, very faintly nerved, closely appressed and overlapping, 2 mm. long; style 3-cleft; achene oblong, trigonous, 1.3 mm. long, about twice as long as thick, narrowed at both ends.

In damp, shaded places, near Vinegar Hill, St. George, at about 1,100 m. alt. (*Harris 12350*). Plant with the habit of *C. elegans* L., but with flat leaves and quite different spikelets.

ELEOCHARIS NODULOSA (Roth) Schultes; R. & S. Mant. **2**: 87. 1824

Scirpus nodulosus Roth, Nov. Pl. Sp. 29. 1821.

Swamp, Belle Vue near Spanish Town (*Harris 12179*).

DISTRIBUTION: Southern United States; Cuba; Hispaniola; Porto Rico; Antigua; Guadeloupe; continental tropical America.

ELEOCHARIS MICROCARPA Torr. (*E. minima* Kunth), was recorded by Mr. Clarke as collected in Jamaica by Purdie, but his determination of the specimen from the interior of Manchester preserved in the Kew herbarium was subsequently doubted by Mr. Clarke, and we have no other knowledge of the existence of this species in Jamaica.

Stenophyllus junciformis (HBK.)

Isolepis junciformis HBK. Nov. Gen. 1: 222. 1815.

Scirpus juncoides Willd.; Griseb. Fl. Br. W. I. 572. 1864.

Summit of Bull Head Mountain (*Underwood 3364*); Liguanea Ridge, St. Andrew (*Harris 12219, 12345*).

DISTRIBUTION: Cuba; South America.

Owing to two different species having been distributed as *Scirpus juncoides* under C. Wright's Cuban No. 1533, I formerly misidentified Professor Underwood's No. 3364 and recorded it* as *Stenophyllus subaphyllus* (Clarke) Britton, a species apparently restricted to eastern Cuba.

FIMBRISTYLIS MILIACEA (L.) Vahl, Enum. **2**: 287. 1806

Savannas and swamps, Belle Vue, near Spanish Town (*Harris 12182, 12188*).

DISTRIBUTION: Southern United States; Cuba; Porto Rico; continental tropical America and Old World tropics.

RYNCHOSPORA OLIGANTHA A. Gray, Ann. Lyc. N. Y. **3**: 212. 1835

Hollis savanna, Upper Clarendon (*Harris 12249*).

DISTRIBUTION: Southeastern United States. Not yet detected in Cuban savannas.

RYNCHOSPORA PUSILLA Chapm.; Curtis, Am. Jour. Sci. II. **7**: 409. 1849

Rynchospora intermixta C. Wright; Sauvalle, Anales Acad. Habana **8**: 88. 1872

Bull Head Mountain, along roadside in wet places (*Harris 12261*).

DISTRIBUTION: Southeastern United States; Santa Clara, Pinar del Rio and Isle of Pines, Cuba.

SCLERIA GRACILIS Ell. Bot. S. C. & Ga. **2**: 571. 1824

Bull Head Mountain, 800–900 m. alt., forming small patches on exposed hillside (*Harris 12262*).

DISTRIBUTION: Southeastern United States; Pinar del Rio and Isle of Pines, Cuba.

45. STENOPHYLLUS RAF. IN THE WEST INDIES

Type species: *Scirpus Stenophyllus* Ell. The generic name dates from 1825 (Neog. 4). The name *Bulbostylis*, taken up by Mr. C. B. Clarke for the genus in 1893 (Hook. f. Fl. Brit. India) and subsequently, was first published by Kunth, under *Isolepis*, in 1837 (Enum. **2**: 205).

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* Bull. Dept. Agric. Jamaica **5**: Suppl. 1, 12. 1907.

A. Spikelet solitary.

Spikelet terminal, not subtended by a bract.

Caudex stout, 2–15 cm. high, densely clothed with persistent leaf-bases. 1. *S. paradoxus.*

Caudex none.

Leaves elongated; spikelet straw-color. 2. *S. leucostachys.*

Leaves short; spikelet dark brown. 3. *S. conifera.*

Spikelet apparently lateral, subtended by a bract.

Achene smooth. 4. *S. floccosus.*

Achene papillose-reticulated.

Achene twice as long as thick. 5. *S. portoricensis.*

Achene scarcely longer than thick. 6. *S. curassavicus.*

B. Spikelets (except in depauperate plants) several or numerous.

a. Spikelets in a single capitate cluster.

Plants leafless or nearly so, or leaves 1–3 cm. long.

Spikelets few, 6 mm. long or less.

Leaf-blade 6 mm. long or less. 7. *S. subaphyllus.*

Leaf-blade 1–3 cm. long. 8. *S. alpestris.*

Spikelets several, 6–20 mm. long.

Scales loosely pubescent. 9. *S. Wilsoni.*

Scales glabrous or ciliolate. 10. *S. Tuerckheimii.*

Leaves about one half as long as the culm. 11. *S. fimbriatus.*

b. Spikelets in a simple or compound umbel, or sometimes compact or capitate.

Spikelets clustered in umbelled heads or spikes, or head sometimes solitary.

Culm pilose above. 12. *S. vestitus.*

Culm glabrous.

Scales mucronate by the excurrent midvein. 13. *S. junciformis.*

Scales acute, the midvein not excurrent; achene papillose. 14. *S. antillanus.*

Spikelets not clustered in the umbels, or somewhat clustered.

Achene 0.5 mm. long, gray, densely pitted; scales suborbicular. 15. *S. coarctatus.*

Achene 0.7–1 mm. long, white, transversely undulate; scales ovate. 16. *S. capillaris.*

1. STENOPHYLLUS PARADOXUS (Spreng.) Standley, Contr. U. S. Nat. Herb. 18: 88. 1916

Schoenus paradoxus Spreng. Syst. 1: 190. 1825.
Bulbostylis paradoxa Linden; Regnell, Cyp. 17. 1900.

TYPE LOCALITY: Mt. Silla de Cacares, near El Pexual, Venezuela.

DISTRIBUTION: Isle of Pines, Cuba: continental tropical America.

One of the noteworthy elements in the vegetation of sandy pine-lands on the Isle of Pines, sometimes occupying areas many acres in extent.

2. **Stenophyllus leucostachyus** (HBK.)

Isolepis leucostachya HBK. Nov. Gen. 1: 220. 1815.
Bulbostylis leucostachya Kunth; Clarke in Urban, Symb. Ant. **2**: 85. 1900.

TYPE LOCALITY: Wet woods of the Orinoco at Maypuri.

DISTRIBUTION: West Indies (*Swartz*, according to Clarke): northern South America. Unknown to me from the West Indies.

3. **Stenophyllus coniferus** (Kunth)

Isolepis conifera Kunth, Enum. **2**: 206. 1837.

TYPE LOCALITY: Surinam.

DISTRIBUTION: Recorded by Clarke as doubtfully collected by Mayerhoff in Hispaniola: northern South America.

4. STENOPHYLLUS FLOCCOSUS (Griseb.) Britton, Torreya **13**: 216. 1913

Scirpus floccosus Griseb. Cat. Pl. Cub. 241. 1866.
Bulbostylis floccosa Clarke; Urban, Symb. Ant. **2**: 86. 1900.

TYPE LOCALITY: Eastern Cuba.

DISTRIBUTION: Known only from the type locality.

5. STENOPHYLLUS PORTORICENSIS Britton, Torreya **13**: 216. 1913

TYPE LOCALITY: Rocky coastal thicket near Guanica, Porto Rico.

DISTRIBUTION: Coastal thickets, southwestern Porto Rico.

6. **Stenophyllus curassavicus** Britton, nom. nov.

Bulbostylis floccosa var.(?) *pumilio* Clarke; Urban, Symb. Ant. **5**: 290. 1907.

TYPE LOCALITY: Curaçao.

DISTRIBUTION: Banks and limestone rocks, Bonaire and Curaçao.

The spikelets of this species are much compressed. The varietal name published by Mr. Clarke is not taken up because the plant attains a greater size than his description indicates. The plant is abundant about Willamsted, Curaçao (*Britton & Shafer 2946*).

7. STENOPHYLLUS SUBAPHYLLUS (Clarke) Britton, Bull. Dept. Agric. Jamaica 5: Suppl. 1, 12. 1907

Bulbostylis subaphylla Clarke; Urban, Symb. Ant. 2: 86. 1900.

TYPE LOCALITY: Eastern Cuba.

DISTRIBUTION: Eastern Cuba; formerly erroneously attributed by me (*loc. cit.*) to Jamaica (see page 443).

8. **Stenophyllus alpestris** (Urban)

Bulbostylis alpestris Urban, Symb. Ant. 7: 168. 1912.

TYPE LOCALITY: Near Constanza, Santo Domingo, in pine-lands, 2,500 m. alt.

DISTRIBUTION: Known only from the type locality.

9. STENOPHYLLUS WILSONI Britton, Torreya 13: 215. 1913

TYPE LOCALITY: Castle Island, Bahamas.

DISTRIBUTION: Castle Island and Little Inagua, Bahamas.

10. **Stenophyllus Tuerckheimii** (Urban)

Bulbostylis Tuerckheimii Urban, Symb. Ant. 7: 169. 1912.

TYPE LOCALITY: Near Constanza, Santo Domingo, in pine-lands, 1,250 m. alt.

DISTRIBUTION: Known only from the type locality.

11. **Stenophyllus fimbriatus** (Nees)

Oncostylis fimbriata Nees; Martius, Fl. Bras. 2: 88, 1843.
Scirpus Dussii Boeckl. Cyp. Nov. 2: 38. 1890.
Bulbostylis fimbriata Clarke; Urban, Symb. Ant. 2: 87. 1900.

TYPE LOCALITY: River-banks at Villa Rica, Brazil.

DISTRIBUTION: Martinique; Peru; Brazil.

12. **Stenophyllus vestitus** (Kunth)

Isolepis vestita Kunth, Enum. 2: 210. 1837.
Oncostylis vestita Nees; Martius, Fl. Bras. 2: 88. 1843.
Scirpus hirtus Griseb. Cat. Pl. Cub. 241. 1866.

TYPE LOCALITY: Surinam.

DISTRIBUTION: Province of Pinar del Rio, Cuba; western Porto Rico: continental tropical America. The Porto Rico plant was referred by Clarke to *Bulbostylis Langsdorffiana.*

13. STENOPHYLLUS JUNCIFORMIS (HBK.) Britton, Bull. Torrey Club 43: 442. 1916

Isolepis junciformis HBK. Nov. Gen. 1: 222. 1815.
Scirpus juncoides Willd.; Griseb. Fl. Br. W. I. 572. 1864.

TYPE LOCALITY: Near the Guachari cavern, 500 feet alt.

DISTRIBUTION: Savannas and pine-lands, province of Pinar del Rio, Cuba; Hispaniola; Jamaica; Trinidad: continental tropical America.

14. **Stenophyllus antillanus** sp. nov.

Culms tufted, nearly filiform, 2–4.5 dm. long, minutely rough-ciliolate or smooth. Leaves filiform, similar to the culm and one half to two thirds its length, rough-ciliolate or smooth, their sheaths pilose. Umbel compact or subcapitate; spikelets few or several, linear, 6–12 mm. long, 1.5 mm. wide, 8–12-flowered; scales ovate, known with a strong, whitish keel, acute, 1.5 mm. long; achene obovoid, nearly white, sharply trigonous, 0.7 mm. long, papillose, tipped by a minute, conic tubercle.

Dominica and Martinique. Type from Grand Savanna, Dominica (*F. E. Lloyd 822*).

Referred by Clarke (in Urban, Symb. Ant. 2: 89. 1900) to *S. capillaris.*

15. STENOPHYLLUS COARCTATUS (Ell.) Britton; Small, Fl. SE. U. S. 189. 1903

Scirpus coarctatus Ell. Bot. S. C. & Ga. 1: 83. 1816.

TYPE LOCALITY: Beaufort, South Carolina.

DISTRIBUTION: On a sand pile in Santiago Harbor, Oriente, Cuba, March, 1909; southeastern United States.

16. STENOPHYLLUS CAPILLARIS (L.) Britton, Bull. Torrey Club 21: 30. 1894

Scirpus capillaris L. Sp. Pl. 49. 1753.
Bulbostylis capillaris Clarke; Hook. f. Fl. Brit. India 6: 652. 1893.

TYPE LOCALITY: Virginia.

DISTRIBUTION: Sandy and rocky soil, provinces of Oriente and Pinar del Rio and on the Isle of Pines, Cuba; pinelands at high elevations in Santo Domingo; Jamaica (not recently collected): continental North America; temperate South America.

Stenophyllus tenuifolius (Rudge).

Scirpus tenuifolius Rudge, Pl. Guian. 18, *pl. 22.* 1805.
Scirpus bufonius Poir. Encycl. Suppl. 5: 105. 1817.
Bulbostylis capillaris tenuifolia Clarke; Urban, Symb. Ant. 2: 89. 1900.

Recorded by Clarke as collected by C. Wright in Cuba (*Wright 3382*), but our specimens of that number are not essentially different from *S. capillaris*. The species inhabits tropical South America.

46. GALACTIA P.BR. IN CUBA

Type species: *Glycine Galactia* L.

A. Corolla 2–2.5 cm. long, the standard parallel with the wings and keel. 1. *G. rudolphioides.*
B. Corolla not more than 1.7 cm. long, the standard erect, not parallel with the wings and keel.
  a. Twining or trailing vines.
    Corolla about 1.7 cm. long; leaflets 8 mm. long or less; peduncle 1-flowered. 2. *G. minutifolia.*
    Corolla less than 1.5 mm. long; leaflets 1–6 cm. long; peduncles mostly few- to several-flowered.
      Terminal leaflet (when 3) long-stalked.
        Calyx-lobes longer than the tube.
          Inflorescence short, 1- to few-flowered.
            Branches prostrate; calyx loosely pubescent.
              Leaflets 3 or 1, oblong to narrowly linear, 2–10 mm. wide. 3. *G. parvifolia.*
              Leaflet only 1, ovate or elliptic, 10–18 mm. wide. 4. *G. monophylla.*
            Branches suberect; calyx densely villous. 5. *G. suberecta.*
          Inflorescence elongated, several- to many-flowered.
            Leaflets membranous or chartaceous, flat, dull; standard 9–11 mm. long.
              Leaflets oblong to obovate-oblong. 6. *G. Combsii.*
              Leaflets ovate to elliptic or ovate-lanceolate.
                Leaflets membranous; raceme usually long-peduncled. 7. *G. striata.*
                Leaflets chartaceous; raceme short-peduncled or sessile. 8. *G. spiciformis.*
            Leaflets subcoriaceous, revolute-margined, shining; standard 7 mm. long. 9. *G. Earlei.*

Calyx-lobes shorter than the tube.	10. *G. brachyodon.*
Leaflets nearly equally short-stalked.	
Leaflets densely or loosely pubescent beneath.	
Leaflets obovate, strongly reticulate-veined, loosely pubescent on both sides.	11. *G. Jenningsii.*
Leaflets linear-oblong, narrowed at both ends, densely silky beneath.	12. *G. revoluta.*
Leaflets glabrous, or with only some scattered hairs beneath.	
Flowering pedicels 1–2 mm. long; pod short-pilose, its pedicel 3 mm. long.	13. *G. galactioides.*
Flowering pedicels 0.5 mm. long; pod long-pilose, its pedicel 1.5 mm. long or less.	14. *G. savannarum.*
b. Erect shrub; leaflets 3.	15. *G. Jussiaeana.*

1. GALACTIA RUDOLPHIOIDES (Griseb.) Benth. & Hook.; Sauvalle, Anales Acad. Habana 5: 337. 1869

Dioclea rudolphioides Griseb. Mem. Am. Acad. II. 8: 178. 1860.
Galactia Odonia Griseb. Cat. Pl. Cub. 75. 1866.

Pinelands, thickets and hillsides, Oriente, Matanzas: Bahamas.

2. GALACTIA MINUTIFOLIA Urban, Symb. Ant. 2: 325. 1900

Dry soil, Oriente. Endemic. Referred by Grisebach to *G. parvifolia* A. Rich.

3. GALACTIA PARVIFOLIA A. Rich. Ess. Fl. Cub. 414. 1845

Galactia stenophylla Urban, Symb. Ant. 2: 313. 1900. Not H. & A.
Galactia parvifolia triphylla Urban, *loc. cit.* 314. 1900.
Galactia parvifolia heterophylla Urban, *loc. cit.* 315. 1900.
Galactia parvifolia monophylla Urban, *loc. cit.* 315. 1900.
Galactia Grisebachii Urban, Symb. Ant. 5: 372. 1908.

Grassy fields and banks at lower elevations, all provinces and Isle of Pines: South Florida; Hispaniola. Consists of races differing in number, form and size of leaflets.

4. GALACTIA MONOPHYLLA Griseb. Cat. Pl. Cub. 75. 1866

Grassy places, Oriente, Havana; Bahamas.

5. **Galactia suberecta** sp. nov.

A somewhat woody trailing vine, with slender, villous, erect or ascending branches 1–2.5 dm. high. Stipules lanceolate, acute, 2–3 mm. long; petioles slender, villous, 1–2 cm. long; leaflets 3, oblong to oblong-oblanceolate or oval, 1–3 cm. long, mostly obtuse or rounded at the apex, appressed-pubescent on both sides, strongly reticulate-veined beneath, the lateral ones nearly sessile, obtuse or rounded at the base, the terminal one narrowed at the base, on a petiolule 3–4 mm. long; peduncles 1–flowered, shorter than the petioles; calyx villous, 6 mm. long, its lanceolate lobes longer than the tube; corolla purple, 1 cm. long.

Savanna near San Juan, Isle of Pines, Cuba (*Britton & Wilson 14973*).

6. GALACTIA COMBSII Urban, Symb. Ant. **2**: 219. 1900

Grassy places, Santa Clara, Pinar del Rio. Endemic. Referred by Combs to *G. angustifolia* HBK.

7. GALACTIA STRIATA (Jacq.) Urban, Symb. Ant. **2**: 320. 1900

Glycine striata Jacq. Hort. Vind. **1**: 32. *pl. 76.* 1770.
Galactia cubensis HBK. Nov. Gen. **6**: 429. 1823.
Galactia Berteriana DC. Prodr. **2**: 238. 1825.
Galactia striata cubensis Urban, Symb. Ant. **2**: 322. 1900.
Galactia striata Berteriana Urban, *loc. cit.* 1900.

Thickets and hillsides at lower elevations, all provinces and Isle of Pines: Jamaica; Hispaniola; Porto Rico; continental tropical America. Recorded by Grisebach and by Wright as *G. filiformis* Benth. Some Cuban specimens with short-peduncled inflorescence are only with difficulty separable from the following species. Races differ in pubescence.

8. GALACTIA SPICIFORMIS T. & G. Fl. N. A. **1**: 288. 1838

Thickets, Cays of Camaguey: southern Florida; Bahamas.

9. **Galactia Earlei** sp. nov.

Stem slender, somewhat woody, twining, finely appressed-pubescent 5 dm. long or longer. Stipules lanceolate-subulate, about 2 mm. long; petioles slender, sparingly pubescent, 3 cm. long or less; leaflets 3, oblong or elliptic, 1.5–3 cm. long, 8–15 mm. wide, glabrous and shining with the midvein impressed above, sparingly appressed-pubescent beneath, revolute-margined, obtuse or slightly emarginate at the apex, rounded at the base, the terminal one with a petiolule 4–8 mm. long, the lateral ones nearly sessile; inflorescence stalked, slender, many-flowered, 6–12 cm. long, densely brownish-pubescent; flowers clustered, almost sessile; calyx 6–7 mm. long, densely brownish appressed-pubescent, its teeth longer than the tube, the upper one ovate, the others lanceolate; standard clawed, nearly orbicular, 7 mm. long.

Pine woods, Baracoa, Oriente (*Underwood & Earle 1342*).

11. **Galactia Jenningsii** sp. nov.

A very slender, slightly woody vine, the branches 1.5–3.5 dm. long, loosely pilose or glabrate. Stipules subulate, striate, about 1 mm. long; petioles slender, pilose, 3–10 mm. long; leaflets 3, nearly equally short-petioluled, obovate, oblong or oblong-obovate, subchartaceous, 6–20 mm. long, rounded or emarginate at the apex, rounded or narrowed at the base, pubescent on both sides, strongly reticulate-veined above; peduncles axillary, 1- to few-flowered, as long as the petioles or shorter; calyx pilose, about 6 mm. long, its lanceolate acuminate lobes about as long as the tube or a little longer; flowers purple; standard suborbicular, clawed, 7–8 mm. long; wings narrowly oblong, about as long as the standard; pod linear, short-beaked, appressed-pubescent, sessile in the calyx, 2.5 cm. long, 5 mm. wide.

White-sand pine-barrens, Isle of Pines, scarce and local (*Britton & Wilson 14,186*, type; *O. E. Jennings 350*).

10. GALACTIA BRACHYODON Griseb. Mem. Am. Acad. II. 8: 178. 1860

Near Monte Verde, Oriente. Endemic.

12. GALACTIA REVOLUTA Urban, Symb. Ant. 2: 333. 1900

Dry hillsides, northern Oriente. Endemic.

13. GALACTIA GALACTIOIDES (Griseb.) Hitchc. Rep. Mo. Bot. Gard. 4: 77. 1893

Dioclea galactioides Griseb. Cat. Pl. Cub. 76. 1866.
Galactia impressa C. Wright; Sauvalle, Anales Acad. Habana 5: 337. 1869.

Near Bahia Honda, Pinar del Rio, collected only by Wright. Endemic. Erroneously recorded from the Bahamas.

14. **Galactia savannarum** sp. nov.

A slender, somewhat woody vine, 6 dm. long or longer, rather densely pubescent with brownish reflexed hairs, or the older parts glabrate. Stipules lanceolate, acuminate, 1–2 mm. long; petioles slender, 5–10 mm. long; leaflets 1 or 3, oblong, oblong-lanceolate, or the terminal one oblong-oblanceolate, subcoriaceous, revolute-margined, 1–3 cm. long, 6–12 mm. wide, glabrous on both sides or with some scattered hairs beneath, obtuse or emarginate at the apex, rounded at the base, the pubescent petiolules equal, about 1.5 mm. long; inflorescence interruptedly spicate, slender, 5–12 cm. long, densely appressed-pubescent; flowering pedicels 0.5 mm. long or less; calyx 4–5 mm. long, appressed-pubescent, its lobes about equalling the tube; flowers blue-purple, about 8 mm. long; standard suborbicular, clawed, about 6.5 mm. broad; wings and keel nearly equal in length; pod borne on a pedicel about 1.5 mm. long, linear, acute, densely villous, 2.5–3 cm. long, 7 mm. wide.

Barren savannas, Oriente, Camaguey, Santa Clara. Type from savanna southeast of Holguin, Oriente (*Shafer 1237*).

15. GALACTIA JUSSIAEANA Kunth, Mimos. 196. 1824

Clitoria glomerata Griseb. Cat. Pl. Cub. 74. 1866.

Pine-lands and plains, Pinar del Rio and Isle of Pines: Jamaica; Hispaniola; tropical South America. Common in pine-lands on the Isle of Pines, attaining a height of 6 dm.

47. THE GENUS MACHAONIA H. & B. IN CUBA

Type species: *Machaonia acuminata* H. & B.

- Fruit essentially glabrous.
    - Fruit constricted below the middle. 1. *M. pauciflora*.
    - Fruit gradually narrowed to the base. 2. *M. littoralis*.
- Fruit pubescent.
    - Fruit sparingly pubescent, the persistent calyx-lobes long. 3. *M. trifurcata*.
    - Fruit densely pubescent, the persistent calyx-lobes short.
        - Fruit broadly obpyramidal, 2.5 mm. long. 4. *M. microphylla*.
        - Fruit narrowly obpyramidal, 3–4 mm. long. 5. *M. calcicola*.

1. MACHAONIA PAUCIFLORA Urban, Symb. Ant. 5: 512. 1908

The species is based on part of *C. Wright's 433*, collected, presumably, in Oriente, and has not been found by us.

2. **Machaonia littoralis** sp. nov.

A shrub, about 2 m. high, with slender branches, the young wigs short-pilose, leafy to their tips. Leaves rhombic-ovate to
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elliptic, 6–10 mm. long, subcoriaceous, entire, 7 mm. wide or less, abruptly acute, obtuse, or some of them rounded at the apex, narrowed at the base, glabrous, pinnately few-veined, the glabrous or somewhat pubescent petioles 0.5–1 mm. long; inflorescence corymbose-cymose, several-flowered; pedicels very slender, sparingly pubescent, 1–2 mm. long; fruit narrowly obpyramidal, sparingly papillose or glabrous, 2 mm. long, 1 mm. thick at the top, evenly gradually narrowed to the rounded base, the persistent calyx-lobes ovate or ovate-lanceolate, about 0.5 mm. long.

Coastal thickets, vicinity of Siguanea, Isle of Pines, Cuba (*Britton & Wilson 14942*.)

3. MACHAONIA TRIFURCATA Urban, Symb. Ant. 5: 512. 1908

Cuba (*C. Wright 2760*). Referred by Grisebach to the Jamaican *M. cymosa* Griseb., but clearly different from that species. Not found by us. A part of *C. Wright 433* in the herbarium of the New York Botanical Garden has the characters of this species.

4. MACHAONIA MICROPHYLLA Griseb. Mem. Am. Acad. II. 8: 510. 1862

Rocky hills at lower elevations in dry districts, province of Oriente.

A barren specimen, collected in the palm barren near the city of Santa Clara, Santa Clara province (*Britton & Wilson 6130*) is doubtfully referred to this species.

5. **Machaonia calcicola** sp. nov.

?*Spermacoce spinosa* Jacq. Stirp. Am. 21. 1763. Not L. 1762. Not *Machaeonia spinosa* C. & S.

?*Spermacoce havanensis* Jacq.; Gmel. Syst. 234. 1796.

A much-branched shrub or small tree up to 3 m. high, the slender twigs densely puberulent, bristle-tipped. Leaves ovate or rhombic-ovate to elliptic or oblong-lanceolate, 6–15 mm. long, acute, short-acuminate, or some of them obtuse at the apex, narrowed or obtuse at the base, glabrous, pinnately few-veined, the short petioles puberulent; inflorescence corymbose-cymose, several- to many-flowered; pedicels slender, pubescent, 1–2 mm. long, calyx densely pubescent, its ovate or ovate-lanceolate lobes as long as the tube or somewhat shorter; corolla white or yellowish, about 1 mm. long, its ovate-oblong obtuse lobes about as long as the tube; stamens shorter than the corolla; fruit obpyramidal, 3–4 mm, long, 1.5 mm. thick at the top, tapering gradually to the base, densely pubescent, the persistent calyx-lobes about 0.5 mm. long.

Limestone rocks, northern parts of Havanna and Pinar de. Rio. Type from coastal hillside, Bay of Mariel, Pinar del Rio (*Britton & Earle 7619*).

A barren specimen from limestone rocks at Cape Corrientes (*Britton & Cowell 9894*) is doubtfully referred to this species.

48. THE GENUS HEPTANTHUS GRISEB.

A Cuban genus, of which three species were described at the place of original publication (Cat. Pl. Cub. 148. 1866); all were from western Cuba, *H. cochlearifolius* Griseb. being typical, and none have since been added to the genus. I now propose three others, all from eastern Cuba.

- Leaf-blades glabrous above or merely puberulent.
  - Peduncles longer than the leaves. 1. *H. cochlearifolius.*
  - Peduncles shorter than the leaves.
    - Leaf-blades orbicular-ovate, 1–2 cm. long; petioles densely villous. 2. *H. cordifolius.*
    - Leaf-blades triangular- ovate, 4–6 mm. long; petioles sparingly villous. 3. *H. Shaferi.*
- Leaf-blades pubescent on both surfaces.
  - Leaf-blades repand-dentate; peduncles much shorter than the petioles. 4. *H. brevipes.*
  - Leaf blades incised-serrate or lobed; peduncles as long as the leaves or longer.
    - Leaf-blades 12 mm. long or less, incised-serrate. 5. *H. ranunculoides.*
    - Leaf-blades 1–2.5 cm. long, deeply 3-lobed, the lobes coarsely few-toothed. 6. *H. lobatus.*

1. HEPTANTHUS COCHLEARIFOLIUS Griseb. Cat. Pl. Cub. 148. 1866

TYPE LOCALITY: Western Cuba.

DISTRIBUTION: Pine-lands and savannas, Pinar del Rio.

The upper leaf-surfaces are glabrous or nearly so.

A plant related in leaf-form, but with the upper leaf-surfaces densely puberulent is common in pine-lands and white sand in the central districts of the Isle of Pines, but could not be found in flower during our visit to this region in February and March, 1916 (*Britton & Wilson 14163*); it is therefore referred to this species with doubt.

2. **Heptanthus cordifolius** sp. nov.

In habit and aspect similar to *H. cochlearifolius*, forming cushion-like tufts 1–1.5 dm. broad. Petioles densely villous, 8 cm. long or less; leaf-blades orbicular-ovate, 1–2 cm. long, nearly or quite as wide as long, repand-dentate, rounded or obtuse at the apex, cordate at the base, distinctly punctate, glabrous above, villous on the few veins beneath; peduncles filiform, sparingly villous, shorter than the petioles; involucre campanulate, about 5-flowered; flowers white.

In damp soil among stones at edge of low thicket in deciduous woods near the base of Loma Mensura, Oriente, about 680 m. alt. (*Shafer 3786*).

3. **Heptanthus Shaferi** sp. nov.

Forming small tufts 4–6 cm. broad. Petioles filiform, loosely villous, 4 cm. long or less; leaf-blades triangular ovate, 4–6 mm. long, rather sharply few-dentate, bluntly acute at the apex, cordate at the base, distinctly punctate, glabrous on both sides or with a few hairs on the veins beneath; peduncle filiform, loosely villous, about 2.5 cm. long; involucre narrowly companulate, 4-flowered, about 1.5 mm. long.

On bank of a stream, Camp La Gloria, south of Sierra Moa, Oriente (*Shafer 8217*).

4. HEPTANTHUS BREVIPES Griseb. Cat. Pl. Cub. 148. 1866

TYPE LOCALITY: Low riparian woods near Toscano [Pinar del Rio].

DISTRIBUTION: Known only from the type locality and from the original collection (*Wright 2821*).

5. HEPTANTHUS RANUNCULOIDES Griseb. Cat. Pl. Cub. 148. 1866

TYPE LOCALITY: Western Cuba.

DISTRIBUTION: Known only from the original specimens (*Wright 2820*).

6. **Heptanthus lobatus** sp. nov.

Densely tufted, the tufts 1–1.5 dm. broad. Petioles densely villous, 7.5 cm. long or less; leaf-blades broadly ovate or orbicular-ovate in outline, pubescent with long hairs on both surfaces, 1–2.5 cm. long, deeply 3-lobed, the lobes coarsely few-toothed, the middle one obovate-cuneate, obtuse; peduncles filiform, loosely villous, as long as the petioles or longer; involucre narrowly campanulate, about 3 mm. long, several-flowered; flowers white.

Sandy bank, alluvial valley of Rio Yamaniguey, Oriente (*Shafer 4201*).

49. UNDESCRIBED SPECIES FROM PORTO RICO

Malpighia Shaferi Britton & Wilson, sp. nov.

A shrub 2–2.5 m. tall, with grayish-brown twigs. Leaves oblong-elliptic to elliptic or somewhat oblong-lanceolate, 13–17 cm. long, 4.5–8.5 cm. broad, acute, or rounded and mucronate, or occasionally retuse at the apex, more or less inequilateral and acute or rounded at the base, reticulate-veined above, armed beneath with closely-appressed stinging hairs, the margin somewhat revolute; petioles stout, 8–12 mm. long; cymes nearly sessile; pedicels 8–18 mm. long; sepals elliptic to broadly ovate, 2–3 mm. long, 1.2–1.5 mm. broad; glands fully one half the length of the sepals; larger petals 10–11 mm. long, the blades 6 mm. broad, pink, prominently keeled on the back; stamens unequal; anthers cordate; styles unequal, the anterior one slightly shorter than the posterior ones; fruit red.

Type collected in the vicinity of Isabel Segunda, Vieques Island (*Shafer 2448*).

Byrsonima ophiticola Small, sp. nov.

Tree up to 8 m. tall, the twigs with dark gray bark, the young tips with dark red pubescence. Leaves clustered at the ends of the twigs, 3–6.5 cm. long, the blades spatulate to narrowly obovate, rounded or obtuse at the apex, closely and finely pubescent when young, sparingly pubescent when full-grown, dull, paler green beneath than above, acute or acuminate at the base, rather long-petioled; panicles 5–9 cm. long, the bracts less than 3 mm. long; pedicels closely pubescent, at least in anthesis; sepals ovate or oblong-ovate, 2.5–3 mm. long, obtuse or acutish, the glands mostly less than one half as long as the sepal-body; petals yellow, turning to scarlet, 8–10 mm. long, the blade broadly reniform or orbicular-reniform, 7–8 mm. wide, the claw shorter than the blades; drupes not seen.

Serpentine slopes, Guanajibo near Mayaguez (*Britton, Cowell, & Brown 4350*). Related to *Byrsonima lucida* DC., from which it differs in the longer petioles, larger panicles, and larger flowers. The petals besides unfolding yellow and turning scarlet, have relatively shorter claws and more broadly reniform blades than in *B. lucida*, and are of very firm texture and more persistent.

Chamaesyce Cowellii Millspaugh, sp. nov.

A small, prostrate, glabrous annual, many-stemmed from the rootstalk; stems short; branches filiform, 2–3 cm. long; nodes swollen and prominent. Inflorescence solitary in the upper axils. Leaves thick, sarcous, ovate, entire, blunt, 2–3.5×1.5–2 mm., strongly inequilateral at the oblique and but slightly cordate base, petiolate; stipules various, those of the upper surface mostly quadrilateral and often bilobed, others triangular, all lacerate; those of the under surface of the branches formless in laceration. Involucres turbinate, short-pedunculate, glabrous without, densely woolly within; lobes triangular, aristate, densely ciliate; sulcus shallow, inconspicuous, flanked by two minute lobes similar in form to the others; glands green, flattened parallel to the walls of the involucre; appendages narrow, greenish, crenate, about half the width of the glands. Capsule glabrous, deeply sulcate; seeds pink, ovate-quadrangular, the dorsal angle most prominent, 1×0.6 mm., the facets finely and anastomosely transverse-ridged in a central longitudinal line. Allied to *Chamaesyce serpens* (HBK.) Small.

Collected from the crevices of limestone rocks at Cayo Muertos (*Britton, Cowell & Brown 5007*). Type, sheet No. 427101, in the herbarium of the Field Columbian Museum.

Sebesten brachycalyx (Urban)

Cordia Sebestena brachycalyx Urban, Symb. Ant. 1: 389. 1899.

This tree, first made known from the southern and eastern coasts of Porto Rico, appears to differ specifically from the related *Sebesten Sebestena* (L.) Britton (*Cordia Sebestena* L.) of wide distribution in the West Indies, Florida and tropical continental America, and there much planted for ornament. *S. brachycalyx* has much rougher upper leaf-surfaces and a much smoother calyx than *S. Sebestena* (often glabrous), and its yellow or orange fruit is shorter-beaked than the white fruit of that species; the corolla of *S. brachycalyx* has a narrower limb than that of *S. Sebestena.* The species inhabits Porto Rico, Vieques, Culebra, and Buck Island, St. Thomas.

Crescentia portoricensis sp. nov.

A vine-like, glabrous shrub, with long, slender branches, the bark light gray. Leaves elliptic-obovate, fascicled at the nodes, 15 cm. long or less, 2–8 cm. wide, coriaceous, shining above, dull beneath, strongly reticulate-veined on both sides, abruptly short-acuminate at the apex, cuneate at the base, the slender petioles 6–12 mm. long; peduncle 1–2 cm. long, slender in flower, much thickened in fruit; calyx 2 cm. long, deeply 2-lobed; corolla subcampanulate, 4 cm. long, yellowish white, reticulate-veined, its broadly ovate, entire, acute or blunt lobes about one fourth as long as the tube; fruit narrowly oblong, 10 cm. long, 3.5 cm. in diameter, terete, pointed at the apex, truncate at the base.

River-valley forests, mountains of western Porto Rico. Type from Rio de Maricao, 500–600 m. alt. (*Britton, Stevens & Hess 2455*).

Mikania Stevensiana sp. nov.

Climbing to a height of 5 m., the branches glabrous, striate, nearly terete, the twigs angular, sparingly pubescent. Leaves triangular-ovate in outline, firm in texture, brittle when dry, 5 cm. long or less, very scabrous and sparingly short-hispid above, pubescent on the elevated veins beneath, 5-nerved, sharply 3-lobed, the middle lobe triangular-lanceolate, long-acuminate, dentate, 3 or 4 times as long as the acute, entire or sparingly toothed, lateral ones; petioles sparingly pubescent, 1–2 cm. long; inflorescence corymbose-paniculate; heads peduncled; bracts of the involucre linear, acute, 7 mm. long; achenes angled, glabrous, 5 mm. long; pappus-bristles about 40; corolla 7 mm. long, as long as the pappus, its lobes acute.

Wooded valley, Maricao River, above Maricao (*Britton & Cowell 4225*, type; *Britton, Stevens & Hess 2439*).

50. UNDESCRIBED SPECIES FROM CUBA

Schoepfia cubensis Britton & Wilson, sp. nov.

A slender, glabrous shrub, 2.5–4 m. tall, the young twigs compressed, longitudinally ridged, often flexuose, glabrous. Leaves elliptic to oval, 2–3.4 cm. long, 1.5–2.8 cm. broad, short-petioled, entire, glabrous, rounded at the apex, equilateral and rounded or occasionally subcordate at the base, lustrous and rather indistinctly veined on both surfaces; principal veins 5 or 6 on each side of the midvein, strongly divergent; peduncles 0.8–1.2 cm. long; fruit sessile, ellipsoid, 8 mm. long, 7 mm. wide.

Camp La Gloria, Oriente (*Shafer 8278*).

Cassia scleroxyla sp. nov.

A slender tree, about 8 m. high, with smooth bark and exceedingly hard wood, the young twigs loosely appressed-pubescent.

Leaves glandular, 8–10 cm. long; petiole and rachis grooved above, sparingly appressed-pubescent; petiole 1–2 cm. long; leaflets 6–8 pairs, linear-lanceolate, chartaceous, 2–4 cm. long, acute and mucronate at the apex, rounded or narrowed at the base, rather dark green and glabrous above, pale green and sparingly pubescent beneath, the pubescent petiolules about 2 mm. long; flowers loosely corymbose; pedicels slender, puberulent, about 1 cm. long; sepals very unequal, sparingly pubescent, ciliate, the larger ones 4–5 mm. long; petals bright yellow, the larger 6–7 mm. long; perfect anthers 7, about 3 mm. long; pod linear, glabrous, 3–4.5 cm. long, 6–7 mm. wide, reticulate-veined, abruptly acute, septate between the seeds.

Hillside, Berraco, near Daiquiri, Oriente (*Britton & Cowell 12664*).

Among West Indian species, perhaps most nearly related to *C. domingensis* Spreng.

Cassia Shaferi Britton & Wilson, sp. nov.

Shrub 1 m. tall; twigs, petioles, rachis, and branches of the inflorescence hirsutulous. Leaves 6.5–10 cm. long, glandular, the gland slender, 1.5–2 mm. high, acutish or obtuse, situated either between the leaflets of the lowest pair or below on the petiole; petioles and rachis grooved; stipules narrowly oblong-lanceolate, 6–7 mm. long, acuminate; leaflets 4–6 pairs, oblong to elliptic, 1.5–3 cm. long, 7–12 mm. broad, rounded and mucronulate at the apex, rounded and very inequilateral at the base, sparingly hirsutulous on the midrib above, hirsutulous beneath, the hairs scattered and mostly appressed, short-petioluled; margin thickened, ciliate; pedicels hirsutulous; buds subglobose; sepals densely hirsutulous; pod flat, 11 cm. long, 9 mm. broad; seeds 3.5–4.5 mm. long.

Pine-lands near the base of Loma Mensura, Oriente (*Shafer 3770*); also collected in open places at base of Loma Mensura (*Shafer 3803*).

Apparently closely related to *Cassia bahamensis* Mill.

Pachyanthus reticulatus Britton & Wilson, sp. nov.

A shrub 1–1.5 m. tall; young twigs compressed, more or less grooved, ferruginous, stellately scabrous-puberulent. Leaves ovate, 9–12 cm. long, 5–7 cm. broad, obtuse at the apex, cordate at the base, above densely ferruginously stellate-puberulent when young, glabrescent, lustrous and dark green in age, the venation strongly impressed, below pale brown, reticulate-veined and densely stellate-canescent, prominently 5-nerved; petioles 1.5–2.5 cm. long; flowers sessile, calyx campanulate, densely stellate-tomentulose, the lobes 5, deltoid at the base, linear above, 5–6 mm. long.

Low dry thickets, pine-lands, Sierra Nipe, near Woodfred, Oriente (*Shafer 2967*).

Labatia aristata Britton & Wilson, sp. nov.

A much-branched shrub, 2–3 m. high, the branches rigid, gray, the young twigs appressed-pubescent. Leaves broadly ovate to suborbicular, 2–3.5 cm. long, coriaceous, glabrous, strongly pinnately and reticulate-veined, dark green and shining above, dull green beneath, aristate at the apex, rounded or subcordate at the base, the yellowish green, rather stout petioles 5–10 mm. long; pedicels solitary or several together, slender, glabrous, 5–8 mm. long; calyx sparingly pubescent, 2.5–3 mm. long, deeply 4- to 5-lobed, the lobes lanceolate or oblong-lanceolate, acutish, scarcely imbricated; corolla green, about 2.5 mm. long, 4–5-lobed to about the middle, the lobes rounded, slightly imbricated; anthers oblong, a little longer than the filaments; staminodia obovate, somewhat longer than the filaments; drupe oval, dark purple, 2.5 cm. long, its flesh very thin; seeds 2, oblong.

Coastal hills and thickets, provinces of Oriente, Santa Clara and Havana, Cuba; type collected between the Rio Chorrera and Marianao, Havana (*Brother Leon 6230*).

Tournefortia Earlei sp. nov.

A shrub, 1–2 m. high, with long, slender branches, or vine-like and 3 m. long, the branches densely pubescent with short, soft, appressed hairs. Leaves narrowly linear, or linear-lanceolate, 3–7 cm. long, 2–6 mm. wide, acute or bluntish at the apex, densely appressed-pubescent above, densely white-tomentulose beneath, the petioles 1.5–3 mm. long; cymes short-peduncled, their few, very slender branches 2–4 cm. long; calyx 1 mm. long, appressed-pubescent, its lanceolate or ovate-lanceolate lobes acute; corolla-tube about 2 mm. long, the narrowly lanceolate lobes about as long; fruit depressed, 4 mm. broad, about one half as high as broad, glabrous.

Hillsides, Guantanamo Bay and Santiago Bay, Oriente. Type from Guantanamo Bay (*F. S. Earle 82*). Related to *T. incana* Lam. and *T. stenophylla* Urban.

Cestrum pinetorum sp. nov.

A glabrous shrub, about 1 m. high, with slender branches. Leaves narrowly oblong to oblong-lanceolate, 7 cm. long or less, 6–16 mm. wide, rather thin in texture, faintly shining, bluntly acute at the apex, narrowed at the base, the midvein slender above, prominent beneath, the lateral veins few, obscure, the slender petioles 3–5 mm. long; clusters axillary, few- to several-flowered; fruiting pedicels very short; fruiting calyx obconic-campanulate, about 5 mm. long, its triangular-ovate teeth acutish, about one third as long as the tube; berry globose-ovoid, purplish, about 7 mm. long.

Open pine-woods Sierra Nipe near Woodfred, Oriente, 500–650 m. alt. (*Shafer 3031*, type; *3591*).

Casasia parvifolia sp. nov.

A much-branched shrub, about 2 m. high, the twigs slender, puberulent when young. Stipules lanceolate, acute, about 3 mm. long. Leaves glabrous, oblong-spatulate, 3 cm. long or less, 5–8 mm. wide, obtuse or acutish at the apex, narrowed or cuneate at the base, coriaceous, clustered at the ends of the twigs, pinnately few-veined, shining and with impressed midvein above, the midvein very prominent beneath, the petioles about 1 mm. long; fruit terminal, solitary, sessile, globose, warty, about 10 mm. in diameter.

Rocky river-banks, mountains of northern Oriente; type collected between Camp La Barga and Camp San Benito, 450–900 m. alt. (*Shafer 4100*).

Baccharis Shaferi sp. nov.

A glabrous shrub, 6 dm. high or less, with slender ascending branches, the twigs angled. Leaves triangular-cuneate, 6–12 mm. long, 7 mm. wide or less at the truncate or subtruncate apex, bright green and shining above, dull and whitish-papillose beneath, the slender midvein slightly elevated on both sides, the lateral veins 1–3; heads sessile, solitary or 2 or 3 together at the ends of short twigs, or in the axils; young involucres about 4 mm. long, the ovate, acute bracts imbricated in about 4 series.

Dry pine woods, Arroyo del Medio above the falls, 450–550 m. alt., Oriente (*Shafer 3257*, type); specimens from Camp La Gloria, south of Sierra Moa, Oriente (*Shafer 8213*), have longer leaves than the type specimens.

51. UNDESCRIBED SPECIES FROM THE ISLE OF PINES, CUBA

Zamia silicea sp. nov.

Caudex slender, completely buried in sand, 2 dm. long or longer. Basal scales lanceolate, villous, 1–2 cm. long; leaves glabrous or the base of the petiole villous, spreading or ascending, 1–4 dm. long; leaflets 30 or fewer, coriaceous, shining, many-veined, obovate-oblanceolate, 3–6 cm. long, 2 cm. wide or less, rounded or obliquely subtruncate and callously denticulate at the apex, narrowed at the base; peduncles densely short-pubescent, 2–4 cm. long; male cone cylindric, about 3 cm. long and 1.3 cm. thick, its scales densely pubescent, hexagonal, the upper and lower ones about as wide as high, the middle ones nearly twice as wide as high; ripe pistillate cones ellipsoid, short-tipped, 5–6 cm. long, about 2.5 cm. thick, the hexagonal scales puberulent, seeds red, about 12 mm. long, broadly grooved on the inner side, rounded on the back, obliquely and obtusely umbonate at the apex.

Frequent in pine-lands and in white silicious sand. Type from near Los Indios (*Britton & Wilson 14166*).

Cyperus pinetorum sp. nov.

Perennial by short rootstocks; culms tufted, stiff and wiry, compressed, 1.5–2.5 cm. high. Basal sheaths striate-veined, acute, 2–4 cm. long; involucral leaves 1 or 2, nearly subulate, 0.5–3 cm. long; spikelets linear, 10–22 mm. long, 1.5 mm. wide, digitate, one cluster subtended by the involucral leaves with usually a similar one on a slender ray 4 cm. long or less; scales elliptic, obtuse, mucronulate, yellowish-brown, 1.5 mm. long; achene sharply trigonous, about 0.6 mm. long, nearly as thick as long, often persistent on the rachis after the scales have fallen away.

White sand pine barrens. Type from the vicinity of Los Indios (*Britton and Wilson 14170*).

Related to *C. Haspan* L., differing in broader spikelets, broader scales and proliferous inflorescence.

Xyris longibracteata Britton & Wilson, sp. nov.

Annual(?); leaves erect, linear, 8–10 cm. long, 1–1.5 mm. broad, occasionally somewhat spirally twisted, the margin rough; scapes several, erect, glabrous, 15–18 cm. tall, terete or nearly so; involucre subtending the spike composed of several bracts of unequal length, each tapering abruptly into a long, linear tip, the longest bract often exceeding the spike; spikes ellipsoid to ovoid, 7–9 mm.

long, 4–6 mm. broad; bracts ovate to orbicular-ovate, 4–5 mm. long, 3.5–4 mm. broad, acute at the apex; lateral sepals included; keel toothed from the apex to below the middle; petals broadly obovate, 5 mm. long, 3.5–4 mm. broad.

White sand, vicinity of Los Indios, Isle of Pines (*Britton, Britton & Wilson 14215*).

Chamaecrista micrantha sp. nov.

Stems several from a woody root, ascending or suberect, few-branched or simple, slender, villous, 2–3 dm. long. Stipules lanceolate acuminate, 2.5–4 mm. long; leaves 8–18 mm. long; petiolar gland short-stalked; rachis villous; leaflets 10–24, oblong, villous, 3–3.5 mm. long, mucronulate, the midvein very excentric; peduncles very slender, villous, 6–15 mm. long; sepals lanceolate, acute, villous, about 4 mm. long; petals rounded, 5 mm. long; pod linear, finely pubescent, 2–3 cm. long, 3–4 mm. wide.

Pine-lands and savannas, Pinar del Rio and Isle of Pines, Cuba. Type collected near San Pedro, Isle of Pines (*Britton & Wilson 14294*). Referred by Grisebach to *Cassia pygmaea* DC., and taken up by Bentham under *Cassia procumbens* L., but the type of *C. procumbens* is the same as *C. nictitans* L.

Chamaecrista savannarum sp. nov.

Stems several from a deep woody root, slender, ascending or erect, short-pubescent, 2–4 dm. high, simple or little-branched. Stipules lanceolate or ovate-lanceolate, 2–4 mm. long, acuminate, strongly veined; leaves 2.5 cm. long or less, the rachis pubescent; petioles 2–4 mm. long, bearing a scutellate, sessile or very short-stalked gland; leaflets 3–13 pairs, appressed-pubescent or glabrate, oblong or linear-oblong, 3–7 mm. long, somewhat oblique, aristulate, the midvein very excentric; peduncles slender or nearly filiform, 8–20 mm. long; sepals lanceolate, acuminate, slightly pubescent; 4–5 mm. long; petals 7–8 mm. long; pod linear, sparingly pubescent, 3–4 cm. long, 4 mm. wide.

Savannas and pine-lands, Pinar del Rio and Isle of Pines, Cuba. Type collected near Siguanea, Isle of Pines (*Britton & Wilson 14379*).

Bauhinia Jenningsii P. Wilson, sp. nov.

A slender shrub or tree, sometimes 5 m. high; young twigs, branches of the inflorescence, under surface of the leaves and pods finely puberulent with minute, mostly appressed hairs; petioles

1.5–2 cm. long; leaves lanceolate-ovate to oblong-ovate or ovate, 7–14 cm. long, 2.5–5 cm. broad, acute at the apex, subtruncate or rounded at the base, 5-nerved, finely reticulate-veined and glabrous above, reticulate-veined and minutely papillose beneath; inflorescence corymbose; flowers long-pedicelled; calyx scarlet, puberulent with appressed hairs; petals lanceolate or occasionally somewhat oblanceolate, 1.2–1.6 cm. long, 2–2.7 mm. broad; sterile stamens 9, half as long as the fertile stamen; ovary stipitate; pods oblong, 5–9 cm. long, 0.8–1.5 cm. broad, brown; seeds oblong-elliptic to elliptic, 7–8 mm. long, 5–5.5 mm. broad, brownish black.

Wooded limestone plain, Coe's Camp, Ensenada de Siguanea (*Britton & Wilson 14851*, type); coastal plain, San Juan (*Britton & Wilson 15544*); coral soil, north of Caleta Grande (*O. E. Jennings 480*).

Savia perlucens sp. nov.

A shrub, about 2 m. high, the slender branches terete, grey. Stipules ovate, acute; leaves obovate or elliptic-obovate, coriaceous entire, 9 cm. long or less, acute or acuminate at the apex, obtuse or acute at the base, bright green and strongly shining above, dull green beneath, the midvein prominent above and beneath, both surfaces reticulate-veined; flower-clusters supra-axillary, depressed, about 3 mm. broad, puberulent.

Limestone plain, Caleta Grande (*Britton, Wilson & Leon 15330*).

Phyllanthus nanus Millspaugh, sp. nov.

A low, spreading, glabrous perennial, about 5 cm. in extent, with thick, strongly imbricated leaves. Root thick, branching, giving off a mass of thread-like rootlets. Stems many, springing from the rootstalk, very short (1–1.5 cm.); branches diffuse, rather thick and striate, 1–2 cm. long. Inflorescence dioecious, biflorate, in the axils of the apical leaves of the short branchlets. Leaves thick, glabrous, ovate, cordate, acute, entire, 1.3×1–2.3×1.75 mm.; petioles very short; stipules entire, aristate from a deltoid base, the upper half withered to a dark brown color. Flowers sessile or nearly so; sepals 5, equal, ovate, acute, strongly striate-keeled; glands 5, verrucoid, minute; staminal column twice the length of the anthers; anthers 2, transversely connate in an apical ring; female calyx as in the male but nearly twice the size; ovary 3-carpelled, 6-celled, nearly sessile; styles 3, short, bifid to half their length, the stigmatic apices cleaveate; capsule depressed-globose, glabrous; seeds dark brown, sharply angled, 0.9×0.75 mm. dorsal facet minutely and closely transverse anastomose-wrinkled.

In white sand in the vicinity of Los Indios (*Britton & Wilson*

14192). Type sheet in the herbarium of the Field Columbian Museum.

Chamaesyce Jenningsii Millspaugh, sp. nov.

Prostrate, spreading from a low rootstock; stems many, divaricately branching, internodes about 1.5–3 cm.; branches 2 to many at each swollen node, wiry, divergently forking; leaves oval to ovate, 5×3–8×4 mm., glabrous above, finely long silvery-pubescent beneath, obliquely cordate, blunt, shallowly but sharply serrate throughout the margins. Inflorescence solitary in the terminal forks and axils; involucres long-turbinate, glabrous without, hairy within; pedicels about twice the length of the tube; lobes triangular; sulcus large, deep, triangular, the fundus unoccupied; glands nearly circular, flattened to the walls of the involucre; appendages none, or rarely merely a marginal line of the same color and texture as the glands; bracteoles as many as the stamens, ligulate, transparent. Capsule glabrous, ovoid; carpels strongly keeled; seeds ovate-quadrangular, 1.2×1 mm., angles sharp, facets sharply and anastomosely transverse ridged including deep, quadrangular pits.

Vivijagua (*O. E. Jennings 621*); type in the herbarium of the Carnegie Museum, Pittsburgh, Pennsylvania. Also in coastal sands at the same place (*Britton & Wilson 14690*).

Tapura obovata Britton & Wilson, sp. nov.

A tree 10 m. tall; young twigs and petioles minutely strigillose; leaves obovate, 3.5–7 cm. long, 1.5–4.4 cm. broad, rounded at the apex, cuneate to rounded-cuneate at the base, dull above, lustrous beneath and reticulate-veined, glabrous, short-petioled; flowers short-pedicelled; calyx-lobes 5, ciliate, sparingly appressed-pilose on the outside, the two outer lobes smaller than the three inner ones, broadly oblong-elliptic to oval, 2.5–3.2 mm. long, 2–2.2 mm. broad, the three inner lobes oval to suborbicular, 3.4–3.8 mm. long, 3–3.3 mm. broad; corolla-lobes 5, unequal, the three smaller lobes spatulate-obovate, 4–4.6 mm. long, 1.2 mm. broad, the two larger lobes spatulate, 4.6–5 mm. long, 2.2–2.5 mm. broad; filaments lanceolate-oblong to oblong; ovary pilose; style filiform, pilose, 3-lobed.

Savanna, Vivijagua (*Britton & Wilson 15607*, type); coastal plain, San Juan (*Britton & Wilson 15524*).

Calyptranthes pinetorum Britton & Wilson, sp. nov.

A depressed, glabrous, much-branched shrub 6 dm. high or less, 3–10 dm. broad, the twigs stout, gray, terete or nearly so. Leaves opposite, thick-coriaceous, ovate to orbicular, flat, 1–3.5 cm. long, rounded or obtuse at the apex, cordate or subcordate at the base, bright green and shining above, pale green and dull beneath, densely punctate, the midvein prominent, the lateral veins faint, the stout petioles 1–2 mm. long; peduncles rather stout, somewhat longer than the leaves; inflorescence cymose, few- to several-flowered; young fruit sessile, subglobose, 2 mm. in diameter, the calyx-limb 2 mm. broad.

Pine-lands, central districts. Type from north of Los Indios (*O. E. Jennings 390*).

Related to *C. nummularia* Berg. of Hispaniola, *C. Maxoni* Britton & Urban of Jamaica, and *C. Boldinghi* Urban of St. Martin.

Evolvulus arenicola Britton & Wilson, sp. nov.

A diminutive perennial, with a slender, woody root, the few or solitary, simple or few-branched stems slender, appressed-pubescent, 2–5 cm. long, ascending or nearly prostrate. Leaves ovate to elliptic, 9–15 mm. long, puberulent or glabrate above, appressed-pubescent beneath, mostly obtuse or rounded at both ends, the midvein faint, the lateral veins wholly obscure, the pubescent petioles 1–2 mm. long; flowers 1 or 2 at the ends of the stems or branches; pedicels 5–8 mm. long, pubescent; sepals linear-lanceolate, acuminate, villous, 5 mm. long; corolla white, rotate, 9–12 mm. broad; obscurely lobed; stamens about one-half as long as the corolla; styles deeply 2-cleft; capsule subglobose, shorter than the sepals.

White sand, vicinity of Los Indios (*Britton & Wilson 14190*).

Gerardia pinetorum Britton & Wilson, sp. nov.

Acaulescent; leaves elliptic-ovate to elliptic, 1.5–2 cm. long, 5–8 mm. broad, rounded at the apex, cuneate or somewhat rounded at the base, hispidulous above and below with jointed hairs; petioles 1–1.5 cm. long, densely hispidulous; scape erect, 4–8 cm. high, more or less hispidulous with jointed hairs, the spikes few-flowered, 1–2 cm. high, the bracts lanceolate, 4–5 mm. long, ciliolate, long-acuminate; calyx-lobes subequal, narrowly lanceolate, 4–4.5 mm. long, 0.5–0.8 mm. broad, ciliolate; corolla rose-pink, glabrous, the tube cylindric, 5–5.5 mm. long, the limb subequally 5-lobed, the lobes broadly obovate to somewhat oval-obovate, 4.5–8 mm. long, 2.5–5 mm. broad.

Along the Los Indios River above Los Indios (*O. E. Jennings 456*).

Rondeletia calcicola sp. nov.

A glabrous shrub about 2 m. high, the twigs slender. Leaves coriaceous, narrowly oblong to oblong-oblanceolate, 5–13 cm. long, 8–18 mm. wide, shining above, dull beneath, acute at the apex, attenuate at the base into petioles about 1 cm. long or less, loosely reticulate-veined with the midvein prominent on the under surface; inflorescence terminal, few-flowered; fruiting pedicels rather stout, 3–7 mm. long; capsule oblong or oblong-obovoid, glabrous, 1 cm. long, about twice as long as thick; fruiting calyx-lobes ovate-lanceolate, acute, 1–1.5 mm. long.

Wooded limestone plain, Coe's Camp, Ensenada de Siguanea (*Britton & Wilson 14842*).

Diodia ciliata Britton & Wilson, sp. nov.

Stems perennial, prostrate, 4–6 dm. or more in length, rooting and partly buried in sand, densely pilose with whitish hairs on the younger growth; leaves elliptic to somewhat elliptic-obovate, 1.5–3 cm. long, 7–14 mm. broad, acute at the apex, cuneate to broadly cuneate at the base, the margin conspicuously and densely ciliate with rather stiff white hairs, yellowish green and glabrous above, the midvein and lateral veins inconspicuous, whitish-pilose beneath, especially on the midvein, sessile; stipules ciliate; ovary 2-celled; fruit elliptic-obovoid, 3 mm. high, glabrous, or with few scattered appressed hairs on the back.

In white sand, vicinity of Los Indios (*Britton & Wilson 15347*).

Diodia arenicola Britton & Wilson, sp. nov.

Perennial; stems ascending, 1–1.5 dm. high, glabrous; leaves lanceolate, 6–14 mm. long, 2–3 mm. broad, acute at the apex, rounded or somewhat acutish at the base, glabrous or with few, stout, scattered, mostly appressed hairs above, glabrous beneath, sessile; stipules linear-lanceolate, 2 mm. long; calyx lobes triangular-ovate, ciliate; corolla 5 mm. high, the lobes ovate, obtuse; anthers ovate-lanceolate; style 3-lobed; fruit ellipsoid, 2.5 mm. high, 1.2 mm. broad, glabrous.

Along arroyo, Los Indios, Isle of Pines (*O. E. Jennings 355* in part, type); vicinity of Los Indios (*Britton & Wilson 15812*).

Mitracarpum depauperatum Britton & Wilson, sp. nov.

A diminutive, woody perennial, 2–5 cm. high, forming small tufts, the stems few-branched or simple, the internodes very short. Leaves narrowly linear, 6–15 mm. long, less than 1 mm. wide, densely clustered, acute, sessile, glabrous; stipules deeply laciniate, about one-third as long as the leaves; calyx very small; corolla salverform, white, its tube cylindric, 2.5 cm. long, its limb spreading, 4-lobed, the lobes ovate, acute, nearly 1 mm. long.

Dry white sand, central districts; type from near Los Indios (*Britton & Wilson 14197*).

Palicourea elongata Britton & Wilson, sp. nov.

A shrub 2 m. or more high; twigs, branches of the inflorescence, and pedicels minutely hispidulous with brownish hairs; leaves in whorls of threes, lanceolate or occasionally broadly oblanceolate, 12–19 cm. long, 4–6 cm. broad, acuminate at the apex, cuneate to somewhat rounded cuneate at the base, puberulent above on the midvein when young, puberulent beneath, especially on the midvein and lateral veins; stipules linear-lanceolate, 8–12 mm. long, ciliate; panicle elongate, 7–19 cm. high; calyx-lobes deltoid-ovate, ciliate; corolla puberulent, 7–10 mm. long, the lobes triangular-ovate; fruit broadly ovoid, 4–5 mm. long, 4–4.5 mm. broad, flattened.

Arroyo, Las Tunas (*Britton & Wilson 14749*, type); Arroyo, vicinity of San Pedro (*Britton & Wilson 15785*); Los Indios (*O. E. Jennings 332*).

Elephantopus arenarius Britton & Wilson, sp. nov.

Plant 6–8 cm. high, the stem branching from the base; leaves cauline, linear, 2–4 cm. long, 1 mm. broad, involute, conspicuously ciliate at the broadened, clasping base with long hairs, entire; peduncles loosely hirsutulous, 2–3.5 cm. long; glomerules 5–6 mm. high; bracts broadly ovate to ovate-orbicular, cordate at the base with a linear, ligulate tip, 0.5–1 cm. long, reticulate-veined on the back, glabrous; scales acuminate, glabrous; achenes (immature) 2 mm. long; pappus-scales triangular to lanceolate, ciliate.

White sand, vicinity of Los Indios (*Britton & Wilson 14206*).

Closely related to *Elephantopus pratensis* C. Wright, but differing in the narrow involute leaves and linear ligulate tipped bracts.

Erigeron purpuripes Britton & Wilson, sp. nov.

A low, scapose perennial. Leaves tufted, erect, the blades elliptic to oblong-obovate, 1–2 cm. long, pinnately few-veined, obtuse at the apex, narrowed at the base, ciliolate, puberulent or glabrate; petioles very slender, purple, 2 to 4 times as long as the blades; scapes nearly filiform, erect, appressed-pubescent, about twice as long as the leaves; involucre 4 mm. high, subcylindric, its bracts in 2 or 3 series, linear, puberulent, the outer shorter than the inner; ligules white; disk-flowers tubular, 5-lobed, the lobes obtuse; achenes flattened, oblong or somewhat oblong-elliptic, minutely hispidulous; pappus-bristles in 1 series, barbellate.

In white sand, vicinity of Los Indios (*Britton & Wilson 14207*).

Helenium scaposum sp. nov.

A low, pubescent, scapose perennial. Leaves several or many, densely tufted, short-petioled, oblong to spatulate, punctate, 1.5–3 cm. long, 6–10 mm. wide, rather strongly 5- to 7-nerved, entire or repand-dentate, obtuse or acute at the apex, narrowed or cuneate at the base; scapes rather stout, 5–11 cm. high; involucre about 5 mm. high; its bracts ovate-lanceolate, acute, appressed or little spreading; rays 10 to 12, bright yellow, obovate, 3-toothed, 5–8 mm. long; disk yellowish, depressed-globose, 8–12 mm. in diameter, its corollas 5-lobed, the lobes triangular-ovate; pappus scales of ray-flowers and disk-flowers alike, elliptic to obovate, lacerate, not aristate.

White sand pine-lands, west-central districts. Type from near Siguanea (*Britton & Wilson 14346*).

A plant with quite the floral structure of *Helenium*, but its scapose habit is aberrant, resembling that of some *Tetraneuris* species.

New or interesting algae from the lakes of Wisconsin

GILBERT MORGAN SMITH

(WITH PLATES 24–26)

The present paper embodies various notes that have accumulated in a study of the algae of Wisconsin lakes for the Wisconsin Natural History and Geological Survey. Although a systematic account of the algae found has been prepared, it has been thought advisable to publish descriptions of the new species and notes on certain other species at this time.

Chaetosphaeridium ovalis sp. nov.

Thallus of five to twenty cells, epiphytic upon filamentous Chlorophyceae, gelatinous sheath indistinct. Cells ovoid, with two parietal chloroplasts each containing a pyrenoid. Sheath at the base of setae conspicuous.

Cells 22–20 μ long, 15–13 μ wide; length of setae about 125 μ; basal sheath of setae 15×3 μ.

PLATE 24, FIG. 1

DISTRIBUTION: along shore, Marion Lake.

The two species of the genus that are generally recognized, *C. globosum* (Nords.) Klebh. and *C. Pringsheimii* Klebh., are found also in the lakes of the state. *C. ovalis* resembles *C. Pringsheimii* forma *conferta* Klebh. in the arrangement of its cells, but the cell-shape is quite different. This species also differs from the others since it is the only one which regularly has more than a single chromatophore, while the basal sheath of the bristle is also more conspicuous in this than in the other species.

Oocystis panduriformis minor var. nov.

Cells 35–30 μ long; maximal diameter 15–12 μ, median diameter 14–11 μ.

PLATE 24, FIG. 2

DISTRIBUTION: plankton, Star Lake.

The type form, described by W. and G. S. West,* is nearly twice as large as the dimensions given above. The peculiar median constriction and the numerous chromatophores, however, show that the above described alga should be considered a variety of *O. panduriformis* W. West.

TETRASTRUM APICULATUM (Lemm.) Brunnthaler

Staurogenia apiculata Lemm. Bot. Centralbl. **76**: 151. 1898; Forschungsb. Biol. Stat. Plön **7**: 119. *pl. 1, f. 14.* 1899; Schmidle, Ber. Deutsch. Bot. Ges. **18**: 157. 1900.

Tetrastrum apiculatum Brunnthaler; Pascher, Süsswasser-flora Deutschlands, Österreichs und der Schweiz. **5**: 177. *f. 258.* 1915.

PLATE 24, FIG. 3

I have observed this alga twice in the plankton of Lake Mendota. Some investigators follow Schmidle in placing *Tetrastrum* as a subgenus of *Crucigenia* Morren, but in my opinion the two genera are distinct.

CHARACIUM STIPITATUM (Bachmann) Wille

Chlamydomonas stipitata Bachmann, Arch. Hydrobiol. u. Planktonkde. **3**: 81. *f.* XI^1–XI^{15}. 1908.

Characium stipitatum Wille; Engler & Prantl, Nat. Pflanzenfam. 1^2 (Nachtr.): 45. 1911; Brunnthaler in Pascher, Süsswasserflora Deutschlands, Österreichs und der Schweiz **5**: 81. *f. 26.* 1915.

PLATE 24, FIGS. 4–6

This peculiar species was previously known only from Scotland, where it was described as a *Chlamydomonas* species. I have found it in the plankton of three lakes, Minocqua, Pardee and Sishebogema, in the northern part of the state. There is but little doubt that this is the same organism as that described by Bachmann, since the cell-shape and dimensions agree and it is only found epiphytic upon the same alga, *Coelosphaerium Naegeliana* Unger (*Gomphosphaeria Naegeliana* Lemm.).

The alga is entirely enclosed by the gelatinous envelope of the *Coelosphaerium* colony and does not, as Bachmann describes, merely have its stipe in the envelope. The figure copied by Brunn-

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* Jour. Roy. Micr. Soc. **1894**: 15. *pl. 2, f. 33–35.* 1894.

thaler is not typical since the pyrenoid is never outside of, but always within, the chromatophore.

Kirchneriella elongata sp. nov.

Colonies of four, eight, sixteen, or many cells embedded in a copious homogeneous matrix. Cells cylindrical, rounded at ends, spirally or irregularly twisted into a knot-like snarl. Chloroplast single, parietal, without (?) a pyrenoid.

Colonies up to 100 μ in diameter. Cells 25–15 μ long, 2.75–2.00 μ wide.

PLATE 24, FIG. 7

DISTRIBUTION: plankton, No Mans Lake; along shore, Plum Lake.

This species approaches *K. contorta* (Schmidle) Bohlin, which I have collected from four Wisconsin lakes, but the cells are larger, some being twice as long as those of *K. contorta*, and there are usually more cells to the colony.

SCHROEDERIA SETIGERA (Schröder) Lemm.

Reinschiella setigera Schröder, Ber. Deutsch. Bot. Ges. **15**: 489. *pl. 25, f. 4.* 1897.

Schroederia setigera Lemm. Hedwigia **37**: 311. 1898.

Raphidium setigerum W. & G. S. West, Trans. Yorkshire Nat. Union **25**: 122. 1901.

Ankistrodesmus setigerus G. S. West, Brit. Freshw. Algae 224. *f. 94F.* 1904.

PLATE 24, FIG. 8

An organism found in the plankton of Devil's Lake agrees very well with the original description of *S. setigera*, with one exception. Schröder and the Wests appear to be the only ones who have observed the living plant and neither mentioned the disc at the end of one of the prolonged apices. There is no doubt in my mind but that this structure was present in the cells they studied, but since it is practically invisible under a magnification of six hundred diameters or less, they probably overlooked it.

An apparently closely related form is *Ankistrodesmus nitzschioides* G. S. West,* which has also been figured by Printz.† It differs

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* Jour. Linn. Soc. Bot. **38**: 140. *pl. 5, f. 18.* 1907.

† Skr. Vidensk. Kristiania, Math.-Naturvid. Kl. 1913^6: 97. *pl. 7, f. 217–220.* 1914.

only in the lack of a pyrenoid and the terminal disc. G. S. West and Brunnthaler place the species in the genus *Ankistrodesmus*. Although the shape of the cells shows a great resemblance to that of *Ankistrodesmus* I believe that the retention of the genus *Schroederia* is to be preferred. If this species with the fine hair-like terminal processes can be shown to reproduce in the same manner as *Ankistrodesmus*, *Schroederia* should be considered a synonym; but since, in my observations on over a thousand individuals, I have never found autospores within the mother cell wall (a condition occurring abdundantly in all species of *Ankistrodesmus*), I am convinced that this species does not reproduce in the same manner as *Ankistrodesmus*. On the other hand the disc-shaped end of one of the apical processes suggests that the species may be an epiphytic *Characium*, possibly like *C. limneticus* Lemm. At first I considered it an epiphytic form that had broken off but since the examination of so many individuals has not shown any attachment to other plankton, it must be assumed to be naturally free-floating and not accidentally detached.

Schroederia Judayi sp. nov.

Cells fusiform, straight or curved, ends attenuated into hair-like projections, one of which terminates in a disc. Chromatophore single, parietal, with one pyrenoid.

Length, with spines, 63–45 μ, without spines, 30–14 μ; breadth 6–2.5 μ; width of terminal disc 4–2 μ.

PLATE 24, FIGS. 9–11

DISTRIBUTION: plankton, Birch, Kawaguesaga, Kegonsa and Mendota Lakes.

This species resembles the Egyptian *Ankistrodesmus setigerus* forma *minor* G. S. West but is somewhat longer, twice as wide, and never lacks a pyrenoid. It is named after Mr. Chauncey Juday, who first called my attention to it.

Gloeocystopsis gen. nov.

Cells elongate, cylindrical, more or less curved, with rounded ends. Cells aggregated in fours or eights within a non-lamellated, sharply defined, spherical, gelatinous sheath. Colonies of an indefinite number of these aggregates arranged in a spherical or ovoid mass. Chromatophore diffuse, assimilation product starch.

Reproduction, aside from cell division, unknown. (Name from *Gloeocystis* and ὄψις, appearance.)

This genus combines the general external morphological characteristics of *Gloeocystis* Naegeli and the cell shape of *Nephrocytium* Naegeli. Although ovoid cells have been described in species of *Gloeocystis*, the cells of this species are too markedly lunate to be classed with *Gloeocystis*. The enveloping mucilaginous mass around the cell aggregates is not lamellated as in *Gloeocystis*, neither is there a common gelatinous envelope for these aggregates. On the other hand although the cell-shape resembles certain *Nephrocytium* species (*N. allantoideum* Bohl. for example) the ovoid colonies of *Nephrocytium* are not composed of distinct aggregates of cells, each with its own envelope.

A further study of the method of reproduction, whether by autospores or zoospores, will determine the exact systematic position of the genus. From the data at hand the natural inference is that it should be placed in the vicinity of *Gloeocystis*.

Gloeocystopsis limneticus sp. nov.

Cells 15–10 μ long, 6–4 μ wide. Cell aggregates 30–25 μ in diameter. Colonies up to 125 μ in diameter.

PLATE 24, FIG. 12

DISTRIBUTION: plankton, Catfish and Harris Lakes.

The alga was found in two lakes in northern Wisconsin which are about fifty miles apart and on different watersheds. The dimensions of the alga are the same in both stations. It is probable that *Gloeocystis Rehmanni* Woloszynska from Africa is another species, but since the original description is very vague and no cell-dimensions are given, it must remain a doubtful species until more fully described.

Pediastrum sculptatum sp. nov.

Colonies oval or circular discs of eight to thirty-two cells. Interior cells four- to six-sided with few interstices between the cells. Marginal cells bilobed, with the lobes produced into divergent or parallel horn-like processes. Cell wall covered with a network of very fine ridges.

Diameter of colonies 150–80 μ; diameter of cells 15–10 μ.

PLATE 25, FIG. 13

DISTRIBUTION: plankton, South Turtle Lake.

The shape of the cells in this species resembles *P. Boryanum* (Turp.) Menegh. but the markings are decidedly different. The nearest approach in cell-marking is found in *P. araneosum*, but reticulations in this species are much coarser.

Pediastrum araneosum (Raciborski) comb. nov.

Pediastrum angulosum var. *araneosum* Raciborski, Verh. u. Sitzungsb. Akad. Wiss. Krakau **20**: 101. 1889.

DISTRIBUTION: plankton, Devil's Lake; along shore, Beaver and Muskallonge Lakes.

This has been regarded as a variety and not a distinct species. In my opinion the coarsely reticulate structure of the wall, which is correlated with a certain cell-shape, is sufficiently distinctive to warrant regarding it as a distinct species and not as a variety of some other species.

Pediastrum araneosum rugulosum (G. S. West) comb. nov.

Pediastrum Boryanum var. *rugulosum* G. S. West, Jour. Linn. Soc. Bot. **38**: 132. *pl. 5, f. 22.* 1907.

PLATE 25, FIG. 14

DISTRIBUTION: plankton, Meta Lake.

With the recognition of *P. araneosum* as a species the variety *rugulosum* very naturally comes under this species instead of *P. Boryanum.*

Peroniella planctonica sp. nov.

Cells single, gregarious, epiphytic upon cells of, and embedded in, mucilaginous envelopes of *Sphaerozosma.* Cell-shape ovoid-pyriform, with a long delicate stipe. Chromatophore single (rarely two), yellow-green in color, without pyrenoid or starch. Reproduction by division of cell contents into two to four zoospores with one (?) cilium.

Length of cell, without stipe, 9.5–6 μ; with stipe, 18–15 μ; stipes 10–8 × 1.2 μ.

PLATE 25, FIG. 15

DISTRIBUTION: on *Sphaerozosma* sp., in plankton of Devil's Lake.

The genera *Peroniella* Gobi and *Stipitococcus* W. & G. S. West are quite similar but differ in that the cells of the latter are apiculate or irregularly expanded at the apex and are not ovoid. Since the apices of the cells are rounded in the above described alga it belongs to the genus *Peroniella*. It differs from the single known species, *P. Hyalothecae* Gobi, in that the cells are ovoid and smaller.

A study of the cell contents shows that the genus should be classified with the Heterokonteae and not with the Chlorophyceae. The chromatophores are without starch or pyrenoids and have a decided yellowish green color. Numerous oil droplets, which are probably the product of assimilation, are scattered throughout the cytoplasm. Few instances of zoospore formation were found, but those that were showed no lateral rupture through which the zoospores escaped, as Gobi* describes for *P. Hyalothecae*. Only one cilium was observed although a very careful search was made for a second shorter one. In this respect it resembles certain other Heterokonteae.

Chodatella ciliata minor var. nov.

Cells ovoid, with eight to six bristles at each end.

Cells 10–8 μ long, 7.5–6 μ wide; bristles about 20 μ in length.

PLATE 25, FIG. 16

DISTRIBUTION: plankton, Muskallonge Lake.

The cells of this species are about the same size as those of *C. subsalsa* Lemm., but the number of terminal bristles is that of *C. ciliata* (Lagerh.) Lemm. The variety *minor* never reaches the minimal limit of the type form.

MICRACTINIUM PUSILLUM Fresenius

Micractinium pusillum Fresenius, Abh. Senckenberg. Naturf. Ges. **2**: 236. *pl. 11, f. 46–49.* 1858; Lemm. Ber. Deutsch. Bot. Ges. **22**: 21. 1904; Wille in Engler & Prantl, Nat. Pflanzenfam. 1^2 (Nachtr.): 57. 1911.

Archerina Boltoni Lankester, Quart. Jour. Micr. Sci. N. S. **25**: 61. *pl. 7, f. 1–23.* 1885; *l.c.* **52**: 423. 1908.

Golenkinia botryoides Schmidle, Allg. Bot. Zeitschr. **2**: 194. 1896.

Golenkinia fenestrata Schröder, Ber. Deutsch. Bot. Ges. **15**: 492. *pl. 25, f. 5.* 1897.

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* Scripta Bot. Hort. Univ. Petrop. **2**: 233–255. *pl. 1.* 1886–1887.

Richteriella globosa Lemm. Forschungsb. Biol. Stat. Plön **5**: 107. 1897.

Richteriella botryoides Lemm. Hedwigia **37**: 307. *pl. 10, f. 1–6.* 1898; Arch. Hydrobiol. u. Planktonkde. **5**: 306. 1910.

Richteriella botryoides forma *fenestrata* Chodat, Matér. pour la Flore Crypt. Suisse 1^3: 194. *f. 110.* 1902.

Richteriella botryoides forma *tetraedrica* Lemm. Arch. Hydrobiol. u. Planktonkde. **5**: 307. 1910; Ber. Deutsch. Bot. Ges. **18**: 90. *pl. 3, f. 9–10.* 1900.

PLATE 25, FIG. 18

This alga is most widely known as *Richteriella botryoides*, a name which is untenable under any circumstance. In 1904 Lemmermann pointed out that the overlooked genus *Micractinium* Fresenius bears considerable resemblance to *Richteriella* Lemm. He thinks, however, since the description is so vague and most of Fresenius's figures illustrate only single cells, that the organism Fresenius saw was what is commonly called *Golenkinia*. Wille holds that all of the spherical-celled forms with radiating bristles constitute a single genus and makes the subgenus *Golenkinia* for the solitary forms and *Richteriella* for the colonial ones. He very logically applies Fresenius's name *Micractinium* to this composite genus.

In my opinion the colonial and solitary habits are too diverse to warrant placing both of them in the same genus. The question then arising is, shall *Micractinium* be substituted for *Golenkinia* or for *Richteriella?* Lemmermann's account (1904) creates the impression that Fresenius's description fits *Golenkinia* better than *Richteriella*. The cell measurements given by Fresenius, 1/170–1/150 mm. (5.88–6.67 μ) as a maximal and 1/300 mm. (3.33 μ) or less as the minimal dimensions, are much nearer *Richteriella botryoides* than *Golenkinia radiata* Chodat or any other *Golenkinia* species. It must be admitted that Fresenius does not emphasize the colonial habit, which characterizes *Richteriella*, but he does state that colonies of two to four cells are found and that there may be more than four cells in the colony so that a berry-shaped (mulberry?) colony is formed. Since *Golenkinia* forms only temporary colonies and since these never contain more than four cells it seems to me that the organism Fresenius saw is the one which Lemmermann has described as *R. botryoides*.

Lankester states that the genus *Archerina* antedates *Richteriella*. There is no question of the identity of the two organisms, *f. 21* of Lankester's plate being especially characteristic. In the material studied by Lankester he mistook a naked amoeboid parasite investing the plant cells for an integral part of the organism and so considered *Archerina* a protozoan and not an alga. The name *Richteriella* cannot be retained in any case, since those who regard the description of *Micractinium* as being too vague should use *Archerina* in its place.

This alga, which I have found in abundance in some of the local lakes, at times forms large irregular colonies containing over a thousand cells. The most common state, however, is the flat plate of sixteen cells with an open central space, the form *afenestrata* Chodat. This name and also the form-name *tetraedrica* Lemmermann are unwarranted since they may both occur in the same colony.

Micractinium quadrisetum (Lemm.) comb. nov.

Richteriella quadriseta Lemm. Hedwigia **37**: 307. *pl. 10, f. 7*. 1898.
Richteriella botryoides var. *quadriseta* Chodat, Matér. pour la Flore Crypt. Suisse 1³: 194. 1902.

PLATE 25, FIG. 17

DISTRIBUTION: plankton, Catfish and Cranberry Lakes.

The character on which the specific name is based, that of four spines, is not constant enough to warrant the establishment of a separate species. It is probably on this account that several investigators have followed Chodat's lead and considered it a form hardly worthy of naming. On the other hand the cell is always distinctly ovoid in this species, whereas it is always spherical in *M. pusillum*. The cell-dimensions in *M. quadriseta* are also always constantly larger. Since there are these differences *M. quadriseta* should be considered a distinct species.

Tetraedron planctonicum sp. nov.

Cells four- or five-sided, sides generally incurved and equal. Angles of cells prolonged into bifurcate or trifurcate processes ending in two or three horns. Processes broad in top view, narrow in side view.

Diameter of cell without processes 24–18 μ; with processes (diagonally) 70–50 μ; diameter of processes 12–9×8–5 μ; length 25–15 μ.

PLATE 26, FIGS. 19–20

DISTRIBUTION: plankton, Cranberry, Lost, No Mans and Pardee Lakes.

This striking form is confined to the plankton of lakes in the northern part of the state. It resembles *T. limneticum* Borge to a certain extent but agrees more nearly with the description of *T. gracile* (Reinsch) Hansg. The processes differ from those of *T. gracile*, however, since when they are seen in a side view they are narrow but in a top view they are broad. The processes end in two horns in *T. gracile* while in this species there are often three.

Tetraedron lobatum polyfurcatum var. nov.

Cells four-sided, flat or pyramidal. Angles prolonged, tapering but slightly. Prolongations branching three to five times, ultimate branches with three spines. Prolongations nearly as long as cell. Sides of cell incurved.

Diameter (without processes) 20–15 μ; (with processes) 40–30 μ; diagonal diameter 50–35 μ.

PLATE 26, FIGS. 21, 22

DISTRIBUTION: plankton, Muskallonge and Pardee Lakes.

This may be classed as a variety of *T. lobatum* on account of the cell-shape, but the extensive system of rebranching apical prolongations is not found in any described variety of *T. lobatum*. The branches resemble *T. enorme* (Ralfs) Hansg. but the sides of the alga under consideration are too deeply incised and the corners of the cells too long to regard it as a variety of *T. enorme*.

Actinastrum gracillimum sp. nov.

Colonies of four or eight cells radiating from a common center. Cells elongate, cylindrical or slightly tapering. Chromatophore single, parietal, without a pyrenoid.

Cells 18–14 μ long, 2–1.75 μ wide.

PLATE 26, FIG. 23

DISTRIBUTION: plankton, Kegonsa and Mendota Lakes.

This is much more delicate than any previously described species of *Actinastrum*.

Cylindrospermum stagnale angustum var. nov.

Cells 4.5–4 μ wide; 10–8 μ long. Heterocysts 6.5–5.5 μ wide; 11–7 μ long. Spores 9–7 μ wide; 25–18 μ long.

PLATE 26, FIG. 24

DISTRIBUTION: bottom of Oconomowoc Lake.

The much narrower and shorter spores distinguish this from the type.

Spirulina laxa sp. nov.

Plant mass dark blue-green. Cells 2.5–2 μ wide, in a very loose spiral. Width of spiral 6–4 μ, distance between turns 20–15 μ. Cell contents blue-green.

PLATE 26, FIG. 25

DISTRIBUTION: along shore, Soft Lake.

The loose spiral suggests *Arthrospira* rather than *Spirulina* but, since a careful examination fails to reveal the presence of transverse walls, I am convinced the plant in question is a *Spirulina*.

Chroococcus limneticus distans var. nov.

Colonies spherical or ovoid, of four to thirty-two cells, rarely more, embedded in a copious, hyaline, unlamellated, gelatinous envelope. Cells hemispherical to spherical, with grayish or light blue-green contents, "gas vacuoles" rarely present.

Diameter of cells 7–6.5 μ; diameter of colonies up to 60 μ.

PLATE 26, FIG. 26

DISTRIBUTION: plankton, Cranberry and Muskallonge Lakes.

This *Chroococcus* variety has the characteristic *C. limneticus* Lemm. structure of a few spherical cells embedded in a wide gelatinous sheath. The cell-dimensions are different from those of the other *C. limneticus* varieties so that it seems best to regard it as a new variety.

Anabaena limnetica sp. nov.

Trichomes free-swimming, solitary, straight or slightly curved. Vegetative cells generally spherical, 10–14 μ in diameter, with "gas vacuoles." Heterocysts spherical, 10–12 μ in diameter. Spores smooth-walled, solitary, ovoid, adjacent to, or a short distance from, the heterocysts, 20–17 μ in diameter, 25–20 μ long.

PLATE 26, FIG. 27

DISTRIBUTION: plankton, Birch, Soft and Tamarack Lakes.

The species resembles *A. macrospora* Klebh. in the general appearance of the trichome, but the cellular dimensions are quite different, since the cells of *A. macrospora* are much smaller and the spores proportionally larger.

Lyngbya Birgei sp. nov.

Filaments free-floating, straight, rarely curved. Sheath firm, hyaline, homogeneous. Trichomes not constricted at cross walls, ends rounded but not attenuated. Cells shorter than broad, with many "gas vacuoles" at times.

Filaments 24–20 μ wide; trichomes 22–18 μ wide.

PLATE 26, FIG. 28

DISTRIBUTION: plankton, Kegonsa, Mendota, Monona, Oconomowoc, Squirrel and Waubesa Lakes.

Almost all of the true plankton species of *Lyngbya* have filaments that are less than 5 μ in diameter. The only other plankton species of any size is *L. Hieronymusii* Lemm., but the Wisconsin *Lyngbya* is much larger. This species is found in abundance in the Madison lakes and at times has been the major constituent of the "blooms" that have appeared in these lakes. This is especially the case in Lake Kegonsa. The cell contents at such times are very characteristic of "bloom"—producing Myxophyceae, since there are large numbers of reddish "gas vacuoles" in each cell. The species is named after Mr. E. A. Birge, Director of the State Survey.

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Explanation of plates 24–26

All the figures were drawn from life with the aid of the Abbé camera lucida, the drawings being made at the level of the base of the microscope. The Leitz objective 6 was used with the ocular 4, and the objective 1/16 with the oculars 1, 3 and 4. The magnifications are, respectively, 750, 1,000, 1,650 and 2,000 diameters. The drawings have been reduced a little more than one half (to eleven twenty-fourths their original size) in reproduction.

PLATE 24

FIG. 1. *Chaetosphaeridium ovalis* G. M. Smith, ×345.
FIG. 2. *Oocystis panduriformis minor* G. M. Smith, ×920.
FIG. 3. *Tetrastrum apiculatum* (Lemm.) Brunnthaler, ×920.
FIGS. 4–6. *Characium stipitatum* (Bachmann) Wille, ×920.
FIG. 7. *Kirchneriella elongata* G. M. Smith, ×920.
FIG. 8. *Schroederia setigera* (Schröder) Lemm., ×920.
FIGS. 9–11. *Schroederia Judayi* G. M. Smith, ×920.
Fig. 12. *Gloeocystopsis limneticus* G. M. Smith, ×920.

PLATE 25

FIG. 13. *Pediastrum sculptatum* G. M. Smith, ×460.
FIG. 14. *Pediastrum araneosum rugulosum* (G. S. West) G. M. Smith, ×920.
FIG. 15. *Peroniella planctonica* G. M. Smith, ×920.
FIG. 16. *Chodatella ciliata minor* G. M. Smith, ×920.
FIG. 17. *Micractinium quadrisetum* (Lemm.) G. M. Smith, ×920.
FIG. 18. *Micractinium pusillum* Fresenius, ×920.

PLATE 26

FIGS. 19, 20. *Tetraedron planctonicum* G. M. Smith, ×920.
FIGS. 21, 22. *Tetraedron lobatum polyfurcatum* G. M. Smith, ×920.
FIG. 23. *Actinastrum gracillimum* G. M. Smith, ×920.
FIG. 24. *Cylindrospermum stagnale angustum* G. M. Smith, ×920.
FIG. 25. *Spirulina laxa* G. M. Smith, ×920.
FIG. 26. *Chroococcus limneticus distans* G. M. Smith, ×760.
FIG. 27. *Anabaena limnetica* G. M. Smith, ×760.
FIG. 28. *Lyngbya Birgii* G. M. Smith, ×760.

A quantitative study of the factors influencing the weight of the bean seed — II. Correlation between number of pods per plant and seed weight

J. Arthur Harris

(WITH FOUR TEXT FIGURES)

I. Introductory remarks

This study, like the one which preceded it,* presents a portion of the results of an attempt to express in quantitative terms the influence of the various differentiable factors to which the weight of the bean seed is due.

Such an investigation has a three-fold significance: (*a*) it has the biological interest common to studies in developmental mechanics; (*b*) it forms a part of the system of physiological data on seed production which can never be too detailed or precise as a foundation for economic science; (*c*) it pertains to a character which through the theories of Johannsen and his followers has assumed a prominent place in genetic literature.

In the first paper I considered the correlation between the characteristics of the pod (number of ovules laid down, number of seeds matured, and position of seed in the pod) and seed weight. In this place I propose to deal with the problem of the relationship between the size of the plant, as measured by the number of fertile pods produced, and seed weight. These constants will be compared with these showing the relationship between the number of pods per plant and pod characteristics, already published.

II. Materials and methods

The materials upon which the present discussion are based comprise 78,975 individually weighed seeds, derived from 15,897 plants, belonging to 27 experimental cultures, representing 5

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* Harris, J. Arthur. A quantitative study of the factors influencing the weight of the bean seed. I. Intra-ovarial correlations. Beih. Bot. Centralbl. 31^1: 1–12. *pl. 1–4.* 1913. See also: The influence of position in the pod upon the weight of the bean seed. Amer. Nat. **49**: 44–47. *f. 1–4.* 1913.

varieties. These cultures were made under a wide range of environmental conditions. They are here designated by the key letters employed in other publications. It is, therefore, unnecessary to burden this paper with information which the reader who cares to do so may obtain elsewhere.*

The biometric methods employed in the analysis of the data should now be familiar in a general way to all serious biological workers.†

III. PRESENTATION AND DISCUSSION OF DATA

The physical constants for the unweighted frequency distributions of both number of pods per plant and weight of seed have been given elsewhere.‡

The weighted frequency constants have little independent biological interest. We may, therefore, limit our attention to the degree of interdependence between the two variables.

The correlation coefficients for number of pods and seed weight with their probable errors and their ratios to their probable errors appear in TABLE I.

The regression straight line equations giving the numerical equivalents of

$$w = \left(\bar{w} - r_{pw}\frac{\sigma_w}{\sigma_p}\bar{p}\right) + r_{pw}\frac{\sigma_w}{\sigma_p}p,$$

where the bars denote means and the sigmas represent the standard deviations of the characters indicated by the subscripts are given in TABLE II. These show the absolute change in seed weight associated with unit change in number of pods per plant. If the regression straight lines and the empirical mean seed weights for plants with various numbers of pods for a number of series be

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* See a bibliography in Amer. Jour. Bot. 1: 410–411. 1915.

† Number of pods per plant is an integral variate which has been treated without grouping. Seed weight has been dealt with in classes of 0.025 gram range, e.g. 0.175–0.200, 0.200–0.225, 0.225–0.250. Sheppards' correction was applied to the second moment for seed weight but not to that for number of pods per plant. Number of pods per plant was of course weighted with number of seeds weighed per plant.

‡ These are sometimes based upon slightly different numbers than these here employed, but the constants are sensibly the same.

TABLE I

Series	Number of Plants	Number of Seeds Weighed	Correlation Pods and Weight	r/E_r
L	185	2861	.157 ±.012	13.08
LL	1141	3947	.074 ±.011	6.73
GG	747	8364	.055 ±.007	7.86
GGH	583	2828	.173 ±.012	14.42
GGH_2	499	1284	.081 ±.019	4.26
GGHH	396	1329	.039 ±.019	2.05
GGD	514	2140	.150 ±.014	10.71
GGD_2	449	1419	.240 ±.017	14.12
GGDD	342	1093	.193 ±.020	9.65
H	160	5778	.145 ±.009	16.11
HH	1484	7325	.191 ±.008	23.87
HHH	1271	5601	.264 ±.008	33.00
HD	1416	6630	.303 ±.008	37.87
HDD	1204	5029	.171 ±.009	19.00
D	445	2362	.031 ±.014	2.21
DD	513	2362	.339 ±.012	28.25
DDD	459	1946	.077 ±.015	5.13
DH	670	3222	.221 ±.011	20.09
DHH	565	2433	.307 ±.012	25.58
USH	361	1164	.154 ±.019	8.11
USHH	224	530	.108 ±.029	3.73
USD	312	1002	.282 ±.020	14.10
USDD	237	789	.210 ±.023	9.13
FSH	476	2117	.005 ±.015	.33
FSHH	429	1788	.053 ±.016	3.31
FSD	428	1989	.205 ±.015	13.66
FSDD	387	1643	.069 ±.017	4.06

expressed graphically on the same diagram, as in FIGS. 1 and 2,* the results seem very irregular indeed. This lack of uniformity appears in both the varying slope of the lines and in the scatter of the observed means about these lines.

The variation in the slope of the lines must be considered in relation to the great diversity in environmental conditions under which the plants were grown.

The slope of the line is determined solely by the magnitude of the absolute variation constants for seed weight and number of pods per plant and the correlation between them. The standard deviation of seed weight is relatively little influenced by the differences in environmental conditions obtaining between the cultures here considered. The standard deviation of number of pods per plant varies greatly from experiment to experiment. Thus with the same degree of correlation, the actual rate of change in seed

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* In order to accommodate as large a series as possible of figures on the same diagram the marginal scales have been given no numerical values. The numbers of pods and the end points of the lines drawn are given in the table.

TABLE II

Series	Regression Equation	End Points of Line
L	$W = .3522 + .0023\ P$	1 = .354, 31 = .422
LL	$W = .3291 + .0012\ P$	1 = .330, 27 = .360
GG	$W = .4167 + .0012\ P$	1 = .418, 26 = .447
GGH	$W = .4298 + .0027\ P$	1 = .433, 33 = .543
GGH_2	$W = .4427 + .0022\ P$	1 = .445, 17 = .479
GGHH	$W = .4409 + .0010\ P$	1 = .442, 15 = .456
GGD	$W = .3385 + .0079\ P$	1 = .347, 8 = .402
GGD_2	$W = .3609 + .0128\ P$	1 = .374, 7 = .451
GGDD	$W = .3670 + .0111\ P$	1 = .378, 9 = .456
H	$W = .2127 + .0007\ P$	1 = .214, 46 = .246
HH	$W = .2184 + .0008\ P$	1 = .219, 67 = .271
HHH	$W = .1825 + .0017\ P$	1 = .184, 34 = .241
HD	$W = .1772 + .0058\ P$	1 = .183, 14 = .258
HDD	$W = .2102 + .0027\ P$	1 = .213, 16 = .253
D	$W = .1723 + .0008\ P$	1 = .173, 9 = .180
DD	$W = .1757 + .0065\ P$	1 = .182, 14 = .266
DDD	$W = .1976 + .0014\ P$	1 = .199, 13 = .216
DH	$W = .1961 + .0009\ P$	1 = .197, 50 = .239
DHH	$W = .1797 + .0020\ P$	1 = .182, 27 = .232
USH	$W = .3182 + .0017\ P$	1 = .320, 39 = .385
USHH	$W = .3018 + .0019\ P$	1 = .305, 15 = .331
USD	$W = .2243 + .0108\ P$	1 = .235, 7 = .300
USDD	$W = .2806 + .0049\ P$	1 = .286, 16 = .358
FSH	$W = .2001 + .0000\ P$	1 = .200, 50 = .201
FSHH	$W = .1645 + .0003\ P$	1 = .165, 34 = .175
FSD	$W = .1501 + .0032\ P$	1 = .153, 10 = .182
FSDD	$W = .1632 + .0012\ P$	1 = .164, 14 = .179

W = Weight in grams, P = Pods per plant. End points of lines give calculated mean seed weight in grams for number of pods indicated.

weight will vary widely because of differences in the variability of number of pods per plant.

The irregularity of the means of seed weight for plants with different numbers of pods is attributable to several factors. Note the following:

Taken as a whole the correlations are of a very low order. In such cases the empirical means must be expected to deviate considerably from the theoretical means as predicted from the regression formula unless the number of observations be very large indeed.

Number of pods per plant is an exceedingly variable character. In consequence, the means for seed weight must, in experiments made under favorable conditions, be based upon a relatively small number of seeds, even in series in which the total number of seeds weighed is very large. It is impossible, if all series are to be treated alike, to increase the number of seeds upon which means

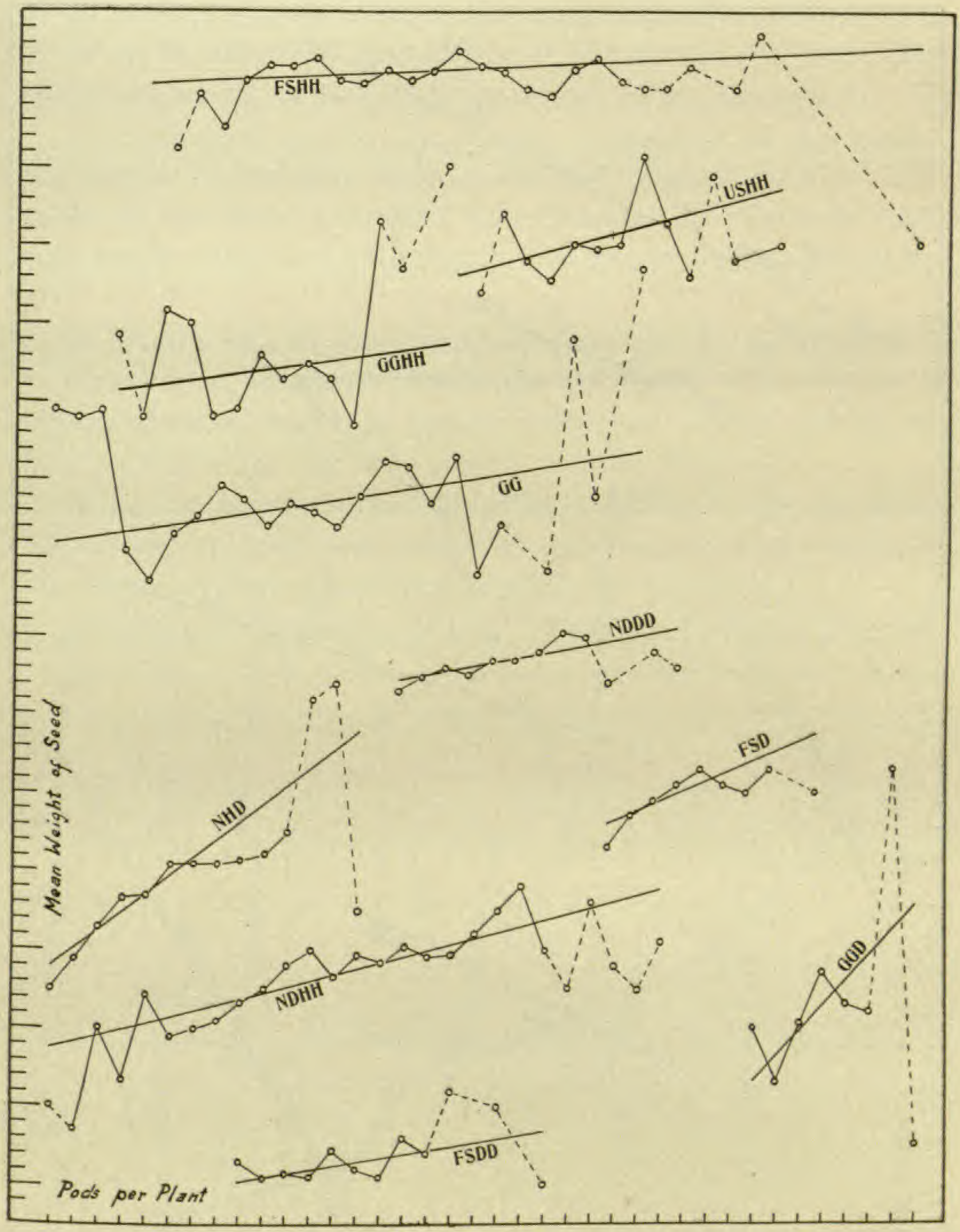

FIG. 1. Regression straight lines showing change in seed weight associated with variation in number of pods per plant.

are based by clubbing together plants with similar numbers of pods, since in many of the experiments the range of variation is too narrow to permit of such combination.

Finally, it is to be noted that in general about five seeds per plant have been weighed. When the number of plants with a

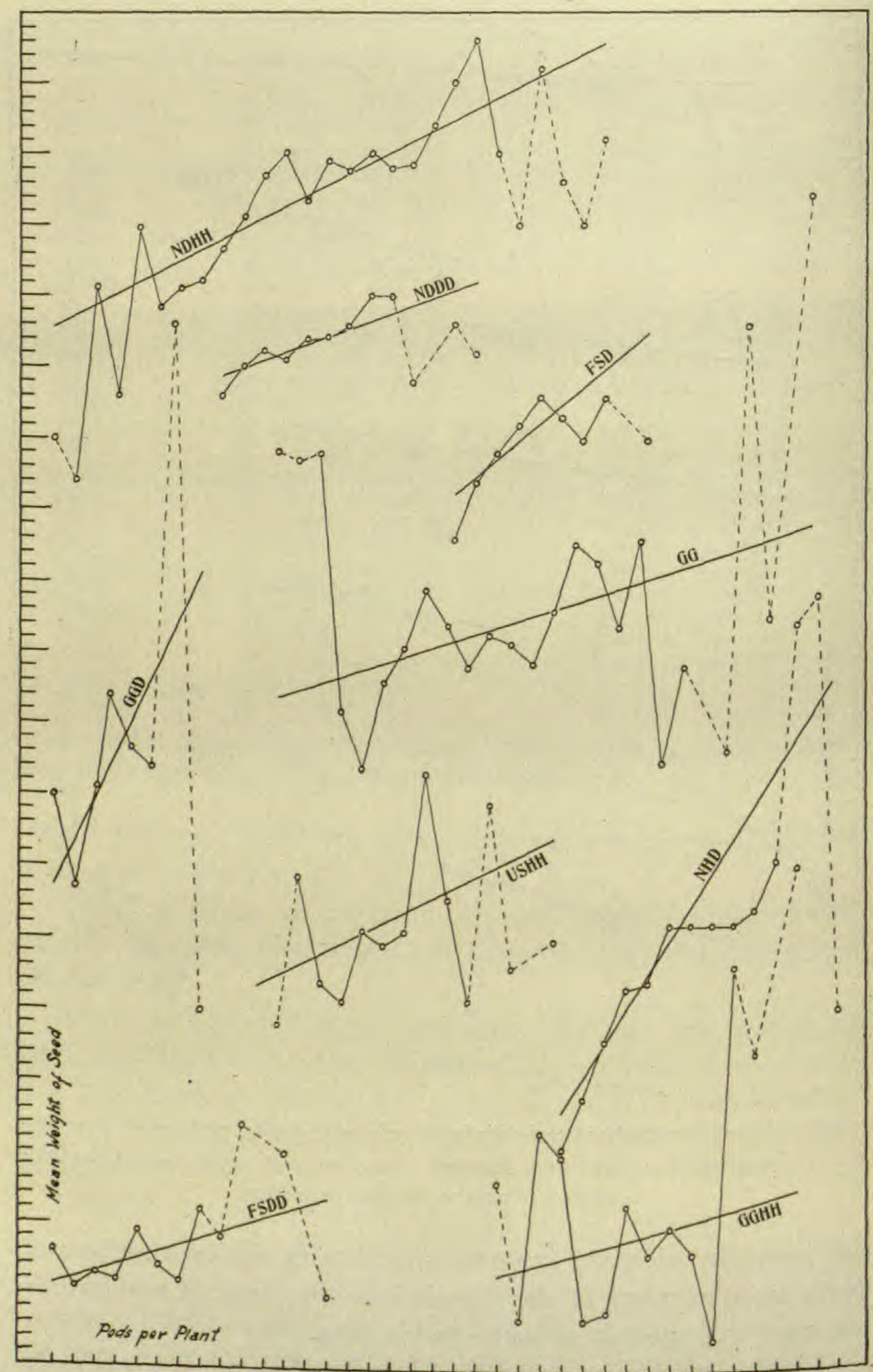

FIG. 2. Regression of seed weight on number of pods per plant. See explanation of FIG. 1.

given number of pods is small, this weighting will, I believe, tend to result in abnormal irregularity of the means of arrays. The biological reason for this condition I hope to discuss later.

Notwithstanding the conspicuous irregularity of the means, the number of regression diagrams in the two figures indicate that, taken by and large, a straight line represents the change in mean seed weight associated with variation in the number of pods on the plant as well as any other single equation would do.

It is quite idle to apply mathematical tests for goodness of fit in these series, for these involve the calculation of a measure of interdependence which is greatly influenced by the special difficulties which are met in graphical tests for linearity.

Thus, notwithstanding difficulties inherent in the materials the correlation coefficient seems the best numerical expression of the degree of interdependence between the variables.

All of the 27 values are positive. Numerically they are of a low

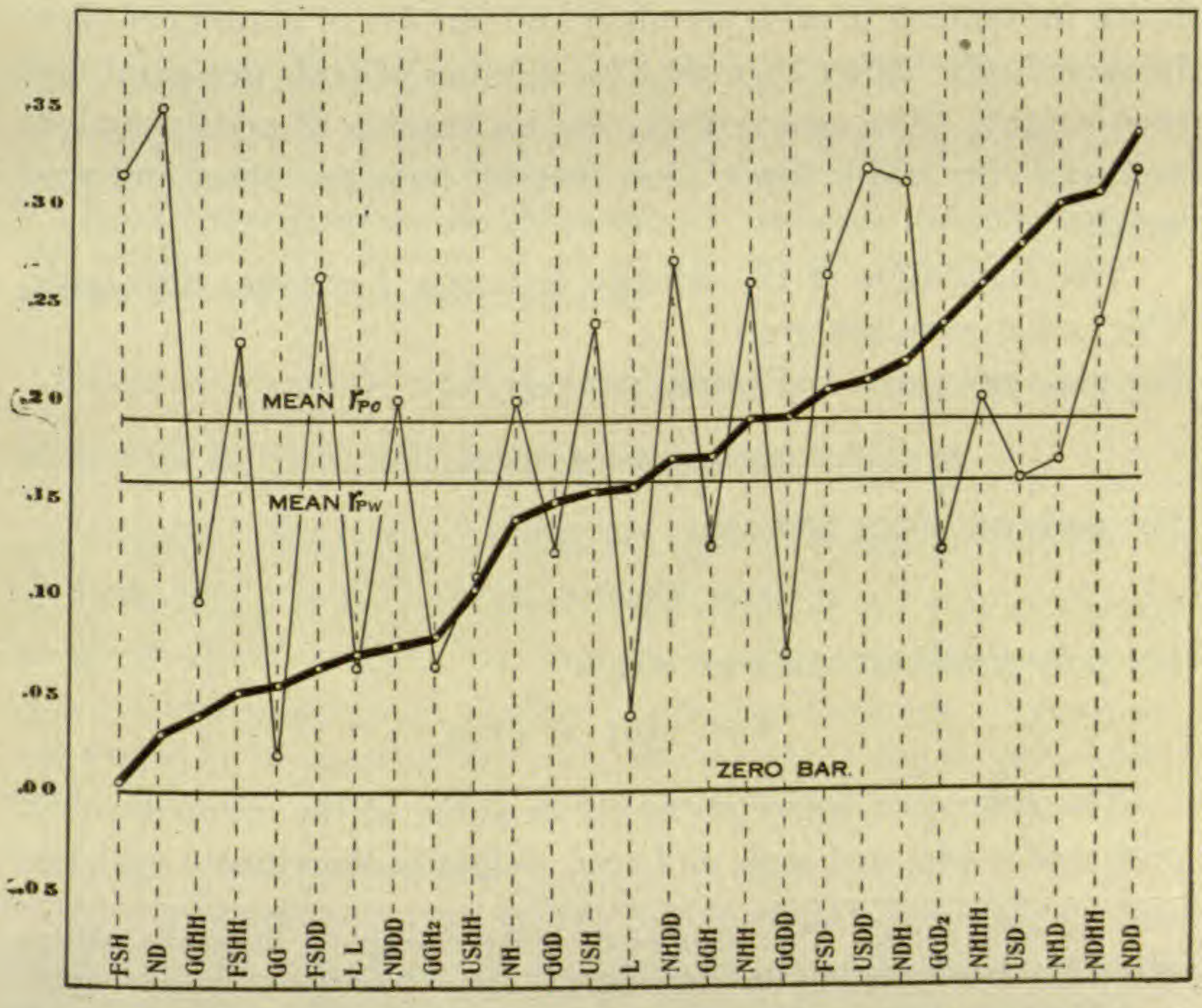

FIG. 3. Comparison of correlations between number of pods per plant and seed weight with that between number of pods per plant and number of ovules per pod in 27 cultures of *Phaseolus*.

order, ranging from +.005 to +.339 with the average value +.159. With two or three exceptions only, the correlation coefficients may be considered statistically significant in comparison with their probable errors.

As a basis of comparison there are available from an earlier paper* the constants showing the relationship between the number of ovules and seeds per pod and the number of pods per plant in these same series.

The results are exhibited graphically in FIGS. 3 and 4. In these the circles on the ordinates joined by the heavy lines show on the scale to the left the values of the correlations for number of pods per plant and seed weight arranged in the order of their magnitude. The circles connected by the narrow lines show on the same scale the magnitude of the correlations for ovules and seeds respectively.

The bars indicating the averages show that the mean correlation for number of pods per plant and number of ovules per plant is numerically higher than that for number of pods per plant and seed weight. The mean correlation for number of pods per plant and seeds per pod is lower than that for pods per plant and seed weight.

The magnitude of the differences is not, however, very large. The actual averages are:†

For pods per plant and ovules per pod,

$$\bar{r} = .1924 \pm .0124.$$

For pods per plant and seeds per pod,

$$r = .1327 \pm .0118.$$

For pods per plant and seed weight,

$$\bar{r} = .1592 \pm .0119.$$

The difference between the mean value of the correlation for pods and ovules and pods and seed weight is therefore

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* Harris, J. Arthur. On the correlation between somatic characters and fertility. II. Illustrations from *Phaseolus vulgaris*. Amer. Jour. Bot. 1: 398–411. 1914.

† The mean values of the correlations for pods and ovules and pods and seeds given here differ slightly but insignificantly from those published elsewhere, because only 27 of the 32 series are used here.

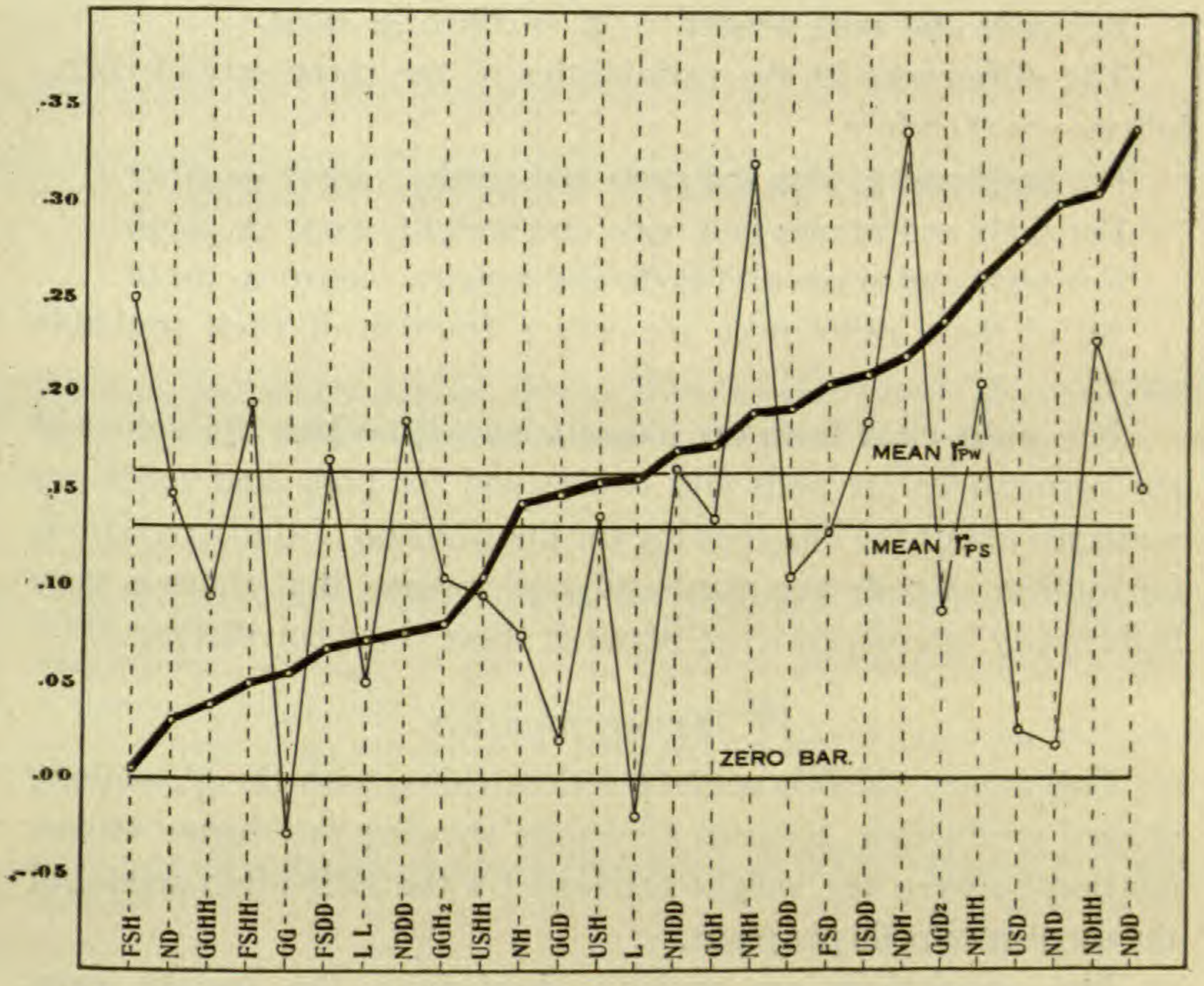

FIG. 4. Comparison of correlations between number of pods per plant and seed weight with that between number of pods per plant and number of seeds matured per pod in 27 cultures of *Phaseolus*.

$$(.1592 - .1924) \pm \sqrt{(.0119)^2 + (.0124)^2} = - .0332 \pm .0172,$$

while that for pods and seeds and pods and weight is

$$(.1592 - .1327) \pm \sqrt{(.0119)^2 + (.0118)^2} = .0265 \pm .0168.$$

Differences in correlations of the order of .03 can ordinarily be given little weight. In the present instance neither of the differences is quite twice as large as its probable error. They cannot therefore be asserted to represent real physiological differences in the closeness of interdependence of the magnitudes of the three variables under consideration.

Not only are the means of the three correlations essentially the same, but the variability of the three sets of constants is practically identical. The values are:

For pods and ovules per pod, $\sigma_r = .0953 \pm .0087$.

For pods and seeds per pod, $\sigma_r = .0906 \pm .0083$.

For pods and seed weight, $\sigma_r = .0916 \pm .0084$.

The differences in the variabilities of the three sets of correlations are therefore:

For pods and ovules and pods and seeds, $.0047 \pm .0117$.

For pods and ovules and pods and weight, $.0037 \pm .0118$.

For pods and seeds and pods and weight, $.0010 \pm .0118$.

All of these differences are only a fraction of their probable errors.

It is quite clear from the irregularity with which the values of the correlations for pods and ovules and for pods and seeds are scattered about the line showing the distribution of the correlations for number of pods per plant and seed weight, that there is very little if any interdependence between these three correlations.

IV. RECAPITULATION

This paper, which is one of a series dealing with the physiology of seed production, presents constants showing the degree of correlation between the weight attained by the individual seed and the number of pods per plant.

The correlations are positive throughout the twenty-seven series for which data are available, but are of a low order of magnitude and highly variable. They range from $+.005$ to $+.339$, with a mean of $+.159 \pm .012$ and an absolute variability of $.092 \pm .008$.

In both average magnitude and variability the correlations for seed weight and number of pods per plant are in excellent agreement with those for number of ovules per pod and number of pods per plant and with the correlation for number of seeds per pod and number of pods per plant.

The average value of the correlation for pods and weight is lower than that for pods per plant and ovules per pod and higher than that for pods per plant and seeds per pod, but both of these differences are low, and may not be significant in comparison with their probable errors.

These studies will be continued.

COLD SPRING HARBOR, NEW YORK.

INDEX TO AMERICAN BOTANICAL LITERATURE

1913-1916

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 the broadest sense.

Reviews, and papers that 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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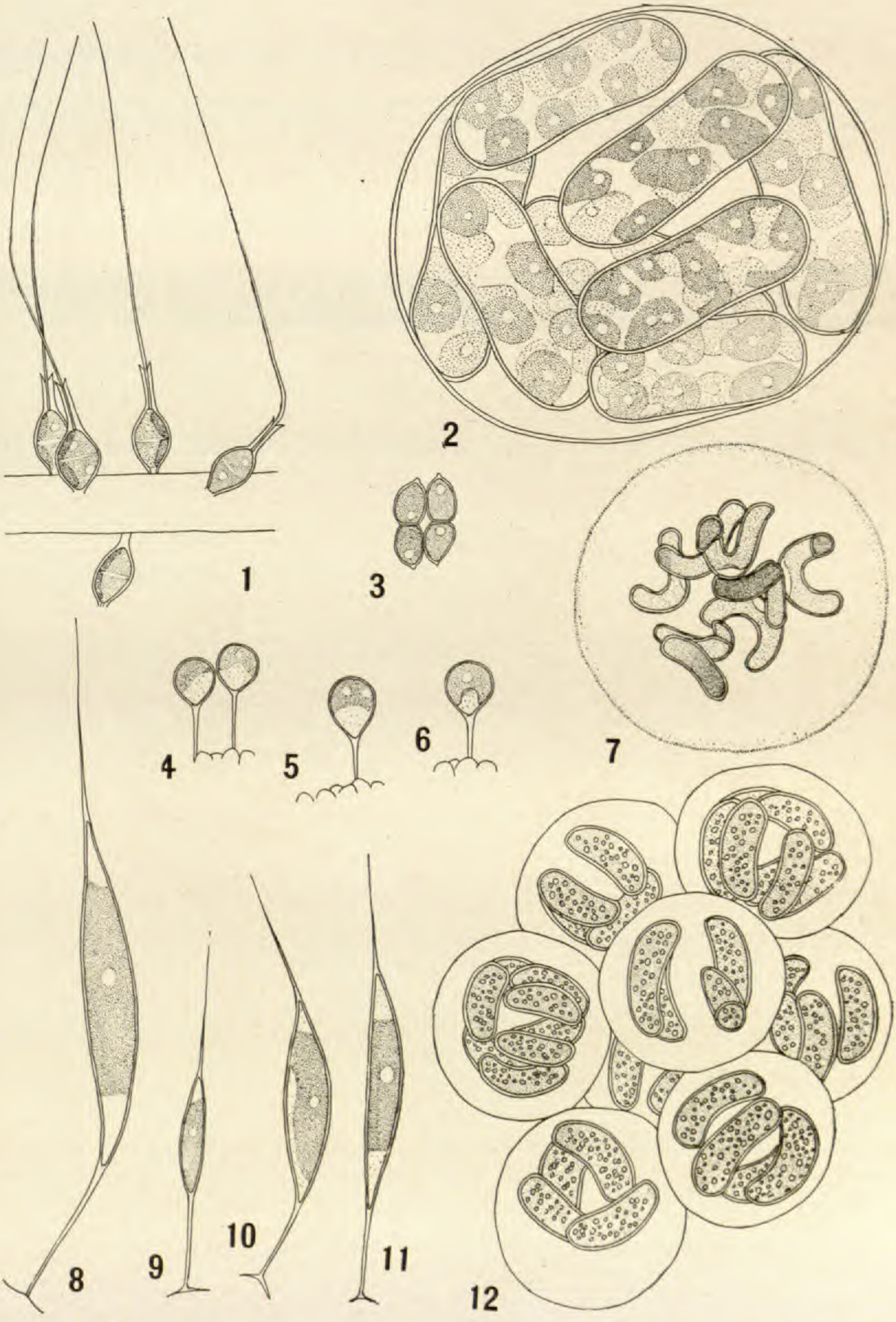

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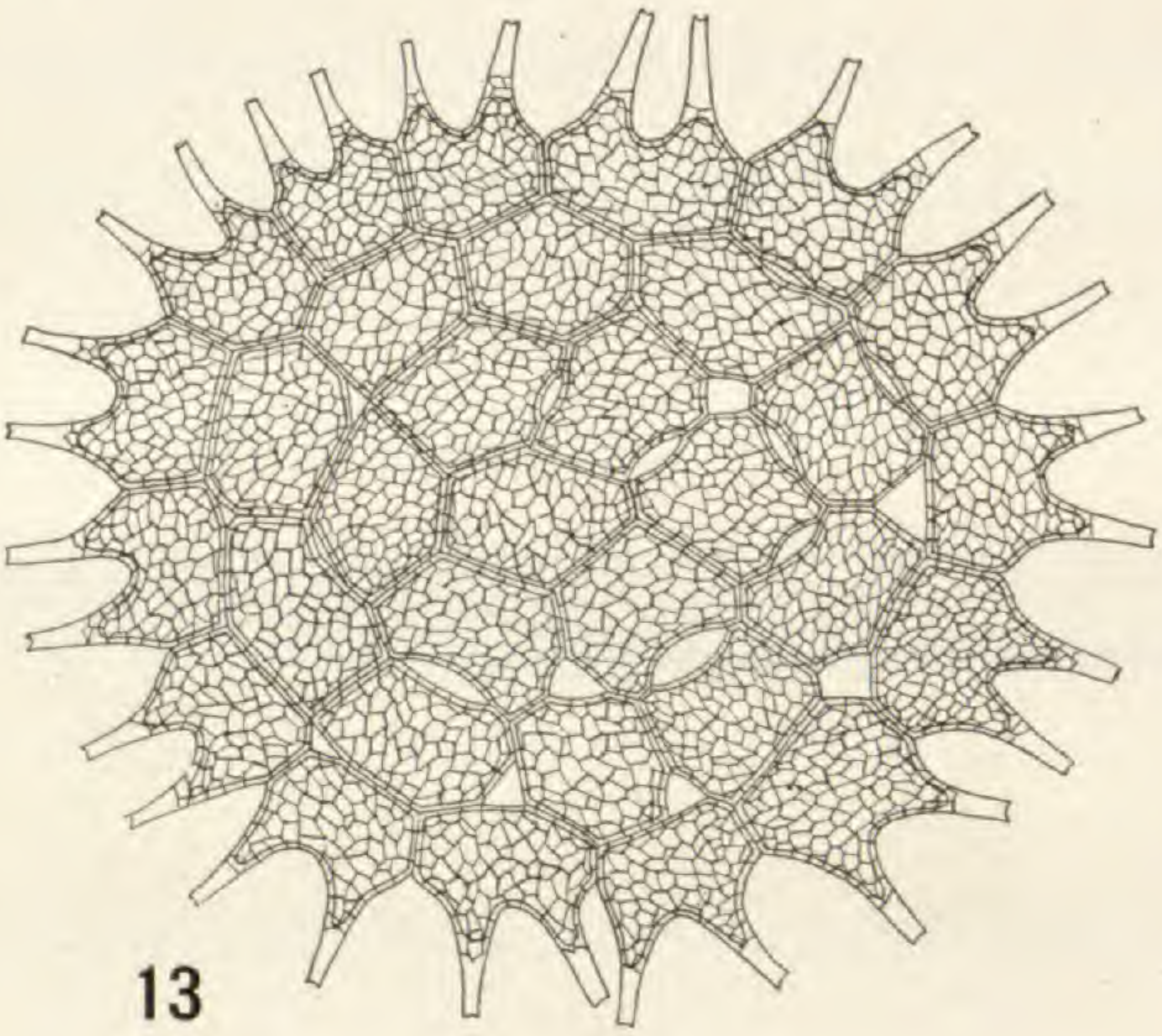
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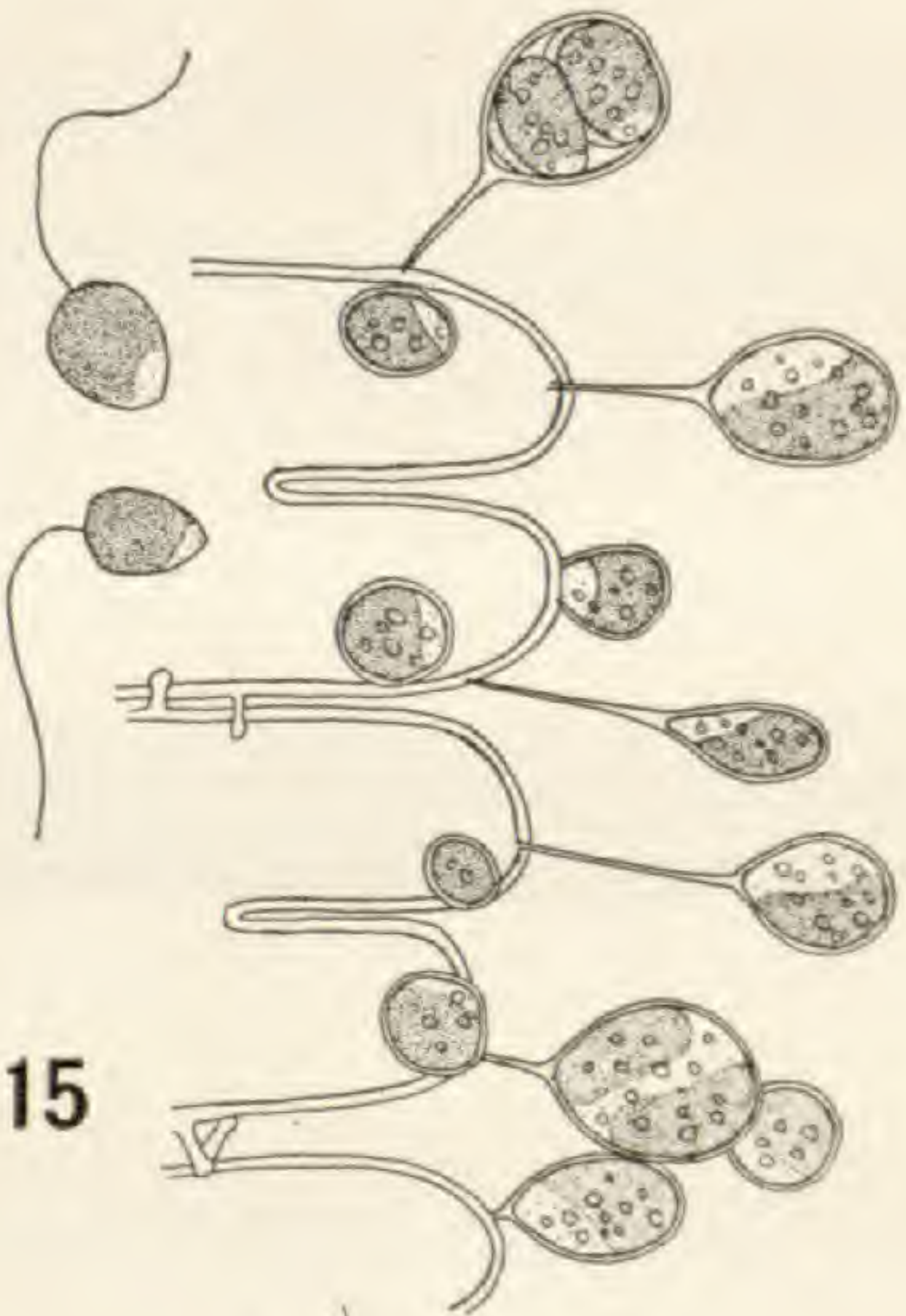
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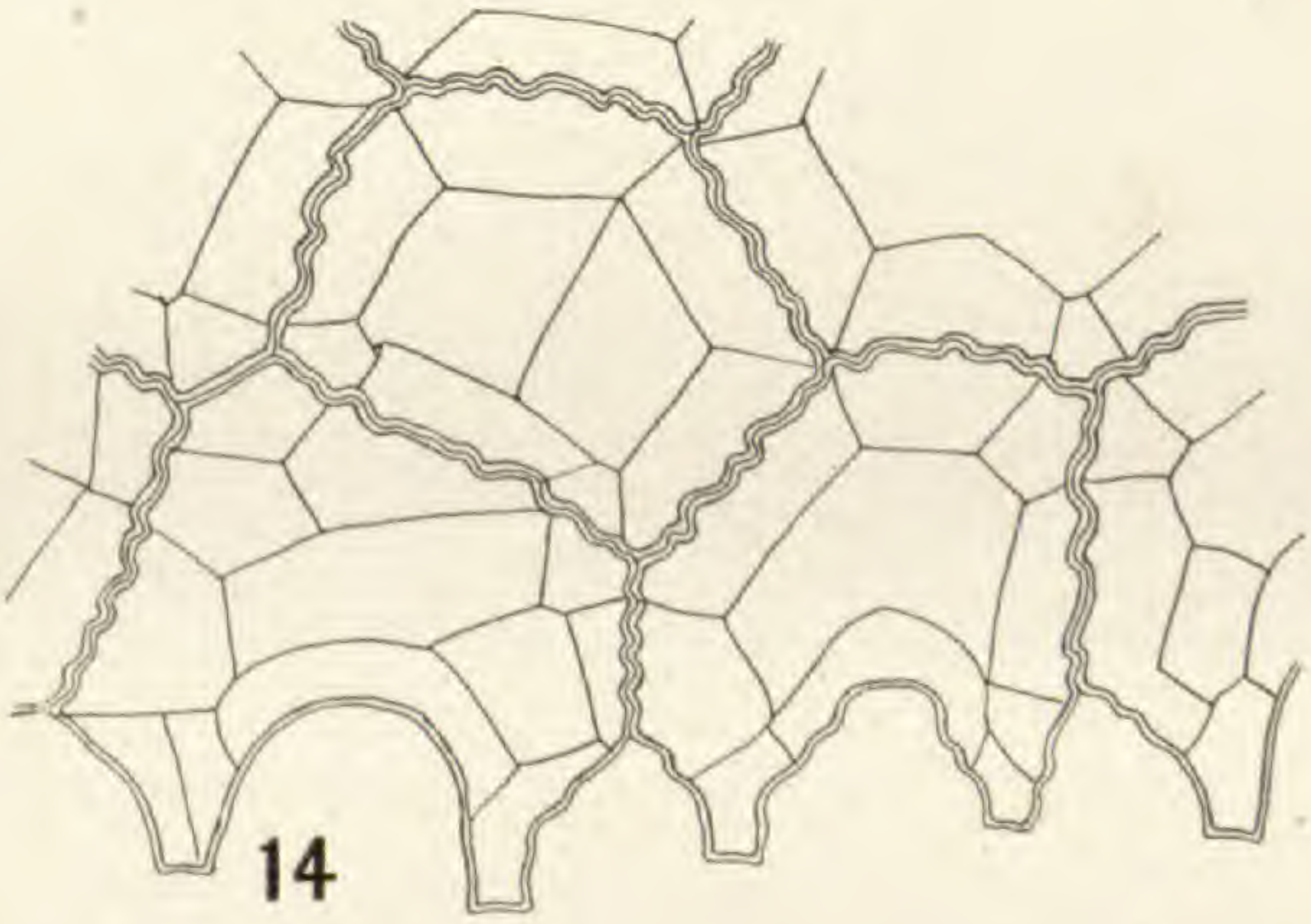
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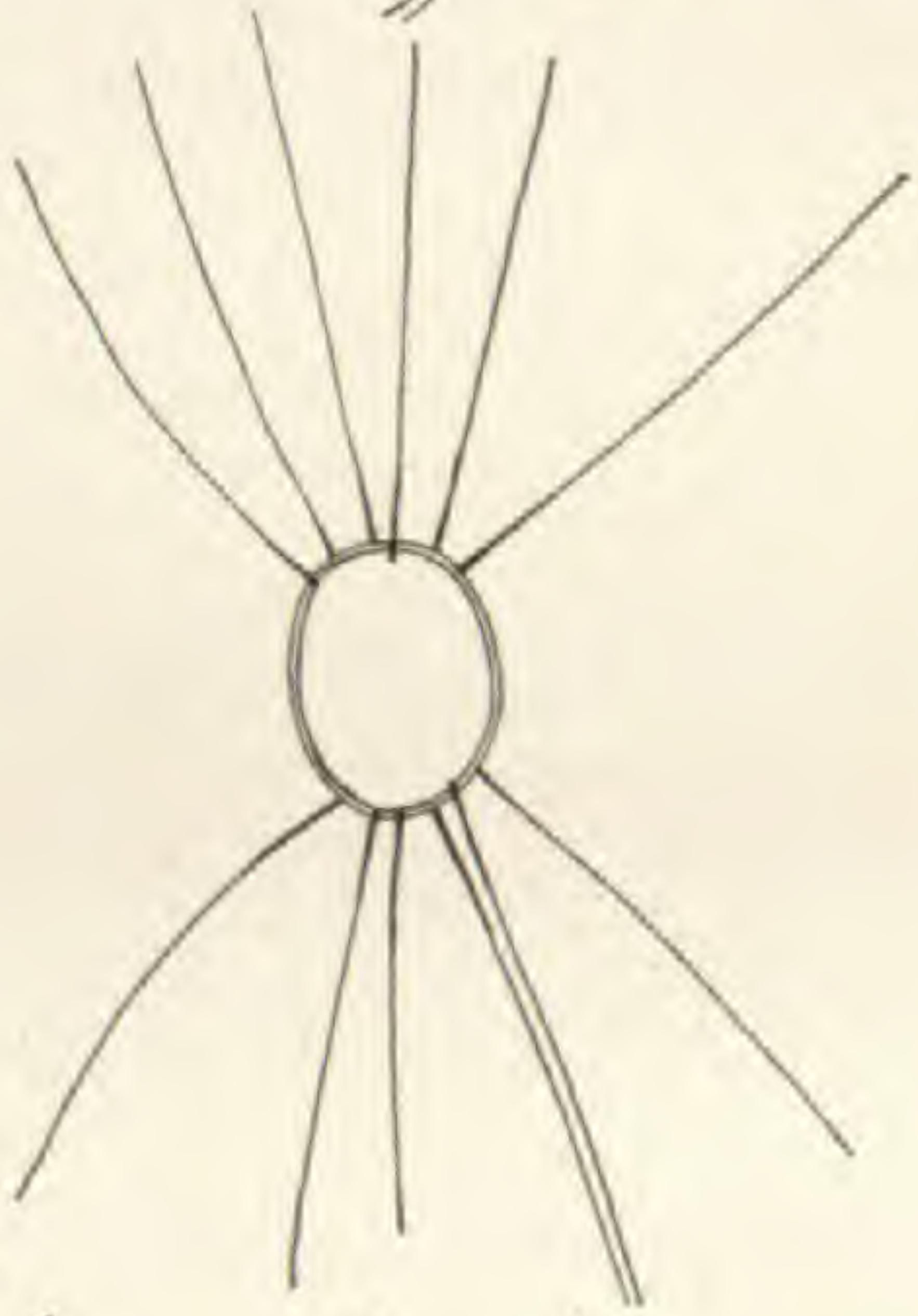
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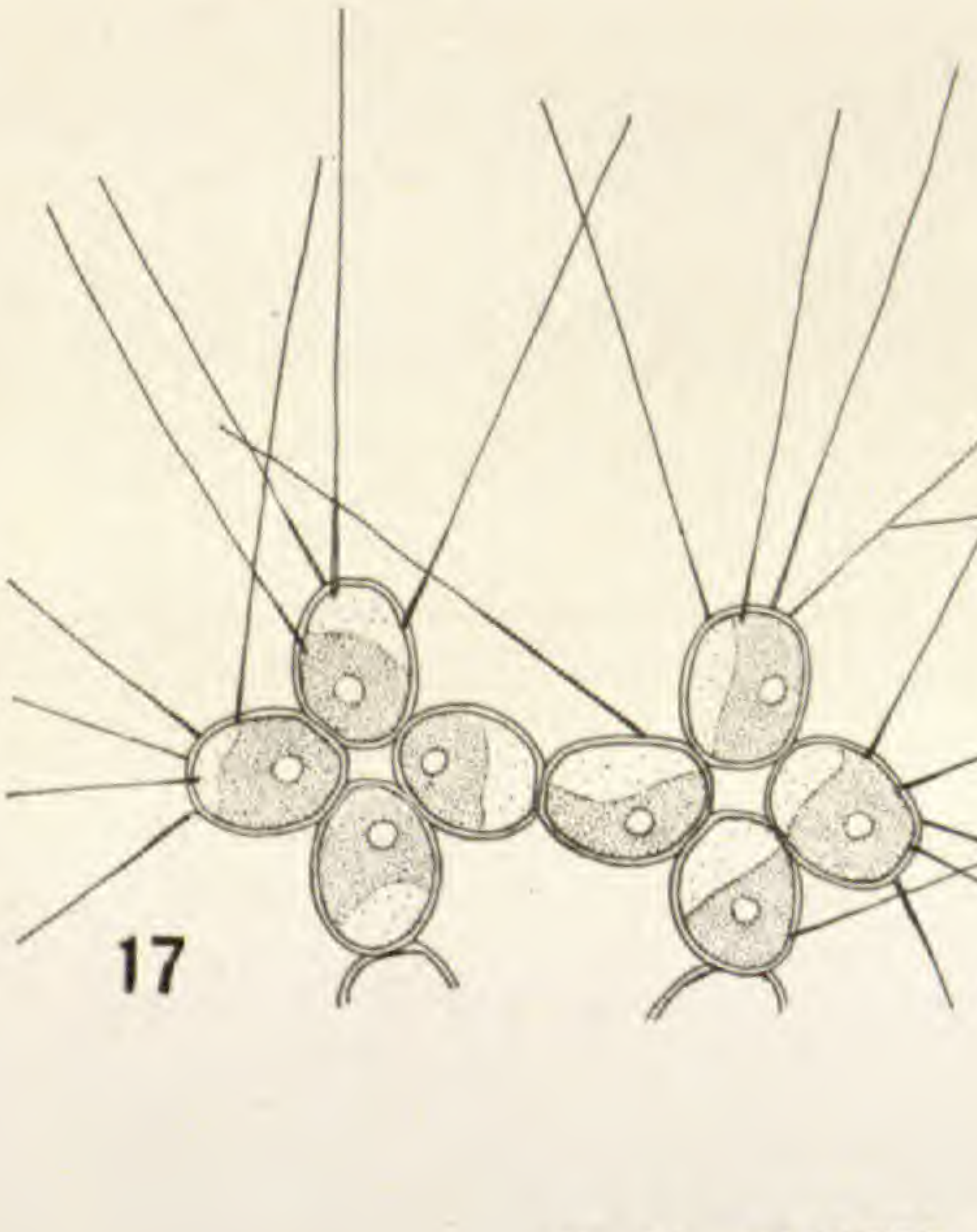
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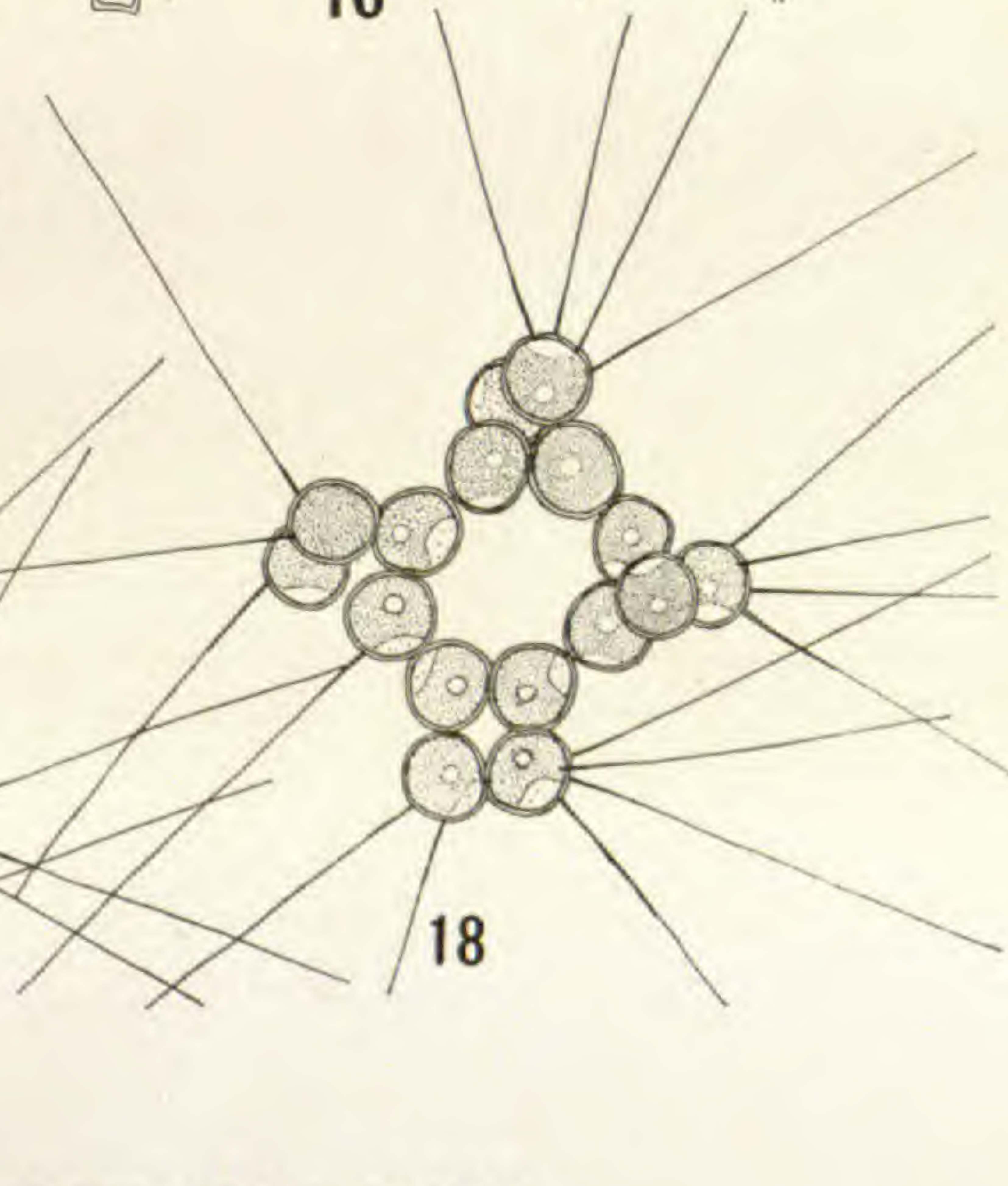
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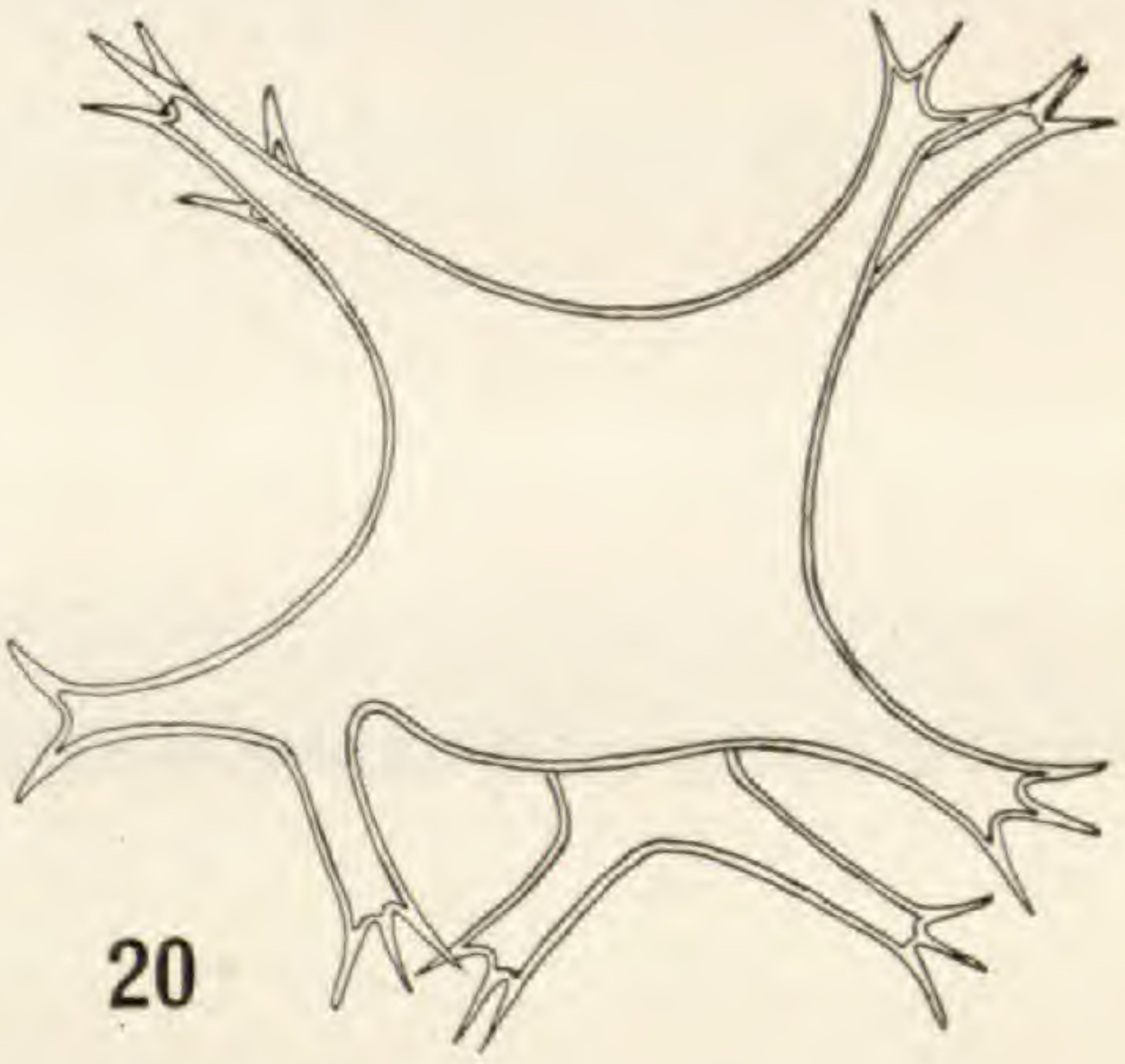
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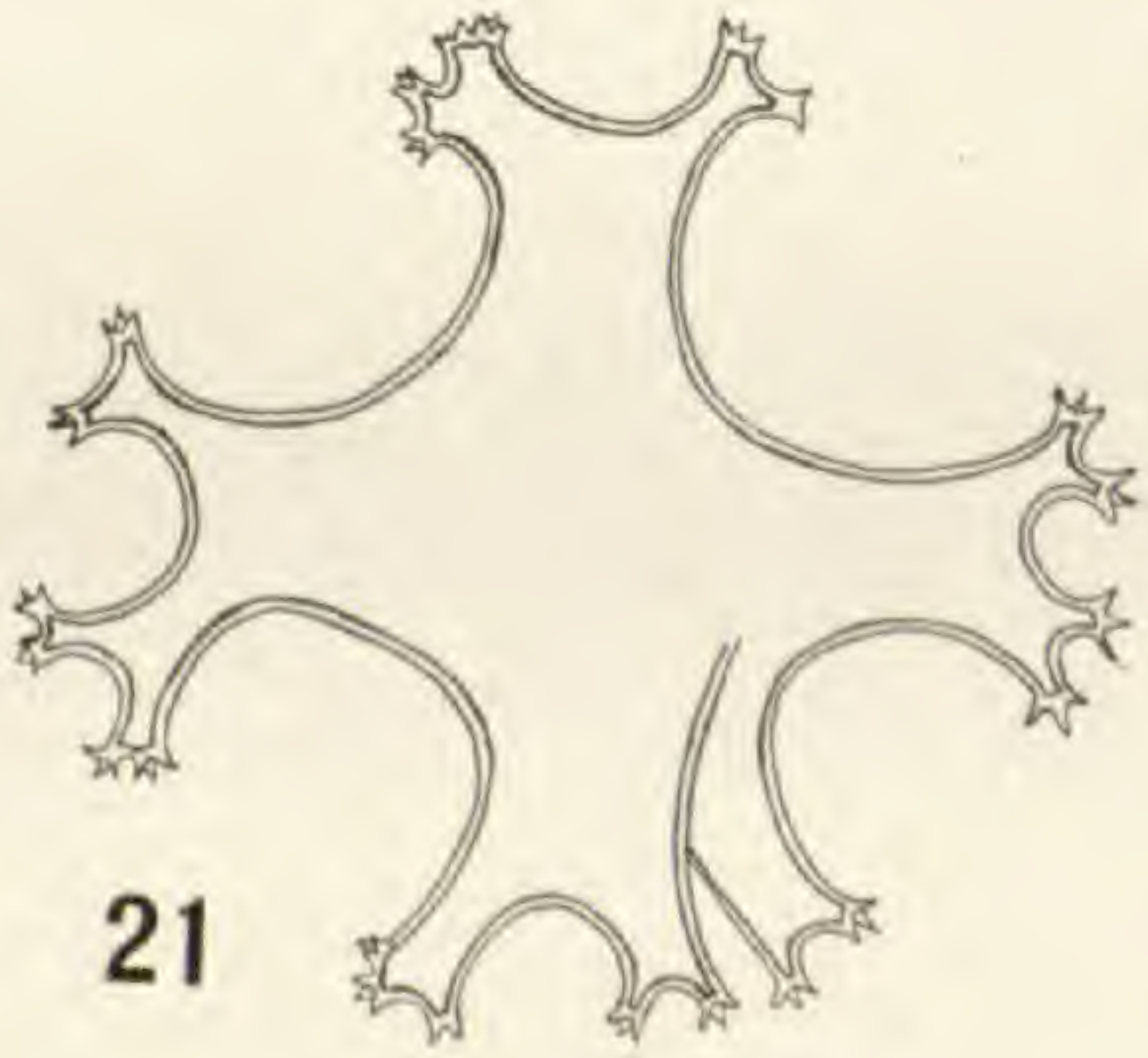
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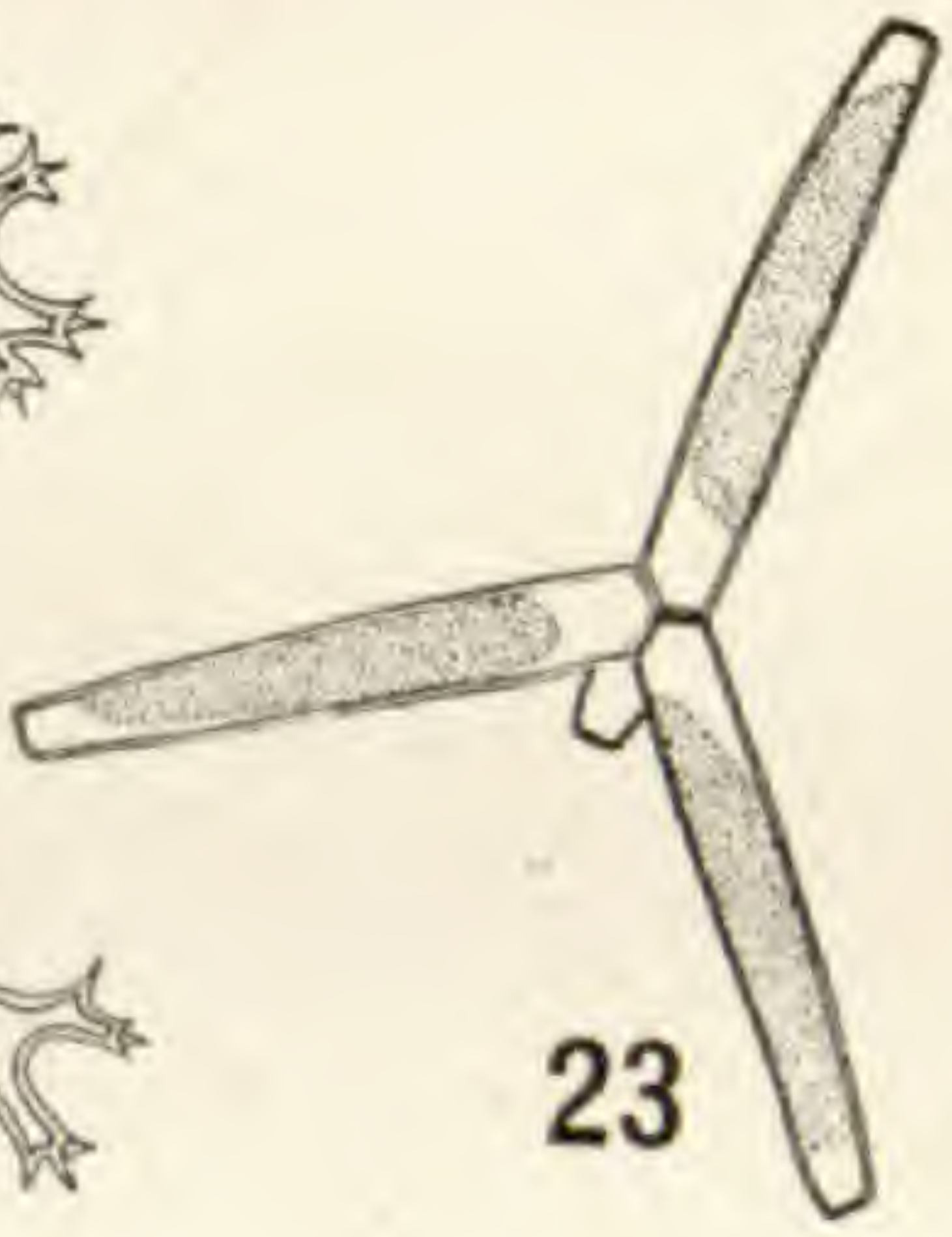
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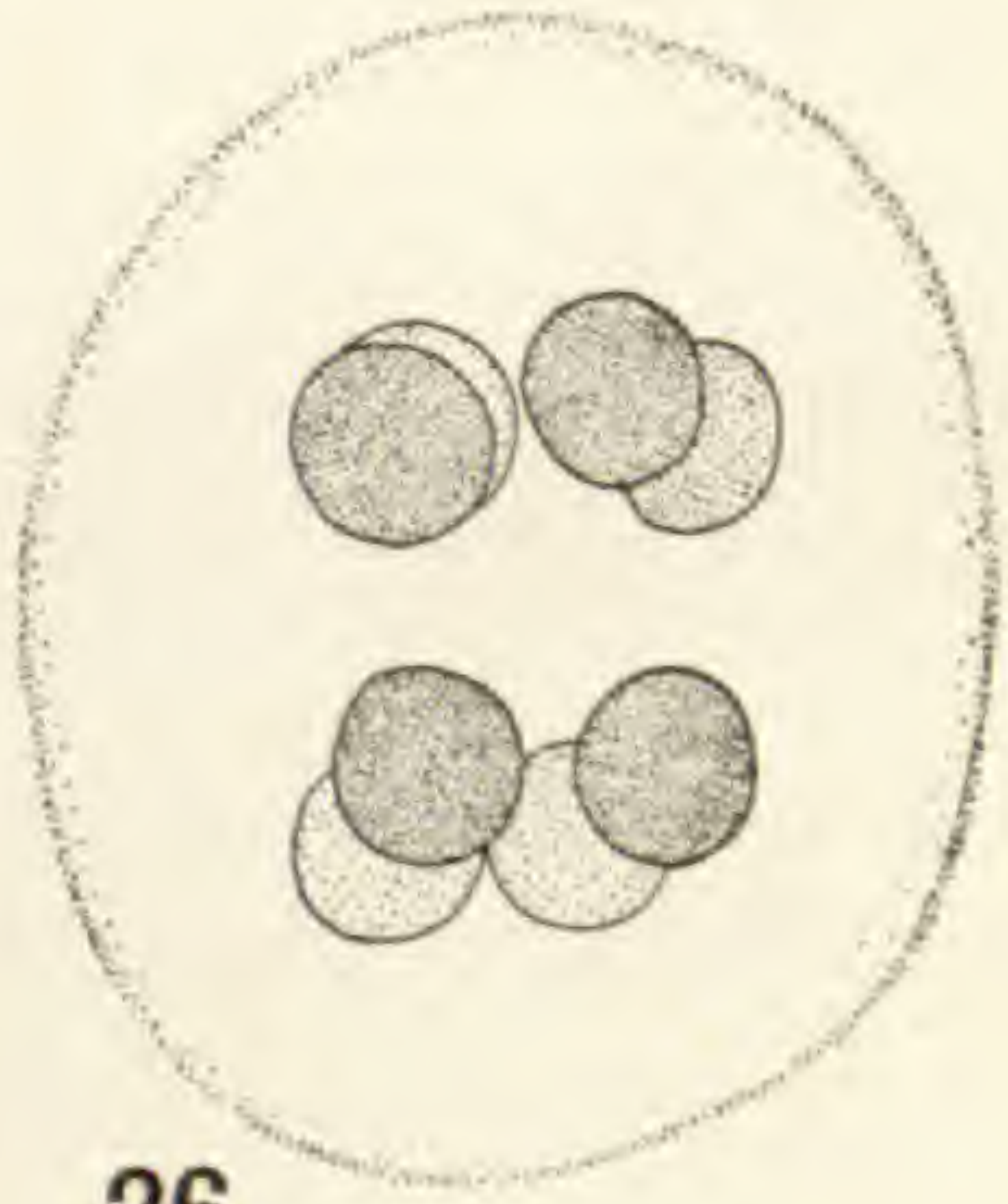
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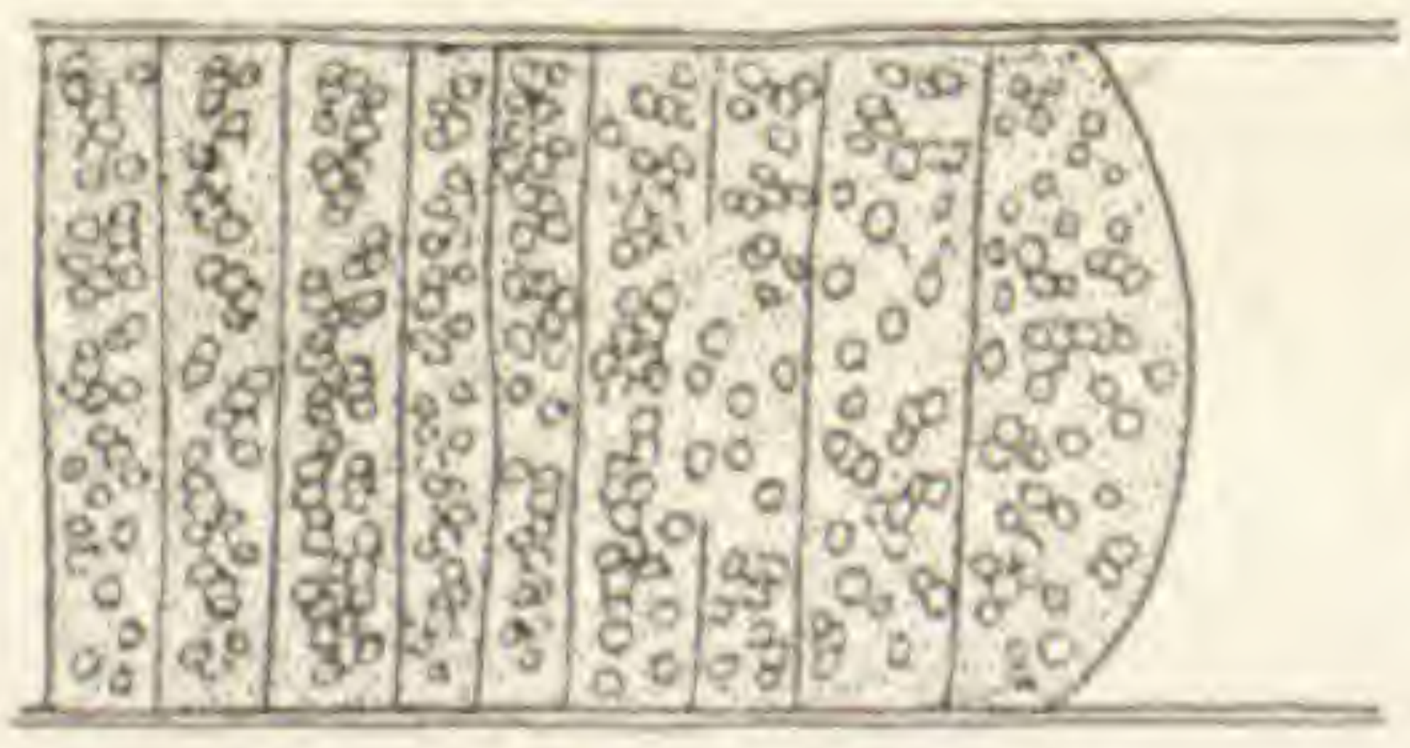
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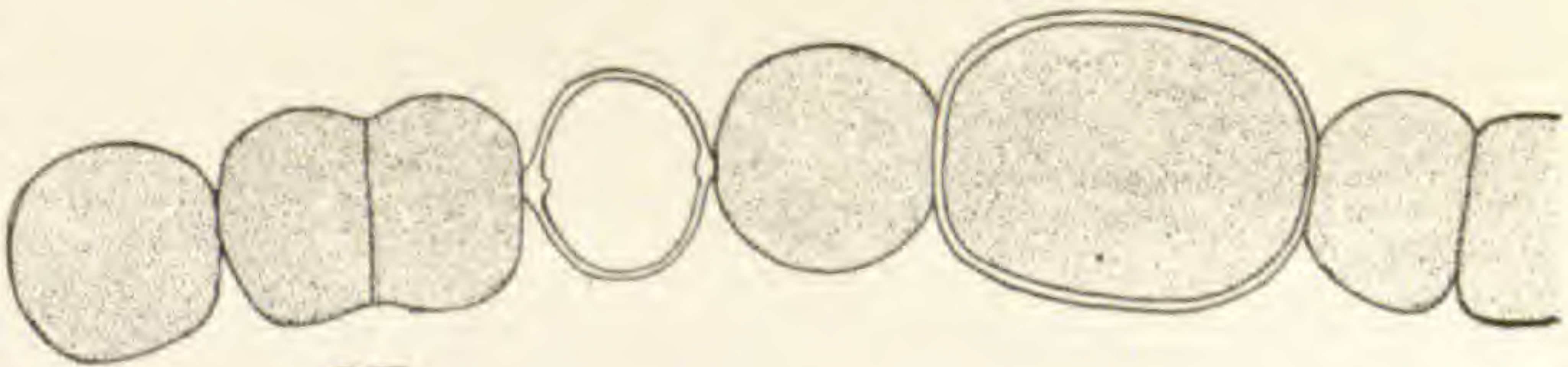
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Fertilization in Fritillaria pudica

KARL SAX

(WITH PLATES 27–29 AND THREE TEXT-FIGURES)

Fertilization in the Angiosperms and especially in the Liliaceae has been the subject of research of many botanists. Yet it is surprising how incomplete and fragmentary is our knowledge of this important and interesting process.

Strasburger (13) in 1884 described fertilization in *Monotropa Hypopitys.* He observed the streaming of the cytoplasm in the embryo sac in the living condition and suggested that the male nucleus was carried to the egg by cytoplasmic streaming.

Guignard (4) in 1891 described fertilization in *Lilium Martagon* and showed a large number of fertilization stages.

In 1897 Mottier (8) first described the vermiform shape of the male nuclei in *Lilium Martagon.*

In 1899 Guignard (5) and Nawaschin (10) published independently their discovery of double fertilization in *Lilium* and *Fritillaria.*

Nawaschin (10, 11, 12) has described fertilization in *Lilium Martagon, Fritillaria tenella, Juglans nigra* and *Helianthus annuus.* In *Lilium Martagon* and *Fritillaria tenella* he describes the vermiform male nuclei and concludes that they are motile. He maintains that the male nuclei are discharged into the space between the egg apparatus and the "Endospermanlage," whence they make their way to the egg and polar nucleus. He believes that the male nuclei must be motile in order to pass from one

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medium to another and to penetrate the membranes of the egg cell and the "Endospermanlage." In one case he finds the male nuclei linked together and attacks Strasburger's (13) theory of cytoplasmic streaming on the ground that streaming could not carry these nuclei in different directions. He also notes that the bodies, the "X-Körper," which accompany the male nuclei in the pollen tube, are not carried with the male nuclei toward the egg or upper polar nucleus. He suggests that in *Helianthus annuus* one synergid penetrates the embryo sac and pours its contents into the micropyle canal and thereby aids in the entrance of the pollen tube. The cases of fertilization found were apparently few.

In 1900 Guignard (6) published his paper on fertilization in the tulip. He describes the male nuclei in the pollen tube as being of curved shape and of almost homogeneous structure. On leaving the tube they are accompanied by a dense granular substance. The pollen tube closes after the male nuclei escape.

Blackman and Welsford (1) in 1913, working on *Lilium Martagon* and *L. auratum*, describe and picture vermiform male nuclei both in the contents of the pollen tube and attached to the egg and polar nuclei. They also mention and show the two dark bodies in the end of the pollen tube. The male nuclei pictured are long vermiform and often pointed at one end, and their contents are arranged in a rather regular network. The authors maintain that the first male nucleus is smaller and suggest that, since the smaller male nucleus is found in contact with the egg, the first male nucleus goes to the egg. They also believe that the male nuclei are motile.

Welsford (14) believes that the "X-Körper" of Nawaschin are the disintegrating cytoplasm which surrounded the male nuclei. Mention is also made that the pollen tube itself enters the embryo sac before the discharge of the contents.

Other writers have published more or less complete descriptions of fertilization in various Angiosperms. But nowhere is there so complete a description of fertilization in the Angiosperms as has been published by Miss Ferguson (2, 3) and others for the Gymnosperms. Miss Ferguson describes a complete series of egg and sperm fusions in *Pinus strobus* and finds the interesting fact that the sexual nuclei do not completely fuse but form independent spindles in close proximity to each other.

The material for the present study was collected near Pullman, Washington, in April and May, 1914 and 1915. *Fritillaria pudica* Spreng. is exceptionally good for the study of the process of fertilization because it seeds so freely. In many ovaries practically every sac contained a stage in fertilization. In several ovaries stages were found from synapsis of the megaspore mother cell to stages in fertilization. In the material cut and stained I have found not less than two thousand cases of double fertilization at various stages.

Strong chrom-acetic acid and Flemming's stronger solution were used as fixatives. Most of the sections were cut 10 μ thick, but a few were cut 15 μ and 20 μ. They were stained with modifications of Flemming's triple stain and with safranin and Lichtgrün. Good results were obtained with all stains used.

Although the development of the ovule has been traced from the stage containing the megaspore mother cell up to the time when the young embryo and endosperm are formed, this paper will deal largely with fertilization. Other processes of interest will be dealt with in a later paper.

The mature embryo sac of *Fritillaria pudica* contains the egg and two synergids at the micropylar end, and one normal antipodal cell and one which is disorganized at the chalazal end. Between these groups of cells is the "Endospermanlage" of Nawaschin, which contains the two polar nuclei, the upper one near the egg apparatus, the lower one near the antipodal end. There are thus usually but seven nuclei in the mature embryo sac. The one nearest the chalazal end is at least partly disorganized. The lowest of the four nuclei resulting from the second division usually fails to divide. The three cells of the egg apparatus are somewhat pear-shaped and arranged symmetrically in the upper end of the sac. They are usually very much alike in size and appearance and it is very doubtful if the egg can be distinguished from the other two cells until the time of fertilization. They are bounded by very delicate membranes, which shows them to be distinct cells. Their cytoplasmic contents are less dense and stain lighter than those of the "Endospermanlage" and antipodal cells. At each end of the "Endospermanlage" is a distinct membrane. At the micropylar end the "Endospermanlage" may project up between or around the cells of the egg apparatus. There is a great deal of variation in this respect, the "Endospermanlage" extending up around the cells of the egg apparatus at different points to varying distances. The upper polar nucleus is smaller and less regular in outline than the lower one. It is always located near the periphery of the sac and surrounded by less cytoplasm. The central portion of the "Endospermanlage" consists of a large vacuole and a thin peripheral layer of cytoplasm. The thickness of this layer is considerably less than the upper polar nucleus (TEXT FIG. 1).

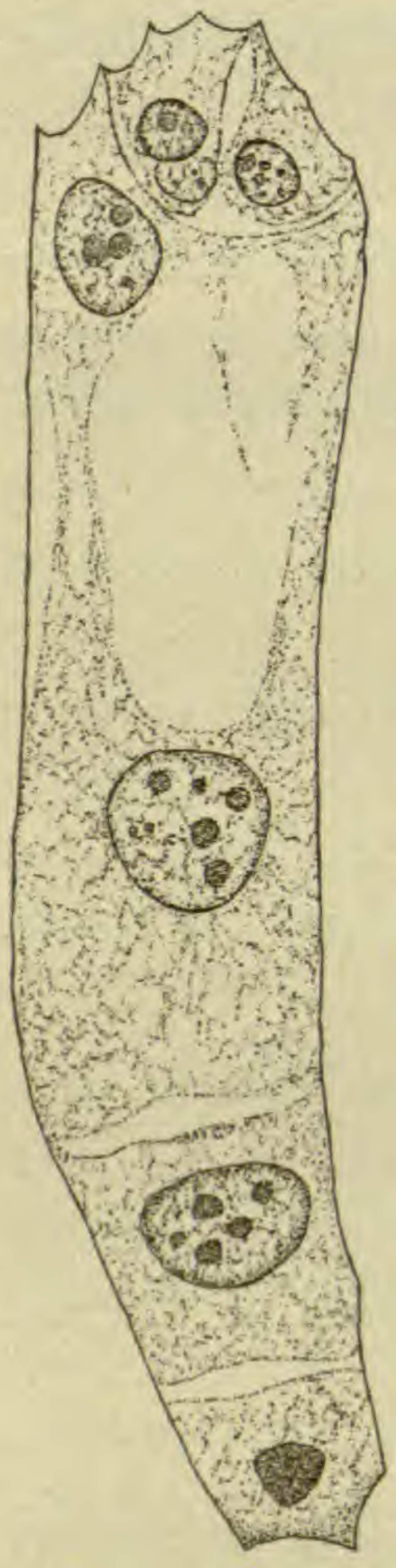

FIG. 1. Mature embryo sac showing: the egg apparatus, one cell of which is only partly visible; the "Endospermanlage" containing the two polar nuclei, the upper one near the egg apparatus; one normal antipodal cell and one which is disorganizing.

Only one case was observed where the tube had reached the embryo sac but had not penetrated it. The tip of the tube was enlarged and rounded and had turned along the nucellus towards one of the nuclei of egg apparatus, probably that of a synergid. In practically all cases one of the synergids is destroyed by the entering pollen tube; but just what the relationship between the synergid and the pollen tube is could not be determined. In one case the cell as well as the nucleus in it, through which the pollen tube is about to enter, has a pointed end towards the end of the pollen tube. But two, or even all of the cells and nuclei of the egg apparatus, may be more or less pointed towards the micropyle. When the pollen tube is in contact with the embryo sac, the cells of the egg apparatus are all intact and show no signs of having emptied their contents into the micropyle, or even of having penetrated the wall of the embryo sac.

In most cases the pollen tube enters the embryo sac somewhat from the side after turning from the micropyle, but sometimes it penetrates the nucellus and embryo sac directly from the micropyle.

The pollen tube just after entering the embryo sac is rounded and swollen at the tip. Only one case was found at this stage but it was well fixed, very clearly stained and apparently normal. The pollen tube and embryo sac are cut longitudinally. The pollen tube contains the two male nuclei. They stain darkly and are much elongated. Two other nuclei are also seen in the sections of the tube. The male nucleus (*a*) nearest the tip shows in FIGS. 3A and 3B. It is long and much coiled and consequently cut across at several places. The second male nucleus (*b*) is seen mostly in FIG. 3C, but the ends of the nucleus are seen in FIG. 3B. This male nucleus is not so long and coiled as the other. The second male nucleus and perhaps the first one are somewhat pointed at the end. The contents at this stage are in an irregular network which takes a deep red stain with saffranin. The chromatin is not entirely peripheral as is shown where the male nuclei are seen in section. To the right in FIG. 3C is a nucleus (*d*) of practically the same size, shape and appearance as the synergid nuclei. The nucleus of the synergid into which the pollen tube has passed, is not found elsewhere in the embryo sac. To the left in FIG. 3C is a second vegetative nucleus (*c*) which is flattened and irregular in shape and situated between the two male nuclei. Portions of these vegetative nuclei are seen in FIG. 3B. FIG. 3A contains some dark-staining granules. The pollen tube did not stain nearly as darkly as others in the same ovary where the male nuclei had already escaped. It is questionable whether both of the vegetative nuclei, (*c*) and (*d*), are tube nuclei, or whether the one to the right (*d*) is the synergid nucleus which has been surrounded by the pollen tube.

The examples of stages in fertilization described so far are comparatively few. But after the male nuclei leave the pollen tube, numerous examples of the stages are found. Not less than eighty male nuclei were found free in the cytoplasm of the cells of the embryo sac, and typical cases of these are figured.

On leaving the pollen tube the male nuclei apparently retain their curved or coiled shape for some time and in many instances it is probable that they never lose their coiled or curved shape during migration. When the male nucleus escapes near the nucleus with which it is about to fuse, which is always true in the case of the egg, it is probable that it seldom loses its coiled shape, although cases were observed where it was practically straightened out. The male nucleus going to the upper polar nucleus is more frequently straightened out than is the case with the one going to the egg nucleus, probably due to the greater distance it has to travel.

A clear example of the male nucleus going to the upper polar nucleus is shown in FIG. 2. The upper polar nucleus is at the right of the "Endospermanlage." The free male nucleus is distinctly pointed at one end and is curved in a manner that gives it the appearance of motility. The end toward the upper polar nucleus is larger, rounded and tapers slightly toward the middle, where it forms a short rounded arch, and then curves to one side and tapers to a point.

FIG. 1 shows almost all of the contents of the upper end of the embryo sac. The pollen tube is seen entering at one side after turning from the micropyle along the outer wall of the nucellus. It contains two red bodies, the "X-Körper" of Nawaschin, in a disorganized condition. The tube is badly ruptured just below the tip. To the right of the pollen tube is the egg nucleus. One male nucleus is just out of the pollen tube and is partly under the egg nucleus. It is curved and is of about the same thickness throughout. At the lower right side of the figure, the upper polar nucleus is seen. Between the egg nucleus and the polar nucleus is a synergid. The long slightly curved male nucleus is seen in the cytoplasm of the "Endospermanlage." It is smaller at the ends but does not have such an appearance of motility as the male nucleus shown in FIG. 2.

FIG. 5 shows a slightly curved male nucleus in the cytoplasm of the "Endospermanlage" almost in contact with the upper polar nucleus. It is slightly curved and tapers back somewhat from the end nearer the polar nucleus. Both ends are rounded. A male nucleus at practically the same stage is shown in FIG. 7. FIG. 6 represents a rather unusual case of this stage. The male nucleus is twisted, and much coiled, and is small at both ends. The end to the left is nearer the polar nucleus and curves beneath the thick central portion.

The contents of all of the male nuclei which are free in the cytoplasm of the cells of the embryo sac show great similarity. A typical, very distinct example is shown in FIG. 7. The chromatin contents are in an irregular network. Usually somewhat larger chromatin granules are present in the network in the central portion of the male nucleus (FIGS. 1, 6, 7). There are apparently no nucleoli to be seen at this stage. The male nuclei stain darker than other nuclei of the sac with the stains used.

After the male nuclei are discharged, there are usually two dark staining bodies to be seen in the end of the pollen tube. These bodies, the "X-Körper" of Nawaschin, often show structure and appear to be more or less disorganized nuclei, but in some instances one or both are entirely lacking in structure. They are of various shapes. Usually, however, one is nearly spherical while the other is larger, ovoid, and often pointed at one end (FIG. 9). In this figure the bodies also show definite nuclear structure. They persist throughout all stages of fertilization and even in young embryo development. That these bodies are nuclei can hardly be questioned. They are probably the two vegetative nuclei corresponding to the vegetative nuclei, (*c*) and (*d*), in FIGS. 3B and 3C.

The male nucleus, when in contact with the egg nucleus, is usually coiled or curved. In some few cases, however, the male nucleus is straightened out when it first comes in contact with the egg nucleus. FIG. 4 shows a long tapering male nucleus with the large end touching the egg nucleus. FIG. 8 shows a male nucleus with the large end in contact with the egg nucleus. Many cases of these examples have been observed and usually the male nucleus is larger at the point of contact with the egg.

Whether the male nucleus reaches the egg nucleus while straightened out or coiled, sooner or later it becomes more or less curved around one side of the egg nucleus. FIGS. 10, 11, 12 and 13 show the male nucleus partly curved around the egg nucleus. In FIG. 13, the side of the egg nucleus is somewhat indented where the male nucleus is in contact. This is not uncommon.

The male nuclei finally lose their long curved shape. They contract somewhat, becoming shorter and more rounded in contact with the egg. In some cases the male nucleus seems to occupy an indentation in the egg (FIG. 15), while in other cases the two sexual nuclei are flattened at the point of contact (FIGS. 16, 17). The male nucleus, on losing its vermiform shape, also loses the fine irregular network of its chromatin contents, characteristic of earlier stages. FIG. 14 shows this condition. The male nucleus has contracted somewhat and its contents consist of large and small granules with some of its earlier net-like structure. The egg nucleus is slightly indented. The chromatin granules of the male nucleus become coarser with finer threads running out from them. Many small pieces of chromatin are also to be seen. A little later in some cases nucleoli appear to be present. FIG. 15 shows the male nucleus after it has lost most of its earlier structure, in an indentation in the egg nucleus. FIG. 16 shows a little later stage than FIG. 15, but with the male and female nuclei flattened at the point of contact. In both cases, the male nucleus stains a little darker. The egg nucleus has very large chromatin granules. In FIG. 16, the male nucleus has very small pieces of chromatin along their common boundary. The male and egg nuclei remain in contact a long while before their common boundary finally disappears and their contents mingle. FIG. 17 shows the male and egg nucleus in contact, each containing a large mass of chromatin and small nucleoli. In FIG. 18 the fusion is almost complete. Most of the contents of the male nucleus are in a thread-like structure. Some of the contents of the egg nucleus are thread-like, but a large part are massed in the center of the nucleus. A large nucleolus is present. The thread-like structure appears to run from one nucleus into the other. In both FIGS. 17 and 18, the male nucleus is smaller than the egg nucleus. FIG. 19 shows a stage where the common boundary has disappeared, the contents have apparently mingled, and those from the male and female nuclei are not to be distinguished, but there is still an indication of the outlines of the two nuclei. A similar stage is shown in FIG. 20. In this case the chromatin contents of the fused nuclei are more irregular.

In most cases it is not until the male nucleus and the egg nucleus have completely fused that we find any appearance of the formation of the spireme. In rare cases, however, the spireme stage is found while the two nuclei are still distinct in outline. A very clear example of this condition is shown in FIG. 21. The spireme thread is rather thick in both nuclei and small nucleoli are still present. It is possible that the nuclear walls have broken down at the point of contact but the nuclei appear to be quite distinct.

Soon after the complete fusion of the egg and the male nucleus, the resulting nucleus becomes more nearly spherical in shape. A spireme is formed. FIG. 22 shows the pear-shaped egg cell with the early spireme of the fertilized egg. The chromatin of the male and female nuclei cannot be distinguished. Delicate threads can be seen at places along the spireme. The thread shortens and thickens until it appears as shown in FIG. 23. Here the spireme is in a late stage—just before the chromosomes are formed. The division of the fertilized egg is normal as is shown in FIGS. 24 and 25. The spindle shows plainly in most cases (FIG. 24), but sometimes it stains lightly (FIG. 25). The figures do not show the entire dividing nuclei but are drawn from sections of the same.

FIG. 25 represents a condition of the egg cell which is characteristic for this and later stages as well as many earlier stages. The egg cell elongates after fertilization. A large vacuole usually forms in the upper part. The fusing sexual nuclei before and after fusion are located in the lower part—lying in a dense cytoplasm. A longitudinal section of the cell shows a more or less crescent-shaped mass of dense cytoplasm, which is well shown in FIGS. 19 and 25.

The two-nucleate embryo is shown in FIG. 26. After division, a definite wall is formed, making two cells, which also appear somewhat crescent-shaped in section. The nuclei are flattened, the short diameter corresponding to that of the cells.

The fusion of the second male nucleus and the two polar nuclei has also been studied. The male nucleus first comes in contact with the upper polar nucleus and together these nuclei migrate to the lower polar nucleus. When the male nucleus comes in contact with the upper polar nucleus, it is usually more or less straightened out. FIG. 27 shows the male nucleus curved along one side of the upper polar nucleus. Several cases were observed where the male nucleus had both ends in contact with the upper polar nucleus (FIG. 29). Sometimes the male nucleus appears to have come in contact with the upper polar nucleus while still coiled. The male nucleus soon shortens and thickens along one side of the polar nucleus (FIG. 28). The contents of the male nucleus are denser and in larger pieces. The polar nucleus is not indented as is often the case of the egg, but often becomes flattened at the point of contact.

The contraction and loss of the vermiform shape of the male nucleus usually occurs before the two nuclei migrate to the lower polar nucleus. The male nucleus may, however, retain its vermiform shape during the time of its migration with the upper polar nucleus, or even after the two nuclei have reached the lower polar nucleus. TEXT FIG. 2 shows a longitudinal section of the entire embryo sac with the egg and one of the male nuclei in contact, a synergid, the upper polar nucleus and the second male nucleus in contact, beginning their migration towards the lower polar nucleus, and the antipodal nuclei. The male nucleus in contact with the upper polar nucleus has lost its vermiform shape. The cytoplasm of the upper part of the "Endospermanlage" is massed mostly along one side of the sac and especially around the two migrating nuclei. The strands of cytoplasm and the massing of the contents largely along the one side of the "Endospermanlage" at the upper end is very characteristic.

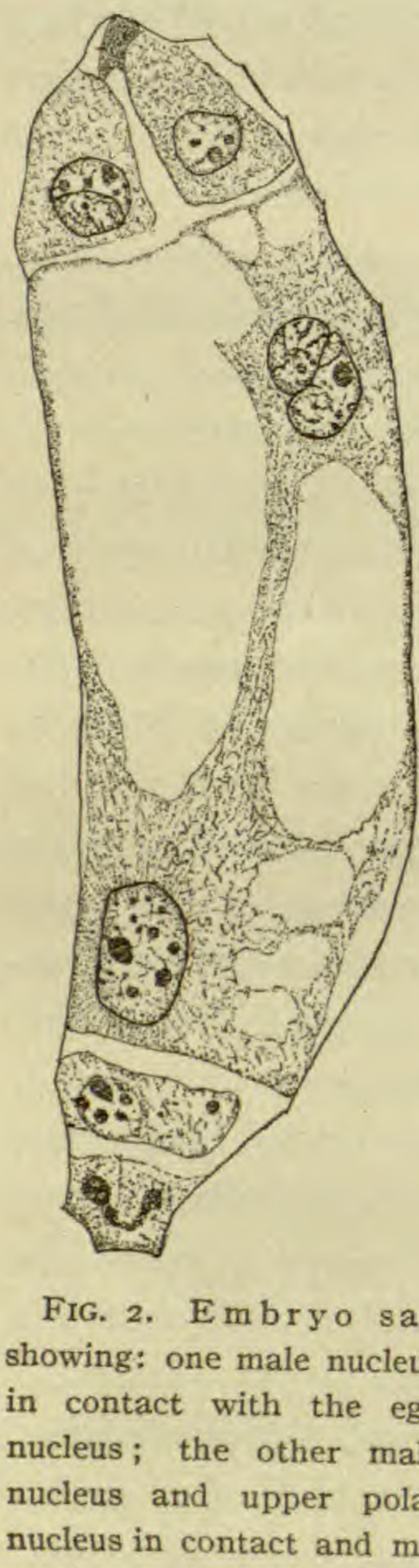

FIG. 2. Embryo sac showing: one male nucleus in contact with the egg nucleus; the other male nucleus and upper polar nucleus in contact and migrating toward the lower polar nucleus.

FIG. 31 shows the migrating nuclei almost in contact with the lower polar nucleus. The male nucleus is on the side nearest the lower polar nucleus and has retained its net-like structure.

Both polar nuclei appear to be in a resting condition. The male nucleus may be attached on any side of the upper polar nucleus.

The cases of migration of the upper polar nucleus together with the male nucleus were not found frequently, only forty-seven cases being found in the great number of fertilization stages. However, the cases of triple fusion of the polar nuclei and male nucleus were very abundant.

TEXT FIG. 3 shows the embryo sac in longitudinal section with a synergid, the egg and male nucleus in contact, and the two polar nuclei and second male nucleus in contact. The male nucleus stains darker and is between the polar nuclei. It will be noted that there is very little cytoplasm in the upper end of the "Endospermanlage" at this time, which is very characteristic. It might appear, on comparing TEXT FIGS. 2 and 3, that the lower polar nucleus migrates also to meet the two approaching nuclei, but if there is a migration of the lower polar nucleus, it is slight, as has been observed in numerous examples, and it is accidental that the two sacs drawn should differ so markedly in this respect.

FIG. 3. Embryo sac showing: the remaining synergid; one of the male nuclei coiled and in contact with the egg nucleus; the other male nucleus and upper polar nucleus just reaching the lower polar nucleus.

FIGS. 33 and 34 show triple fusion. In FIG. 34, the male nucleus is at the side, while in FIG. 33, it is between the two polar nuclei. At this stage the chromatin of the male nucleus has lost some of its net-like structure and contains large pieces of chromatin with delicate threads, and in some cases, nucleoli. FIG. 32 shows a case where the two polar nuclei and male nucleus are in contact, but the latter is still vermiform and its contents are in a net-like structure.

The polar nuclei remain in contact without fusing for considerable time. At the time of fusion the chromatin contents are partly thread-like with large irregular pieces of chromatin scattered throughout. FIGS. 35, 36 and 37 show the three nuclei completely fused. In FIG. 37, the outlines of the three nuclei can be seen but their common membranes have disappeared. A fine network is to be noted in the central part of the fused nuclei.

Many cases of complete fusion were observed. There is no question but that the two polar nuclei and the male nucleus completely fuse and that no chromatin is thrown out in the process.

The duration of the spireme must be very short, as only a few very clear spireme stages of the triple fusion, or endosperm nucleus, were found. A clear example of a late spireme stage is shown in FIG. 38. There is an irregular nucleolar mass to the left. At this stage the thread is thickened and apparently approximately equally distributed throughout the nuclear cavity. The thread is just beginning to form chromosomes. The nuclear membrane has disappeared and delicate strands of cytoplasm are in contact with the forming chromosomes.

The cases of first division of the endosperm nucleus were abundant and in every case appeared to be normal, apparently an equal number of chromosomes going to each pole. FIG. 39 shows a very clear anaphase of the first division of the endosperm nucleus. The spindle is very clear in this and most other cases. The spindle is pointed at both ends. The first division of the endosperm nucleus results in the formation of two free nuclei. These divide rapidly and often the four or six nucleate endosperm is formed before the egg and male nuclei are completely fused.

Aberrant fertilizations are occasionally encountered. In three cases both the egg and the remaining synergid were being fertilized. The male nuclei were still distinct. In two of these cases the upper polar nucleus was in its usual position near the egg apparatus, but unfertilized. In the third case the upper polar nucleus had almost reached the lower polar nucleus, having migrated alone.

Two cases were observed where two pollen tubes had entered the ovule, one coming down the micropyle, the other entering the ovule at about the level of the egg apparatus. Only the pollen tube coming down the micropyle had entered the embryo sac.

Besides the fertilization of the egg and polar nucleus there are other processes of interest. Many cases were observed where the contents of the nucleus of the remaining synergid were in the spireme stage. Other stages in the division of the synergid as well as the two-celled stage were observed. No stage of development beyond the two-celled stage was observed.

Several stages were found where the normal antipodal nucleus was dividing. It will be interesting to follow the development of the dividing synergid and the antipodal nucleus through later stages of embryo and endosperm development.

It was noted that the embryo sac becomes longer and curved as it develops. In some stages of early embryo development, it is bent at almost right angles.

DISCUSSION

The cases of the entrance of the pollen tube into the embryo sac, although few, throw some light on problems relating to this process. There is no evidence in *Fritillaria pudica* to show that the synergid empties its contents into the micropyle in order to aid in the entrance of the pollen tube, as has been suggested by several writers. The fact that all the cells of the egg apparatus are intact at the time the tip of the pollen tube is in contact with the wall of the embryo sac excludes such possibilities in *Fritillaria pudica.*

The pollen tube turns along the nucellus and apparently is attracted as close as possible to the nucleus of a synergid before entering. One synergid is practically always destroyed by the entering pollen tube. The suggestion lies close at hand that the synergid is a factor in attracting the pollen tube. The suggestion that the synergid, or parts of it, are used as food by the pollen tube, seems quite tenable.

It is practically certain that in *Fritillaria pudica* the "X-Körper" of Nawaschin are more or less disorganized nuclei. They may be two tube nuclei, but whether there are two tube nuclei formed here has not been determined. Or one of the red bodies may be the disintegrating nucleus of the synergid through which the pollen tube has passed. At all events it is clear that the "X-Körper" of Nawaschin are more or less disorganized nuclei, and not disintegrating masses of cytoplasm from which the male nuclei have escaped, as Welsford (14) has maintained is the case in *Lilium.*

The male nuclei while free in the cytoplasm of the cells of the embryo sac usually do not have the appearance of motility (FIGS. 1, 5, 7). However, the vermiform appearance of some of the male nuclei while free in the cytoplasm and in contact with the female nuclei, is certainly suggestive of motility (FIGS. 1, 2, 6, 11, 13, 27, 30). It has been noted that the male nuclei, while in the pollen tube, are more or less coiled. Yet when seen part way to the nuclei with which they fuse, especially when the distances are long, the male nuclei are quite straight. The uncoiling is also slightly suggestive of motility. The male nuclei in contact with the egg and polar nuclei are seen to curve around the latter, which suggests independent motility and movement on the part of the male nuclei. The large number of stages found at this time as well as the appearance of the male nuclei, suggests that their movement may be rather slow, perhaps a creeping amoeboid motion. It might be suggested that it is possible that the male nuclei may be conveyed to the nuclei with which they fuse, both by their own motility and by the streaming of the cytoplasm.

It is quite certain that the upper polar nucleus and male nucleus in contact, migrate to the lower polar nucleus by cytoplasmic streaming. In most cases the male nucleus has lost its vermiform appearance before migration. Moreover, it is found in contact at any side of the upper polar nucleus. The accumulation of cytoplasm around the migrating nuclei and the small amount left in the upper portion of the "Endospermanlage" at the time of triple fusion, is evidence that the two nuclei are very probably carried by cytoplasmic streaming (TEXT FIGS. 2, 3).

It has been suggested that the rapidity of movement of the male nuclei is evidence of their motility. Yet the migration of the upper polar nucleus with the male nucleus, which appears to be brought about by streaming, even though the latter have further to go, is observed quite as rarely as free male nuclei.

The abundance of material showing the various stages leading to the complete fusion of the male and female nuclei, as well as the numerous examples of complete fusion and subsequent stages in the division of the fertilized egg, leaves no doubt that at least in *Fritillaria pudica* the complete union of the male and female nuclei actually occurs. The rare appearance of such cases as that of the spireme stage in the egg and male nuclei when their outlines are still distinct, is probably of little significance in this respect. It is probable that these nuclei subsequently fuse completely because no later stages of incomplete fusion were found. If the adjacent walls of these two nuclei are not broken down, it would suggest that the fusion of the two sexual nuclei is not necessary to stimulate the formation of the early stages in division. This suggestion is supported by cases found in the Gymnosperms by Miss Ferguson and others.

From the many stages and abundant cases of triple fusion, there is no doubt that the two polar nuclei and the male nucleus fuse completely and that the subsequent division is normal. In this fusion there are at least twice as many female as male chromosomes. If this phenomenon of a normal triple fusion holds true for plants whose hybrids show a Mendelian ratio in endosperm characters, then an interesting question arises as to the distribution of the characters among the chromosomes.

SUMMARY

The results obtained from the study of fertilization in *Fritillaria pudica* may be summarized as follows:

1. In the mature embryo sac of *Fritillaria pudica* the egg cell cannot be distinguished from the other two cells of the egg apparatus. The "Endospermanlage" extends up between and around the cells of the egg apparatus.

2. The pollen tube usually turns along the outer wall of the nucellus or embryo sac before entering. At this time the cells of the egg apparatus are all intact.

3. The pollen tube practically always enters and at least partly destroys one synergid.

4. Although a distinct appearance of motility is evident in many male nuclei, the majority do not suggest much motility.

5. The male nucleus and the egg nucleus fuse completely before division.

6. The upper polar nucleus, with the male nucleus in contact

with it, migrates to the lower one, probably by cytoplasmic streaming.

7. The two polar nuclei and male nucleus fuse completely and the subsequent division is normal.

8. The two red bodies, the "X-Körper" of Nawaschin, which remain in the pollen tube after the male nuclei have been discharged, are very probably nuclei. They probably correspond to the two vegetative nuclei described in the pollen tube before the two male nuclei were discharged.

In conclusion I wish to acknowledge my indebtedness to Dr. C. E. Allen for literature, to Dr. F. L. Pickett for extending the privileges of his laboratory, and especially am I indebted to my wife, Dr. Hally Jolivette Sax, for her constant encouragement and assistance throughout the work.

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Explanation of plates 27–29

All drawings were made with the aid of the camera lucida. All figures were drawn from single sections. The magnification is as follows: FIG. 8, 520 diameters; FIGS. 1, 30–39, 720 diameters; FIG. 2, 750 diameters; FIGS. 3–7, 9, 10–29, 1,120 diameters.

PLATE 27

FIG. 1. Micropylar end of the embryo sac in section, showing entrance of pollen tube, with disorganized red bodies—a portion of one synergid—one male nucleus coming in contact with the egg nucleus on the under side, and the second male nucleus in the cytoplasm of the "Endospermanlage" on its way to the upper polar nucleus.

FIG. 2. Section of upper part of embryo sac showing one of the male nuclei on way to polar nucleus.

FIGS. 3*A*, 3*B*, 3*C*. Consecutive longitudinal sections of a pollen tube after entering the embryo sac. The two male nuclei, (*a*) and (*b*), stain darker than the vegetative nuclei. Two vegetative nuclei are shown, (*c*) and (*d*).

FIG. 4. Male nucleus coming in contact with the egg nucleus.

FIG. 5. Male nucleus almost to upper polar nucleus.

FIG. 6. Male nucleus coiled and twisted, on way to upper polar nucleus.

FIG. 7. Male nucleus on way to upper polar nucleus.

FIG. 8. Male nucleus touching the egg nucleus.

FIG. 9. Pollen tube containing the two dark bodies which show nuclear structure.

FIG. 10. Male nucleus coiled and in contact with the egg nucleus.

FIG. 11. Male nucleus in contact with egg nucleus.

PLATE 28

FIGS. 12, 13. Male nucleus in contact with egg nucleus.

FIG. 14. A later stage. The male nucleus has lost its vermiform shape and its earlier net-like structure.

FIG. 15. Male nucleus in indentation of egg nucleus.

FIGS. 16, 17, 18. Male nucleus and egg nucleus fusing.

FIG. 19. Egg cell with male nucleus and egg nucleus completely fused.

FIG. 20. Complete fusion of egg and male nucleus.

FIG. 21. Case of formation of spireme before complete fusion.

FIG. 22. Egg cell containing the fertilized egg in early spireme.

FIG. 23. Egg cell containing the fertilized egg in late spireme.

FIG. 24. Equatorial plate stage in first division of fertilized egg.

FIG. 25. Typical crescent-shaped section of the equatorial plate stage of dividing fertilized egg cell.

FIG. 26. Two-nucleate stage of embryo.

PLATE 29

FIG. 27. Male nucleus in contact with upper polar nucleus.

FIG. 28. A slightly later stage than Fig. 27.

FIG. 29. Male nucleus with both ends in contact with upper polar nucleus.

FIG. 30. Male nucleus in contact with upper polar nucleus while on way to lower polar nucleus.

FIG. 31. Male nucleus and upper polar nucleus almost touching the lower polar nucleus.

FIG. 32. Two polar nuclei and coiled male nucleus in contact.

FIG. 33. Triple fusion. Male nucleus between the polar nuclei.

FIG. 34. Later stage of triple fusion with male nucleus on the side.

FIGS. 35, 36, 37. Endosperm nucleus resulting from the complete fusion of male nucleus and polar nuclei.

FIG. 38. Late spireme stage of endosperm nucleus.

FIG. 39. Early anaphase of first division of endosperm nucleus.

Additional species of Opuntia

David Griffiths

(WITH PLATE 30)

Plants of the following species have been growing in our collections for the past five to eight years. Some of them have been held under provisional names for a long time in the hope that they might eventually be referred to species already described. They can not, however, be so referred and must receive new names.

Opuntia columbiana sp. nov.

A low, half prostrate species, seldom over 15 cm. high; the distal joints mostly erect, the ones on the ground rooting freely; joints narrowly obovate, about 5 × 15 cm. in last year's growth, at first yellowish to medium light green but the second year becoming decidedly yellowish green, slightly raised at areoles, fragile, and easily broken, making it very difficult to grow plants to maturity; areoles subcircular to obovate, 2 mm. long, enlarging in age and prominent, 2 mm. high on account of the profuse development of wool, light brown; spicules yellow at first, in a compact tuft 1 to 1.5 mm. long in upper part of areole, later, especially the second year, becoming unequal and scattering, and 5 mm. or more in length; spines yellowish to white, centrals one to three with one long, porrect or sloping down 3–4 cm. long and the other one or two 2 cm. long and widely spreading, and commonly three or four about 1 cm. long in the lower angle of the areole tightly recurved, often there are two or three porrect-spreading, long spines, and the others (three short and about two 2 cm. in length) all tightly recurved; flowers light yellow, filaments reddish brown, style white, stigma light green.

This species is apparently confined to the sandy lands along the Columbia and Snake River valleys, and is particularly abundant near Pasco, Washington. The above description applies to my inventory No. 10041, from Pasco, Washington, but the spines vary greatly in color, and associated with this difference in color of the spines is a comparable difference in coloration of the plant body. Specimens collected under my inventory No. 10042 have darker colored spines; the joints commonly about 4 × 9 cm. and the spines in part brown, especially on apex of joints.

Opuntia cucumiformis sp. nov.

A low, branched, cylindrical-oval-jointed plant, 18 cm. high and 35–50 cm. in diameter; at first yellowish green, turning gray; joints 10 cm. long, 3.5 cm. in diameter, broadly pointed to rounded above, cylindrical, tubercular, raised at areoles, the low, rounded ridge extending downward 1.5–2 cm.; areoles obovate, 2.5 mm. long, gray, rather sunken, 1.5–2 cm. apart, only upper ones armed; leaves conical, ascending, 5 mm. long, slightly flattened on inside; spicules yellowish, at first not visible but at one year of age filling entire areole, which becomes subcircular, the spicules developing in successive lengthening zones from center of pulvinus; spines yellowish, translucent, bone-like, 1–2.5 cm. long, porrect, diverging but slightly, one to five in upper areoles only, not sheathed; flowers deep yellow, lighter within, having faint tinge of red in upper edges, about two rows of petals opening to 4 cm. in diameter; filaments white, style white, stigma white, variable, six-parted, small; bud distinctly reddish tinged at apex which is bluntly pointed and subtended by spicules, 3–5 mm. long, from the marginal areoles of the ovary; fruit oval to obovate, about 16 by 38 mm., deeply pitted at apex with small cavity about 4 by 8 mm. containing numerous small, atrophied ovules, its areoles small and distant below but closer above, bearing around top of ovary one or two yellowish spines 12–15 mm. long, and a small tuft of spicules 4–5 mm. long.

This species has been received from European collections as *Opuntia ciribe* Engelm., a native of the peninsula of Lower California, but it has little relation to that species and in all probability is native to the Cordillera region of South America. Several plants of it have been grown to maturity, but in no case have the fruits, which are produced in considerable abundance, matured seeds. The pulp cavity is always empty and the fruit remains attached to the plants indefinitely.

Opuntia calantha sp. nov.

A low, creeping, prostrate species, 15 cm. high and a meter in spread; joints obovate, sub-pointed above and below, inequilateral, about 4 × 11 cm., tuberculate-wrinkled, mostly deep green; areole small, 1–1.5 mm. long, obovate, at first tawny, turning gray; leaves small, subulate, cuspidate, red, 1 mm. long;

spicules yellow, not prominent at first but later 3–4 mm. long and scarcely distinguishable from the spines, from which they differ only in size and position, and very slightly in color; spines white, short, porrect-divergent, five to ten in number, 5 mm. or less in length with often as many spicules a trifle less divergent in upper portion of areole; flowers carmine, filaments carmine, stigma very deep, dark green, thirteen-parted, with short segments and open throat; fruit, with us, greenish to yellowish, hemispherical, deeply pitted, 1.5 cm. in diameter.

This species is more or less common in European collections, and is probably of South American origin. It is commonly received as *Opuntia microdisca* A. Weber, but differs from that species in almost every diagnostic character. We have had plants of it in blossom for three or four years but in no case have fertile fruits been produced, although hand-pollination has been resorted to and natural pollination by insects has been universal. The reason for this sterility is not apparent, but it may be due to our intense heat and drought during the time that the flowers are open.

Opuntia longiclada sp. nov.

An erect, open-branched shrub a meter or more high and having a spread of 2 m.; joints elliptical, widest slightly below middle and gradually narrowed both ways, pointed above and below, commonly 12 × 36 cm., this season's growth now in blossom commonly 10.5 × 33 cm., at first rather bright yellowish green, turning slightly gray green yet having but little bloom, slightly raised at areoles and this disappearing the second year; areoles gray or light tawny, oval to subcircular, commonly 4 mm. long, bearing a darker central area; spicules inconspicuous, yellow, becoming noticeable and 2 mm. long in a compact, connivent tuft in upper portion of areole at one year of age; spines one to three, 1–1.5 cm. long, yellow, turning white, increasing with age to six to eight and often becoming 3 cm. long, usually one or two on sides of joints and more numerous on edges, flattened, twisted, with translucent tips; flowers yellow, greener within, 5.5 cm. in diameter or 6 cm. when fully opened; turning deeper yellow and developing the faintest tinge of red within at close of day; filaments greenish, style white, stigma large, light green, nine-parted; inner petals nearly orbicular; buds dull light green with tinge of dull red on the upper edges of the sepals; fruit pyriform, purplish red throughout. (PLATE 30.)

This species has been carried in our collections for the past eight years under S. T. G. No. 2838, and has been grown successfully in two situations in Texas besides Chico, California. It was not known for a long time whether it was hardy or not, consequently we grew it inside at Chico where it produced a moderate crop of fruit and a prolific vegetative growth. In the field, however, its vegetative development is very much curtailed but it is loaded with fruit. It was received originally from some European collections. Since being transferred to Chico it has grown under S. T. G. No. 2838. Its natural habitat is unknown.

Opuntia platynoda sp. nov.

A low, erect to ascending, densely branched, fragile-jointed species, seldom 45 cm. high, but often 60–100 cm. in diameter; joints flattened, small, obovate to mostly fusiform-oblong, 4 × 13 cm. for old joints of this season, but very variable, many joints of last season's growth only 3.5 × 9 cm., dark, glossy green, and darker and often purplish below the areoles, which are slightly raised, tubercular at areoles first season but later entirely smooth, but always more or less darkened in color below them; areoles gray to light tawny, obovate, about 4 mm. long, increasing in age to subcircular; spicules at first inconspicuous in a small tuft in upper portion of areole, but later at two or three years occupying half of the areole, and fading to a light dirty brown or yellowish; spines erect, divergent, at first brown, turning through a mottled condition to white with translucent bone-like tips, flattened, twisted, stout, one to three, seldom four, with lower areoles naked, upper terete spine largest, 2.5–3 cm. in length, and ascending or porrect, the others lateral or situated directly below, besides these often there are two delicate short lower lateral ones, 3 mm. in length in addition; flowers lemon yellow, 4.5–5 cm. wide when fully opened, outer segments greenish red and tightly appressed as is typical of South American forms in the bud; petals tipped with greenish red, obovate, retuse, and minutely cuspidate in the notch; filaments white, style white, stigma white, six-parted, petals about 3 cm. long; fruit pyriform, green with blush of greenish red on one side, or entirely greenish red, with exception of basal portion, large, subcircular, gray to tawny areoles, 12–18 mm. apart, and an occasional short spine.

With us the plant grows very rampant in the sash house, requiring constant pruning to keep it in check. It blossoms very freely in June and July. Up to this time the fruit has been all but sterile, none having over one half dozen mature seeds, but a great many aborted ones, showing that there is something wrong with the fertilization of the plant in this situation.

The description is drawn from No. 9266 P. I. G., cultivated at Chico, California, from cuttings secured from European collections. I have no definite information of its habitat, but feel certain that it is of South American origin. Its affinity is clearly that of a large group of South American species with short, blunt buds of closely appressed, wide, thick scales, short leaves, and copperized areolar stains. The species is frequently injured by cold weather out-of-doors at Chico, California.

OPUNTIA MICROCARPA Engelm.

A stout, robust, large-jointed, erect species, making a bush 1.5 m. high and 2 m. in spread, with the main lower arms mostly resting on edges or self-supporting, ascending or nearly horizontal; joints large, light bluish, moderately glaucous, often 25 × 35 cm., sharply rounded above, not raised at areoles after first year; areoles variable in size, light brown, obovate, 5–6 mm. long on sides and some 8 mm. on edges of last year's growth, becoming subcircular and black in age; spicules light-brownish yellow, scattered, unequal, 3–10 mm. in length, not especially prominent excepting on margins of joints; spines white, with brown bases of very ununiformly tinted but always dull and dark brown, strongly flattened, twisted, bent and variously curved, variable in number and length, two to six and 1–4 cm. long, increasing in length and numbers in age; flowers large, 9–10 cm. in diameter, yellow with greenish centers, filaments yellow, style greenish to very faintly reddish tinted, stigma large, deep green, ten- to thirteen-parted, coarse; buds rather sharply pointed, olive green with a very faint blush of red in the tips of the outer, lax to recurved sepals; fruit deep purplish red throughout and bearing prominent, tawny areoles, having the usual quota of spicules, rather lighter than those of the plant, and a few fugacious spines 1 cm. long; umbilicus broad, flat to slightly concave.

This is one of the larger, more robust of the southern Arizona species. The description of the spines might be misleading for the general impression which they give is that of white, leaning toward that peculiar translucent aspect common to so many species. It is not at all abundant but occurs commonly in scattering individuals in the foothills at an elevation of about 3,000 feet. This is the first time this species, which was named by Dr. Engelmann* from Stanley's figures, has been recognized, although it has a considerable known distribution and is a very characteristic thing. I have seen fine specimens of it in the type locality near Solomonville, Arizona, and at various points to the southwestward. It extends in this direction as far as the Tucson region. I have had it in manuscript under a provisional new name for years from the latter region, but refrained from publishing on account of a suspicion that it might be this species on account of the shape of the joints as shown in the Stanley figures. A careful study of the pears of the type locality leaves no doubt in my mind as to its identity.

Opuntia crystalenia sp. nov.

An erect, tree-like form, 2–2.5 m. high with a distinct cylindrical trunk and tree-like top; joints broadly obovate to nearly subcircular, about 18 × 25 cm., glaucous, blue-green, becoming more yellow after two years of age, at one year about 3 mm. long on sides of joints but enlarging irregularly and becoming subcircular in age, at first tawny but turning gray; leaves small, 4 mm. long, subulate, cuspidate, slightly flattened and becoming somewhat recurved at tip; spicules yellow, in a compact tuft in upper part of areole, not prominent, scarcely protruding from surface of joint, increasing only in occasional areoles in age; spines white, porrect in upper two thirds of joints only, one to three or four, usually two, variable, the longest 10–15 mm. in length and there are usually present one to two or three hair-like, delicate spines besides in the lower angle of the areole; flowers yellow, lighter colored within, filaments yellow above and greenish below, style white, stigma large, conical, dull dark green, ten-parted; buds light, dull greenish red, with a slight grayish, glaucous sheen; fruit subglobose, medium sized, about 4–4.5 cm. in diameter, light red all the way through, flower-scar moderately dished to nearly flat, areoles tawny to brown, about 8 mm. apart and having prominent wool, variable spicules 1–2 mm. in length and four to ten delicate fugacious spines, 4–12 mm. long, tawny brown.

This is a common species both native and in cultivation upon the Mexican highlands and is prized for its edible fruits. The type was collected at Cardenas, Mexico, under my inventory number 8030 in August, 1905. It has been grown in our experimental plantings at Brownsville and San Antonio, Texas, and Chico, California.

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* Emory's Recon. Append. 2: 158. 1848.

Opuntia ithypetala sp. nov.

A tall, erect, tree-like, open-branching plant 2 m. high or more with a distinct trunk and widely spreading, ascending to drooping branches; joints large, obovate, contracted below into a long stipitate base, very often 19 × 45 cm., but commonly only 14 × 26 cm., bright dark green, tubercular-raised at the areoles, the surface not becoming flat and smooth for two or three years at least, bright dark green, mostly without bloom; leaves subulate, cuspidate-pointed, slightly flattened, 5–6 mm. long; areoles oval to subcircular and often 1 cm. in diameter, 4–5 cm. apart on sides of joints; spicules not visible; spines white on second year's growth, three to five, mostly three or four, the central one porrect and largest 3–4 cm. long, the lower one short, 1–2 cm. and recurved, the others divergent, flattened, twisted, formidable, increasing on old trunks to six to ten and often becoming 8 cm. long and very stout; flowers light canary yellow, fading to light rose purplish late in the day, the petals erect, not spreading, becoming 3 cm. in diameter when fully opened; filaments white to slightly greenish below and very light pinkish tinted above, style white, stigma very light green, six-parted; buds conical-pointed, light olive with only a tinge of red at the tip, the scales wide and closely appressed; fruit light purplish red, slightly raised tubercular at areoles and deeply pitted, each upper areole bearing mostly 1 white, porrect spine 1 cm. long and occasionally an additional smaller one 3 to 5 mm. long below the big one, the pulp being much deeper purplish red than the outside and brittle with a pleasant touch but not very sweet.

This species was received from the Royal Botanical Garden at Berlin as *Opuntia Hanburyana* A. Weber. It is more closely related to *Opuntia Schumanni* A. Weber but as the description above indicates it is very different from either one. It agrees with the latter in having the petals erect when the flower is fully opened; it does not agree with the former in any particular. It has been grown to maturity very successfully in our two situations in Texas as well as at Chico, California. When first received it was assigned the inventory number of our San Antonio garden, 506, and under this number it has been carried at Chico, California.

Opuntia rubiflora sp. nov.

Plant low, spreading, 30–45 cm. high and having a spread of a meter or more; joints obovate, mostly 12 × 18 cm. in last year's growth, but older ones larger, medium dark green with a little pruinosity, broadly rounded above and gradually narrowed below into a short stipe; areoles obovate above and subcircular below, about 3–4 mm. long with prominent gray wool the second year; spicules brown on this year's growth, changing to yellow in situ the second year, situated in a compact tuft in upper portion of areole, 2 mm. long; spines white with brown to straw-colored bases, on last year's joints two or three, usually one recurved 1–2 cm. long, white, the others stouter, 3–4 cm. long, white with brown to straw-colored bases, porrect, divergent, flattened, slightly twisted and at times showing a very faint annulation, increasing and becoming six to eight in number and somewhat lengthened in age; bud medium-pointed with loose, narrow scales of an olive green color but with a tinge of dull pinkish red in the upper portion; flowers pink, filaments yellow, greenish below, style white, stigma very light greenish, six-parted, with long-pointed divisions which are cuspidate, the general shape of the stigma being conical.

The species was received originally in the form of cuttings from European collections, designated by an unpublished varietal name under *Opuntia camanchica* Engelm. & Bigel. It is, however, a perfectly good species. Its habitat was not stated.

Opuntia megalantha sp. nov.

A tall, robust, erect, open-branching plant 2 m. or more in height; joints obovate, broadly rounded or often, when young, bluntly pointed above, becoming more rounded the second year, glaucous-gray-green, last year's joints commonly 14 × 21 cm.; areoles at first brown turning gray, variable, oval-obovate to subcircular, enlarging in age, about 3–5 mm. long the first season; spicules yellow, scattered through the edge of the areole, wool 4–5 mm. long, increasing slightly in age but only in scattered places on the plant, usually there is no increase at all but the wool increases or grows anew and the areoles on the old trunks three or more years old often bright brown like new growth, often becoming transversely elongated and 1 cm. in width on old trunks; spines yellow, in some cases slightly tinted at base, some more or less mottled after first year but semi-translucent, dirty yellow in age, one to three, the longest 2.5 cm., increasing to 4–5 cm. in length and four or five in number on old wood; flowers yellow, 10–11 cm. in diameter, petals 5 cm. long, obovate, usually notched at the rounded apex, filaments greenish below and white or yellowish above, style white, stigma large, in rare instances 1 cm. in diameter, white or slightly greenish tinged, flattened by incurving of points, eight- to nine-parted; fruit dark red throughout with subcircular areoles 3 mm. in diameter, the upper especially with prominent spicules 3–4 mm. long, merging imperceptibly into the delicate, fugacious spines which may be a cm. long or less.

This species was received from the Royal Botanical Garden at Berlin as *Opuntia Bergeriana* A. Weber, and has been grown with us in two situations in Texas and one in California. In some respects the plant does suggest *Opuntia Bergeriana* but the character of the flowers alone would exclude it from that species. It differs also in general habit, nature of spination and form and character of joints. In the season of 1914 our plants at Chico, California, blossomed profusely and set a good crop of fruit, but in no case did any seed form, the fruit being made up mainly of rind with a very small, empty seed cavity, save for the minute dried ovules. In 1915, however, the earlier fruits did not differ very materially from those of the previous year except that two or three seeds were produced in the fruit; but later crops, blossoming in late June and early July, produced an abundant seed crop. The species is carried in our collections under No. 2825 S. T. G. Its habitat is not known.

UNITED STATES DEPARTMENT OF AGRICULTURE

Explanation of plate 30

OPUNTIA LONGICLADA Griffiths

Terminal joints and flower buds, about half natural size, cultivated at Chico, California.

Cambial activity in certain horticultural plants*

LEWIS KNUDSON

As stated by the writer in a previous publication,† there is a scarcity of data respecting the season of cambial activity in woody plants. This lack of knowledge, particularly with respect to cambial activity in the fruit trees, is the more surprising when one considers its significance to pruning and fertilizer practices, and since ultimately a rational system of fruit culture will be based on an accurate knowledge of the life history of the plant. It was in the hope of supplying some of the desired information that an investigation on this subject was begun in the summer of 1909.‡ It was found impossible to continue the investigation, except for a few observations made in the summer of 1913, but because of the scarcity of data on this subject it seems advisable to record the results of the observations made.

OBSERVATIONS ON THE GRAPE

Methods.—For the investigation a number of vines were selected of the Worden variety (*Vitis labrusca*). They were uniform as regards size and conditions of growth. They had been growing for four years on a plot of land on the campus of Cornell University, Ithaca, New York. The vines were under the care of the Department of Pomology, and had been properly pruned during the previous seasons.

At intervals throughout the season cuttings were taken from the one-year-old wood. These cuttings were removed in all cases from the basal internodes of different shoots and, as far as possible, from shoots of the same exposure and the same diameter. Cuttings from new shoots were likewise made from the basal

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* Contribution from the Laboratory of Plant Physiology, Cornell University.

† Observations on the inception, season, and duration of cambium development in the American larch [*Larix laricina* (Du Roi) Koch]. Bull. Torrey Club 40: 271–293. *pl. 18, 19.* 1913.

‡ The field notes and collection of material were made by Dr. George R. Hill, Jr.

internodes. The material was fixed in Gilson's solution, imbedded in celloidin, and later sectioned and stained. On the same days that material was collected, observations were taken on the external manifestations of growth in order that the formation of xylem and phloem could be correlated with the growth of leaves, elongation of new shoot, and development of fruit.

In TABLE I are given the data on the growth-measurements in the grape.

TABLE I

DIAMETER INCREASE OF PHLOEM AND XYLEM IN ONE-YEAR-OLD SHOOTS OF THE GRAPE

Number of cutting	Date	Diameter of branch, mm.	Increase of xylem, microns	Increase of phloem, microns	Leaf, fruit, and shoot development
4	May 8	3·5	0	0	Buds swelling
12	" 15	4·75	0	0	Largest leaf 2 mm. wide
25	" 23	6	0	0	New shoot 30 cm. long. Largest leaf 11 mm. wide. Fruit-bud cluster 3 cm. long
46	" 29	4·5	102	61	Leaf 16×16 cm. New shoot 60 cm. long. Fruit-bud cluster 6–8 cm. long, not yet open
74	June 7	4·75	0	0	Largest leaves 18×18 cm. New shoot 86 cm. Fruit-bud cluster 5·5 cm. long; some open
94	" 15	5	143	73	Leaf 20×19 cm. New shoot 96 cm. Tendril developing. Axillary shoot 12 cm. long, with leaves 4 cm. broad. Fruit set. Only occasional stamens to be seen
110	" 20	—	102	71	Leaf 20 cm. broad. New shoot 100 cm. Grapes size of peas
144	" 29	6.5	486	222	Leaf 20×20 cm. New shoot 155 cm. Size of berries (largest) 12 mm. diameter
168	July 19		1,000	445	New shoot 195 cm.
185	Aug. 9		980	405	Grapes nearly full-grown, 16 mm. diameter
197	Nov. —		729	405	

Diameter increase began simultaneously in both phloem and xylem. The cambial activity began between May 23 and May 29, at which time the leaves were almost completely developed. Cambial activity ceased before August 9, for at this time the new xylem and the new phloem were completely differentiated and the cambium was in the resting condition. Between July 19 and August 19 a periderm layer was produced, cutting off the old phloem from the new. At the base of the new shoot, at about the same time, a periderm layer developed just outside the phloem, cutting off the entire cortex.

OBSERVATIONS ON THE PEACH

In studying cambial activity in the peach the methods employed were essentially the same as for the grape. Three peach trees were used, all growing under apparently identical conditions on the grounds of Cornell University. The trees were of the variety known as Wakefield and they were probably fifteen years of age. They had produced a good crop of fruit during the preceding season, and the same held true for the year when the observations were made. Cuttings were taken of one-year-old, five-year-old, and ten-year-old branches, the branches being respectively of approximately the same exposure and the same diameter. The detailed data follow in TABLE II.

TABLE II

AVERAGE DIAMETER INCREASE IN THE PEACH

Date of cutting	One-year-old branches		Five-year-old branches		Ten-year-old branches		General notes on growth
	Xylem microns	Phloem microns	Xylem microns	Phloem microns	Xylem microns	Phloem microns	
May 8..	61.5	—	112	92.2	287	102	Buds just opening
" 15..	61.5	49	153	82	184	102	Leaves 4 cm. long. Late blooming period
" 23..	143	114	143	120	205	102	Leaves 9 cm. long. New shoots 2 or 3 cm. in length
" 29..	—	—	225	123	307	123	Leaves 9 cm. long, full-grown. New shoot 6 cm. Fruit 20×10×12 mm.
June 7..	174	94	225	120	410	266	New shoot 9 cm. long. Fruit 22×25×33 mm.
" 1 ..	—	—	246	164	512	307	New buds evident. Fruit 27×30×36 mm.
" 20..	266	116	205	153	584	320	Fruit 38×30×28 mm. Stone just hardened
" 29..	95	69	250	205	500	287	Fruit 40×35×30 mm.
July 19..	166	75	205	164	492	307	Fruit just beginning to ripen
Aug. 9..	145.9	75	266	164	389	205	

An examination of the table reveals the fact that cambial activity began in the peach at the time of the opening of the buds. This is contrary to the condition found in the larch, grape, and apple. Complete differentiation of the new xylem was evident by July 19, when the cambium layer appeared to be in a resting condition. It is not possible to draw conclusions regarding the period of greatest cambial activity, since the variation in growth in the different branches is apparently considerable.

OBSERVATIONS ON THE APPLE

The methods of investigation in the apple were essentially the same as in grape and peach. Only one tree was used. It was growing on the campus at the foot of a four-foot road embankment The tree was about forty years old, and for several years no practical attention had been given it. Cuttings were removed from one-year-old branches, from four-year-old branches and from one of the main branches having a diameter of 4 cm. The detailed data are given in TABLE III.

TABLE III

AVERAGE DIAMETER INCREASE IN THE APPLE

Date of cutting	One-year-old branches		Four-year-old branches		Ten-year old branches		General notes
	Xylem microns	Phloem microns	Xylem microns	Phloem microns	Xylem microns	Phloem microns	
May 8..	32	0	—	—	0	0	Leaves 2.5 × 1.5 cm. Pink of fruit buds evident.
" 15..	40	0	20	—	123	—	Leaves 2.5 × 2 cm. Full bloom
" 23..	40	40	100	—	—	—	Leaves 6.5 × 3 cm. Fruit set
" 29..	150	82	157	133	205	—	Leaves 11 × 4 cm. Full-grown. Fruit 8 mm. diameter
June 15..	287	98	180	123	246	143	Fruit 18 mm. diameter
" 20..	430	143	246	205	512	185	Fruit 23 mm. diameter
" 29..	686	123	440	125	540	164	New buds appearing. Fruit 36 mm. diameter
July 19..	—	—	594	246	492	164	Fruit 37 mm. diameter
Aug. 9..	379	82	840	205	738	160	
Nov. 4..	594	90.2					

In each case cambial activity began before May 15, but it was impossible to determine from the sections whether or not phloem formation had begun. In all cases xylem formation was completed by July 19 and the characteristic thickening of the cell walls was also practically completed. By August 9, the date of the last observations, the cambium was in its resting condition. The most rapid increase began just after the leaves had attained full size.

INCIDENTAL OBSERVATIONS IN 1913

Material for examination was collected in 1913 from the apple, peach, pear, plum, and cherry. Two apple trees were examined, a Baldwin and a Rhode Island Greening. The trees were about seventy years of age and were growing in an old orchard. In both cases examination of sections from one-year-old, three-year-old, and five-year-old branches revealed the fact that by July 17 the last few layers of xylem cells were being formed, and sometimes between July 23 and July 30 the xylem and phloem formation was completed and the cells were completely differentiated. The cambium was then in its resting condition. Material was also taken from three-year-old and five-year-old branches of the pear. The tree was about twenty years of age and was growing in a yard. In each case xylem formation was completed by July 17. Incidental observations made on the plum, peach, and cherry on three- and four-year-old branches indicated that xylem formation was complete by July 23 and the cambium was in a resting condition. These trees were bearing trees about twenty years old and were growing in a farmyard.

In concluding, mention should be made of the fact that no evidence was obtained to indicate that phloem formation continued later than xylem formation.

INDEX TO AMERICAN BOTANICAL LITERATURE

1913-1916

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 the broadest sense.

Reviews, and papers that 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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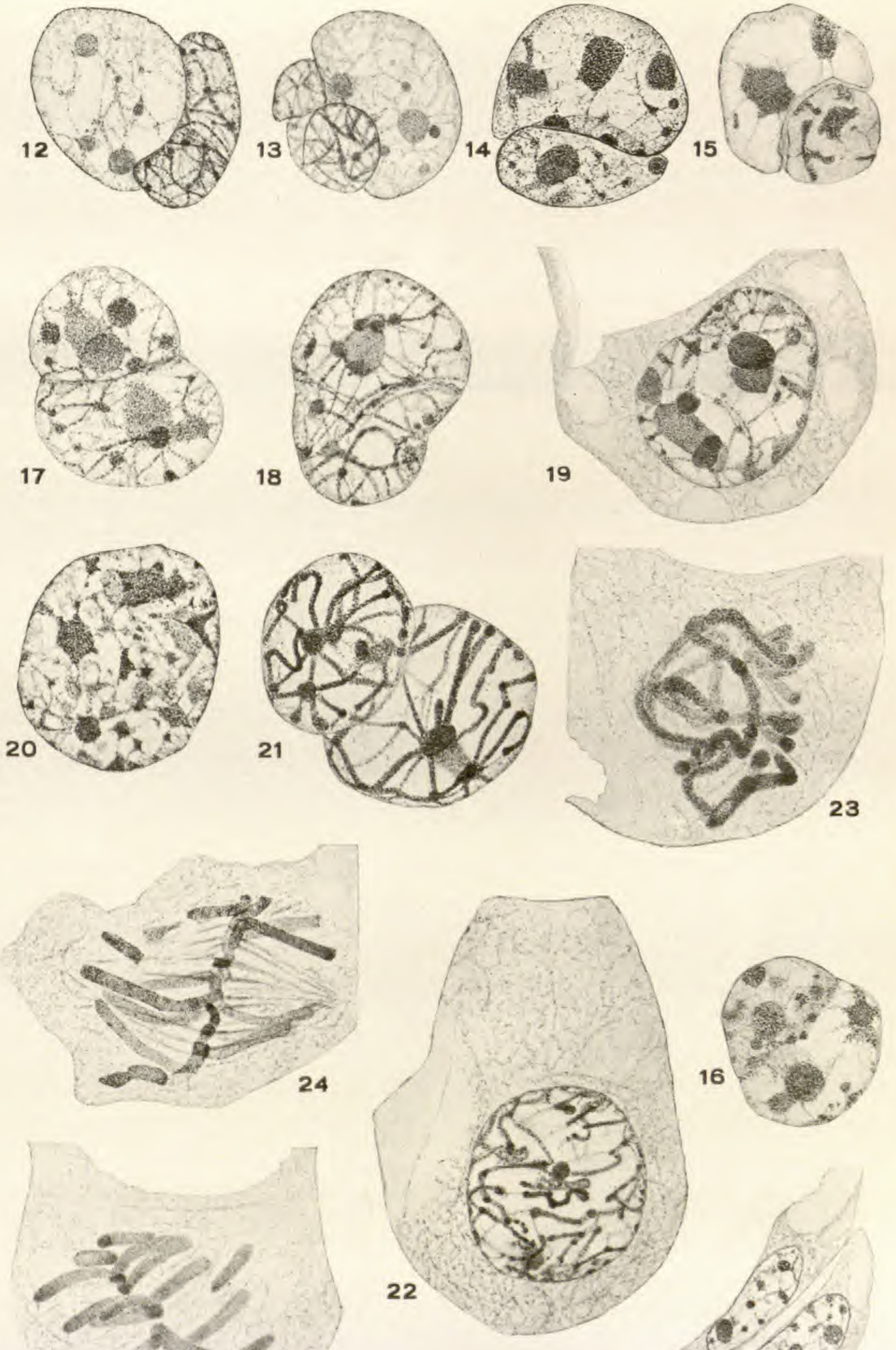
SAX: FERTILIZATION IN FRITILLARIA



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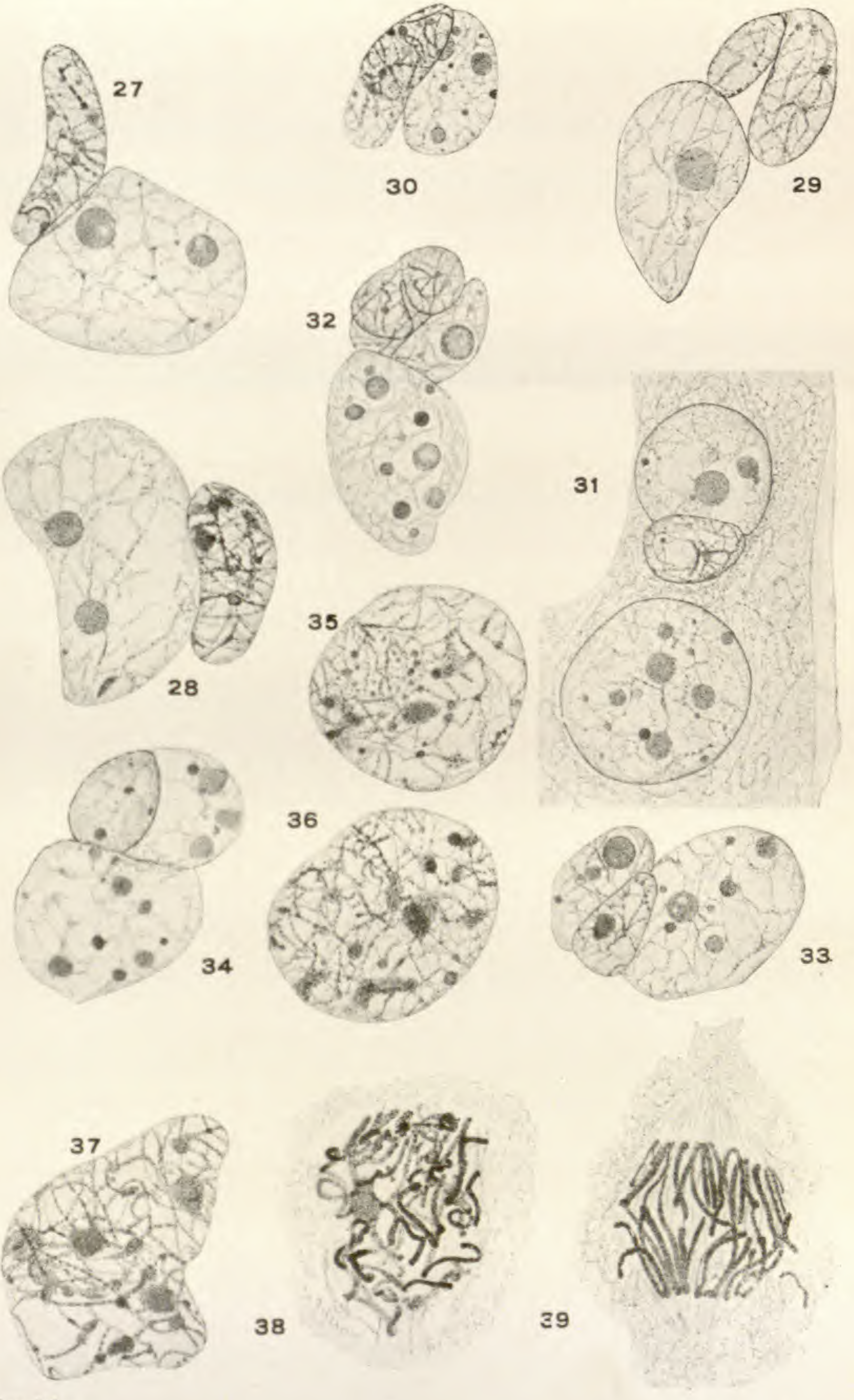

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The development of the embryo and seedling of Dioscorea villosa

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(WITH PLATES 31–34)

INTRODUCTION

According to the standard manuals, *Dioscorea villosa* L. is the only North American species of the Dioscoreaceae, a family that is mainly tropical and subtropical in distribution. Bartlett (1910), however, considers the name *D. villosa* at once a misnomer and a possible source of confusion and error, and proposes that it be dropped. In his classification, the Dioscoreae of the United States are referred to five separate species; the one treated in the present paper he calls *D. paniculata* Michx.

The early discussions of the embryos and seedlings of members of this family are confined to the mature embryo and its behavior in germination, and were prompted chiefly by taxonomic considerations. Dutrochet (1835) says that the embryo of *Tamus communis* is at first globular, then pear-shaped; the slender part is the cotyledon, the swollen part the body of the embryo. He describes two cotyledons: the one, conical in form, remaining within the seed during germination; the other, so closely applied to the globular part of the embryo that it is distinguishable only after germination. The larger cotyledon persists until the middle of summer. Dutrochet also describes the structure of the aerial stem, whose fibro-vascular bundles are of the monocotyledonous type, but arranged in a ring. He thinks that this apparent mingling of monocotyledonous and dicoty-

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ledonous characters indicates that the genus is intermediate between the two classes, although he refers it to the Asparageae. Endlicher (1836, p. 157) notes a resemblance in stem structure between *Tamus* and *Aristolochia*.

Jussieu (1839) finds a structure corresponding to the "second cotyledon" of Dutrochet in the embryos of *Dioscorea villosa*, *D. cordifolia*, and *Rajania hastata*. However, he thinks it to be not a cotyledon, but a sheath formed by the growth of the cotyledon, its development being coincident with the elongation of the cotyledonary limb. In his classification the genera in question are placed among the Asparageae.

Beccari (1870*a*), in agreement with Dutrochet, concludes from his examination of the embryos of *Dioscorea bonariensis*, *D. brasiliensis*, *D. sinuosa*, *Rajania cordifolia*, *Tamus communis*, and *Trichopus zeylanicus* (*Trichopodium zeylanicum*) that the organ in question is a rudimentary cotyledon; he finds it present, with some variation in shape and size, in all the species named. Beccari also studied the germination of *D. bonariensis;* his description and figure agree substantially with Dutrochet's account of the process in *Tamus communis*.

The textbook of Le Maout and Decaisne (1873, p. 794) contains a figure of a longitudinal section of a germinating seed of *Tamus communis*, which shows very clearly the structures described by Dutrochet and others.

According to the view advanced by Strasburger (1872, pp. 317, 318), monocotyledons were derived from dicotyledons by the loss of one cotyledon. Obviously, if the Dioscoreaceae can be held to constitute a transition stage, or transition stages, between monocotyledons and dicotyledons, the "second cotyledon" might well represent a stage in the degeneration of one of the cotyledons of the latter group. Stimulated by these considerations, Solms-Laubach (1878) studied the embryology of *Dioscorea pyrenaica* and *Tamus communis*, the latter in some detail, but his results did not convince him that a second cotyledon was formed. However, he found a type of embryological development quite different from that which, since the work of Hanstein (1870), had been considered characteristic of monocotyledons. The growing point of the stem appears early in a terminal or nearly terminal position, from which it is pushed aside by the development of the lateral true cotyledon. The so-called second cotyledon is, he thinks, merely a sheath. Both cotyledon and sheath are developed, however, according to Solms-Laubach, from a ring-shaped primordium.

Bucherer (1889) points out the additional fact that in *Tamus* not only the first secondary leaf, but all the secondary leaves, have similar sheaths. He also describes the anatomy of the mature embryo, and the processes of germination and of tuber formation. His account of the germination of the seed does not differ from the accounts of his predecessors.

MATERIAL AND METHODS

Material was collected in the vicinity of Madison, Wisconsin, at intervals of two or three days during the months of June, July, and August, 1913 and 1914. The flowers were fixed entire; when the ovules became sufficiently large, they were removed from the capsules before fixing. Later, the embryos were dissected out of the young seeds and then fixed. Difficulty was experienced in inducing the seeds to germinate, but germination was finally secured by keeping the seeds in soil out of doors all winter and bringing them into the greenhouse in the spring.

Strong and medium chrom-osmic-acetic acid solutions were used for all material of the embryo-sac and embryo which was to be sectioned; the stronger solution proved the more satisfactory. For embryos to be mounted *in toto* Carnoy's solution was used; for the seedling, a chrom-acetic acid solution, containing three tenths of a gram of chromic acid and seven tenths of a gram of acetic acid in each hundred grams of the solution, gave good results. The usual methods of hardening and embedding in paraffin were followed. Microtome sections were cut from five to seven microns thick.

Material containing embryo-sacs or early embryonic stages was stained with Flemming's triple stain. For the study of the later stages in embryo-development, Heidenhain's iron-alum-haematoxylin gave the best results. Some of the mature embryos were stained *in toto* with Delafield's haematoxylin. Staining with safranin and Lichtgrün proved useful in differentiating the tissues of the seedling.

THE EMBRYO-SAC

Two anatropous ovules are borne in each cell of the three-celled ovary and are pendulous on rather short funiculi. Beccari (1870*b*) figures the ovules in *Trichopus zeylanicus* as turned towards the axis of the pistil, but in *Dioscorea villosa* they are turned away from the axis.

At the time when the embryo-sac is fully organized (FIG. 1), the three antipodal cells have already begun to degenerate and fusion of the polar nuclei has taken place. Before the egg divides, its cytoplasm is highly vacuolate, and the nucleus occupies a position either approximately in the center or at the distal end of the cell. Both synergids persist, at least in some cases, until after the first division of the egg. When the embryo is somewhat older, only one structure is found beside it which I take to be a synergid. This structure (FIG. 5, *s*) sometimes forms a beak with faint longitudinal striations, which extends into the micropyle and corresponds closely in form and appearance with the "Fadenapparat" first described by Schacht (1856).

THE EMBRYO

The first division of the egg takes place only after several nuclear divisions have occurred in the endosperm. In an embryo-sac containing a two-celled embryo a count of the endosperm nuclei shows that five divisions have taken place, and the general appearance of the endosperm in other similar cases indicates that about the same number of divisions has occurred. In all cases observed, the plane of the first division of the egg is oblique (FIG. 2), approaching in a few instances the vertical (FIG. 4) or the horizontal (FIG. 5). The corresponding division is in an oblique plane in *Tulipa Gesneriana* (Ernst, 1901), and occasionally in *Avena fatua* (Cannon, 1900), and *Aglaonema* (Campbell, 1900). But in most monocotyledons, so far as has been reported, the plane of this division is transverse, as for instance in such forms as *Sagittaria variabilis* (Schaffner, 1897), *Lilaea subulata* (Campbell, 1898), and *Lilium philadelphicum* (Coulter, 1897). A transverse first division is found also in *Tamus communis* (Solms-Laubach, 1878), another of the Dioscoreaceae. The cells produced by this division in *Dioscorea villosa* are usually of about the same size (FIG. 4), but sometimes the basal cell is larger (FIG. 2). On account of the flattened shape of the seed it is possible to section the ovules always in the same plane. All figures of sections of the embryo are drawn from median longitudinal sections which are vertical to the plane of the cotyledon and which consequently afford a fair basis for comparison. In no case is a large vesicular basal cell formed, such as has been described in the embryos of the Najadaceae and Alismaceae.

The second division occurs in the basal cell, at right angles to the first wall (FIG. 3). Next, the terminal cell divides (FIG. 4); the position of the wall formed as a result of this division varies: in some embryos it is in the same plane as that of the second division (FIG. 4); in others, it is at right angles to the second wall, as in the embryo shown in FIG. 5, in which the third wall is nearly in the plane of the section and therefore cannot be shown in the figure. By either method, four similar cells are formed, as is the case in a few monocotyledons which have a massive proembryo rather than one of the filamentous sort that was formerly considered typical for the class. Quadrant formation has been observed in three genera of monocotyledons, *Lysichiton* (Campbell 1900), *Lilium* (Coulter, 1897), and *Erythronium* (Schaffner, 1901). It can hardly, however, be considered typical for the Dioscoreaceae, since in *Tamus communis* (Solms-Laubach, 1878) a filamentous three-celled proembryo has been described.

The next division may take place in one of the two distal cells or in one of the two basal cells. In the embryo shown in FIG. 5, the nucleus of one of the distal cells of a four-celled embryo is dividing; the wall separating the two distal cells is, as already noted, so nearly parallel to the plane of the section that it cannot be indicated in the figure. The spindle is at a lower focus than the resting nucleus shown.

In most cases, the second of the two distal cells of the four-celled stage now divides, so that a six-celled embryo is formed. Up to this time the embryo has not materially increased in size, but from now on there is a gradual growth. At the eight-celled stage (FIG. 6) the embryo is already noticeably larger, the size of the individual cells at this time being approximately equal to that of the cells at the six-celled stage. At the sixteen-celled stage, the embryo assumes one of two typical shapes, each of which has been observed in several cases: it may be either elongated (FIG. 7), or nearly globular (FIG. 8). The exact sequence of divisions cannot be followed with any certainty after the eight-celled stage, nor is it possible to trace the development of the organs of the full-grown embryo from particular cells.

As the embryo develops a region is differentiated at the apex in which division is especially active, as indicated by the smaller size of the cells (FIG. 9, *m*). An elongation of the embryo, together with the increased rate of growth in its apical region, renders it a little later roughly pear-shaped (Fig. 10). The suspensor is now definitely marked off from the rest of the embryo (FIG. 10, *s*), and reacts differently to stains in this and succeeding stages. Now, too, the dermatogen is differentiated except on the side from which the first secondary leaf is to develop (FIG. 10, *l*; compare also FIG. 11, *l*). An embryo of the age of that shown in FIG. 10 bears a fairly close resemblance to one of *Lilium philadelphicum* figured by Coulter (1897, *pl. 34, f. 31*). Solms-Laubach (1878) shows no embryo of *Tamus communis* or of *Dioscorea pyrenaica* at a similar stage of development. Older stages than that of my FIG. 11 are represented in his figures only by drawings of surface views of whole embryos. According to Solms-Laubach's description the original terminal arch of the embryo becomes somewhat flattened and laterally displaced by the growth of one side of the embryo. From the flattened portion the plumule develops, surrounded by a ring-shaped wall of tissue. In my preparations of *D. villosa*, it appears clear that the lateral swelling shown at FIG. 11, *l*, which probably corresponds to that described by Solms-Laubach, is the primordium of the first secondary leaf, whose further development is shown in FIGS. 15–24. The growing point of the stem lies in the axil of the first secondary leaf, and it is obvious that both these structures are lateral in origin. The cotyledon (FIG. 11, *c*) develops in a terminal position. In *Tamus communis* and *Dioscorea pyrenaica*, according to Solms-Laubach, first the cotyledon and then the sheath develop from opposite points in the ring-shaped primordium, and are hence of lateral origin.

A careful study of serial sections of embryos of *Dioscorea villosa*, corresponding in size to those figured by Solms-Laubach, shows that no ring-primordium is formed, but that the first secondary leaf and cotyledon originate as limited areas of meristematic activity in an embryo which is still meristematic in all its parts; there is a very great increase in the size of the embryo as a whole after the first secondary leaf and the cotyledon have begun their development (FIGS. 15–24, all drawn on the same scale). The growing point of the stem consists merely of a group of cells in the axil of the first secondary leaf, and remains quite undifferentiated (FIG. 12, *g*) until germination occurs. The growth of the first secondary leaf is more vigorous at the start than that of the cotyledon (FIG. 15); but the latter soon begins to elongate rapidly, then expands to form a foliaceous structure which, in the fully-developed embryo, is peripherally very thin and flat, but is much thicker in the middle portion and at the base (FIGS. 13, 24). The first secondary leaf continues to swell out, then arches over and finally covers the growing point of the stem (FIG. 24). In the full-grown embryo, the edges of the base of the cotyledon extend for a short distance over the first secondary leaf, but by no means cover it (FIG. 13). A strikingly different structure has been described for embryos of other members of the Dioscoreaceaé, which have a distinct sheath entirely covering the first secondary leaf. Beccari (1870*a*) finds this sheath entire in the genera *Dioscorea* and *Trichopus*, and two-parted in *Rajania* and *Tamus;* Solms-Laubach (1878) says that it is entire in *Testudinaria*. The short, thick suspensor persists to the time of the maturity of the seed (FIG. 13, *s*).

A vascular system, consisting of procambium strands, is present in the full-grown embryo of *Dioscorea villosa*. Cross-sections through the hypocotyl show a solid plerome cylinder which becomes a hollow cylinder at the base of the cotyledon. The hollow cylinder opens out into a trough-shaped mass as it passes into the cotyledon, then branches into three main bundles, which, in turn, branch profusely (FIG. 13). The first secondary leaf has a well-marked median bundle and two rather weakly developed lateral bundles. Bucherer (1889) describes but one vascular strand in the cotyledon of *Tamus communis;* in *Tamus*, however, the cotyledon is tongue-shaped and not flattened. Bucherer also says that the primary root is endogenous and breaks through several rows of parenchyma cells when the seed germinates. No evidence of this condition has been found in *D. villosa*. There are no parenchyma layers outside the well-defined root-cap, which lies in immediate contact with the suspensor.

THE ENDOSPERM

As has been said, the polar nuclei fuse early and the primary endosperm nucleus undergoes several divisions previous to the first division of the egg; the nuclear divisions in the endosperm are simultaneous. The young embryo is at all times closely invested with a thick layer of endosperm cytoplasm. The endosperm makes rapid inroads on the nucellar tissue, using up all of it excepting two layers at the sides of the embryo-sac cavity and thicker masses at the chalazal and micropylar ends before cell division begins in the endosperm. Cell formation in the endosperm begins when the embryo has reached about the stage shown in FIG. 10. Tissue is formed at first throughout the whole of the cavity; later, but before the maturing of the seed, enough of this tissue is dissolved to form a large fissure in the central part of the seed which affords room for the rapid growth of the cotyledon at the time of germination. The cells of the endosperm contain abundant reserves of hemicellulose, protein, and oil. Dutrochet (1835) and Beccari (1870*a*) refer to the food material in the seeds of various Dioscoreaceae as "perisperm," but in *Dioscorea villosa* the material is clearly endosperm.

Formation of endosperm tissue is accompanied by, and is perhaps responsible for, certain changes in the contour of the seed and in the position of the embryo. When cell walls begin to form in the endosperm, nuclear division continues and is especially active in the region opposite the funiculus and adjacent to the embryo with the final result that this portion of the seed becomes proportionately larger than the other parts. As a result of this one-sided growth, the embryo, whose long axis at first corresponds to the long axis of the embryo-sac, comes to lie with its axis at an angle of approximately forty-five degrees to the long axis of the seed.

THE SEEDLING

In the mature seed, the embryo is very small in proportion to the size of the seed. On germination the cotyledon increases rapidly in size (FIG. 28, *c*), filling the entire fissure which has been referred to as formed within the endosperm, and remaining within it. The basal part of the cotyledon elongates, forming a trough-shaped petiole in whose hollow the first secondary leaf lies. The primary root elongates rapidly and soon begins to give off secondary roots. The first secondary leaf elongates, then arches itself until its tip becomes free from the seed coats. Beccari (1870*a*) says that in *Dioscorea bonariensis* the first secondary leaf is bent over so that the upper surface of the lamina lies against the petiole until the entire leaf emerges. In *D. villosa* the leaf is not bent over while in the seed, but assumes the position described by Beccari on freeing itself from the seed and retains it until it is well above ground. In the seedling illustrated in FIG. 28, the second, third, and fourth secondary leaves have already begun to develop.

The three bundles of the cotyledon fuse in the petiole to form a single massive bundle (FIG. 27) which extends the entire length of the petiole, is clearly recognizable in the hypocotyl (FIG. 26, *t*), and forms one of the poles of the tetrarch root (FIG. 25, *t*). This condition differs from that in *Tamus*, in which, according to Miss Sargant (1903), the symmetry of the root stele depends upon plumular traces alone. No traces of cambium, such as often occur in monocotyledonous seedlings, were found. Each secondary leaf has three bundles. Excepting the traces from the second and third secondary leaves, no vascular strands are present in the seedling that are not represented in the embryo by procambial tissue.

There are eight bundles in the hypocotyl (FIG. 26). The largest one (*t*) is continuous with the cotyledonary bundle. Of the remaining bundles, the three largest (*lt*) are continuous respectively with the three bundles of the first secondary leaf. The hypocotyl is short, as in most monocotyledons, so that the bundles of the hypocotyl converge rather rapidly as they enter the root and are consequently difficult to follow. It is evident, however, that branching of the phloem groups of the four main bundles occurs, and that the branches fuse in pairs to form the phloem groups of the root. At the same time, a rearrangement of the xylem groups takes place, with the result that the protoxylem, which is external in the hypocotyl, becomes internal in the root.

CONCLUSIONS

Apparently the early divisions in the embryo of *Dioscorea villosa* have no very definite relation to the formation of organs or to the constitution of the embryo, since no important differences are found among the ripened embryos which might correspond to the observed differences in the plane of the first division or in the shape of the proembryo.

Widely accepted generalizations on the embryology of monocotyledons and dicotyledons have been based on cases such as *Sagittaria* and *Capsella* in which a filamentous proembryo is formed whose terminal cell gives rise to the cotyledon in monocotyledons and to the stem primordium in dicotyledons. However, as Coulter and Land (1914) have pointed out in the case of *Sagittaria*, the origin of organs from particular cells of filamentous proembryos has been assumed rather than proved. Moreover, a number of genera, both of monocotyledons and dicotyledons, have now been investigated in which the proembryo is massive. In several monocotyledonous genera, including *Zannichellia* (Campbell, 1897), *Lilaea* (Campbell, 1898), *Sparganium* (Campbell, 1899), *Avena* (Cannon, 1900), and sometimes *Limnocharis* (Hall, 1902), both cotyledon and growing point are found to originate from the terminal segment. However, a considerable amount of growth, resulting in a mass of tissue, must occur in the embryo before actual differentiation of organs takes place. If the positions of the primordia of the cotyledon and stem on this mass of tissue can be said to be terminal or lateral, this difference might serve as a basis for the distinction between monocotyledonous and dicotyledonous embryos. Unfortunately, it is at just this period of development that gaps in embryological studies are usually found. If position of origin be considered the criterion, the embryo of *Dioscorea villosa* is strictly monocotyledonous.

Lyon (1901) has advanced the view that an area extending entirely around the axis of the embryo is potentially cotyledonary.

The maximum development in this area takes place at the point or points that are in the most favorable position to function; in monocotyledons maximum development occurs on only one side, while in dicotyledons equal growth occurs at two points diametrically opposite each other. This notion has been further developed by Coulter and Land (1914) in connection with their work on some of the South African Liliaceae, particularly *Agapanthus*. Coulter (1915) even extends the generalization to gymnosperms. According to his view, a variable number of primordia appear on the cotyledonary ring; one, two, or more of these develop, the growth of the others being checked, principally by the growth of other organs of the embryo. As I have pointed out, no cotyledonary ring was observed at any time in the embryo of *Dioscorea villosa*, although such a structure has been described for *D. pyrenaica* and *Tamus communis* (Solms-Laubach, 1878). The two primordia that do appear in *Dioscorea villosa* develop into the cotyledon and the first secondary leaf respectively. The only way in which this case can be made to fit Coulter's theory is by assuming that the vigorous development of the first secondary leaf has entirely checked the development of the cotyledonary zone except at one point. However, the figures of Solms-Laubach (1878) indicate that the development of the first secondary leaf is just as vigorous in *Tamus*. I have no explanation to offer of the entire absence in *D. villosa* of a sheath covering the first secondary leaf, which is so prominent a feature in the embryos of other Dioscoreaceae.

There is so much diversity of opinion in regard to the phylogenetic significance of seedling anatomy that it seems hardly worth while to discuss the question to any extent in connection with *Dioscorea villosa*. Miss Sargant (1903) considers the tetrarch root such as is found in *D. villosa* primitive; however, in her opinion, this form of root structure is associated with the early development of the plumule which is characteristic of climbers. On the other hand, Hill and De Fraine (1913) consider diarch root structure primitive, but think that the root structure in any given case is largely dependent upon the size of the seedling. The seedling of *D. villosa* is small so that the formation of a tetrarch root cannot be accounted for on the basis of the size of the seedling. The plant is a climber, however, and the structure of the root might be explained on that ground, thus losing its phylogenetic significance.

SUMMARY

1. The plane of the first division of the egg is oblique.
2. A spherical four-celled proembryo is formed.
3. The first secondary leaf is the first organ of the embryo to be differentiated. The growing point of the stem consists, up to the time of germination, of a group of cells in the axil of the first secondary leaf. Both structures are lateral in origin.
4. No "cotyledonary ring" was observed. The cotyledon originates in a terminal position.
5. No structure which is in any way comparable to a second cotyledon is present; the sheath which is described as covering the plumule in other Dioscoreaceae is wanting.
6. Abundant endosperm is present in the seed.
7. The growing point of the stem begins to give off secondary leaves soon after the seed germinates.
8. The root of the seedling is tetrarch; the hypocotyl is polyarch.

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Description of plates 31-34

With the exception of FIG. 28, all drawings were made with an Abbé camera lucida, the drawing being at the level of the base of the microscope. Leitz oculars and objectives were used: FIG. 1, ocular III and objective 7; FIGS. 2-9, ocular III and objective 1/16; FIGS. 10-12, ocular I and objective 7; FIG. 13, ocular I and objective 3; FIGS. 14-24, ocular I and objective 4; FIGS. 25-27, ocular I and objective 6. The drawings have been reduced one fourth in reproduction.

PLATE 31

FIG. 1. Mature embryo-sac.

FIG. 2. Two-celled embryo.

FIG. 3. Three-celled embryo.

FIG. 4. Four-celled embryo.

FIG. 5. Four-celled embryo with one of the terminal cells in mitosis.

FIG. 6. Eight-celled embryo.

FIGS. 7, 8. Sixteen-celled embryos.

FIG. 9. Embryo somewhat older than those shown in FIGS. 7 and 8; region in which cell division has become especially active, *m*.

FIG. 10. Older embryo in which suspensor and body have become differentiated and which shows the first indication of the development of the primordium of the first secondary leaf, *l*; suspensor, *s*.

FIG. 11. Still older embryo in which the first secondary leaf, *l*, has begun development. The section was cut somewhat obliquely so that not all of the suspensor is shown; cotyledon, *c*.

PLATE 32

FIG. 12. Median longitudinal section through the fully-developed embryo, showing first secondary leaf, *l*, and the growing point of the stem, *g*.

FIG. 13. Surface view of the full-grown embryo; suspensor, *s*; first secondary leaf, *l*; cotyledon, *c*.

FIGS. 14-21. Series of outlines, all on the same scale, of median longitudinal sections of embryos, showing the development of the mature organs; first secondary leaf, *l*; cotyledon, *c*.

PLATE 33

FIGS. 22-24. Continuation of the preceding series, FIG. 24 showing the full-grown embryo.

FIG. 25. Cross-section through the primary root of the seedling; cotyledonary trace, *t*.

PLATE 34

FIG. 26. Cross-section through the hypocotyl of the seedling; cotyledonary trace, *t*; traces from the first secondary leaf, *lt*.

FIG. 27. Cross-section through the base of the petiole of the cotyledon.

FIG. 28. Seedling dissected out of the seed; first secondary leaf, *l*; cotyledon, *c*.

Further studies of the orange rusts of Rubus in the United States

L. O. KUNKEL

(WITH FIVE TEXT FIGURES)

INTRODUCTION

The writer's previous studies of the orange rust, showing that the *Caeoma* spores in material from New York, Illinois, Missouri and Wisconsin (6, 7) germinate like teleutospores, left the question as to the relationships of *Puccinia Peckiana* Howe unsolved.

Fischer (5) has recently tested the germination of the aecidiospores of the European *Gymnoconia interstitialis* (Schlecht.) Lagerh. He obtained long germ tubes having all the characteristics of ordinary aecidiospore germ tubes. No promycelia were observed and no cross walls were to be seen in any of the tubes. In one case a thinner tube that resembled somewhat a long sterigma developed at the end of a germ tube. This he thinks may have been the result of growth disturbances. Fischer also made infection experiments and obtained *Puccinia Peckiana* by sowing the aecidiospores on supposedly healthy plants of *Rubus saxatilis*. His results, taken in connection with those of Tranzschel (13), Clinton (3), and Liro (9), give strong evidence in favor of the view that *Caeoma interstitiale* Schlecht. and *Puccinia Peckiana* are connected. Fischer (5) explains the seeming contradiction between his results and those of the writer by assuming that we have been working with two different fungi. According to this view there would be two orange rusts on the blackberries of America: one the aecidial stage of *Gymnoconia interstitialis*, the other a short-cycled rust closely related to the genus *Endophyllum*. So far as known the short-cycled rust, which we may refer to under the name *Caeoma nitens* Burrill, does not occur in Europe. The fact that there, both are limited to the same low-growing wild species of *Rubus* is evidence in favor of such an assumption. *Puccinia Peckiana*, however, is not uncommon in several different parts of America, and we must expect to find its aecidial stage in these localities.

If there are, then, two orange rusts on the blackberries of the United States it would seem highly interesting and important to study them side by side in order to determine whether in addition to the difference in the way their aecidiospores germinate there are to be found morphological differences between the two Caeomas. The object of this paper is to bring the evidence which shows that we have two orange rusts on the American blackberries and to give a brief comparison of the two forms which have previously been confused and supposed to be one and the same rust.

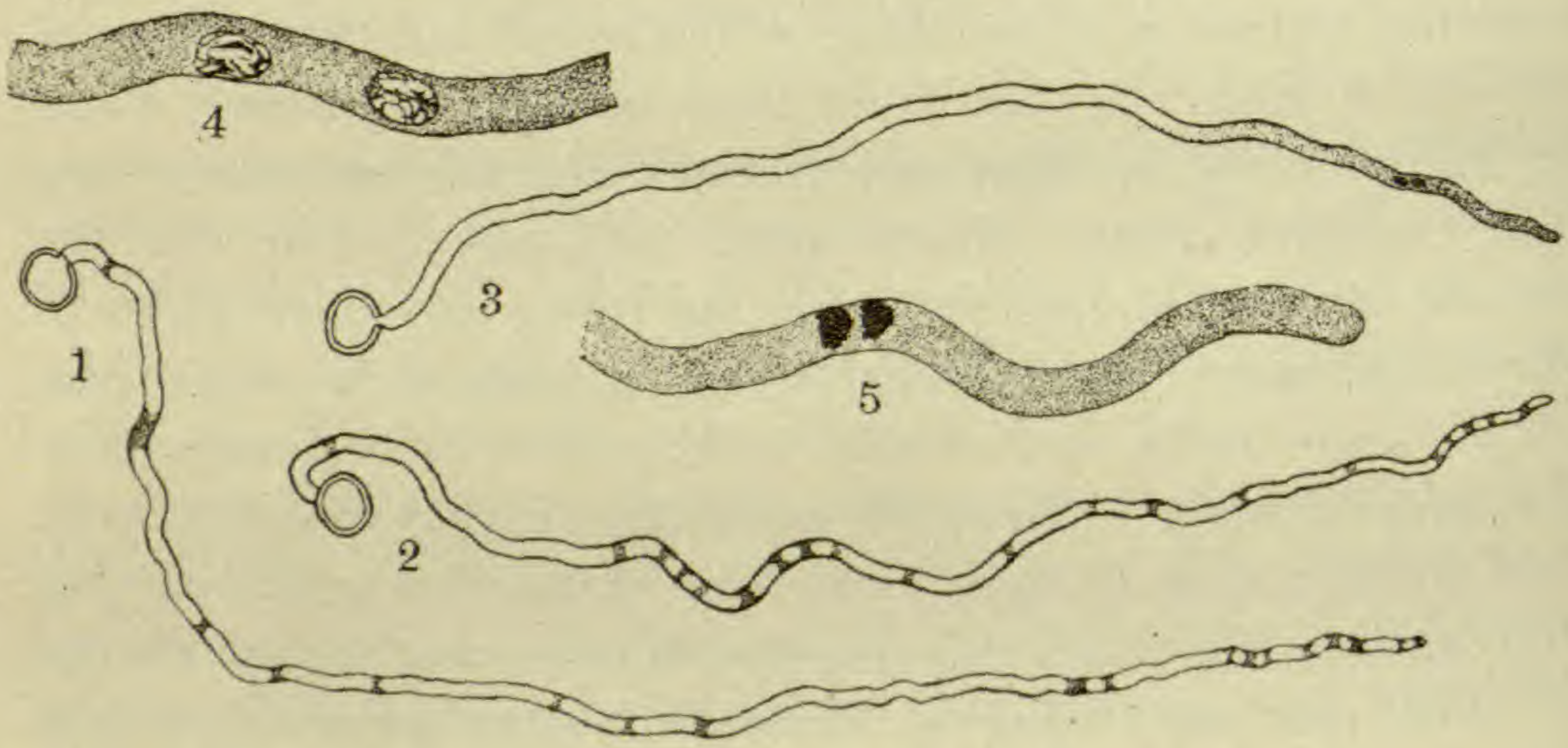
OBSERVATIONS

It was in the hope of obtaining material for testing Fischer's assumption that the writer, at the suggestion of and in company with Professor R. A. Harper, made a trip to the White Mountains of New Hampshire. Here in the vicinity of the village of Glen the writer had on two previous occasions marked spots where the wild blackberry plants were infected with *Puccinia Peckiana*. On visiting these spots June 28, 1916, we found the plants well infected with a *Caeoma*. So far as we were able to determine macroscopically this *Caeoma* had all the characteristics of *Caeoma nitens*. The young infected shoots were chlorotic and somewhat taller than the normal ones. Many of the infected leaves were more or less deformed just as may be observed in the case of plants diseased with *Caeoma nitens*. Spermogonia were present in great abundance. Several infected plants and a considerable number of well-infected leaves were taken to New York City. The plants were put into flower pots and placed in a greenhouse, the purpose being to find out whether they would produce teleutospores later in the summer.

In order to test the germination of the aecidiospores they were dusted over the surface of tap water in Petri dishes. Twenty-one cultures were thus made and incubated at room temperature (about 25° C.). In twenty-four hours most of the spores had germinated. They produced long germ tubes having all the characteristics of aecidiospore germ tubes. No cross walls were to be found and no branches that might be taken for elongated sterigmata. The twenty-one cultures of germinating aecidiospores were carefully observed under the microscope and in only one case must an exception be noted. One spore was found which had put forth a long germ tube that branched into two parts. On one of these branches two quite normal sporidia were borne on typically formed sterigmata. It is difficult to explain this case. Either the spore which gave the promycelium was a contamination or the aecidiospores of *Gymnoconia interstitialis* are in rare instances capable of functioning as teleutospores. The writer is inclined to the latter view.

In order to further test the germination of these aecidiospores a second sowing was made. This time the spores were dusted over the surface of three plates of tap water and three plates of Beyerinck agar. At the same time material of *Caeoma nitens* on *Rubus frondosus* Bigel. was brought into the laboratory from Van Cortlandt Park. These spores were also dusted over the surface of three plates containing tap water and three plates of Beyerinck agar. All of the cultures were made at the same time, on the same media and all were incubated at room temperature. A large percentage of the spores germinated in each of the cultures. The aecidiospores brought from New Hampshire produced long non-septate germ tubes that resemble in every way the germ tubes of other rust aecidiospores. Somewhat better germination was obtained on the agar than on the tap water, but the manner of germination was the same on the two media. The spores brought from Van Cortlandt Park gave practically one hundred per cent. germination and they produced in all cases promycelia.

Having used up all of the aecidiospores brought from New Hampshire in germination and inoculation experiments a second trip was made to Glen on July 7. This time the *Caeoma* was collected from three different localities and on two species of *Rubus*, namely, *Rubus canadensis* L. and *Rubus nigrobaccus* Bailey. Many cultures were made from the aecidiospores obtained from the three different localities. In each case a high per cent. of the spores germinated and they all produced long non-septate germ tubes like those shown in FIGS. 1 and 2. In order to study the nuclear behavior in the germ tubes a considerable quantity of germinating spores was fixed and stained according to a method outlined in an earlier paper (7). A study of the stained material shows that the long tubes typically contain two nuclei. These nuclei lie close together near the end of the tube as is shown in FIG. 3. Sometimes they are separated by a distance of two or three hundred microns but they are never very far apart. The close proximity of the nuclei suggests that these germ tubes would give rise to sporophytic mycelium. The bases of the tubes appear quite empty while the protoplasm shows more and more density as we pass toward their apices. This is well shown in FIG. 3. The nuclei are strikingly large. They often show almost as great a diameter as the tubes that contain them. In some cases they have the appearance of ordinary resting nuclei with a distinct nuclear membrane and blue staining chromatin strands. Such nuclei are illustrated in FIG. 4. In other cases, however, it is difficult to make out a nuclear membrane; the chromatin strands are quite dense and stain so deeply that the whole nucleus appears a dark blue color. Such nuclei are illustrated in FIG. 5. In no case have nucleoli been observed and nuclear division figures seem to be absent from the preparations. One tube was found that had three nuclei, but this is a very rare case. The length of the germ tubes, the presence of only two nuclei, the large size of the nuclei, the absence of division figures and the lack of septa are all char-



GYMNOCONIA INTERSTITIALIS (Schlect.) Lagerh.

FIGS. 1 and 2 show the long unbranched aecidiospore germ tubes as they appear in the living condition, × 175. FIG. 3 shows a germ tube stained; the two nuclei lie near the end of the tube where the protoplasm is dense, × 175. FIG. 4 shows the nuclei in the resting condition; nuclear membranes and chromatin strands are clearly seen, × 590. FIG. 5 shows the deep-staining nuclei; nuclear membranes are not to be observed and chromatin strands are indistinct, × 590.

acteristics which show that these spores in their germination function as aecidiospores. The appearance and behavior of the nuclei in the tubes is in striking contrast to what was observed in the study of the germination of the spores of *Caeoma nitens* (6, 7).

The germination tests show that the aecidiospores brought from New Hampshire function in an entirely different way from those collected in the vicinity of New York City. An experiment was next performed for the purpose of determining whether they would infect wild blackberry plants growing in this region and whether or not they would give rise to the teleuto-stage of *Gymnoconia interstitialis*. A number of plants of *Rubus villosus* Ait. and *Rubus argutus* Link found growing wild in the Bronx, New York City, were transplanted to flower pots and placed in a greenhouse. After they had recovered somewhat from wilting due to the cutting of the larger roots, nine plants of *Rubus villosus* Ait. and three plants of *Rubus argutus* Link, were placed in a moist chamber after being dusted with aecidiospores brought from New Hampshire. Unfortunately most of the spores had been used in the germination tests and only a limited quantity of the material was left for the infection work. An equal number of plants of each of the species used in this experiment were left uninoculated and served as checks. The plants were inoculated on the afternoon of July 1 and were left in a damp chamber for twenty-four hours. They were then placed in the open greenhouse beside the uninoculated plants. On August 15, all of the plants were carefully observed. One plant of *Rubus argutus* Link, was found to bear sori of *Puccinia Peckiana*. Only four leaves were infected but each of these showed numerous sori. All of the other plants appeared quite healthy and showed no signs of infection. It is difficult to understand why more of the plants inoculated did not become infected, but Liro (9) and Fischer (5) both report similar experiences with *Gymnoconia*. The check plants were all quite free of rust. Since *Puccinia Peckiana* has never been found on the blackberry plants in the vicinity of New York City we must assume that the plants brought into the greenhouse from the Bronx were free from this rust and that the infection obtained was the result of sowing the aecidiospores of the New Hampshire *Caeoma*. This experiment confirms the results of Tranzschel (13), Clinton

(3), Liro (9), and Fischer (5). Without a doubt, *Puccinia Peckiana* is the teleuto-stage of *Gymnoconia interstitialis.* The plants of *Rubus canadensis* L. that were brought here from New Hampshire bearing the *Caeoma* and planted out in flower pots were on August 15 found to be well infected with teleutospores of *Gymnoconia.* These results, together with the germination tests, seem to show conclusively that the orange rust common on wild blackberries in the vicinity of Glen, New Hampshire, is *Gymnoconia interstitialis.*

It seems proper to report at this point an infection experiment with *Caeoma nitens.* This experiment was performed in 1913 and 1914, but has not previously been reported. Sixteen plants of *Rubus villosus* Ait. found growing wild in Van Cortlandt Park were transplanted to flower pots and placed in a greenhouse. The plants were all quite free from rust infection and no infected plants were observed near where they were found growing. They were brought into the greenhouse the latter part of June. Ten of the plants were well dusted with the spores of *Caeoma nitens* and placed under bell jars for about one week. They were then placed in the open greenhouse. The other six plants were left uninoculated and were used as checks. No infection was observed on any of the plants during the summer and fall of 1913. In the spring of 1914, however, the young shoots of three of the plants that had been inoculated the preceding summer bore leaves well infected with *Caeoma nitens.* None of the check plants gave any infected shoots. The experiment shows that the spores of *Caeoma nitens* are capable of infecting new plants. It further shows that the *Caeoma* can reproduce itself without an intermediate stage. A similar experiment was performed in which the teleutospores of *Gymnoconia interstitialis* were used instead of the functional teleutospores (aecidiospores) of the short-cycled form. Ten plants of *Rubus procumbens* were inoculated by scraping teleutospores from mature sori with a wet knife blade and then smearing them over the surface of the leaves and young shoots. The plants thus inoculated were kept under bell jars for one week and then placed in the open greenhouse. They have been under observation for more than two years but the plants have not become infected. The viability of the spores was shown by germination tests and the writer is unable to explain why infection did not result. The experiment should be repeated.

After being fully convinced that the orange rust, so common around New York City, is functionally different from the one in New Hampshire a special effort was made to discover possible morphological differences between the two forms. Infected plants from the two sources were placed side by side and carefully compared. Special notice was taken of the color of the spores in mass, the size and distribution of the Caeomas, the effect on the host, etc. Material of both forms was fixed in Flemming's weaker solution, embedded in paraffin in the usual way, sectioned with a microtome and studied under the microscope. Spermogonia are abundant in both cases. Their form, size and distribution was noted as well as the size and shape of the spermatia. In both forms the aecidiospores are born in chains with intercalary cells. The spores from the two sources were compared as to size, shape, content, thickness of spore wall and spore wall markings. Fifty ripe aecidiospores from the New Hampshire material were chosen at random and measured along their greatest diameters. The average diameter for the fifty spores was found to be 25.25 μ. Fifty aecidiospores of *Caeoma nitens* were likewise chosen and measured in the same way. Here the average diameter was found to be 25.29 μ. The difference obtained is not great and may well be attributed to errors in making the measurements.

This comparative study has failed to disclose either macroscopic or microscopic morphological differences between the two rusts. So far as the writer has been able to observe both are exactly alike morphologically. Only after having germinated the spores is it possible to distinguish between the two forms.

DISCUSSION

The close morphological and pathological similarity between two apparently different rusts at once raises the question as to whether or not they are genetically related. Do we have here a case of parallelism or has one of the Caeomas been derived from the other? It is possible to conceive that two rusts living on the same hosts may after a time show similar morphological characteristics, but it is hard to think they would become so much alike as to be morphologically indistinguishable. If we consider only the life cycles of the two forms we find that they belong in groups that are rather widely separated in our classifications of the rusts. The short-cycled *Caeoma nitens* we would place near the genus *Endophyllum; Gymnoconia interstitialis* belongs near *Phragmidium.* Arthur (1) puts *Gymnoconia* in the Aecidiaceae while *Endophyllum* he places in the Uredinaceae. When we consider the two rusts from a morphological standpoint we find that in their *Caeoma* stage they are alike and we are inclined to consider them related forms. Werth (14) believes the aecidiospores of *Endophyllum Sempervivi* are capable of functioning either as aecidiospores or as teleutospores, according to the conditions under which they germinate. Maire (10) reports a variety of *E. Sempervivi* that regularly produces ordinary aecidiospore germ tubes. These suggestions are interesting in this connection and they deserve consideration in our studies of the two orange rusts. The finding of a basidium in cultures of the aecidiospores of *Gymnoconia interstitialis* offers a further suggestion and leads the writer to believe that the two rusts may be related. If a strain of the orange rust could be found in which some of the aecidiospores germinate by ordinary germ tubes while others produce promycelia the question as to the relationship of the two forms would be much clearer. An effort should be made to find such an intermediate strain.

The two Caeomas have undoubtedly been confused in this country. There is no way of knowing which rust Burrill (2) described as *Caeoma nitens* since it seems that both occur in the vicinity of Urbana, Illinois. Both are reported from Missouri and it is impossible to determine which form Newcombe and Galloway (11) used in their work. From their drawings of the germinating spores, however, one would guess that they had the short-cycled form. It is also probable that the material used by Olive (12) in his study of sexual cell fusions in the rusts was *Caeoma nitens*, but of this we can not be sure.

As one looks over the group of host species as given by Arthur (1) the question presents itself as to which ones are really host species for *Gymnoconia* and which ones are the host species of *Caeoma nitens.* This list undoubtedly includes the hosts of both rusts and it is not possible in any given case to determine with certainty which rust was collected. Since *Gymnoconia* occurs on *Rubus saxatilis* and *R. arcticus* in Europe it seems natural to assume that the *Caeoma* on related species in this country belongs to *Gymnoconia.* It is probable, therefore, that the orange rust on the low-growing *R. arcticus* L. of Yukon, *R. stellatus* Smith of Alaska, and *R. triflorus* Richardson or *R. americanus* Britton of New Hampshire and Wisconsin will prove to be *Gymnoconia.* The writer has collected *Gymnoconia* on *R. frondosus* Bigel., *R. canadensis* L. and *R. nigrobaccus* Bailey. These are all upright-growing species and it may be that the orange rust on many of the other upright species is *Gymnoconia.* The writer feels inclined to think, however, that *Caeoma nitens* is the more common of the two rusts and that it will prove to have a wider range of host species than *Gymnoconia.* According to Clinton (3) the *Caeoma* has been reported from Carolina, Connecticut, Georgia, Illinois, Iowa, Kansas, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Texas, West Virginia and Wisconsin while the teleuto-stage is reported from only four states: Illinois, Massachusetts, Missouri and New York. The orange rust in most of those states where the teleuto-stage has not been found is probably *Caeoma nitens.* New Hampshire, however, must be mentioned as an exception, since the rust common in that state has proven to be *Gymnoconia.* The fact that the orange rust is much more conspicuous than the teleuto-stage may to some extent account for its being more often reported. Only a careful study of the distribution and host limitations of the two forms in the several states can furnish grounds for definite conclusions. Nevertheless we may predict that the orange rust reported on *R. cuneifolius* Pursh, *R. occidentalis* L., *R. Randii* (Bailey) Rydb., *R. strigosus* Michx., *R. trivialis* Michx., *R. villosus* Ait., *R. vermontanus* Blanch. and *R. vitifolius* Cham. & Schlecht. is *Caeoma nitens.*

So far as is at present known the short-cycled orange rust does not occur in Europe. Before accepting this conclusion, however, a careful study of the manner of germination of the aecidiospores from various localities should be made. Special attention should be given to the *Caeoma* in those sections where the teleuto-stage of *Gymnoconia* has not yet been found. Lageheim's (8) suggestion, "dass das *Caeoma* sich reproduciren kann," is interesting in this connection. He writes: "Aus mehreren Gründen scheint es mir nun nicht unmöglich, dass die Aecidien unserer Gymnoconia sich zu reproduciren vermögen. Während dieselben nämlich an vielen Orten des europäischen und asiatischen Russlands, im nördlichen, mittleren und südlichen Schweden und bei München gefunden worden sind, so sind die dazu gehörenden Teleutosporen (in Europa) nur bei Kuikkjokk im Schwedisch-Lappland, bei St. Petersburg und Moskau beobachtet worden." The orange rust of Europe seems to be of no economic importance and so far as the writer knows has not been found on cultivated blackberries or raspberries. This suggests that the rust so often reported as doing great damage to cultivated blackberries and raspberries in the United States is the short-cycled form. The writer has twice collected the orange rust on cultivated blackberries and in both cases it proved to be *Caeoma nitens*. It would be an interesting experiment to determine whether *Gymnoconia* is capable of infecting our cultivated blackberries and raspberries. This and many other experiments that suggest themselves must be left for future studies. Questions as to which of the two forms is the more primitive and as to what environmental conditions may have led to the development of two rusts with such different life histories and yet so much alike morphologically must at present be left unanswered. Both forms deserve further study.

SUMMARY

1. There are two forms of the orange rust on the blackberries of the United States. One is the *Caeoma*-stage of *Gymnoconia interstitialis* (Schlecht.) Lagerh.; the other is a short-cycled rust with a life history like the Endophyllums as described by Arthur (1).

2. The two rusts are morphologically alike in their *Caeoma*-stage though so different in their life histories.

3. The germination of the *Caeoma* spores is in the one case (*Caeoma nitens*) teleutoid, in the other (*Gymnoconia interstitialis*) it is just as typically aecidioid.

4. It is impossible at present to determine in the numerous references to orange rust of blackberries which form was under

observation except in a few cases where germination tests or infection experiments were made.

5. The short-cycled *Caeoma nitens* seems more widespread in the United States than *Gymnoconia interstitialis*.

6. It seems to be the short-cycled form of the orange rust that is so destructive to our cultivated blackberries and raspberries in this country.

I wish to thank Professor R. A. Harper for much helpful advice and criticism in connection with this work.

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The flora of Ladak, Western Tibet. I. Discussion of the flora

RALPH RANDLES STEWART

(WITH TWO TEXT FIGURES)

INTRODUCTION

In the books that deal with the "Trans-Himalaya" region there is the greatest confusion in the way the term "Western Tibet" is applied. The term may mean any place from the arid region, north of Sikkim, to the Karakoram Mountains, on the road to Turkestan. The result is that when the record "Western Tibet" appears in Hooker's Flora of British India (**22**)* one knows very little about where the specimen really came from. Even when the name of the collector is given, the source of the specimen cannot always be determined, as several explorers travelled extensively. As a result, a number of the species mentioned in the check list in the second part of the present paper may not grow in Ladak, but they are listed for the sake of completeness.

The region with which this paper deals is properly called Ladak to distinguish it from the other parts of Little or Western Tibet. Its inhabitants are largely Tibetan Buddhists and its flora is closely related to that of Tibet proper, but it is under the political control of Great Britain, being a part of the dominions of the Maharajah of Kashmir. Hemsley and Pearson's list of the plants of Tibet (**20**) does not include those from this region.

In their Flora Indica (**23**) Hooker and Thomson limit Ladak to a narrow strip on each side of the Indus, but I shall follow Neve's Tourist Guide (1913 edition).† According to Neve:—"Ladak is a large tract of country including Rupshu, Zanskar, Nubra, as well as Middle Ladak, and the lofty plateaux south of the Karakoram. It contains the loftiest inhabited districts in the world. No part is below 9,000 ft. and a large portion of the population live at

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* The numbers refer to the Bibliography at the close of the second part of this paper.

† Neve, A. Tourist's guide to Kashmir, Ladakh and Skardo. 1913.

elevations of from 12,000 to 15,000 feet. While this is the height of the valleys and plateaux, the mountain ranges average from 17,000 to 21,000 feet and many peaks are 25,000 feet high."

In the check list of plants an effort has been made to list those reported from the region as given by Neve, using the "Great" or Snowy Range as the boundary on the Indian side, Baltistan on the west, the foot of the Karakorams on the north, Tibet on the east and also on the southeast.

One of the most characteristic features of Ladak is the Indus. The main caravan routes follow it or its branches and the villages are all placed so that they can get a little of its water for the fields. In fact, Ladak might be called the part of the drainage system of the Indus above 8,500 feet. The next lower part is called Skardo or Baltistan.

Contrary to the popular opinion, Tibet, including Ladak, is a very rugged country, rough, rocky and stony with countless mountain peaks and sandy desert valleys. The level places are either troughs between the mountains or the basins of extinct lakes. The further into the country one penetrates the more rounded are the hills and the gentler the slopes of the valleys, because of the smaller amount of erosion. There are many things that indicate that the Indus has been doing efficient work in clearing out the valleys near Kashmir, such as its deep gorges, the V-shaped valleys and the old marks of higher levels. Other great rivers are doing the same thing farther east.

Of the parts of Ladak visited, Rupshu is the least eroded. The whole country is above 15,000 feet and is extremely cold, barren and desolate. Springs are sometimes a day's journey apart and many valleys seem without any water. Many streams dry up before they reach a permanent river and in other places are shallow saline lakes, devoid of outlets. Despite its great altitude eighty flowering plants were found. There are practically no cryptogams. Both the flora and the topography resemble that of Tibet proper.

At the other extreme, Suru is supplied with much more water. The snow line is much lower and there are many streams and springs. The valleys in Suru are deep and the flora is more like that of Kashmir than that of Tibet. Dras is also more fertile than the rest of Ladak.

GEOLOGY

Although the geology of Ladak is not very well known, the following interesting facts are gathered from Burrard and Hayden (8):—

> "All the geologic series is reproduced in Tibet from almost the earliest till modern times. Tibet, counting everything behind the great Himalayan range, consists of more than 20,000 feet of sediments, almost entirely of marine origin and represented by such rocks as slate, sandstone, conglomerate and limestone. Along its southern border it is in contact with the Himalayan granite which throws out branches ramifying through and metamorphosing the sediments.
>
> "During almost all geologic time all of Tibet and the northern slope of the Himalayas was under a sea which at one time stretched to China and at another to the Mediterranean. The region kept subsiding and subsiding and later was elevated. In Cambrian times it is believed that Tibet and North America were joined, as the fossils are similar while they differ from those of Europe. At the close of the Cambrian this sea (the Tethys of Suess) linked up with the Palaeozoic sea of Europe.
>
> "Crystalline and metamorphic rocks, granite, gneiss and schist cover the greater part of northern Kashmir, including Baltistan and west to the mountains of Afghanistan. To the east they run through northern Ladak. In eastern Kashmir they constitute much of Zanskar."

In view of the agreement among geologists that the elevation of the Himalayas has taken place in very recent time, and that Tibet, including Ladak, was under a sea which piled up tremendous sedimentary deposits until the Tertiary period, the flora can not be considered an old one. Nevertheless, the Russian botanist, Maximowicz (27), who worked on the plants of the untiring Tibetan explorer Prejevalsky, says that the flora is extremely ancient.

As the Workmans and other travellers have remarked, Ladak and Baltistan are lands of rock ruin. In the summer the heat in the daytime is so intense and it is so cold at night that the mountains are cracked and crumbling and there are huge talus slopes at their feet. Even in the winter Moorcroft reports that the heat may be intense for an hour or two in the sun, making a great daily variation in temperature.

CLIMATE

Ladak is almost cloudless in the summer time and the glare from the bare rocks and the sand is so intense that travellers must wear smoked glasses and pith helmets and must take especial care to protect the skin. Sun temperatures are so high that it is a wonder that any plant can live out in the deserts. India is noted for its heat but the Workmans found that the sun temperatures in India rarely go to 170° F. At altitudes of 14,000–19,000 feet, however, they obtained maximum temperatures of from 183° to 204° F., although it was from 47° to 60° in the shade. The result is that one frequently finds it uncomfortably cool in the shade of a great rock while the sand is blazing hot in the sun.

The plants, therefore, that are not in damp places are exposed to extremes of temperature. This is true even in the winter time, for although a little snow falls, it does not lie long in the valleys. The missionaries at Khalotse, however, told us that the Indus remains frozen over during a part of the winter at least.

The growing season in Ladak is a very short one, even in the lower parts, and a traveller who visits the country only in July and August can therefore find the great majority of the species. There are several causes for this. In the first place, there is no rainy season to give birth to an ephemeral desert flora such as we have in the American Southwest. In the second place, plants that are in fruit at one altitude can be found in flower at higher altitudes. Further, most of the wild flora, excluding the annual weeds in the villages, is perennial and the leaves can be found even if the flowers are missing.

At Leh, Moorcroft reported that frosts began early in September and continued until May. Barley sown May 10th was cut September 12th. At Spituk, nearly 1,000 feet lower, he says that it took barley only two months to mature. Strachey says that in western Tibet elevations below 14,000 feet appear to be exempt from night frost for the greater part of the summer quarter. At 15,500 feet it freezes every night in the year. At 18,000–19,000 feet it thaws only during the afternoons of July and August. While we were in Rupshu in August we suffered greatly at night from the cold. One night half an inch of ice formed and the thermometer registered 21° F.

The country is practically without rainfall. The average at Leh is about three inches a year. Usually what precipitation there is falls at night and only on the mountain ridges and passes. A number of times in July and August we noticed that a light blanket of snow fell on the mountain tops while there was no precipitation in the valleys. This is the reason that up to a certain altitude the number of species tends to increase instead of decrease. Even passes like the Fotu and Namika that are not near perpetual snow have more plants near the summit than in the deserts that have to be crossed in the ascent.

BOTANICAL EXPLORATIONS

Considering its remoteness, Ladak has been visited by a surprisingly large number of explorers who collected plants. This is due to the fact that it is on the only practicable highway from India to Central Asia, since Afghanistan is closed, and because it has been the base of a great deal of Tibetan exploration.

Despite its many visitors and the abundance of meager references the only attempt to bring together the work of the different visitors is that of the Flora of British India by Hooker (**22**) and here of necessity the plants are scattered through the seven volumes in their natural arrangement. Hooker never visited the Northwest Himalaya himself but we would be lost without his book. When we use Hooker's volume we are tempted to complain of the indefiniteness of many descriptions, the lack of keys to genera, and the "lumping of species"; but when we consider that he has done for British India what no one has done for the United States we are thankful indeed.

It is probable that the first Europeans to visit our region were the Jesuits, Desideri and Freyre, who passed through Ladak in 1714 on their way to Lhassa, but they have given us no botanical information. It was not until the expedition of Dr. Moorcroft, from 1819 to 1825, that we learn anything first-hand. In 1812 he had gained experience by penetrating into Tibet and exploring the region of the sacred Lake Manasarowar. In 1819 he started with Trebeck and Guthrie in an attempt to open up Central Asia to British trade. He entered Ladak from Lahoul, crossing over the Baralacha Pass and penetrating to Leh *via* Rupshu. He desired to press on to Turkestan, but although he waited about two years he failed to get permission from the authorities because of the jealousy of the Kashmir merchants. During his stay, however, he took time to explore Nubra, Zanskar, Dras and other parts of the country. He was not a botanist but he took a keen interest in the agriculture of the people and the plants that might be useful elsewhere. Though his book (29) is nearly a hundred years old it is the best account of the crops and methods of cultivation. The few specimens he collected were sent to Wallich or Royle.

Vigne (38), who visited Kashmir, Astor, Skardu and Ladak in 1835, collected ninety species, but some were in such bad shape that Royle could not determine them.

Falconer, who was in charge of the Saharunpur Gardens, collected a little later (1839?) in Kashmir and Baltistan but he does not seem to have penetrated into Ladak any further than Dras.

The best collecting that has been done was probably by Thomas Thomson (36, 37), from 1847 to 1848. He was botanist to the Tibetan Boundary Commission appointed by Lord Hardinge. Captain Henry Strachey, another keen observer, was in charge of the survey. Western Tibet was explored from Spiti to the Karakorams and large collections were accumulated which were widely distributed. Most of the Ladak specimens in the herbarium of the New York Botanical Garden were collected at this time.

In 1848, Richard Strachey (35) with J. E. Winterbottom, visited Lake Manasarowar and explored the Tibetan course of the Sutlej. This is really outside of Ladak but the flora is much the same. The next year, with his brother Henry, Richard Strachey went in from Ladak and explored Hanle and the Tibetan province of Guge. We are indebted to these three men for a great deal of valuable botanical and geographical information.

From 1855 to 1857 the Schlagintweit brothers (32) visited the Himalayas, crossing Ladak and going into Tibet. They were not botanists but they collected plants carefully and their collections have been worked up by different specialists.

About 1862, while on a pleasure trip, William Hay made a collection of Rupshu plants to which Hooker had access He does not seem to have published anything.

J. L. Stewart (33), about 1868, made a botanical tour through Rupshu and Ladak. Although he mentions some of his findings in his publications he did not publish a complete list.

In 1873 Henderson and Hume (21), members of the Forsyth Mission, published a list of four hundred and twelve plants collected in Ladak and Yarkand. About two hundred and seventy-six of these are definitely listed from Ladak.

A great deal of our knowledge of the plants of Gilgit, Skardu, and the Karakoram is due to C. B. Clarke (12), although he does not seem to have done much, if any, work in Ladak proper.

J. F. Duthie crossed the Zoji in July, 1893, visited Dras, the Deosai Plains, and went back to Kashmir *via* Bandipur. In his reports (16) he does not list many of the plants he found.

A. Meebold entered Ladak from Kashmir *via* the Bhot Khol Pass in 1905 and explored parts of Suru, the Kangi region, and the road to Dah. He visited Leh and the Khardong, and has published interesting lists of plants (28).

A number of other men who collected in Ladak did not publish anything of their findings. Among these are Lance, Cayley, Stoliozka, and the Moravian missionaries, Heyde and Jaeschke. Hooker had access to most of these collections. Mention should also be made of the illustrated works of Royle (31), Jacquemont and Hoffmeister. The last two did not live to reach Europe and complete their work but Jacquemont's plants were published by Cambessedes and Decaisne (9), while Klotsch and Garcke (25) completed the work of Hoffmeister. Although none of these men visited Ladak they explored adjacent regions and their books are therefore very useful.

Recent lists of plants by Conway, Deasy, the Workmans and De Filippi of the Abruzzi expedition give us a good idea of the flora of the Baltistan and Karakoram region and are useful for comparison. The paper by Hemsley and Pearson on the Flora of Tibet (20), which covers the work of Thorold, Prejevalsky, Hedin and the other Tibetan explorers, is very valuable.

My own work was undertaken in 1912 and 1913. It covers Dras, Suru, Middle Ladak as far up the Indus as Upshi, and the region of Rupshu. The only districts that do not seem to have been collected in before are the Sapi, Rusi, and Yarungshan Passes in Suru and the obsolete road from Bosgo to Khalotse, *via* Tingmogung.

Itinerary of my trips.—I entered Ladak July 18, 1912, with three other men. We crossed the Zoji Pass (11,500 ft.) from Kashmir and followed the main caravan road to Leh (11,500 ft.), arriving there July 30. August 2 we climbed to the Khardong Pass (17,500 ft.) but a snowstorm made it impossible to see what grew near the summit. This was the highest point reached in 1912.

Leaving Leh we returned to Kashmir by another route. From Bosgo we took the old and higher road *via* Timisgam and Tingmogung, rejoining the new road at Khalotse. August 14 we left the main path below Moolbeck and turned off toward Suru, crossing the Sapi La (16,000 ft.) on the 16th and visiting the Pakartse on the 19th. The 21st we crossed the Yarungshan La (15,500 ft.) and returned to Kashmir via the Wardwan Valley.

With another party I returned to Ladak in the same way (*via* the Zoji) in 1913 and arrived at Leh by the end of the month of July, staying a week in the vicinity. August 6th we started on up the Indus, passing the famous Himis Monastery and leaving the Indus at Upshi in order to visit Rupshu, reputed to be the highest inhabited part of the world. The inhabitants are nomads, depending for their livelihood on their herds of yaks, goats and sheep. From Gya we ascended the Takalung La (17,500 ft.) and descended to the plains that seem to be the favorite home of the wild ass, *Equus kyang*, and the Tibetan hare. August 9, we visited the salt lake called the Tsokar, one of the many Central Asian lakes without an outlet. August 12, we crossed the Lachalung La (16,600 ft.) and the Baralacha (16,000 ft.) the 15th, arriving in Kyelang, the main village of Lahoul, the next day. Thence *via* the Rotang and Kulu we went on to Simla.

Travelling on foot we covered about 400 miles in Ladak each summer. Not many novelties were found, though four or five things seem to be new. In order to make sure a trip to Calcutta or Kew would be necessary. With the exception of a few from Kargil (8,700 ft.) my specimens, which amount to about 475 species, were gathered at altitudes of from 9,000 to 17,500 feet.

FLORISTICS

Though the flora on the Indian side of the "Great range" of the Himalayas, which separates Kashmir from Ladak, is luxuriant and abundant, the opposite is true on the other side. In Kashmir, forests with *Betula utilis* at the upper limit are found up to about

13,000 feet but there is no forest in Ladak. Trees will grow when they are irrigated, or in a rare spot where they can find water naturally, but they form a very small part of the covering of the country.

Between Kashmir and Ladak there is, to be sure, a transition zone which is possibly widest in the Suru region, Himalayan alpine plants being found where there is water far into the heart of Tibet. Taking the flora as a whole, however, there could hardly be a more pronounced contrast than between these two regions. This is due not to altitude but entirely to water relations. The high mountains stop the rain-laden clouds and very little moisture gets across. Wherever there is enough water from melting snow, which can be led out by irrigation ditches to carefully prepared terraces, crops and trees flourish. Wheat or barley may be growing on one side of an irrigation ditch while desert plants are on the other. These ditches are prepared with great care and run along the hillsides for long distances. They are conspicuous objects because of the border of grass due to the extrat moisture.

FIG. 1. An oasis in the Rupshu region, altitude about 15,000 feet.

There are, as Meebold also notes, three main elements in the flora of Ladak, alpine, desert and oasitic. These three are very easily recognizable and separable. The alpine element is largely confined to narrow belts below the melting snows and along the upper courses of the streams and does not spread out into the valleys. The main part of the country is desert with a flora that connects up with Turkestan more than it does with India. The flora of the oasis (FIG. 1) is cosmopolitan. A few things like *Lancea tibetica*, *Pedicularis longiflora*, and species of *Gentiana*, which grow out in the desert if there is water, are indigenous without doubt, but most of the plants are weeds that may be native but are probably introduced. When a country has been settled as long as parts of Central Asia it becomes difficult to tell what the indigenous flora is.

If one unfamiliar with Ladak were to read through a systematic list of the species growing there he would suppose that the flora as a whole was mesophytic. This is chiefly because of the large number of weeds growing in the villages. As a matter of fact, most of the country is desert, but the number of truly xerophytic species is not proportionately large.

FOTU LA AND NAMIKA LA*

The following list of the plants collected on and near the barren Fotu and Namika Passes gives an idea of the type of plants that are found out in the open, away from the villages, at altitudes of from 10,000 to 13,000 feet. Even in this list there are a good many, such as the buttercups, the species of *Triglochin*, the gentians, the dandelion and the saxifrages, that grow only near springs in the desert.

Funaria submicrostoma
Ephedra Gerardiana
Triglochin palustris
" *maritima*
Pennisetum flaccidum
Agrostis alba
Bromus tectorum
Polygonum aviculare
Atriplex crassifolia
Eurotia ceratioides
Kochia prostrata
Silene Moorcroftiana
Ranunculus Cymbalaria
" *pulchellus*
Corydalis flabellata
Lepidum latifolium
Sisymbrium Columnae
Christolea crassifolia
Sempervivum acuminatum
Saxifraga sibirica
Potentilla anserina
" *bifurca*

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* The Tibetan word "La" signifies Pass.

Potentilla multifida
Rosa Webbiana
Caragana pygmea
Astragalus Munroi
" *macropterus*
" *nivalis*
Oxytropis cachemirica
Epilobium Royleanum
Bupleurum falcatum nigrocarpa
Ligusticum Thomsoni
Primula sibirica
Androsace villosa
Acantholimon lycopodioides
Gentiana humilis
" *serrata*
Pleurogyne Thomsoni
Cynanchum acutum
Lindelofia Benthami
Eritrichium strictum?
Nepeta floccosa
Stachys tibetica
Lancea tibetica
Pedicularis longiflora
Rubia tibetica
Lonicera spinosa
Aster tibeticus
Erigeron andryaloides
Leontopodium alpinum
Chrysanthemum Richteria
Cousinia Falconeri
Scorzonera divaricata
Taraxacum officinale

Suru, Yarungshan La, Sapi La, and Rusi La

Along the transition zone between Kashmir and Ladak almost any Kashmir plant that will live above 10,000 feet may be found, especially in Suru. Most of the plants are alpine mesophytes. Only 10 per cent. of these were also found in Rupshu, and they are forms like *Delphinium Brunonianum*, *Potentilla bifurca*, *Leontopodium*, *Taraxacum*, and *Aster heterochaeta*, which are widespread at high altitudes. Most of the plants in my list, that do not seem to have been reported before from Ladak, are from this transition region and are common Kashmir types. Examples are *Podophyllum Emodi*, *Lavatera Kashmiriana*, species of *Impatiens*, *Lotus corniculatus*, and *Astragalus frigidus*. The same may be said of the species from this region which were first collected by Meebold.

Coming from Kashmir, Meebold was impressed with the barren, Tibetan aspects of Suru, but going in the other direction later in the summer I was struck by the greater amount of green on the hillsides. While there are no forests and few trees, except willows, *Juniperus* and *Lonicera glauca*, there is much more herbaceous vegetation than in the rest of Ladak and everything indicates more moisture. This increased water supply is no doubt due to the presence of the Nun Kun peaks and glaciers. The greater cloudiness, too, probably prevents the ground from drying out the way it does further into Ladak.

A list of plants from this region is given below. Definite stations will be cited in the second part of this paper.

Bryum tibeticum
Cystopteris fragilis
Juniperus macropoda
Ephedra Gerardiana
Andropogon Ischaemum
Panicum miliaceum
Phleum alpinum
Alopecurus himalaicus
Agrostis alba
Trisetum subspicatum
Poa annua
" *nemoralis*
Elymus dahuricus
Carex rigida
Juncus membranaceus
Salix daphnoides?
Polygonum affine
" *polystachyum*
" *tortuosum*
Axyris amaranthoides
Stellaria graminea
Arenaria Griffithii
" *foliosa*
Silene vulgaris
" *tenuis*
Lychnis apetala
" *nutans*
" *himalayensis*
Dianthus anatolicus
Aquilegia vulgaris pyrenaica
Delphinium Brunonianum
" *cashmirianum*
Aconitum heterophyllum
Aconitum Napellus multifidum
Anemone rupicola
Ranunculus pulchellus
" *hirtellus*
Podophyllum Emodi
Corydalis Gortschakovii
Thlaspi arvense
Draba glacialis
" *alpina*
Chorispora sabulosa
Sedum Rhodiola
" *asiaticum*
" *Ewersii*
" *tibeticum Stracheyi*
Sempervivum acuminatum
Saxifraga cernua
" *Hirculus indica*
" *Jacquemontiana*
" *flagellaris*
" *Stracheyi*
Ribes orientale
Potentilla Sibbaldi
" *fruticosa Inglisii*
" *bifurca*
" *argyrophylla*
Rosa Webbiana
Thermopsis inflata
Astragalus tibetanus
" *melanostachys*
" *himalayanus*
" *coluteocarpus*
" *frigidus*
" *rhizanthus*

Astragalus subulatus
Lotus corniculatus
Hedysarum microcalyx
Cicer songaricum
Geranium collinum?
Impatiens brachycentra
" *Thomsoni*
Lavatera kashmiriana
Hypericum perforatum
Epilobium latifolium
" *angustifolium*
Chaerophyllum acuminatum
Trachydium Roylei
Pleurospermum Candollii
Bupleurum falcatum
Acantholimon lycopodioides
Primula Stuartii
Androsace villosa
Gentiana Moorcroftiana
" *aurea*
" *tenella*
" *carinata*
" *decumbens*
Pleurogyne carinthiaca
Swertia cordata
" *patiolata*
Cuscuta capitata
Myosotis sylvatica
Scutellaria prostrata
Nepeta discolor
" *leucolaena*
Dracocephalum nutans
Phlomis bracteosa
Lamium album
Origanum vulgare
Elsholtzia densa
Verbascum Thapsus
Scrophularia scabiosaefolia
Lagotis glauca
Veronica deltigera
Pedicularis tenuirostris
" *bicornuta*
Galium verum
" *boreale*
Lonicera glauca
" *asperifolia*
" *microphylla*
Campanula latifolia
" *aristata*
Aster heterochaeta
Erigeron alpinus multicaulis
" *alpinus uniflorus*
Leontopodium alpinum
Anaphalis nubigena
" *virgata*
Inula barbata
" *rhizocephaloides*
Chrysanthemum Richteria
Tanacetum artemisioides
Allardia glabra
" *nivea*
" *tomentosa*
" *Stoliczkai*
Artemisia amygdalina
" *salsoloides*
Senecio chrysanthemoides
" *arnicoides frigida*
Cremanthodium Decaisnei
Arctium Lappa
Saussurea Jacea
" *albescens*
" *sorocephala*
Jurinea ceratocarpa
" *ceratocarpa depressa*
Koelpinia linearis
Tragopogon pratense?

Taraxacum officinale parvulum
Lactuca Scariola?
Lactuca decipiens

BARALACHA LA

Farther east, where Rupshu adjoins Lahoul, the plant life is very scanty because of the great altitude and because conditions of rainfall are very different from those in Suru. Lahoul itself is the transition zone to the luxuriant flora of the outer Himalaya. On the Baralacha Pass (16,000 ft.) scarcely twenty species were noticed, as shown by the following list. On each side of the Pass there is a very cold alpine lake that seems too icy for plant life. As early as 1820 Moorcroft wrote quaintly of one of them:—"Not a weed deformed its pellucid and tranquil waters. There seemed to be no fish in it, nor was any bird or even a fly in its vicinity."

Carex nivalis
Oxyria digyna
Polygonum cognatum
"   *affine*
"   *molliaeforme*
Stellaria decumbens
Silene Moorcroftiana
Dianthus anatolicus
Ranunculus hirtellus
Meconopsis aculeata
Corydalis meifolia
Draba lasiophylla
Sedum Rhodiola
Saxifraga sibirica
Potentilla fruticosa pumila?
"   *argyrophylla leucochroa*
Nepeta glutinosa
Allardia tomentosa
Werneria nana affinis

RUPSHU

As mentioned earlier, the most Tibetan part of Ladak visited was Rupshu. Plants must grow there to an elevation of fully 18,000 feet, for we found half a dozen species at 17,500 feet. All of the plants listed, with possibly two or three exceptions, grew above 15,000 feet. Species of *Oxytropis*, *Potentilla*, and *Nepeta*, *Sedum tibeticum Stracheyi*, *Aster heterochaeta*, *Elsholtzia pusilla*, *Delphinium Brunonianum* and *Caragana pygmea* grew at the upper limit of plant life. On hillsides *Caragana* was the most conspicuous and abundant plant, spreading out on the ground in the way juniper does in the northeastern United States (FIG. 2). It furnishes the chief fuel in these lofty regions. The *Delphinium* is also a conspicuous plant with much the largest leaves and flowers of any plant near the top of the passes. The blades of its leaves may be two inches in diameter. The wild rhubarb is the only Rupshu plant with good sized leaves. They are thick and very coriaceous.

The wind on the passes is so terrible that the plants that grow on the very top are prostrate and scarcely an inch high with very small leaves and flowers. Examples are *Oxytropis densa*, *Potentilla bifurca*, *P. sericea* and *Nepeta longibracteata*.

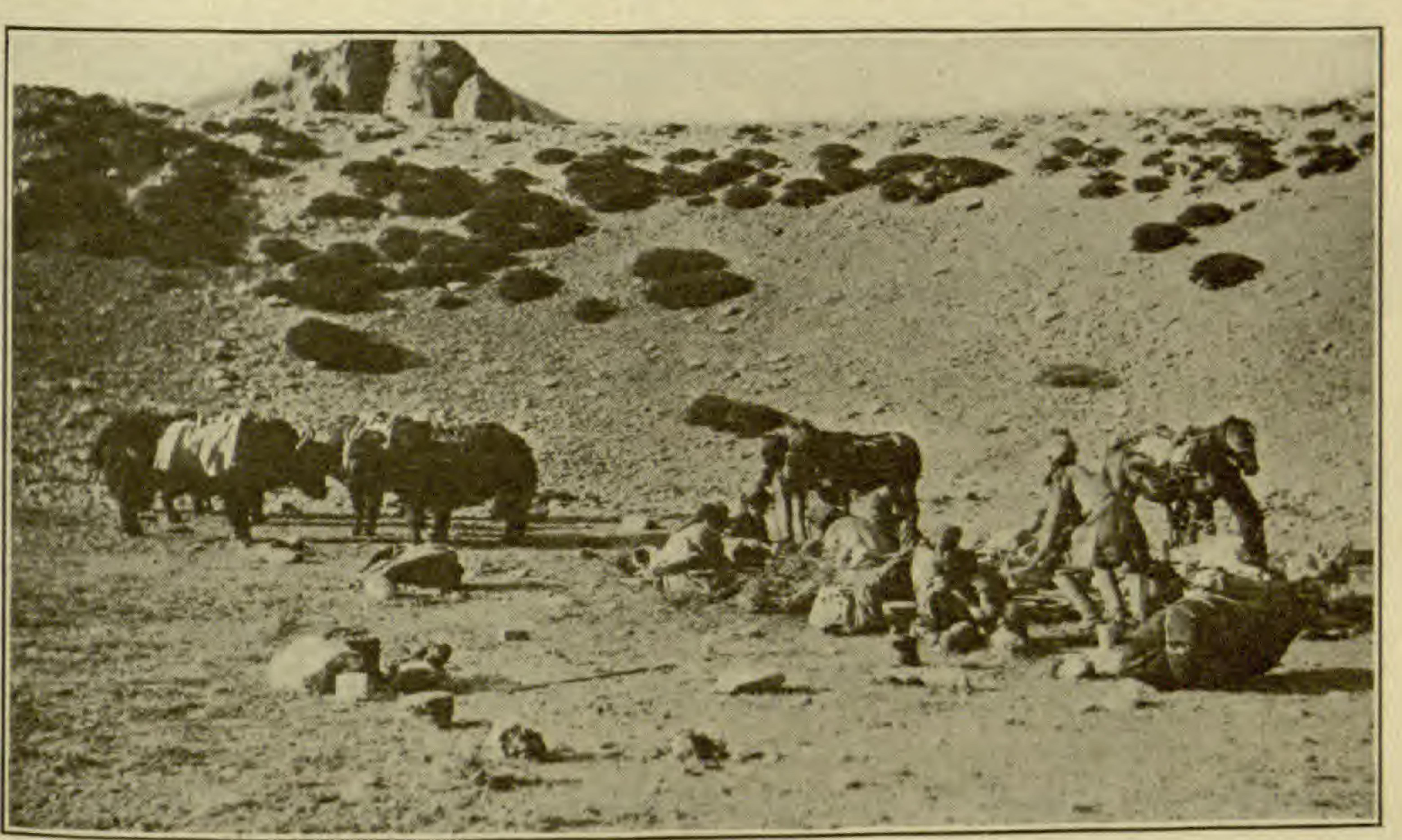

FIG. 2. A shrubby pea, *Caragana pygmea* DC., the only conspicuous plant in large sections of Western Tibet, above an altitude of 14,000 feet.

Potamogeton pectinatus
Triglochin maritima
Stipa barbata
Deschampsia caespitosa
Poa pratensis
" *nemoralis ligulata*
Festuca rubra
Bromus crinitus
" *barbatus*
" *macrostachys*
Kobresia schoenoides
Carex Moorcroftii
Urtica hyperborea
Rheum spiciforme
Polygonum tortuosum
Polygonum sibiricum
Chenopodium album
Atriplex crassifolia
" *rosea*
Eurotia ceratioides
Salsola collina
Stellaria graminea
Arenaria musciformis
" *holosteoides*
Lychnis macrorhiza
" *brachypetala*
Isopyrum grandiflorum
Aquilegia vulgaris viscosa
Delphinium Brunonianum
Ranunculus pulchellus

Hypecoum leptocarpum
Corydalis crassifolia?
" *stricta*
Lepidium capitatum
Arabis tibetica
Alyssum canescens
Braya alpina
Christolea crassifolia
Sedum tibeticum Stracheyi
Sempervivum acuminatum
Saxifraga Hirculus indica
Potentilla tetrandra
" *fruticosa ochreata*
" *ambigua*
" *bifurca*
" *multifida*
" *sericea*
Caragana pygmea
Oxytropis densa
" *lapponica*
" *microphylla*
" *tatarica*
Biebersteinia Emodii
Pleurospermum stellatum
Primula sibirica
Gentiana aquatica
Marrubium lanatum
Nepeta longibracteata
" *nivalis*
" *tibetica*
Dracocephalum heterophyllum
Thymus Serpyllum
Elsholtzia pusilla
Veronica ciliata?
Rubia tibetica
Galium pauciflorum
Lonicera spinosa
Aster heterochaeta
" *tibeticus*
Leontopodium alpinum
Anaphalis nubigena
Tanacetum fruticulosum
Artemisia minor
Senecio arnicoides frigida
Werneria nana
Saussurea bracteata
" *glanduligera*
Taraxacum officinale
" *officinale parvulum*

Native and naturalized species of the eastern United States occurring in Western Tibet

In comparing the flora of Ladak with a distant flora like that of the eastern United States there are many more similarities than one would suspect and it is possibly worth while to make a list of species that are common to both countries. Plant lists do not, of course, give a picture of a region, and the aspect of the two countries is absolutely different, but there are enough things similar to make an American feel somewhat at home.

At least 140 of the plants of Ladak, which amount to about 825 forms, occur here in America, too, but when one comes to examine them it appears that no less than 85 are weeds and not native. As mentioned before it cannot be stated how many are introduced in Ladak. When one looks at the list of those that are native here it appears that nearly all are plants that like a great deal of water. An abundance of moisture is a great equalizer of environments and plants like Potamogetons, *Lemna* and Triglochins are very cosmopolitan. A smaller group consists of wide ranging temperate plants. There are therefore three groups of plants native to both countries: weeds, water-loving plants, and a few temperate cosmopolitan types.

Native species

Cystopteris fragilis
Equisetum arvense
Juniperus communis
Potamogeton pectinatus
" *perfoliatus*
Zannichellia palustris
Triglochin maritima
" *palustris*
Milium effusum
Deschampsia caespitosa
Phragmites communis
Koeleria cristata
Catabrosa aquatica
Poa alpina
" *pratensis*
" *nemoralis*
Festuca rubra
Scirpus pauciflorus
" *rufus*
Eleocharis palustris
Carex stenophylla
" *rigida*
" *Goodenovii*
Lemna minor
Oxyria digyna
Polygonum aviculare
" *viviparum*
Polygonum Hydropiper?
Chenopodium hybridum
Corispermum hyssopifolium
Salsola Kali
Sagina procumbens
Ranunculus Cymbalaria
" *aquatilis*
Barbarea vulgaris
Cardamine pratensis
Braya humilis
Sedum Rhodiola
Saxifraga oppositifolia
Parnassia palustris
Potentilla Sibbaldi
" *Anserina*
" *fruticosa*
Astragalus alpinus
Epilobium angustifolium
Hippuris vulgaris
Primula farinosa
Glaux maritima
Limosella aquatica
Veronica Anagallis-aquatica
Utricularia minor
Plantago major
Galium Aparine
" *boreale*

NATURALIZED SPECIES

Panicum miliaceum
Setaria viridis
Heleochloa schoenoides
Alopecurus pratensis
Polypogon monspeliensis
Agrostis alba
" *canina*
Aira caryophyllea
Avena fatua
Eragrostis minor
Briza media
Dactylis glomerata
Poa annua
Festuca Myuros
Bromus tectorum
" *japonicus*
Lolium perenne
Agropyron repens
Salix alba
" *fragilis*
Populus alba
" *candicans*
" *nigra italica*
Urtica dioica
Parietaria debilis
Morus alba
Rumex Acetosa
Polygonum lapathifolium
" *Persicaria*
" *Convolvulus*
Chenopodium album
" *glaucum*
" *Botrys*
Atriplex rosea
Stellaria glauca
" *graminea*
" *media*
Cerastium vulgatum
Arenaria serpyllifolia
Dianthus deltoides
Saponaria Vaccaria
Aquilegia vulgaris
Berberis vulgaris
Lepidium ruderale
Sisymbrium Sophia
" *Thalianum*
Brassica juncea
" *nigra*
Sedum Rhodiola
Ribes Grossularia
Pyrus Malus
Trifolium pratense
Medicago falcata
" *sativa*
" *lupulina*
Melilotus alba
" *officinalis*
Lotus corniculatus
Geranium pratense
" *sibiricum*
Erodium cicutarium
Tribulus terrestris
Malva verticillata
Carum Carvi
Pimpinella Saxifraga
Convolvulus arvensis
Cuscuta europaea
Lithospermum arvense
Lycopsis arvensis
Lamium amplexicaule
Thymus Serpyllum
Mentha longifolium
Verbascum Thapsus
Veronica Beccabunga

Veronica agrestis
Galium verum
Gifola germanica
Tussilago Farfara
Arctium Lappa
Carduus nutans
Cnicus arvensis
Tragopogon pratense
Taraxacum officinale
Sonchus oleraceus
Lactuca Scariola

GENERA BEST REPRESENTED IN WESTERN TIBET

When we come to look at the commonest genera in Ladak, we find that only two are not represented in the eastern United States. These are members of the Compositae, *Allardia* and *Suassurea*. In addition, we have no native species of *Dianthus* or *Nepeta*. It is interesting to note that the genera such as *Tanacetum*, *Artemisia*, *Astragalus* and *Oxytropis*, which are more numerous in Ladak than in the eastern United States, are genera which are common in the Russian parts of Central Asia.

*Stipa**
Poa
*Bromus**
Festuca
Scirpus
*Kobresia**
Carex
Juncus
*Allium**
Populus
Salix
Polygonum
Chenopodium
Stellaria
Arenaria
*Dianthus**†
Ranunculus
Thalictrum
*Corydalis**
*Sisymbrium**
*Draba**
*Geranium**
*Sedum**
Saxifraga
Potentilla
*Astragalus**
*Oxytropis**
Epilobium
*Primula**
*Androsace**
*Gentiana**
*Nepeta**†
Veronica
*Pedicularis**
Lonicera
Galium
Campanula
Erigeron
*Inula**
*Tanacetum**
*Allardia**†
*Artemisia**
Senecio
*Saussurea**†
Lactuca

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* More species in western Tibet than in the eastern United States.

† No native species in the eastern United States.

PLANT ASSOCIATIONS

From the foregoing we have seen that most of Ladak is covered by open desert associations with bare ground between the individual plants. Many hillsides have so little soil and the summer heat is so intense that there is scarcely any vegetation at all. Sometimes a plant that would otherwise be sure to be eaten off can find a refuge beneath a thorny bush of *Caragana*, but as a rule they stand alone or in tufts.

Occasionally we find a modification of the desert flora. Where there is a spring on the mountainside and the water cannot drain away readily we get a continuous sod and a typical association of *Pedicularis longiflora* and species of *Triglochin*, *Carex*, *Gentiana*, and *Taraxacum*. The ground is often boggy in such situations and the water may be alkaline.

Alpine meadows are rare except in the transition zone near Kashmir. The places along the streams that may have been meadows ages ago have been made to grow a few food plants. Usually the streams are so swift that they are bounded by steep banks and there is very little opportunity for plants to gain a foothold or for a sod to form.

The oases which surround the villages contain practically the only trees, and these, with the exception of the *Hippophaë*, which is frequently used for hedges, are practically all introduced. The commonest trees are willows, poplars, walnuts, mulberries, apples and apricots. Small groves of the native juniper, *Juniperus macropoda*, are sometimes found. The commonest crops are barley, wheat and buckwheat. Our common garden vegetables do well and so do many of our common garden weeds.

Although there are no forests in Ladak, there are frequently thickets along streams and on little islands in the rivers. These have a typical association of the *Myricaria*, *Hippophaë*, *Rosa* and *Clematis orientalis*. These furnish shade for more delicate plants, such as species of *Veronica* and *Epilobium*.

INDEX TO AMERICAN BOTANICAL LITERATURE

1912-1916

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 the broadest sense.

Reviews, and papers that 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.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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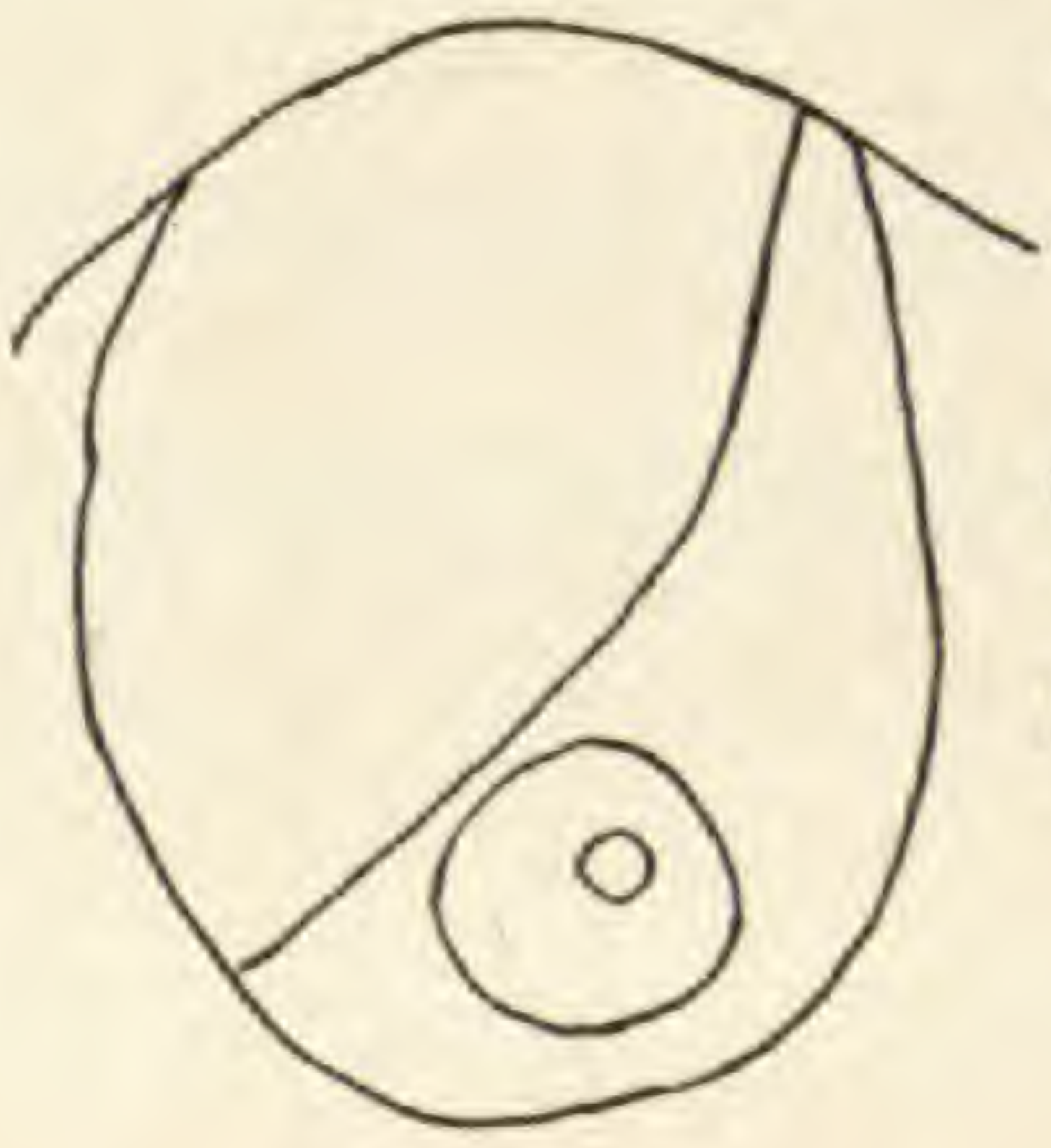

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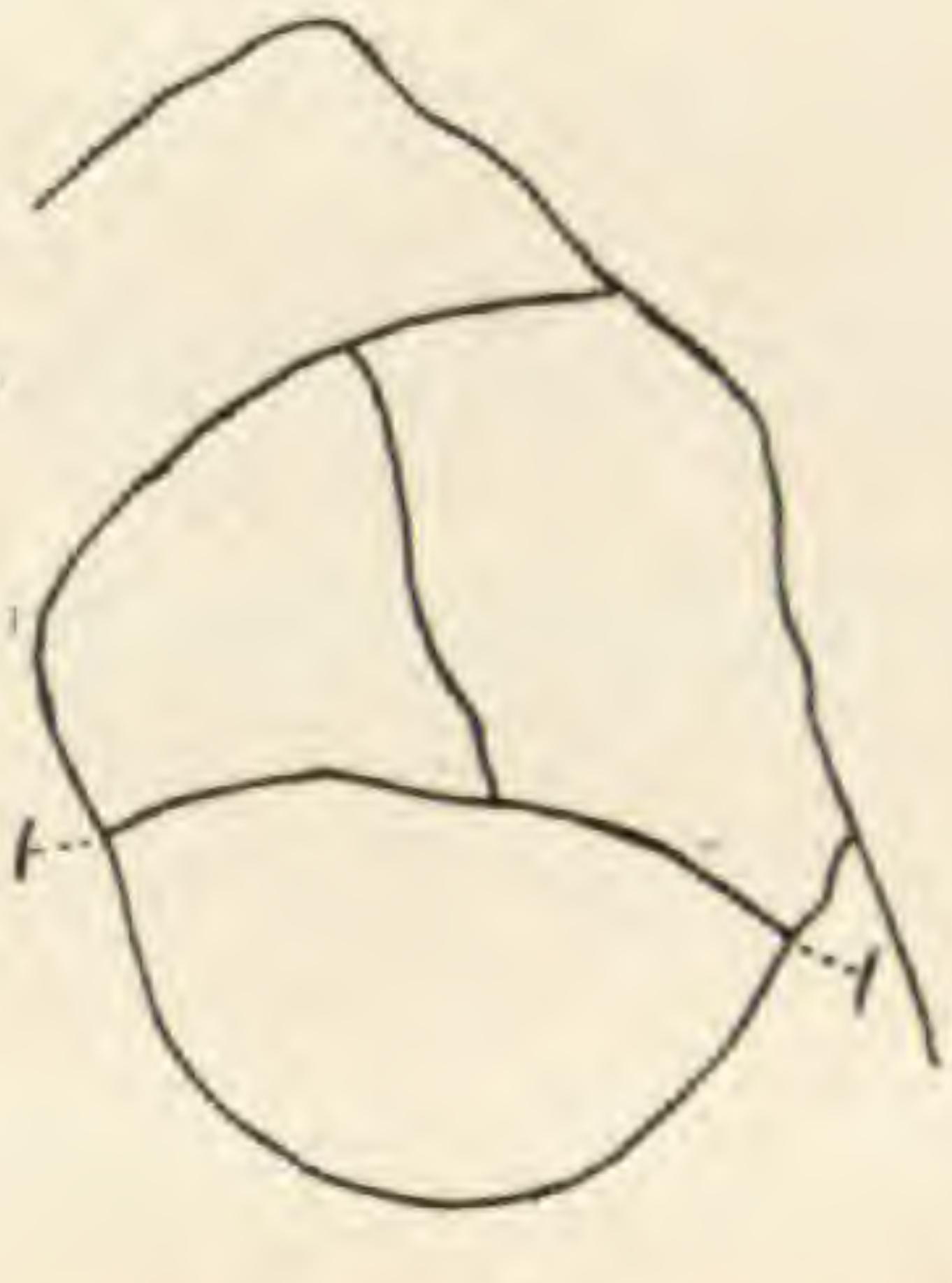

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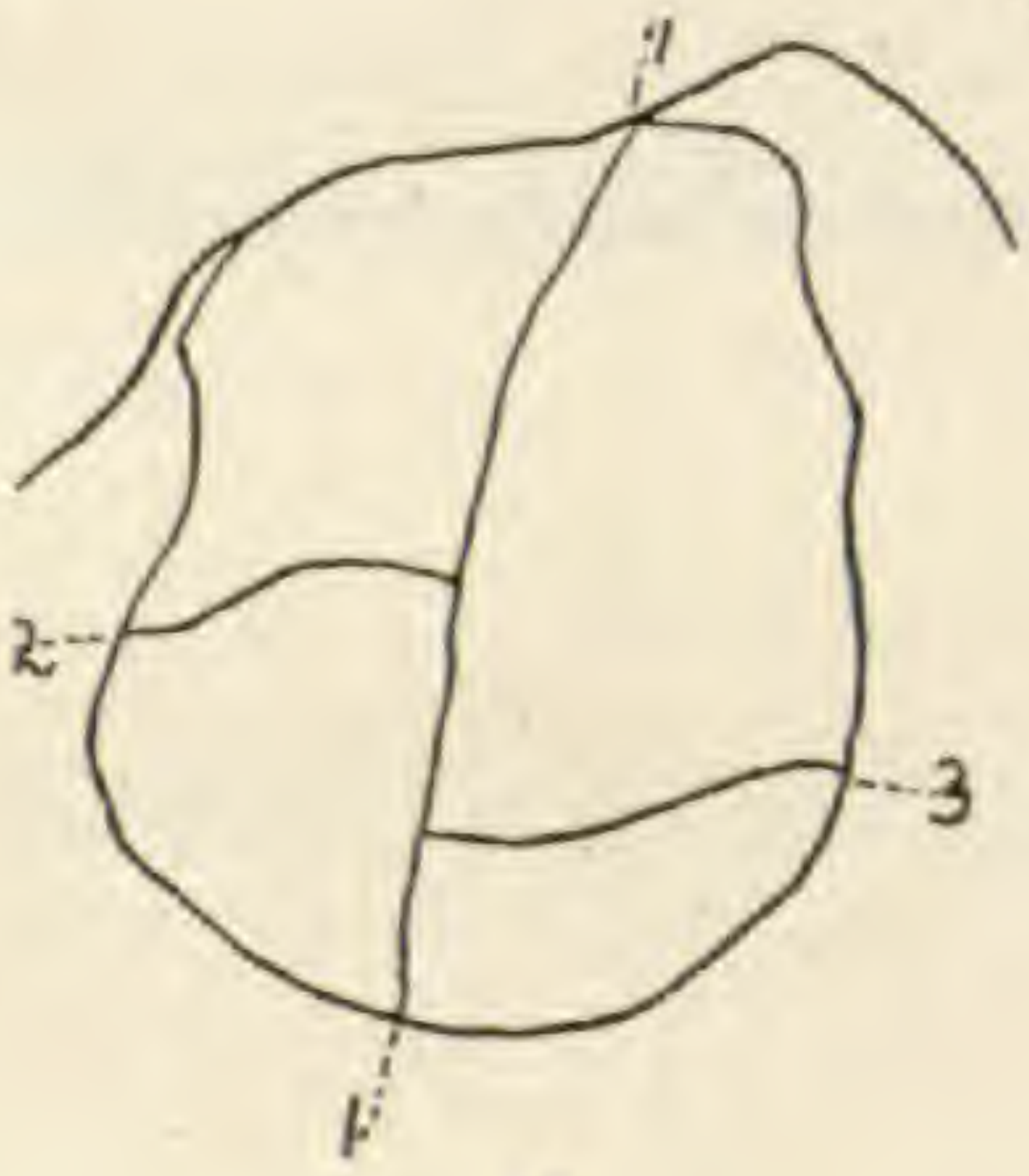

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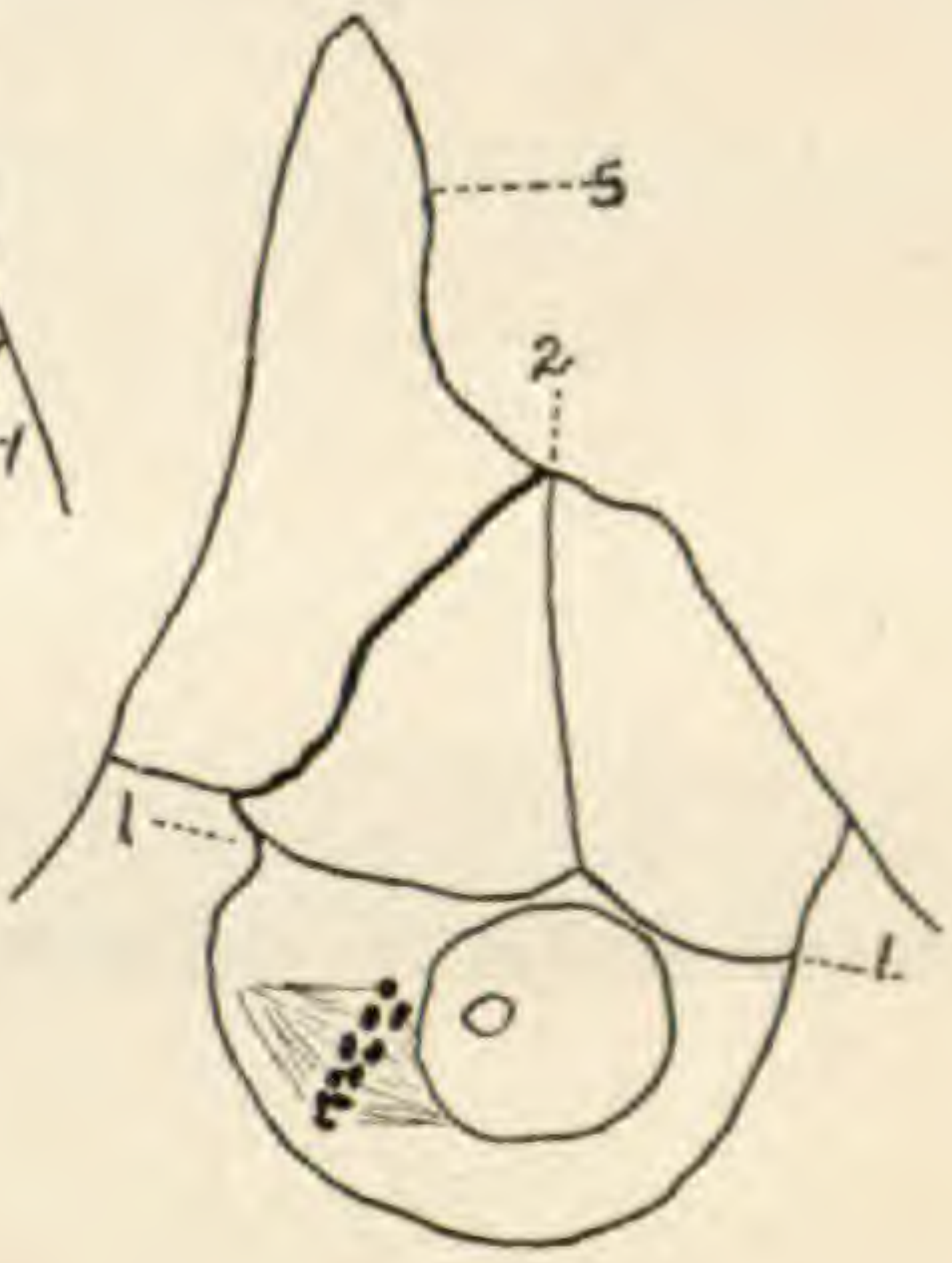

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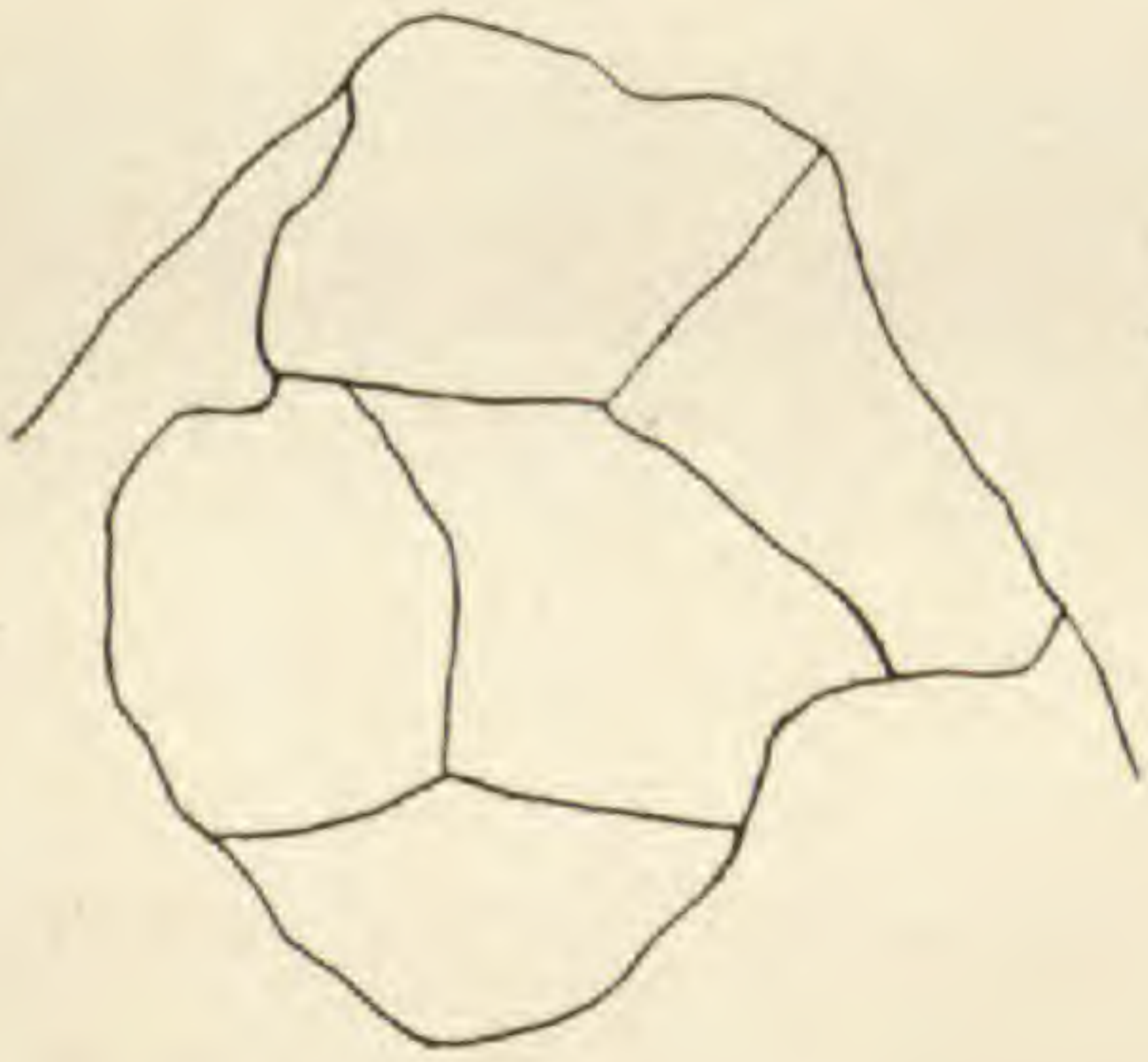

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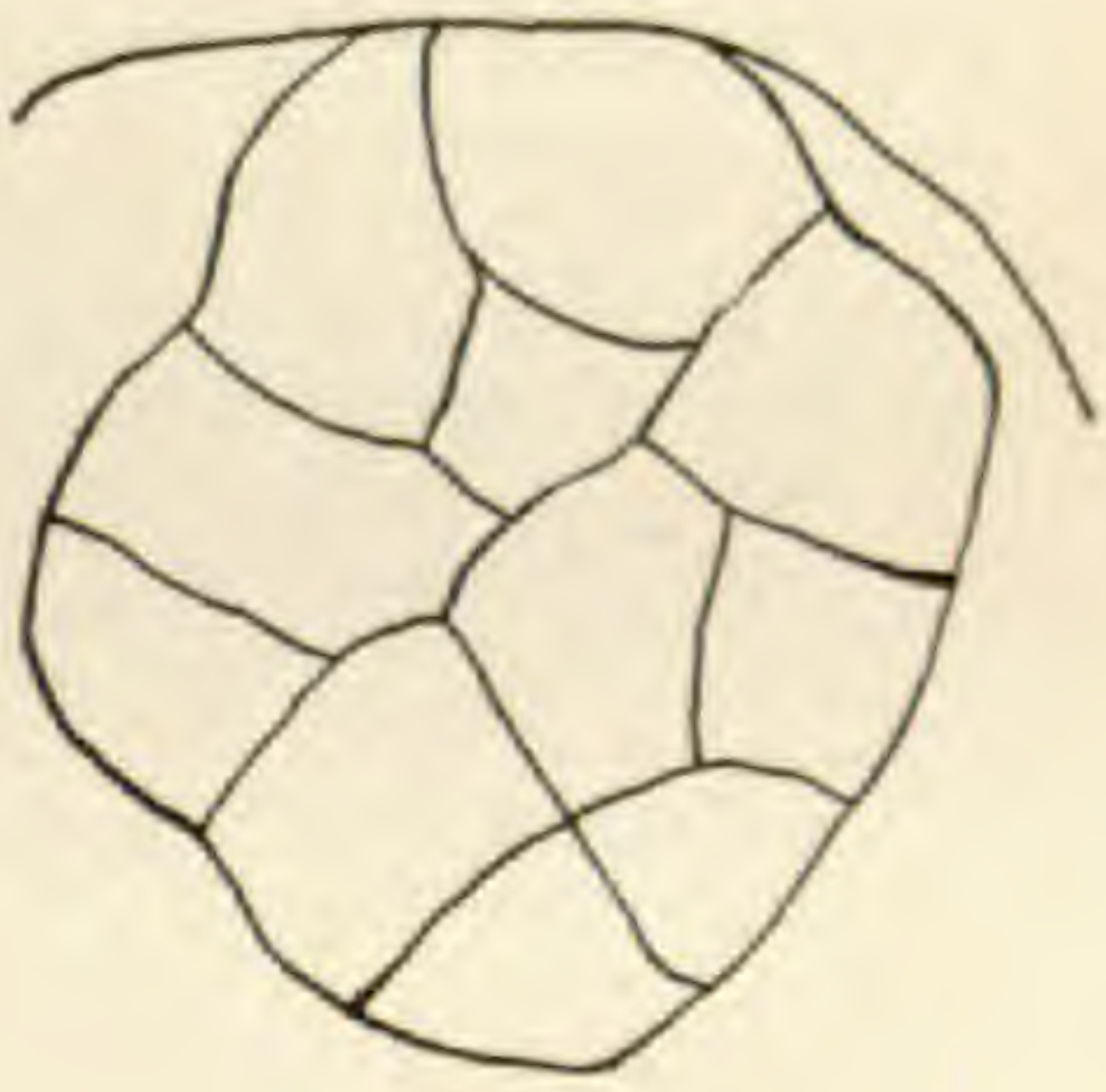

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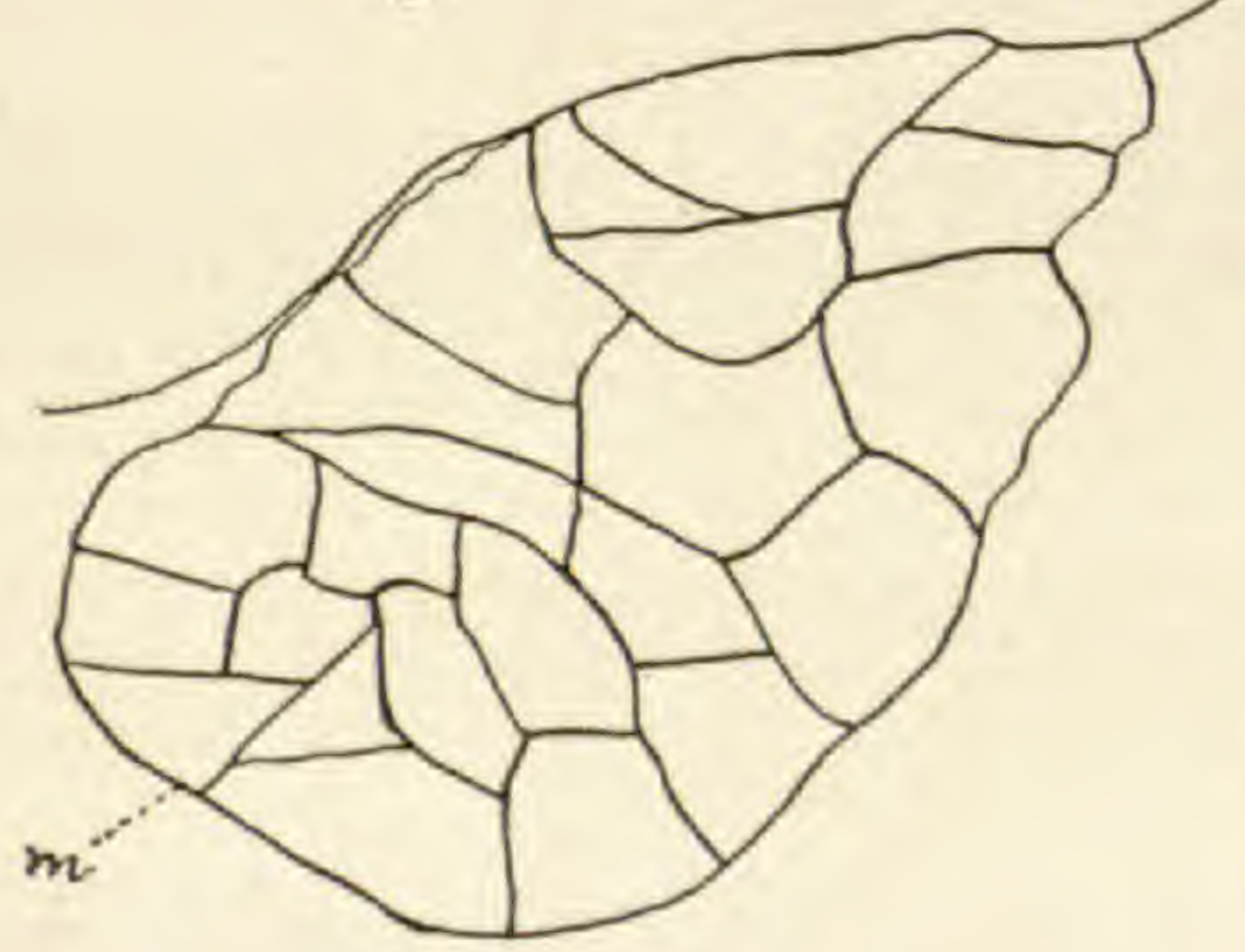

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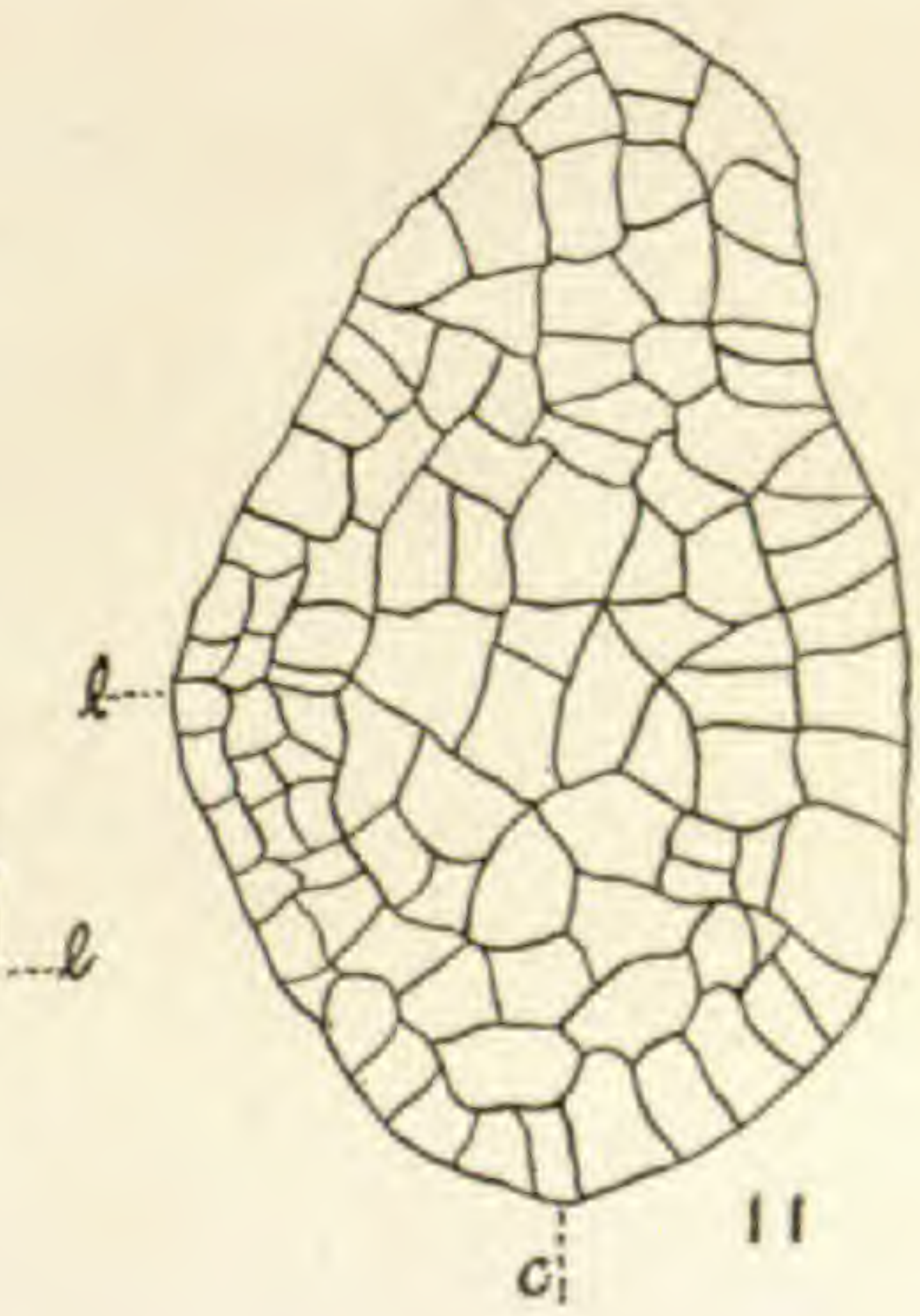

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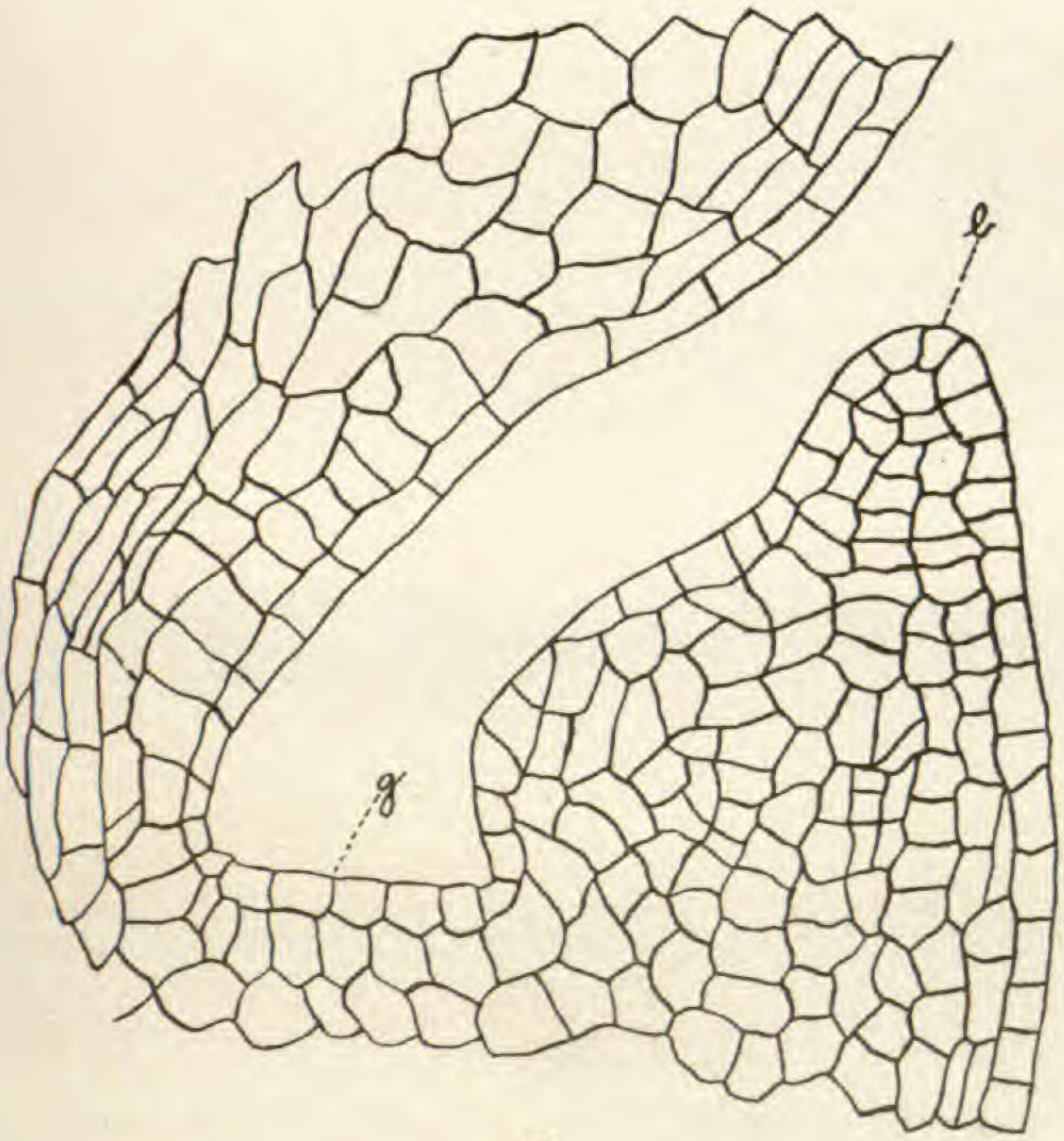
P. M. SMITH: EMBRYOLOGY OF DIOSCOREA VILLOSA



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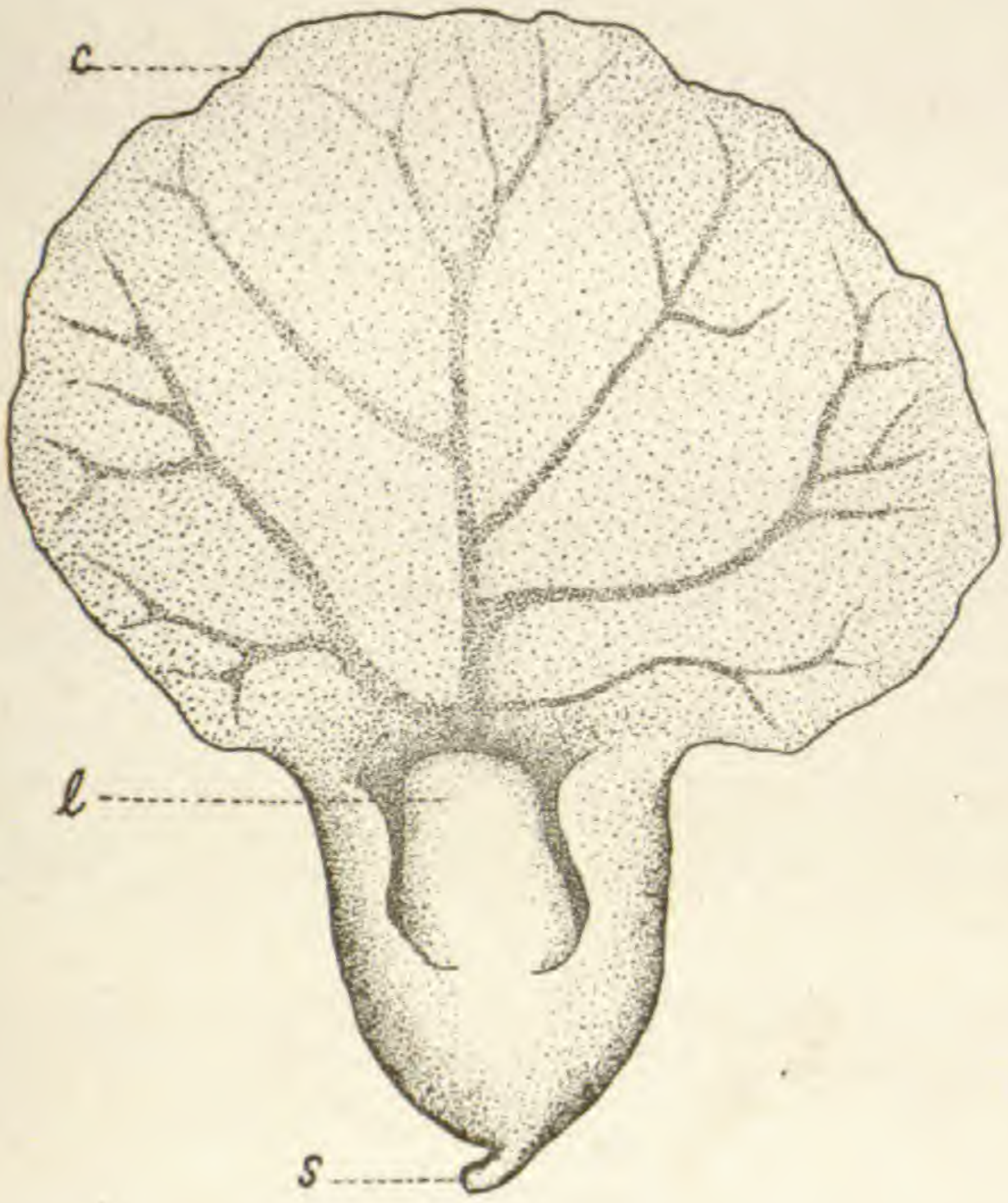

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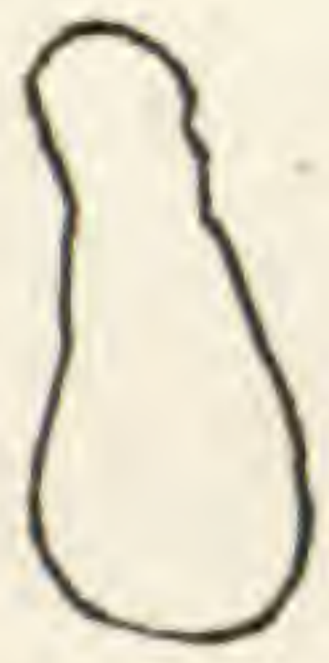

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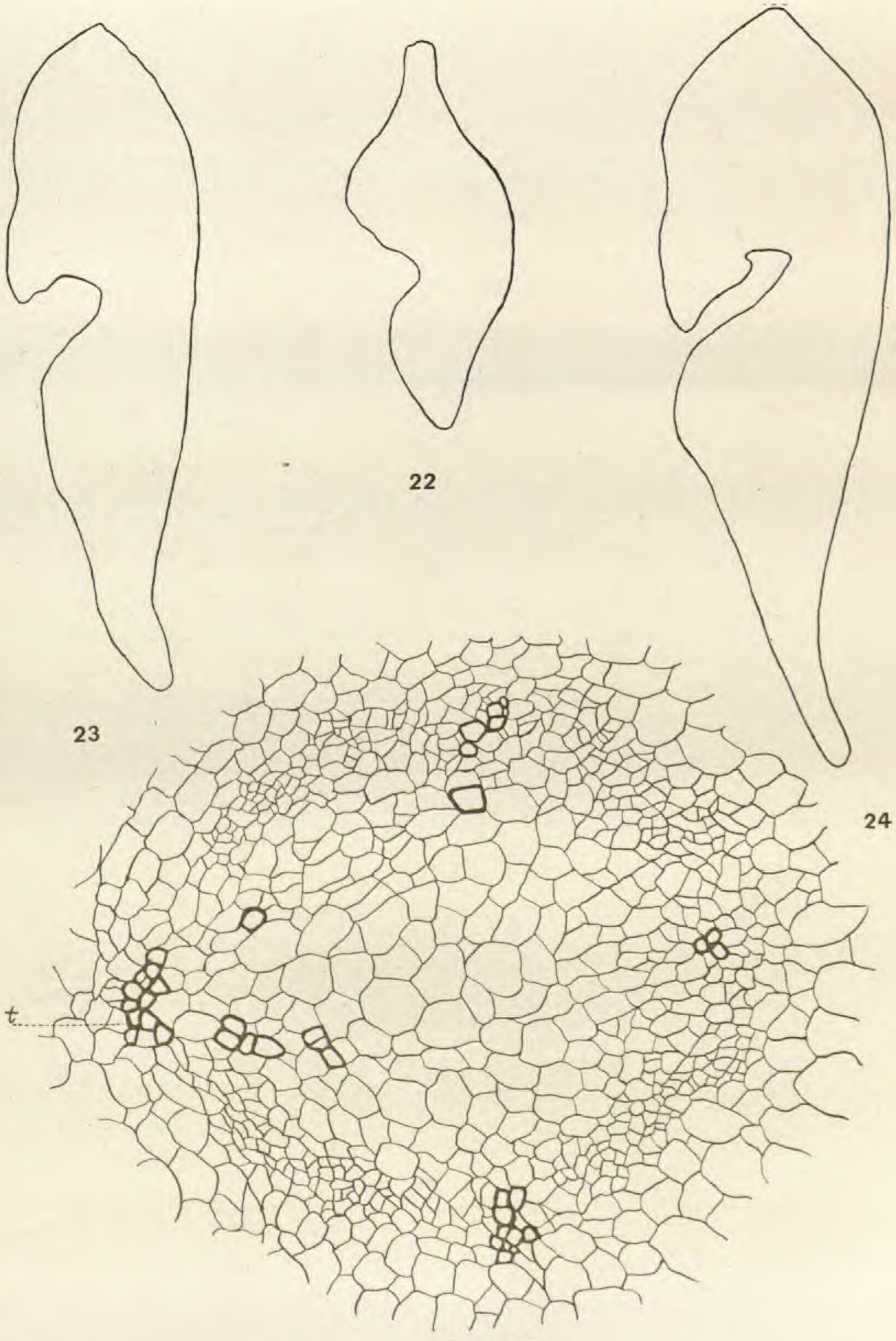

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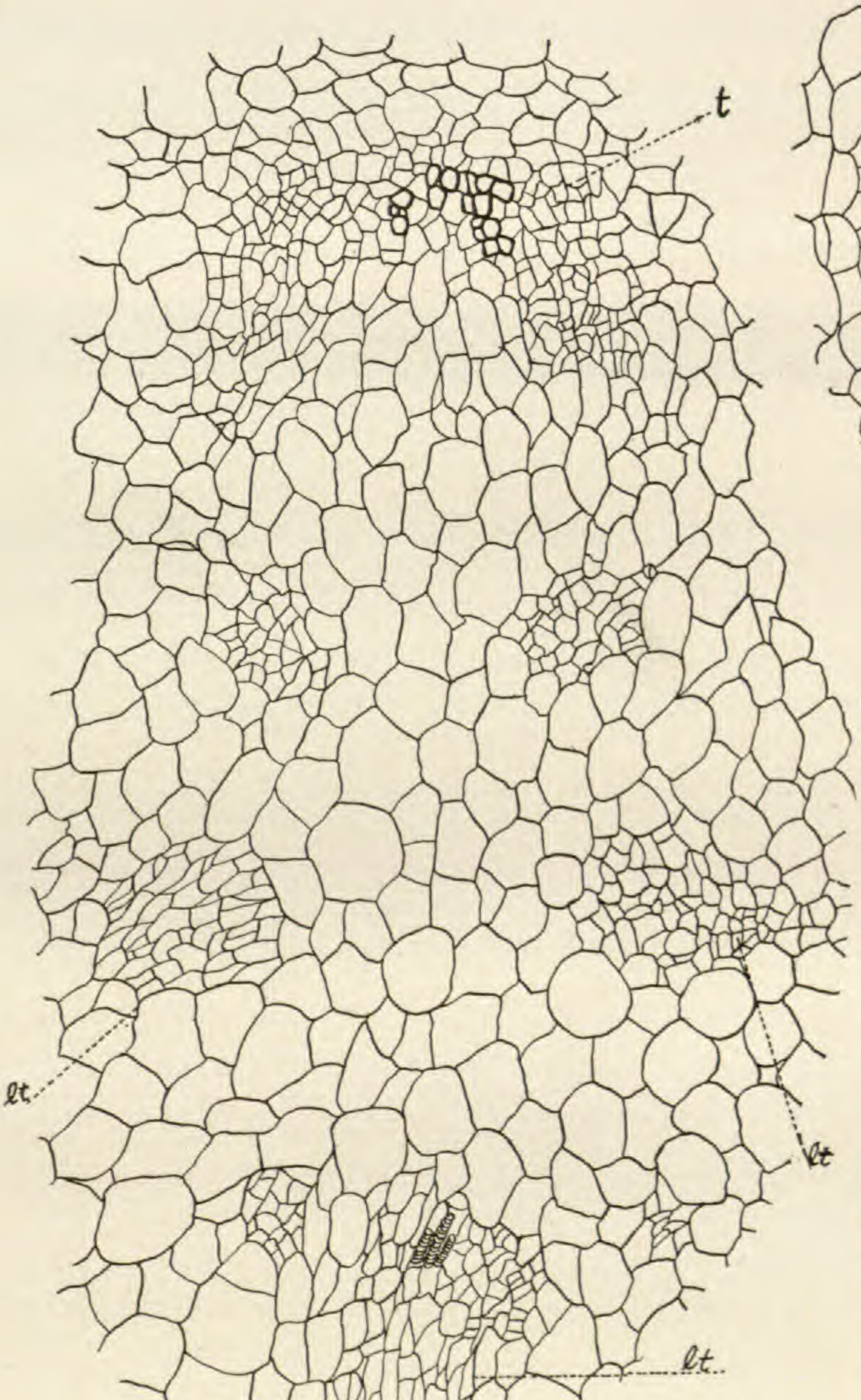

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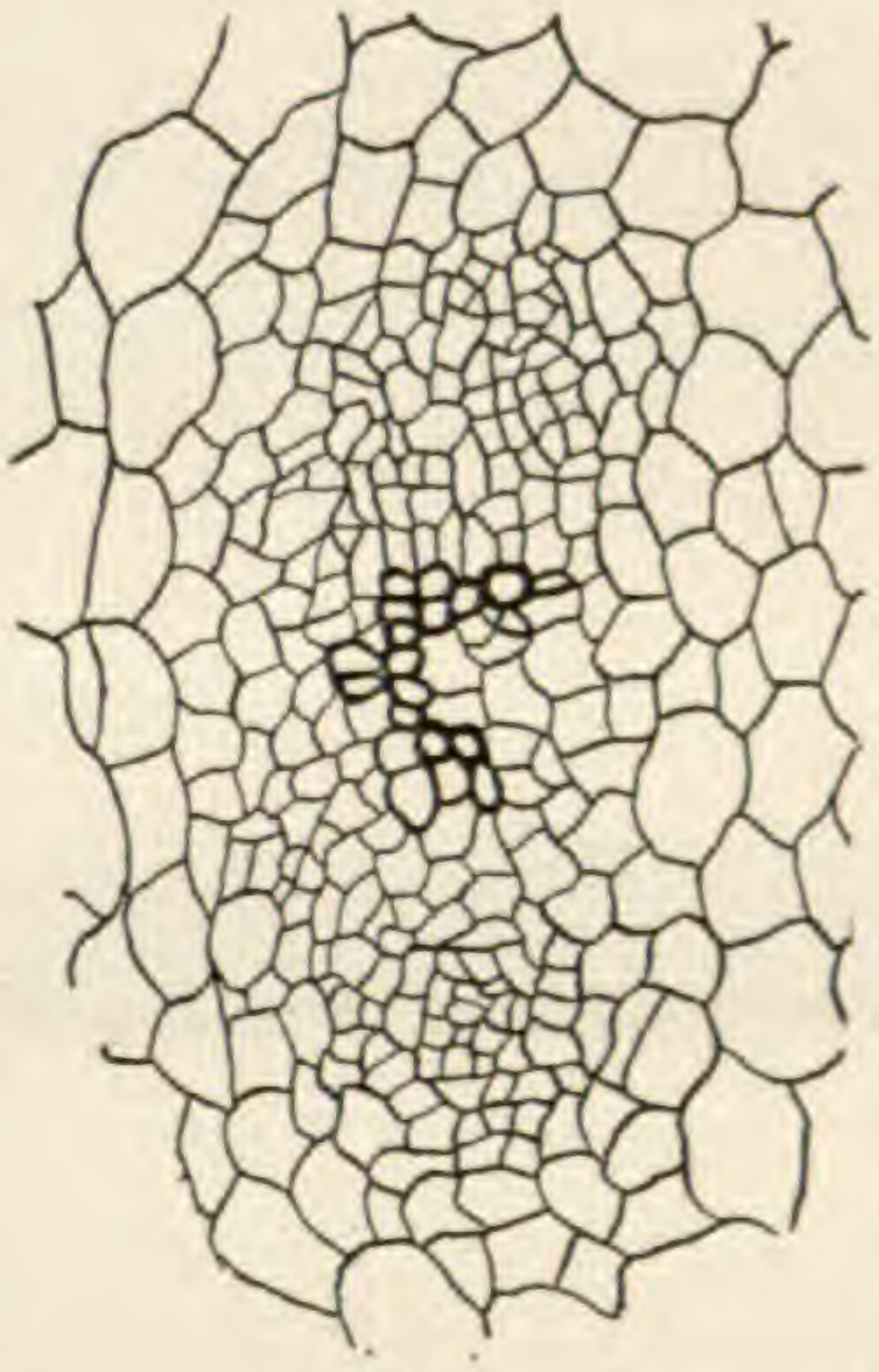

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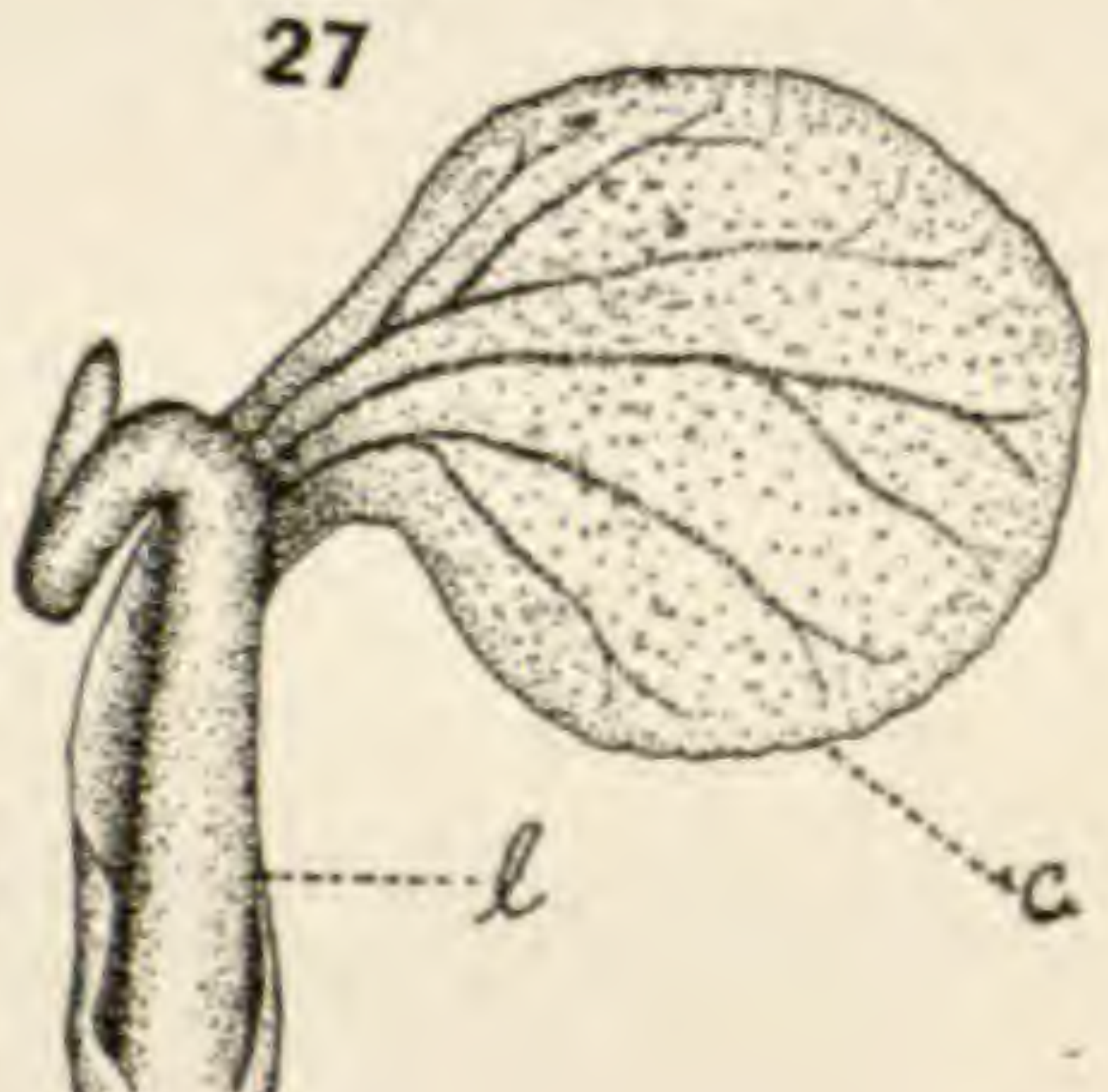

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Vol. 43 No. 12

BULLETIN

OF THE

TORREY BOTANICAL CLUB

DECEMBER, 1916.

Notes on Carex—XI

Kenneth Kent Mackenzie

Californian representatives of the Ovales

During the past few years I have been favored with opportunities to examine a very considerable percentage of all collections of *Carex* heretofore made in the state of California. With the exception of specimens referable to the *Ovales*, these collections contain comparatively few plants not readily referable to species heretofore described. In the case of the *Ovales*, however, it has turned out that there are a number of undescribed species in California. In fact, most of the Californian collections in the group belong to undescribed species.

This situation arises from the fact that attempts have been made in the past to refer the Californian *Ovales* to species in the group found in the eastern portion of the United States or in the Rocky Mountain region. Similar attempts were made at one time with a number of species belonging to other groups of *Carices*, but these have gradually been corrected. In the case of the *Ovales* little has been done in this direction, and as a result a number of species are attributed to California which do not occur within a great many miles of that state.

The fact is that the species of *Carex* found in California are very largely peculiar to that state, and this is just as true in the case of the *Ovales* as in other groups.

The collections examined for the purpose of this paper were those of the University of California (abbreviated "Cal."), Leland

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Stanford, Jr., University (abbreviated "L. S."), S. B. Parish, E. Brainerd, Columbia College (abbreviated "C.") and New York Botanical Garden (abbreviated "N. Y."), and the new species described below are in these collections, as indicated, or in my own herbarium (abbreviated "K. M.").

A key covering all members of the *Ovales* known to me from California is given immediately below, and this is followed by descriptions of the new species proposed.

I. Beak of perigynium flat and serrulate to tip.
  Sheaths white-hyaline opposite blades.
    Upper sheaths (at least) strongly prolonged upward opposite point of insertion of blade, the prolongation very membranaceous. *C. specifica.*
    Sheaths not prolonged upward opposite point of insertion of blade.
      Perigynia thin with margins conspicuously wrinkled dorsally; culms 1–3.5 dm. high; spikes ovoid, densely capitate. *C. straminiformis.*
      Perigynia thick with margins not wrinkled dorsally; culms 6–9 dm. high; spikes oblong in an oblong head. *C. multicostata.*
  Sheaths green striate opposite blades, except at mouth. *C. feta.*
II. Beak of perigynium terete towards apex, the upper 1–3 mm., smooth or nearly so.
  A. Perigynia appressed, nearly or entirely covered by scales, the tips of the beaks not conspicuous in the spikes.
    Culms slender; spikes in a flexuous nodding head. *C. praticola.*
    Culms stiff; spikes approximate in an erect head.
      Culms 1–6 dm. high, the leaves not bunched near base; blades 2–3 mm. wide, flat; beak of perigynium not hyaline at orifice. *C. leporina.*
      Culms 1–3 dm. high, the leaves bunched near base; blades 1.5–2 mm. wide, more or less involute; perigynium beak hyaline at orifice.
        Perigynia oblong-ovate, rather strongly margined. *C. phaeocephala.*
        Perigynia linear-lanceolate, very narrowly margined, boat-shaped. *C. leporinella.*
  B. Upper part of perigynia conspicuous, not covered by scales.
    (*a*) Perigynia lanceolate, 5.5–8.5 mm. in length, 3–5 times as long as wide.
      Spikes about 3, not capitate; scales little more than half length of perigynia. *C. Davyi.*
      Spikes 6–12, capitate; scales equalling bodies of perigynia. *C. lancifructus.*
    (*b*) Perigynia ovate or lanceolate; if lanceolate shorter than 5.5 mm. in length.

Lower bracts leaflet-like, much exceeding head.

Perigynia obscurely nerved ventrally, the beak ferruginous at orifice, bidentate. *C. athrostachya.*

Perigynia strongly nerved ventrally, the beak hyaline at orifice, bidentulate. *C. tenuirostris.*

Lower bracts scale-like, much shorter than or slightly exceeding head.

Perigynia flat, except where distended by achenes about equally in front and behind. *C. microptera.*

Perigynia strongly plano-convex.

Perigynia 2.25–3.5 mm. in length.

Margins of perigynia entire (or very obscurely subserrulate). *C. integra.*

Margins of perigynia strongly serrulate.

Head stiff; culms stiff, smooth; leaf-blades averaging 2.5 mm. in width, light green. *C. subfusca.*

Head nodding; culms very slender, roughened above; leaf-blades averaging 1.5 mm. in width, deep green. *C. teneraeformis.*

Perigynia 3.5 mm. or more in length.

Perigynia beaks at tip and scales brownish or blackish tinged. *C. olympica.*

Perigynia beaks at tip and scales reddish or reddish-brown tinged.

Perigynia and scales little reddish tinged; lower bracts at least strongly amplectant. *C. amplectens.*

Perigynia and scales strongly reddish tinged; lower bracts not strongly amplectant.

(*) Perigynia with thick firm walls.

Perigynia strongly few- to several-nerved dorsally.

Perigynia nerveless or very nearly so ventrally.

Spikes strongly capitate; blades averaging 3 mm. wide; culms 3.5–12 dm. high. *C. sub-bracteata.*

Spikes not capitate, the head slender; blades averaging 1.5–2 mm. wide; culms 1–5 dm. high.

Culms slender; leaves not clustered, the blades 1–2 dm. long; spikes with ten to twenty perigynia. *C. gracilior.*

Culms stiff; leaves clustered, the blades short; spikes with few perigynia. *C. paucifructus.*
Perigynia strongly nerved ventrally. *C. Harfordii.*
Perigynia obscurely impressed striate on both faces. *C. pachycarpa.*
(**) Perigynia with thinnish submembranaceous walls and with conspicuous raised nerves on inner face at maturity.
Scales reddish-brown; spikes four to eight, closely aggregated. *C. abrupta.*
Scales reddish; spikes six to twelve, the lower separate. *C. mariposana.*

Carex multicostata sp. nov.

Cespitose, the culms 3–9 dm. high, rather stout, many-striate, bluntly triangular, smooth or slightly roughened on angles beneath head, exceeding leaves, aphyllopodic; sterile shoots not seen. Leaves with well-developed blades usually three or four to a fertile culm, on lower fourth, but not bunched, the sheaths strongly white hyaline ventrally, but not prolonged upward beyond blade; the blades flat, 2.5–6 mm. wide, usually 1–3 dm. long, not long attenuate. Head oblong, 2–4 cm. long, 1–2 cm. wide, containing about ten closely aggregated but readily distinguishable gynaecandrous oblong or oblong-ovoid spikes 8–16 mm. long, 6–8 mm. wide, rounded or short pointed at apex, the lateral rounded and the terminal short tapering at base, the twenty to thirty perigynia appressed in many rows, the tips not conspicuous, the staminate flowers inconspicuous; lowest one to several bracts slightly prolonged, the others scale-like. Scales ovate, obtuse or acute, reddish brown with lighter midvein and conspicuous white hyaline margins, narrower and shorter than perigynia. Perigynia green or in age straw-colored, ovate, 3.5–4.5 mm. long, 2–2.25 mm. wide (widest near top of achene), plano-convex, winged to the rounded base, serrulate to below middle, conspicuously many nerved on outer and several nerved on inner face, abruptly contracted into a broad, flat, bidentate, non-hyaline, tawny tipped beak 1 mm. long, winged and serrulate to the tip, the teeth erect, contiguous. Achenes lenticular, broadly oval, substipitate, 1.75 mm. long, 1.5 mm. wide, short apiculate, the style slender, at length deciduous; stigmas two.

This species is related to the eastern *Carex brevior* (Dewey)

Mackenzie, but is distinguished by the more colored scales, more strongly nerved perigynia and relatively longer perigynia beaks. It is found in the higher mountains of southern California and extends north in the Sierra Nevadas to Nevada County.

Specimens examined

CALIFORNIA: Bear Valley Dam, San Bernardino County, *Parish 3609*, June, 1895 (type, in Herb. S. B. Parish); Lake Surprise, San Jacinto Mountains, 8,200 ft., *Hall 2492*, July–August, 1901 (Cal.); Truckee River Basin, Nevada County, 7,000 ft., *Davy*, June 25–30, 1897 (Cal.).

Carex leporinella sp. nov.

"*Carex tenuirostris* Olney" Bailey, Mem. Torrey Club 1: 15. 1889 (as to plant described).

Very densely cespitose from short creeping rootstocks, the culms 1.5–3 dm. high, exceeding the leaves, stiff, biennial, aphyllopodic, sharply triangular, smooth, brownish at base. Leaves with well-developed blades three to five to a fertile culm, on lower fourth and more or less bunched, the blades involute, 0.75–1.5 mm. wide, mostly 5–10 cm. long, sparingly roughened towards apex. Inflorescence consisting of three to six gynaecandrous spikes aggregated into a head or more or less separate, the head erect, rather stiff, 1.5–3 cm. long, less than 1 cm. wide, the spikes narrowly oblong-oval, 6–15 mm. long, 3–5 mm. wide, short clavate at base, short pointed at apex, the staminate flowers few, the perigynia eight to twenty, closely appressed, the tips erect-appressed; bracts scale-like, the lowest occasionally short prolonged. Scales oblong ovate, reddish-brown with lighter midvein and white hyaline margins, acute, slightly longer and wider than and concealing perigynia. Perigynia narrowly lanceolate, widest near middle of achene, 4 mm. long, scarcely 1 mm. wide, strongly plano-convex, very narrowly margined, serrulate above middle, finely striate dorsally, at first nerveless ventrally, at maturity few nerved, yellowish tinged, contracted and tapering at base, tapering into the short (1 mm. long), beak, which is light reddish tinged, not bidentate, hyaline at apex and obliquely cut dorsally. Achenes lenticular, oblong obovoid, 2 mm. long, less than 1 mm. wide, apiculate, the slender style at length deciduous. Stigmas two.

This species bears a close outward resemblance to *Carex phaeocephala* Piper, but is readily distinguished by the narrowly margined "boat-shaped" perigynia. *Carex tenuirostris* Olney, with which this species has been confused, is much like *Carex athrostachya* Olney in appearance, and is the plant described by Kükenthal as *Carex macloviana* var. *pachystachya* forma *involucrata* (Pflanzenreich 4^{20}: 197. 1909). Like *Carex phaeocephala* the present species is found on the higher peaks.

SPECIMENS EXAMINED

CALIFORNIA: Soda Springs of Tuolumne, *Congdon*, August 18, 1890 (Bailey); Summit Valley, Sierra Nevadas, *Pringle*, September 18, 1882 (Bailey); among summit rocks, Pyramid Peak, Eldorado County, 10,020 ft., *Hall & Chandler 4716*, August 1–2, 1903 (type, in Herb. Cal.); "Cal." (C.).

OREGON: Head of Wallowa River, 9,000 ft., *Cusack 2479*, August 17, 1900 (N. Y.).

WASHINGTON: Skamania County, *Suksdorf 5229*, August 13, 1905 (L. S.).

Carex Davyi sp. nov.

Densely cespitose, the culms 2.5–3.5 dm. high, strongly biennial, much exceeding leaves, erect but slender, sharply triangular, smooth on angles, brownish at base. Leaves with well-developed blades three to four to a fertile culm, on lower fourth, but not bunched, the blades flat or canaliculate, 1.5–2.5 mm. wide, mostly 8–12 cm. long, the sheaths strongly hyaline ventrally and fragile. Spikes mostly three, approximate in a head about 2.5 cm. long, the spikes oblong-obovoid, 12–18 mm. long, 6–8 mm. wide, rounded at apex, clavate and staminate at base, the perigynia ten to fifteen, in several to many rows, closely appressed, the beaks erect. Bracts scale-like. Scales oblong-ovate, very obtuse, chestnut with lighter center and hyaline margins, about width of but only half length of perigynia. Perigynia lanceolate, thin, green or in age straw-colored, 7.5 mm. long, 2 mm. wide, strongly many striate dorsally, less so ventrally, contracted into a substipitate base, narrowly margined from base, serrulate from middle of achene, tapering into a sharply bidentate beak, not differentiated from body, the apex and dorsal suture reddish tinged, obliquely cut dorsally at mouth. Achenes lenticular, oblong-obovoid, 2.5 mm. long, 1.25 mm. wide, substipitate, apiculate, the slender style at length deciduous. Stigmas two.

Carex petasata Dewey (*C. Liddoni* Boott), to which this species has been referred, has the perigynia practically concealed by the scales. The leaf-blades also are noticeably wider. The present species seems to be confined to the Sierra Nevadas.

SPECIMENS EXAMINED

CALIFORNIA: In meadows along Truckee River, Placer County, *Davy 3266*, June 25–30, 1897 (type, in Herb. Cal., sheet 50814); Devil's Basin, Eldorado County, 8,300 ft., *Brainerd*, July 19, 1897 (Cal. in part); near Snowy Cascade, Eldorado County, 6,500 ft., *Brainerd 191*, July 13, 1897 (Brainerd).

Carex lancifructus sp. nov.

Culms 2.5–4.5 dm. high, stiff, erect, triangular, smooth or nearly so, much exceeding leaves, aphyllopodic, brownish at base. Leaves with well-developed blades, two to four to a fertile culm, bunched above base, the blades flat or canaliculate, thick, 2–3.5 mm. wide, mostly 7–12 cm. long, the sheaths tight, hyaline ventrally, little prolonged above blade, not readily rupturing. Head globose, 1.5–2 cm. long, and nearly as wide, the spikes six to ten, densely aggregated, gynaecandrous, oblong-ovoid, 6–9 mm. long, 4 mm. wide, tapering at both ends, the staminate flowers inconspicuous, the perigynia eight to fifteen in several ranks, appressed, the beaks not spreading. Bracts scale-like. Scales lanceolate-ovate, acute, reddish brown with lighter midvein and narrowly hyaline margins, about width of, but shorter than perigynia. Perigynia lanceolate, thin plano-convex, straw-colored, 6 mm. long, 1.5 mm. wide, finely several to many nerved on both faces, contracted to a substipitate base, narrowly margined (serrulate above) to base, tapering into beak one-third length of body, slender above, serrulate below, bidentate, light-reddish tipped, obliquely cut dorsally. Achenes lenticular, short-oblong, nearly 2 mm. long, 1 mm. wide, stipitate, apiculate, the slender style at length deciduous. Stigmas two.

In Californian collections this plant has been most often confused with *Carex specifica* Bailey, a species differentiated from all others of the *Ovales* by the very membranaceous texture of the sheaths opposite the leaf-blades. This thin membranaceous easily ruptured portion is also strongly prolonged upward opposite the point of insertion of the blade. *Carex lancifructus* lacks these characters, and also differs in other respects, as shown in the key published herewith. It is, in fact, most closely related to *Carex ebenea* Rydb., a species with blackish scales, although the difference in the color of the scales gives it a very different appearance.

SPECIMENS EXAMINED

CALIFORNIA: Volcano Creek, Upper Kern River, Tulare County, 7,500 ft., *Hall & Babcock 5472*, July, 1904 (type, in Herb. Cal., sheet 127,723); Little Lake, Meisner's Ranch, Eldorado County, 7,500 ft., *Brainerd*, July 17, 1897 (Cal.); Echo Lake, 7,500 ft., *Brainerd 188*, July 11, 1897 (Brainerd); mountain north of Slippery Ford, 7,500 ft., *Brainerd 191*, July 19, 1897 (Brainerd).

Carex integra sp. nov.

Very densely cespitose, the culms 1.5–3.5 dm. high, slender but erect, rather bluntly triangular, smooth, much exceeding the leaves, aphyllopodic, light brownish at base. Sterile shoots numerous, with five to eight erect leaves. Fertile culms with one or two old leaves at base and with three or four well-developed leaves just above the base, the sheaths hyaline ventrally, the blades flat, 1–2 mm. wide, 3–10 cm. long; sterile shoots with leaf-blades much longer. Spikes four to eight, densely aggregated in a head 1–2 cm. long, 6–10 mm. wide, the spikes gynaecandrous, obovoid or oblong-obovoid, 4–8 mm. long, 3.5–5 mm. wide, rounded at apex, tapering at base, the perigynia ten to twenty in several ranks, appressed or appressed-ascending. Lowest bract slightly prolonged, much shorter than head, the upper scale-like. Scales ovate, dark chestnut with prominent green midvein and in age hyaline margins, acute or short-cuspidate, nearly width of, but shorter than mature perigynia. Perigynia very small, 2.25–2.75 mm. long, 0.75–1 mm. wide, plano-convex, thickish, brownish tinged, lightly few nerved dorsally, nerveless or very obscurely nerved ventrally, lanceolate, narrowly margined to the round tapering base, tapering or somewhat contracted into a slender beak one-half to three-fourths length of body, the margins smooth (or very sparingly subserrulate under a microscope), chestnut-brown tipped with white-hyaline apex, obliquely cut dorsally. Achenes lenticular, yellowish, filling perigynia, short oblong, 1–2 mm. long, 0.6 mm. wide, short apiculate, the straight slender style at length deciduous. Stigmas two.

This species bears a strong outward resemblance to *Carex subfusca* W. Boott. It is well distinguished, however, by the very small, narrow perigynia, and especially by the margins of body and beak being smooth.

SPECIMENS EXAMINED

CALIFORNIA: Summit, Placer County, 7,000 feet, *Heller 9841*, July 16, 1909 (type, in Herb. K.M.); Jason & Stewart's Camp, headwaters of Hat Creek, Shasta County, 2,120 m., *Eggleston 7380, 7430*, July 31, 1911 (K.M.); meadow near Stoneman Bridge, Yosemite Valley, *Abrams 4399*, July 19, 1911 (K.M.); trail to Slippery Ford, Eldorado County, *Brainerd 216*, July 10, 1897 (Brainerd); above Slippery Ford, Eldorado County, *Brainerd 205* in part, July 15, 1897 (Brainerd).

OREGON: West slope of Three Sisters, 5,000 ft., *M. E. Peck 72*, July 19, 1914 (K.M.).

Carex teneraeformis sp. nov.

Cespitose, the culms 3–4.5 dm. high, erect, very slender, triangular, smooth or nearly so on angles, exceeding leaves, aphyllopodic, light brownish at base. Sterile shoots conspicuous with four to six erect leaves. Fertile culms normally making growth in one year, with three to four leaves on lower fourth, but not bunched, the sheaths strongly hyaline ventrally, the blades flat or with slightly revolute margins, 1.5 mm. wide, usually 6–18 cm. long; sterile shoots with similar leaves. Spikes five to eight, readily distinguishable, ± strongly separate in a slender head, 1.5–2.5 cm. long and much narrower, the spikes gynaecandrous, 3.5–6 mm. long, 3.5–4.5 mm. wide, rounded at apex, the lateral rounded and the terminal short tapering at base, the six to twelve perigynia loosely appressed in several ranks, with rather conspicuous tips, the staminate flowers few and inconspicuous; bracts scale-like or lowest sometimes slightly prolonged. Scales ovate, acute, light brownish with lighter midvein and inconspicuous white hyaline margins, narrower and slightly shorter than perigynia. Perigynia green, ovate, widest near middle of achene, 3.25 mm. long, 1.25 mm. wide, plano-convex, thickish, winged to base, the walls submembranaceous, conspicuously several nerved on outer face, nerveless or nearly so on inner, rounded at base, serrulate above and on beak, tapering into a slender white hyaline slightly dark tipped beak, 1 mm. long, obliquely cut dorsally, the tip wingless and scarcely serrulate, the teeth strictly erect and closely contiguous. Achenes lenticular, short suborbicular, sessile, 1 mm. long, nearly 1 mm. wide, apiculate, the style slender, at length deciduous; stigmas two.

Related to *Carex subfusca* W. Boott, from which it is to be distinguished by the loose inflorescence and in general by being a much more slender plant. It bears about the same relation to that species that *Carex tenera* Dewey does to *Carex Bebbii* Olney. The type specimen was collected "in shade of thicket" at Jonesville, Northern Butte County, at an elevation of 5,100 feet, on July 25, 1914, by Professor H. M. Hall (No. 9781), and is in my herbarium. Professor Jepson's 4374, collected July 6, 1911, at Eagle Pass, Yosemite, is to be referred here, as is probably also a young specimen collected by Bioletti near Nevada Falls, Yosemite Valley, in May, 1900.

Carex olympica sp. nov.

Densely cespitose, the rootstocks short, slender, conspicuously fibrillose covered; culms in small clumps very slender, but stiff and erect, 1.5–6 dm. high, 1–2 mm. wide at base, much exceeding leaves, roughened on angles beneath head, aphyllopodic, and light brownish at base, maturing second year, old leaves of first year's growth conspicuous. Leaves with well-developed blades, three or four to a fertile culm, inserted on lower fifth, the blades flat with slightly revolute margins, 1–2 mm. wide, 7.5–15 cm. long, light green, roughened towards apex; the sheaths hyaline opposite blades, truncate at mouth and not prolonged upward; sterile culm leaves similar. Spikes three to six, aggregated or in a slender more or less strongly interrupted head, 12–24 mm. long, 5–10 mm. wide, the spikes orbicular, 4–6 mm. in diameter, rounded at apex, rounded or the terminal one clavate at base, the perigynia eight to fifteen closely packed in several rows, ascending or in age more or less spreading, the tips conspicuous; basal staminate flowers inconspicuous, except in terminal spike; bracts scale-like or lower slightly prolonged. Scales ovate, acute or subcuspidate, at maturity chestnut brown with lighter midvein and slightly hyaline margins, as wide as but conspicuously shorter than perigynia. Perigynia narrowly to broadly ovate, thickish and strongly plano-convex, narrowly winged, the walls thickish, 3.5–5 mm. long, 1.5–2 mm. wide, greenish but soon becoming olive-brown tinged, rounded at base, several nerved on outer face, nerveless or very obscurely nerved at base on inner face, the body little serrulate, tapering into the serrulate beak half length of body, which is dark tipped, minutely bidentate, smooth and obscurely hyaline at the extreme apex, obliquely cut on convex side, the orifice not hyaline. Achenes lenticular, ovate, 1.25 mm. long, 0.75 mm. wide; stigmas two, slender, short.

The species here described is a widely distributed plant in British Columbia, Washington and Oregon, and extends as far south as the northern part of California. It is one of the species of the *C. festiva* group with the scales dark colored at maturity, and the perigynia strongly plano-convex. In general it is most closely related to *Carex pachystachya* Cham., but it is a more slender plant with looser inflorescence and less spreading perigynia and narrower lighter-green leaf-blades. In *Carex pachystachya*, too, the culms make their growth and flower in the same year, and the white hyaline band of the leaf-sheath is very conspicuous. Another widely distributed plant of the same region is *Carex Preslii* Steud. (*Carex multimoda* Bailey). In its deep green foliage, habit of growth and leaf sheaths it closely simulates *Carex pachystachya*, but it has a looser inflorescence like the present species. From both *Carex olympica* and *Carex pachystachya* it differs in the reddish scales and reddish tipped perigynium beak, which, although slender at the top, is serrulate more nearly to the apex.

SPECIMENS EXAMINED

CALIFORNIA: Humboldt County, 3,000 ft. alt., *Tracy 3390*, July 7, 1911 (K.M.); Sisson, Siskiyou County, 3,500 ft., *Hall & Babcock 4063*, June, 1903 (Cal.).

OREGON: Meacham, *M. E. Peck 39*, July 18, 1915 (K.M.); *E. Hall 585*, 1871 (N.Y.).

WASHINGTON: Falcon Valley, Klickitat County, *Suksdorf 6254*, July 1, 1908 (K.M.); Seattle, *E. C. Smith 996*, June 12, 1890 (Piper); Bingen, *Suksdorf 2617*, June 26, 1896 (K.M.); Chiquash Mountains, *Suksdorf 3143*, September 7, 1898 (K.M.); Sequin, *J. M. Grant 701, 703, 709* in 1915 (K.M.); Olympic Mountains, *Elmer 2700*, June, 1900 (N.Y.).

BRITISH COLUMBIA: Roger's Pass, *Henry*, June 27, 1913 (Henry); Castlegar, Kootenay, *Henry*, June 14, 1914 (Henry); Carbonate, *Petersen 366*, July 16, 1904 (N. Y.); Chilliwack Valley, *Macoun 26648*, June 20, 1901 (N.Y.); Comox, *Macoun 349*, June 21, 1893 (C.).

Carex amplectens sp. nov.

Cespitose, the culms 5–8 dm. high, exceeding leaves, aphyllopodic, triangular, stiff, slightly roughened immediately beneath head, brownish at base; sterile shoots with well-developed tall culms. Leaves with well-developed blades four to six to a fertile culm, on lower half, not bunched, the sheaths rather loose, hyaline ventrally, soon breaking, conspicuously many-striate dorsally; the blades erect, flat, 2.5–4 mm. wide, mostly 1–2 dm. long. Head 2.5–3.5 cm. long, 8–15 mm. wide, the spikes six to twelve, closely approximate or lower slightly separate, ovoid or oblong ovoid, 7–15 mm. long, about 4–5 mm. wide, short clavate and sparingly staminate at base, rounded at apex, the fifteen to thirty-five perigynia closely appressed with erect tips. Bracts conspicuous, dilated at base, closely appressed to spikes, the lower three or four usually prolonged and from nearly equalling to exceeding head, the others less prolonged. Scales ovate, acute or short cuspidate, greenish and slightly tawny tinged, the midvein prominent, somewhat narrower and shorter than perigynia. Perigynia (young) ovate, 3.5–4 mm. long, 1.75 mm. wide, rounded and contracted at base, margined, several nerved on both faces, strongly serrulate, light green, contracted into a beak one third to one half length of body, the tip slightly tawny tinged and obliquely cut dorsally. Achenes lenticular, apiculate, the slender style at length deciduous. Stigmas two.

The type specimen of this species in the herbarium of Dr. Brainerd was called to my attention by him several years ago as probably representing an undescribed species. The bracts are especially amplectant at flowering time. At maturity this character is less evident. It is a species of the Sierra Nevada Mountains.

SPECIMENS EXAMINED

CALIFORNIA: Yosemite, 4,000 ft., *Jepson 4265* in part, June 24, 1911 (K.M.); Nevada Falls, Yosemite Valley, *Bioletti*, May, 1900 (K.M.); Snow Creek Trail, Yosemite, 6,000 ft., *Jepson 4388* in part, July 8, 1911 (K.M.); Big Tree Grove, 4,788 ft., *Bolander 4978*, 1866 (Cal., Brainerd); road near Lover's Leap, Eldorado County, 5,900 ft., *Brainerd 209*, July 22, 1897 (type, in Herb. Brainerd).

Carex sub-bracteata sp. nov.

Cespitose, from short creeping tough black fibrillose rootstocks, the culms erect, 5–8 dm. high, obtusely triangular, smooth, much exceeding leaves, light brownish at base. Leaves with well-developed blades usually three to five to a fertile culm, on lower fourth, but not bunched, the blades flat, 2.5–4 mm. wide, usually 1–3 dm. long. Head globose or ovoid, 1.5–2.5 cm. long, and rather narrower, the spikes five to ten, closely aggregated, gynaecandrous, ovoid, rounded at base, round tapering at apex, 6–10 mm. long, 4–6 mm. wide, the staminate flowers few, the perigynia ten to twenty in several to many rows, appressed or in age appressed-ascending, the beaks not spreading; one to several of lower bracts conspicuous, dilated at base, brown with hyaline margins, the tips shorter than or occasionally exceeding head. Scales ovate, obtuse or acutish, reddish brown with lighter center and hyaline margins, slightly narrower and shorter than perigynia. Perigynia dull green or soon yellowish brown, narrowly ovate, thick, plano-convex, 4 mm. long, 1.5 mm. wide, finely few nerved dorsally, nerveless or essentially so ventrally, round-tapering at base, tapering somewhat abruptly into the bidentate beak, narrowly margined (serrulate above) from base, the beak one third length of body, slender, serrulate below, chestnut tinged, obliquely cut and hyaline at apex. Achenes lenticular, thick, short oblong, 1.75 mm. long, 1.2 mm. wide, apiculate, the slender style at length deciduous. Stigmas two.

This species is closely related to *Carex gracilior*, described below, but is a much more robust plant with a more capitate head and wider leaf-blades. It is a plant of the Coast Ranges and extends from Santa Barbara County on the south to Mendocino County in the north. A specimen collected by Bolander at Oakland and in the Columbia College herbarium is taken as the type.

SPECIMENS EXAMINED

CALIFORNIA: Meadow on Russian River, Sonoma County, *Bolander 3868*, April, 1864 (Cal.); Mendocino City, *Bolander 4771*, Spring, 1866 (Cal.); *Bolander 6203* (C., Brainerd); Monterey, *Parry*, April, 1850 (C.); Oakland, *Bolander* (type, in Herb. C.); Santa Cruz, *Wood*, 1866 (C.); Lake San Andreas, San Mateo County, *Davy 763*, June 21, 1893 (C.); and *Bioletti*, June 20, 1893 (C.); San Francisco, *Jones*, May 12, 1882 (N.Y.); Crystal Springs Lake, San Mateo County, *Elmer 4429*, April, 1903 (N.Y.); *Kellogg & Harford 1065*, 1868–9 (N.Y.); Santa Barbara, *Elmer 3756*, May, 1902 (N.Y.); Comptche, Mendocino County, *McMurphy 431*, May, 1903 (N.Y., L.S.); Humboldt Bay, *Chandler 1115*, May, 1901 (L.S., N.Y.); Oakland, *Bolander*, May–June, 1862 (L.S.); "California," *Brewer* (L.S.).

Carex gracilior sp. nov.

Cespitose, but with slender short-creeping black fibrillose rootstocks, the clumps medium-sized, the culms slender, 3–6 dm. high, exceeding leaves, smooth or nearly so on angles, aphyllopodic, brownish at base. Leaves with well-developed blades three to five to a fertile culm, on lower third, but not bunched, the blades flat, 1–2 mm. wide, 5–15 cm. long. Inflorescence consisting of three to six small few-flowered spikes aggregated (or lower one or two a little separate) into a narrow or oblong head 12–20 mm. long, 5–12 mm. wide, the spikes sessile, bluntish, suborbicular, 5–8 mm. long, 4–6 mm. wide, the basal staminate flowers few and inconspicuous, the perigynia four to twelve to a spike, ascending to rather strongly spreading-ascending with conspicuous beaks; lower bract present, setaceous and from shorter than to (rarely) exceeding the head; the upper wanting or very much reduced. Scales ovate, obtusish or acutish, chestnut brown with lighter colored midrib and narrow hyaline margins, about width of, but shorter than perigynia. Perigynia plano-convex, thick, narrowly winged, 3.5–4.5 mm. long, 1.5 mm. wide, lance-ovate, dull green, the body faintly nerved dorsally, nerveless ventrally or nearly so, round tapering at base, tapering somewhat abruptly into the slender beak, one half length of body of perigynia, chestnut-brown and then hyaline at apex, obliquely cut dorsally at mouth, smooth towards apex, serrulate below. Achenes lenticular, obovate, 2 mm. long, 1.2 mm. wide, apiculate, the slender style at length deciduous; stigmas two.

Bolander's No. 3822, collected April, 1864, at Cloverdale, Sonoma County, and mounted on a sheet in the Leland Stanford University herbarium is taken as the type. This is a plant of the Coast Ranges and is found from San Francisco Bay, northward at least to Mendocino County.

SPECIMENS EXAMINED

CALIFORNIA: Mark West's Creek, *Bigelow 19* (Whipple Expedition), April 30, 1854 (C.); same station, *Bolander 3814*, April, 1864 (L.S., Cal.); Petaluma, *Bolander 4635*, Spring, 1866 (Cal.); Berkeley, *Mrs. Walker 18*, Spring, 1906 (Cal.); Sonoma, *R. Kuhn*, April 18, 1913 (K.M.); Cloverdale, Sonoma County, *Bolander 3822, 3822-A*, April, 1864, (L.S.); Mendocino County, *Bolander 4635*, April 12, 1866 (L.S.); *Bolander & Keller*, 1872 (C.).

Carex paucifructus sp. nov.

Densely cespitose, the culms 1–2.5 dm. high, erect, stiff, sharply triangular, smooth, much exceeding leaves, aphyllopodic, brown at base. Leaves with well-developed blades two to four to a fertile culm, bunched above the base, the blades 1.5–3 mm. wide, flat or canaliculate, short, mostly 3–7 cm. long. Head ovoid or oblong, 1–2 cm. long, 6–12 mm. wide, the spikes four to eight, aggregated, gynaecandrous, ovoid, tapering at base, round-tapering at apex, 6–9 mm. long, 4.5 mm. wide, the basal staminate flowers rather conspicuous, the perigynia six to twelve, in few to several rows, appressed or appressed-ascending, the beaks not conspicuous. Lowest bract short-prolonged, much shorter than head, the others scale-like. Scales ovate, chestnut with lighter midvein and conspicuous hyaline margins, about width of, but shorter than perigynia. Perigynia dull green or soon yellowish brown, ovate, thick, strongly plano-convex, 4 mm. long, 1.5 mm. wide, nerveless ventrally, finely many nerved dorsally, round-tapering at base, tapering into the scarcely bidentate beak, margined (serrulate above) from base, the beak one third length of body, slender at tip, serrulate below, reddish tipped, obliquely cut dorsally. Achenes lenticular, short-oblong, 1.75 mm. long, over 1 mm. wide, substipitate, apiculate, the slender style at length deciduous. Stigmas two.

Dr. Brainerd's specimen cited below and in his herbarium is taken as the type of this species. Mounted on the same sheet with a duplicate of the type in the University of California collection is a specimen of *Carex Davyi* Mackenzie. The plant here described is a species of the Sierra Nevada Mountains.

SPECIMENS EXAMINED

CALIFORNIA: Devil's Basin, Eldorado County, 8,300 ft., *Brainerd 200*, July 19, 1897 (Brainerd, Cal. in part); Webber Lake, Sierra County, 6,769 ft., *Kennedy & Doten 70*, July 2, 1901 (Cal.); Sierra Nevada, *Brandegee* (N. Y.).

Carex Harfordii sp. nov.

Cespitose, the thick rootstocks short, the culms erect, stiff, 2.5–8 dm. high, obtusely triangular, smooth, much exceeding leaves, light brownish at base. Leaves with well-developed blades usually three to five to a fertile culm, on lower fourth, but not bunched, the blades flat, 2.5–4.5 mm. wide, usually 1–3 dm. long. Head globose to oblong-ovoid, 1.5–2.5 cm. long, 1–2 cm. wide, the spikes ten to twenty, all closely aggregated, and the upper scarcely distinguishable, gynaecandrous, ovoid, rounded at base, rounded or tapering at apex, 6–10 mm. long, 4–6 mm. wide, the staminate flowers few, the perigynia ten to thirty in several to many rows, appressed-ascending or in age spreading, the beaks not conspicuous; one to several of lower bracts conspicuous, dilated and brown with hyaline margins, their tips usually shorter than or rarely little exceeding head. Scales ovate, acute, reddish brown with lighter midvein and very narrow hyaline margins, about width of and somewhat shorter than perigynia. Perigynia dull green or soon yellowish brown, narrowly ovate, thick and strongly plano-convex at maturity, 4.25 mm. long, 1.5 mm. wide, several nerved ventrally, strongly finely nerved dorsally, round-tapering to a substipitate beak, tapering into the bidentate beak, narrowly margined (serrulate above) from base, the beak one fourth length of body, slender, serrulate below, chestnut-tinged, obliquely cut dorsally and hyaline at apex. Achenes lenticular, thick, short-oblong, 2 mm. long, 1.25 mm. wide, apiculate, the slender style at length deciduous. Stigmas two.

This is a species only reported from near the coast. So far it has been found between Sonoma County on the north and Monterey County on the south. The bracts are often quite conspicuous. A specimen collected by Messrs. Kellogg and Harford (No. 1173) in 1868–9, and preserved at the New York Botanical Garden is taken as the type.

SPECIMENS EXAMINED

CALIFORNIA: *Kellogg & Harford 1073*, 1868–9 (type, in Herb. N. Y.); Pacific Grove, Monterey County, in pine woods, *Heller 6786*, May 25, 1903 (N.Y., L.S.); "In salt marsh at Fort Point, San Francisco", *Bolander 1568a*, June, 1862 (Cal.); "California" (C.); Punta de los Reyes, *Bigelow*, 1853–4 (C.); San Francisco, *Congdon*, May 3, 1881 (L.S.); Petaluma, Sonoma County, *Congdon*, May 12, 1880 (L.S.).

Carex pachycarpa sp. nov.

Carex adusta var. *congesta* W. Boott, Bot. Calif. **2**: 238. 1880.
Carex Liddoni var. *incerta* Bailey (in part), Bot. Gaz. **13**: 88. 1888.

Culms 3–6 dm. high, erect, obtusely triangular, smooth, much exceeding leaves, light brownish at base. Leaves with well-developed blades three to four to a fertile culm, on lower fourth, but not bunched, the blades flat, 2.5–4 mm. wide, usually 1–2 dm. long. Head globose or short ovoid, 1.5–2.5 cm. long, nearly as wide, the spikes 5–8, closely aggregated, gynaecandrous, ovoid, rounded at base, round-tapering at apex, 6–10 mm. long, 6–9 mm. wide, the staminate flowers few, the perigynia ten to twenty in several to many rows, appressed, the beaks not spreading; bracts scale-like, not prolonged. Scales ovate, acute or subcuspidate, light reddish-brown, with sharply defined lighter midvein and hyaline margins, about width of, but somewhat shorter than, mature perigynia. Perigynia dull green or soon straw-colored, ovate (rather narrowly), thick and strongly plano-convex, 5 mm. long, 2 mm. wide, many-striate dorsally, very faintly many-striate ventrally, round-tapering at base, contracted into bidentate beak, narrowly margined (serrulate above) from base, the beak half length of body, serrulate below, slender, reddish-tinged, obliquely cut dorsally and hyaline at apex. Achenes lenticular, thick, light brown, short oblong, 2 mm. long, 1.5 mm. wide, substipitate, apiculate, the slender style at length deciduous. Stigmas two.

Two specimens of this species in the herbarium of the University of California are in fully mature condition and are both labeled "*Carex Liddonii*" var. *incerta* Bailey. At least two of the three specimens cited by W. Boott under his *Carex adusta* var. *congesta* belong here, and as Prof. Bailey's *Carex Liddonii* var. *incerta* is based on Boott's variety primarily, it also is to be regarded as a synonym of the present species, although the only specimen cited by him (collected by Dr. Kellogg) may belong to something else. In general appearance specimens of this species strongly resemble coarse specimens of *Carex abrupta* Mackenzie. The perigynia, however, are markedly different, as shown in the key. This is apparently an Oregon species which ranges southward in the Sierra Nevadas.

SPECIMENS EXAMINED

CALIFORNIA: Big Tree Road, Silver Valley, 8,000 ft., *Brewer 1977*, July 31, 1863 (type, in Herb. Cal., part of sheet 1060); Big Trees, 4,788 ft., *Hillebrand 2310* (Cal., mounted with type); Echo Lake, Eldorado County, 7,500 ft., *Brainerd 197*, July 11, 1897 (Brainerd); Meisner's, Eldorado County, 7,600 ft., *Brainerd 198*, July 17, 1897 (Brainerd); Dinsmore's Ranch, Humboldt County, *Tracy 4145*, June 16, 1913 (K.M.).

OREGON: Anthony Lake, Elkhorn Mountains, *M. E. Peck 1*, August 19, 1915 (K.M.); Rock Creek Lake, Elkhorn Mountains, *M. E. Peck 31*, August 12, 1915 (K.M.); East Pine Creek, near Cornucopia, *M. E. Peck 45*, August 30, 1915 (K.M.); top of Mt. Ashland, Jackson County, *M. E. Peck 6*, July 16, 1913 (K.M.).

Carex abrupta sp. nov.

Densely cespitose, the culms 4–6 dm. high, slender but erect, triangular, smooth, much exceeding the leaves, aphyllopodic, light brownish at base. Sterile shoots less numerous than fertile, with four to six erect leaves. Fertile culms normally making growth in one year, with three or four well-developed leaves just above the base, the sheaths hyaline ventrally, the blades flat, 1.5–2.5 mm. wide, 5–15 cm. long; sterile shoots with similar leaves. Spikes four to eight, very densely aggregated in a suborbicular head 9–16 mm. long and nearly as wide, the spikes gynaecandrous, with few staminate flowers, ovoid, 5–8 mm. long, 5–6 mm. wide, rounded at base and apex, the perigynia ten to twenty in several ranks, ascending. Bracts scale-like. Scales ovate, chestnut brown with greenish center and at length hyaline margins, the midvein not conspicuous, obtuse, narrower and shorter than perigynia. Perigynia 3.75–4 mm. long, 1.5 mm. wide, plano-convex but thin-walled, soon brownish tinged with several conspicuous slender nerves on both sides, oblong-lanceolate, rather narrowly margined to the rounded base, the body serrulate on the margins above, abruptly contracted into the slender blackish-tipped beak with smooth margins and white-hyaline apex, obliquely cut dorsally. Achenes lenticular, oblong-ovoid, yellowish, substipitate, 1.8 mm. long, nearly 1 mm. wide, apiculate, the style slender straight, at length deciduous; stigmas two.

Distinguished by its abruptly beaked thin-walled strongly nerved perigynia.

SPECIMENS EXAMINED

CALIFORNIA: West Branch of North Fork of Feather River, near Sterling, Butte County, 3,000 ft., *Heller 10820*, June 7, 1913 (type, in Herb. K.M.); Hot Springs Valley near Lassen Peak, 6,000 ft., *Jepson 4101*, June 9, 1910 (K.M.); Poison Meadow, Big Arroyo, Sierra Nevada, 9,500 ft., *Jepson 1131*, August 1–12, 1900 (K.M.); Vivian Creek, San Bernardino County, 9,500 ft., *Geo. B. Grant 6403*, July 24, 1904 (Parish, K.M.); Mt. Tallac, near Lake Tahoe, 9,000 ft., *Abrams 4848*, July 29, 1911 (K.M.); Northeastern Modoc County, *Mrs. Manning 952* in part, June, 1903

(Cal.); Round Valley, San Jacinto Mountains, 9,500 ft., *Hasse*, June, 1903 (Parish); east slope of San Jacinto Peak, 9,600 ft., *F. M. Reed 2499*, July 11, 1908 (Parish); Bluff Lake, San Bernardino Mountains, *Mrs. Benton*, September, 1908 (Parish); San Jacinto Mountains, 10,800 ft., *Hall 2416*, July, 1901 (L.S.); Mt. Dana, 11,000 ft., *Bolander 5069*, 1866 (Cal.); alpine meadows along river, Truckee River Basin, Nevada County, 7,000 ft., *Davy*, June 25–30, 1897 (Cal.); Ebbett's Pass, 8,500 ft., *Brewer 2024*, August 3, 1863 (Cal.); *2075* (L.S.); Lassen's Peak, 9,000 ft., *Brewer 2178*, September 26–28, 1863 (Cal., L.S.); Echo Lake, 7,600 ft., *Brainerd 193*, July 11, 1897 (Brainerd); Mt. Goddard, 11,000 ft., *Hall & Chandler 693*, July 24–26, 1900 (L.S.); "California," 1866 (N.Y.); Soda Springs of Tuolumne, *Congdon*, August 14, 1894 (L.S.); near Bear Valley, San Bernardino County, *Abrams 2856*, August 2, 1902 (N.Y.).

OREGON: Head of East Pine Creek, *M. E. Peck 58, 59*, September 3, 1915 (K.M.); Anthony Lake, Elkhorn Mountains, *M. E. Peck 4, 5*, August 19, 1915 (K.M.); Silvies River, near mouth of Emigrant Creek, Harney County, *M. E. Peck 1*, July 9, 1912 (K.M.).

Carex mariposana Bailey, sp. nov.

Densely cespitose, the culms 2.5–6 dm. high, slender, much exceeding leaves, triangular, smooth, aphyllopodic, light brownish at base. Leaves with well-developed blades three to five to a fertile culm, on lower fourth, somewhat bunched, the blades flat, 2–3 mm. wide, usually 1–2 dm. long. Head 2–3.5 cm. long, oblong or ovoid, the spikes four to twelve, the upper closely approximate, the lower one to three slightly separate, ovoid or oblong ovoid, 8–12 mm. long, 4.5–7 mm. wide, short clavate and sparingly staminate at base, rounded at apex, the ten to twenty perigynia closely appressed with erect tips. Lower one or two bracts short prolonged, much shorter than head, the others scale-like. Scales ovate, acute, reddish with lighter center, noticeably narrower and shorter than perigynia. Perigynia deep green or in age greenish straw-colored, contrasting strongly with scales, narrowly ovate, 5 mm. long, 1.75 mm. wide, plano-convex at maturity, the walls membranaceous, strongly striate on both faces, narrowly winged, serrulate to middle, round tapering at base, tapering into slender, bidentate beak, one fourth length of body, light reddish tipped and scarcely hyaline at apex, obliquely cut dorsally. Achenes lenticular, obovoid, 2 mm. long, 1.5 mm. wide, substipitate, short apiculate, the slender style at length deciduous. Stigmas two.

Professor Bailey has long had in his herbarium under the name here published, the four sheets of this species referred to below, all collected in Mariposa County by Mr. J. W. Congdon. As all of these specimens are in very poor desiccated condition, I have taken the liberty of designating as the type of this species a most excellent specimen collected by Professor W. L. Jepson in the Tuolumne Meadows, No. 4476, on the 20th of July, 1911, and in my herbarium. This species is closely related in technical characters to *Carex abrupta* Mackenzie. However, the red scales in strong contrast with the green perigynia, together with the looser inflorescence, give it quite a different aspect, especially in fresh material.

SPECIMENS EXAMINED

CALIFORNIA: Yosemite, *Bolander 6222*, Summer, 1866 (Cal.); Yosemite, 4,000 ft., *Brewer 1641*, June 17, 1863 (Cal.); Soda Springs of San Joaquin, *Congdon*, Aug. 20, 1895 (Cal.); Lake Tahoe, Bear Valley, *Kellogg* (L.S.); Summit Camp, Sierra Nevada, *Kellogg*, July 9 (L.S.); headwaters of Hat Creek, Shasta County, 2,120 m., *Eggleston 7880*, July 31, 1911 (N.Y.); Clark's ranch, on branch of Merced River, *Torrey 551*, 1865 (N.Y.); Little Lake, near Meisner's Ranch, 7,600 ft., *Brainerd*, July 17, 1897 (Brainerd); above Slippery Ford, *Brainerd 205* in part, July 13, 1897 (Brainerd); Strawberry Creek, *Brainerd 226*, July 15, 1897 (Brainerd); Yosemite Valley, *Bioletti*, 1900 (Cal.); Lake Tenaya, Yosemite, *Hall & Babcock 3639*, June, 1902 (Cal.); Tuolumne Meadows, Sierra Nevada, 8,800 ft., *Jepson 4476*, July 20, 1911 (type, in Herb. K.M.); Johnson Lake, Mariposa County, *Congdon*, August 2, 1898 (Bailey); Crescent Lake, Mariposa County, *Congdon*, August 2, 1898 (Bailey); Yosemite, *Congdon*, August 28, 1899 (Bailey); Bridal Veil Trail, Mariposa County, *Congdon*, August 3, 1898 (Bailey); Butte Mountain, Northern Butte County, *Hall 9792*, 7,000 ft., July 27, 1914 (K.M.).

A note on the structural dimorphism of sexual and tetrasporic plants of Galaxaura obtusata

MARSHALL A. HOWE

In a monograph of *Galaxaura*, a genus of calcified red algae of the family Chaetangiaceae, published by the late Professor Kjellman of Upsala in 1900,* two groups of species, denominated the "Cameratae" and the "Spissae," are recognized in the section *Dichotomaria*, the section that includes the West Indian *Galaxaura obtusata* (Ell. & Sol.) Lamour. and its allies. The plants of these two groups differ markedly and constantly in the structure of the cortex, as may be determined by a microscopic examination, particularly after decalcification. In both groups, the cortex consists essentially of three layers of cells. In the "Cameratae," the cells of the outermost or superficial layer are funnel-shaped or broadly obconic and are supported by the cylindric, clavate, or narrowly funnel-shaped, widely spaced cells of the middle layer, which, in turn, spring from the very large firmly united cells of the inmost layer; the funnel-shaped superficial cells are in contact by their edges only and they arch over large intercellular chambers, which are continuous or confluent, being bounded below by the large cells of the inmost layer and merely traversed rather than bounded by the widely spaced stalk-cells; in other words, the single superficial layer constitutes a sort of a roof or outer sheath, supported by short pillars. In the "Spissae," the cells of the outermost or superficial layer are hemispheric or saucer-shaped and are supported by the ovoid or subglobose, connivent or rather close-set cells of the middle layer, which, in turn, rest upon the large firmly united cells of the inmost layer; the intercellular spaces are comparatively small and instead of obviously extending from the superficial layer to the inmost layer they are commonly divided into two series or strata by the rounded connivent cells of the middle layer. In other words, the middle layer of the

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* Kjellman, F. R. Om Floridé-slägtet *Galaxaura*, dess organografi och systematik. Kongl. Sv. Vet.-Akad. Handl. 33^1: 1–109. *pl. 1–20.* 1900.

cortex in the "Cameratae" consists chiefly of large obviously confluent intercellular *chambers* filled with lime, while in the "Spissae" this middle layer is made up chiefly of rounded calcified *cells*. Expressed in another way, it may be said that the two outer layers of the cortex in the "Cameratae" are filamentous, if two cells in a row (or, often, two or three cells supported capitately by a single stalk-cell) may be said to constitute a filament, while in the "Spissae," the cortex is parenchymatous or subparenchymatous throughout. In the process of decay or on teasing to pieces with needles after decalcification, it often happens that the outer cortex peels off, leaving the inner cortex still surrounding the central strand of filaments. In the "Cameratae", such a separation commonly takes place near the base of the stalk-cells constituting the middle layer, so that the two outer layers are exfoliated together, leaving the stumps of the stalk-cells protruding from the large firmly coherent cells of the inmost layer. In the "Spissae," the separation under such circumstances takes place between the two outer layers, only the single superficial layer being exfoliated, the middle layer of rounded subparenchymatous cells remaining firmly attached to the larger cells of the inmost layer.

In the course of a microscopic examination of certain specimens of *Galaxaura* from Bermuda, Florida, and the West Indies, representing forms currently referred to *G. obtusata*, it was noted that some of these specimens showed the cortex structure of the "Cameratae" group while others showed that of the "Spissae" group. It was at first supposed that two or more species were represented in this material, but it was afterwards observed that the two forms were often collected together almost throughout their range, that they showed the same or parallel variations in external characters, and that they could not be separated without a microscopic examination. A little later it was noted that whenever reproductive organs could be found (and by search they could be found in most of the specimens), the plants of the "Cameratae" structure were always tetrasporic, while those of the "Spissae" structure were always antheridial or cystocarpic. This discovery led to a careful reexamination of all the available material, with results that were confirmatory of this correlation.

One of the largest single collections at hand was that made by the writer on Condé Beach, Guantanamo Bay, Cuba, in March, 1909 (*no. 6460*), where nineteen plants or fragments of plants were picked up on the shore (the species is apparently an inhabitant of rather deep water and is found washed ashore or by dredging in 7–18 meters). Of these nineteen, three were antheridial and of the "Spissae" structure, three were cystocarpic and of the "Spissae" structure, twelve were tetrasporic and of the "Cameratae" structure, and the remaining one was apparently sterile and of the "Cameratae" structure. Of five plants dredged in 18 meters off Ratones Island near Ponce, Porto Rico (*no. 7575*), four belonged to the "Cameratae" and were tetrasporic, and one belonged to the "Spissae" and was cystocarpic. Of numerous plants or fragments dredged in 7–10 meters at the mouth of Guanica Harbor, Porto Rico (*no. 7005*), all of the thirteen examined showed the "Spissae" structure, three or four of them being evidently antheridial, one cystocarpic, and the rest apparently sterile. Of five plants found washed ashore in the harbor of Port Morant, Jamaica (*no. 6276*), two had the "Spissae" structure and were cystocarpic, while three showed the "Cameratae" structure, though tetraspores could actually be found on only one of the three. In six plants from Barbados, similar to each other in general habit, though not all collected at the same time and place, five were "Cameratae," four of them with obvious tetraspores, while the sixth showed the structure of the "Spissae" group and was cystocarpic. On the coast of Florida also, in the region of Jupiter Inlet, Indian River, and Lake Worth, in plants that are somewhat larger, coarser, and longer-segmented than the typical *Galaxaura obtusata*, the same correlations may be observed.

Finally, it is to be noted by consulting Kjellman's monograph, that all of the species that he placed in the group "Cameratae," in so far as their mode of reproduction was known to him, are tetrasporic, while of the "Spissae" the one species of which the reproductive organs are described is cystocarpic.

For complete proof that the "Cameratae" structure is a constant characteristic of the tetrasporic plants of *Galaxaura obtusata* and its allies and that the "Spissae" structure is likewise a constant character of the sexual plants, it would of course be desirable that actual cultures should be made under control conditions as has been done by Hoyt* and by Lewis† to demonstrate the alternation of generations in certain other tetraspore-producing algae. This could be done only in tropical or subtropical waters, would probably require months for its accomplishment, and is not likely to be achieved in the immediate future. Meanwhile, however, it seems to the writer that the proof is conclusive that the suggested correlation exists, that the "Spissae" and "Cameratae" characters, first accurately pointed out by Kjellman, do not offer a proper basis for subgeneric groupings of species as supposed by him, but merely distinguish the gametophytic and sporophytic phases in the life-cycle of a single species.

It is well known that differences of habit occur between sexual and tetrasporic plants of certain red algae, as, for example, in species of *Griffithsia*, but such differences seem to be due largely to the presence of the reproductive organs themselves or to differences in the form of the cells that are rather directly concerned with their production. So far as is known to the writer of these notes, there has been no previous record of a case in which there has been alleged to exist any such constant and pronounced dimorphism in the purely vegetative microscopic structure of the sexual and tetrasporic plants in the Rhodophyceae as is here attributed to *Galaxaura obtusata*—differences that do not express themselves in general habit, but afford an easy means of distinguishing a tetrasporic from a sexual plant, even though apparently sterile.

NEW YORK BOTANICAL GARDEN,
BRONX PARK, NEW YORK CITY

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* Hoyt, W. D. Alternation of generations and sexuality in *Dictyota dichotoma*. Bot. Gaz. **49**: 55–57. 1910.

† Lewis, I. F. Alternation of generations in certain Florideae. Bot. Gaz. **53**: 236–242. 1912.

The flora of Ladak, Western Tibet. II. List of Ladak plants

RALPH RANDLES STEWART

The terminology employed in the present list does not always agree with the most advanced usage in North America because of the desire to make it conform to that in Hooker's Flora of British India (22). Hooker's work is likely to be used in India for years to come, and Kew standards rather than American will be followed. Where Hooker's name has been changed it is given as a synonym in parentheses.

The identifications in most cases are my own, though I have had a great deal of assistance from members of the staff at the New York Botanical Garden and from Mr. Hutchinson of Kew, who kindly determined a number of difficult specimens.

As my plants were all collected between July 17th and August 21st, it is hardly necessary to print the date of each specimen and as Hooker is careful to give altitudes, only those that differ from his or those that seem specially noteworthy are given. A list of the heights of the localities mentioned is appended, however, so that the approximate height at which individual plants grew can be found out if desired.

The following abbreviations are used: FBI, Hooker's Flora of British India (22); Hend., Henderson and Hume's Lahore to Yarkand (21); J.L.S., J. L. Stewart's Punjab Plants (34), etc.; R.R.S., R. R. Stewart. Species marked with an asterisk (*) were not found by me.

FUNARIACEAE

FUNARIA SUBMICROSTOMA C. Müll. Fotu La.

BRYACEAE

BRYUM TIBETICUM Mitt.† Sapi La.

POLYPODIACEAE

CYSTOPTERIS FRAGILIS (L.) Bernh. Common throughout.

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† A second undetermined species of *Bryum* was collected at Yarungshan.

EQUISETACEAE

EQUISETUM ARVENSE L.* Dras (Hend.).

" DIFFUSUM Don. Khalotse to Yuru.

" RAMOSISSIMUM Desf. Spitug. Baker (1) says this is equally *E. elongatum* Willd. and *E. ramosum* Schk.; Henderson and Hume call their Indus Valley specimens *E. ramosum*.

PINACEAE

JUNIPERUS MACROPODA Boiss. Not rare; specimens from Himis Shukpa grove the best.

JUNIPERUS WALLICHIANA Hook. f. (*J. Pseudo-Sabina* Fisch. & Mey.). "Western Tibet" (Brandis, FBI).

JUNIPERUS COMMUNIS L.* Dras Valley (Hend.).

GNETACEAE

EPHEDRA GERARDIANA Wall. Common, very variable in height.

" INTERMEDIA Schrenk & C. A. Mey.* Zanskar (Brandis, FBI).

NAIADACEAE

POTAMOGETON PECTINATUS L. Common.

" PERFOLIATUS L. Common.

ZANNICHELLIA PALUSTRIS L.* "Western Tibet" (FBI).

JUNCAGINACEAE

TRIGLOCHIN MARITIMA L. Common.

" PALUSTRIS L. Common.

GRAMINEAE

ERIANTHUS RAVENNAE Beauv.* "Western Tibet" (FBI); probably from Skardo.

ANDROPOGON ISCHAEMUM L. Common.

PASPALUM AMBIGUUM DC.* "Western Tibet" (FBI).

PANICUM MILIACEUM L. Suru, cultivated.

SETARIA VIRIDIS (L.) Beauv. Leh, Shergol.

PENNISETUM LANATUM Klotzsch.* "Western Tibet" (FBI); probably not from Ladak.

PENNISETUM FLACCIDUM Griseb. Very common.

STIPA BARBATA Desf. (under *S. orientalis* Trin. in FBI). Tralse, Leh, Himis Shupka, Tsokar Lake.

STIPA BASIPLUMOSA Munro.* Nubra and Lanak La (FBI).

" PURPUREA Griseb.* Lake Rukshan (FBI).

" PURPUREA LONGE-ARISTATA.* "Western Tibet" (FBI).

" MONGOLICA Turcz.* Ladak (FBI).

" SIBIRICA Lam.* Dras (Hend.).

" HOOKERI Stapf.* Nubra (FBI).

" SPLENDENS Trin. Spituk, Himis Shupka.

ORYZOPSIS LATERALIS Stapf.* "Western Tibet" (FBI).

" MUNROI Stapf.* Ladak, Nubra, Zanskar (FBI).

MILIUM EFFUSUM L.*

HELEOCHLOA SCHOENOIDES (L.) Host. "Western Tibet" (FBI).

PHLEUM ALPINUM L. Suru to Sirimarg.

ALOPECURUS HIMALAICUS Hook. Rusi La.

" PRATENSIS L.* Zoji La (Hend.).

POLYPOGON MONSPELIENSIS Desf. Saspola.

AGROSTIS ALBA L. Common.

" CANINA L. Ladak (Hend.), "Western Tibet" (FBI).

CALAMAGROSTIS LITTOREA DC. Common.

" STOLICZKAI Hook.* Zanskar on Pensi La (FBI).

DEYEUXIA COMPACTA Munro.* Nubra (FBI).

" SCABRESCENS Munro.* Leh (Meebold).

AIRA CARYOPHYLLEA L.* "Western Tibet" (FBI).

DESCHAMPSIA CAESPITOSA (L.) Beauv. Rogshin.

" KOELERIOIDES Regel.* Dras (FBI).

TRISETUM SPICATUM (L.) Richter (*Avena subspicata* Clairv. in FBI). Khardong La, Rusi La.

AVENA FATUA L. Field work in Ladak.

" SATIVA L. Himis Shukpa, not cultivated.

DANTHONIA KASHMIRIANA Duthie.* "Western Tibet" (FBI).

CHLORIS VIRGATA Sw.* "Western Tibet" (FBI); doubtfully in Ladak.

PHRAGMITES COMMUNIS Trin. Spituk, Himis Shupka.

ERAGROSTIS MINOR Host. Leh.

KOELERIA CRISTATA Pers.* Dras Valley (Hend.), "Western Tibet" (FBI).

" ARGENTEA Griseb.* "Western Tibet" (FBI).

CATABROSA AQUATICA ANGUSTA Stapf.* Lanak La (FBI), Leh (Meebold).

" THOMSONI Hook.* Nubra (FBI).

MELICA CUPANI Guss.* (*M. ciliata* L. of Hend. and of Duthie). Dras (Hend.), "Western Tibet" (FBI).

BRIZA MEDIA L.* "Western Tibet" (FBI).

DACTYLIS GLOMERATA L. Dras.

SCHIZMUS MARGINATUS Beauv.* Nubra, Dras (FBI).

POA PERSICA Trin.* "Western Tibet" (FBI).

" BULBOSA L.* Zanskar (FBI).

" ALPINA L.* Ladak (Hend.), "Western Tibet" (FBI).

" TIBETICA Munro.* Ladak, saline plains (FBI).

" PRATENSIS L. Rogshin, Nyemo?

" ATTENUATA Trin. Khardong La.

" NEMORALIS LIGULATA Stapf. Rokshin, Suru, Yarungshan.

" TREMULA Stapf.* Ladak (FBI).

" ANNUA L. Yarungshan.

GLYCERIA DISTANS Wahlenb.* "Western Tibet" (FBI).

" THOMSONI Stapf.* Rupshu (FBI), Leh (Meebold).

" POAEOIDES Stapf.* Rupshu (FBI).

FESTUCA NITIDULA Stapf.* Nubra. (FBI).

" ALTAICA Trin.* Dras. (FBI).

" RUBRA L. Rogshin.

" SIBIRICA Hack.* Ladak. (FBI).

" MYUROS L.* "Western Tibet" (FBI).

BROMUS CRINITUS Boiss. & Hohen. Rachogpa.

" TECTORUM L. Namika La, Timisgam.

" PATULUS Mert. & Koch.* Ladak (Hend.).

BROMUS OXYODON Schrenk.* Dras, Zanskar (FBI).
" MACROSTACHYS Desf. Rupshu.
" BARBATUS Beauv. Tsokar Lake; common in Indus Valley.
DUTHIEA BROMOIDES Haeckel.* "Western Tibet" (FBI).
LOLIUM PERENNE L.* "Western Tibet" (FBI).
AGROPYRON LONGE-ARISTATUM Boiss. Khardong.
" JACQUEMONTII Hook.* Nubra (FBI).
" REPENS (L.) Beauv.* Ladak (FBI).
" DENTATUM ELATUM Hook. f.* Dras. (FBI).
TRITICUM VULGARE L. Cultivated in Ladak.
HORDEUM VULGARE L. Cultivated widely to about 14,000 ft. alt.
" NODOSUM L. (*H. secalinum* Schreb. in FBI). Common.
ELYMUS SIBIRICUS L. Common.
" DAHURICUS Turcz. Common.
" DASYSTACHYS Trin. Common.

CYPERACEAE

SCIRPUS PAUCIFLORUS Lightf.* "Western Tibet" (FBI).
" PUMILUS Vahl.* Skardo and Hanle (FBI).
" SETACEUS L. Timisgam.
" LACUSTRIS L.* Ladak (FBI).
" CARICIS Retz.* Leh (FBI).
" RUFUS (Huds.) Schrad. "Western Tibet" (FBI), Himis Shupka?
ELEOCHARIS PALUSTRIS (L.) R. & S. Khardong.
KOBRESIA PYGMAEA C. B. Clarke.* Ladak (FBI).
" CAPILLIFOLIA (Decne.) C. B. Clarke.* Kangi (Meebold).
" SCHOENOIDES (C. A. Mey.) Steud. Tsokar Lake, Khardong.
" ROYLEANA (Nees) Boeck.* "Western Tibet" (FBI).
" ROYLEANA KOKANICA (Regel) Kükenth.* Kangi (Meebold).
" MACRANTHA Boeck.* Nubra and Ladak (FBI).
CAREX INCURVA Lightf.* Kunawar and Kashmir to the Karakorum (FBI).
" STENOPHYLLA Wahlenb.* Piti and Kashmir to the Karakorum (FBI).
" RIGIDA Good. Khardong, Rusi La?
" VULGARIS Fries.* From Gilgit to Lahoul (FBI).
" MICROGLOCHIN Wahlenb.* Karakorum to Kunawar (FBI).
" PARVA Nees.* Deosai to Sikkim (FBI).
" NIVALIS Boott. Suru, Baralacha.
" MOORCROFTII Falc. Often common at high altitudes.
" USTULATA Wahlenb.* Karakorum to Sikkim (FBI).
" DILUTA M. Bieb.* Indus Valley (FBI).
" HAEMATOSTOMA Nees.* Nubra (FBI).
" OLIGOCARPA Schkuhr.* Dras to the Karakorum (FBI).
" HIRTELLA Drej.* Eastern Kangi (Meebold).

LEMNACEAE

LEMNA MINOR L.* "Western Tibet" (FBI).

JUNCACEAE

JUNCUS MEMBRANACEUS Royle. Rusi La, Dras, Sapi La, Suru to Sirimarg.
" SPHACELATUS Decne. Khardong La (immature and possibly *J. himalensis* Klotzsch.), East Kangi (Meebold).

JUNCUS LAMPOCARPUS Ehr.* "Western Tibet" (FBI).
" TRIGLUMIS L.* "Western Tibet" (FBI).
" HIMALENSIS Klotzsch.* "Western Tibet" to Bhotan (FBI).
" LEUCOMELAS Royle.* "Western Tibet" (FBI).

LILIACEAE

EREMURUS HIMALAICUS Baker. Near Dras.
GAGEA PERSICA Boiss. Kangi (Meebold).
ALLIUM CEPA L. Cultivated.
" SEMENOVI Regel.* Kangi (Meebold).
" SCHOENOPRASUM L. Kangi (Meebold).
" PLATYSPATHUM FALCATA Regel.* "Western Tibet" (FBI).
" JACQUEMONTI Regel.* "Western Tibet" (FBI); probably southeast of Ladak.
ALLIUM ODORUM L.* Indus Valley, Ladak (Hend.), "Western Tibet" (FBI).
" GOVANIANUM Wall.* Dras Valley (Hend).
" OREOPRASUM Schrenk.* Zalung-Karpo Pass (FBI).
" LORATUM Baker.*† "Western Tibet" (FBI).
FRITILLARIA ROYLEI Hook. Zoji to Matayan.
LLOYDIA SEROTINA Roxb. Ladak (Hend., FBI).
POLYGONATUM VERTICILLATUM All.* Dras Valley (Hend.).

IRIDACEAE

IRIS ENSATA Thunb. Common in the Indus Valley.
" KAMAONENSIS Wall.* Dras (Duthie), Ladak (Hend., J.L.S.).

ORCHIDACEAE

ORCHIS LATIFOLIA L. Zoji Matayan.
HERMINIUM MONORCHIS R. Br. Himis Shupka.
EPIPACTIS LATIFOLIA THOMSONI Hook. f.* "Western Tibet" (FBI).

SALICACEAE

POPULUS ALBA L.* To 9,200 ft. alt. in Tibet (FBI).
" EUPHRATICA Oliv.* Nubra along the Shayok (FBI).
" CANDICANS Ait. Commonly cultivated in Ladak; especially fine specimens are in the commissioner's garden at Leh.
POPULUS NIGRA ITALICA Du Roi. Commonly cultivated, especially in Leh.
" CILIATA Wall.* Leh (Meebold).
SALIX ALBA L.* Commonly cultivated.
" ELEGANS Wall.* Dras Valley near Snow (Hend.).
" SCLEROPHYLLA Anderss.* Dras (FBI).
" FRAGILIS L.* Cultivated in "Western Tibet" (Brandis).
" HASTATA L.* North side, Zoji (Hend., named *S. arbuscula?*), "Tibet" (FBI).
" DAPHNOIDES Vill. Sapi River?, "Western Tibet" (FBI), Ladak (Hend.).
" FLABELLARIS Anderss.* Cultivated in Ladak (Brandis), Kangi (Meebold).
" PYCNOSTACHYA Anderss.* Cultivated in Ladak (Brandis).
" ANGUSTIFOLIA Willd. Cultivated at Khalotse (R.R.S.), Nubra and Shayuk (FBI).

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† An undetermined species of *Allium*, close to *A. rubellum* Bieb., was collected at Suru.

SALIX DIVERGENS Anders.* Zanskar. (FBI).
" TETRASPERMA Roxb.* Dras Valley (Hend.).
" OXYCARPA Anderss.*† Kangi (Meebold).

JUGLANDACEAE

JUGLANS REGIA L. Cultivated in Indus Valley.

BETULACEAE

BETULA UTILIS D. Don. Not noticed beyond the Zoji Pass (R.R.S.), (Hend.).

ULMACEAE

ULMUS PARVIFOLIA Jacq. Saspola (R.R.S.), Nubra (FBI).

URTICACEAE

URTICA HYPERBOREA Jacq. Lachalung, Kargil?
" DIOICA L.* "Western Tibet" (FBI).
PILEA PEPLOIDES Hook. & Arn.* Zanskar (FBI).
PARIETARIA DEBILIS Forst.* "Western Tibet" (FBI).

MORACEAE

MORUS ALBA L. Cultivated in the Indus Valley.

SANTALACEAE

THESIUM HIMALENSE Royle.* Dras Valley (Hend., under *Th. multicaule* Ledeb.), East Kangi (Meebold), "Western Tibet" (FBI).

POLYGONACEAE

RUMEX ORIENTALIS Bernh. Nyemo. The fruit is almost free from tubercles and the plant may therefore be *R. aquaticus* L. The same thing, collected by Schlagintweit, is marked "*R. crispus* L. var."
RUMEX ACETOSA L.* Dras (Hend.).
OXYRIA DIGYNA (L.) Hill. Saspola, Baralacha.
RHEUM SPICIFORME Royle. Lachalung La.
" TIBETICUM Meissn. Gya.
" WEBBIANUM Royle.* Kangi (Meebold).
" EMODI Wall.* Kangi (Meebold).
POLYGONUM ISLANDICUM Hook. Gya.
" FILICAULE Wall.* Ladak (FBI).
" COGNATUM Meissn. Dras, Baralacha.
" PARONYCHIOIDES C. A. Mey. Kharbu, Leh?
" AVICULARE L. Fotu La.
" TUBULOSUM Boiss.* "Western Tibet" (FBI), Leh (Meebold).
" MOLLIAEFORME Boiss. Baralacha, very dwarf.
" VIVIPARUM L. Khardong La, Kharbu.
" SPHAEROSTACHYUM Meissn.* "Western Tibet" (FBI).
" AMPLEXICAULE D. Don. Suru.
" AFFINE D. Don. Sapi La, Baralacha.
" VACCINIIFOLIUM Wall.* Ladak (FBI).
" LAPATHIFOLIUM L. Khalotse to Yuru.

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† An undetermined species of *Salix* was collected at Rusi La.

Polygonum tomentosum Schrank. Leh (R.R.S.); a specimen of this from Schlagintweit is mixed with *P. Persicaria*.

Polygonum Persicaria L.* "Western Tibet" (FBI).

" Hydropiper eglandulosa Hook. f.* Ladak (FBI).

" polystachyum Wall. Suru.

" tortuosum D. Don.* Rupshu, Sapi La, Lachalung.

" sibiricum Laxm. Gya, Himis, Lachalung; very dwarf.

" Convolvulus L.* Nubra (FBI), Eastern Kangi (Meebold, as *P. nepalense* Meissn.).

Polygonum alatum Buch.-Ham. Timisgam.

Fagopyrum tataricum Gaertn. Leh, etc., cultivated.

" esculentum Moench.* Weed of cultivated grounds in Ladak (Hend.), Zanskar, etc. (FBI).

CHENOPODIACEAE

Chenopodium album L. Lachalung, 16,000 ft. alt. A Himis specimen is only 2 in. tall. Ubiquitous.

Chenopodium opulifolium Schrad.* "Western Tibet" (FBI).

" hybridum L.* Ladak (FBI).

" glaucum L.* Ladak (FBI).

" Botrys L. Common weed in Indus Valley; Ladak.

" Blitum Hook. Matayan.

Atriplex hortensis L.* "Western Tibet" (FBI).

" crassifolia C. A. Mey. Rachogpa, Fotu La, Kargil.

" rosea L. Leh (Hend.), Sassar and Haule (FBI), Rokshin (R.R.S.).

Eurotia ceratoides C. A. Mey. Common, sometimes furnishing the only fuel at high altitudes.

Axyris amaranthoides L.* "Western Tibet" (FBI).

" amaranthoides humifusa? Rusi La.

Chenolea divaricata Hook. Nyemo; a colonial annual, forming dense, hairy, pyramidal masses in the desert. This may be the *Echinopsilon mollis* of Henderson, which he noted in the Indus Valley.

Kochia prostrata Schrad. Dras, Namika, Kargil.

" odontoptera Schrenk. Saspola, Himis.

Corispermum hyssopifolium L.* "Western Tibet" (FBI).

Suaeda corniculata Bunge.* "Western Tibet," Parang Valley and Hanle plains (FBI).

Suaeda microsperma Ledeb. Ladak, banks of the Indus, Pangong Lake, etc. (FBI); I have immature specimens from Spitug by the Indus that seem to be this.

Salsola Kali L. Khalotse to Leh.

" collina Pall. Khalotse to Leh, Tsokar Lake.

Haloxylon Thomsoni Bunge. Tralsi, Nyemo, Leh.

Halocharis violacea Bunge. Saspola, Gya, Tralse, Leh?

Halogeton glomeratus C. A. Mey. Gya, Leh.

CARYOPHYLLACEAE

Stellaria media (L.) Cyrill. Leh.

" tibetica Kurz.* Trantse Lundo (FBI).

" graminea L. Common.

" decumbens Edgew. Baralacha.

Stellaria glauca With.* Indus Valley (FBI).
" subumbellata Edgew.* Nubra (FBI).
" semivestita Edgew.* Kangi (Meebold).
Cerastium trigynum Villars. Khardong.
" vulgatum L. Zoji to Matayan.
" vulgatum tibetica Edgew. & Hook. f.* Ladak.
" vulgatum nepalense Wall.* Kangi (Meebold).
Sagina procumbens L.* "Western Tibet" (FBI).
Arenaria Griffithsii Boiss. Dras Kharbu, Sapi La, Rusi La.
" kashmirica Edgew.* Kangi (Meebold), "Western Tibet" (FBI).
" musciformis Wall. Lachalung.
" foliosa Royle. Sapi.
" serpyllifolia L.* "Western Tibet" (FBI).
" Stracheyi Edgew.* Ladak (FBI).
" holosteoides Edgew. Common in fields.
Thylacospermum rupifragum Schrenk.* "Alpine Western Tibet" (FBI).
Silene vulgaris (Moench.) Garcke (*S. inflata* Smith). Common in fields.
" conoidea L.* Moolbeck (Hend.), Leh (Meebold), Ladak (FBI).
" Moorcroftiana Wall. Namika La, Kharbu, Baralacha.
" tenuis Willd. Common.
Lychnis apetala L. Yarungshan, Khardong, Lachalung.
" himalayensis Edgew. Leh, Suru; more than minutely pubescent.
" nutans Benth. Suru.
" macrorhiza Royle. Lachalung.
Gypsophila sedifolia Kurz. Zanskar and Dras (FBI); mine is *sine loco.*
Dianthus anatolicus Boiss. Zoji to Matayan, Sapi, Baralacha.
" deltoides L.* "Western Tibet" (FBI).
" Seguieri Vill. Ladak (FBI).
" angulatus Royle.* Zanskar (FBI).
" crinitus Sm.* Moolbeck (Hend.), Western Tibet (FBI).
Saponaria Vaccaria L. A common weed in fields.

RANUNCULACEAE

Isopyrum grandiflorum Fisch. Lachalung.
Aquilegia vulgaris viscosa Hook. f. & Thoms. Kargil, Lachalung.
" vulgaris pyrenaica (DC.) Hook. f. & Thoms. Moolbeck, Sapi La.
Delphinium Brunonianum Royle. Khardong, Takilung La, Yarungshan, etc.
" cashmirianum Royle. Sapi La.
Aconitum heterophyllum Wall. Suru to Sirimarg, Yarungshan.
" Napellus multifidum (Royle) Hook. f. & Thoms. Suru, Sapi La.
Anemone rupicola Cambess. Rusi La, Zoji to Matayan.
" rivularis Buch.-Ham. Timisgam.
" albana Stev.* "Western Tibet" (FBI).
Clematis orientalis acutifolia Hook. f. & Thoms. Common in the Indus Valley; one collection near Saspola Drokpo had almost black flowers.
Oxygraphis polypetala Hook. f. & Thoms.* Kangi La (Meebold), Dras (Duthie, etc.).
Ranunculus Cymbalaria Pursh. Common; the leaves are smaller and less lobed than American specimens.

Ranunculus hyperboreus natans Regel. Khardong.

" hyperboreus multifidus Hook. f. & Thoms.* Ladak (FBI).

" pulchellus C. A. Mey. Common at high levels.

" laetus Wall.* Near Zoji (Hend.), "Western Tibet" (FBI).

" affinis R. Br. Kharbu.

" hirtellus Royle. Common, especially along the great range of the Himalaya.

Ranunculus lobatus Jacquem.* Ladak (Hend.), Zanskar (FBI).

" aquatilis trichophyllus Gray. Matayan.

Thalictrum minus L. To Matayan.

" minus foetidum (L.) Hook. f. & Thoms. Common in villages.

" alpinum L.* "Western Tibet" (FBI).

" platycarpum Hook. f. & Thoms.* Nubra (FBI).

" rutaefolium Hook. f. & Thoms.* "Western Tibet" (FBI).

Adonis chrysocanthus Hook. f. & Thoms. Matayan.

BERBERIDACEAE

Podophyllum Emodi Wall. Suru.

Berberis vulgaris L. Near Kargil (Hend.), "Western Tibet" (FBI).

" ulicina Hook. f. & Thoms.* Nubra (FBI).

PAPAVERACEAE

Hypecoum leptocarpum Hook. f. & Thoms. Lachalung La.

Meconopsis aculeata Royle. Baralacha Pass and along "great range."

Papaver nudicaule L. Khardong La.

Corydalis tibetica Hook. f. & Thoms. Back of Leh.

" Moorcroftiana Wall.* Guge (FBI).

" Gortschakovii Schrenk. Yarungshan.

" stricta Steph. Lachalung.

" flabellata Edgew. Numika La, Kargil to Moolbeck.

" adiantifolia Hook. f. & Thoms.* Zanskar (FBI).

" crassifolia Royle. Rachogpa? (R.R.S.), Dras (Duthie).

" meifolia Wall. Baralacha Pass.

CRUCIFERAE

Lepidium latifolium L. Namika La, Saspola, Spituk, etc.; Thellung notes several varieties of this in Ladak.

Lepidium capitatum Hook. f. & Thoms. Lachalung La.

" apetalum Willd. A species close to the above, Gya, "Western Tibet" (FBI, under *L. ruderale* L.).

Dilophia salsa Thoms.* "Western Tibet" (FBI).

Thlaspi arvense L. Sapi La, Kharbu, Nyemo, Shergol.

" alpestre L. Matayan, Spituk.

Cochlearia scapiflora Hook. f. & Thoms.* Masimik La (Hend.).

Sisymbrium mollissimum C. A. Mey. Leh.

" humile C. A. Mey.* (*Braya humilis* Robinson). Chang La (Hend.), Kangi (Meebold), "Western Tibet" (FBI).

Sisymbrium minutiflorum Hook. f. & Thoms.* Zanskar (FBI).

" Sophia L.* Leh, Nyemo.

" Columnae Jacquem. Namika La, Gya.

" Thalianum (L.) J. Gay.

TAUSCHERIA LASIOCARPA DC.* "Western Tibet" (FBI).

BRASSICA NAPUS L. Sometimes very dwarf; Spituk, Khalotse to Yuru. It is probable that other species of *Brassica* occur, such as *B. nigra* (L.) Koch and *B. juncea* (L.) Coss.

CRAMBE CORDIFOLIA Stev.* "Western Tibet" (FBI).

BARBAREA VULGARIS R. Br.* Dras (Hend.), "Western Tibet" (FBI).

CARDAMINE MACROPHYLLA LOBATA Hook. f. & Thoms.* "Western Tibet" (FBI).

CAPSELLA ELLIPTICA C. A. Mey.* Leh (Meebold), "Western Tibet" (FBI).

" THOMSONI Hook. f.* Ladak, Nubra (FBI).

DRABA GLACIALIS Adams. Rusi La.

" ALPINA L. Yarungshan, Sapi?

" INCANA L.* "Western Tibet" (FBI).

" LASIOPHYLLA Royle. Baralacha Pass.

" FLADNIZENSIS Wulf.* Leh, Kangi (Meebold), "Western Tibet" (FBI).

" FLADNIZENSIS HOMOTRICHA (Ledeb.) Hook. f. & Thoms. Nubra (FBI).

" TIBETICA THOMSONI Hook. f. & Thoms.† Zanskar (FBI).

ARABIS TIBETICA Hook. f. & Thoms. Lachalung.

" GLANDULOSA Kar. & Kir.* Near Ladak (FBI).

" GLABRA (L.) Bernh.* Leh (Meebold).

" ALPINA L. Zoji La (Hend.).

ERYSIMUM ODORATUM Ehrh. Zoji to Matayan.

" HIERACIFOLIUM L.* Dras Valley (Hend., under *E. strictum* Gaertn.).

CHEIRANTHUS HIMALAYENSIS Cambess.* Kangi La (Meebold), "Western Tibet" (FBI).

CHEIRANTHUS STEWARTII T. Anders.* Near Ladak (FBI).

" ALBIFLORUS T. Anders.* Zanskar (FBI).

ALYSSUM CANESCENS DC. Tsokar Lake.

BRAYA ALPINA Sternb. & Hoppe. Rokshin.

" UNIFLORA Hook. f. & Thoms.* Nubra (FBI).

" TIBETICA Hook. f. & Thoms.* "Western Tibet" (FBI).

" ROSEA Bunge.* "Western Tibet" (FBI), Leh (Meebold).

ATELANTHERA PERPUSILLA Hook. f. & Thoms.* Zanskar (FBI).

MALCOLMIA AFRICANA R. Br.* Ladak (J.L.S.), "Western Tibet" (FBI).

EUCLIDIUM SYRIACUM R. Br.* East Kangi (Meebold).

MATTHIOLA ODORATISSIMA R. Br. Near Leh, to Kargil.

CHORISPORA SABULOSA Cambess. Suru, Zoji to Matayan.

CHRISTOLEA CRASSIFOLIA Cambess. Common on high dry passes such as the Fotu, Namika and Lachalung.

PARRYA EXSCAPA C. A. Mey.* "Western Tibet" (FBI).

" MACROCARPA R. Br.* Alpine region of Western Tibet (FBI).

" LANUGINOSA Hook. f. & Thoms.* Gugi (FBI); probably not Ladak.

CONRINGIA PLANISILIQUA Fisch. & Mey. Saspola.

CAPPARIDACEAE

CAPPARIS SPINOSA L. Khalotse.

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† An undetermined species of *Draba*, close to *D. incana* but with the fruit not hairy, was collected at Rokshin and Yarungshan; a second undetermined species, probably undescribed, was likewise found at Yarungshan.

CRASSULACEAE

SEDUM RHODIOLA DC. Dras, Suru, Rusi La, Baralacha.
" TILLAEOIDES Duthie? Khardong.
" QUADRIFIDUM Pall.* Leh oasis (Meebold).
" ASIATICUM Spreng. Suru, Sirimarg.
" EWERSII Ledeb. Sapi La, Suru to Sirimarg, Khalotse to Yuru.
" TIBETICUM STRACHEYI Hook. f. & Thoms. Common at high altitudes; Rupshu, Suru and Ladak.
SEMPERVIVUM ACUMINATUM Jacquem. Common.

SAXIFRAGACEAE

SAXIFRAGA SIBIRICA L. Fotu La, Baralache Matayan.
" CERNUA L. Yarungshan.
" HIRCULUS L. "Western Tibet" (FBI), the typical form and varieties.
" HIRCULUS INDICA C. B. Clarke. Rokshin, Rusi La, Yarungshan, Khardong.
SAXIFRAGA JACQUEMONTIANA Decne. Yarungshan.
" RAMULOSA Wall.* Kangi (Meebold).
" FLAGELLARIS Willd. Khardong La, Rusi La, Yarungshan.
" FLAGELLARIS MUCRONULATA (Royle) C. B. Clarke. Zoji to Matayan, Moolbeck.
SAXIFRAGA OPPOSITIFOLIA L.* "Western Tibet" (FBI).
" STRACHEYI Hook. f. & Thoms. Sapi La.
PARNASSIA OVATA Ledeb. Kharbu, Gya.
" PALUSTRIS L.* "Western Tibet" (FBI); probably from Skardo.
RIBES ORIENTALE Desf. Dras, Dras to Kharbu, Barso Valley.
" GROSSULARIA L.*

ROSACEAE

COTONEASTER VULGARIS Lindl.* "Western Tibet" (FBI).
" NUMMULARIA Fisch. & Mey. Near Kargil.
" ACUMINATA Lindl. Eastern Kangi (Meebold).
PYRUS MALUS L. Cultivated in Ladak.
" COMMUNIS L. "Western Tibet" (FBI); rare in Ladak, if present at all.
RUBUS SAXATILIS L.* Dras (FBI).
POTENTILLA SIBBALDI Hall. f.(*Sibbaldia procumbens* L.). Suru to Sirimarg.
" TETRANDRA Hook. f. Lachalung, back of Leh.
" FRUTICOSA L. Ladak, Baralacha; not the typical American *P. fruticosa.*
POTENTILLA FRUTICOSA OCHREATA (Lindl.) Lehm. Rachogpa.
" FRUTICOSA INGLISII (Royle) Hook. f. Yarungshan Pass.
" FRUTICOSA PUMILA Hook. f. Ladak (place lost), Kangi (Meebold).
" SALESOVII Steph.* Ladak (J.L.S.), Eastern Kangi (Meebold), "Western Tibet" (FBI).
POTENTILLA AMBIGUA Cambess. Zingzingbar, Rupshu.
" ANSERINA L. Leh, Timisgam, Fotu La.
" BIFURCA L. Common.
" MULTIFIDA L. Common; the typical form and varieties.
" SERICEA L. Common.
" CURVISETA Hook. f.* Kangi (Meebold).

Potentilla argyophylla Wall. Matayan, Baralacha?

" argyrophylla leucochroa (Lindl.) Hook. f. Baralacha, Khardong.

" atrosanguinea Lodd. Zoji.

" gelida C. A. Mey.* "Western Tibet" (FBI).

" nivea L. "Western Tibet" (FBI).

Chamaerhodos sabulosa Bunge.* "Western Tibet" (FBI).

Rosa Eglanteria L. Zoji to Matayan, Kharbu, Himis Shukpa; some of the flowers are double.

Rosa Webbiana Wall. Common; large and very handsome, often covering arid hillsides with pink.

Prunus Armeniaca L. The chief fruit tree in Ladak up to 11,000 ft. alt.

" tomentosa Thunb. Saspola.

" Persica (L.) Stokes.* Ladak (Vigne, J.L.S.).

LEGUMINOSEAE

Sophora Moorcroftiana Benth.* Ladak (FBI).

" alopecuroides L.* "Western Tibet" (FBI).

Thermopsis inflata Cambess. Rusi La.

Trigonella Emodi Benth. Himis Shupko.

" corniculata L.* Dras (Hend.), Ladak (FBI).

Trifolium pratense L.*

Medicago falcata L. Common in villages.

" sativa L. Cultivated.

" lupulina L. Matayan, Leh, Gya.

Melilotus officinalis (L.) Lam. Common in villages.

" alba Desr.* Saspola? (R.R.S.), Nubra, Ladak (FBI).

Colutea arborescens nepalensis (Sims) Baker.* Ladak (Brandis).

Caragana pygmea DC. Common from 12,000 to nearly 17,000 ft. alt. Its thick woody roots and thorny stems furnish the only fuel for travellers in many places. Especially common in Rupshu.

Caragana cuneata Baker.* Ladak (FBI), Leh (Meebold).

Astragalus Heydei Baker.* Tsokar Lake (FBI).

" tribulifolius Benth.* Hanle and Rupshu (FBI).

" Falconeri Bunge.* Kangi (Meebold), "Western Tibet" (FBI).

" adesmiaefolius Benth. Kargil.

" ophiocarpus Benth.* Ladak (FBI).

" gracilipes Benth.* Zanskar and Indus Valley (FBI).

" confertus Benth.* Ladak (Hend., FBI).

" tibetanus Benth. Sapi La, Gya.

" strictus R. Grah. Leh, Himis.

" oxyodon Baker.* Khardong (Meebold).

" densiflorus Kar. & Kir.* Leh (Meebold), Ladak (FBI).

" melanostachys Benth. Suru to Sirimarg.

" himalayanus Klotzsch. Suru, Matayan to Dras.

" Munroi Benth. Moolbeck, Himis Shupko, Khalotse, Namika La. A remarkable, densely hairy species with large inflated pods and yellow flowers, growing in the open desert.

Astragalus macropterus DC. Kharbu, Namika La.

" ciliolatus Benth.* Dras (Hend.), Ladak (FBI).

Astragalus coluteocarpus Boiss. Dras, Barso Valley.
" frigidus (L.) Bunge. Zoji, Suru Sirimarg?
" rhizanthus Royle.† Matayan, Dras, Khardong, Suru to Sirimarg.
" Webbianus R. Grah.* "Western Tibet" (FBI).
" Royleanus Bunge. *A. Candolleanus* Royle,* not Boiss., "Western Tibet" (FBI); I found this species at Amarnath just over the Great Range on the Kashmir side.
Astragalus ciceripolius Royle. Leh.
" multiceps Wall.* Ladak (FBI).
" peduncularis Royle.* Dras, Zanskar (FBI).
" subulatus Pall. Kharbu, Matayan, Gya, Sapi La.
" nivalis Kar. & Kir. Fotu La.
" hypoglottoides Baker.* "Tibetan Himalayas" (FBI).
" zanskarensis Benth.* Zanskar (FBI).
Lotus corniculatus L. Suru.
Oxytropis lapponica Gaud. Nyemo, Leh, Spitug, Khardong, Lachalung.
" mollis Royle. To Matayan.
" densa Benth. Lachalung.
" tatarica Cambess. Dras, Kharku Moolbeck, Lachalung, etc.
" cachemirica Cambess. Namika La.
" microphylla DC. Gya, Tsokar, Lachalung.
" Thomsoni Benth.*‡ Ladak (FBI).
Stracheya tibetica Benth.* Pangong Lake (FBI).
Hedysarum microcalyx Baker. Suru.
Cicer songaricum Steph. Commonly cultivated.
Vicia Faba L. Cultivated.
" tenuifolia Roth. Kharbu.
Ervum lens L. Cultivated in Ladak.
Lathyrus sativus L.* In fields (J.L.S., Hend.).
" altaicus Ledeb. To Matayan, Suru to Wardwan.
Pisum sativum L. Cultivated in Ladak.

GERANIACEAE

Geranium collinum Steph. Khardong, Sapi?
" grandiflorum Edgew.* Kangi (Meebold).
" pratense L. Kharbu, Himis.
" sibiricum L.* Ladak (FBI).
" polyanthes Edgew. & Hook. f.* Dras (Duthie).
Erodium Stephanianum Willd.* Ladak (FBI).
" tibetanum Edgew. Gya.
" cicutarium (L.) L'Her. "Little Tibet" (FBI).
Biebersteinia Emodii Jaub. & Spach. (*B. odora* Royle.) Lachalung, Khardong (given by Dr. Schmidt).

LINACEAE

Linum perenne L. Dras.

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† Another species of *Astragalus*, close to *A. rhizanthus* but not matched at Kew, was found at Namika La.

‡ A species of *Oxytropis*, not matched at Kew, was found between Suru and Sirimarg.

ZYGOPHYLLACEAE

PEGANUM HARMALA L. Himis, Leh, Saspola.

TRIBULUS TERRESTRIS L. Leh.

EUPHORBIACEAE

EUPHORBIA TIBETICA Boiss. Kharbu, Himis.

" THOMSONIANA Boiss. Matayan.

" MADDENII Boiss.* Ladak (Hend.).

BALSAMINACEAE

IMPATIENS BRACHYCENTRA Kar. & Kir. Suru to Sirimarg.

" THOMSONI Hook. f. Suru.

MALVACEAE

LAVATERA KASHMIRIANA Cambess. Suru.

MALVA VERTICILLATA L. Leh.

HYPERICACEAE

HYPERICUM PERFORATUM L. Suru.

TAMARICACEAE

TAMARIX GALLICA PALLASII (Desv.) Thist.-Dyer.* Ladak (Hend.), "Western Tibet" (FBI).

MYRICARIA ELEGANS Royel. Common in the thickets along the Indus and tributaries.

" GERMANICA Desv. In similar situations as the above.

" GERMANICA PROSTRATA Hook f. & Thoms. Ladak, 16,000 ft. alt. (Hend.)'

VIOLACEAE

VIOLA KUNAWARENSIS Royle. Near Leh (specimen given by Dr. Schmidt).

" CINEREA Boiss.* Ladak (Hend.); probably the above.

ELAEAGNACEAE

HIPPOPHAË RHAMNOIDES L. Common; its spinous branches are much used for hedges.

HIPPOPHAË SALICIFOLIA D. Don.* Dras (Duthie, 17).

ELAEAGNUS HORTENSIS Bieb. Leh (specimens given by Dr. Schmidt).

ONAGRACEAE

EPILOBIUM ROYLEANUM Haussk. Common and very variable.

" ROSEUM ANAGALLIDIFOLIUM (Lam.) C. B. Clarke.* "Western Tibet" (FBI).

EPILOBIUM LATIFOLIUM L. Suru-Sirimarg, Rusi La.

" ANGUSTIFOLIUM L. In the shade of willows; Kharbu, Dras, Sapi River, etc.

EPILOBIUM MINUTIFLORUM Haussk.* (*E. palustre minimum* C. B. Clarke of FBI). Leh, Nubra (Hausskneсht).

HALORAGIDACEAE

HIPPURIS VULGARIS L. Leh.

UMBELLIFERAE

Eryngium Billardieri Delar.* Ladak (FBI).

Chaerophyllum villosum Wall. Without definite locality (R.R.S.), Dras and Lamayuru (Hend.).

Chaerophyllum acuminatum Lindl. Suru.

Trachydium Roylei Lindl. Rusi La.

Pleurospermum Hookeri Thomsoni C. B. Clarke.* "Western Tibet" (FBI).

" Candollii Benth.? Yarungshan, Suru-Sirimarg (not mature).

" stellatum Lindleyanum (Klotzsch) C. B. Clarke. Lachalung.

Prangos pabularia Lindl. Matayan.

Bupleurum falcatum L. Zoji to Matayan, Suru.

" falcatum nigrocarpa (Jacquem.) C. B. Clarke. Fotu La.

" tenue Buch.-Ham.* Lamayuru (Hend.).

Pituranthos Thomsoni C. B. Clarke.* "Western Tibet" (FBI).

Carum Carvi L. Leh, in the village.

Pimpinella Saxifraga dissectifolia C. B. Clarke. "Western Tibet" (FBI), Gya? (R.R.S.).

Ligusticum Thomsoni C. B. Clarke. Common.

Ferula Jaeschkeana Vatke. Matayan.

Heracleum Thomsoni C. B. Clarke.* Ladak (FBI).

" Thomsoni glabrior C. B. Clarke.* Dras (Hend.).

" pinnatum C. B. Clarke. Moolbeck, Himis?

" candicans Wall. Zoji to Matayan, Dras?

PRIMULACEAE

Primula denticulata capitata (Hook.).* Zoji La (Hend.).

" farinosa L.* "Western Tibet" (FBI).

" Heydei Watt.* "Western Tibet" (FBI).

" sibirica Jacq. Fotu La, Lachalung, Chamba Kharbu.

" brevicalyx DC. Kangi (Meebold).

" involucrata Wall.* "Western Tibet" (FBI).

" elliptica Royle. Rupshu to Lahoul (R.R.S.), Ladak (FBI).

" Meeboldii Pax.* Kangi (Meebold).

" purpurea Royle (included under *P. Stuartii* in FBI). Leh (specimens given by Dr. Schmidt), Yarungshan.

Primula Stuartii Wall.* "Western Tibet" (FBI).

Androsace rotundifolia glandulosa Hook. f.* "Western Tibet" (FBI).

" rotundifolia Thomsoni Hook. f.* "Western Tibet" (FBI).

" septentrionalis L. Spituk.

" Aizoon Duby.* Dras (Hend.), "Western Tibet" (FBI).

" sempervivoides Jacquem.* "Western Tibet" (FBI).

" microphylla Hook. f.* "Western Tibet" (FBI).

" sarmentosa Wall.* Ladak (Hend.).

" sarmentosa primuloides (Duby) Hook. f. Matayan.

" Chamaejasme Wulf.* Ladak (Hend.).

" Chamaejasme coronata Hook. f.* "Western Tibet" (FBI).

" villosa L. Fotu La, Sapi.

Glaux maritima L.* Ladak (Hend.), "Western Tibet" (FBI).

PLUMBAGINACEAE

ACANTHOLIMON LYCOPODIOIDES Boiss. A remarkable sharp-leaved, tufted plant; common on the passes in Ladak.

STATICE MACRORRHABDOS Boiss.* Ladak (FBI).

OLEACEAE

FRAXINUS EXCELSIOR L.* Ladak (FBI).

GENTIANACEAE

JAESCHKEA LATISEPALA C. B. Clarke.* "Western Tibet" (FBI).
GENTIANA MOORCROFTIANA Griseb. Kharbu, Sapi La, Suru to Sirimarg.
" AUREA L. Kharbu, Sapi La, Moolbeck?
" THOMSONI C. B. Clarke.* Karakorum, Nubra (FBI).
" BOREALIS Bunge.* "Western Tibet" (FBI).
" TENELLA Rottb. Yarungshan, Himis Shupko.
" AQUATICA L. Leh, Himis Shupka, Himis Lachalung La.
" HUMILIS Stev. Fotu La.
" PSEUDO-HUMILIS Burk.* Leh, Himis, Kargil, Rupshu, etc. (7)
" PYGMAEA C. B. Clarke.* Karakorum, Nubra (FBI).
" SQUARROSA Ledeb.* "Western Tibet" (FBI).
" CARINATA Griseb. Yarungshan.
" HUGELII Griseb.* Zanskar (FBI).
" DECUMBENS L. Sapi La.
" SERRATA Gunner. Kharby, Gya, Fotu La.
" SERRATA **Stracheyi** (C. B. Clarke) comb. nov. (*G. detonsa Stracheyi* C. B. Clarke). Himis Shupka.
GENTIANA LEUCOMELAENA Maxim.* Kangi (Meebold).
PLEUROGYNE CARINTHIACA G. Don. Rusi La, Sapi La.
" THOMSONI C. B. Clarke. Fotu La.
" BRACHYANTHERA C. B. Clarke.* Karakorum (FBI).
SWERTIA CORDATA Wall. "Western Tibet" (FBI).
" PETIOLATA Royle. Rusi La, Sapi La?
HALENIA ELLIPTICA D. Don. Himis Shupka.

APOCYNACEAE

APOCYNUM VENETUM L. Khalotse.

ASCLEPIADACEAE

CYNANCHUM GLAUCUM Wall. Kargil, Saspola.
" ACUTUM L. Namika La.
" HEYDEI Hook. f. Between Saspola and Khalotse. My specimens are from the type locality, and it seems that this may be only a form of *C. acutum* with overlapping basal lobes to the leaves.

CONVOLVULACEAE

CUSCUTA CAPITATA Roxb. Barso Valley, on Galium.
" EUROPAEA L. Indus Valley, up to 11,000 ft. alt. The species which J. L. Stewart reported as common under the name *C. planiflora* Tenore is probably this.
CONVOLVULUS ARVENSIS L. A weed of cultivated land in Ladak.

BORAGINACEAE†

ACTINOCARYA TIBETICA Benth. Nubra, near Karsar Village (FBI).

OMPHALODES THOMSONI C. B. Clarke.* Nubra (FBI).

CYNOGLOSSUM PETIOLATUM A. DC.* Zanskar (FBI).

" WALLICHII G. Don. Dras, Kharbu? I am following Collett (13) in including *C. denticulatum* G. Don here.

LINDELOFIA BENTHAMI Hook. f. Leh, Namika La.

SOLENANTHUS CIRCINATUS Ledeb. Zanskar (FBI).

PARACARYUM HELIOCARPUM Kern. Matayan to Dras.

" THOMSONI C. B. Clarke.* Nubra (FBI).

" HIMALAYENSE C. B. Clarke. Nubra (FBI), without definite locality (R.R.S.).

PARACARYUM TIBETICUM C. B. Clarke. Himis Shupka, Khalotse to Yuru.

ECHINOSPERMUM BARBATUM Lehm.* Ladak (Hend.).

" REDOWSKII Lehm.* Leh (FBI).

" SEMIGLABRUM Ledeb.* "Western Tibet" (FBI).

ERITRICHIUM STRICTUM Decne. Fotu La? Khardong? (R.R.S.), "Western Tibet" (FBI).

ERITRICHIUM SPATHULATUM C. B. Clarke.* "Western Tibet" (FBI).

" TIBETICUM C. B. Clarke.* Ladak (FBI).

ASPERUGO PROCUMBENS L.* "Western Tibet" and the Karakorums (FBI).

MICROULA BENTHAMI C. B. Clarke.* "Western Tibet" (FBI).

LYCOPSIS ARVENSIS L. Kharbu.

MYOSOTIS SYLVATICA Hoffm. Yarungshan, Spituk? very near *M. alpestris* F. W. Schmidt.

MERTENSIA ECHIOIDES Benth.* "Western Tibet" (FBI).

" TIBETICA C. B. Clarke.* Karakorum (FBI).

LITHOSPERMUM ARVENSE L.* "Western Tibet" (FBI).

MACROTOMIA BENTHAMI DC.* Kangi (Meebold).

" PERENNIS Boiss. Dras.

ARNEBIA TIBETANA Kurz. Saspola, Nyemo.

" THOMSONI C. B. Clarke. Ladak.

ONOSMA ECHIOIDES L. Matayan.

ROCHELIA STELLULATA Reichb.* Nubra (FBI).

" RECTIPES Stocks.* Zanskar (FBI).

" CARDIOSEPALA Bunge.* Nubra (FBI).

LABIATAE

SCUTELLARIA PROSTRATA Jacquem. Zoji to Matayan, Suru to Wardwan.

" HEYDEI Hook. f.* Zanskar (FBI), Kangi (Meebold).

MARRUBIUM LANATUM Benth. Tsokar Lake.

NEPETA BOTRYOIDES Ait. Rupshu (FBI).

" LINEARIS Royle. Matayan.

" THOMSONI Benth.* Hanle (FBI).

" DISCOLOR Royle. Zoji to Matayan, Khardong La, Rusi La, Nyemo, etc., Suru to Sirimarg; the specimens are rather large and may be near *N. spicata* Benth.

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† Failure to get specimens in fruit made determinations of some of the Boraginaceae impossible.

NEPETA LONGIBRACTEATA Benth. Lachalung.
" GLUTINOSA Benth. Baralacha.
" FLOCCOSA Benth. Common in the Indus Valley.
" LEUCOLAENA Benth. Dras, Suru, Kharbu.
" SALVIAEFOLIA Royle. Near Kargil. The relationship of the last two should be studied in the field. The dry specimens seem to intergrade.
NEPETA NIVALIS Benth. Lachalung La.
" TIBETICA Benth. Lachalung La.
" ERIOSTACHYA Benth.* Khardong (Meebold).
CALAMINTHA UMBROSA Fisch. & Mey. Zoji to Matayan.
DRACOCEPHALUM HETEROPHYLLUM Benth. Gya, Khardong La, Lachalung.
" STAMINEUM Kar. & Kir.* Ladak (Hend.), "Western Tibet" (FBI).
" NUTANS L. Suru.
PHLOMIS BRACTEOSA Royle. Yarungshan La.
LAMIUM RHOMBOIDEUM Benth.* "Western Tibet" (FBI).
" AMPLEXICAULE L. A weed in cultivated ground.
" ALBUM L. Suru.
STACHYS TIBETICA Vatke. Common in Indus Valley.
PEROWSKIA ABROTANOIDES Kiril. Common in Ladak.
ORIGANUM VULGARE L. Suru.
THYMUS SERPYLLUM L. Dras, Lachalung.
MENTHA SYLVESTRIS L. Common.
" ARVENSIS L.* Ladak, Indus Valley (Hend.).
ELSHOLTZIA DENSA Benth. Suru.
" PUSILLA Benth. Lachalung (FBI, as a variety of *E. eriostachya* Benth.).
" CRISTATA Willd.* "Western Tibet" (FBI).

SOLANACEAE

LYCIUM RUTHENICUM Murr. Nyemo, Tralse.
PHYSOCHLAINA PRAEALTA Miers. A common weed.
HYOSCYAMUS PUSILLUS L. Kharbu, Khalotse Himis; a remarkable range, from Egypt to Persia and the Altai.
PHYSALIS ALKEKENGI L.* Burgo (Hend.), probably cultivated.
SOLANUM NIGRUM L. Kargil.
" TUBEROSUM L. Introduced by the missionaries. About the finest tops I have ever seen were in Dr. Schmidt's garden in Leh, 11,500 ft. alt.
NICOTIANA RUSTICA L.* Ladak (J.L.S.).
" TABACUM L.* Dras (Hend.)

SCROPHULARIACEAE

VERBASCUM THAPSUS L. Dras to Kharbu, Barso Valley.
SCROPHULARIA LUCIDA L. Zoji, Matayan.
" VARIEGATA Bieb.* Moolbeck (Hend.).
" DENTATA Royle. Kharbu? (R.R.S.), Ladak (FBI).
" SCABIOSAEFOLIA Benth. Sapi La.
MIMULUS STRICTUS Benth.* Indus Valley, Ladak (Hend.).
LANCEA TIBETICA Hook. f. & Thoms. Fotu La, Leh.
LIMOSELLA AQUATICA L.* "Western Tibet" (FBI).
VERONICA DELTIGERA Wall. Matayan to Dras, Suru to Sirimarg.
" CILIATA Fisch.? Rokshin, Nyemo.

VERONICA MACROSTEMON Bunge.* Zanskar (FBI).
" ANAGALLIS-AQUATICA L. Leh.
" BECCABUNGA L.* Ladak (Hend.).
" BILOBA L.* "Western Tibet" (FBI), Eastern Kangi (Meebold).
" LAXA Benth. Zoji to Matayan.
" AGRESTIS L.† "Western Tibet" (FBI).

LAGOTIS GLAUCA J. Gaertn. Rusi La.
" GLOBOSA Hook. f.* "Western Tibet," Therichan Pass (FBI), Kangi La (Meebold).

LEPTORHABDOS BENTHAMIANA Walp.* Dras (FBI).

EUPHRASIA OFFICINALIS L. Himis, Kharbu, Shergol.

PEDICULARIS TENUIROSTRIS Benth. Suru.
" CHEILANTHIFOLIA Schrenk. Himis, Kharbu, Khalotse to Leh.
" MOLLIS Wall.* Nubra (FBI).
" PYCNANTHA Boiss.* Kangi (Meebold).
" BICORNUTA Klotzsch. Suru-Sirimarg.
" SIPHONANTHA D. Don. Kharbu.
" RHINANTHOIDES Schrenk. Dras. It is difficult to separate this species, from the preceding at least when working with dry material.

PEDICULARIS LONGIFLORA Rudolph (*P. tubiflora* Fisch.). This is an unusually interesting species, with yellow flowers and a very long corolla tube. It is abundant in wet places.

PEDICULARIS DOLICHORRHIZA Schrenk (*P. fissa* Hook. f.). Zoji to Matayan.
" OEDERI Vahl. *P. versicolor* Wahlenb. Lanak La (FBI), Zoji (Hend.). Like dozens of other plants this is found chiefly on the Indian side of the backbone of the Himalayas and has only scattered stations on the Tibetan side.

OROBANCHACEAE

OROBANCHE CERNUA Loefl.* "Western Tibet" (FBI).
" HANSII Kern. Shergol.

LENTIBULARIACEAE

UTRICULARIA MINOR L.* Nubra (FBI).

PLANTAGINACEAE

PLANTAGO MAJOR L. Shergol.
" TIBETICA Hook. f. & Thoms. Saspola, Gya, Tralse.
" BRACHYPHYLLA Edgew.* "Western Tibet" (FBI), Kangi (Meebold).

RUBIACEAE

GALIUM APARINE L. Leh.
" VERUM L. Zoji to Matayan, Dras, Barso Valley.
" BOREALE L. Zoji, Zoji to Matayan, Sapi La, Barso Valley, Spituk.
" TRICORNE Stokes.* Leh (Hend.), "Western Tibet" (FBI).
" PAUCIFLORUM Bunge. Rachogpa.

RUBIA TIBETICA Hook. Fotu La, Rachogpa.

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† An undetermined species of *Veronica* with glandular hairs and very small flowers was collected at Dras.

CAPRIFOLIACEAE

LONICERA GLAUCA Hook. f. & Thoms. Leh, Sapi La, Lachalung.

" ASPERIFOLIA Hook. f. & Thoms. Zoji to Matayan, Sapi La.

" RUPICOLA Hook. f. & Thoms.* "Western Tibet" (FBI).

" SPINOSA Jacq. Lachalung, Fotu La, Chamba Kharbu.

" MICROPHYLLA Willd. Sapi La.

" HETEROPHYLLA Decne. To Matayan.

" MYRTILLUS Hook. f. & Thoms.* Ladak (Hend.), Kangi (Meebold).

" CAERULEA L. Zoji La; not the typical form.

VALERIANACEAE

VALERIANA DIOICA L. Ladak, probably correct but not in fruit; Kashmir to the Karakorum (FBI).

VALERIANA STRACHEYI C. B. Clarke. Kargil.

" WALLICHII DC.* Kangi (Meebold).

CAMPANULACEAE

CAMPANULA LATIFOLIA L. Suru.

" COLORATA TIBETICA Hook. f. & Thoms. Sapi [La, Kharbu, Saspola, Khalotse to Yuru.

CAMPANULA ARGYROTRICHA Wall.* Eastern Kangi (Meebold).

" CASHMIRIANA Royle. Leh, Sapi La, Chamba Kharbu.

" ARISTATA Wall. Gya, Himis Shupka, Suru to Sirimarg.

CODONOPSIS OVATA Benth. Moolbeck, Kharbu.

COMPOSITAE

ASTER HETEROCHAETA C. B. Clarke. Common up to 17,000 ft. alt. and very variable.

ASTER TIBETICUS Hook. f. Common.

" ALTAICUS Willd.*† "Western Tibet" (FBI).

BRACHYACTIS UMBROSA Benth. Gya.

" ROBUSTA Benth. Leh. May be a large variety of *B. umbrosa.* The pappus is lighter colored than in Thomson's specimens.

ERIGERON ANDRYALOIDES Benth. Namika La, Fotu La.

" BELLIDIOIDES Benth.* Kangi (Meebold).

" ALPINUS UNIFLORUS Hook. f. Yarungshan La, Leh.

" MULTICAULIS Wall. (under *E. alpinus* L. in FBI.) Common, especially in the Suru region.

ERIGERON MULTIRADIATUS Benth. & Hook. f,† Zoji to Matayan.

BLUMEA BIFOLIATA DC.* Leh (Meebold).

FILAGO ARVENSIS L.* Dras (FBI).

GIFOLA GERMANICA (L.) Dumort.*

ANTENNARIA NANA Hook. f. & Thoms.* Nubra and Shayok Valleys, etc. (FBI).

LEONTOPODIUM ALPINUM Cass. Very abundant and beautiful in the alpine region.

ANAPHALIS NUBIGENA DC. Sapi La, Matayan to Dras, Lachalung, near Leh (Dr. Schmidt).

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† There is much confusion over the limits of the Himalayan asters and erigerons, as they seem to intergrade. A species of *Erigeron*, apparently undescribed, was collected at Baralacha Pass.

Anaphalis Stoliczkai C. B. Clarke.* "Western Tibet," 5,000–10,000 ft. alt. (FBI). There is no part of Western Tibet as low as 5,000 ft. Hooker considers the species a state of *A. virgata*.

Anaphalis virgata Thoms. Himis Shukpa, Sapi La, near Kargil.

" contorta Hook. f.* Dras (Hend.).

Gnaphalium Stewartii C. B. Clarke.* Karakorum (FBI).

Inula obtusifolia Kern. Common in Ladak.

" falconeri Hook. f.* "Western Tibet" (Falconer), Skardu (Clarke).

" barbata Wall. Suru. My specimen seems to match *I. barbata* Wall., No. 2961, a species listed by Clarke (10) but not mentioned in FBI.

Inula rhizocephaloides C. B. Clarke. Sapi La.

" Royleana DC.*† Kangi (Meebold).

Chrysanthemum tibeticum C. B. Clarke. Himis Shupka (specimens viscid), Khalotse to Yuru (specimens not viscid).

Chrysanthemum Stoliczkai C. B. Clarke. Zoji-Matayan; much larger than Thomson's specimens.

Chrysanthemum Richteria Benth. Namika La, Leh, Fotu La, Sapi La.

" indicum L.* Ladak (J.L.S.); cultivated.

Tanacetum fruticulosum Ledeb. Lachalung.

" artemisioides Sch. Bip. Shergol Dras, Sapi La.

" gracile Hook. f. & Thoms. Ladak.

" tomentosum DC.* (FBI, as *T. Senecionis* J. Gay.) Reported by Stewart as common. This is a more eastern plant and is probably a mistake.

Tanacetum nanum C. B. Clarke.* Nubra Valley (FBI).

" tibeticum Hook. f. & Thoms.* Parang and Lanak Passes (FBI), East Kangi (Meebold).

Tanacetum longifolium Wall.* East Kangi (Meebold).

Allardia glabra Decne. Khardong, Sapi La, Rusi La.

" vestita Hook. f. & Thoms.* Zanskar (FBI).

" nivea Hook. Sapi River; Khardong La.

" tomentosa Decne. Rusi La, Baralacha.

" Stoliczkai C. B. Clarke. Suru to Sirimarg.

Artemisia salsoloides Willd. Sapi La.

" Dracunculus L.* Ladak (Hend.), "Western Tibet" (FBI).

" desertorum Spreng. Suru? "Western Tibet" (FBI).

" parviflora Buch.-Ham. Reported by J. L. Stewart but probably misnamed (not listed from Ladak in FBI).

Artemisia scoparia Waldst. & Kit. Leh.

" stricta Edgew. "Western Tibet" (FBI).

" maritima L.* Ladak (FBI).

" Tournefortiana Reichb. Shergol.

" biennis Willd. Leh (Meebold).

" laciniata Willd. Dras and Tankse Valleys (Hend.), Leh? (R.R.S.).

" sacrorum Ledeb.* Ladak (J.L.S.), "Western Tibet" (FBI).

" Moorcroftiana Wall. Himis, Shupka.

" persica Boiss. Dras; immature and possibly *A. maritima;* "Western Tibet" (FBI).

Artemisia Falconeri C. B. Clarke.* "Western Tibet" (FBI), probably from Skardo.

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† An undetermined species of *Inula* was found in the Barso Valley.

Artemisia Stracheyi Hook. f. & Thoms.* Rupshu and Lanak La (FBI).

" Absinthium L. Dras.

" minor Jacquem. Tsokar Lake, Lachalung La.

" Siversiana Willd. Nyemo, Leh, Dras.

" macrocephala Jacquem.* "Western Tibet" (FBI).

" amygdalina Decne.? Suru.

Tussilago Farfara L. Zoji, Khalotse to Yuru.

Doronicum Falconeri C. B. Clarke.* Karakorum (FBI).

Senecio chrysanthemoides DC. Sapi La, Zoji to Matayan, Matayan to Dras.

" coronopifolius Desf.* Kangi (Meebold).

" pedunculatus Edgew. Common in Indus Valley, Ladak.

" dubius Ledeb. Parang Pass (FBI).

" arnicoides frigida Hook. f. "Dwarf Sunflower," one of the prettiest Ladak flowers; found in wet places.

Senecio tibeticus Hook. f.* Karakorum (FBI).

Cremanthodium Decaisnei C. B. Clarke. Rusi La, Yarungshan La.

" oblongatum C. B. Clarke.* Leh (Meebold).

Werneria nana (Decne.) Benth. & Hook. f. (*Ligularia nana* Decne.), Rokshin, Lachalung. The involucre is cut more deeply than described.

Werneria nana affinis C. B. Clarke. Baralacha Pass. Involucral cup cut more than half way down, ligules many nerved and twice as long as the bracts, leaves toothed.

Echinops cornigerus DC. "Globe Thistle," dry hillsides in Ladak.

" niveus Wall.* Dras (Hend.).

Arctium Lappa L. Near Suru.

Cousinia Falconeri Hook. Fotu La.

Saussurea Schultzii Hook. f. Near Leh (specimens from Dr. Schmidt).

" bracteata Decne. Lachalung.

" Thomsoni C. B. Clarke.* Nubra (FBI).

" subulata C. B. Clarke.* Nubra (FBI).

" Stoliczkai C. B. Clarke.* "Western Tibet" (FBI).

" taraxifolia Wall. Gya.

" Falconeri Hook. f.* Karakorum (FBI).

" graminifolia Wall.* Ladak (FBI).

" glanduligera Sch.-Bip. Lachalung.

" elliptica C. B. Clarke.* Karakorum (FBI).

" Jacea C. B. Clarke. Barso Valley.

" albescens Hook. f. & Thoms. Suru.

" sorocephala Hook. f. & Thoms. Rusi La, Yarungshan La.

Jurinea ceratocarpa Benth. Near Suru.

" ceratocarpa depressa C. B. Clarke. Kharbu, Sapi La.

Carduus nutans L.* Ladak (Hend.), Nubra (FBI).

" Thomsoni Hook. f.* Ladak (FBI).

Tricholepis tibetica Hook. f. & Thoms.* "Western Tibet" (FBI).

Centaurea depressa Bieb. Moolbeck.

Cnicus Wallichii platylepis Hook. f.* Dras (FBI).

" arvensis (L.) Hoffm. Kargil.

Koelpinia linearis Pall. Sapi La.

Tragopogon pratensis L. Sapi La? "Western Tibet" (FBI).

TRAGOPOGON PORRIFOLIUS L.* "Western Tibet" (FBI).

SCORZONERA DIVARICATA Turcz. Dras, Kargil, Himis, Namika La.

" PURPUREA L. Zoji to Matayan.

CHONDRILLA GRAMINEA Bieb. Karakorum (FBI).

TARAXACUM OFFICINALE Weber. Common, very variable and growing almost to the snow line. The Himalayan dandelions could be split up into species much more marked than Dahlstedt's European ones. Some are very hairy, some alpine specimens have white flowers, some are very dwarf.

TARAXACUM OFFICINALE PARVULUM (Walb.) Hook. f. Common.

" LEUCANTHUM Ledeb.* Kangi (Meebold).

SONCHUS ASPER (L.) Hill. Tralsi.

" OLERACEUS L. Saspola.

LACTUCA ORIENTALIS Boiss. Himis Shupka.

" SCARIOLA L. Suru? (R.R.S.), "Western Tibet" (FBI).

" SATIVA L.* Cultivated in Ladak (Hend.).

" UNDULATA Ledeb.* "Western Tibet" (FBI).

" LONGIFOLIA DC.* Common in Ladak (Hend.); possibly a mistake as Hooker (FBI) does not list the species from Ladak.

LACTUCA TATARICA C. A. Mey. Without definite locality (R.R.S.), Nubra, Hanle, etc. (FBI).

LACTUCA DECIPIENS C. B. Clarke. Suru to Sirimarg, Kharbu?

CREPIS FLEXUOSA Benth. & Hook. f. Himis Shupka.

" TENUIFOLIA Willd. Khalotse to Yuru.

" STOLICZKAI C. B. Clarke.* "Western Tibet" and Karakorum (FBI).

TABLE OF ALTITUDES†

Baralacha Pass	16,200 ft.
Barso Valley, Suru	11,000
Dras	10,000
Fotu La‡	13,000
Gya	13,000
Himis	11,000
Himis Shupka	11,000
Kargil	8,700
Khalotse	9,500
Kharbu	11,000
Khardong La	17,600
Lachalung La	16,600
Lamayuru	11,000
Leh	11,500
Matayan	10,500
Moolbeck	9,000
Namika La	13,000
Nyemo	10,000
Rachogpa	13,400 ft.
Rokshin	15,300
Rusi La	16,000
Sapi La	14,500
Saspola	9,700
Saspola Drokpo	11,000
Shergol	9,000
Shishpur to Iljook	11,000
Spituk	10,500
Suru	11,000
Suru to Sirimarg	11,000 to 13,700
Timisgam	11,000
Tralse	11,000
Tsokar Lake	15,500
Yarungshan	15,500
Zoji La	11,300
Zoji to Matayan	11,300 to 10,500

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† The plants were gathered very frequently between towns and so altitudes are only approximately correct as applied to the plants.

‡ "La" is Tibetan for Pass.

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1912-1916

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Reviews, and papers that 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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