Transactions of the Wisconsin Academy of Sciences, Arts and Letters. volume XVII, Part II, No. 5 1914

Madison, Wis.: Wisconsin Academy of Sciences, Arts and Letters, 1914

TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS, AND LETTERS

VOL. XVII, PART II, NO. 5

MADISON, WISCONSIN
1914

CONTENTS

The annual half-volume of the Transactions of the Wisconsin Academy of Sciences, Arts, and Letters is issued in six numbers, under the editorial supervision of the Secretary.

The price of this number is 50c.

SPECIES OF HYPHOLOMA IN THE REGION OF THE GREAT LAKES.

EDWARD T. HARPER.

The genus Hypholoma is characterized by dark brown or purple brown spores, adnate or adnexed lamellae and an evident appendiculate veil. Plates LXXII B, LXXVII A and LXXXII E show the nature of the veil. It tears away from the stem as the pileus expands and remains hanging in patches from the margin of the pileus. In plants with a fibrous universal veil like Hypholoma lacrimabundum, Pl. LXXVII C the veil scarcely differs from the cortina in Cortinarius. The veil is so fragile that it soon disappears and can be seen to advantage in young plants only.

A glance through the photographs will show the general appearance of plants in the genus. There is no common type as in Mycena or Omphalia and it is sometimes difficult to decide whether a plant belongs to this genus or not. Dr. Peck has changed several plants described as Hypholoma to Psilocybe. Hypholoma ornella he changed to Pholiota ornella. Plants in which the veil varies to annulate are apt to be placed in the genus Stropharia. Attempts hitherto made to divide the genus do not avoid this difficulty. It would probably exist with any arrangement as there are few sharp dividing lines in nature.

The genus is divided into five sections.

I. Fasciculariа. Pileus smooth, dry, bright colored.

II. Viscida. Pileus viscid.

III. Velutina. Pileus fibrous or scaly.

IV. Flocculosa. Pileus covered with floccose scales.

V. Appendiculata. Pileus hygrophanous.

Fascicularia, Velutina and Appendiculata are natural divisions and contain three distinct groups of plants. Viscida and Flocculosa are not natural divisions. Few species have been referred to them and viscid and floccose plants are found in the other sections. We have retained them only because we did not wish to burden the other sections with unrelated forms. Our first aim has been to place all closely related species and varieties in natural groups. Our purpose is to encourage observation and to this end we seek to accomplish three things: (a) To place the agarics in groups large enough to be easily recognized so that observers can identify their plants without too much labor and with a good degree of certainty. (b) To place in the groups all recorded species and forms that need to be taken into account if one is to recognize the significance of the form he has collected. (c) To open up the lines of variation so that observation may be intelligently directed. We hope that such grouping will help in securing a phylogenetic arrangement which is the only final and scientific classification.

The groups are based on the common well known species. Almost everyone of these species is surrounded by a number of forms which have been described as species but whose exact affinities need further observation. There are four large groups in the genus Hypholoma: The brick tops in the section Fascicularia constitute the first. Our common species is easily distinguished and we have associated with it the forms which need to be especially studied in relation to it. There are two groups in the section Velutina. One of the scaly forms based on Hypholoma lacrimabundum and another based on Hypholoma velutinum, a group which appears to be well characterized by the peculiar spores. All of the common hygrophanous forms in the section Appendiculata with a single exception, have been placed in one group. The few remaining plants which appear to be without evident affinities are in the sections Viscida and Flocculosa.

Two groups, the Hypholoma sublateritium group and the Hypholoma candolleanum-appendiculatum group are valuable as food plants. The species are common and edible. The plants in the other groups are more rare.

We have used photographs made at Sumner, Washington, for some species of which we had no negatives made in our region. Two or three species have been included which have not yet been reported in the Great Lakes Region.

Thanks are due to Prof. R. A. Harper and Dr. B. O. Dodge of Columbia University for examining species in Dr. Peck's collection at Albany, N. Y.; to Prof. C. E. Allen and Prof. J. B. Overton of Madison, Wis. for the loan of literature from the University library and to others whose names are mentioned in the text for information and help of various kinds.

Synopsis of the Species.

I. Fascicularia. Pileus smooth, dry, bright colored.

The Hypholoma sublateritium group.

Hypholoma sublateritium, Schaeff. Plate LXXII.
Hypholoma perplexum, Pk. Plate LXXIII.
Hypholoma capnoides, Fr. Plate LXXIV.
Hypholoma fasciculare, Huds. Plate LXXV.

Related species: Hypholoma sublateritium var. squamosum, Cke. Hypholoma epixanthum, Fr. Hypholoma elaeodes, Fr. Hypholoma dispersum, Fr.

II. Viscida. Pileus viscid.

Hypholoma ambiguum, Pk. Plate LXXVII.
Hypholoma ..... Plate LXXVI.

III. Velutina. Pileus fibrous or scaly.

The Hypholoma lacrimabundum group.

Hypholoma lacrimabundum, Fr. Plate LXXVII C.
Hypholoma echiniceps, Atk. Plates LXXVII B, LXXVIII.

Related species: Hypholoma rigidipes, Pk.

The Hypholoma velutinum group.

Hypholoma velutinum, Pers. Plate LXXIX.

Related species: Hypholoma velutinum var. leiocephalum B & Br. Hypholoma boughtoni, Pk. Hypholoma rugocephalum, Atk. Hypholoma pyrotrichum, Fr. Hypholoma delineatum, Pk.

IV. Flocculosa. Pileus silky or floccose with separating scales.

Hypholoma artemisiae, Pass. Hypholoma aggregatum, Pk. Hypholoma aggregatum var. sericium, Pk. Hypholoma olivaesporum, Ell. & Ev.

V. Appendiculata. Pileus hygrophanous.

The Hypholoma candolleanum-appendiculatum group.

Hypholoma candolleanum, Fr. Plates LXXX, LXXXIII B.

Hypholoma appendiculatum, Bull. Form Hypholoma incertum, Pk. Plate LXXXIII C.

a. Pileus rugose wrinkled.

Hypholoma leucotephrum, Berk. Plate LXXXI.

b. Pileus cracked and split.

Hypholoma cutifractum, Pk. Plate LXXXII.

c. Pileus with a dark watery disk and light colored margin.

Hypholoma madeodiscum, Pk.

d. Thin pileus and slender striate stem.

Hypholoma hymenocephalum, Pk.

e. Long slender stems and narrow pilei.

Hypholoma longipes, Pk. Plate LXXXIII A.

Related species: Hypholoma campanulatum, Pk. Hypholoma californicum, Earle.

f. Pileus floccose.

Hypholoma appendiculatum var. flocculosum, Boud. var. lanatum, B. & Br. Hypholoma flocculentum, McClatchie. Hypholoma fragile, Pk. Hypholoma hololanigerum, Atk.

g. Veil annulate.

Stropharia irregularis, Pk. Stropharia longistriata, Murrill.

h. Doubtful forms.

Hypholoma atrofolium, Pk. Hypholoma subaquilum, Bann.

Description of the Species.

1. FASCICULARIA.

THE HYPHOLOMA SUBLATERITIUM GROUP.

The group contains five closely related European species all of which have been reported from the United States: Hypholoma sublateritium, Hypholoma capnoides, Hypholoma epixanthum, Hypholoma elaeodes and Hypholoma fasciculare.

Dr. Peck added his own Hypholoma perplexum to the list and gave a key to the species in N. Y. state Mus. Mem. 4. He based the principal division on taste but the taste test is not to be relied on. Peck himself says in later reports that Hypholoma sublateritium is often mild tasting and Bresadola reports the same of that species in Europe. In his summary of the New York species of Hypholoma, N. Y. state Mus. Bull. 150, Peck reports only three species, Hypholoma, sublateritium, Hypholoma perplexum and Hypholoma capnoides.

McIlvaine in One Thousand American Fungi includes all the species but speaks of them as confused and perplexing.

As far as our collections go the distribution of species appears to be about as follows:

The small plants with yellow caps tinged with red found in clusters on coniferous logs in the northern woods are Hypholoma capnoides. Dr. Peck limits the species in the same way. The plants agree with Cooke's Illust. 559, but are smaller than the descriptions call for and as some writers make Hypholoma capnoides a variety of Hypholoma sublateritium, observers should watch for forms more nearly resembling that species.

Hypholoma fasciculare is found on the Pacific coast where it appears to take the place of Hypholoma sublateritium with us. The latter species is not found there so far as we have seen. Murrill does not report it among the Agaricaceae from the Pacific coast. Hypholoma fasciculare was identified by Berkeley from early collections in Ohio, but Dr. W. G. Stover informs me that he does not think it has been confirmed in recent years.

Dr. Peck separated the mild tasting forms of Hypholoma sublateritium and based on them a new species, Hypholoma perplexum. It has usually been considered a form of Hypholoma sublateritium, compare Atkinson, Mushrooms, p. 27, but Peck retains the species in his later writings and bases it on other characters as well as taste. We have collected the form in the northern woods. It approaches in some respects Hypholoma epixanthum which is mild tasting and it is possible that Peck's report of that species in Report 22 was based on this form. Peck does not include Hypholoma epixanthum in his summary of the N. Y. species and it seems to be little known in the United States. According to Cooke's Illustration Pl. 560 it is a brilliant red and yellow plant of the size and habit of Hypholoma sublateritium. The gills are light yellow, becomming cinereous not purple or green, taste mild. It should be looked for on fir logs and stumps.

We know nothing of Hypholoma elaeodes. It is said to be intermediate between Hypholoma fasciculare and Hypholoma sublateritium. Cooke Pl. 562 figures it as a small dull colored variety of Hypholoma fasciculare. The figure shows a plant quite similar to our photograph of Hypholoma capnoides with more slender and flexuous stems.

The abundant brick tops about stumps and logs in Illinois, Wisconsin and Michigan we refer to Hypholoma sublateritium. The taste is mild or bitter. The plants are very common and much used for food.

Hypholoma sublateritium, Schaeff. Pl. LXXII.

The plants are very common throughout our whole region. They grow in dense clusters about stumps and logs in woods and pastures. The species is illustrated by Cooke Pl. 557. Our photograph of the young plants shows the character of the veil and the cobwebby covering of the caps.

Pileus 2–3 inches or more broad, fleshy, convex becoming plane, often irregular in crowded clusters, obtuse, glabrous, sometimes covered with a thin white cobwebby coat when young,

dry, dark brick red or brown, paler on the margin especially when young. FLESH whitish or yellowish. TASTE mild or bitter. LAMELLAE adnate, close, narrow, whitish to olivaceous and finally purplish brown. VEIL membranous, torn, soon disappearing. STEM. 2–4 or more inches long, about ½ inch thick, equal or tapering downward, fibrillose becoming glabrous, stuffed to hollow, ferruginous below, pale above, striate at the apex. SPORES 3–4 x 6–8μ.

Densely caespitose about old stumps, logs and roots. Late summer and autumn, often earlier, common, edible.

NOTE. Hypholoma sublateritium var. squamosum Cke., Illust. 558, is shown in Atkinson's photograph, Mushrooms Pl. 6. It has floccose scales in concentric rows near the margin of the pileus, Peck reports the same form from New York State.

Hypholoma perplexum Pk. Pl. LXXIII.

The species was first described in N. Y. State Mus. Rep't 23 p. 99. It is illustrated and further described in N. Y. State Mus. Mem. 4 pp. 166–167 and Pl. 60. It is also included in the summary of the N. Y. species of Hypholoma, N. Y. State Mus. Bull. 150 p. 78. Peck says it differs from Hypholoma sublateritium in its "smaller size, paler margin of the pileus, somewhat umbonate pileus, mild taste, paler and more slender stem which is always hollow even when young." The plants in Pl. LXXIII were taken from a cluster which grew at Neebish, Mich. They had the peculiarities claimed for the species.

"PILEUS convex or nearly plane, sometimes umbonate, glabrous, reddish or brownish red, usually yellowish on the margin. FLESH white or whitish. TASTE mild. LAMELLAE thin, close, slightly rounded behind, adnexed, pale yellow becoming tinged with green, finally purplish brown. STEM rather slender, equal or nearly so, firm, hollow, slightly fibrillose, whitish or yellowish above, reddish brown below, SPORES 3–4 x 6–8μ.

Pileus 2.5–7 cm. broad, stem 5–7 cm. long, 4–8 mm. thick.

Generally caespitose. On or about stumps or prostrate trunks of trees in woods or open places. Common, August to November. Edible."

Hypholoma capnoides Fr. Pl. LXXIV.

The species grows on stumps and logs of coniferous trees in the northern woods. The average size of the plants is shown in the photograph. The European plants are said to have caps 1–3 inches broad but we have not seen them so large. The New York plants as reported by Peck agree with ours. Ours also have the reddish tint in the center of the pileus noted by Peck. This agrees with the illustrations of Cooke and Fries but not with the descriptions which call for an evenly colored ochraceous or yellowish pileus. The stems in the cluster photographed are not as long as in Cooke's figures but the length of the stem depends on the position of the plants. The plants from which our cluster was taken grew on a balsam log at Neebish, Mich. in September.

PILEUS 1–3 inches broad, convex or expanded, obtuse, dry, smooth, even on the margin, ochraceous or yellowish. TASTE mild. LAMELLAE adnate with slight lines down the stem, separating, gray with a bluish tinge when young becoming brown or purple brown. STEM 2–3 inches long, 2–3 lines thick, nearly equal, hollow, curved or flexuous from position., silky, striate at the top, whitish, darker below. SPORES 4–5 x 7–8μ.

Caespitose or scattered on logs of pine, spruce and balsam.

Hypholoma fasciculare Huds. Pl. LXXV.

The photograph is from plants which grew on the ground and on logs at Sumner, Washington. The whole plant was yellow except the brown center of the pileus. The disk was somewhat umbonate. The gills were yellow becoming greenish and finally olive brown. The plants photographed have stems shorter than usual and slightly thickened at the base as in var. robustior. In the dense clusters on logs the stems were long and slender and the plants agreed with Cooke's figures Pl. 561. Murrill reports the plant as very common on the Pacific coast. It seems to take the place of our Hypholoma sublateritium in that region. The taste is bitter and the plants are supposed to be poisonous.

PILEUS about 2 inches broad, fleshy, convex to expanded, umbonate, obtuse, even, smooth, dry, yellowish on the margin, reddish bay in the center. FLESH yellow, bitter. LAMELLAE adnate, close, linear, yellow, becoming greenish and olivaceous brown. STEM 2–5 inches long, 2–3 lines thick, hollow, slender, flexuous, fibrillose, yellow. SPORES 3–4 x 6–7μ. On stumps and logs and on the ground.

II. VISCIDA.

Hypholoma ambiguum Pk.* Pl. LXXVII A.

The plants represented in Pl. LXXVII A grew solitary on the ground in open woods at Sumner, Washington. They were very beautiful with the characters well defined. The pileus was convex, smooth, buff, evenly colored except on the very margin which was whitish like the veil. The margin was even and the pileus only slightly if at all viscid. The gills were close, adnate, whitish becoming dark brown with spores which measured 8 x 12μ. The white veil hung in large reflexed flaps on the margin of the pileus. It was quite thick and with striate ridges on the upper surface as in species of Stropharia. The stem was bulbous at the base, stuffed, covered with a white floccose coat on a buff background. It was striate groved above the annulus and slightly striate with lines toward the base.

Dr. Murrill recognized the photograph at once as Hypholoma ambiguum Pk. It appears to be a well known plant on the Pacific coast. Murrill in Mycologia Nov. 1912 pp. 304–305 reports a large number of collections and says "It is one of the most striking and abundant gill fungi on the coast."

Peck's description, Torr. Bull. June 1898, pp. 325–326, was based on plants collected in fir woods near Portland, Oregon. We give Peck's description below but we should not have recognized the plant from the description. We are informed that the type specimens at Albany have been lost.

"PILEUS thin, convex becoming nearly plane, glabrous, subviscid when moist, straw color inclining to pale orange, the mar-

* Mr. Sanford M. Zeller, Mycologia, May, 1914, makes a study of the development of this species and concludes that it belongs to the genus Stropharia.

gin in immature plants appendiculate with the remains of the white thick veil which in very young plants conceals the lamellae but which in mature ones wholly disappears. FLESH white. LAMELLAE close, adnexed, grayish at first, changing to dark brown where wounded, becoming blackish brown with age. STEM slender, equal, stuffed or hollow, squamose near the base, paler than the pileus. SPORES elliptical 7.5x12.5—15μ

Pileus 5—13 cm. broad, stem 12—22 cm. long.

Fir woods, Portland, Oregon, November.

The dried plants have the general appearance of some species of Stropharia but the appendiculate character of the veil and the entire absence of an annulus indicate that the species is a Hypholoma."

Hypholoma ..... Pl. LXXVI.

The plants shown in Pl. LXXVI grew on the ground beside a log in open woods at Sumner, Washington. They were scattered in habit. The pileus was convex or campanulate becoming expanded with a slight umbo, slightly viscid when moist, innate fibrous and fibrous scaly on the margin, yellow. Flesh cream color. The lamellae were close, ventricose, adnate or slightly decurrent, sometimes with a broad shallow sinus, white becoming purple brown with the spores. The veil was thick and fibrous covering the gills when very young remaining as a fibrous margin on the pileus when the plants were mature. The stem was equal or tapering slightly downward, hollow or stuffed, fibrous striate or scaly, smooth at the top, white above becoming yellowish red below. Spores purple brown, elliptical 8x12μ.

The plants have many points in common with Hypholoma ambiguum as described by Peck and we would probably have referred them to that species if Dr. Murrill had not claimed it for the plant in Pl. LXXVII A. The plants also agree well with the description of the European Hypholoma dispersum but that species is not said to be viscid and our plants do not look like Cooke's figure Pl. 586. Fries Icones 133 agrees better but there is not much evidence for such an identification.

III. Velutina.

The Hypholoma Lacrimabundum Group.

Hypholoma lacrimabundum Fr. Pl. LXXVII B C and LXXVIII.

Typical Hypholoma lacrimabundum is shown in Pl. LXXVII C. compare Atkinson's fig. 28. The pileus is covered with tawny fuscous scales composed of tufted fibers on a whitish background. The flesh is whitish and also the fibers of the annulus. The plants are umber rather than tawny when dry.

The plants in Pl. LXXVIII differ somewhat. They are very large and dull tawny yellow with concolorous flesh and veil. The gills are very white flocculose on the edges and the spores are smaller 3—5x7—8μ. The plants appear to be what Atkinson has described as Hypholoma echiniceps, Ann. Mycol. 1909 p. 371. They agree in the large size, Atkinson gives the dimensions 12—14 cm. high, 3—7 cm. across the pileus and the stem 8—12 mm. thick, in the densely scaly pileus of the young plants, in the ochraceous brown colors, in the ample veil which in our plants soon disappears and in the size of the spores and basidia. Spores 3.5—5x7—9μ. Basidia 7x28—30μ. We did not examine fresh plants for cystidia which Atkinson says are in clusters of 2—8 and 10—12μ thick, extending 30—40μ above the hymenium. Atkinson says the plants are similar to Hypholoma pyrotrichum but have smaller spores and more dense scales in the center of the pileus. The spores are not only smaller but entirely different in character from those of Hypholoma pyrotrichum which belongs to the Hypholoma velutinum group. Our plants are very close to Hypholoma lacrimabundum. Pl. LXXVII B shows an intermediate form which cannot be distinguished in the photograph from LXXVII C except by the thinner stem.

The plants grow in damp grassy places and in pastures and about stumps and logs in woods. The collection from which Pl. LXXVII C was taken was found by an oak stump in a pasture at Glencoe, Ill. The photograph has been published already by Dr. W. S. Moffatt in Bull. VII, Pl. XI of the Chicago Acad. of Sciences.

Pl. LXXVII B is from a collection found at Devil's Lake, Wisconsin and the large cluster in Pl. LXXVIII grew on the ground in open woods at Neebish, Mich. Atkinson gives an extended description of Hypholoma lacrimabundum in Mushrooms, pp. 28—30 and figure 28. The usual brief description of the species is as follows:

PILEUS 1—3 inches broad, fleshy, convex or umbonate, obtuse, pileus squamose with tufted fibers, tufts dark fuscous with a tawny or yellowish tinge on a white background. FLESH whitish or tawny, LAMELLAE adnate or broadly sinuate, rounded when old, close, slightly ventricose, becoming dark purple and spotted with the blackish spores, often with drops of moisture on the edge. STEM 2—3 inches long, ½ inch or less thick, hollow, scaly like the pileus below the annulus, smooth or white pruinose above. SPORES almost black 5—6x8—10μ. Atkinson gives 7—8x9—11μ.

NOTE. Hypholoma rigidipes, Pk. N. Y. State Mus. Bull. 139, p. 24, Pl. III fig. 1—6, is based on plants found growing among tall weeds in September. Dr. Peck in Bull. 150, says "This species is well marked by its gregarious modes of growth. In the ornamentation of the pileus it is related to Hypholoma lacrimabundum, but it differs in its mode of growth, smaller size, more slender rigid stem and larger apiculate spores." Prof. R. A. Harper says "The type of Hypholoma rigidipes has rather narrow spores slightly apiculate and slightly rough, not exactly like the spores of Hypholoma rugocephalum." It may belong to the following group.

THE HYPHOLOMA VELUTINUM GROUP.

The spores are the most diagnostic character in this group. They are almost black in mass, broadly oval, slightly inequilateral or irregular, apiculate at each end, rough or echinulate and not pellucid under the microscope, 6—7x8—11μ.

Plants sent me by Dodge which he had referred to Hypholoma rugocephalum Atk. have exactly the same kind of spores and they are so described by Atkinson. According to Dodge the spores of authentic specimens of Hypholoma boughtoni Pk. are the same though Peck does not describe them as rough or echinulate. Furthermore Dr. Dodge examined the spores of Hypholoma velutinum Pers. in Massee's collection at the New York Botanical Garden and found them the same. As described

in Sylloge they are not quite so broad and not said to be rough. Massee's figure of Hypholoma pyrotrichum Fr. also shows the same broad rough warty spores though they are dark brown in the illustration rather than blackish.

But while the spores show remarkable agreement these four species vary in color and surface of the pileus. Hypholoma velutinum has a thick matted fibrous universal veil as in Pl. LXXIX and Cooke's Illus. 563 and is lurid or tawny brown. Hypholoma pyrotrichum has the same kind of veil but is bright fiery tawny as shown in Cooke's Illus. 564. Atkinson describes the pileus of Hypholoma rugocepholum as smooth, not hairy or scaly, slightly viscid and marked by strong radiating wrinkles. Peck says the pileus of Hypholoma boughtoni is glabrous or slightly fibrillose often concentrically or areolately cracking. Prof. R. A. Harper who has examined many of Peck's type specimens of Hypholoma for me reports that the dried specimens of Hypholoma buoghtoni are the same as those of Hypholoma rugocephalum. He says "the spores are broad, rough, black and apiculate and the specimens are the same in external appearance."

The illustrations of the different plants show the different external characters as described. The spores are so diagnostic however that care should be taken by observers to see if the differences are not due to age or weather conditions.

NOTE. Forms with different spore characters have been associated with this group and we mention them here though they probably belong to another group.

Hypholoma velutinum var. leiocephalum B. & Br. is said to be a smaller plant growing coespitose on stumps with a smooth ragged pileus. Dodge says specimens so labelled in Massee's collection have spores entirely different. It has not been reported from this country.

Hypholoma delineatum Pk. is placed in this group by the author who says "It has the general appearance of Hypholoma rugocephalum but differs in the narrow, obtuse and smooth spores and broader flask shaped cystidia.

Hypholoma velutinum Pers. Pl. LXXIX.

The plants illustrated in Pl. LXXIX grew on the ground near a stump in a pasture at Geneseo, Ills. They agree with the description of Hypholoma velutinum, having a universal veil of matted fibers, an hygrophanous lurid pileus becoming

tawny and finally clay colored when dry and the characteristic broad, rough, apiculate, opaque spores. It is the only form in the group which I have collected.

PILEUS 2—3 inches broad, fleshy, from ovate to campanulate and expanded, obtusely umbonate, even on the margin, covered when young with a veil of appressed matted fibers becoming glabrate, hygrophanous, lurid when young becoming tawny and finally clay colored or isabelline. FLESH very thin, concolorous. LAMELLAE adnexed, easily separating, broad, not crowded, pallid with the edge white, becoming dark brown, black dotted. STEM 2—4 inches long, up to ½ inch thick, hollow, equal, covered with a fibrous coat like that on the pileus below the annulus, white tomentose above. Colored like the pileus but lighter. Veil of fibrous tufts adhering chiefly to the margin of the pileus, whitish becoming black with the spores. SPORES ellipsoid, oblique or irregular, apiculate, fuscous, not pellucid, 5x9—10μ. BASIDS 7—8x8—25μ. CYSTIDS 9x40μ.

NOTE. Hypholoma rugocephalum Atk. is fully described and illustrated in "Mushrooms" p. 30 and Pl. 8. Hypholoma boughtoni Pk. and Hypholoma delineatum Pk. are described in N. Y. State Mus. Bull. 150 pp. 82—84. The former is figured in Bull. 139 Pl. II, figs. 1—7.

IV. FLOCCULOSA.

As stated above the group is not a natural one. There is a whole series of forms in which the pileus is covered with separating floccose scales in the Hypholoma candolleanum-appendiculatum group and Hypholoma sublateritium also has a scaly form. We have no photographs of the plants which remain in the section.

Hypholoma artemesiae Pass, is reported in Farlow's index.

Hypholoma aggregatum Pk. and var. sericeum Pk. are described in N. Y. State Mus. Rep't 46 p. 106 and Bull. 54 p. 972, Pl. 79, figs. 8—14. The plants are densely tufted and grow about the base of stumps. They are said to resemble Hypholoma candolleanum but are not hygrophanus. Hypholoma aggregatum is distributed in Shear's N. Y. Fungi No. 13.

Hypholoma olivaesporum Ell. & Ev. is a small plant about 1' inch high and ½ inch broad growing among sphagnum. It has

free gills and the pileus is covered by a reddish gray furfuraceous coat. Morgan transfers it to the genus Pilosace.

V. Appendiculata.

About half of the species of Hypholoma reported from the United States are in this section. All except Hypholoma hydrophilum which is reported from Michigan by Kauffman appear to belong to a single group. We have named the group after the two common European species Hypholoma candolleanum and Hypholoma appendiculatum both of which are reported from this country.

The Hypholoma Candolleanum-Appendiculatum Group.

Hypholoma candolleanum Fr. Pl. LXXX.

Typical plants of the species Hypholoma Candolleanum Fr. are shown in Pl. LXXX. Compare also Cooke's Illustration Pl. 546. They grow scattered or in clusters on the ground or on very rotten logs in the borders of woods and bushy places. The plants photographed were collected at Sumner, Washington.

The plants are acorn shaped at first as in D, becoming campanulate and expanded, often with the margin split and upturned. The surface usually appears smooth but there is a slight universal veil which under favorable weather conditions appears as separating floccose scales on the pileus. This is true of all the species in the group. A few such flocci are seen on the young plant in D. The margin of the pileus is usually even but sometimes appears finely striate with long lines. Especially is this true of the dried plants Pl. LXXXIII B. The striate margin is noted in a number of plants in the group. The partial veil is a thin woven membrane seen also in D, which clings in patches to the margin of the pileus as it expands. This veil is characteristic and gives the name to the section. The gills, seen in C, are close and rather narrow, slightly ventricose, rounded and adnexed or broadly sinuate behind with a slight tooth connecting with lines down the stem. The gills are violoceous when young becoming purple brown in age and this is the

chief diagnostic mark of the species. All other species in the group have the gills whitish at first. The stem is smooth and white, sometimes slightly floccose like the pileus, equal and fistulose. It is striate at the apex as in A and this is the second diagnostic mark of this species. The spores are elliptical, dark brown, 4—5x8—9μ. The two marks by which the species is known are the gill color and striate apex of the stem. The plant does not appear to be well known. Atkinson mentions it very briefly and Peck reports it as rare in New York State. He is also doubtful about the color of the young gills and says the European illustrations do not show them violaceous. It would appear however that Cooke's Illust. 546 is intended to represent them so as contrasted with the white gills in Pl. 547. The color of the young gills should be carefully noted by collectors and the distribution of the plants recorded.

Hypholoma appendiculatum Bull.

Hypholoma appendiculatum Bull. is the most common species in the group. It occurs everywhere, in lawns and pastures, on or near logs, stumps and buried roots. The species is distinguished from Hypholoma candolleanum by the gills being whitish when young, becoming flesh colored and finally purplish brown. The stem also is more floccose and less striate at the apex though Hypholoma appendiculatum often has the apex of the stem somewhat striate.

The exact relation of our plants to those of Europe is somewhat uncertain. Atkinson, Mushrooms p. 27, and Murrill, Mycologia Jan., 1912, consider them the same species. Prof. Farlow, than whom there is no better authority, in a letter to me takes the same view. Peck separates the pale yellowish or whitish forms found scattered on lawns and makes them a new species. Ten of the collections at Albany are named Hypholoma incertum and only two Hypholoma appendiculatum, both of which are doubtful. The plants in our region vary much. Some are nearly white or pale yellow, others are deep hygrophanous brown. Some are very caespitose and others single or scattered. All the forms run together however. The pure

white plant with floccose stem in Plate LXXXIII C we have labelled Hypholoma incertum though it is doubtful whether the form is separate enough to merit a distinct name.

Illustrations of the species are common. Murrill figures both the light and dark colored forms in Mycologia Jan. 1912. Atkinson, Mushrooms Pl. 7 shows photographs of the floccose forms. McIlvaine and Hard show very slender forms. Peck gives illustrations of Hypholoma incertum in N. Y. State Mus. Mem. 4 Pl. 60.

A large number of forms more or less closely related to Hypholoma candolleanum or Hypholoma appendiculatum have received specific names. They differ chiefly in size, shape or color, in the split and cracked pileus, in the character of the universal veil (floccose forms) or in the character of the partial veil (annulate forms).

a. Pileus rugose wrinkled.

Hypholoma leucotephrum B. & Br. Pl. LXXXI.

Plate LXXXI shows whitish plants with long flexuous stems which are deeply sulcate striate at the top. The pileus is rugose wrinkled. The plants grew in clusters on logs and on the ground at Sumner, Washington in June. The plant is illustrated by Cooke, Pl. 548. The gills are whitish at first becoming grayish and almost black. The spores are 4—5x6—8μ. The form agrees with Hypholoma candolleanum in the striate apex of the stem and with Hypholoma appendiculatum in the whitish color of the young gills though they have no incarnate tinge. We have collected the species also in Stuart West's yard at Geneseo. Ills.

b. Pileus cracked and split.

Hypholoma cutifractum Pk. Pl. LXXXII.

Under certain weather conditions the plants in this group crack and split and the cuticle of the pileus peels off in patches from the flesh. A cracked form which Peck calls Hypholoma

cutifractum is shown in Pl. LXXXII. The plants grew in a yard among grass at Geneseo, Ill, in June. A perfect pileus could scarcely be found. The plants began to crack and peel as soon as they started to grow. Peck's Hypholoma cutifractum, Torr. Bull. Dec. 1895 p. 490, was based on forms like this collected in Kansas by Bartholomew. The plant is distributed in Fun. Col. 1303. The specimens in our copy are not much cracked. A series of cracked forms can probably be found corresponding to each species in the group.

c. Pileus with a dark watery disk and light colored margin.

Hypholoma madeodiscum Pk. is described in N. Y. State Mus. Rep't 38 p. 88, and Bull, 150 p. 75. The characteristic feature which gives the plant its name is that the moisture escapes from the margin of the pileus before it does from the disk. The plant grows on logs with a scattered habit, has the young lamellae whitish and the stem striate at the apex. Peck has seen the plant but once. It suggests Hypholoma leucotephrum. In our photographs of that species the disk of the pileus is darker than the margin.

d. Pileus thin, stem slender, striate.

Hypholoma hymenocephalum Pk. is described in N. Y. State Mus. Rep't 31, p. 34. It grows on damp ground among fallen leaves and is remarkable for the very thin pileus and slender stem. It has young gills whitish and stem striate nearly to the top. The photograph of Hypholoma incertum in McIlvaine Pl. XCVII and Hard, Pl. XXXVII suggests this form though the illustration does not show a striate stem.

e. Stem long, pilei relatively narrow.

Hypholoma longipes Pk. Pl. LXXXIII A.

Long stemmed plants are reported from the Pacific coast. The photograph was made from dried specimens of plants collected at Sumner, Washington. They agree exactly with Peck's description of Hypholoma longipes, Torr. Bull. May, 1895, p. 204, even to the umbilicate apex of the pileus in

dried plants. We have observed this character in Hypholoma candolleanum, Pl. LXXXIII B. The apex is often perforate. The gills are whitish becoming nearly black, the apex of the stem is striate and the base very white myceloid. Spores 7½x12μ, quite large for the group.

There are two more Californian species which Murrill, who has examined the type specimens says are very similar to Hypholoma longipes, Hypholoma campanulatum Pk. Torr. Bull. June, 1909, p. 336 and Hypholoma californicum Earle. Bull. N. Y. Bot. Garden 2 p. 344. The latter is larger than Hypholoma longipes and has ventricose gills and smaller spores, 3x5—6μ.

f. Pileus floccose, especially when young.

Atkinson, Mushrooms, Pl. 7 shows the floccose form of Hypholoma appendiculatum.

Bondier Icon. Mycol. I. t. 137 figures Hypholoma appendiculatum var. flocculosum. It is larger than the type with the pileus more sulcate and covered with soon disappearing flocci.

McClatchie. Proc. S. Cal. Acad. Sci., 1, p. 381 has named a very floccose form of Hypholoma appendiculatum Hypholoma flocculentum. It appears to be the most extreme form that has been noted. The flocci form a thick coat and are somewhat persistent. It must be very similar to Berkeley and Broome's var. lanatum which is said to be "a curious form, densely woolly when young, traces of the woolly coat remaining at the apex when the pileus is fully expanded."

Another form is Hypholoma hololanigerum Atk. Ann. Mycol. VII p. 371. The plants grew on rotten wood and the whole sporophore was covered with long white squamules. The plants are small and may be nearer the Psilocybe pennata group.

Still another form is Hypholoma fragile Pk. N. Y. State Mus. Bull. 131, p. 22 and Pl. V. figs. 1—7. It is a small plant which the author places in the section flocculosa. Dr. Peck suggests the resemblance to Hypholoma incertum and the illustrations confirm this. It is however reported as not hygrophanous.

These floccose forms are due to the greater or less development of the universal veil and their appearance is probably largely

determined by weather conditions. A whole series of them can probably be found.

g. Veil annulate.

In these plants the veil makes a ring on the stem instead of clinging to the margin of the pileus. They are of course described in the genus Stropharia. Such variations between annulate and appendiculate in the character of the veil often occur in the praecox-dura group in the genus Pholiota and elsewhere.

Peck describes such a form as Stropharia irregularis, Torr. Bull. Jan. 1900, pp. 16—17. It had a slight annulus soon breaking into fragments and disappearing. The author expressed the opinion later that it is a form of Hypholoma incertum.

Murrill in Mycologia, Nov. 1912, pp. 301—302, has described a form with a much more persistent annulus, Stropharia longistriata of which he says "Similar to Hypholoma appendiculatum in general appearance but always furnished with a thick persistent annulus."

h. Doubtful forms.

Hypholoma atrofolium Pk. Torr. Bull. Oct. 1896, p. 417 is of doubtful affinities. Murrill suggests that it may belong to the genus Psathyrella.

Hypholoma subaquilum Bann. N. Y. State Mus. 44 pp. 70—71 shows nothing distinctive according to the brief description except the small spores 4x5μ.

Species Omitted.

1. Changed to Pholiota. Hypholoma ornella Pk. (= Pholiota appendiculata Pk.) changed to Pholiota ornella Pk.

2. Changed to Psilocybe. Hypholoma nitidipes Pk. Hypholoma phyllogenum Pk. Hypholoma squalidellum Pk. (Hypholoma squalidum Pk.) Hypholoma modestum Pk.

3. Omitted in Peck's summary of N. Y. species. Hypholoma saccharinophilum Pk. Hypholoma hirto-squamulosum Pk.

4. Hypholoma camoropsis Mont., named from Sullivant's collection, is omitted by Ohio mycologists.

INDEX

For list of doubtful and omitted species see p. 1161.

NOTE ON PHOLIOTA EREBIA Fr.

(With Plate LXXXIV)

Since publishing the photographs of Pholiota erebia in Part I, Plate XXX of this volume I have collected a number of plants closely connected with that species some of which are shown in Plate LXXXIV.

Figures A–E are from specimens collected at Frankfort, Mich. in August 1913. They grew singly on the ground under beech and maple trees. They differ from the plants from Blue Mounds, Wis. shown in Pl. XXX, in the scattered habit, less squamulose base of the stems and in the slightly shorter spores 5—6×9—11μ instead of 6×12—14μ. They agree more closely than the others with the typical plants of Fries description the only noticeable difference is the less striate margin of the pileus. The spore measurements also agree more closely with those given by Britzelmayr for Pholiota erebia, 4—6×10—12μ. The pileus was convex, subumbonate, slightly viscid, smooth, even or reticulated wrinkled, dark ferruginous brown when moist, becoming clay colored when dry, stem nearly equal, whitish, fibrous striate, veil apical, ample, membranous, Gills adnate, not crowded, grayish becoming rusty.

The same plants were found also on logs of beech and maple. They often had the stems curved from position. The colors, characters and spore measurements were exactly the same as in the plants growing on the ground. Figure H shows one of these plants. Dr. W. S. Moffatt found similar plants on beech logs at Griswolda, Mich. He described the pileus as "honey color or pale tan, whitish on the margin" and gives the spore measurements as 4—5×8—9μ. These plants agree well with the description of Pholiota acericola Pk. N. Y. State Mus. Bull. 122 pp. 155–156.

Figures F and G represent the plants found at Neebish, Mich. and mentioned in the previous article, p. 481 of these Transactions. They differ from both the Blue Mounds and Frankfort specimens in the more umbonate pileus, in the distinctly striate margin of the pileus, in the rather more distant lamellae and in the distant annulus. The spores agree exactly in shape and size with those of the plants from Blue Mounds. 5—6×12—14μ. The distant annulus accords with the descriptions of Pholiota ombrophila.

The Pholiota erebia group appears quite variable in Europe as well as in this country. I have already noted the caespitose forms with the base of the stems scaly and the forms with rugose wrinkled pileus both of which occur in this country. Britzelmayr illustrates a form which he considers a cross between Pholiota erebia and Pholiota togularis. He also describes several new species, Pholiota confoederans, Pholiota praecavendus, Pholiota propinquatus etc. all of which are shown by their colors, characters and spore measurements to be very close to Pholiota erebia. His figures of Pholiota erebia are somewhat larger and have thicker stems than the plants we have photographed. It is however impossible to determine from the brief descriptions whether the variation in the group is similar to that among our plants.

EDWARD T. HARPER.

EXPLANATION OF PLATES.

Plate LXXII. Hypholoma sublateritium Schaeff. A. Cluster of mature plants. B. Young plants showing the veil. C. Young plants showing the cobwebby surface of the pileus.

Plate LXXIII. Hypholoma perplexum Pk. A. Mature plant. B. Plant showing the attachment of the gills and the striate apex of the stem. C. Gill surface and hollow stem. D. Surface of pileus showing the umbo.

Plate LXXIV. Hypholoma capnoides Fr. Cluster of mature plants.

Plate LXXV. Hypholoma fasciculare Huds. A. Two mature plants. B. Young plants showing the appendiculate veil and fibers remaining on the stem. C. Section showing gills and flesh.

Plate LXXVI. Hypholoma.....Plants in various stages of growth.

Plate LXXVII. A. Hypholoma ambiguum Pk. Young plant showing smooth pileus, appendiculate striate veil, striate upper part of the stem, surface and bulbous base of the stem. B. Small plant of Hypholoma echiniceps Atk. showing surface of the pileus. C. Hypholoma lacrimabundum Fr. Young plant showing cortina like veil, surface of the pileus and of the stem.

Plate LXXVIII. Hypholoma echiniceps Atk. A. Cluster of large plants. B. floccose edge of gills × 4.

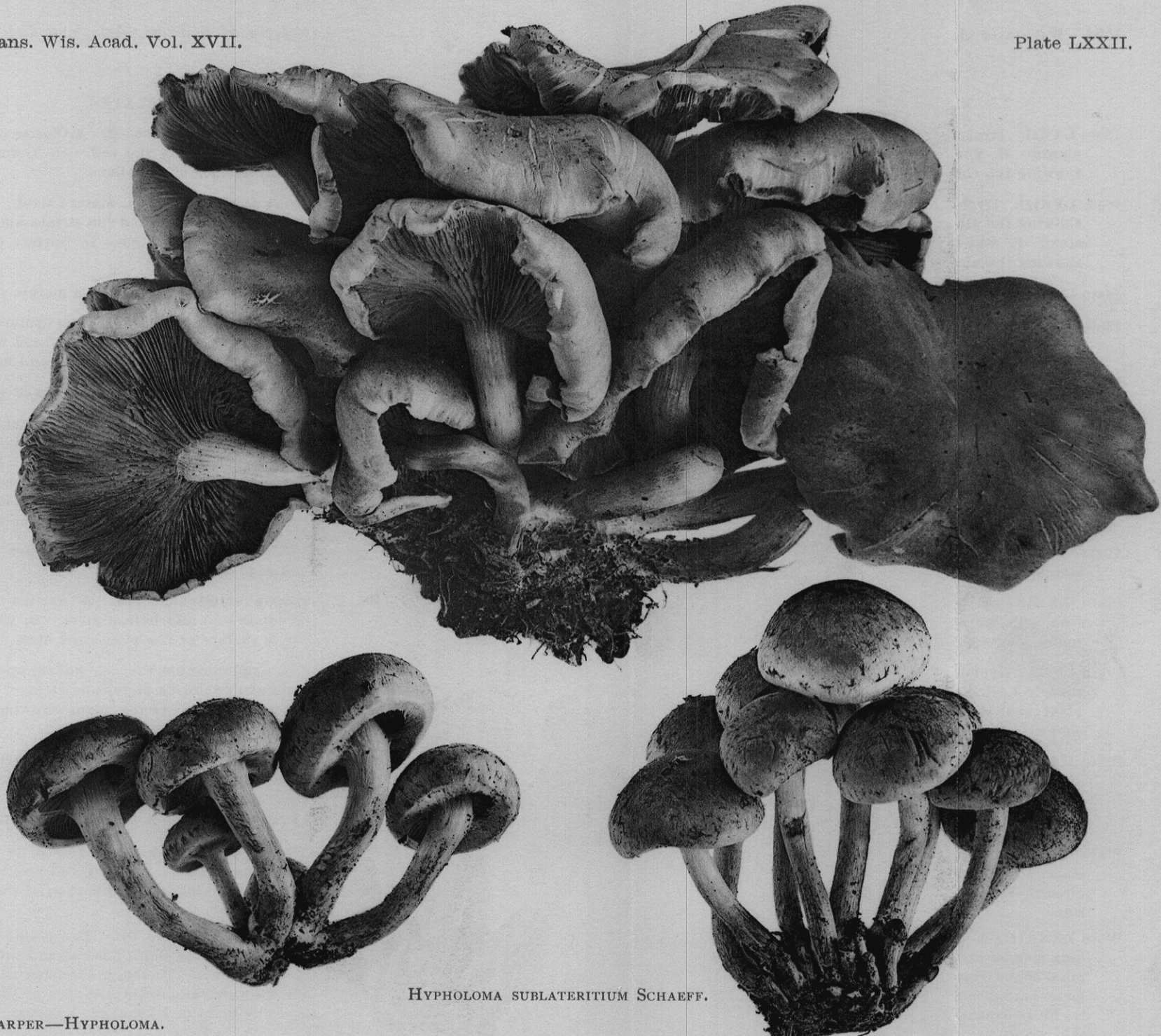
Plate LXXIX. Hypholoma velutinum Pers. A. Section showing flesh, gills, appendiculate veil and hollow stem. B. Cluster of young plants showing surface of the pileus and stem.

Plate LXXX. Hypholoma candolleanum Fr. A. Striate apex of the stem × 4. B. Mature plant showing pileus and stem. C. Mature plant showing gill surface. D. Young plant showing acorn-shaped pileus and appendiculate veil.

Plate LXXXI. Hypholoma leucotephrum B. & Br. A. Striate apex of the stem × 4. B. Large plant with thick shreddy stem, striate at the apex, gill surface. C. Young plants showing smooth stems, rugose wrinkled pilei and appendiculate veil.

Plate LXXXII. Hypholoma cutifractum Pk. Plants in various stages of growth, showing splitting, cracking and peeling of the pileus. E. Young plant showing veil and section of the hollow stem.

Plate LXXXIII. A. Hypholoma longpipes Pk. Two plants showing long slender stems with the base white floccose and the narrow pilei, taken from dried plants. B. Dried specimen of Hypholoma candolleanum showing thin imbilicate apex of the pileus. C. Fully expanded white plant of Hypholoma incertum Pk.



HYPHOLOMA SUBLATERITIUM SCHAEFF.

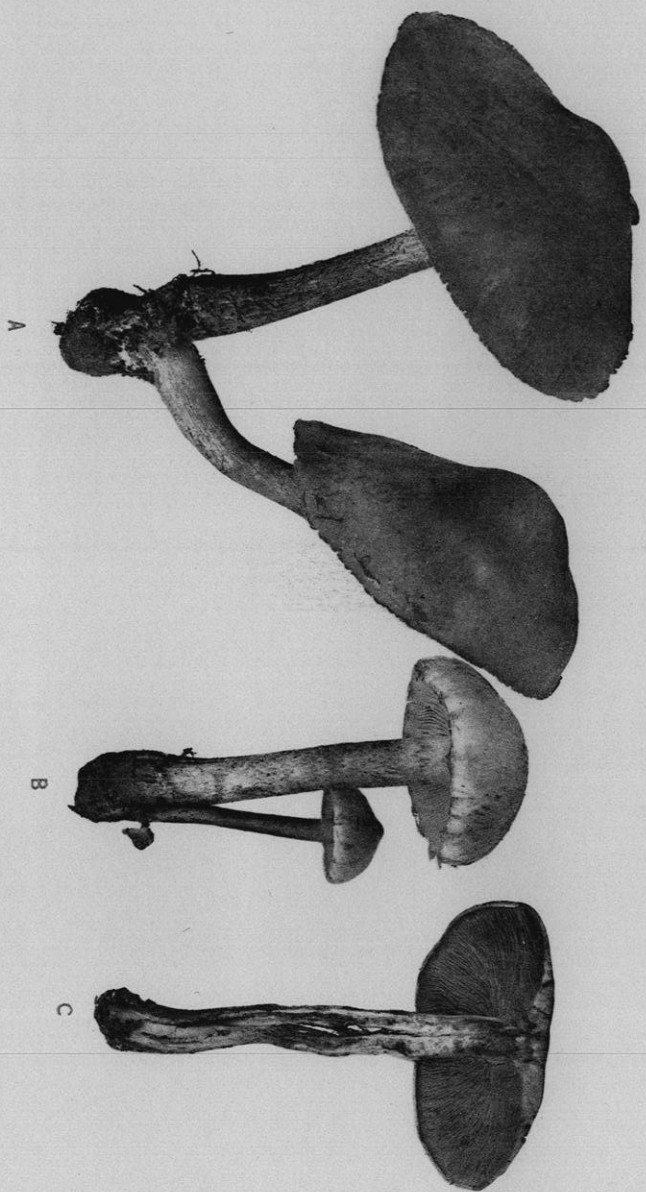
HYPHOLOMA PERPLEXUM PK.

COCKAYNE—BOSTON

HYPHOLOMA CAPNOIDES FR.

HARPER—HYPHOLOMA.

COCKAYNE—BOSTON



HYPHOLOMA FASCICULARE HUDS.

HARPER—HYPHOLOMA.

COCKAYNE—BOSTON

HYPHOLOMA .....

COCKAYNE—BOSTON

A—Hypholoma ambiguum Pk.
B—Hypholoma lacrimabundum Fr.,
Form Hypholoma echiniceps Atk.
C—Hypholoma lacrimabundum Fr.

Harper—Hypholoma.

COCKAYNE—BOSTON

B

A

HYPHOLOMA LACRINABUNDUM. FR.

FORM HYPHOLOMA ECHINICEPS. ATK.

HYPHOLOMA VELUTINUM PERS.

HARPER—HYPHOLOMA.

COCKAYNE—BOSTON

HYPHOLOMA CANDOLLEANUM FR.

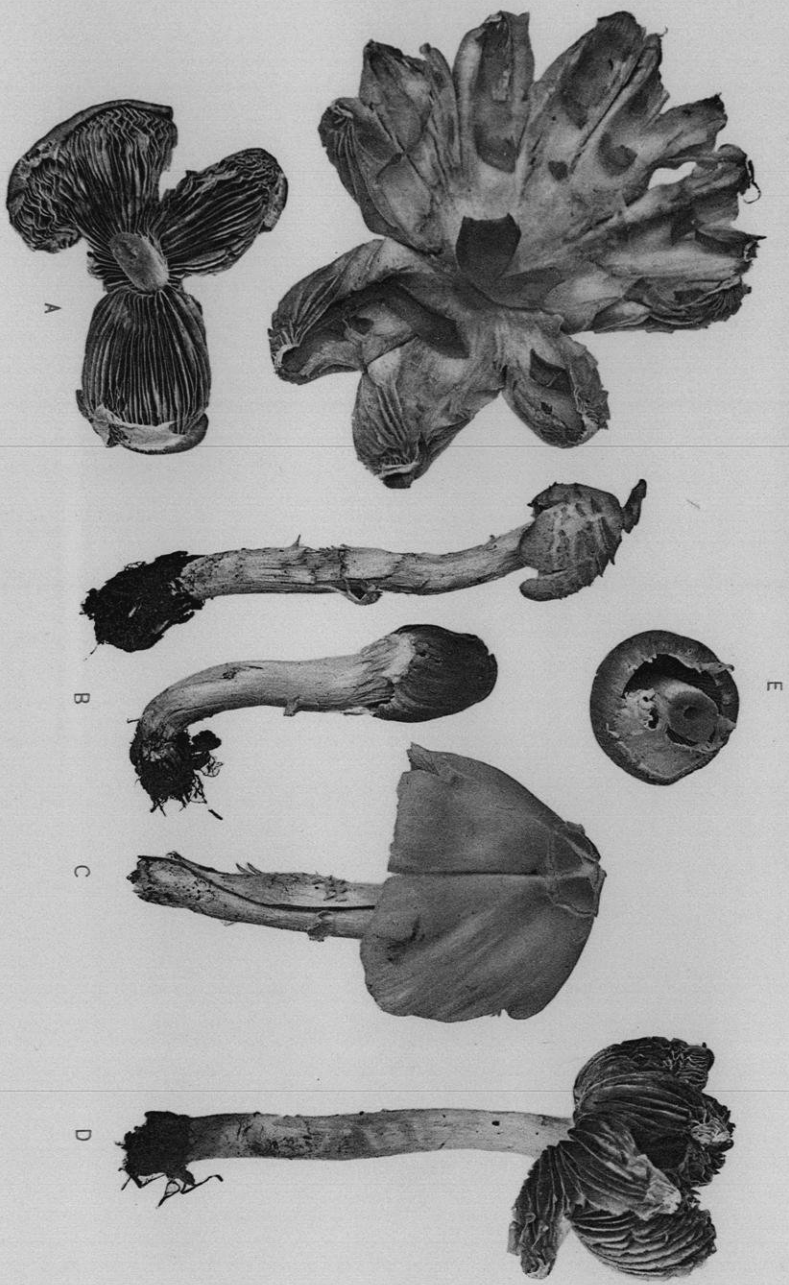
HARPER—HYPHOLOMA.

COCKAYNE—BOSTON

HYPHOLOMA LEUCOTEPHRUM B. & BR.

HARPER—HYPHOLOMA.

COCKAYNE—BOSTON



HYPHOLOMA CUTIFRACTUM PK.

HARPER—HYPHOLOMA.

COCKAYNE—BOSTON

A—Hypholoma longipes Pk.
B—Hypholoma candolleanum Pk.
C—Hypholoma incertum Pk.

Harper—Hypholoma.

COCKAYNE—BOSTON

PHOLIOTA EREBIA FR.

HARPER—PHOLIOTA.

COCKAYNE—BOSTON

THE ORGANIZATION OF THE COLONY IN CERTAIN FOUR-CELLED ALGAE

GILBERT MORGAN SMITH

INTRODUCTORY.

The arrangement of the cells in a few-celled coenobic colony presents several interesting problems. There are various possible combinations of the cells of a colony composed of four cells arranged in a definite symmetrical structure. If the individual cells are spherical *(isoaxial)*, their arrangement may be either in a linear series, a plane or a pyramid. Colonies of isoaxial cells with the cells regularly occurring in a linear series

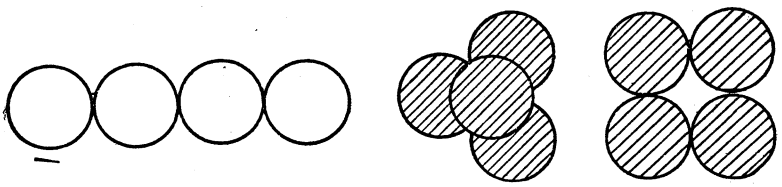


Figure 1. Diagrammatic representation of possible combinations of isodiametric cells in a four celled coenobe. Shaded diagrams represent those arrangements which are known to exist in nature.

are unknown. *Tetracoccus botryoides* West is a type of colony whose cells are in a plane; *Coelastrum microporum* Naeg. constitutes the only known form with axially undifferentiated cells arranged in the form of a pyramid.

If the individual cells have each a long and a short axis (i. e. are *heteraxial*), many more colony forms are possible. The range of possible symmetrical arrangements is shown in Text Figures 2-6. All normal coenobic colonies are symmetrical.

Certain colonies may lose their symmetry either because of variation in the position of certain individual cells, or because of the abnormal growth of certain cells. All such cases should really be classified with symmetrical forms, since each deviation is for a single generation only and the irregular coenobe gives rise in the next generation to symmetrical colonies.

Classifying the arrangement of the cells in the coenobe according to the relationships of their long axes, we may divide colonies first into those the long axes of whose cells are all in a single plane (*coplanar* colonies) and those whose long axes are not in a plane (*noncoplanar* colonies). In the coplanar series the long axes may all meet at some one point, if they are projected far enough, in which case they are called *concurrent.*

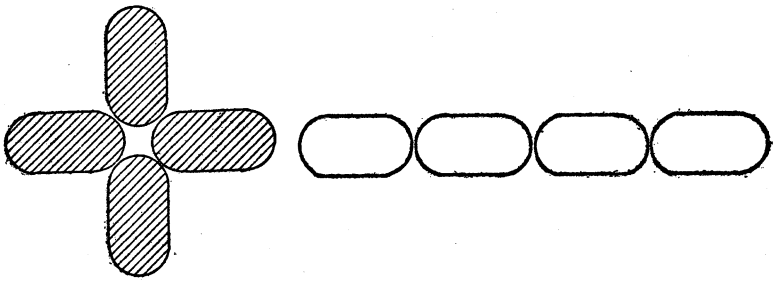


Figure 2. Possible combinations of the four cells of a coenobe in a concurrent coplanar series. Shaded diagrams represent those arrangements which are known to exist in nature.

Nonconcurrent coplanar colonies are those whose axes will not meet, no matter how far they are projected. The coplanar concurrent forms may be further separated into those the long axes of whose cells lie in a single straight line *(colinear)*, and those whose axes meet at a common center *(nonparallel)*. No four-celled colonial forms are known with the coplanar concurrent colinear arrangement of the major axes of the cells; but among the coplanar concurrent nonparallel forms may be mentioned *Pediastrum Boryanum* (Turp.) Mengh., *Crucigenia tetrapedia* (Kirch.) W. & G. S. West, and *Tetrastrum Staurogeniaeforme* (Schroed.) Chodat. In coplanar nonconcurrent forms

the major axes may be either *parallel,* as in those shown in Text Figure 3, or *nonparallel,* as in the forms shown in Text Figure

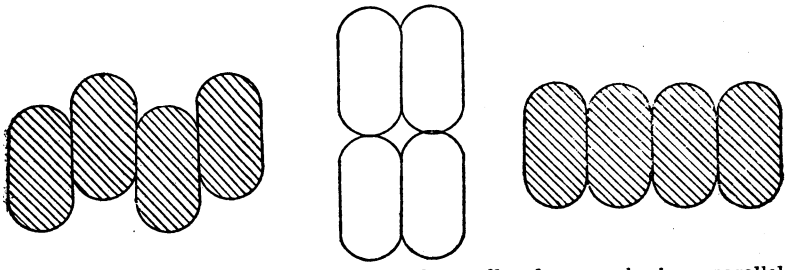


Figure 3. Possible combinations of the four cells of a coenobe in a parallel nonconcurrent coplanar series. Shaded diagrams represent those arrangements which are known to exist in nature.

4. *Scenedesmus* Meyen may be cited as an example of the parallel nonconcurrent coplanar forms, while certain species of *Crucigenia,* as *C. rectangularis* (Naeg.) Gay should be classi-

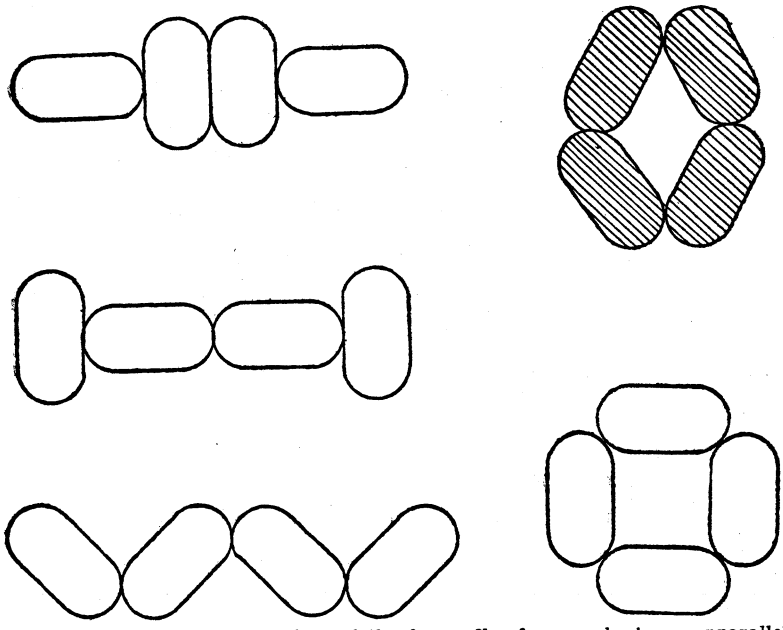


Figure 4. Possible combinations of the four cells of a coenobe in a nonparallel nonconcurrent coplanar series. Shaded diagrams represent those arrangements which are known to exist in nature.

fied among the nonparallel nonconcurrent coplanar forms. In the noncoplanar series the axes all meet at a certain point (*concurrent* colonies), or they may not (*nonconcurrent* colo-

nies). For the concurrent forms there is only the single possibility shown in Text Figure 5 A. The nonconcurrent noncoplanar forms may have their axes either *parallel* (Text Figure 5 B) or *nonparallel* (Text Figure 6.) The only known parallel nonconcurrent noncoplanar arrangement of the cells is that

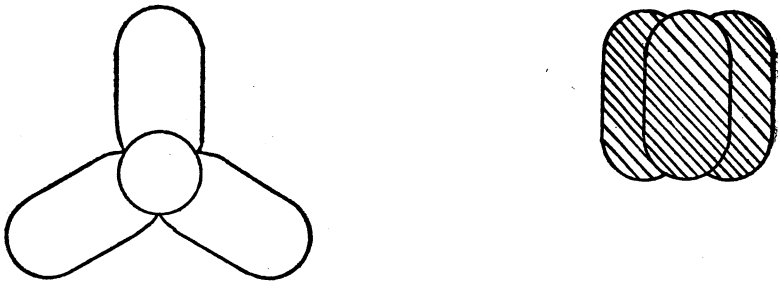


Figure 5. Possible combinations of the four cells of a coenobe in a colinear noncoplanar or a parallel nonconcurrent noncoplanar series. Shaded diagrams represent those arrangements which are known to exist in nature.

found in *Tetradesmus wisconsinensis* Smith. There are no algae which can be regularly classified as nonparallel nonconcurrent noncoplanar forms, although, as will be later pointed out, *Scenedesmus acutus* Meyen may at times have the cellular arrangement shown in the shaded portion of Text Figure 6.

Arranging the possible combinations of the four-celled coenobic algae in a table, we have the classification given below. All of these possibilities are illustrated in Text Figures 1–6, the shaded diagrams representing the forms known to occur in nature.

I Cells **Isoaxial.**

1—**Linear colonies.**

2—Plane colonies: ***Tetraccocus botryoides*** West.

3—Pyramidal colonies: *Coelastrum microporum* Naeg.

II Cells Heteraxial.

1—Coplanar series.

A—Concurrent forms.

a—Colinear colonies.

b—Nonparallel colonies: *Pediastrum Boryanum* (Turp.) Meng., *Crucigenia* (Kirch.) W. & G. S. West, *Tetrastrum Staurogeniaforme* (Schrod.) Chodat.

B—Nonconcurrent forms.
a—Parallel colonies: *Scenedesmus acutus* Meyen.
b—Nonparallel colonies: *Crucigenia rectangularis* (Naeg.) Gay.
2—Noncoplanar series.
A—Concurrent forms.
B—Nonconcurrent forms.
a—Parallel colonies; *Tetradesmus wisconsinensis* Smith.
b—Nonparallel colonies.

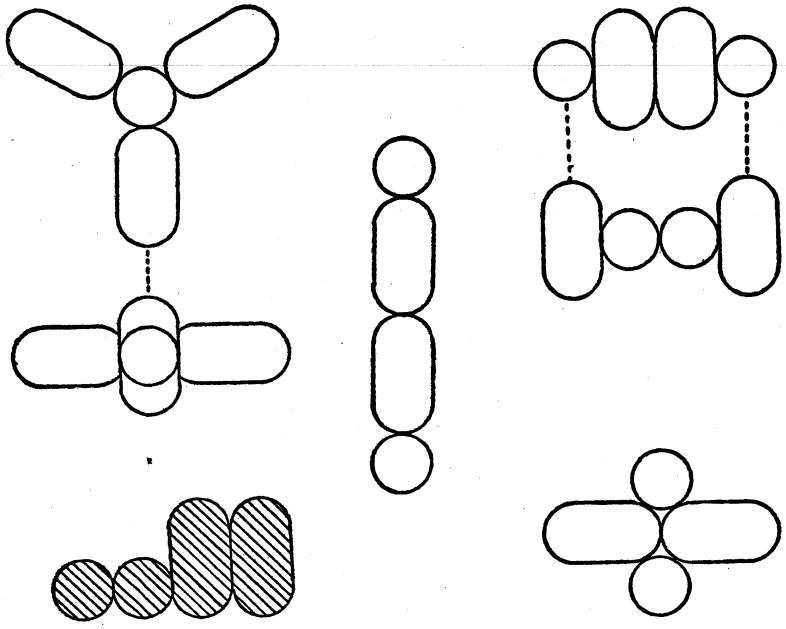


Figure 6. Possible combinations of the four cells of a coenobe in a nonparallel nonconcurrent noncoplanar series. Shaded diagrams represent those arrangements which are known to exist in nature.

In the present paper a form from each of the main classes will be taken up and discussed both with respect to the variations that normally occur in the coenobe, and to the modifications that can be produced in the cellular arrangement by altered environmental conditions.

Systematic Discussion

The nomenclature for the systematic classification of the *Protococcales* is one which offers considerable difficulty, even when the form under consideration is fairly well known. The Brussels Congress of 1910, according to the report of Farlow and Atkinson (16), decided that Ralfs' "British Desmidieae" (1848) should be taken as the starting point for systematic work in the Desmidiaceae. In this work *Scenedesmus* and *Pediastrum* are classed as Desmidaceae. Whether it was the intention of the Congress that we should base our nomenclature for the systematic classification of these two genera on this work is a matter that is perhaps open to question, but in my work I have followed Ralf's classification.

The species of *Scenedesmus* studied were *S. acutus* Meyen and *S. quadricauda* (Turp.) Bréb. The classification of the species of *Pediastrum* is a more difficult matter. Although Ralfs recognizes the danger of using the arrangement of the cells in the colony as a specific character, his system of classification is based both on the shape of the cell and on the number of cells in the colony. Little reliance can be placed on this latter character, since there is great variation, within specific limits, in both the number and the arrangement of the cells. Certain species are described by Ralfs in which the chief determining character is the fact that the number of cells is not a multiple of two. These so-called species are merely abnormal forms. The species of *Pediastrum* that I have obtained in my cultures agrees more nearly with the description of *P. Boryanum* (Turp.) Mengh. than with that of any other species. Observations were also made on *Pediastrum tetras* (Ehrenb.) Ralfs.

Senn (35) has gathered together the widespread literature on *Coelastrum* and monographed the genus. His work is especially authoritative in that he had several species under cultivation and so was able to determine the variation in appearance within each species. The species that I have had in my cultures is *Coelastrum microporum* Naeg.

Only one species of *Tetracoccus* is known, according to Wille (43). The cell dimensions of the form that I have studied are well within the limits set by West (42).

Tetradesmus wisconsinensis Smith was originally described from the same material that was used for the study reported in the present paper.

Material and Methods

The forms, work upon which is reported in the present paper, were isolated by the general method first used by Beyerinck (5), and later by Chodat and Grintzesco (11), Chodat (8) (9), Grintzesco (17) (18), Artari (1) (2), and others.

The medium used was a 2.0 per cent Knop's solution in 2.0 per cent agar. The tube containing the nutrient agar was melted in the usual manner, and then a drop of water containing the algae was added. In practice I have found it better to add very small portions of water, even inoculating the melted agar with a sterile needle dipped in water containing the algae, rather than to use the ordinary method of successive dilutions. The agar is then poured into Petri dishes in the customary manner.

The growth of bacteria in the medium is comparitively rapid: the algal colonies grow very slowly. The rate of growth is influenced by heat and light. Ward (40) has shown that direct sunlight kills many algae, but that they grow luxuriantly in diffuse light. Grintzesco (18) also found that growth was faster when the cultures were exposed continuously to an electric light than when they were exposed to daylight. The same author found 20 degrees centigrade to be an optimum temperature for the growth of *Scenedesmus acutus*.

Under ordinary summer conditions, the algal colonies become visible as small green dots in from eight to twelve days. All algal colonies do not develop at the same rate, and I have usually found that the first colonies to appear were those of *Chlorella* and other simple forms. For this reason it is best to let the plate cultures stand twenty days before trying to isolate the

different species. This is especially true in the case of the Cyanophyceae.

The algae do not form colonies of characteristic appearance so that the species cannot be determined by macroscopical examination. I have not found a report by any investigator who was able to determine his alga before isolating it in pure culture. In my attempt to isolate as many forms as possible, the determination of the species in plate cultures containing a mixture of forms has been very important. The method used was to cut out a colony from the agar with a sterile needle and mount it on a sterile slide and under a sterile cover glass. A microscopical examination could then be made and the species determined. In this manner two to three hundred colonies could be examined in a day and perhaps only twenty of them retained for further study, thus saving the time necessary to transfer all colonies to an agar slant and to allow them to grow before determining the species.

If the alga on the slide was a species that was desired for further study, it was plated again by removing the cover glass from the slide and mixing the crushed colony with a drop of melted agar. This melted agar was then transferred to a tube containing melted agar and the whole mass plated again. The disadvantage of this method is that there is a loss of time in waiting for the second Petri dish culture to grow, and a danger of infection from the various manipulations. There is undoubtedly some chance for bacterial infection from the slide and also in transferring the colony to the melted agar, but this is small enough to be neglected. The distinct gain from this method is that in case the culture is slightly infected in the original Petri dish, the replating is apt to separate the bacteria from the algae, while a slightly infected colony put on a agar slant would prove a total loss. The method described above is especially valuable in the case of the rarer algae. My results show a distinct saving in the total time required for manipulation by the method here described, but if one wishes to obtain a pure culture of an alga, irrespective of the particular species,

the method of inoculation directly on the agar slant is to be preferred.

There is more or less confusion in the use of the term "pure culture." According to the usage of some authors, a pure culture is one that contains only one algal species; others understand it to be a culture of a single algal species that is also free from other organisms, including bacteria and fungi. To differential between the two I propose the term *unialgal culture* to designate one which contains but a single species of alga, but which may contain other organisms. The term *pure culture* is reserved for one which contains a single species of alga, and is absolutely free from all other organisms.

The second series of Petri dish cultures would then be unialgal cultures. After allowing these cultures time to develop, single colonies are again lifted out and inoculated on agar slants. The colonies should be removed from these cultures as soon as they become visible. This work has usually been done under a Zeiss binocular microscope. The work should be done in a special room where transfers are made, since any infection is fatal at this stage. By this method very small colonies are obtained, and the smaller bacterial and fungus colonies, which would ordinarily be overlooked, can be seen.

Almost all investigators who have worked with pure cultures have noted that algae develop faster in a medium containing a small percentage of glucose than one which does not. Accordingly, a third series of cultures is made by inoculating an agar medium, to which has been added 1 per cent of glucose, with colonies from the unialgal cultures. This series is made on agar slants instead of Petri dishes. There are two advantages in the use of this medium. The glucose favors the development of fungi and bacteria, so that if there are any in the culture they will soon appear. At the end of three or four days the infected cultures can easily be separated from those that appear to be pure. In general, in spite of all possible precautions, many cultures will be infected. For the inoculation of the unialgal cultures from the Petri dish, it is usually best to

make about a dozen cultures on glucose agar. As a rule, about half of the cultures are uncontaminated at the end of two weeks. In earlier experiments the third inoculation was made into a medium containing agar and a mineral solution only, but the development was very much slower and it was more difficult to separate the cultures that contained bacteria and fungi. The purity of cultures was determined at first by plating a sample of the culture in a nutrient medium which was known to favor the development of bacteria, to see whether or not there were any bacteria present. Later this was found unnecessary, since all infected glucose-agar cultures are readily detected.

Having obtained pure cultures, they can be preserved on the agar surface or in a liquid medium. I have preferred to keep my cultures running in 200 cc. Erlenmeyer flasks containing about 50 cc. of the mineral solution to which 0.2 per cent of glucose has been added. This small proportion of glucose is better, since, as Artari has pointed out (3), the algae are apt to degenerate in stronger concentrations of glucose.

The algae used in this investigation, which were grown in pure culture were *Scenedesmus acutus* Meyen, *Scenedesmus quadricauda* (Turp.) Bréb., *Dactylococcus infusionem* Naeg., and *Tetradesmus wisconsinensis* Smith. These algae were all collected from Murphy's creek where it flows past the Dane county fair grounds near Madison, Wisconsin. The unialgal cultures of these forms were obtained in August 1911, and the pure cultures in September of the same year.

The observations on *Pediastrum Boryanum* (Turp.) Mengh. and *Coelastrum microporum* Naeg. were made on material in unialgal culture. These were obtained in unialgal culture in January 1913.

The observations on *Pediastrum tetras* (Ehr.) Ralfs, and *Tetracoccus botryoides* West were made on these organisms as they occurred mixed with other algae in nature; as yet I have not succeeded in obtaining them in unialgal or pure culture. The material was collected from Murphy's Creek, and the Dane county fair grounds, in the summer and fall of 1912,

and the spring of 1913. Drawings were not made at once, but the material was preserved in a 10 per cent solution of Amann's copper-lacto-phenol.

The Isodiametric Series

Although, from the morphological standpoint, the sphere is the simplest possible form that a cell may assume, this shape is found in but few coenobic algae. This may be because the formation of autocolonies within the mother cell wall is a considerable advance over the condition of free-lying spherical cells, and because along with the development of this autocolonial habit there has gone almost necessarily an axial differentiation of the individual cells. It is true that certain of the Volvocales have symmetrical colonies composed of spherical cells but since these cells have a certain axial differentiation they have been excluded from consideration in this paper. Two coenobic algae with isodiametric cells are *Tetracoccus botryoides* West and *Coelastrum microporum* Naeg.

Tetracoccus, A Plane Isodiametric Colony

In *Tetracoccus botryoides* West, which is taken as a type of coenobe whose cells lie in a single plane, my observations were made on material as it was collected from a small, sluggish stream near Madison, Wisconsin.

There is little variation in the arrangement of the cells when they are found in a single plane. They may be arranged either so that the outline of the coenobe is rectangular (Fig. 1 A, Plate LXXXV) or so that it is diamond shaped (Fig. 1 B). This difference in outline depends upon the manner in which the cells of the coenobe come in contact with one another; sometimes there is a small open space in the center of the colony (Fig. 1 A), in which case the colony is rectangular in outline, sometimes two opposite cells of the colony are in contact with one another, and the remaining pair of cells are not in contact but are prevented from touching each other by the first pair (Fig.

1 B), then the colony has the diamond shaped outline. All gradations between these two conditions are found. The cells in a single coenobe are all the same size; but two coenobes may differ with respect to size of the constituent cells. This difference results from differences in the age of the coenobe. Occasionally a colony is found whose cells are in two planes forming a pyramid with a three celled base and one cell for the apex (Fig. 1 C).

These differences in colony form are due to differences in the manner of origin of the cells of a colony. According to West (42) multiplication takes place by the formation of four daughter cells within a mother cell wall, the division of the mother cell contents being in two planes. This gives rise to the rectangular type of colony. In the formation of the pyramidal colony apparently the cleavages that formed the daughter cells have been not in two planes but in three. This pyramidal position of the cells suggests that the cleavage of the mother cell was not simultaneous but progressive. This view is strengthened by our knowledge that progressive cleavage takes place in such nearly related forms as *Scenedesmus acutus, S. quadricauda, S. obtusus,* and *Tetradesmus wisconsinensis* according to my results (36) (37); in *Dictyosphaerium pulchellum* Wood according to Senn (35); and according to Braun (7) in *Pediastrum granulatum* Ktzg.

G. S. West (41) and W. West (42) emphasize the fact that there is always a division of the mother cells of *Tetracoccus* into four daughter cells. According to my observations, eight daughter cells are sometimes formed. Thus in Figure 1, Plate LXXXV, we have the remains of a mother colony showing two old cells and the daughter colonies derived from the division of five other cells, the old cell walls of the latter being still present. One of the cells of the mother colony has apparently been lost. Unfortunately this alga was not obtained in unialgal culture, so that the percentage of eight-celled colonies formed could not be determined. It is probable that, as in *Pediastrum, Coelastrum,* and *Scenedesmus,* the colonies with the larger num-

ber of cells are formed only under conditions very favorable for growth.

Coelastrum, A Pyramidal Isodiametric Colony.

The cells of *Coelastrum microporum* Naeg. are not always perfectly spherical; but since the axial differentiation is usually very slight and often quite negligible, it seems best to classify this species among those with isodiametric cells.

Under ordinary conditions the cells of a *Coelastarum* colony are approximately symmetrically arranged, the cells being in tiers, each tier in one half of the colony corresponding to a tier of the same number of cells in the other half. In an eight-celled colony there are two possible symmetrical arrangements. The cells may either be in four tiers, the respective tiers containing 1—3—3—1 cells, or the cells may be in two tiers of four cells each. Both of these arrangements were found in the eight-celled colonies in my cultures. Figures 2, 6, and 13, Plate LXXXV, shows colonies whose cells are arranged in two tiers of four cells each. Figure 6 shows the most perfectly symmetrical colony, the small central intercellular spaces being of the same size in the two tiers. In the colonies of this type shown in Figures 2 and 13 the cells in one tier are much closer together than are those in the other tier. Figure 2 shows a colony in which the tier of cells with the small intercellular space is below and the upper has a large intercellular space. In Figure 13 this arrangement is reversed. It may very well be that in these two cases we are not dealing with eight celled coenobes but rather with fragments of sixteen-celled colonies. The coenobes with the 1—3—3—1 arrangement of the cells have a single small central intercellular cavity (Fig. 10). This figure also shows the symmetrical nature of the 1—3—3—1 type of colony.

In sixteen-celled colonies there are five possible symmetrical arrangements of the cells in tiers. There may be two tiers, each of eight cells; or four tiers containing varying numbers of cells. The possible arrangements in four tiers are 1—7—7—1,

2—6—6—2, 3—5—5—3, and 4—4—4—4. Of these possible arrangements only two were found in my cultures, those of 3—5—5—3 and of 4—4—4—4, the latter being much the more abundant. This latter arrangement is shown in the drawing of Senn (35). When the cells are so arranged that the different tiers contain respectively 3—5—5—3 cells (Fig. 7), there is a single large central cavity. This peripheral arrangement of the cells about a central cavity was first noted by Pringsheim (34).

In my opinion, the variation in cellular arrangements in the eight and sixteen-celled colonies of *Coelastrum* depends upon variations in the manner of cleavage of the mother cell which formed these colonies. Pringsheim (34) held that this cleavage is simultaneous; Senn (35) is in doubt as to the method of cleavage but thinks that it is probably progressive. It seems to me highly probable that Senn is correct. Instances of progressive cleavage among Protococcales nearly related to *Coelastrum* have been cited above in connection with the cleavage of *Tetracoccus*. The 4—4 arrangement in the eight-celled coenobe would be brought about by three successive divisions at right angles to one another. The 1—3—3—1 arrangement in the eight-celled coenobe may result from the fact that the tertiary divisions are not in the same plane, but that within each half of the original mother cell one of these planes is at right angles to, and the other parallel to the primary cleavage plane. The different arrangements found in the sixteen-celled coenobes may be accounted for by similar variations in the manner of formation of the cleavage planes.

This variation in the planes of cleavage is of more importance in forms which produce nonmotile autospores than in those which have motile spores. In *Pediastrum* and *Hydrodictyon* it matters little in what planes the cleavage takes place, since it is the movement of the swarm spore which determines the position of the cells in the adult colony. However, Harper (20) holds that the manner of cleavage in the formation of the swarm spores of *Hydrodictyon* is one of the determining factors

in their arrangement when they come to rest. In *Scenedesmus* and *Tetradesmus* there is a very slight movement of the autospores due to their elongation. Those of *Tetracoccus* and *Coelastrum* do not move but round up and develop into mature cells *in situ*. For this reason the manner of cleavage in *Tetracoccus* and *Coelastrum* is the chief factor determining the shape of the adult colony.

At times the cells of the coenobe are arranged, not in the form of a more or less hollow sphere, but in that of irregular plates (Fig. 4), or in an irregular, somewhat branching plate-like mass (Fig. 17). Strictly speaking the cells, in such a case, do not lie in a plane like those of *Pediastrum,* but constitute a partially flattened mass some of whose cells are above or below the others. Such a condition suggests that, in making a mount of the *Coelastrum* material, the pressure of the cover-glass may have crushed and flattened a coenobe of regular form. I do not believe this to have been the case, since I have observed these flattened masses in material that was carefully lifted from the culture by means of a platinum loop and then examined in a hanging drop. In some of these irregular cell masses there has plainly been a rupture of the tender gelationous processes that ordinarily hold the cells of the coenobe together (Fig. 17); in others (Fig. 4) the remains of such processes cannot be seen.

There are two possible explanations for these variations from the ordinary arrangement of the cells of the coenobe. In *Stigeoclonium* Livingston (25) (26) (27) (28) (29), investigating the cause of the change from the filamentous to the "Palmella" condition, finds that it may be due to an increased osmotic pressure of the nutrient solution, or that it may be induced by the toxic action of certain compounds, either organic (as bog extracts) or inorganic (as copper salts). The change in the arrangement of the cells of *Scenedesmus acutus* from a symmetrical coenobe with the cells all in one plane to an indefinitely branching system, which has been called the "Dactylococcus stage" by Grintzesco (17), might well be cited as another instance of this kind, but I will show in the discussion of

my results on *Scenedesmus acutus* that this change really does not take place as Grintzesco supposed. Senn (35) does not report these irregularly branching colonies in *Coelastrum,* but he does describe a separation of the colonies into individual cells. This breaking down was especially abundant in cultures poor in oxygen in Senn's cultures. I have also found isolated cells quite frequent in certain of my cultures. Possibly the variation which I have described in the form of the colony of *Coelastrum* is due to some similar cause, but I am of the opinion that neither a deficiency of oxygen nor a change in the osmotic pressure of the nutrient solution, is the chief factor involved.

A more likely explanation is that of a mechanical rupture of the colony. It is well known that at times the oxygen formed in photosynthesis does not leave the vicinity of the plant but adheres it to the form of bubbles, large enough to be seen with the naked eye. This phenonomon may be observed both in filamentous algae and in aquatic seed plants such as *Elodea.* I have been able to demonstrate the presence of oxygen bubbles in connection with *Coelastrum,* and believe that they are the cause for the rupture of the colony. The oxygen given off by the cells probably accumulates in the form of small bubbles both outside and inside the colony. Bubbles given off on the inside might very well coalesce and form a single large bubble, which when large enough would cause the rupture of the colony and the appearance of the "Palmella" condition above described.

Several groups of four cells were observed in my cultures. Some of these are complete unbroken four-celled colonies (Figs. 11, 14, 15), others are undoubtedly fragments of larger colonies (Figs. 5, 8, 16). In the four-celled groups, which seem to be complete colonies, the cells are arranged in the form either of a plate (Figs. 11 & 15), or of a pyramid (Fig. 14). The latter arrangement is less frequent. This variation in arrangement, like that observed in the four-celled *Tetracoccus* colony, is due to variations in the cleavage planes by which the daughter cells were formed.

The Axially Differentiated Series.

COPLANAR FORMS.

Pediastrum, A Nonparallel Concurrent Colony.

In *Pediastrum* the number of cells in the colony is normally a multiple of two. Coenobia containing 8–32 cells are commonest in *Pediastrum Boryanum*, while in *Pediastrum tetras* the number varies from 4–16. In *P. Boryanum*, however, the formation of coenobia that contain only four cells is by no means an abnormal condition. The number of cells in the coenobium is largely dependant on the vitality of the mother cell which produced it. When the alga is growing under favorable conditions, the coenobia formed contain comparatively large numbers of cells; when environmental conditions are not so favorable, the number of cells is smaller. This same variation in the number of cells in the coenobe, coincident with changes in external condition, has been observed in *Scenedesmus*. In cultures of *Pediastrum Boryanum* that have been running for two weeks four-celled colonies are of rare occurrence, but in the same cultures two months later four-celled colonies are comparatively abundant. When the alga is grown on a firm substratum, as an agar slant, many four-celled coenobia are present. The occurrence of four-celled colonies in nature is quite rare. In *Pediastrum tetras*, which I have observed only as it occurred in nature, four-celled colonies are quite abundant.

Chodat and Huber (12) have cultivated *P. Boryanum* in different concentrations of Naegeli's solution. They find that the more concentrated solutions inhibit the formation of swarm spores, and that the cells are apt to be arranged in rounded masses resembling *Coelastrum*. The swarm-spores become rounded forming cells which resemble hypnospores, the hypnospores having a wall which, at times, may bear horns.

Figures 27–30, Plate LXXXVI, show variations in arrangement in four-celled coenobia of *Pediastrum tetras*. The normal

condition is that shown in Figures 28 and 30, where the cells are arranged in one plane about a common center. The cells may all be in contact with one another at a central point, or there may be a small rectangular space with which they are all in contact (Fig. 30). In other cases a pair of cells opposite one another are in contact, and the other two cells are separated by the first pair (Fig. 28). This last described arrangement makes the outline of the coenobe more diamond-shaped than in the two former cases. Sometimes the cells are not all in the same plane (Fig. 29), but one cell is superimposed upon the others. In this the cellular arrangement is not coplanar concurrent but non-concurrent nonparallel noncoplanar. That these irregular colonies are abnormal is shown by the differences in the size of the cells (Figs. 27 & 29). When the cells are all of the same size the arrangment is nearly always regular; when they are not of the same size, the arrangement is irregular. These irregularities in size and arrangement suggest that the swarm-spores were not all as vigorous or as healthy, as those which formed the colonies of regular shape, and that, as a result of their more or less pathological condition, they were unable to arrange themselves in the normal position.

Since *Pediastrum Boryanum* was obtained in unialgal culture, the variations of the four-celled coenobes could be easily studied. The variations, in the case of *P. Boryanum,* may be either in the shapes and relatives sizes of the cells, or in their spatial relationships. As in *P. tetras,* a dwarfing of certain cells of the colony sometimes occurs, with a consequent irregularity in the arrangement of the cells (Figs. 24, 25). Nothing brings out more strikingly the fact that the cells of a colony are independent of each other, at least as far as nutrition is concerned, as the occurrence of colonies one or more of whose cells are dwarfed and wholly abnormal in appearance. Another equally striking variation is that the "horns" of the cells in one colony differ in length from those of the cells in another colony. All conditions, from that of colonies whose cells have quite long "horns" (Fig. 18) to that of colonies whose cells

have very short "horns" (Fig. 38), or wholly lacking (Fig. 32), may be found in a single unialgal culture. One not familiar with the history of the cultures would say that Figures 34 and 35 represent different species. Such is not the case, however, since both of these colonies came from the same unialgal culture. Systematists have not paid enough attention to this variation in the length of the horn, which is usually correlated with variation in the shape of the cell. The length of the horns is usually the same for the cells of a single coenobe, but Figure 21 shows a colony one of whose cells has quite long "horns," the other cells have short "horns" and are polyhedral. This variation was not found in four-celled ceonobia, but was found several times in coenobia containing more than four cells.

The systematic bases for the classification of species of *Pediastrum* are rather indefinite, but probably the surest points for the classification of species are the shape of the cells and the size of the horns. As a result of my cultures, I am convinced that a good many variations that have been considered marked enough to warrant specific differentiation are merely normal variations within the limits of another species. The exact cause of this variation I am unable to explain. A possible explanation is that differences in the length of horns of different coenobia are due to somewhat the same environmental conditions that cause different cells in a coenobe to form daughter colonies with different numbers of cells. This explanation, however, does not account for the variation in length of horns in different cells of the same coenobe. This variation in the length of horns is another proof of the independence of the individual cells.

In cultures of *Pediastrum Boryanum* grown on agar slants there are more irregularities than in those grown in a liquid medium. In the former, the cells of the coenobe are rarely all in one plane, but are usually in a more or less flattened mass. These colonies fragment easily, so that in examining them in a mount in water one is sometimes in doubt as to whether one is examining a normal four-celled coenobe or a four-celled frag-

ment of a larger colony. Ordinarily the cells of four-celled colonies, or fragments of larger colonies, are in a plane but the long axes of the cells have no definite relationships (Figs. 20, 23, 25, 26, & 31). On the other hand, the cells of coenobia of more than four cells grown on agar slants are usually not in one plane but in an irregular mass

When the culture medium is a liquid, the cells are more likely to be regularly arranged. In four-celled coenobia having the regular nonparallel concurrent coplanar arrangement, there are the same differences as to the contact of the cells at the center of the colony that were described for *Pedistrum tetras* (Figs. 33–35). All gradations between the condition shown in Figure 33 and that in Figure 35 can be found. At other times the arrangement shown in Figure 33 is so exaggerated that the nonparallel concurrent coplanar arrangement is entirely lost, and the cells are arranged in an alternating manner that approaches the parallel nonconcurrent coplanar structure found in *Scenedesmus* (Fig. 19). In comparing Figures 19 and 33 it should be borne in mind that this classification is based on the position of the long axes of the cells, and while there seems to be no great difference between these two colonies on a casual examination, the analysis of the relationships of the long axes shows there is a marked difference. In still other cases, the cells are not at all in the same plane but one or two of them may be in a different plane from that of the other three or two. The cells that are not in the same plane may either be parallel to the plane of the coenobe (Figs. 26 & 38), or in a plane at an angle with the plane of the coenobe (Figs. 18 & 37). Occasionally the cells of the coenobe have a regular concurrent noncoplanar arrangement (Fig. 36) so that the colony might easily be taken for one of *Sorastrum* rather than *Pediastrum,* did we not know the history of the particular colony under observation. Sometimes the cells form a linear series, with the cells all in one plane (Fig. 25), or in different planes (Fig. 22).

Harper (21) has given an explanation for this variation in

the cellular arrangement of *Pediastrum.* He believes that all swarm-spores are morphogenetically equivalent; and that the development of the horns is determined by cellular interaction. The arrangement of the cells in the form of a symmetrical coenobe results when the swarm-spores possess the normal motility; but when the vitality of the swarm-spores is diminished, as in old cultures in which the general vitality of the alga is lowered, or in cases where the motility of the swarm-spores is hindered by unfavorable conditions, such as the lack of water on an agar slant, the swarm-spores do not reach a regular symmetrical arrangement before they cease moving, the result being the formation of an irregular colony. Practically all deviations from the normal, in the arrangement of the cells, may be accounted for by the failure of the swarm-spores to assume the regular arrangement before the completion of the period of swarming.

Scenedesmus, A Parallel Nonconcurrent Colony

Scenedesmus acutus.

Several investigators have studied the effects of external conditions upon the shape of the colony and of the individual cells in this form. The species has been studied in pure culture by Beyerinck (5), Grintzesco (17), Chodat (9), Tischutkin (38), and Artari (3); and in unialgal culture by Chodat and Malinesco (13) (14), Artari (4), and Senn (34). Chodat and Malinesco describe a remarkable series of transformations. At one stage there are individual cells which resemble those of *Pleurococcus,* at other times of *Ankistrodesmus (Raphidium),* and at still other times branching systems of cells which resemble those of Naegeli's *Dactylococcus.* This statement has been somewhat modified by Chodat (9) in a more recent publication, but not wholly abandoned. Senn (35) stated, as a result of his observations, that *Scenedesmus* colonies could not be changed into other forms by varying the cultural conditions. When the alga was grown in water half saturated with carbon dioxid or oxygen the colonies separated into individual cells, but did not take on the chain-like arrangement of *Dactylococcus.* Nutritive solu-

tions of different concentration had no effect on the form of the colony, but they did affect the individual cell, since Senn found the stronger the solution the more nearly spherical were the cells. Artari (4) studied *Dactylococcus infusionum* Naeg. as a separate form and did not obtain *Secenedesmus*-like colonies, although he grew the alga under various conditions.

One of the forms Beyerinck worked with in his first pure cultures (5) was ***Scenedesmus acutus.*** Beyerinck found that an abundance of organic food material cause the cells of *S. acutus* to lose their acicular shape and become more nearly spherical. He makes no mention of the formation of chain-like colonies.

The cellular arrangement of *Scenedesmus acutus* underwent considerable modification in Grintzesco's pure cultures. He describes three different development phases. There may be the ordinary *Scenedesmus* coenobe of 2, 4, or 8 cells, all arranged in a single plane. At other times the cells exist singly, the individual cells resembling *Ankistrodesmus (Raphidium).* Again the cells are arranged end to end in the form of small branching chains of cells. An alga with acicular cells arranged end to end in a branching fiament has been given the name of *Dactylococcus infusionum* by Naegeli (32). Grintzesco believes that the branching colonies he obtained in his cultures are wholly identical with the *Dactylococcus infusionum* of Naegeli. He therefore concludes that *Dactylococcus infusionum* is not a specific form but merely a growth condition of *S. acutus.* He finds that solid media, as agar or gelatin combined with a nutrient mineral solution, hinders the formation of the plate-like coenobes of *Scenedesmus* but favors the formation of the *Dactylococcus* condition instead. When the alga is grown in a liquid medium the ordinary coenobes are formed in the first few days, but when the cultures are some weeks old they begin to have the cells arranged end to end in branching chains. If material forming chains of cells in an old liquid culture be put in a fresh liquid medium there is a return to the formation of the plate-like colonies for a while. He considers the *Dactylococcus* condition an adaptation for increasing the surface for respiration when the medium is poor in oxygen, or rich in mineral matter.

In my experiments I have grown *Scenedesmus acutus* under a variety of conditions and have been able to cause the dissociation of the cells of the coenobe, to some extent, but have never obtained a cellular arrangement resembling the *Dactylococcus* condition found by Grintzesco. Cultures have been kept under observation for nine months and at the end of that time many plate-like colonies were present, and although some isolated cells appeared there was not the slightest tendency toward the formation of chains of cells.

On the other hand, an alga was also isolated in the summer of 1911 that gave beautiful chains of cells with the regular *Dactylococcus infusionum* arrangement. Photomicrographs of this alga are shown on Plate XCI. Changes in the cultural conditions of this alga cause a cessation of the chain formation and a breaking down into isolated cells, recalling the "*Raphidium*" stage of Grintzesco (Figs. 133 and 134). There is never a formation of plate-like colonies. A slight approach to this may be found at times where two or three cells lie side by side but these cannot be regarded as regular *Scenedesmus acutus* coenobes (Figs. 130, 134-136). Under certain conditions the arrangement of the cells in a polygonal meshwork suggests *Hydrodictyon* (Figs. 138-141), but these polygons never form a closed net as do the cells of *Hydrodictyon*. As a result of the work of Grintzesco, West (41), Oltmanns (33), and Wille (43), abandon the *Dactylococcus infusionum* of Naegeli and treat it as merely a physiological stage of *Scenedesmus acutus*. My observations show that the two species are distinct, both of them having a constant form, and that one never gives rise to the other.

Comparing the coenobia of *Scenedesmus*, in a culture containing only the descendants of a single colony, more or less variation will be found. That the number of cells in a colony varies from 2 to 16 is well known. The earlier systematists, Kuetzing (23) for example, were inclined to consider the four and the eight-celled colonies as belonging to different species, but this view is no longer held. It is generally agreed that environmental conditions cause this variation in the number of

cells in the colony, the four-celled coenobes being much more common when the environment is less favorable.

In colonies that have come from a common ancestry, as those in a pure culture, and which have been kept under the same cultural conditions all the time, there is considerable variation. The most striking difference is that the cells may be arranged in a linear series (Text Figure 7 A) or in an alternate or zig-zag arrangement (Text Figure 7 B). Associated with this variation in cellular arrangement is an eccentric arrangement of the pyrenoid.

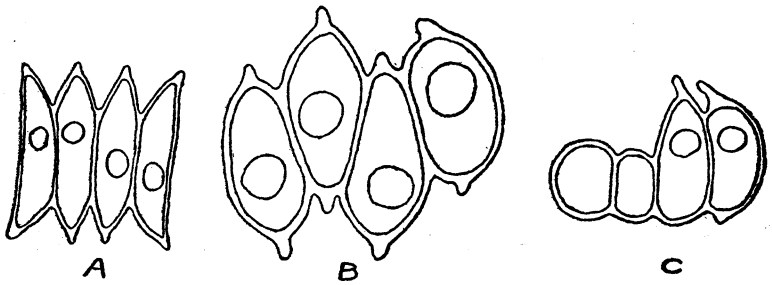


Figure 7. The three types of colony in *Scenedesmus acutus*. Fig. A from a culture in 0.1% Knop's solution, Figs. B & C from cultures in 1.0% Knop's solution.

When the cells have the alternate arrangement the pyrenoids are in an alternate eccentric position, while when the cells are in a linear series the pyrenoids are eccentrically placed two by two. Besides these two general types there is a third which does not agree with the distinguishing character of the genus as described by De Toni (39). *Scenedesmus* cells similar to those shown in Text Figure 7 C would not come under De Toni's description (p. 563); "....cellulae ... ..in seriam simplicem vel subduplicem lateraliter conjunctae." This type has the long axes of the cells in two planes, the long axes of two of the cells having revolved through an arc of 90 degrees. This type is quite rare and may sometimes consist of only three cells (Fig. 42 A & B, Plate LXXXVII) instead of the usual four. This arrangement may possibly be considered an extreme case of the deviating type shown in Figure 45.

Petri dish cultures were used to determine whether these different types of coenobe would give rise to the same type of coenobe. Here each colony in the agar medium is the descendant of a single coenobium and microscopical examination shows that the two common types of coenobium are always present. The alternate arrangement is most noticeable in *Scenedesmus acutus,* although found in *S. obtusus* Meyen and *S. quadricauda.* I have also obtained *S. obtusus* in pure culture and find that Collins (15) is perfectly justified when he says that the variety *alternans* (Reinsch) Hansg. of this species is "merely a form, hardly worthy of a name." In *S. quadricauda* the alternate arrangement of the cells is the least pronounced of the three species studied.

That a change in the composition of the nutrient medium does not affect the general arrangement of the cells in the coenobe, although it may affect the individual cells, has been shown by Beyerinck (5) and more fully discussed by Senn (35). Colonies grown in 0.1 per cent and 1.0 per cent Knop's solution show both the linear and the alternate arrangement of the cells but there is a marked difference in the shape of the individual cells. (Compare Text figures 7 A and 7 B). When certain organic compounds, as glycerine or glucose, are added to the nutrient solution there is a marked abnormal development of the individual cells, and a consequent abnormal appearance of the coenobe, but the fundamental axial relationships remain the same. Many of the abnormalities occurring under these conditions have been figured by Chodat (9). To explain them he says that (p. 92), "the greater part of the forms obtained are accidental, that is they are the result of an unequal growth produced by premature germination of the autospore within the interior of the mother cell." Livingston (25) (26) (27) (28) (29) studied the cause which produces a change from the filamentous condition of *Stigeoclonium* to the "Palmella" condition, where the cells are approximately spherical instead of being cylindrical. In his earlier studies he considered osmotic pressure to be the sole controlling factor, since when the osmotic pressure of the medium is above a certain point the cells change

from cylindrical to spherical. Later he found that culture media with low osmotic pressure but containing traces of toxic substances, as copper or silver salts (27), or certain bog extracts (28), produced a change from the filamentous to the "Palmella" condition.

By growing *Scenedesmus* in mineral solutions of different concentrations I have also found that with the increase in the concentration there is a tendency for the cells of the coenobe to become spherical, this tendency being much more marked in *Scenedesmus quadricauda* than in *S. acutus*. In *S. acutus* I do not have the cells approaching so closely to the spherical as Senn (35) finds them. I have also found that in the more concentrated solutions the cells are much more apt to be abnormally shaped. The different forms produced in the concentrated solutions by *S. acutus* are shown in Plates LXXXVII and LXXXVIII, the colonies of *S. quadricauda* grown under the same condition in Plate LXXXIX.

In both of these algae there are two classes of malformations. One class consists of irregularities in the individual cells, malformations of this type being given in Figures 47, 60, and 61. Advanced cases of this sort lead to greatly distorted coenobia. In the other class there is almost a complete loss of the coordinate axial arrangement, although the cells of the coenobe remain attached in an irregular mass. These abnormalities are especially abundant in colonies containng eight cells. It is almost impossible to classify these abnormalities, as an examination of Figures 48, 54, 55, and 41 shows. This general arrangement of the colony is comparable to the "Palmella" stage of *Stigeoclonium*, although the use of the term "Palmella" is perhaps hardly applicable to *Scenedesmus*. We have, however, the same sort of response to similar changes in extreme conditions that Livingston obtained with *Stigeoclonium*. The response is not so general, only occurring in isolated cases.

The experiments show that external conditions cannot cause a change from one type of coenobe to another. There may be changes in the individual cells of the coenobe, or an almost complete inhibition of the development of the colony in its ordinary

form, but the general axial relationships cannot be changed by external conditions.

In another connection I have described the manner of formation of the young colonies (37), suggesting that in the variation of the cleavage planes forming the daughter cells lies the chief cause for the variations in the cellular arrangement of the coenobe. The four daughter cells are formed by a primary transverse cleavage of the mother cell, this division being followed by simultaneous cleavage of the two daughter cells, at right angles to the primary cleavage plane. The four cells thus formed then elongate and become arranged in two tiers within the old mother cell wall. During the elongation of the daughter cells the planes separating them commonly become parallel to the long axis of the mother cell. In this way the linear type of colony is formed. At other times the planes of separation do not become parallel to the long axis of the mother cell but remain at an angle to it. Under these conditions the cells of the coenobe will not have the linear arrangement, when they unroll, but the alternate arrangement. It is difficult to say why these separation planes become parallel to the long axis of the mother cell in some cases and do not in others. These cleavage planes vary considerably in the angle they make with the long axis of the mother cell and so as a result there are certain colonies of the alternating type that are much more pronounced than others.

That the type of coenobe which will be formed can be predicted before the liberation of the daughter colony is seen in cells just ready to liberate young coenobia (Figs 73–75, Plate LXXXVIII). Figure 74 shows a cell the contents of which will unroll into a coenobe whose cells are arranged alternately, while the cells of one of the young colonies in Figure 79 will form a linear series. All of the cells in a single colony do no produce the same type of coenobe but one cell may produce a coenobe in which the cells are arranged alternately, while the one next to it may produce the linear type of colony (Figs. 73 & 79).

The colonies whose cells will be arranged in an irregular mass can also be determined at the time of the liberation of the young coenobe. Thus the young coenobe shown in Figure 69 will form a colony of the irregular type shown in Figure 59.

In connection with the normal cleavage of the cytoplasm certain abnormalities in the manner of the formation of the second cleavage planes were described (37). In these abnormal cases the second cleavage planes are not formed at right angles to the primary cleavage plane, as is usually the case, but more or less parallel to the primary cleavage plane. When the daughter cells thus formed elongate and are liberated the colonies formed are similar to those shown in Figures 50 and 53. The extreme variation in cellular arrangement resulting from this abnormal cleavage is the rotation of one or two of the cells through an arc of 90 degrees so that the cells are in two different planes (Figs. 42 & 43).

Figure 60 is due to another type of abnormality in cleavage. Here there has been the usual first cleavage into two daughter cells, but in the second clevage of these cells there has been the failure to complete the cleavage in one of them. The beginning of this cleavage is shown in the notch at the top of the central cell. In the maturation of the cell, the elongation, and the formation of two pyrenoids has taken place in the usual manner. The nuclei of this cell were not seen but it seems likely that such a cell would possess two nuclei. Figures 61 and 62 show three-celled coenobes in which one cell is much larger than the other two. Such abnormalities are probably due to the complete inhibition of the second cleavage in one of the daughter cells.

The liberation of the young colony from the mother cell wall is accomplished by the longitudinal splitting of the wall and the unrolling of the young colony. When the colony is first liberated the cells are not in one plane, as in normal mature coenobia, but in the form of a curved plate (Figs. 69, 73, 79, and 81). Usually after the liberation there is a growth of the coenobe so that the cells form a flat plate. Some colonies do not become flattened but remain curved during their entire existance. All gradations may be found in mature colonies between a flattened plate and one that is markedly curved (Figs. 86, 93-95). The cells of the colony are held together by a gelatinous material that forms the outer layer of the cell wall.

Either on account of the lack of this material, or on account of a rupture of it during the liberation of the young coenobe, in certain colonies the cells are not completely united but there may be two halves of the coenobe that are only partly joined (Fig. 45). At other times the two halves of the coenobe may be completely united but these halves are at an angle with each other (Fig. 97).

Briefly summarizing the causes for the variations occurring in the cellular arrangement of the four cells of *Scenedesmus acutus* we may catalogue them in the following manner:

I. Normal Variations.
   Variation in the elongation of the daughter cells causing either the linear or alternate type of coenobe.
II. Abnormal Variations.
   1. Cellular monstrosities.
   2. Irregularities in the formation of the second clevage planes.
      A. Formation of cleavage planes in unusual directions.
      B. Incomplete formation of cleavage planes.
      C. Failure to form second cleavage planes.
   3. Irregularities occurring in liberation of young colonies.
      A. Failure of colony to unroll completely and a resultant curved colony.
      B. Partial fragmentation of colony during liberation.

Scenedesmus quadricauda.

There is the same normal variation in the arrangement of the cells of the coenobe of *Scenedesmus quadricauda* that there is in the coenobe of S. *acutus,* although in the former the linear type of colony is much more abundant that the alternate type. The alternating character of the cellular arrangement is not so sharply marked as is the case in *S. acutus.* In another connection I have pointed out that there is a difference between

the manner of cleavage of *S. acutus* and *S. quadricauda* (37). In the former there is a change in the position of the primary cleavage plane so that the second cleavage planes, which are formed at right angles to it, are laid down at varying angles to the long axis of the mother cell; in *S. quadricauda* the primary cleavage plane remains at right angles to the long axis of the mother cell. This causes the second planes, which are likewise formed at right angles to the primary cleavage plane, to be formed parallel to the long axis of the mother cell. The elongation of the daughter cells is not always equal and when this does occur the alternating type of colony is formed.

The number of horns in a four-celled colony varies. Normally there are four, one at each end of the terminal cells, but sometimes horns appear on the central cells. On account of this variability in the position of the horns Kirchner (22) has described certain forms which De Toni (39) calls varieties, but which Collins (15) and Migula (31) consider forms unworthy of varietal rank. Besides the form *typicus* Kirchner recognizes *setosus*, in which there are projections on some of the median cells; *horridus*, with projections on all cells, and *abundans*, with projections on the middle as well as the ends of the terminal cells. Migula (31) also includes with these forms *Naegeli* (Breb.) Rabenh., which is characterized by pear-shaped cells that are irregularly arranged. I have found all of these variations in pure cultures from a single strain. The occurrence of one or more horns on the middle cells of the coenobe *(setosus)* is much more common that horns on all of the cells *(horridus)*, or more than two horns on the terminal cells *(abundans)*. I was unable to isolate any of these forms in pure or unialgal culture, a fact which suggests that the presence of more than four horns in the coenobe is a variation that persists for a single generation only and is unworthy of being named.

The presence of horns on the median cells of the coenobe is of interest from the morphogenetic standpoint. At one stage in the reproduction of the alga there are four daughter cells arranged lengthwise within the mother cell wall. This group

of cells then unrolls so that they all lie in one plane. There are different combinations possible in the unrolling of these cells, so that a particular cell may be either terminal or median in the mature coenobe. I was unable to distinguish any horns on the cells of the young coenobe before the rupture of the mother cell wall, but have found stages similar to that which Senn (35) has figured, where he shows that the two cells lying next to the split in the mother cell wall form horns while the other cells do not. If the splitting should occur on the other side of the mother cell wall, the two cells that are the inner pair in the first case would be the outer cells and consequently develope horns while the other cells did not. Thus we have a totipotence of every cell similar to that which Harper (21) has described for *Pediastrum,* where he finds every cell of the coenobe capable of forming spines and that only the marginal cells are able to do so easily, but that the inner cells of the coenobic plate form them when they can. The formation of horns in *Scenedesmus quadricauda* may well result from some interaction between the cells which is of the nature of a contact stimulus and response. As a result of the totipotence of the cells we have the stimulus causing horns to be formed on the median cells of the coenobe as well as the terminal cells.

A much greater response to changes in external environment is shown by *Scenedesmus quadricauda* than *S. acutus.* This is especially the case where cultures are made in a nutrient solution of comparatively high osmotic pressure. All of the drawings in Plate LXXXIX, were made from colonies of *S. quadricauda* grown in 1.0 per cent. Knop's solution to which 1.0 per cent. sodium chlorid had been added. The nutrient medium affects both the shape of the individual cell and the cells of the colony. In the individual cells monstrosities appear more frequently than they do in *S. acutus.* These monstrosities are not so much in the form of abnormally shaped cells as in the form of giant cells. Normally these cells are from 3–8 by 4–12 microns but in cells that have been grown in solutions of high osmotic pressure the cellular measurements

may reach 15 by 20 microns. The shape of the cell varies from nearly spherical (Fig. 104) to ovoid (Fig. 103). The majority of the cells are ovoid.

Chodat (9) has figured a large number of aberrant forms of *Scenedesmus quadricauda* that were obtained chiefly on solid media, agar and gelatin, containing glucose, cane sugar, glycerine or some other organic compound. Some of his drawings show cells that are quite similar to what I have described above for *S. acutus,* in that there has been the same sort of failure to complete the normal cleavage. He also finds that in some cells horns do not develope in the usual manner, but thick buttons are formed instead. The cells bearing these buttons are irregular in shape. Chodat finds that the outer gelatinous covering of the cell wall may also be thickened, the covering showing a lamellated appearance in extreme cases.

I have found that there is sometimes an inhibition of the formation of the characteristic horns. Some coenobia composed of giant cells have horns that appear quite normal (Fig. 114), while others have no horns, or merely a small nodule at the ends of the terminal cells (Fig. 99).

There is considerable fragmentation of the coenobia in cultures in solutions of high osmotic pressure and isolated cells are quite frequent. These single cells are usually giant cells rather than those of normal size. The formation of the free cells is due to the failure of the coenobe to form the gelatinous material that binds the cells together. Senn (35) has already shown that in *Scenedesmus* there is an inhibition of cell division in the more concentrated culture media. These large cells in my cultures are filled with oil and an immense number of starch grains. Apparently the concentrated medium does not hinder the process of photosynthesis, but does hinder the assimilation of starch after it is formed. This increase in size may be due, to a certain extent, to the formation of large amounts of starch. Unfortunately material from cultures containing these large cells was not fixed and stained, so that I am unable to state the exact nature of the cell contents; but from the appearance of occasional giant cells in normal cul-

tures, which have been fixed and stained and found to be bi- or tetranucleate, I am inclined to the view that the giant cells in question have more than one nucleus. If this be true then the more concentrated culture media do not inhibit the division of the nucleus but do inhibit the cytoplasmic cleavage that normally follows nuclear division. The excessive growth may then be a result of the maintainance of the nucleocytoplasmic relationship. In colonies composed of giant cells a cleavage to form young colonies was not observed.

Besides causing a formation of giant cells, that apparently do not divide, the concentrated culture media also influence the shape of the colonies in cells that do divide. Some of the colonies, usually those composed of smaller cells, have the normal cell arrangement (Fig. 114), although irregularities in this arrangement may occur (Figs. 99 & 113). In these cases the cleavage of the cytoplasm takes place in the normal manner and then there is the elongation of the daughter cells to form the characteristic ovoid cells. After the maturation of these cells, liberation of the young colony and its unrolling is wholly normal. In other cases the cleavage and maturation of the cells takes place as usual, up to the time of the liberation of the young colony from the mother cell wall, but then there is no unrolling of the young colony but the four cells remain within the mother cell wall (Figs. 101, 102, 108, 110). Again, the whole mass of cells is liberated from the mother cell wall, but there is no unrolling of the colony but the four cells have the parallel nonconcurrent noncoplanar arrangement that is characteristic of *Tetradesmus* (Figs. 101, 112, 115). Some colonies are surrounded by the old mother cell wall (Fig. 106) but usually the wall is lacking (Figs. 112 & 115). These colonies are not necessarily all in the same plane but one or more colonies may be at an angle to the others (Figs. 101 & 115).

Many colonies remain attached to the mother cell wall after liberation. This may persist for two or three generations so that masses of cells are formed (Figs, 101 & 108). This formation of irregular cell masses, which is accompanied by a change in the shape of the cells from the ovoid to the more

nearly spherical, is the nearest approach to a true "Palmella" condition that has been found in any of the forms studied. It is noteworthy that such a parenchymatous mass of cells is formed in response to exactly the same stimuli that Livingston used in his earlier work on *Stigeoclonium* (25) (26).

Noncoplanar Forms.

Tetradesmus, A Parallel Nonconcurrent Colony.

Although when viewed from the standpoint of the classification of the relationships of the long axes of the cells, *Tetradesmus* is not very closely related to *Scenedesmus,* yet from the phylogenetic standpoint these two forms are very closely related. This is especially true when *Tetradesmus wisconsinensis* and *Scenedesmus acutus* are compared. I have shown (36) (37) that the manner of formation of the daughter colonies in these two forms is very similar, up to the point of the liberation of the young colony from the mother cell wall. At this point the young colony of *Scenedesmus* unrolls and the cells become arranged in a plate, while the colony of *Tetradesmus* does not unroll but the cells retain the same relationship that they had within the mother cell wall.

We should therefore naturally expect much the same variations to occur in *Tetradesmus* as in *Scenedesmus* and this expectation is realized. There is again the variation in both the individual cells and the arrangement of the cells in the coenobe. There is the same rounding up of the cells in concentrated culture media that there is in *Scenedesmus acutus.* As in *S. acutus* the cells do not become completely spherical but retain their acute apices. The *Tetradesmus* cells are much more pointed at the apex than are cells of *S. acutus* when this rounding occurs (Fig. 118, Plate XC).

Cells of coenobia grown in nutrient solutions of comparatively low osmotic pressure also show variations from the normal. These irregularities may be either in the size or the shape of the cell (Figs. 116 & 117). The walls of the cell also show variations in that the end may form short blunt horns in some instances (Fig. 116).

The variations occurring in the position of the cells in the coenobe correspond to the linear and alternate arrangement in the *Scenedesmus* colony. A plane passed through the ends of all of the cells is at right angles, (Fig. 125), or at an angle (Fig. 118), to the long axis of the coenobe. This variation in the arrangement of the cells is due to the same sort of variation in cleavage that occurrs in *Scenedesmus acutus.*

In connection with the description of *Tetradesmus* (36) the statement was made that there was always four cells present. A very few cases have since been found of two- and three-celled colonies. The formation of the two-celled colony is due to the elimination of one series of cleavages. Figure 122 shows that there may also be a rotation of one of the daughter cells through an arc of 90 degrees. To explain such a change we must assume a change in the polarity of the daughter cell before the elongation takes place.

Certain other abnormalities are connected with the liberation of the young colony from the old mother cell wall. One might expect that some of the colonies would unroll and take the form characteristic of *Scenedesmus* but this has never been found. The cells are ordinarily attached along the middle third of their length (Fig. 119) but sometimes the attachment is in the terminal third and the rest of the cell lie free (Fig. 124). Such an arrangement may be due to an arresting of the liberation of the young coenobe and a pressing together of the portion of the colony that has not been liberated. Eventually the colony becomes free but the unusual cellular arrangement persists.

Discussion.

The study of the variations occurring within the limits of any particular species naturally leads to a discussion of the doctrine of polymorphism. The historical side of the question has been thoroughly reviewed by both Grintzesco (17) and Chodat (9) and reference may be made to the work of these authors. The earlier view, expressed by Kützing (24), that there could be a change in algae as great as a passage from one

genus to another, has been more and more restricted until the recent polymorphists believe that this variation is confined to a few species. The change in the concept of polymorphism has been due to more accurate methods of study, notable the application of the pure culture methods first used by Beyerinck (5). It is noteworthy that the most aggressive of the modern polymorphists, Hansgirg (19) and Borzi (6), did not use the method of pure cultures, and that Chodat, who began his work with cultures that were not pure (10) (13) (14), modified his views considerably (9) when he did apply this method. His latest extensive monograph deals largely with the variations in the cell that can be caused by changes in the culture medium. He concludes (p. 165) that there are certain algae which by their extreme variability merit the name polymorphs, if by this term one wishes to imply that a plant can present several different phases without changing its nature. Consequently one is able to some extent to defend the thesis that algae are polymorphic. But their polymorphism is the same order as that shown by many of the higher plants. As in the higher plants there are some that are quite plastic and others less so.

Lotsy (30) has proposed (p. 177) the term *Biaiometamorphosis* to cover those cases in which the form changes as a result of changes in external conditions; the variations in *Scenedesmus acutus* described by Grintzesco (17) being a case of this type. To my mind the term, although cumbersome, is better than polymorphism, since the term has been used by many authors in many different senses. The latest view of Chodat (9) is more a concept of Biaiometamorphism than polymorphism.

In the biaiometamorphic results observed in my unialgal cultures, there has been little change in the cellular relationships but a considerable change in the structure of the individual cells. The variations occurring in the arrangement of the cells are chiefly dependant on the variations in the manner of cleavage of the mother cells. In the cells in which the autospores are not motile, or only slightly so. *(Tetracoccus, Coelastrum, Scenedesmus* and *Tetradesmus)* there is a marked influ-

ence in the variation of the cleavage of the mother cell on the position of the cells in the coenobe. When the autospores are motile (*Pediastrum*) there is little influence in the manner of cleavage of the mother cell on the arrangement of the cells in the colony, but the variations in the cellular arrangement are largely biaiometamorphic.

The fact that these variations are not uniformly present in all of the colonies of a culture shows that a distinction should be made between variations in the external environment and changes in internal conditions of the cell. Possibly it would be better to distinguish between internal and external biaiometamorphosis. External conditions can be varied but the internal conditions cannot be controlled and when variations are laid to changes in internal conditions we are using a phrase which gives us absolutely no concept of the actual processes involved.

Since we have this great divergence in different coenobia that are all descendants of a single cell and which, at least in a liquid medium, have been kept under the same conditions of temperature, light, and chemical environment we must say that a greater importance must be attached to internal that external conditions. The internal conditions in the cell are constantly changing and as a result the four cells formed from a single mother cell are not alike in internal condition and the colonies formed are not wholly alike. It is this constant change in the cell that is the main cause for whatever variation occurs in the process of reproduction.

Summary.

The arrangement of the cells in coenobic algae may be classified conveniently according to the relationships of the cell axes.

Pure cultures or unialgal cultures should be used for studying the variations occurring in any given species.

The marked variation described by Grintzesco for *Scenedesmus acutus* was not found in my pure cultures.

Changes in the environment produce changes in the individual cells of the coenobe (Biaiometamorphosis), but have small effect upon the special interrelationships of the cells.

The variations in cleavage of the mother cell are little affected by external conditions.

When the autospores are motile they are influenced by external conditions through the influence on the motility of the zoospores.

The variations occurring in the cultures of the algae studied are not sufficient to warrant any assumption of widespread polymorphism among the algae.

I wish to express my thanks here to Professor Charles E. Allen for his kind criticism during the progress of the investigation and in the preparation of the manuscript.

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PLATE LXXXV.

EXPLANATION OF PLATE LXXXV.

All figures in Plates LXXXV to XCI were drawn with the aid of the Abbe camera lucida, the drawing being at the level of the base of the microscope, and with the Leitz objectives 1/16 and 6 in combination with oculars 4 and 3; the magnifications being about 2000x and 750 X with the ocular 4, and 1650 with the objective 1/16 and ocular 3.

Tetracoccus botryoides

Fig. 1. Group of colonies as occurring in nature. (2000 X)

Coelastrum microporum

Figs. 2–17. Colonies one month old. From cultures grown in 0.1% Knop's solution. Fig. 12, 750 X, all others 2000 X.

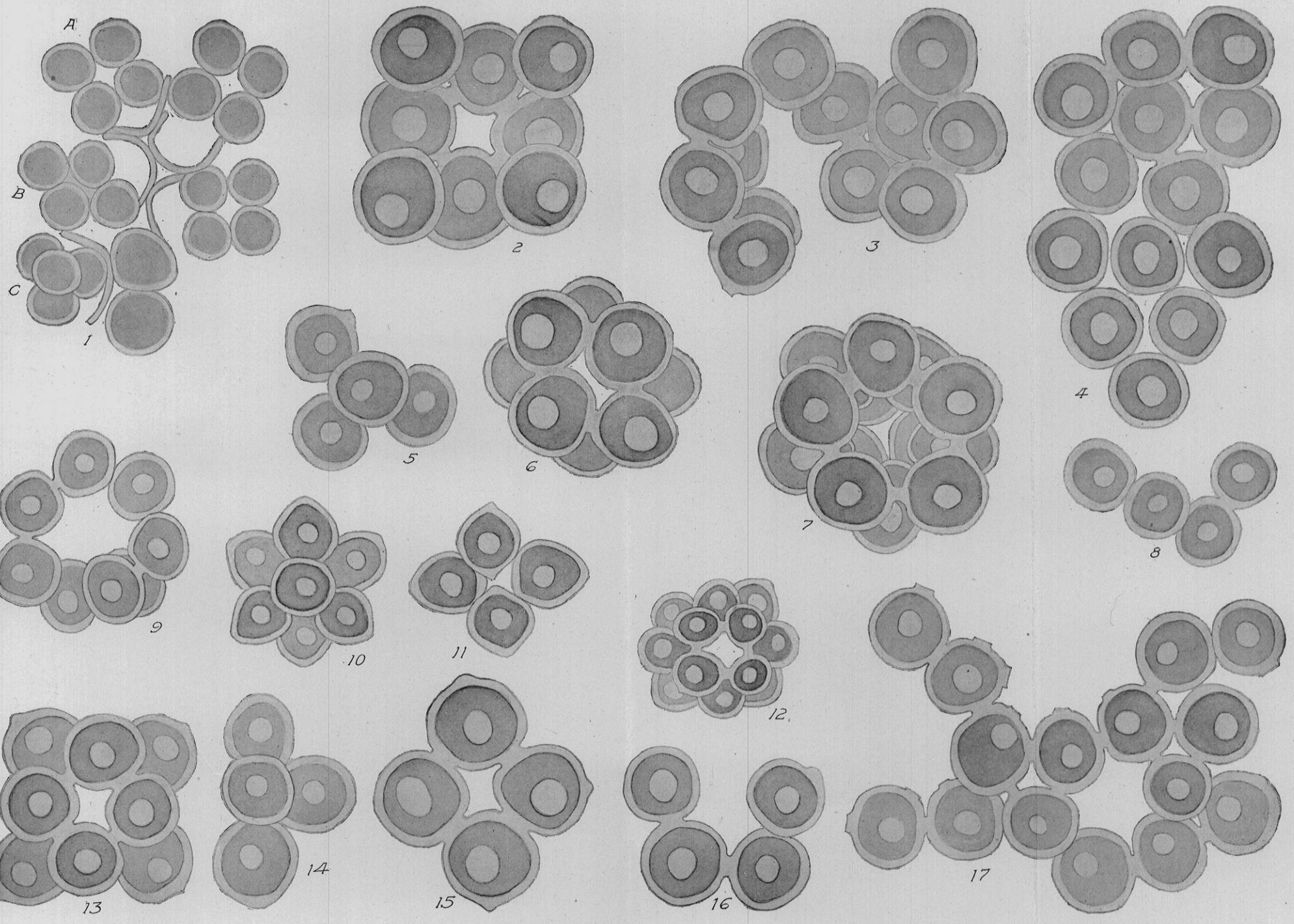
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PLATE LXXXVI.

EXPLANATION OF PLATE LXXXVI.

Pediastrum Boryanum

Figs. 20, 23–26, 31–35, are magnified 750 X; Figs. 21, 37 and 38, 1650 X; Figs. 18, 19, and 22, 2000 X.

Figs. 18, 19, 21, 22, 31–38. Colonies one month old, from cultures grown in 0.1% Knop's solution.

Figs. 20, 23–26. Colonies two months old, from cultures grown on agar slants containing 0.1% Knop's solution.

Pediastrum tetras

Figs. 27–30. Colonies as occurring in nature. The magnification in Fig. 27 is 750 X, the rest 2000 X.

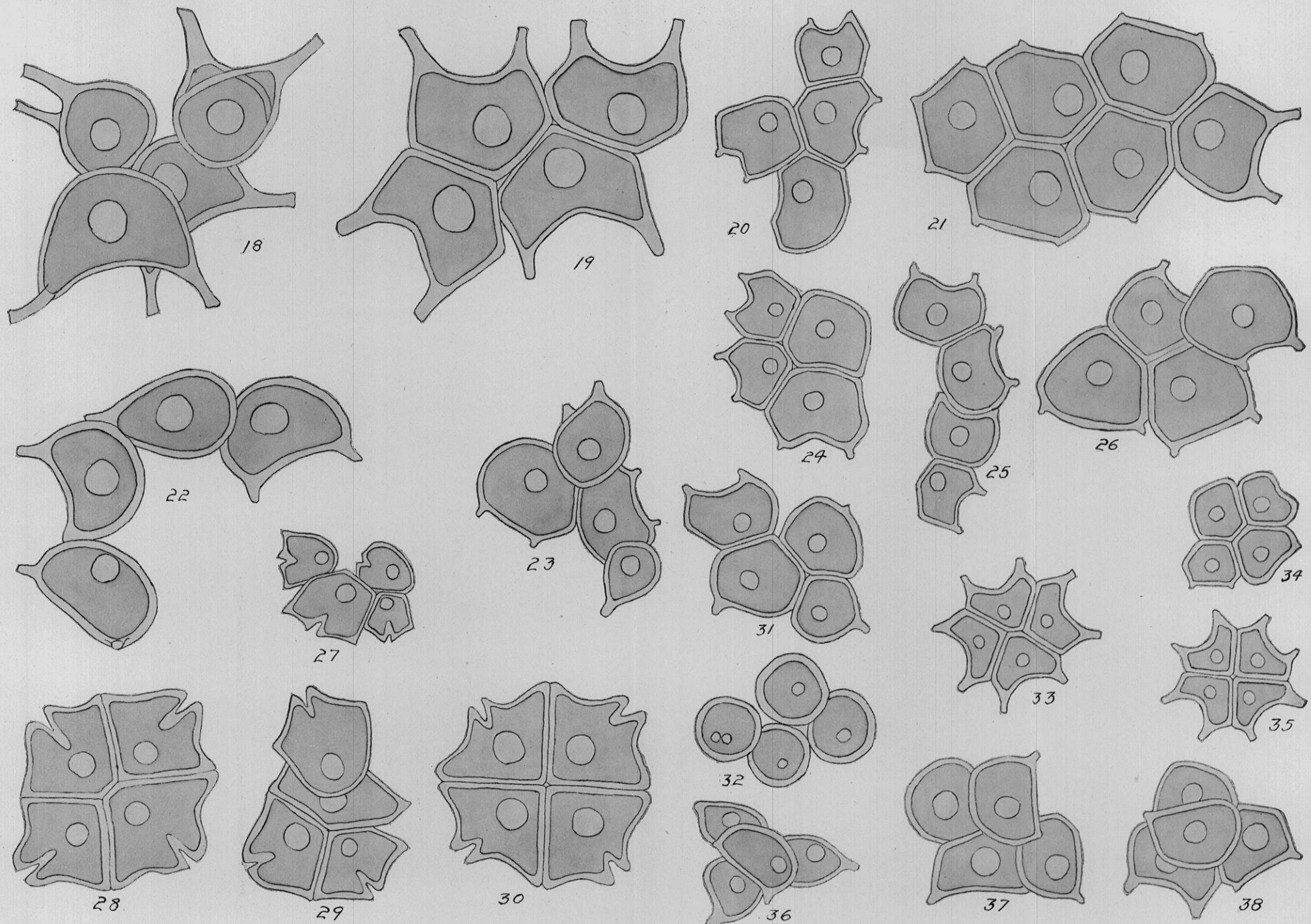
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PLATE LXXXVII.

EXPLANATION OF PLATE LXXXVII.

Scenedesmus acutus

Figs. 39–67. Colonies one month old, from cultures grown in 1.0% Knop's solution with the addition of 1.0% glucose.

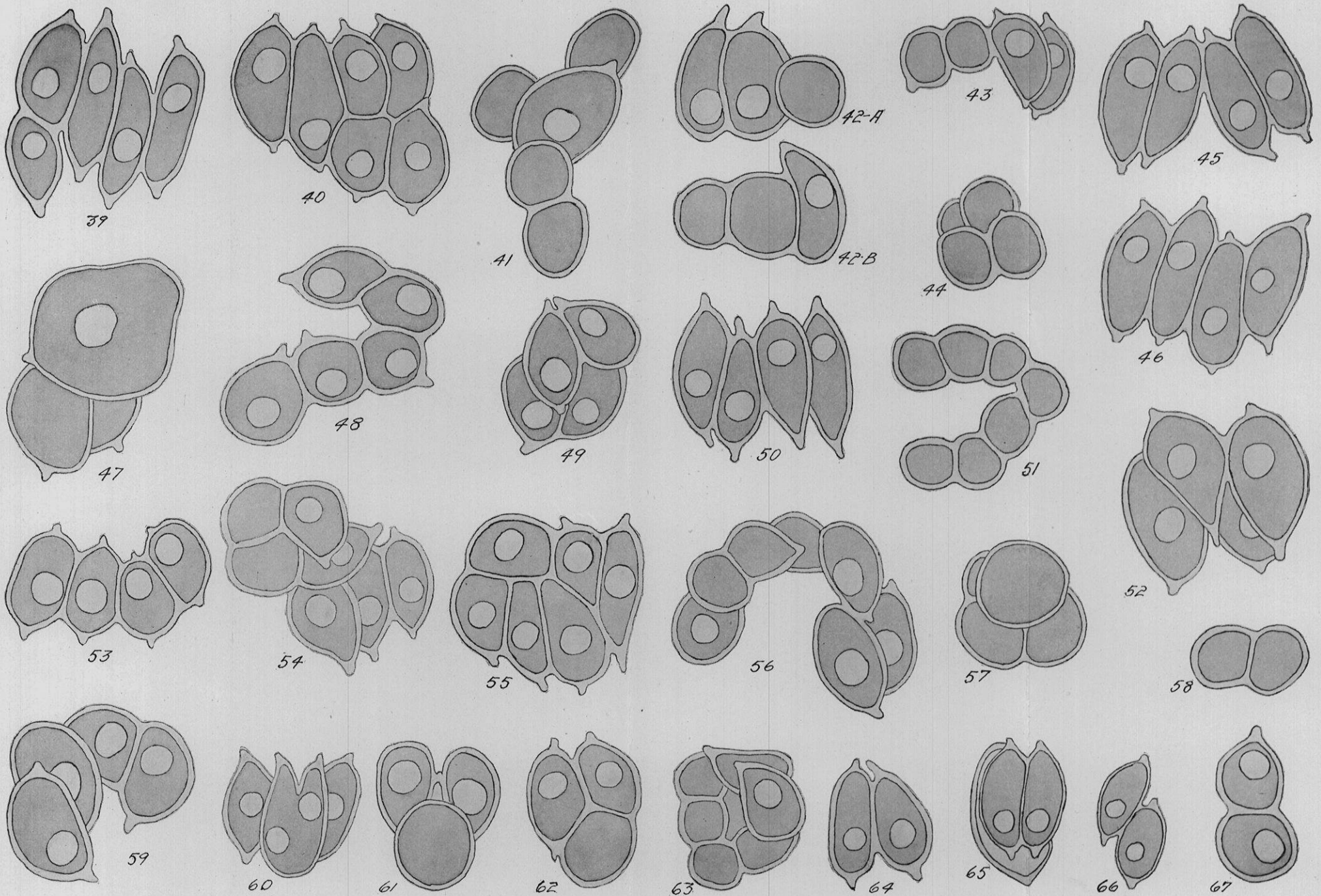
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PLATE LXXXVIII.

EXPLANATION OF PLATE LXXXVIII.

Scenedesmus acutus

Figs. 68–98. Colonies one month old, from cultures grown in 1.0% Knop's solution with the addition of 1.0% glucose.

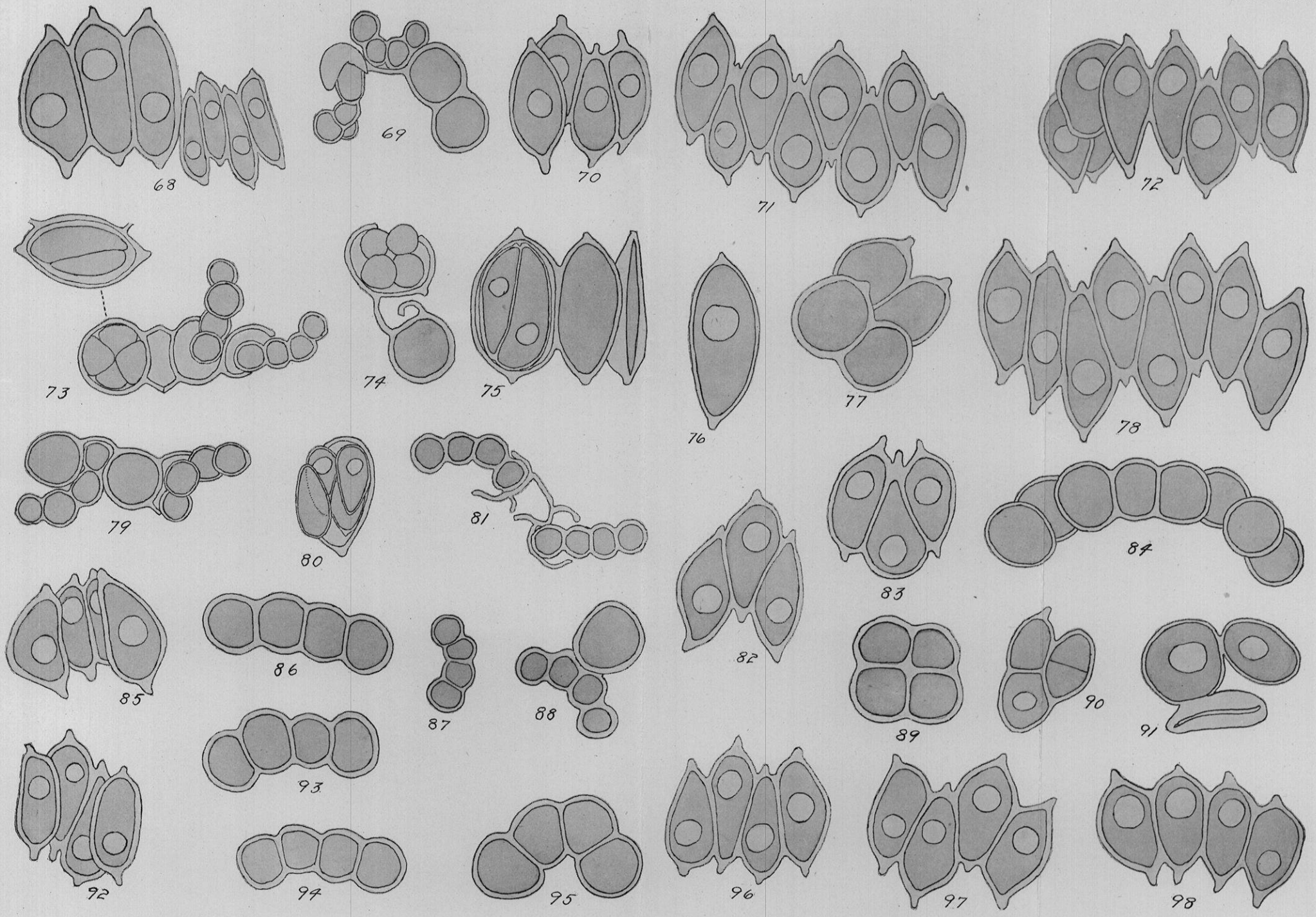
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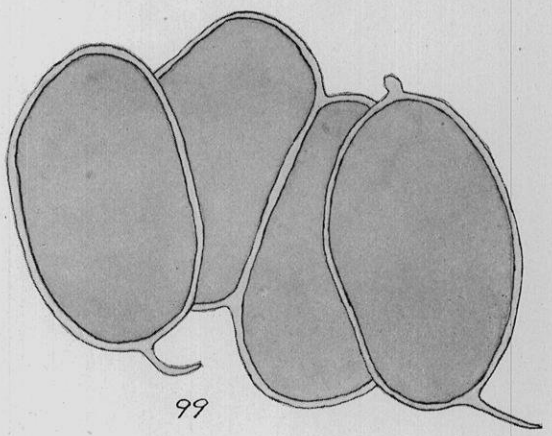
PLATE LXXXIX.

EXPLANATION OF PLATE LXXXIX.

Scenedesmus quadricauda

Figs. 99–115. Colonies four months old, from cultures grown in 1.0% Knop's solution with the addition of 1.0% glucose and 1.0% sodium chlorid.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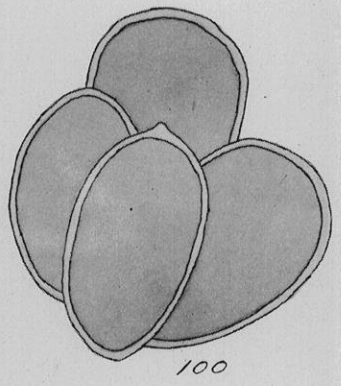
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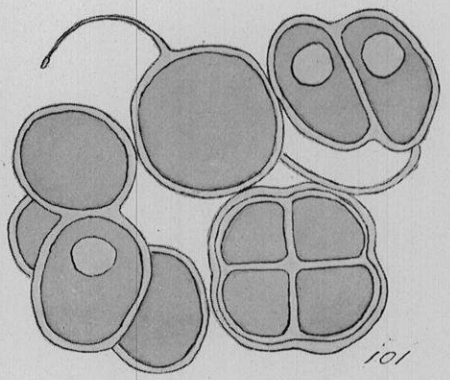
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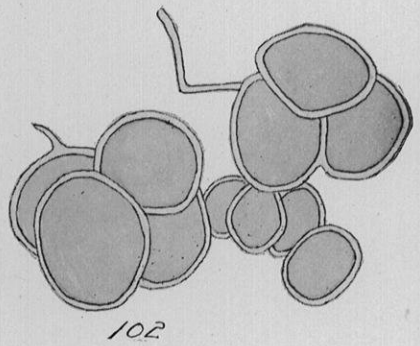
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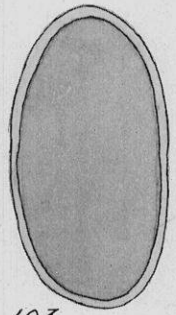
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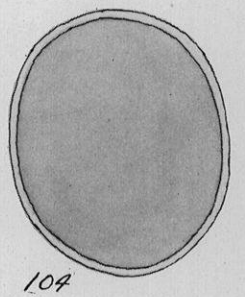
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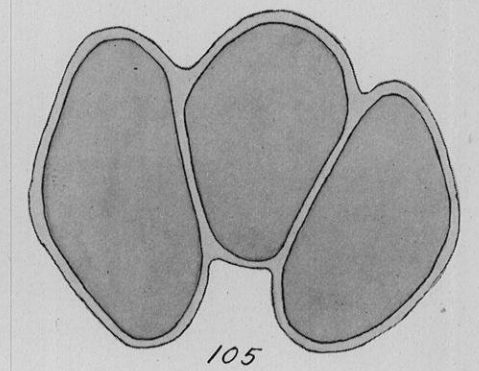
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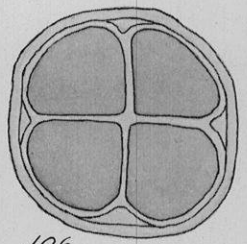
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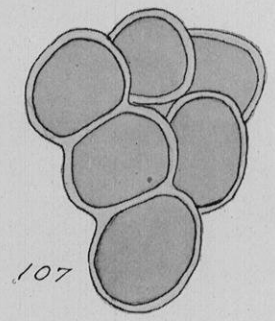
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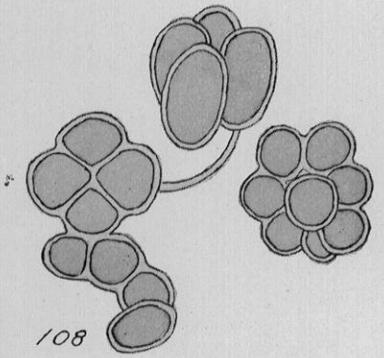
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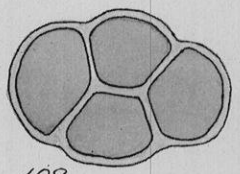
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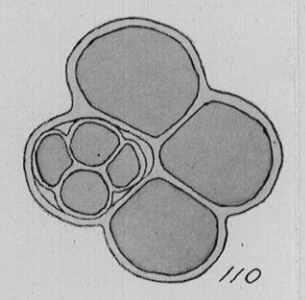
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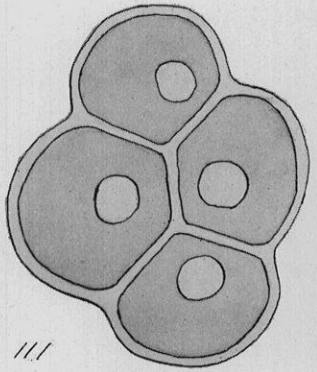
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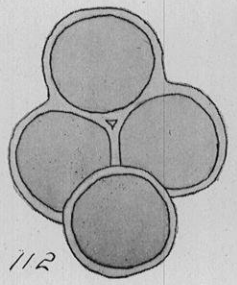
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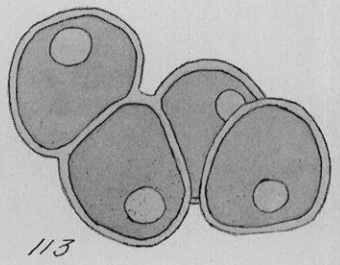
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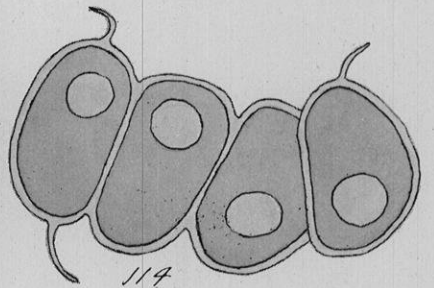
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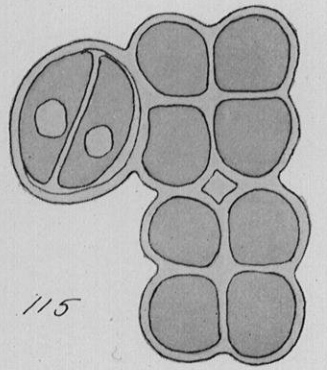
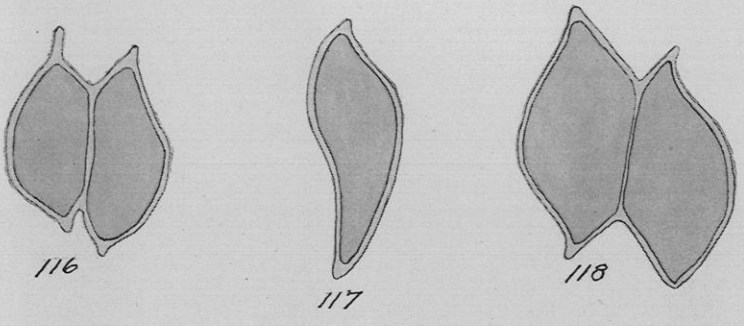

115

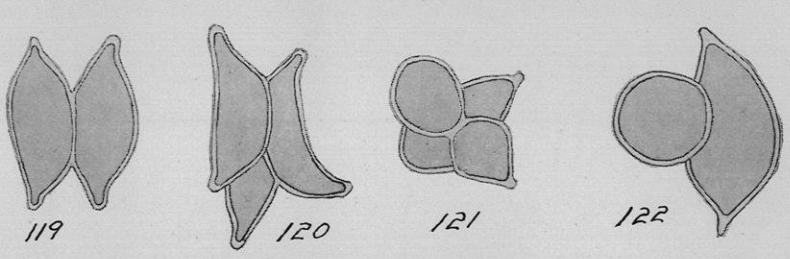
PLATE XC.

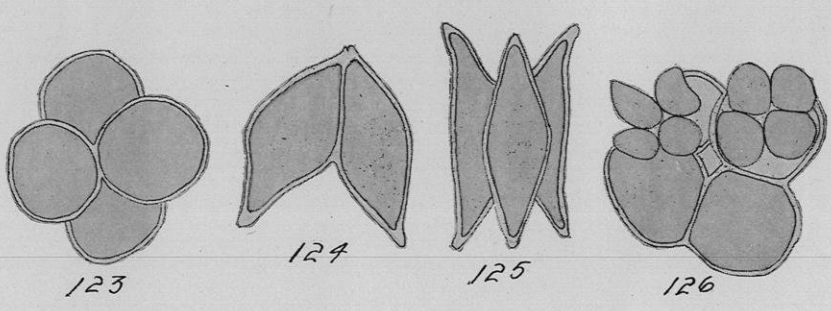
EXPLANATION OF PLATE XC.

Tetradesmus wisconsinensis

Figs. 116–126. Colonies two months old, from cultures grown in 1.0% Knop's solution with the addition of 1.0% glucose.







SMITH:—COENOBIC ALGAE

COCKAYNE—BOSTON

PLATE XCI.

EXPLANATION OF PLATE XCI.

The photomicrographs in this plate were made with the Zeiss camera in combination with the Zeiss apochromatic objective 8, and compensating ocular 12. The magnification is about 210 X.

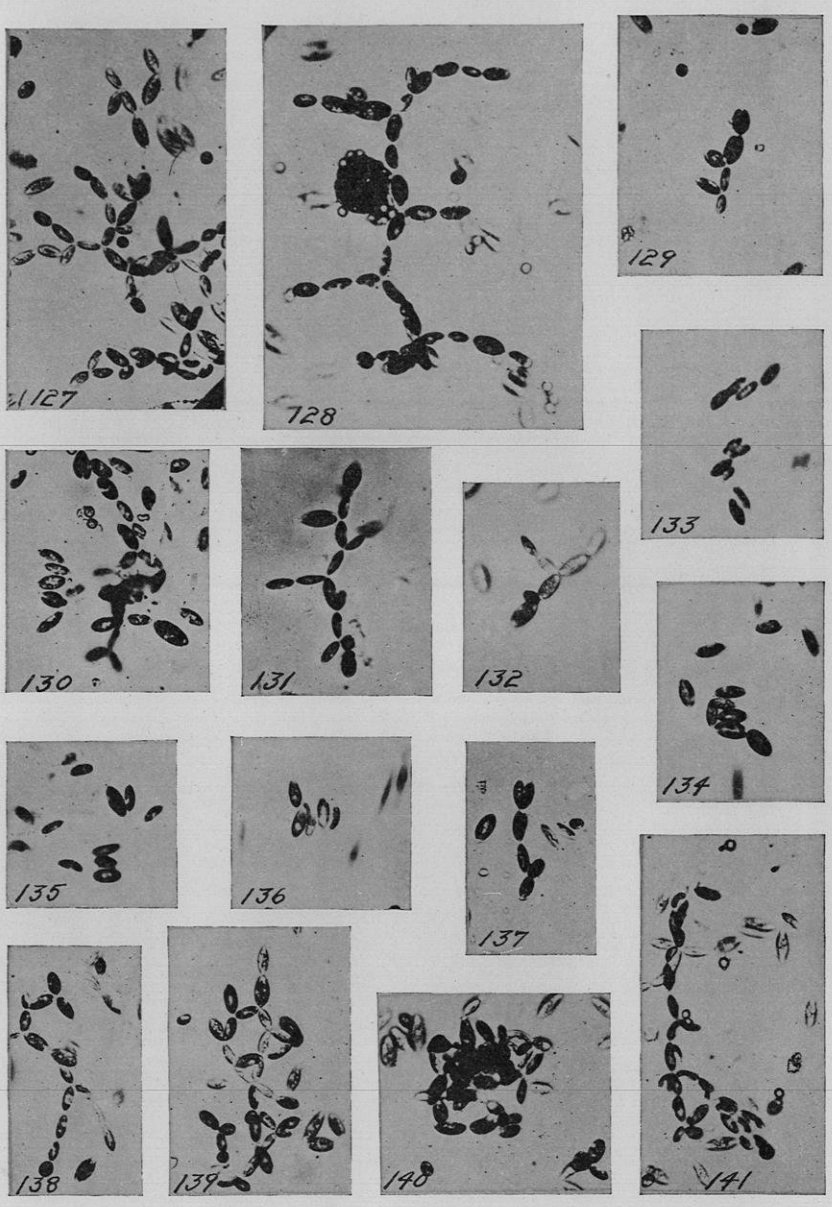
Dactylococcus infusionum

All of the illustrations in this plate were made from cultures one month old. The alga was grown in 1.0% Knop's solution with the addition of 1.0% glucose.

Figs. 127–132, 137. Colonies showing characteristic manner of branching.

Figs. 130, 133–135. Cultures showing isolated cells with some joined laterally.

Figs. 138–141. Colonies with reticulate arrangement of the cells.



SMITH :—COENOBIC ALGAE

COCKAYNE—BOSTON

THE MYXOMYCETES OF WISCONSIN

ALLETTA F. DEAN.

INTRODUCTION

The Mycetozoa include about 400 known species, the greater part of which are contained in the group of the Myxomycetes, or Slime-Moulds (the Myxogasteres of Fries,) and the smaller part in the group of the Acrasieae.

The nearly 400 species are distributed among 50 genera. In the United States 200 or more species have been recognized. McBride, in 1894, reported 75 species from eastern Iowa.

The present paper embodies the results of collections and studies begun in 1903. Down to the present year I have identified seventy-four species of Myxomycetes collected in the state of Wisconsin. The specimens upon which this list is based are in the herbarium of the University of Wisconsin. Collections have been made in relatively few localities within the state. A more extended search would doubtless considerably increase the number of species.

In the determination of species I have consulted mostly Saccardo's *Sylloge Fungorum,* Lister's *Mycetozoa,* Massee's *Myxogasteres,* and Macbride's *North American Slime-Moulds.* In the descriptions which follow I shall refer to these works simply by the names of their authors.

When in doubt in naming a specimen I have followed Macbride, except that in the cases of *Fuligo septica* Gmelin, and *Enteridium Rozeanum* Wing, I have followed the usage of Lister which seems to me to be more nearly in accordance with the rules laid down by the International Botanical Congress of

1905 and 1910. In the arrangement of genera and species, again I have followed Macbride.

I desire to make grateful acknowledgment to Dr. Robert A. Harper, first for suggesting to me this most enjoyable subject for study, and second for his invaluable advice and assistance in the work during the first three years; to Dr. Charles E. Allen for help during the past year; to Dr. Thomas H. Macbride for assistance in determining several difficult specimens; and to various members of the Department of Botany of the University of Wisconsin for assistance in collecting material.

Ceratiomyxa fruticulosa (Muell.) Macbr.

1775. *Byssus fruticulosa* Mueller, *Fl. Dan.*, t. 718, fig. 2.
1889. *Ceratiomyxa mucida* Schroeter, *Eng. u. Prantl Nat. Pflanz.*, I, i. p. 16.

Macbride: "Plasmodium in rotten wood, white or nearly transparent; when fruiting, forming on the substratum mold-like patches composed of the minute sporiferous pillars, generally in clusters of three or more together; spores white, ovoid or ellipsodial, smooth, 10–12 x 6μ."

Saccardo adopts the name *Ceratium hydnoides* (Jacq.) Alb. and Schw. He gives the color as white or yellow, and the spores as ovoid, 10–12μ by 8μ, or globose, 10μ in diameter. He finds the spores to be minutely guttulate and hyaline.

Lister: "Sporophores white or pinkish yellow, membranous, either rising from a common hypothallus in a tuft of simple or forked, fasciculate obtuse branches, 1 mm. or more high, .07 mm. thick, or more or less interwoven in broad perforated bands, from which arise irregular and anastomosing lobes; the membranous wall is divided, chiefly on the upper part of the sporophore, into somewhat hexagonal areolae about 10μ broad; a membranous stalk bearing the spore arises from the center of each areola. Spores 10x6 to 13x7μ."

The above descriptions are excellent for this species. I find spores that are ovoid or ellipsoid, 8-11 by 6-8μ, and globose ones 10-11μ in diameter.

I found a small specimen of this species in Cemetery woods October 14, 1903. In February, 1904, some chips under a bell-jar in the herbarium room produced some of this species, giving me good material for microscopic preparations. April 25, 1904, in the greenhouse, a piece of decayed poplar 3 ft. by 6 in. suddenly became nearly covered with the fruiting bodies. It looked like a small snow-drift and was a beautiful sight. Since then this species has frequently appeared in the greenhouse. On May 27, 1904, a quite large log of decayed poplar became nearly covered with specimens of this species of a clear sulphur yellow, excepting at one end of the log, where they were white. The yellow did not gradually fade out to white, but the colors were

mixed together in spots for a short distance. Under the microscope the two kinds showed no differences. As the yellow kind dried or grew old it became white, and no difference is now noticeable between the dried specimens.

Fuligo septica (Linn.) Gmelin.

1753. *Mucor septicus* Linn., *Sp. Pl.*, II,. no. 1656 (?).
1791. *Fuligo septica* (Linn) Gmel., *Syst. Nat.*, p. 1466.

Macbride adopts Schaeffer's name, *F. ovata*. "Plasmodium bright yellow; æthalium pale brown or yellowish brown, of variable size and shape, one to five inches in diameter, and one half an inch to an inch thick, enclosed by a distinct calcareous crust, which varies greatly in texture, thickness, and color, anon brown, stout, persistent, sometimes thin, bright yellow, scarce recognizable; capillitium well developed but variable in color and extent; spore-mass dull black, sooty; spores spherical, purplish brown, smooth, 7–10μ."

Saccardo uses the name *F. septica* (Linn.) Gmel. He speaks of the peridia as forming a common interwoven colored membrane, and says the color varies from deep yellow to white.

Lister adopts the same name as Saccardo. He calls the æthalia pulvinate, and adds: "The cortex is sometimes wanting, when the surface is grey and marked with brain-like convolutions.....Columella none. Capillitium a loose net-work of slender hyaline threads more or less expanded at the axils, with rounded, fusiform, or branching yellow or whitish lime-knots, varying much in size." He gives the diameter of the spores as 6–10μ.

Massee calls this species *F. varians* Rost. He differs from the above-quoted descriptions in no point excepting the diameter of the spores, which he gives as 7-11μ.

The specimens which we have, agree in general with the foregoing descriptions, the spores, however, being from 7–10μ in diameter. I find the æthalia of my specimens to be from 1 to 5 inches long and of varying widths.

This species seems to be quite common throughout the state. I have specimens growing upon oak and other bark, moss, grass stems, and one æthalium upon an oak leaf. They were found in the university campus woods and elsewhere in Madison in Octo-

ber, 1899 and 1903; in Nelson's woods August 22, 1903; at Star Lake in August 1901; Palmyra, July 3, 1903; Blue Mounds, August 8, 1903; Brule river, July 17, 1897, and near Webster in the summer of 1894. An æthalium also formed and ripened under a bell-jar in the herbarium room upon a piece of bark brought from Elmside woods in the fall of 1903. The plasmodium of this specimen was at first a delicate creamy white, but just before aggregating into the æthalium it became yellow. Another small æthalium was found at Algoma, October 1904.

Fuligo violacea Persoon.

1801. *Fuligo violacea* Persoon, *Syn. Meth.*, p. 160.

Macbride: "Æthalium thin, two or three inches wide, covered by a cortex at first bright yellow and very soft, at length almost wholly vanishing, so that the entire mass takes a purple violet tint, upper surface varied with white; capillitium rather open, the more or less inflated, large, irregular nodes joined by long, slender, delicate, transparent filaments; spores dark violet, minutely roughened, spherical, about 7.5μ."

Neither Lister nor Massee recognizes this species.

This is very different in general appearance from *F. septica.* The absence of the cortex almost as soon as the æthalium is ripe, the delicate violet color of the remainder, and the small spores make this species not impossible to differentiate from *F. septica.* I find the spores to be from 7–8μ, and none over 8μ in diameter.

We have one specimen growing on decayed wood, found in the lake shore woods at Sturgeon Bay, July 24, 1907.

It is quite possible that among the older specimens in our collection there may be some that should bear the name, which are labelled *F. septica,* but which are so badly preserved or so much eaten by insects that it is difficult to determine them. Macbride says of *F. violacea,* "Probably everywhere, but not distinguished from *F. ovata,*" the latter being the name which he adopts for *F. septica.*

Physarum sinuosum (Bull.) Weinm.

1791. *Reticularia sinuosa* Bulliard, *Champ,* p. 94, t. 446, fig. 3.
1828. *Physarum sinuosum* Weinmann, *Fries teste, l.* c.

Macbride: "Sporangia distinct or plasmodiocarps the plasmodiocarp creeping in long vein-like reticulations or curves, laterally compressed; sometimes distinct and crowded, always sessile. Peridium double; the outer thick, calcareous, fragile, snow-white; the inner delicate, the dehiscence by longitudinal fissure. Capillitium strongly developed with abundant white, calcareous granules. Spores smooth, dull violet, 8–9μ. Easily recognized at sight by its peculiar form, bilabiate and sinuous."

Saccardo credits the generic name of this species to Rostafinski. He calls the color snowy, grayish, or yellowish-white. The remainder of his description does not differ from Macbride's.

Lister finds the sporangia sometimes pulvinate, bursting irregularly, and white, gray, or yellowish. The spores he calls violet-brown, spinulose, and 8–10μ in diameter.

The general character of my specimens is well described above. I find the three different colors in different specimens, the snowy, grayish, and the yellowish-white. The spores are from 7–10μ in diameter and are distinctly though minutely spinulose.

One specimen found upon dead oak leaves on a lawn in Madison, July 20, 1904, has a quantity of *Diderma hemisphericum* mingled with it. Another specimen was found upon dead oak leaves and small stems in Vilas woods, July 16, 1904, another upon dead leaves I found at Blue Mounds, July 23, 1904, and still another was collected at Blue Mounds July 13, 1907.

Physarum contextum Persoon.

1796. *Diderma contextum* Persoon, *Obs. Myc.,* I., p. 89.
1801. *Physarum contextum* Persoon, *Syn. Meth.,* p. 168.

Saccardo: "Sporangia distinct, sessile, densly crowded, subrotund or reniform, base broad, 1–1.5 mm. long, .25 mm. wide; peridia double, outer layer thick, calcareous, yellow or yellowish white, inner layer thin, yellowish; capillitium with numerous, irreguar, closely packed, colorless, calcareous granules; columella commonly none; spores very dark, spinulose, 11–13μ diameter.

Macbride's description is almost identical with Saccardo's, but he adds that the outer peridium, especially its upper part, is entirely evanescent.

Lister says that the capillitium has scanty hyaline threads connecting the branching lime-knots. He calls the spores dark violet-brown. He states that Rostafinski was the first to detect and point out that in *P. contextum* the spores are rough and measure 10–13μ, while in *P. conglomeratum* they are nearly smooth and measure 8–9μ in diameter.

Massee differs from Lister only in the dimensions of spores, which he finds to be 11–14μ in diameter. He says this species is known from *P. conglomeratum* by the denser capillitium of numerous large, irregular lime-knots, and the larger sporangia usually of a pale lemon yellow, sometimes with a very faint tinge of green.

My specimens agree very closely with the above quoted descriptions.

I have two specimens which I found in Cemetery woods in October 1903, growing on and under poplar bark. One group is about one inch long by a third as broad, the other is about a fourth as large; another from Blue Monuds, August 8, 1904; another from East Madison on a dead straw found August 10, 1904.

Physarum cinereum (Batsch.) Pers.

1786. *Lycoperdon cinereum* Batsch, *Elench. Fung.*, p. 249, fig. 169.

1805. *Physarum cinereum* Persoon, *Synopsis,* p. 170.

Macbride: "Plasmodium watery-white or transparent, wide-streaming on decayed sod, etc. Sporangia sessile, closely gregarious or even heaped, sub-globose, elongate or plasmodiocarpous, more or less calcareous, gray; peridium simple, thin, more or less densely coated with lime; capillitium strongly developed, the nodes more or less richly calcareous, the lime-knots rounded, angular; spore-mass brown, spores violaceous-brown, 10–12μ, distinctly warted." He calls it a "delicate, inconspicuous species, ashen gray."

Lister varies somewhat from the above. He says in part: "Sporangia pulvinate, heaped, crowded, or scattered, cinereous, more or less warted or veined with white; capillitium sometimes

forming a *Badhamia*-like network with few hyaline threads. Spores bright violet-brown, almost smooth or spinulose, 7–10μ diam."

The species described by Massee under the name *P. scrobiculatum* Massee, and for which he gives the synonym *P. cinereum*, differs so materially from the above, that it is quite evidently a different species.

I find the sporangia globose, elongate, plasmodiocarpous, scattered, and crowded, and I have one pulvinate set of sporangia; when they are ripe they are gray; the capillitium nodes are large, irregular. Spores are 8–9μ in diameter in my specimens.

One collection is on fresh green leaves of several kinds; there are many immature sporangia among them; this was collected near Madison, July 7, 1904; a small group packed solidly together is on some little branched stems, found at Blue Mounds, July 8, 1905; and another was collected in Madison July 1, 1913.

Physarum auriscalpium Cooke.

1877. *Physarum auriscalpium* Cooke, *Myx. U. S.*, p. 384.

Macbride: "Sporangia gregarious, stipitate, small, bright yellow, depressed globose, rough; stipe reddish-brown or fuliginous, even, slender; hypothallus scant, black, or none; columella none; threads of the capillitium yellow, delicate, connecting the rather dense and abundant lime granules; spore-mass brownish black, spores violaceous, minutely but distinctly spinulose, 9–11μ". He says that this species is easily recognizable by its brilliant yellow color, somewhat rugose, sometimes scaly, peridium, its richly calcareous capillitium, also bright yellow where not weathered or faded, its dark brown translucent non-calcareous stem. Spores 9–10μ.

Lister's description agrees very closely with MacBride's, but he says the sporangia are scattered or in small clusters.

Massee, under the name *P. ornatum*, describes this form very nearly as given above, but he does not give the synonym *P. auriscalpium*. He makes out the spores to be from 10–11μ in diameter.

I have but one collection of this attractive species with its vivid yellow sporangia and reddish stipe. The capillitium nodes are

large, the filaments short. The spores I find to be a rich violet, 9–10μ in diameter.

I found this group in Cemetery woods, July 28, 1904, growing on decaying bark.

Physarum variabile Rex.

1893. *Physarum variabile* Rex., *Proc. Phil. Acad.*, p. 371.

Macbride (In part): "Sporangia scattered, stipitate or sessile, globose, ellipsoidal, etc.; sporangium-wall of a dingy yellow or brownish ochre color, slightly rugulose on the surface, crustaceous, brittle, rupturing irregularly, sometimes thin, etc.; stipes nearly equal, occasionally much expanded at the base, rugose, variable in size, color varying from yellowish white to dull brownish gray; capillitium a small-meshed network of delicate colorless tubules with large, many-angled, rounded masses at nodes; no columella, but often a central irregular mass of white lime granules; spores dark violet brown, verruculose, 9–10μ." He adds that it differs from *P. citrinellum* in the size of the sporangium, the habit of fruiting, size, color, and marking of the spores; from *P. melleum* in having no columella; and from *P. auriscalpium* by having a much closer capillitium with paler nodules, as well as by much stouter habit, and the peculiar metallic or bronze yellow of the peridial wall.

Lister describes it as glossy, yellowish-olive; the stalk conical, furrowed, yellowish-brown, densely charged with white lime-granules; capillitium a close network of slender hyaline threads with membranous expansions at the axils of the branches; lime-knots numerous, irregularly branching, many large and confluent, white or pale yellow. In other respects he does not differ from Macbride, whom I have but partially quoted.

Massee does not describe this species.

This is neither the bright yellow of *P. auriscalpium,* nor the honey-yellow of *P. melleum.* It is a dull light yellow with the stipe a trifle darker. The nodes in the sporangia that I have are few, large and irregular. The spores are pale reddish-brown 9—10μ.

We have one collection, made at Elmside, Madison, July 15, 1904.

Physarum nefroideum Rostafinski.

1875. *Physarum nefroideum* Rost., *Mon.*, p. 93.

Macbride: "Sporangia gregarious, sessile, stipitate, or even plasmodiocarpous; when stipitate, globose, depressed, or anon reniform, usually concave or umbilicate below, the peridium strongly calcareous, cinereous-white; stipe variable, generally tapering upward, always distinctly deeply plicate-furrowed, varying in color from nearly pure white, through different shades of gray to brown fuliginous or black; hypothallus none or obscure; columella none; capillitium abundant, the white lime-knots varying in size and shape, connecting by rather long hyaline threads, with here and there an empty node; spore-mass black, by transmitted light dark, sooty brown, minutely papillose, 10–11.5μ." Macbride says also that, while normally stipitate, it often shows from the same plasmodium all sorts of forms. The amount of lime also varies, especially in the capillitium, where there is always a tendency to the formation of something like a pseudo-columella.

Lister adopts the name *P. compressum* Alb. and Schw. He describes the sporangia as erect, splitting along the upper ridge, scattered, closely aggregated or confluent. The stalk never has a chalk-white fracture at the base. He finds the spores to be dark purplish-brown, more or less spinulose or echinulate and from 9–14μ in diameter. He finds much difference in size and roughness of the spores in sporangia from the same cultivation. He finds also American specimens with nearly globose sporangia, and buff or white, long or short, stout stalks, and says that these forms are more symmetrical than European forms.

The description in Saccardo of the species *P. compressum* A. and S., with the synonym *P. nefroideum* Rost, and the description in Massee of the species *P. nefroideum* Rost., are identical, and offer no material departure from the above. This description, however, calls the spores globose or angularly subglobose, 11–13μ in diameter, minutely verruculose.

The abundant material which I have agrees with Macbride's description excepting that I find the spores to be 9–11μ in diameter.

My specimens are mostly upon the bark and wood of decayed

poplar. I have specimens from Blue Mounds gathered October 12, 1901; from Dead Lake, October 1903; several gatherings from Cemetery woods during the last ten days of October, 1903; and from Vilas woods, July 16, 1904.

In the winter of 1912–13 tobacco stems which had been put on the plant benches of the greenhouse of the Biology Building bore a large crop of *P. nefroideum,* all the sporangia of which were distinctly reniform, many of them being also bent into a crescent shape laterally. They were very dark gray in color.

Physarum globuliferum (Bull.) Pers.

1791. *Sphaerocarpus globuliferus* Bulliard, *Champ.,* pl. 484, fig. 3.

1801. *Physarum globuliferum* Pers. *Syn.,* p. 175, t. III., figs. 10–12.

Macbride: "Sporangia gregarious, stipitate, globose, or slightly depressed above, pale gray or pure white; stipe sometimes equal to the sporangium, generally longer, slender, slightly wrinkled, white or yellow, pallid, when longer tapering upward; columella white conical, sometimes obsolete; hypothallus none; capillitium dense but delicate, persistent, a close net-work of hyaline threads, with white or yellowish nodes sparingly thickened and calcareous, many without lime; spore-mass brown; spores by transmitted light violet, minutely warted, 7.5–9μ."

Lister's description varies but little from the above. He says that sometimes the stalk is red-brown towards the base, that the capillitium is persistent, retaining the form of the sporangium after the dispersion of the spores; that the spores are violet-brown, almost smooth, 6–8μ in diameter.

Massee says that the sporangia are grayish; the stem equal to the sporangium or twice as long, rigid, fragile, white, sulcate; columella large, cylindrical, obtuse, white; vesicles containing lime in the capillitium are numerous, of variable size, yellowish or reddish: spores smooth, 9–11μ in diameter.

In my collections I find the long, slender, wrinkled yellow stipe; I find the persistent capillitium; other characteristics agree with Macbride's description.

One collecton was made at Blue Mounds, July 1904, growing

on green moss and dead wood, another at Blue Mounds, July 1907, on green grass stems.

Physarum melleum (Berk. and Br.) Mass.

1873. *Dydymium melleum*, Berk. & Br., *Jour. Linn. Soc.* XIV:, p. 83.

1892. *Physarum melleum* Massee, *Mon.*, p. 278.

Macbride: "Sporangia scattered, stipitate, globose, flattened below, clear yellow or honey-colored; stipe short, about equaling the sporangium, pure white, somewhat wrinkled; columella small but distinct, white: hypothallus none; capillitium abundant, open, snow-white, with rather large angularly stellate nodes; spore-mass brown, almost black; spores by transmitted light pale violet or lilac-tinted, almost smooth, 7.5–10μ: Easily distinguished by its white stipe, columella and capillitium in strong contrast with yellow peridial walls."

Lister describes the plasmodium as yellow; sporangia yellow or brownish-yellow; sporangium-wall membranous, often wrinkled, persistent at the base, yellowish, with minute yellow lime granules sparsely distributed; stalk white, buff, or rufous, stout, opaque, with few shallow furrows; capillitium consisting of irregularly branching delicate hyaline threads sometimes expanded at the axils, with lime-knots white or yellowish, various in shape and size, mostly large and angled. Spores 7–8μ in diameter.

Massee calls the color of this species yellowish-olive or honey-colored, sprinkled with minute particles of lime. He describes the capillitium as very dense, snow-white, the nodes numerous, very large, angularly stellate, separated from each other by constrictions only, lime in the form of granules present in every portion; spores minutely verruculose, 6–7μ in diameter. In other particulars his description does not differ from those above given.

This species is a dull brownish-yellow—honey-color describes it well; it is not the vivid yellow of *P. auriscalpium*, and it has a white stipe, whereas that of *P. auriscalpium* is dark. In *P. melleum* the stipes often remain after the sporangia disappear. The above descriptions render it easy to determine.

We have one collection, gathered in the campus woods, July 22, 1904:

Physarum leucopus Link.

1809. *Physarum leucopus* Link, *Diss.*, I., p. 27.

Macbride: "Sporangia gregarious, stipitate, globose, snow-white, with a *Didymium*-like covering of calcareous particles; stipe not long, conical or tapering rapidly upward, slightly sulcate, brittle, from an evanescent hypothallus; columella none or small: capillitium consisting of rather long hyaline threads, connecting the usual calcareous nodes, which are large, angular, snow white; spore-mass black; spores by transmitted light violet brown, distinctly warted, about 10μ." He adds that the snow-white, nearly smooth stem and the small sporangia covered with loose calcareous granules, distinguish this rare species. It looks like a small *Didymium squamulosum*.

Lister says, in part: "Plasmodium opaque-white. Sporangia grayish white or glaucous, gregarious or clustered, stalked, rarely almost sessile; stalk white, stout, thick, with a few shallow longitudinal furrows, erect, rigid, brittle, somewhat narrowing upwards, chalk-white in section to the base, rising from a more or less developed white hypothallus." He finds the spores to be 7–10μ in diameter.

Massee differs in a few particulars: "Sporangia globose, broadly ellipsoid or a little depressed, stipitate or sessile, rarely elongate and flexuous or anastomosing, wall at first covered with a continuous snow-white coat of lime, which soon becomes broken up into smooth innate patches; stem variable in length, white, passing into a more or less evident hypothallus; spores globose, dingy lilac, rather coarsely warted, warts almost black, 9-12μ diameter."

The short, stout, white, rigid stipe is a distinctive characteristic of this species. I do not find any flexuous or anastomosing sporangia in my specimens.

Our one group was found growing on dead wood beside the Windsor road, July 7, 1904.

Physarum nucleatum Rex.

1891. *Physarum nucleatum* Rex., *Proc. Phil. Acad.*, p. 389.

Macbride: "Sporangia gregarious, spherical, ½ mm., white, stipitate; peridial wall membranaceous, rupturing irregularly,

thickly studded with rounded white lime granules; stipe about 1 mm., subulate, yellowish white, rugose; columella none, capillitim dense snow-white, with minute white round or rounded white nodes, in the center a conspicuous mass of lime forming a shining ball, not part of the stipe, although sometimes produced toward it; spore-mass black; spores brown violet, delicately spinulose, 6–7μ. This species may be distinguished from *P. globuliferum* by the absence of a columella, by the central ball of lime, and the very small rounded lime granules in the meshes of the capillitium."

Lister finds the stalk pale buff, or yellow, translucent above, without deposits of lime, enclosing refuse matter at the base; the capillitium threads colorless with scattered minute rounded white lime-knots; in the centre of the capillitium is usually suspended a shining white calcareous ball. Otherwise his description does not differ from Macbride's.

Massee has no mention of this species.

The snow-white sporangia before rupturing, the pale yellow stipe, the dense white capillitium, and, more distinctive than any other feature, the shining white calcareous ball suspended in the center, make this pretty species easy to determine. I find that after the spores are dispersed the groups of sporangia have a faint brownish tinge. The spores in my specimens are 6–7μ in diameter.

We have many specimens gathered in the campus woods during the last part of July 1904.

Tilmadoche polycephala (Schw.) Macbr.

1822. *Physarum polycephalum* Schweinitz, *Syns Fung. Car.*, no. 382.

1899. *Tilmadoche polycephala* Macbride, *N.—A. S.—M.*, p. 57.

Macbride: "Sporangia spherical or irregular, impressed, gyrose-confluent, helvelloid, umblicate below; peridium thin, ashy, covered with evanescent yellow squamules, fragile; stipe from an expanded membranous base, long subulate yellow; spores smooth, violet, 9–11μ: A most singular species and well defined. The plasmodium as it emerges white, then yellow, spreading far over all adjacent objects; by morning fruit, a thousand stalked sporangia with their strangely convoluted sculpture. The winds

bear off the sooty spores, and naught remains but twisted yellow stems crowned with a pencil of tufted silken hairs. August." I have quoted but part of Macbride's description.

Lister uses the name *Physarum polycephalum* Schw. He finds the sporangia stalked, compressed vertically, lenticular, undulate or lobed, confluent in clusters of five to ten together, grey or yellow; capillitum a loose network of slender threads with many flat expansions at the axils; he finds the spores violet-brown, minutely spinulose, 8–10μ in diameter.

Massee does not describe this species.

The little sporangia with their irregular convoluted tops make the species a noticeable one. I have a collection on a green compound leaf of three leaflets; the upper surface and the stem are completely covered, and the under surfaces more than half covered with these odd little forms.

We have but this one collection which came from Winnequah, July 22, 1905.

Tilmadoche alba (Bull) Macbr.

1791. *Sphhaerocarpus albus* Bulliard, *Champ.*, p. 137, etc.
1899. *Tilmadoche alba* Macbride, *N.—A. S.—M.*, p. 58

Macbride: "Sporangia gregarious, depressed spherical, stipitate, umbilicate, gray or white, thin-walled, nodding; stipe long, tapering upward, brown or ashen-white above, lightly striate, graceful; capillitium abundant, threads delicate, intricately combined in loose persistent network with occasional minute, rounded, or elongate calcareous nodules; spores minutely roughened, globose, about 10μ. The nodding, lenticular, umbilicate sporangium, barely attached to the apiculate stipe, is sufficient to distinguish this elegant little species. The stipe is usually white above, fuscous below, at the apex almost evanescent; hence the cernuous sporangia."

Lister calls this species *Physarum nutans*. His description does not differ from that of Macbride in any important detail.

Massee adopts the name of *T. nutans* Rost. He notes that the thin greyish or white walls, having a thin layer of minute amorphous lumps of lime, become irregularly cracked; that there is a small hypothallus; the spores pale lilac, smooth, or very minutely verruculose, 9–11μ.

This tiny species is not difficult to determine. Macbride's description is adequate.

Our specimens are from near Fond du Lac July 1897; Olin's drive, Madison, July 1904; Vilas woods, July 1904; and Blue Mounds, July 1904.

Tilmadoche viridis (Bull.) Saccardo.

1791. *Sphaerocarpus viridis* Bulliard, *Champ.*, t. 407, fig. i.
1880. *Tilmadoche viridis* (Bull.) Sacc., *Michelia* II., p. 263.

Macbride: "Sporangia globose, flattened or lenticular, beneath plane or concave, variously colored, yellow, greenish yellow, rusty orange, stipitate, nodding; the peridium splitting irregularly or reticulately; stipe variable in length and color, through various shades of red and yellow, subulate; capillitium strongly developed, concolorous with sporangium, the tubes with colorless or yellow calcareous thickenings; spores smooth, fuscous or violet black, 8μ. A very handsome and rather common little species, like *T. alba*, but generally greenish yellow in color, and occasionally brilliant orange without a suggestion of green."

Lister adopts the name *Physarum viride* Pers. He finds the sporangium wall dehiscing in fragments; the stalk slender subulate, striate, grey or straw-colored, sometimes yellow at the apex shading to red below, usually brown in the lower half; capillitium a loose irregular network of slender, acutely branching hyaline threads, with fusiform orange lime-knots. Spores brownish violet, almost smooth, 7–10μ in diameter

Massee calls this species *T. mutabilis* Rost. He describes the sporangium wall as having a thin layer of yellow, dingy orange, or greenish colored particles of lime; capillitium rather dense, with small elliptical nodes containing colored granules of lime; he finds the spores minutely verruculose, 9–11μ in diameter.

This tiny species seems to be quite common, and is easily determined. I found no essential differences from the descriptions given.

We have twenty-one collections, the sporangia growing on dead wood or bark. The dates of collection range from 1901 to 1905, and from June 22 to October 21. The most are from Madison and vicinity, but we have specimens from Mauston, Algoma, Palmyra, and Blue Mounds.

Badhamia utricularis (Bull.) Berkeley.

1791. *Sphaerocarpus utricularis* Bulliard, *Champ.*, p. 128, t. 417, fig. 1.

1852. *Badhamia utricularis* (Bull.) Berk., *Tr. Linn. Soc.*, XXI., p. 153.

Macbride: "Sporangia clustered, spherical or ovoid, large sessile or mounted on long thin strand-like stalks, blue-gray, violet-iridescent or cinereous, smooth or more often rugulose; the stipes when present poorly differentiated, as if thread-like filaments and strips of the plasmodium, often branched and always reclining or even prostrate; hypothallus none; capillitium a large-meshed open network of rather slender tubules, the nodes unequally developed, white with the enclosed lime; spores not strictly adherent though not without some tendency to stick together, delicately warted, bright violet brown, 10–12μ."

Lister says that the plasmodium is chrome yellow, the sporangia ovoid, subglobose, or confluent and lobed, sessile or on membranous straw-colored branching stalks; that the spores usually adhere in loose clusters of 7–10; that in some specimens in the Strassburg collection the spores show but slight indication of clustering, in others this character is well marked.

Massee, calling this species *B. varia* Massee, says that the stem when present is generally weak and decumbent, several often more or less grown together, pale yellow or reddish, springing from a well-developed hypothallus of the same color.

I find the long, weak, thread-like, yellow stipes very distinctive; there is no evidence of a hypothallus in one extensive group of specimens that I have, and in another small group a well-developed, thick, dark reddish hypothallus; the spores seem to have no tendency to cluster. I find spores 10μ, 12μ, and some as large as 13μ in diameter.

One piece of bark half a foot wide and a foot and a half long with the surface very nearly covered with the sporangia, and accompanying it a dead elm leaf having a large group, were found at Blue Mounds November 5, 1904. A small fine specimen from Algoma was found in October 1904.

Badhamia papaveracea Berk. and Rav.

1873. *Badhamia papaveracea* Berk. and Rav., *Grev.*, II., p. 66.

Saccardo: "Sporangia sessile or stipitate, fasciculated, globose smooth, white or grayish-white; when the spores are out, snowy-white; stipes branched or simple, straw-colored or reddish; spores adhering in rounded masses of 5 to 20; epispore very thick, spinulose, dark violet or black, 10–12μ."

Massee: "Spores at first in clusters of 3–7, triangularly pyramidal, with the rounded base, which corresponds to the free portion of the spore, covered with minute warts, the remainder smooth; pale lilac or brownish lilac, 9–10μ in diameter."

Macbride: "Sporangia closely gregarious, globose, large stipitate, iridescent gray; the peridium thin, translucent, and containing but little calcareous deposits, smooth or slightly rugulose; stipe very short but generally very distinct, black or very dark brown; hypothallus none; capillitium a network of large meshes with expanded nodes, prominent, white, persistent after the spores have blown away; sporemass deep brown; spores adhering in clusters of from 5 or 6 to 20 or more, exposed surface of spores most distinctly warted, 10–12.5μ." He says that it is distinguished by its short, dark stipe and adherent spores, and that it is not common.

Lister: "Sporangia subglobose, grayish-white, nearly smooth; 0.7 to 1 mm. diameter, shortly stalked or sessile, gregarious; sporangium wall with scanty deposit of lime. Stalk firm, dark brown, rarely straw-colored, 0.2 to 0.3 mm. high. Capillitium a network of flat bands with broad, thin expansions at the angles. Spores purple-brown, closely compacted in clusters of 6–10, more strongly warted on the outer third, 10–13μ diameter."

My specimen agrees with Macbride's description, the short, dark stipe and the compacted balls of spores being very distinctive.

We have but one group of specimens, which was found at Algoma in October 1904.

Badhamia rubiginosa (Chev.) Rost.

1826. *Physarum rubiginosum*, Chevalier, *Fl. Par.*, p. 338.
1876. *Badhamia rubiginosa* (Chev.) Rost., *Mon. App.*, p. 5.

Macbride: "Sporangia gregarious, obovoid, grayish brown, stipitate, the peridium simple, membranous, above thin, pale, more or less calcareous below, persistent, blending with the stipe; stipe erect, reddish-brown or purplish, expanded below into a small hypothallus, above prolonged within the sporangia more than half its height as a definite columella; capillitium very dense snow-white, long persistent with the lower two-thirds of the sporangial wall; spore-mass dark brown; spores by transmitted light dark violet or purple brown, minutely roughened or spinulose, not adherent, 12–14μ."

Lister differs but little from Macbride. He says the sporangia are rarely sessile, columella clavate or cylindrical, capillitium a white or pale rufous rugged network, usually densely charged with lime-granules, sometimes with a few hyaline connecting threads.

Saccardo: "Peridia round-top-shape, stipe slender; sporange twice as broad as it is long; reddish-brown, smooth, shining; columella distinct, cylindrical, firm, dark, formed from the elongated stipe; capillitium very much unrolled, white; peridium opening with a delicate dehiscence; spores violet, 14–15μ, scarcely warted."

The different forms which I have agree in general with the description by Macbride. The hypothallus is very prominent and of a greenish-brown. As many of the sporangia are immature, I think the prominent hypothallus may be but a portion of the plasmodium arrested in its development. The spores are 12–14μ in diameter and are distinctly spinulose.

We have but one group of sporangia, found at Blue Mounds, July 8, 1905.

Craterium leucocephalum (Pers.) Ditmar.

1791. *Stemonitis leucocephala* Persoon, *Gmelin, Syst. Nat.*, II., p. 1467.

1813. *Craterium leucocephalum* (Pers.) Ditmar, *Sturm, Deutsch. Flora, Pilze,* p. 21, pl. 11.

Macbride: "Sporangia gregarious, short cylindric or ovate, pure white above, brown or reddish brown below, stipitate, dehiscence irregularly circumscissile, the persistent portion of the peridium beaker-shaped; stipe short, stout, expanded above into the base of the peridium with which it is concolorous; hypothallus scant; capillitium white or sometimes, toward the center, brownish, the calcareous nodules large, conspicuous, and persistent; spore-mass black, spores violaceous brown, minutely spinulose, 8–9μ." He says it is distinguished by its white cap, and that in some gatherings curious patches of yellow mark the otherwise snow-white cap and sides.

Lister finds the plasmodium rich yellow; the sporangia ovoid or turbinate, stalked, red-brown with white incrustations of lime and usually spotted with miunte yellow warts on the upper half; plasmodiocarp forms sometimes occurring; the columella either absent or represented by a central mass of confluent lime-knots, spores violet-brown, spinulose, 7–9μ in diameter.

Massee differs but little from the above quoted descriptions in essentials. He calls the spores minutely warted, the warts often with a tendency to form anastomosing lines, 8–11μ in diameter.

I find Macbride's description good for this species. It is a pretty form and easily determined. The little vase-shaped sporangia, light above, dark at the base, have a sunken "lid" which breaks away leaving the calcareous nodules showing in the top of the vase, like tiny eggs in a nest. They can be seen with the unaided eye. I have gatherings which have the curious patches of yellow of which Macbride speaks. They are on living and dead leaves, and on dead wood.

We have specimens from the campus woods, October 1903, and on three different days of July 1904; from cemetery woods, October 1903, from Vilas woods, July 1904, Devil's Lake, June 1905, from Blue Mounds, July 1904 and July 1905, from campus

woods on dead oak leaves, July 18, 1904, these last mixed with *Didymium nigripes.*

Leocarpus fragilis (Dicks.) Rost.

1785. *Lycoperdon fragile* Dickson, *Fasc., Pl. Crypt, Brit.*, I., p. 25.
1875 *Leocarpus fragilis* (Dicks.) Rost., *Mon.*, p. 132

Saccardo: "Peridia aggregated, sessile or stipitate, obovoid rarely subrotund, yellowish- or reddish-brown, polished, stipe filiform, ascending, white or yellowish; spores globose, dusky-dark, spinulose, 12–14μ in diameter."

Macbride calls the sporangia rusty or brownish-yellow, opening in a somewhat stellate fashion. He describes the stipe as weak and short, and the spores as dull black. He says the sporangia are recognizable at sight as they resemble the eggs of certain insects. The capillitium, he states, is of two or more distinct systems, the one a delicate network of hyaline, limeless threads, the other calcareous throughout, or nearly so, the meshes large and the threads or tubules broad.

Lister says of the capillitium that it is a network of rigid hyaline threads with flattened expansions at the axils and with few lime-knots, connected with a system of coarse branches often combined into a dense network and charged throughout with brownish lime-granules. He finds the spores occasionally 15–20μ in diameter, rarely clustered as in *Badhamia.*

Massee sometimes finds several sporangia more or less grown together.

For the capillitium as I find it, Lister's description is very good. The reticulated hyaline threads are continuations of the coarser reticulated threads containing yellowish lime granules. There are not two distinct systems of capillitium threads as I see them. I find the spores to be dusky purplish, distinctly warted, and from 9–15μ in diameter. The weak, white stipes are quite often united, sometimes as many as five making a thin expanded common stipe. The sporangia seem to open irregularly.

Some of this species were found at the Brulé river, July 19, 1897, growing upon dead leaves and twigs.

One specimen which I have was found July 13, 1904, in Cemetery woods, growing upon decayed wood; another, found July

16, 1904, in Vilas woods, is upon decayed wood and a thin layer of green moss growing on the wood. On July 21, 1904, I found several specimens in Cemetery woods, some upon wood, some upon bark, and one very beautiful group about two inches long and a third as wide upon a thin curled dead oak leaf upon which was also a group of *Diachea leucopoda*. A fine group of the sporangia was found growing upon the bark of a little thrifty hard maple tree about six inches from the ground, at Blue Mounds, July 23, 1904.

Mucilago spongiosa (Leyss.) Morgan.

1783. *Mucor spongiosus* Leysser, *Fl. Hal.*, p. 305.
1897. *Mucilago spongiosa* (Leyss.) Morgan, *Bot. Gaz.*, XXIV., p. 56.

Saccardo: "Æthelia grayish-white, 2–6 cm. long, 2–3 cm. wide, spongy; columella hollow, cylindrical, branched, not reaching the apices of the peridia, capillitium threads thick, branched, with much thickened nodules; spores spinulose, dark violet, 10μ in diameter."

Macbride speaks of the component sporangia as resting upon a common hypothallus and being protected by a more or less deciduous calcareous, porous cortex. He finds the columella indefinite or none, the hypolhallus white, spongy. He finds the spore-mass black, the spores violaceous, exceedingly rough, large, 10–15μ in diameter. In fruiting, the plasmodium, he states, ascends preferably living stems of small bushes, herbaceous plants, or grasses, and forms the æthalium around the stem some distance above the ground.

Lister finds the æthalia to be 2 to 4 cm. long, 1 to 2 cm. wide, and about 1 cm. thick, which agrees with the measurements of my specimens. He finds the columella to be sometimes absent. The capillitium is a network of widely branching, anastomosing, stout, purplish-brown threads, with numerous dark calciform thickenings, hyaline at the extremities. This statement I find to be true, the thickenings on the capillitium threads being quite distinctive. The spores he makes out to be dull purple, strongly spinulose, 10–13μ in diameter.

Massee does not differ from the descriptions quoted above.

This species is also called *Spumaria alba* (Bull.) D. C.

My specimens agree very closely with the descriptions given. They vary in length from 1½ to 4 cm. The spores are dark violet, strongly spinulose, from 12 to 15μ in diameter.

Three specimens surrounding small stems were found in Madison. October 14, 1899, and two in campus woods July 14, 1904. One of the latter is nearly globular and is formed on the extreme end of the stem of a dead oak leaf; the other is irregular, upon the base of another dead oak leaf. The other specimen which I have nearly surrounds a hardwood twig, and was found at Blue Mounds, July 23, 1904.

Didymium squamulosum (Alb. and Schw.) Fries.

1805. *Diderma squamulosum* Alb. and Schw., *Consp. Fung.*, p. 88.

1829. *Didymium squamulosum* (Alb. and Schw.) Fries, *Syst. Myc.*, III., p. 118.

Macbride: "Sporangia in typical forms gregarious, globose or depressed globose, gray or snow white, stipitate; the peridium a thin iridescent membrane covered more or less richly with minute crystals of lime; the stipe when present, snow white, fluted or channeled, stout, even; columella white, conspicuous; hypothallus small or obsolete; capillitium of delicate branching threads, usually colorless or pallid, sometimes with conspicuous calciform thickenings; spores violaceous, minutely warted or spinulose, 8–10μ." He adds that this is one of the most beautiful species in the whole series, and is remarkable for the variations it presents in the forms of the sporangia, in hypothallus, in capillitium; and he describes the different forms that have come under his observation.

Lister gives details of the variations, but does not otherwise differ from Macbride.

Massee also agrees in general with the above.

We have the gray and the white forms, the stipitate and the sessile. In some sporangia where the peridium is broken away, the columella can easily be seen with a hand-lens. I find the spores 8–10μ in diameter.

Six of our collections were made in June and July, 1904, and the seventh in March, 1904, on a few straws in a laboratory. All but one were collected in Madison, one at Blue Mounds. Most of them are on dead oak leaves, found in the woods or on lawns.

Didymium melanospermum (Pers.) Macbr.

1794. *Physarum melanospermum* Pers.. *Rom. N. Mag. Bot.*, p. 89.
1899. *Didymium melanospermum* (Pers.) Machr., *N.–A. S.–M.* p. 88.

Macbride: "Sporangia gregarious, hemispheric, depressed, umbilicate below, stipitate or sessile; the peridium firm, dull brown in color, frosted with minute crystals of lime, breaking irregularly; stipe, when present, short, stout, dull black, opaque, arising from a broad base or hypothallus; columella large, prominent; dark-colored, rough above, concave below; capillitium of more or less sinuous, usually dark colored threads, sparingly branched, and often with calciform thickenings; spore-mass black, spores by transmitted light pale, purplish gray, spinulose or rough, 10–12μ." Macbride adds that this is a well-marked and common species, distinguished by its depressed sporangium and dark-colored, opaque stipe, wich is very short.

Lister finds the plasmodium colorless or grey, the sporangia often confluent, white or grey mottled with purple-brown, and beset with stellate crystals of lime. He finds the spores dark purplish-brown or purplish-grey, with a thick spore-wall, nearly smooth or spinose, 9–12μ diameter. In other respects he does not differ from Macbride.

Massee adopts the name. *D. farinaceum* Schrad. He diffesr but little from the foregoing descriptions. He says the sporangia are at first white with a continuous crust of lime, which soon becomes broken up into white glistening granules scattered on the inner dark, wrinkled wall; stem expanding at the base into a rudimentary hypothallus; he finds the spores minutely warted, 10–13μ in diameter.

In my one collection I find a few confluent sporangia. The stellate lime crystals in the walls distinguish it from any *Physarum*, with some of which it might easily be confused. The foregoing descriptions leave nothing to add. This was collected at Blue Mounds July 23, 1904. It was growing on green moss and decayed wood.

Didymium clavus (Alb. and Schw.) Rabenhorst.

1805. *Physarum clavus* Alb. and Schw., *Consp. Fung.*, p. 96.
1844. *Didymium clavus* (Alb. and Schw.) Rabh., *Ger. Cr. Fl.* no. 2282.

Macbride: "Sporangia gregarious, pale gray, discoid or piliate, depressed, stipitate; the peridium dark-colored, frosted with calcareous crystals above, naked below; stipe short, slender, tapering upward, furrowed, arising from a hypothallus more or less distinct, black; columella obsolete; capillitium of delicate threads, pale or colorless, little branched; spores violaceous, pale, nearly smooth, 6–8μ." Macbride adds that this species is well differentiated, easy of recognition by reason of its peculiar discoid sporangia, calcareous above, naked and black beneath. He gives no figure of this form.

Lister: "Sporangia scattered, disc-shaped, thick grayish white; sporangium-wall thickened and brown at the base; capillitium profuse colorless or purple-brown threads; spores pale violet-brown, almost smooth, 5–8μ."

Massee finds sporangia plane below; some small ring-like dark-colored thickenings on the capillitium threads; spores smooth, dingy lilac, 6–8μ."

In my one small group of sporangia I find many differences from the above descriptions, yet enough correspondence to make it certain, in my opinion, that it is *D. clavus*. The hypothallus is not very evident but is noticeably black; the sporangia are discoid, not very much depressed; the stellate crystals are nearly all asymmetrical, having one arm or ray longer than the others; the crystals are not as large and noticeable as Massee has pictured in his figures; the sporangia are markedly umbilicate both above and below; I do not find the base bare and dark, unless it is so up under the curve or umbilicus; the stipe I find as described; the capillitium is darker than the spores, purple-brown; I found some darker spots on the threads, but failed to see many of them and could not make them out to be rings, as seen by Massee; the spores in mine are quite uniformly 6μ, yet I found a considerable number to be 8μ in diameter. They are pale violaceous and nearly smooth, although I saw some which showed small spines.

My one group was found growing on live moss at Blue Mounds, July 13, 1907.

Didymium Nigripes (Link) Fries.

1809. *Physarum nigripes* Link, *Obs. Diss.*, I., p. 27.
1829. *Didymium nigripes* (Link) Fries, *Syst. Myc.*, III., p. 119.

Macbride: "Sporangia gregarious, globose or hemispheric, umbilicate beneath, small, white, stipitate; the peridium smoky, covered with minute calcareous crystals; stipe slender, erect, black, opaque; hypothallus thallus scutate, black; columella distinct, globose, black or dark brown; capillitium of delicate threads, pale brown or colorless, with occasional brown thickenings or nodes, sparingly branched; spores pale, violaceous by transmitted light, minutely warted, 6–8μ."

Lister, under the name *D. nigripes*, groups *D. nigripes*, *D. xanthopus* and *D. eximium*. For the discussion of the differences among these forms I would refer to Macbride and to Lister.

Massee, under the name of *D. microcarpon*, gives a description which differs considerably from Macbride's description of *D. nigripes*.

Macbride's description is determinative and quite correct for my specimens. I find the spores, however, to have a diameter of 7–11μ.

We have this species growing on dead oak leaves from Cemetery woods and Eagle Heights in July 1905, and on tobacco stems which were being used as an insecticide in the greenhouse in January 1913.

Another group came from Winnequah, July 1904, and is on a little oak branch.

Diderma reticulatum (Rost.) Morgan.

1875. *Chondrioderma reticulatum* Rost., *Mon.*, p. 170.
1894. *Diderma reticulatum* (Rost.) Morg., *Jour Cin. Soc.*, p. 71.

Macbride: "Sporangia gregarious, generally rounded and much depressed, flat, sometimes, especially toward the margin of a colony, elongate, venulose or somewhat plasmodiocarpous, dull white, the inner peridium ashen or bluish, remote from the calcareous crust, which is extremely fragile, easily shelling off; columella indistinguishable from the base of the sporangium, thin, alutaceous; capillitium of short, generally colorless, deli-

cate, sparingly branching or anastomosing threads perpendicular to the columella; spores black in mass, by transmitted light violet tinted, smooth, 6–8μ." He calls this our most common species, recognized by its rather large, white, depressed or flattened sporangia tending to form reticulations. He says the lines of fruiting tend to follow the venation of the supporting leaf; when the sporangium is round, the columella is a distinct rounded or cake-like body; when the fruit is venulose, the columella is less distinct.

Lister gives the synonym *D. reticulatum* to the form which he calls *D. effusum*, and refers to *D. effusum* as described by Macbride, and also to the form which Macbride calls *D. reticulatum*, as though the two forms were included in his one *D. effusum*. Macbride makes the two names apply to two distinct species, and says that *D effusum* "might be taken for an exceptionally plasmodic form of *D. reticulatum* but is distinguished by the extreme thinness of the fructification and its pure white color; it looks like a splash of whitewash." He gives the diameter of the spores of *D. effusum* as 8–10μ, whereas those of *D. reticulatum* are 6–8μ.

Massee adopts the name *Chrondrioderma reticulatum* Rost. He says: "Plasmodium sessile, vein-like, flattened, arcuate, combined into an irregular network, seated on a whitish, delicate, reticulated, spreading hypothallus; columella absent; threads of capillitium colorless, very thin, combined to form a dense net; spores smooth, obscure violet, 7–8μ in diameter."

Macbride's description is excellent for the specimens that I have, although I do not find them "following the venation of the supporting leaf." The inner peridium in some of mine has a tinge of brown, while others are ashen or bluish on the same leaf. The spores I find to be smooth, 6–8μ in diameter.

I have many groups on several kinds of both living and dead leaves, which I collected at Blue Mounds, July 23, 1904; some on dead oak leaves from Cemetery woods, July 21, 1904; and some on both living and dead leaves from Vilas woods, July 16, 1904.

Diderma persoonii Macbr.

1899. *Diderma Persoonii* Macbride, *N.-A. S.-M.* p. 96.

Macbride: "Sporangia sessile, gregarious or closely aggregate, depressed, roundish, elliptical, elongate or plasmodiocarpous; outer peridium pure white, smooth, fragile, remote from the inner, which is thin, ashen, or bluish, and inclined to iridescence; columella alutaceous or brownish, not distinguishable from the base of the fructification, the so-called hypothallus; capillitium very scanty, short and nearly colorless, simple or slightly forked; spores violet-brown, smooth, 10–15.5μ." He adds, as distinctive characteristics, that the inner peridium in good specimens shows a peculiar lustre of a coppery tinge unlike anything else. The spores, also, he considers as immediately diagnostic, large, nearly smooth, dark purple-brown in color.

Lister gives the plasmodium as colorless or yellow; sporangia scattered, pulvinate on a broad base or forming irregularly elongated plasmodicarps, smooth, white; columella none; the capillitium threads, he says, are flattened, usually broad at the base, branching dichotomously and slender above; he finds the spores usually faintly and closely warted, sometimes marked with stronger scattered warts, and 11–14μ in diameter. He calls the species *D. difforme*.

Massee describes it as sessile on a broad base, convex, circular or irregularly elongated; columella absent or represented by a small accumulation of lime at the base of the sporangium; capillitium scanty, sometimes almost obsolete, threads springing from the base of the sporangium, slightly attenuated upwards, forked, pale brown or colorless; spores globose, smooth, dingy violet, 10–13μ in diameter.

In the one set of abundant specimens which I have I find no pulvinate sporangia, but many of the other forms mentioned above. The capillitium is very scanty and short; the spores are dark violet-brown, very minutely and closely warted, and I find them from 12 to 14μ in diameter. This collection was found growing on dead leaves of several kinds, and on dead twigs nearby, in the campus woods, July 20, 1904.

Diderma spumarioides Fries.

1892. *Diderma spumarioides* Fries, *Syst. Myc.*, III., p. 104.

Macbride: "Sporangia sessile, crowded, spherical, or by mutual pressure irregular, white; the peridium plainly double, but the layers adhering, the outer more strongly calcareous, but very frail, almost farinaceous; hypothallus more or less plainly in evidence, white or pale alutaceous; columella distinct though often small, globose, yellowish; capillitium variable in quantity, sometimes abundant, brown, somewhat branching and anastomosing outwardly, the tips paler; spores minutely roughened, dark violaceous, about 10μ." He says that although this species has the outward appearance of a *Didymium*, the crust is made up of minute granules of lime, not crystals.

Lister describes the hypothallus as strongly developed and white; the columella convex or hemispherical, white or pale flesh-colored; spores spinulose, 8–10μ.

Massee adopts the name *Didymium spumarioides* Fr. He finds the columella sometimes almost obsolete; spores warted, 9–12μ.

Macbride's description is as a whole adequate, but I fail to see the "peridium plainly double." This might be *Physarum cinereum*, but that it has a columella in most sporangia, and has no calcareous nodes in the capillitium—these characteristics making a vital distinction, of course. I find the spores dark purplish, distinctly warted, and quite uniformly 10μ in diameter.

We have one collection, made at Devil's Lake, July 15, 1905, growing on a green moss and its ripe sporophyte setae; another, having many variations of form, on dead leaves, from the campus woods, July 1904.

Diderma globosum Persoon.

1794. *Diderma globosum* Pers., *Rom. N. Mag. Bot.*, I., p. 89.

Macbride: "Sporangia more or less gregarious, sessile, globose, or by mutual pressure prismatic or polyhedral, white, the outer wall smooth, polished, crustaceous, fragile, far remote from the inner, which is thin, smooth or rugulose, irridescent blue; hypothallus usually pronounced and spreading beyond the sporangia,

sometimes scanty or lacking; columella variable, sometimes very small, inconspicuous, sometimes large globose, ellipsoidal, even pedicellate; capillitium abundant, brown or purplish-brown, branching and occasionally anastomosing to form a loosely constructed superficial net; spores globose, delicately spinulose, 8μ." In his "key" to the genus *Diderma*, Macbride gives the spores as 8–10μ in diameter. He adds that this species seems rare in this country; that the only specimens so far are from Iowa; that it is distinguished by small spores and general snow-white color.

Lister says in part: "The outer wall is egg-shell like, composed of globular lime-granules 1–2μ in diameter; spores dark purplish brown, spinulose, 10–14μ in diameter."

Massee adopts the name *Chondrioderma globosum* Rost. He says the inner wall is cinereous, often iridescent; spores 8–10μ.

I find most of the characteristics like those described above. The sporangia are noticeably two-walled, the outer wall at a distance from the inner; the inner wall, while not noticeably bluish, yet is iridescent when held in sunlight; the columella is generaly white and varies in size even in adjoining sporangia; in one collection the hypothallus is abundant, in another it is scanty; the spores are from 8 to 12μ in diameter, none larger, and most of them 10μ, dark purplish, and distinctly spinulose.

One group was found at the St. Louis River, opposite New Duluth, August 2, 1897, on wood burned to charcoal; another at Eagle Heights, near Madison, August 6, 1904, on green moss and dead oak leaves and twigs.

Diderma crustaceum Peck.

1871. *Diderma crustaceum* Peck, *Rep. N. Y. Mus.*, XXVI., p. 74.

Macbride: "Sporangia closely crowded or superimposed, in a cushion-like colony, creamy-white, globose, imbedded in the substance of the hypothallus, the outer peridium smooth, delicate crustaceous, fragile, remote from the blue iridescent inner membrane; hypothallus prominent; columella variable, generally present, globose; capillitium dark colored, the threads branching and combining to form a loose net: spore-mass black, spores by transmitted light dark violaceous, delicately roughened, 12–15μ."

Lister classes this species with *D. globosum*, but Macbride says

that *D. globosum* is rare in this country, and that almost everything distributed in he United States as *D. globosum* belongs in *D. crustaceum.* Lister's description does not apply as closely to this species as does Macbride's description of *D. crustaceum.*

Under the name *Chondrioderma crustaceum* Berl., Massee calls this species effused or circumambient, crowded, sessile, subglobose, smooth, white, outer peridium crustaceous, like the shell of some small egg. He finds the spores globose, black, about 13μ in diameter.

Macbride's description is accurate for the specimens which we have. We have collections from Blue Mounds, August 18, 1903; from *Eagle Heights,* Madison, August 31, 1904; another from Madison, no date; and one from Devil's Lake July 14, 1906, on very much decayed leaves.

Diderma hemisphericum (Bull.) Horne.

1791. *Reticularia hemispherica* Bull., *Cham. de Fr.,* I., p. 93.
1829. *Diderma hemisphericum* (Bull.) Horne,*Fl. Dan.,* XI., p. 18.

Macbride: "Sporangia gregarious, orbicular, discoid, depressed above and often umbilicate below, stipitate or sometimes sessile, the outer peridium white, fragile, crustaceous, soon breaking about the margins, closely applied to the inner, which is delicate, cinereous, and ruptures irregularly; stipe about equal to the diameter of the sporangium, 1 mm., rather stout, calcareous but colored, brownish or alutaceous, more or less wrinkled longitudinally, the wrinkles when present forming veins on the lower surface of the sporangium: hypothallus small; columella not distinct from the thickened brownish or reddish base of the sporangium; capillitium of delicate threads, mostly simple and colorless, often scanty; spores pale violaceous, nearly smooth, 8–9μ."

Macbride adds that this is a well-marked species, easily recognized by its remarkable discoid or lenticular sporangia in the stipitate type.

Lister's description differs but little from Macbride's. He says the plasmodium is white, the sporangium scattered, rarely confluent; often seated on a white hypothallus; spores pale violet-brown, almost smooth, 7–9μ in diameter.

Massee calls the stem pale ochraceous or whitish; columella

flattened, dingy red; mass of spores black with purple tinge; spores dingy lilac, smooth.

The above descriptions are accurate for my specimens.

This species is indeed well marked. In the one large collection which I have, there are both stipitate and sessile forms, and some confluent forms. The spores are about 8μ in diameter. They are on dead oak leaves, and were collected on a lawn in Madison, July 20, 1904.

Brefeldia maxima (Fries.) Rost.

1825. *Reticulari maxima* Fries, *Syst. Orb. Veg.*, I., p. 147.
1875. *Brefeldia maxima* (Fries) Rost., *Versuch.*, p. 8.

Saccardo: "Æthalia nude, surface warted, purplish-black, resting upon a well developed silvery-shining hypothallus; 3–6 cm. long and wide, 5–10 mm. thick; spores purplish to brownish dusky black, globose, spinulose, 11–12μ in diameter."

Macbride calls the æthalia papillate above. He says the sporangia in favorable cases are distinct, indicated above by the papillae; columella obscure, black; capillitium abundant, the threads united by multifid ends to surround as with a net the peculiar vesicles. He gives the diameter of the spores as 12–15μ and calls them distinctly papillose. He states that in well-matured æthalia the sporangia stand out perfectly distinct, particularly above and around the margins. In the center of the fructification, next the hypothallus, the sporangia are very imperfectly differentiated.....Each filament bears at its middle point a peculiar plexus which embraces several large cysts or vesicles.

Lister speaks of the spongy basal tissue continuing among the sporangia as folds forming distinct rigid columellae.

Massee speaks of the surface as being rough with irregular wart-like nodules. He gives the diameter of the spores as 13–17μ. He adds: "Forming large pulvinate patches of irregular form varying from 1–9 inches across."

This species is easily determined by the papillate character of the surface and the peculiar character of the capillitium, which is well described by Macbride. I find the spores to be 10–12μ in diameter. We have but one specimen, which was found in Madison in October 1882, growing upon what seems to be a mass of half-decayed leaves.

Stemonitis maxima Schweinitz.

1834. *Stemonitis maxima Schw., N. A. F.*, p. 260, No. 2349.

Macbride: "Sporangia in more or less widely scattered tufts at first dark brown or purple black, at length gray, always with a purplish tinge, long cylindric, even, 10–15 mm. in height. stipitate; stipe polished, black and shining, about ¼ the total height, expanded below into a thin hypothallus, which is continuous, transparent, shining; columella dissipated near the apex; capillitium consisting of an inner network of very loose, open structure, an outer net of small 14–56μ) meshes more or less abundantly supplied with projecting peridial processes; spores dark violaceous, the surface reticulate, 7–8μ." He says this is the commonest American species. The rough-netted epispore instantly distinguishes it. The sporangia are long and slender in tufts, spreading from the center. The inner network of rich brown threads tends to show expanded nodes; sometimes the threads are thickened throughout. The columella often fails of reaching the apex of the sporangium, becoming completely dissolved in capilitial branches.

Lister adopts the name *S. fusca* Roth. "Plasmodium white in rotten wood, maturing at the place of emergence. Total height 5–20 mm. Sporangia cylindrical, obtuse, stalked, brownish-purple, at first closely fasciculate. Stalk black, shining, 1–4 mm. long, rising from a well developed brown membranous hypothallus. Columella reaching to near the apex of the sporangium." He finds the spores grey or rufous-violet, reticulated with rows of minute spines or with raised bands, and 8–10μ in diameter. He finds great variations in the surface-markings of the spores; he finds sporangia widely differing in length and in stalks.

Massee differs but little. He calls the walls blackish, reflecting metallic tints, evanescent; peripheral meshes of the capillitium much larger than the diameter of the spores; mass of spores blackish brown; spores globose, very minutely verruculose, 5–10μ in diameter. A fine large species, distinguished amongst the dark-spored species by the large peripheral meshes of the capillitium.

There is a great variation in the color and size of the sporangia and the proportion of the stipe, in the specimens that I have of

this species, as well as in the length of the columella, the character of the external net, and the number of the peridial processes. I find sporangia from 7 mm. to 15 mm. tall. The markings on the epispore, when visible at all, are determinative. The spores are always reticulated, dusky or purplish, and from 6 to 8μ in diameter.

Dr. Macbride determined for me one large group of very short and quite dark brown sporangia, found at Blue Mounds, July 1904.

Collections:—Campus and cemetery woods, four collections, July 1904; small sporangia, Science Hall greenhouse, July 1904; from Blue Mounds a large and very beautiful group of long sporangia, June 13, 1904; another group of much shorter and darker sporangia collected on the same date and from the same locality, both collections made by Prof. R. A. Harper; and in July from the same locality a group of quite different general appearance.

Stemonitis Morgani Peck.

1880. *Stemonitis Morgani* Peck, *Bot. Gaz.*, V., p. 33.

Macbride: "Sporangia clustered irregularly, sometimes forming patches several centimeters in extent, rich purple brown in mass, cylindric, long, 15–18 mm., stipitate; stipe black, polished, shining, rising from a common hypothallus, which extends as a thin silvery film beneath the entire colony, but does not transcend its limits; columella black, percurrent, sparingly branched; capillitium of fuscous threads, within forming a network very open, the branches scarcely anastomosing until they reach the surface where they form the usual net of small meshes, pretty uniform in size, and presenting very few small, inconspicuous peridial processes; spores brown, very minutely warted, about 8μ. The clear brown tufts appear in fall, marvels of graceful elegance and beauty. At sight easily recognizable by the large size and rich color."

Lister adopts the name *S. splendens* Rost. He finds the plasmodium to be creamy-white; the sporangia rising from a well-developed silvery or purplish hypothallus; columella reaching to near the apex of the sporangium, rigid; capillitium of purplish-brown threads, the principal branches springing at distant in-

tervals from the columella, at first almost simple, suddenly branching to form a smooth superficial net with rounded variously shaped meshes. Spores pale reddish-purple, nearly smooth or minutely and closely warted, 7–9μ in diameter. The spores are remarkably constant in color and size, and in the minute, evenly distributed warts. The capillitium exhibits wide differences.

Massee finds the stem much shorter than the sporangium, black, shining. He thinks the spores smooth, and 6–7μ in diameter.

The variations within the same species of *Stemonitis* make specimens of this genus extremely difficult to determine. I find the sporangia about 18 mm. tall; there is almost no inner net, the main branches from the columella scarcely branching again until they reach the surface. The spores are minutely warted and 8μ in diameter.

One group of sporangia which we have was obtained near Webster, growing on rotten wood, in the summer of 1894. A small group grew on the soil in the greenhouse in January 1913.

Stemonitis Webberi Rex.

1891. *Stemonitis Webberi* Rex. *Proc. Phil. Acad.*, p. 390.

Macbride: "Sporangia clustered, usually in small tufts, rusty brown in color, 8–10 mm., including the stipe, which is jet black, shining, and much expanded at the base; hypothallus continuous, well-developed, a thin transparent pellicle; columella black, tapering upward, giving off at intervals the capillitial branches, and becoming dissipated just below the obtuse apex; inner capillitial network very open, the branches far apart, anastomosing but a few times before breaking into the surface net to form large, irregular meshes, 50–125μ; spores minutely roughened, fuscous, 8–9μ."

Lister makes this a variety of *S. splendens* Rost., which is his synonym for *S. Morgani*. He gives no determinative characteristics.

Massee does not have the name *S. Webberi* in his list.

As is often the case among specimens of *Stemonitis*, this is difficult to determine. The sporangia are about 10 mm.; the inner net is very loose, the outer net coarse, irregular, the

meshes from 15μ to 60μ. The spores are brownish, minutely roughened, 7–8μ in diameter.

We have one collection, made near Wausau, in the summer of 1894.

Stemonitis Smithii Macbr.

1893. *Stemonitis Smithii* Macbr., *Bull. Lab. Nat. Hist. Ia.,* II., p. 381.

Macbride: "Sporangia in clusters, close packed and erect, not spreading, bright ferruginous prior to spore dispersal, cylindric, stipitate, of varying height; stipe jet black shining, about one-third the total height; hypothallus generally well developed; columella black, gradually tapering, at length dissolving in capillitial threads and net some distance below the diminished plumose apex; capillitium of fuscous threads, the inner network of sparingly united branches uniformly thickened, the surface net composed of small, regular, polygonal meshes, the peridial processes few; spore-mass bright ferruginous, spores by transmitted light pale, almost colorless, smooth, 5–7μ. The species as now constituted includes forms varying in size from 2.5–25 mm."

Lister: "Plasmodium white. Total height 7–12 mm. Sporangia cinnamon-brown. Stalk 3–6 mm. long, arising from a membranous hypothallus. Capillitium as in *S. ferruginea,* but the superficial net has rounded, more regular meshes, 5–10μ in diameter, and the threads of the meshes are often rather stout. Spores 4–6μ in diameter."

My specimens do not agree entirely with the above descriptions, but neither do they agree with that of *S. ferruginea.* The sporangia are from 7–12 mm. tall, but the stems are not over one-fourth the entire height. Many nodes of the inner network are broadened somewhat. The meshes of the outer net are not regular, and they vary from 5–14μ in diameter. The other characteristics, however, leave this species, without doubt, where I have placed it.

One of my specimens was found growing upon much decayed wood in Madison, October 1901, one was found upon bark near Tomahawk, and a third upon wood near the Whirlpool rapids of the Wisconsin, in the summer of 1893.

Comatricha longa Peck.

1890. *Comatricha longa* Peck, *Rep. N. Y. Mus.*, 43, p. 70.

Peck: "Stems growing from a shining membranous hypothallus, closely gregarious, penetrating the peridia as a columella, capillary, black; peridia narrowly cylindrical, generally elongated, 12–40 mm. long, often flexuous, very fugacious, its branches generally somewhat reticulately connected near their base and forming a few large meshes, externally divided into slender, sharp-pointed, divergent, spine-like branchlets, with free apices blackish; spores globose, even, .0003 to .00035 in. in diameter."

Macbride describes this species as having sporangia crowded in depressed masses or tufts. He says the stipe is generally very short and the hypothallus black. He calls the spore-mass blue-black and the spores by transmitted light dark brown, globose, warted, and about 9μ in diameter. He says the sporangia, though generally about 20–25 mm., occasionally reach 50 mm.

Lister notes the further fact that the columella is wavy, with angular flexures in the upper part, tapering in breadth from 20μ at the base to 2μ near the summit, and that the terminal branches of the capillitium are rigid and fork at an acute angle. He calls the spores dark gray, spinulose, the spines usually connected by faint lines forming a reticulation.

Massee includes this species in the genus *Stemonitis*, calling it *S. longa* Massee. He finds the axils of the capillitium branches usually rounded, and often occupied for some distance by a thin membrane, sometimes connected laterally. He finds the spores to be very minutely reticulated, 7–8μ in diameter.

The specimen which I have shows the general characteristics as described above. The sporangia are from 30 to 40 mm. long. The authorities whom I have quoted differ in regard to the epispore. I find the spores to be finely reticulated, but by very narrow bands so much raised above the surface as to look along the border like a regular row of sharp spines. I find the spores to be dark brown and 9μ in diameter.

My one specimen I found in the campus woods near the lake, growing upon smooth bark, in October 1903.

Comatricha nigra (Pers.) Schroeter.

1791. *Stemonitis nigra* Pers., *Gmel., Syst. Nat., p.* 1467.
1889. *Comatricha nigra* (Pers.) Schroeter, *Pils. schles.,* p. 118.

Macbride: "Sporangia scattered, ferruginous or dark brown, globose or ovoid, stipitate; stipe long, hair-like, tapering upward, black; hypothallus none; columella rapidly diminishing toward the top, at length dissipated; capillitium of slender flexuous threads, radiating horizontally, repeatedly branching and anastomozing to form an intricate dense network, from the surface of which project a few short hook-like peridial processes; spore-mass black, spores by transmitted light dark violaceous, smooth or nearly so, 7–10μ in diameter. This species is easily recognized by its almost globose sporangia mounted on long, slender stalks These are 2 or 3 mm, high and generally persist a long time after the sporangium has fallen."

Saccardo adopts the name *C. friesiana* (De By.) Rost. He does not differ from Macbride in his description.

Massee adopts the name *Stemonitis friesiana* De Bary. He states that the sporangium wall is very thin, disappearing, whitish with a silver sheen or purple black. He also speaks of the stem expanding at the base into a small, circular, irregularly ribbed or latticed hypothallus. The wall I have not seen. The hypothallus as he describes it shows plainly under the microscope, but is not noticeable without a lens.

Lister gives the total height of this species as from 1 to 6 mm., the color as purplish brown. He finds the capillitium threads anastomosing and branching in semicircular curves. This character of the branching I do not find to be constant. The spores he describes as nearly smooth, or minutely and closely spinulose.

I find the globose or ovoid sporangia with their long stipes quite determinative; and the long, slender columella, with the capillitium threads freely branching from its entire length, prevent its being taken for a *Lamproderma.* It agrees in general with the descriptions given above, though I find the spores smooth or nearly so, not spinulose.

Our one specimen I found growing upon a small, very hard, decorticated oak branch in the campus woods, July 18, 1904.

Comatricha stemonitis (Scop.) Sheldon.

1772. *Mucor stemonitis* Scopoli, *Fl. Carn.*, II., pp. 493-494.
1895. *Comatricha stemonitis* (Scop.) Sheldon, *Minn. Bot. Stud.*, p. 473.

Macbride: "Sporangia gregarious, scattered, cylindric, erect, sometimes arcuate, obtuse, 2–3 mm. high, at first silvery, then brown, as the peridium vanishes, stipitate; stipe black, about one half the total height or less; hypothallus distinct, more or less continuous, reddish brown; columella tapering upward, black, attaining more or less completely the apex of the sporangium; capillitium arising as rather stout branches of the columella, soon taking the form of slender, flexuous, brownish threads, which by repeated anastomosing form at length a close network, almost as in *Stemonitis*, the free ultimate branches very delicate and short; spore-mass dark brown; spores by transmitted light, pale, almost smooth, except for the presence of a few scattered but very prominent umbo-like warts, of which four or five may be seen at one time, 5–7.5μ in diameter."

Lister adopts the name *C. typhoides* Rost. He gives but little in his description differing from the above. He says the capillitium varies in the closeness of the network, and that forms occur in which the threads are less flexuose. He finds the spores to be pale lilac-brown, marked with 3–5 dark, flattened warts on the hemisphere, and 3.5 to 7μ in diameter.

Saccardo calls the spores smooth and from 4.5 to 5μ in diameter.

The specimens which I have agree very closely with Macbride's description. Remains of the violet-tinted peridium are upon the apices of many of the sporangia. The spores are quite determinative—the few umbonate warts being very characteristic.

One specimen was found growing on dead soft wood, at Edgewood, Madison, July 18, 1903; two at Elmside, July 15, 1904, one being on a much decayed oak stump and the other on a dead poplar log; another on the inside of poplar bark found in the cemetery woods, July 21, 1904; another on poplar wood found in the campus woods, July 22, 1904; another on dead wood found on the Windsor road, July 30.

Comatricha Persoonii Rost.

1875. *Comatricha Persoonii* Rost., *Mon.*, p. 201.

Macbride: "Sporangia gregarious, erect, cylindric, obtuse, pale brown, stipitate; stipe short, one-half to one-third the total height, 1–1½ mm., black, slender, even; hypothallus thin, scanty, transparent or white; columella black, tapering gradually to the apex, or very near it; capillitium very dense, formed of flexuous fuscous threads, branching abundantly, especially outwardly, and ending in numerous short, free tips; spores covered with distinct but scattered warts, pallid, tinged with purple, 9–10μ."

Macbride also says: "This species in form and stature closely resembles *C. tyhina*, but differs in the capillitial structure and the epispore markings. In these particulars it more nearly corresponds with *C. pulchella*, from which its slender cylindric form and blunt, sometimes widened apex distinguishes it."

Lister has no single species to which this corresponds.

Massee does not recognize the genus *Comatricha*, but puts all of these forms in the genus *Stemonitis*. He does not give *C. Persoonii* among his synonyms, and does not describe any form which corresponds to this as Macbride describes it.

Of this species I have but one group. I find the sporangia, including the stipe, from 2 to 3 mm. high, the stipe alone ½ to 1 mm. The spores are dusky, warted, and about 8μ in diameter.

This collection was made in Vilas woods, July 16, 1904.

Comatricha flaccida (Lister) Morgan.

1894. *Comatricha flaccida* (Lister.) Morgan, *Jour. Cin. Soc.*, p. 51.

Macbride: "Sporangia semi-erect, closely crowded in tufts an inch or two in diameter, ferruginous, from a dark brown hypothallus, sessile or short stipitate; columella weak, crooked, percurrent, generally enlarged irregularly at the apex; capillitium of few slender brown branches which anastomose sparsely and irregularly; spore-mass ferruginous brown; spores by transmitted light bright reddish brown, minutely warted, 8–10μ."

Lister adopts the name *Stemonitis splendens* Rost., but although Macbride gives this name (var. *flaccida*) as a synomym,

Lister's description does not agree very well with either Macbride's description or my specimen. Lister says the plasmodium is creamy white, maturing at the place of emergence, which I find to be true. He says the sporangia are at first closely fasciculate. I find them persistently so at and after maturity. He describes a superficial net of the capillitium which I fail to find, and the lack of which causes Macbride to place this species in the genus *Comatricha*. My specimen agrees with Macbride's description.

I have one specimen, growing on poplar wood, found in the cemetery woods October 22, 1903.

Diachea leucopoda (Bull.) Rost.

1875. *Diachea leucopoda* (Bull.) Rost., *Mon.*, p. 190.

Saccardo: "Peridia cylindrical, obtuse, stipitate; stipe short, base thickened, snow-white, lengthened within the peridium into a white cylindrical columella which does not reach the obtuse vertex of the peridium; capillitium threads white, slender; spores dark violet, iridescent, 6–8μ in diameter."

Macbride adds to the above characteristics that the sporangia are rather closely gregarious, metallic blue, or purple iridescent, cylindrical or ellipsoidal and sub-umbilicate below. The hypothallus is white, venulose, occurring from stipe to stipe to form an open network over the substratum. The capillitium threads he calls brown, which agrees with the specimens that I have. The spores in mass he finds to be nearly black. I find them slightly iridescent. The spores he calls dull violaceous, minutely roughened, 7–9μ in diameter. The peridium is exceedingly thin and early deciduous; the stipe long persistent.

Lister finds the stalk to be stout, brittle, furrowed, one-third or one-half the height of the sporangium. He finds the capillitium of profusely branched and anastomosing threads connecting the columella with the sporangium wall, dark violet-brown, colorless at the extremities. The spores he calls minutely spinulose.

Massee adds nothing new to the above descriptions.

I find this beautiful little species easily determined from its very white stipe and its dark iridescent sporange. The whole sporange is quite likely to disappear early, leaving sometimes a

large number of the white conical stipes without a single sporange to show what it had been.

I have specimen gathered at Blue Mounds, August 18, 1903, of which none of the sporanges remain; the white stipes covering the setae of a green moss. Two specimens in which this species was growing on leaves, grass, moss and small twigs were found opposite Fond du Lac, July 28, 1897. Not many of the sporanges remain on the stipes of these. I found some fine specimens in the cemetery woods, July 21, 1904, and two lots were found at Blue Mounds, July 23, 1904. Of these last some were growing on a piece of dead twig which was about three-fourths of an inch in diameter, some on a living green fern frond, and a great quantity on dead leaves which had lodged beside a decayed log. Specimens found in Vilas woods, July 28, 1904, include one group on a thick dead oak leaf, the hypothallus in this showing its venulose character very beautifully. Another group on many green leaves and stems was found at Blue Mounds, July 13, 1907.

Lamproderma violaceum (Fries) Rost.

1829. *Stemonitis violacea* Fries, *Syst. Myc.*, III., p. 162.
1875. *Lamproderma violaceum.* (Fries) Rost., *Mon.*, p. 204.

Macbride: "Sporangia closely gregarious or scattered, depressed globose, more or less umbilicate below, metallic blue or purple, sessile or short stipitate; stipe stout, dark brown or black, even; hypothallus when the sporangia are crowded, a thin, continuous, purplish membrane; when the sporangia are scattered, the hypothallus discoidal; columella cylindric or tapering slightly upward, the apex obtuse, black, attaining the center of the sporangium; capillitium lax and flaccid, made up of flexuous threads branching and anastomosing to form a network, open in the interior, more dense without, the threads at first pale brown as they leave the columella, becoming paler outward to the colorless tips; spores minutely warted, violaceous gray, 9–11μ. When the sporangia are empty the pallid extremities give a whitish appearance to the little spheres. Only when the spores are ready for dispersal does the peridium assume its rich metallic purple tints."

Saccardo's description does not differ from the above.

Lister speaks of the capillitium threads as springing from the upper part of the columella. He gives the total height of the fruit-body as 0.6 to 1.5 mm.

Massee says the branches of the capillitium spring from the apex and sides of the columella. He calls the spores smooth and 9–12μ in diameter.

I find Macbride's description to be the most satisfactory for my material. The peridium is evanescent, but the fragments remaining are of an intense metallic violet-blue. The capillitium is attached almost entirely to the top of the columella, the points of attachment not extending below the rounded edges of the truncated top. The spores I find violaceous, evidently warted, and 9–11μ in diameter.

Large groups of this species were found at the mouth of the Brulé River, July 17, 1897, growing on the stems of green moss, and at Sturgeon Bay, July 24, 1907, growing on dead leaves and twigs in the woods.

Reticularia lycoperdon Bulliard.

1791. *Reticularia lycoperdon* Bulliard, *Champ. de la France,* p. 95.

Saccardo: "Spores, columella, and capillitium brown, cortex also of the same color, opaque, thin, silvery-smooth or unequally covered with warts; spores reticulated upon half their surface, 8–9μ in diameter.

Macbride's description is much more complete: "Æthalium pulvinate, 2.8 cm. broad, at first silvery white, later less lustrous, the cortex irregularly and slowly deciduous; hypothallus at first conspicuous as a white margin extending round the entire æthalium, evanescent without, but persisting as a firm membrane beneath the spore-mass; spore-mass umber." He calls the reticulated portion of the spore-surface about two-thirds, and says the remaining portion is slightly warted.

Lister describes the capillitium as consisting of the persistent remains of the sporangium walls, forming irregular chambered and branching strands arising from the hypothallus, dividing above into numerous flattened and delicate flexuous threads. He speaks of the spores as somewhat turbinate, thickened and closely

reticulated on the rounded side, the remaining part marked with scattered warts. He gives their size as 6–8μ in diameter.

Massee describes the color as varying from dull umber, through reddish-brown to pale gray with silver lustre. He also speaks of the slender anastomosing branches of the capillitium. He calls the spores 7–9μ in diameter.

The one specimen which I have is about an inch and a half long, a beautiful silvery-white, cortex slightly roughened. Lister has described the character of the capillitium as I find it, quite exactly. I find the spores as he describes them, appearing turbinate in some positions; but the reticulated portion is more nearly two-thirds than a half, as given in the original description. The edge of the reticulated portion stands out from the remainder of the surface in quite a marked way, as if a part had been cut off. I find the spores to be from 7 to 11μ in diameter.

This specimen was found growing on the bark of an erect maple in Madison, October 18, 1901.

Enteridium rozeanum Wing.

1892. *Enteridium rozeanum* Wingate, Macbr., *Bull. Lab. Nat. Hist. Iowa*, II., p. 117.

Massee gives Wingate's original description, which I quote in part: "Æthalium of irregular shape, globose, ovoid, or rounded pyramidal, attached to the substratum by a wide base. Variable in size from 5–30 mm. in diameter. Cortex and mass of spores ferruginous brown; occasionally the cortex shining; sometimes membranous, pellucid. .... The walls of the sporangia (which form a capillitium) membranous, pellucid, bandlike, combining into an all-sided network attached uniformly to all sides of the cortex. The bands have triangular or polygonal expansions at the angles where they join each other. Spores globose, about two-thirds of the surface covered with a delicate, regular, fine-meshed network, the remainder with simple warts or elongated ridges. .... Spores measure 7.5–9μ."

Macbride adopts the name given by Morgan, *E. splendens*. His description adds to the excellent one given above: "Æthalium pulvinate, even, or somewhat irregular, unevenly swollen or inflated, lobate or compound, covered by an exceedingly thin, generally smooth, shining, but never white pellicle or cortex;

.... hypothallus white, often wide extending. .... Easily distinguished by its brown color and smooth, shining, though uneven surface."

Lister does not differ from the above quoted descriptions.

The foregoing descriptions are very satisfactory. I have found small specimens of this species growing in the midst of *Lycogala epidendrum* of about the same size. There was, however no difficulty in distinguishing them. The *Enteridium rozeanum* has generally a broader base, and always more or less of a thin light brown, often white, hypothallus partly or wholly surrounding it. The surface, too, is more irregular and of a redder brown than the *Lycogala*. Many are pulvinate and lobed. Those I have vary from ½ to 6 cm. in length. I find the spores to be more regularly globose than those of *Reticularia lycoperdon*, and with less of the surface reticulated—not more than half, with the rest of the spore minutely roughened; spores 7–9μ

We have two specimens from Wisconsin which do not have the exact locality and date given; another from near Webster on dead wood, collected in the summer of 1894; one from Blue Mounds, October 4, 1902; three from Madison, 1901; several marked Madison, October 14, 1897; several Madison, October 19, 1901; and a large number from the cemetery woods, Madison, October 20, 1903. Many of the latter show large tubules, whitish inside, extending to or above the surface, which have been made by insects. In some of these tubules the dead insect is still to be found.

Macbride says in his description, "capillitium none," yet on Plate I. of the same book he gives a figure which he, on the opposite page, calls the capillitium of this species. The illustration agrees with the structure which I find in the interior of the æthalia.

Lindbladia effusa (Ehr.) Rost.

1818. *Licea effusa* Ehr., *Sylv. Myc. Ber.*, p. 26.
1875. *Lindbladia effusa* (Ehr.) Rost., *Mon.*, p. 223.

Saccardo: "Æthalia nude, upon a common well-developed hypothallus, cortex very early becoming dry and dark, thick, brown, shining, wrinkled: spore-mass ochraceous or umber-brown; spores clear, brownish, smooth, 6–7μ."

Macbride gives a fuller description than the foregoing. "Sporangia minute, either closely combined and superimposed, so as to form a pulvinate æthalium, or crowded together in a single layer, sessile or short stipitate; the peridia thin, membranous, marked by scattered plasmodic granules, often lustrous, sometimes dull lead-colored or blackish, especially above; stipe, when present, very short but distinct, brown rugulose." He calls the spores nearly smooth, almost colorless, 6–7.5μ in diameter. He adds that the sporangia are sometimes free and even short-stipitate. In the more complex phase the sporangia are heaped together in a pulvinate mass. The hypothallus is a prominent feature.

Lister's description varies but little from the foregoing. He speaks of the sporangium-wall as membranous, yellow-brown, uniform, beset with scattered clusters of dark, round, plasmodic granules, 1μ in diameter. He calls the spores faintly warted, 4–6μ in diameter.

Massee makes this species a *Tubulina* (*T. effusa* Massee). His description contains nothing different from the above except that he calls the spores yellowish-brown, very indistinctly verruculose, 6–8μ in diameter. He adds: "Often forming compact, flattened cakes extending for three or four inches."

We have fine specimens on moss and the decayed wood on which the moss grew; the masses are from one-half to two and one-half inches long, the most of each mass in a single stratum and thin, but in some places the sporangia are superimposed; the hypothallus is very marked but not extending beyond the sporangia; sporangia not noticeable wrinkled; capillitium none; spores almost colorless, faintly warted, 6–7μ in diameter.

These specimens were collected near Wausau in the summer of 1894.

Tubifera ferruginosa (Batsch) Macbr.

1786. *Stemonitis ferruginosa* Batsch, *Eleuch.*, p. 261, fig. 175.
1791. *Tubifera ferruginosa* Gmelin, *Syst. Nat.*, p. 1472 (ex parte).

Macbride: "Sporangia crowded, cylindric or prismatic, elongate, connate, more or less distinct above, pale umber brown, generally simple though occasionally branched above, the per-

idia thin, sometimes fragile, but generally persistent, transparent iridescent; hypothallus strongly developed, spongiose white, often projecting beyond the æthalioid mass of sporangia; sporemass umber-brown or ferruginous; spores by transmitted light almost colorless, plainly reticulate over three-fourths of the surface, 6–7μ. Not rare on old logs, mosses, etc., from Maine to Alaska. Apparently more common north than south. Easily known by its long, tubular sporangia packed with rusty spores and destitute of any trace of columella or capillitium, the hypothallus explanate, rather thick, but not columnar. A single plasmodium may give rise to one or several colonies, at first watery or white, then red, of somewhat varying shades, then finally umber-brown.'' Macbride goes on to say that the peridia are sometimes acuminate, and widely separate above. In most cases, however, the peridia are connate throughout, and sometimes present above a common membranous covering.

Saccardo adopts the name *Tubulina cylindrica* (Bull.) D. C. He calls the spores 5–6μ in diameter.

Lister differs from the above description in his measurement of the spores, which he gives as 7–9μ. He also says that the sporangia when immature and pulpy are of a beautiful strawberry color.

The two specimens which I have were found at Watertown, August 31, 1903. They were growing quite close together on the end of a decayed piece of wood. They are well-rounded masses about two-thirds and seven-eighths of an inch in diameter respectively, each on an inconspicuous white hypothallus. When found they were bright red. When fully ripe they become umber-brown. Macbride's description seems accurate for these specimens.

Later, on July 9, 1904, a mass of this species nearly covering a space 4 by 5 inches was found growing on much-decayed wood at Blue Mounds. Another small specimen I found at Blue Mounds, July 23, 1904.

Tubifera stipitata (Berk. & Rav.) Macbr.

1868. *Licea stipitata* Berk. and Rav., *Jour. Linn. Soc.*, X., p. 350.

1875. *Tubulina stipitata* (Berk. & Rav.) Rost.

Macbride: "Sporangia crowded in a globose or more or less hemispheric, expanded head, borne upon a spongy, stem-like, sulcate hypothallus, their apices rounded, their walls very thin, evanescent; spores in mass umber-brown, small, about 5μ, the epispore reticulate as in *T. ferruginosa*. This species differs from *T. ferruginosa* chiefly in the cushion-like receptacle on which the crowded sporangia are borne, and in the smaller spores."

Saccardo adopts the name *Tubulina stipitate* (Berk. & Rav.) Rost. He differs from Macbride in calling the spores delicately warted.

Lister finds the spores to be minutely reticulated over the greater part of the surface, the remaining part smooth or marked with ridges, and 3 to 5μ in diameter.

Massee adopts the name *Tubulina stipitata* Rost. He describes the spores as having about three-fourths of the surface covered with a regular small network, the remainder with much larger meshes.

I find the distinctive points of this species to be the stem-like hypothallus, and the small size of the spores. The spores are finely reticulated over the greater part of the surface, the remainder having a very irregular network of rather coarse ridges.

The one group of specimens which I have was found in Vilas woods, July 16, 1904, growing on much decayed oak.

Cribraria aurantiaca Schrad.

1797. *Cribraria aurantiaca* Schrader, *Nov. Gen. Pl.*, p. 5.

Saccardo: "Sporangia gregarious, spherical, more or less cernuous, stipitate, tawny to dark tawny; stipe attenuate above, dusky; calyculus well developed, hemispherical, the margin armed with short acute teeth; nodules commonly much branched, the apices prolonged so as to at length join with one another;

spores from pale golden to dusky yellow, smooth, 5–9μ in diameter.''

Macbride adds a very important distinction—that the calyculus is more or less distinctly marked by fine delicate radiating venules. He finds that the net forms rather large three- to five-sided meshes with small, irregular, brownish nodules and showing only here and there a free extremity. He also states that this species is generally recognized by the large sporangia, 0.5–0.9 mm., the comparatively short stipe, simple net, and more or less orange color, the color being uncertain.

Lister describes the calyculus as one-third the height of the sporangium, and beset with round plasmodic granules 0.5 to 1μ in diameter, arranged in close lines radiating from the base. I find this description very good for the character of the calyculus.

Massee adds that the sporangia are scattered, which I find to be true. They are never crowded.

My specimens agree with the above quoted descriptions. Among the ripe sporangia I found a small quantity of little intensely black and shining droplets, which may have been immature sporangia. Many of the ripe ones which had not lost their spores had a tiny black spot on top. I tried to induce the black droplets to develop in a moist chamber, but they at once became covered with a white mold and failed to develop.

I made a large collection of this species from a decayed oak stump at Elmside, Madison, July 15, 1904.

Cribraria dictydioides Cke. and Balf.

1881. *Cribraria dictydioides* Cke. and Balf., *Rav. Fung. Am.*, 475.

Macbride: ''Sporangia gregarious, of medium size, globose, cernuous, stipitate; the stipe long, slender, tapering upwards, dull brown in color; hypothallus none; the calyculus variable, sometimes well-developed, as in *C. aurantiaca*, sometimes rudimentary or represented only by irregular node-like ribs; the network delicate, the meshes small, few-sided; the nodules large, prominent, brown, irregular, with many radiating, free projecting threads, besides the single continuous filaments which pass

from node to node; spore-mass pale, ochraceous; spores nearly smooth, colorless, 5–7μ."

He says that this seems to be the most common *Cribraria* in the Mississippi valley, and that it is generally distinguished by the scant calyculus and the beautiful richness of its complex net; that the calyculus is often entirely absent, and this would seem to be the typical condition. The rather large sporangia, 0.6 mm., and the especially numerous radiating threads, seem to be the most distinctly diagnostic characters.

Lister places this as a variety *dictydioides* of *C. intricata* Schrad. He finds the cup almost or quite obsolete; the nodes in the lower part of the net elongated and confluent, forming ribs converging to the apex of the stalk.

Massee gives as the most distinctive characteristics: permanent ribs broad and flattened below, anastomosing laterally, filled with granules, passing upwards into numerous elongated or irregularly angular, prominently convex, colored nodes containing granules, and connected at various points by very thin, colorless threads; the spores minutely verrucose, 5–7μ in diameter.

The variability of the calyculus makes this species sometimes difficult to determine. In one collection that I have, the calyculus is entirely absent, the sporangia having only ribs and nodules. In another, the calyculus is quite noticeable. The spores I find to be colorless and about 6μ in diameter.

Our specimens are on much-decayed wood, and were found in Vilas woods in July 1904, and at Mauston, in June 1905.

Cribraria tenella Schrader.

1797. *Cribraria tenella* Schrad., *Nov. Gen. Pl.*, p. 6

Macbride: "Sporangia gregarious, small, 0.4–0.5 mm. in diameter, olivaceous or ochraceous, long-stipitate, nodding; stipe slender, dark brown or blackish, very long, reaching 6 mm., weak and flexuous; calyculus variable, sometimes well-defined, brown, costate, sometimes represented by the costae only connected by a thin, transparent membrane; net well differentiated, the meshes small, irregular, the nodes small, black, more or less globular, prominent, connected by transparent threads with occasional or numerous free ends; spores in mass olivaceous-ochraceous, under the lens pallid, globose, smooth, 5–7μ. Generally

easily recognized by its very long stipe, small globose sporangium dotted with numerous small roundish nodules projecting plainly above the general surface. The obconic calyculus is always represented in the outline, if not in definite structure."

Lister calls the cup one-third the height of the sporangium, or more or less obsolete. The nodes are connected by three to six very slender threads, and few or no rays.

Massee finds the calyculus occupying about half the sporangium, often perforated above.

The description of Saccardo does not differ essentially from the above.

The specimens which I have agree with the above descriptions in general. The calyculus is variable, as Macbride has said.

My one collection of specimens was found at Madison, May 1902, growing on much weather-worn soft wood, mixed with the ripe sporangia of *Hemitrichia clavata*.

Dictydium cancellatum (Batsch) Macbr.

1789. *Mucor cancellatus* Batsch, *Eleuch. Fung.*, II., p. 131.
1889. *Dictydium cancellatum* (Batsch.) Macbride, *N.-A. S.-M.*, p. 172.

Macbride gives the best description: "Sporangia gregarious, depressed globose, nodding, the apex at length umbilicate, stipitate, in color brown, or brownish purple; the stipe varying much in length from two to ten times the diameter of the sporangium, attaining from 5 to 6 mm., generally erect, more or less twisted and pallid at the apex, below dark brown, with hypothallus small or none; calyculus often wanting, when present a mere film connecting the ribs of the net; the net made up chiefly of meridional ribs connected at intervals by transverse parallel threads, above an open *Cribraria*- like network closing the apex and more or less rudimentary; the spores varying in color through all shade of brown and purple when seen in mass, by transmitted light reddish, 5–7μ, smooth or nearly so."

Saccardo adopts the name *D. cernuum* (Pers.) Nees. He calls the spores yellow-brown, smooth, and 4–5μ in diameter.

Lister calls the color red-brown; the spores pale red, minutely warted, and from 4–7μ in diameter. He finds the spores "usu-

ally with two to four purple plasmodic granules on the spore wall."

Massee adopts the name *D. cernuum* Nees. His description agrees essentially with the foregoing.

In the specimens which I have I find some of the spores with the purple plasmodic granules mentioned by Lister, but I think their connection with the spores is accidental, the granules having been separated from the ribs and merely touching the surface of the spores.

I find the spores by transmitted light not reddish but rather faintly yellowish, nearly colorless and smooth. The meridional ribs of this species render the determination certain.

One of my specimens from the campus woods, July 18, 1904, and another from a different part of Madison, growing on decayed wood, are of a decided purplish tinge; another from the cemetery woods, July 9, 1904, is a light rusty-brown, showing no hint of purple, and three gathered in Vilas woods, July 16, 1904, and one at Blue Mounds, July 8, 1904, are brown with a more or less purple tint. All are on wood except one of the Vilas woods specimens, which is partly on a thin bark.

Lycogala epidendrum (Buxb.) **Fries.**

1721. *Lycoperdon epidendron,* etc., Buxbaum, *En. Pl. Hal.,* p. 203.

1829. *Lycogala epidendrum* (Buxb.) Fries, *Syst. Myc.,* III., p. 80.

Saccardo: "Æthalia gregarious, spherical, shining, warted, at first pink, then red, at length ashen or dusky; spores and capillitium various colors, pink, purple, violet-red, at length pale, lead-color or gray; spores smooth, 3–5μ in diameter."

Macbride has found the æthalia solitary as well as clustered. He calls them depressed-spherical, or when crowded, irregular, 3–10 mm. in diameter. He finds them dehiscing irregularly, but more often near the apex. He adds: "Peridium thin, but tough and persistent, made up of numerous agglutinated tubules, enclosing in their meshes peculiar cell-like vesicles; capillitium parietal, consisting of long, branching, and anastomosing flattened tubules extending inwardly among the spores, everywhere marked by transverse wrinkles, ridges and warts, the free ends of the ultimate branchlets rounded, concolorous with the spores;

.....spores by transmitted light colorless, minutely roughened or reticulate, 5–6μ.''

Lister's description agrees with those already given excepting as to the size of the spores, which he gives as 5–7μ in diameter.

Massee finds the diameter of the capillitium thread 8–12μ, its tube soon collapsing; he finds the spores minutely but distinctly warted and from 4 to 6μ in diameter.

The above descriptions are fairly correct for my specimens. I find the capillitium to be of long, branching, anastomosing tubes from 3 to 21μ thick, wrinkled, with free ends which are clavate, spherical, or merely rounded off. The spores are minutely roughened, 6–7μ in diameter.

We have specimens from upwards of a dozen different localities in the state, including the Lake Superior region. This species seems to be one of the most common and most plentiful. We have it collected April 29, 1904, at Blue Mounds, evidently just grown. We have collected it in July, October, and November. We have three groups of æthalia growing on three different species of *Polyporus,* one on wood charred by fire, on cedar, oak, and poplar, both on wood and bark, and on moss and the decayed wood on which the moss is growing.

Lycogala flavo-fuscum (Ehr.) Rost.

1818. *Diphtherium flavo-fuscum* Ehr., *Syl. Myc. Berol.,* p. 27.
1873. *Lycogala flavo-fuscum* (Ehr.) Rost., *Versuch.,* p. 3.

Æthalia spherical, surface opaque, smooth or indistinctly reticulate, brownish-gray; spore and capillitium-mass brownish-gray; spores delicately minutely spinulose 3.3–5.8μ in diameter, of a faint clay color.

Macbride speaks of the æthalia as solitary or two or three together, 2–4 cm. in diameter, purplish-gray or brown, smooth, shining; the peridium showing two or three layers in microscopic section: capillitium of abundantly branching, irregular, transparent tubules, marked by numberless warts and transverse rings or wrinkles; he calls the spore-mass yellowish gray, the spores by transmitted light colorless, smooth or faintly reticulate or roughened, 5–6μ in diameter. He says this species is generally mistaken for a puff-ball.

Lister states that the middle layer of the peridium is an aggregation of yellow vesicles intermixed with the peripheral ends of the capillitium, the inner layer homogeneous, pierced by the capillitium threads: he gives the diameter of the threads as 6 to 20μ or more, and speaks of their having numerous blunt-ended free branches.

Massee gives as the diameter of the æthalia 3–9 cm. He calls the tubes of the capillitium rather scanty, 4–5μ thick, slightly rugulose or with indistinctly raised bands.

The specimens which I have are from 2–3.5 cm. in diameter, brownish-gray, surface shining, under the hand lens showing reticulations. The spores agree with Macbride's measurements, 5–6μ. I find them faintly reticulate and colorless. The capillitium is distinctive and would separate it at once from the *Reticularias* or *Enteridiums,* with which it might be confounded. The capillitium thread is very broad in places, even 45μ, in others as narrow as 6μ; it is irregular, branched, wrinkled, minutely warted, with blunt ends. It resembles the capillitium of *L. exiguum* except in width. The color under the microscope is pale yellow. The figures given in Lister, Pl. LXXV., A, are correct for the capillitium as I find it.

This species does not seem to be common; our eight specimens are from Madison, collected in September, 1901, and November 16, 1894; one group of three æthalia growing on dead maple bark.

Lycogala exiguum Morg.

1893. *Lycogala exiguum* Morg, *Jour. Cin. Soc.,* p. 134.

Morgan: "Æthalia small, globose, gregarious, the surface dark brown or blackish, minutely scaly, irregularly dehiscent. The wall thin; the vesicles with a dark polygonal outline, disposed in thin reticulate patches, which are more or less confluent. The tubules appear as an interwoven fibrous stratum upon the inner membrane; they send long slender branched extremities inward among the spores. Spores in mass pale ochraceous, globose, nearly smooth, 5–6μ in diameter. Growing on old wood. Æthalium 2–5 mm. in diameter, the threads 2–10μ in thickness, with very slight thickenings of the membrane. The polygonal vesi-

cles give a reticulate appearance to the dark-brown patches which ornament the surface of the wall."

In Macbride's description are the statements that this is found in the same situations as *L. epidendrum* and at the same season; that this species is recognizable by its gregarious habit, small size, and dusky color; and that the little spheres are dark lead-colored, shading to black.

Neither Massee, Lister nor Saccardo mentions this species.

The specimens which I have agree with the above descriptions very closely. The æthalia besides being smaller than those of *L. epidendrum*, are of a dusky brown or nearly black color from the first. The irregular scales on their surface under the lens show the vesicles as having nearly regular polygonal outlines, quite different from those in the peridium of *L. epidendrum*. The spores are smoother and not tinted with yellow. The capillitium threads I find to be from 3–9μ wide, and although preserving the general appearance of those of *L. epidendrum*, yet the wrinkles in these are less deep, fewer, and are irregularly placed.

We have but one specimen, which was found growing on decaying basswood, at Devil's lake, July 2, 1904.

Ophiotheca Wrightii Berk and Curtis.

1868. *Ophiotheca Wrightii* Berk. and Curtis, *Jour. Linn. Soc.*, X., p. 349.

Macbride: "Plasmodiocarp bent or short-flexuous, often arcuate or completely annular, dark chestnut brown or black, opening irregularly: peridium thin, brittle, translucent, covered without by a rather dense layer of brownish or blackish brown scales; capillitium of long, sparingly branched threads furnished with projecting spinules remarkable for their length, about twice the diameter of the thread; spores yellow, minutely but distinctly warted, about 12μ. It is readily distinguished at sight by the peculiar annular, looped, and U-shaped plasmodiocarps, with their dark umbrine or blackened surface."

Saccardo gives the diameter of the spores as 10.8 to 12.5μ, capillitium threads as 2.5 to 3.3μ thick, and spines on the thread as 1.7 to 3μ long.

Massee says the sporangia dehisce in a circumscissile manner. He describes the threads of the capillitium as densely and very

minutely verruculose, in addition to the numerous spines, which he finds to be 2 to 4μ long. The diameter of the spores he gives as 10 to 14μ.

Lister puts the species into the genus *Perichaena,* and names it *P. chrysosperma.* His description leaves no doubt that it is the same species described by Macbride as above. He says, however, that the sporangium wall is of two layers, the outer composed of brown granular matter, which either forms a complete crust or is more or less obsolete; the inner layer is subcartilaginous, yellowish-olive, translucent. Stalk, when present, stout, black.

My one specimen consists of eight sporanges, one of which is a thick ring, another about two-thirds of a ring, one dumb-bell shaped, and two nearly spherical; the other three are too much broken for their shape to be distinguished.

They have a thin, dull, dark membrane on the outside, broken away in places, showing a shining yellow inner membrane; capillitium irregular, branched, 3–5μ thick, with scattered, slender, bent, curved, or twisted spines, 3–5μ long; free ends few, clavate, spinescent; spores yellow, warted, 9–12μ. The long spines on the threads are very distinctive.

I found this species on the bark of a knot of a small dead oak twig which had a few hours before been blown from a tree to a walk on the university campus. The sporangia must have formed while the twig was still high above the ground—an unusual position for a myxomycete.

Perichaena depressa Libert.

1837. *Perichaena depressa* Libert, *Fl., Crypt. Ard.,* IV., No. 378.

Saccardo: "Peridia very much depressed, gregarious, crowded, polygonal, united laterally, red to chestnut-brown, shining, top coming off like a lid; capillitium well developed, threads of various forms and thicknesses 8 to 33μ; spores globose, smooth, 9–11μ."

Macbride says the capillitium is of slender yellow threads of various widths, almost smooth; spores minutely warted, 10–12μ in diameter; shallow spore-cases in which lie the yellow spores and scanty capillitium.

Lister speaks of this species as having a sporangium-wall of two layers, the outer cartilaginous, charged with brown granular

matter, and more or less closely combined with the membranous, smooth inner layer. He calls the spores minutely warted, 8–12μ in diameter.

Massee calls the capillitium threads smooth, rarely notched or furnished with rudimentary scattered spinules; spores minutely warted, 9–12μ in diameter.

In my material the capillitium is not very abundant, varying in width, with irregular projections, branched; spores minutely warted, 9–12μ in diameter.

My one group of sporangia I found on a piece of oak bark in the campus woods in October, 1903.

Perachaena corticalis (Batsch) Rost.

1783. *Lycoperdon corticale* Batsch. *Eleuch, Fung.*, p. 155.
1875. *Perichaena corticalis* (Batsch) Rost., *Mon.*, p. 293.

Saccardo: "Peridia gregarious, sessile, resting upon a hypothallus, spheroidal, depressed, dehiscence circumscissile; from dirty yellow to obscure red; capillitium scantily developed, threads 8–25μ thick; spores smooth, light yellow, 10–12μ."

Macbride calls the upper part or lid chestnut brown, the lower almost black; capillitium smooth, attached to the lid and usually coming away with it.....On and under the bark of dead elms of various species.....Prior to maturity the future line of fission is plainly indicated by the difference in color. In another place he says the capillitium is nearly smooth; spores only slightly roughened by minute warts.

Lister says the sporangia sometimes form short, broad plasmodiocarps; that they are crowded, sessile on a broad or narrow base, rarely substipitate. He calls the color dark purple or purplish-brown, nut-brown, gray, or white. "Dehiscing along definite lines, either horizontally with a convex lid, or in broad sinuous lobes." He calls the capillitium threads irregularly compressed, angled and constricted, minutely warted, rarely smooth. Size of the spores, 12–14μ in diameter.

Massee describes the color as brown, bluish-purple, sometimes whitish; capillitium sometimes almost obsolete, threads thin, smooth, or here and there notched; spores warted, warts variable in size, sometimes very indistinct, at others well developed, never smooth, 9–12μ in diameter. The spores vary in marking from vague granulations to well-defined warts.

My material shows sporangia that are gregarious, sessile or substipitate, globose, ellipsoidal, sometimes umbilicate below, or forming short plasmodiocarps, but none are flattened; dehiscence circumscissile by a convex lid with sinuous lobes, as Lister states; the color medium or dark brown, sometimes with a purplish tinge; sometimes but not always showing in lighter color the line of dehiscence; there are no such differences of color between the cap and cup in my specimens as Macbride mentions; thin, shining, extended hypothallus. Macbride states that the capillitium is smooth, then he says nearly smooth, yet in his figures the capillitium is represented as angled, notched, and with projections. I find the capillitium scanty or almost wanting, branched, unequal, yet none as wide as Saccardo gives, never smooth, but angled, constricted, with projections, but no minute warts; capillitium and spore-mass yellow; spores minutely warted, 10–12μ.

I obtained this species in large quantities, October 19, 1903, from all parts of the bark of a poplar log in the Elmside woods. I found none on the wood itself. April 29, 1904, the log had been removed, but a few rods away was a piece of poplar bark bearing several groups of the species, of the last year's fruit. With these was a group nearly white, wrinkled and shriveled: these put into a warm moist-chamber became plump and came to maturity. I think that they had started to grow one unusually warm April day and that the succeeding cold had arrested their development.

Some pieces of the bark brought into the herbarium room in October and in April, put under a bell-jar on a tin plate and kept moist, fruited plentifully, giving me material for the study of their life-history. The plasmodium appears on the surface only as tiny milky white drops which are the beginnings of the sporangia. The time from the first appearance of the plasmodium to that of the fully ripe spores does not ordinarily exceed thirty-six hours.

Somewhat later in the spring of 1904, several logs which had been brought into the Science Hall greenhouse bore large crops of several kinds of myxomycetes, among them a large quantity of *Perichaena corticalis,* which I used for further study of its life-history.

These logs came from the university campus near the buildings, but I have never found this species growing in those woods.

Lachnobolus occidentalis Macbr.

1885. *Lachnobolus incarnatus* (Alb. and Schw.) Macbr., *Bull Lab. Nat. Hist. Iowa*, II., p. 126.

Macbride: "Sporangia scattered or crowded upon a hypothallus more or less distinct, globose or ellipsoidal, short-stipitate, varying somewhat in color, at first rosy or flesh-colored, later brownish or ochraceous; the peridium exceedingly thin, pellucid, mealy, evanescent above, persisting as a shallow cup below, capillitium inelastic, rather closely netted of threads variable in thickness, marked by frequent thickenings or expansions, everywhere warted, attached to the peridial wall; spores in mass flesh-colored, under the lens colorless, smooth, globose, 7.5–9μ. When newly formed the sporangia have a peculiar rosy or flesh-colored metallic tint, which is all their own. Within a short time this color passes, and most of the material comes from the field brownish or ochraceous in color. Typical sporangia are spherical on distinct short stipes. The capillitium never expands as in *Arcyria*."

Saccardo makes the diameter of some of the capillitium nodes 10μ, the thread 3–5μ thick, and the spores 6.5–7.5μ in diameter.

My specimens have about the same habit of growth and the same size of sporangia as *Trichia persimilis, T. scabra,* and *T. favoginea*. From the color when old this species might be mistaken for *T. persimilis*. The sporangia are sometimes pear-shaped with the smaller end uppermost. There is a thin, papery hypothallus. The most distinctive feature in the general appearance of this species is the non-elastic capillitium-mass, and its gradual disappearance as the peridium wears away, leaving the tops of the sporangia with their capillitium and spore-mass always clean-cut and level. The capillitium-thread is very unequal in width, with frequent enlarged nodes, and with small and large loops and rings formed in the thread. The spores are smooth, colorless, 6–9μ in diameter.

One specimen was found at Lake Mills, November 1901, another in the cemetery woods, October 29, 1903, both growing on dead poplar wood; another on dead wood in the cemetery woods, October 21, 1903; one at Eagle Heights October 2, 1912, also on wood; another on dead wood at Eagle Heights, October 21, 1904.

Arcyria nutans (Bull.) Grev.

1791. *Trichia nutans* Bulliard, *Champ.*, p. 122, t. 502, III.
1824. *Arcyria nutans* Grev., *Fl. Edin.*, p. 455.

Saccardo: "Peridia clustered, evanescent, short-stiped, cylindrical; spores and capillitium dull whitish-yellow; capillitium expanded, long, curved, at length decumbent; threads attached to the tube of the stipe, 3–4μ thick, bearing stout spines irregularly; spores smooth, 7–8μ."

Macbride calls the sporangia pale yellow or buff, and speaks of forms that are sessile by an acute base. The base alone of the peridium persists, and that is a shallow, colorless, often inwardly spinulose, plicatulate calyculus. He says the hypothallus is thin, but usually in evidence. The capillitium, besides the spines, has sharp-edged transverse plates, sometimes rings, the surface especially marked by an indistinct reticulation, all of which characteristics I have noticed in my specimens. He says, also, that the capillitium is very lightly attached, and that the spores are colorless.

Lister names about the same characteristics as given above, but adds: "Stalk short, or elongated and weak, filled with spore-like cells, buff; free ends more or less numerous, with clavate tips."

Maseee's description agrees with the foregoing.

I find these descriptions accurate for my specimens. The long, soft, plumose, ochraceous capillitium mass makes this species easy to distinguish.

Our two specimens were obtained, one near Wausau in the summer of 1894, growing on bark, the other on poplar wood near Fond du Lac, July 30, 1897.

Arcyria incarnata Persoon.

1791. *Arcyria incarnata* Pers., *Gmel., Sys. Nat.*, II., p. 1467.

Macbride: "Sporangia closely crowded, cylindric, 1–15 mm. high, rosy or flesh-colored, stipitate or almost sessile, stipe generally short, sometimes barely a conical point beneath the calyculus; hypothallus none; peridium wholly evanescent except the

shallow, saucer-like, inwardly roughened calyculus; capillitium loose, broad, pale reddish, attached to the cup at the center only, by strands which enter the hollow stem, the threads adorned with transverse plates, cogs, ridges, etc., arranged in an open spiral; spore-mass rosy, spores by transmitted light colorless, nearly smooth, 7–8μ. This common species is well marked, both by its color and by the delicate attachment of the capillitium to the calyculus. This is so frail that the slightest breath oftimes suffices to effect a separation, and the empty calyculi are not infrequently the only evidence of the fructification."

Lister says that the cup of the sporangium wall is membranous, even or interrupedly plicate, and spinulose. He finds in the capillitium here and there broad perforated or ring-like expansions, and the thread often swollen at the axils of the branches. He finds free ends present and more or less numerous, clavate or pointed, spinose. He also speaks of the capillitium as being without attachment to the cup, and says that it is more diffusely expanded than that of *Trichia punicea*.

Massee, as well as the other authors quoted, describes the capillitium as "having very few attachments to the basal portion of the thin sporangial wall."

This species I distinguish from *A. denudata* by the slight attachment of the capillitium to the calyculus, the greater expansion of the capillitium mass, and by the much shorter stipe. I find few free ends, one specimen showing none at all; large and small rings are numerous and there are some swellings along the thread. Another specimen shows several free ends. In general, Macbride's description is accurate for my specimens.

We have specimens from Brulé River, July 19, 1897, growing on moss, and on Norway pine bark; from Lake Mills on poplar wood, gathered November 1901; from the cemetery woods and other parts of Madison, October 1903, and on a poplar log in the Science Hall greenhouse, October 1903.

Arcyria denudata (L) Sheld.

1753. *Clathrus denudatus* Linn., *Syst. Nat.*, p. 1179.
1895. *Arcyria denudata* (Linn.) Sheld., *Minn. Bot. Studies*, No. 9, p. 470.

Macbride: "Sporangia crowded or gregarious, ovoid or short cylindrical, tapering upward, red-brown, stipitate; peridium evanescent except the plicate calyculus; stipe about equal to the expanded capillitium, concolorous, plicate or striate, ascending from a small hypothallus; capillitium attached to the whole inner surface of the calyculus, and connate with it, hence not deciduous, bright red or carmine when fresh, turning brown or paler with age, the threads even, about 3μ, adorned with a series of rather distant cogs or half rings, which form around the thread a lengthened spiral; spore-mass red or reddish-brown, spores by transmitted light colorless, nearly smooth, 6–8μ. This species is easily distinguished from all others of similar tints by the attachment of the capillitium. In adornment of the threads it is like *A. incarnata.*"

Saccardo says that the color of all parts of this species varies from saffron to purplish, and to brick-red.

Lister calls the color of the sporangia crimson. He says the stalk is filled with spore-like cells. He describes the capillitium as an elastic network of flattened or terete red threads, with many attachments to the cup, and usually without free ends.

Massee calls the color vermillion, sometimes with a brownish or purplish tinge, rarely yellowish-brown. He also speaks of the attachment of the capillitium to the sporangial wall.

My specimens do not vary from the above quoted descriptions. The chief difference between this species and *A. incarnata* are the longer, more twisted, and plicate stipe, and the less expanded capillitium with its permanent attachment to the calyculus. The capillitium of my specimen from the cemetery woods is 5–6μ thick, while that of other specimens is about 3μ.

One of my three specimens was found near Doherty lake in summer of 1893, growing on green moss and much-decayed wood; one very small specimen growing on wood I found in the cemetery woods, October 27, 1903. For the third I have not the exact locality or date. It is on the end of a knot of poplar, with many sporanges of a *Dictydium* commingled with it.

Arcyria cinerea (Bull.) Pers.

1791. *Trichia cinerea* Bull., *Champ. de France,* p. 120, Tab. 477.
1801. *Arcyria cinerea* (Bull.) Pers. *Syn. Fung.,* p. 184.

Macbride: "Sporangia scattered or gregarious, ovoid or cylindrical, generally tapering upward, about 2–3 mm. high, ashen gray, sometimes with a yellowish tinge, stipitate; calyculus very small, thin; stipe about half the total height, rising from a small hypothallus, thin, gray or blackish, densely crowded with spore-like cells; capillitium dense, freely branching, ashen or yellowish, little expanded in dehiscence, the threads almost even, though a little wider below, minutely spinulose; spore-mass concolorous, spores by transmitted light colorless, smooth, 6–7μ. A very common little species easily recognized by its color and habit. The capillitium is more dense than in any other species and expands less. The stipe is about equal to the expanded capillitium, unusually long."

Lister's description agrees with Macbride's.

Massee says that the sporangia are simple or digitato-fasciculate on a common stem; that the capillitium is dense, protruding elastically, and remaining erect. The rest of his description agrees with Macbride's.

My specimen agrees with Macbride's description excepting as to spores, which I find to be from 7 to 9μ in diameter. The sporanges are tiny bodies, under a hand lens showing beautiful dense pear-shaped masses of soft gray capillitium with a yellowish tinge, which keep their shape and erectness under many adverse conditions.

The one small group of this species which I have was found at Blue Mounds, August 8, 1903. The sporangia were growing on wood so much weather-worn that it fell into fragments.

Arcyria magna Rex.

1893. *Arcyria magna* Rex, *Proc. Phil. Acad.,* p. 364.

Macbride (in part): "Sporangia tawny gray or ashen, cylindric, when expanded reaching a length of half a centimeter or more, stipitate; peridium evanescent except the small, shallow, cup-like base; stipe long, weak, pale brown or reddish; capilli-

tium gray or drab-colored, the threads regular, cylindric, coarsely sculptured with rings, half-rings, cogs, spines, etc.; spores in mass dull gray, drab, under the lens colorless, papillate, with few papillae, 7–8μ."

Lister does not recognize this as a separate species, but calls it a form of *A. Oerstedtii,* which is pale red in all its parts. He says this form has smoother calyculi and stouter markings on the threads.

Massee has no description which agrees with that quoted above, and the name is not included in his list of synonyms.

My specimens agree with Macbride's description, except that the stipe is variable in length, and the hypothallus is quite evident, thin and glassy. I find the spores as described, and 7–8μ in diameter.

This is a beautiful species, very different in color from *A. nutans,* and from *A. cinerea,* which it most nearly resembles in general appearance.

We have one collection which was found growing on a maple tree beside a street in Madison, July 3, 1905.

Hemitrichia serpula (Scop.) Rost.

1722. *Mucor serpula* Scop., *Fl. Carn.,* II., p. 493.
1873. *Hemitrichia serpula* (Scop.) Rost., *Versuch,* p. 14.

Saccardo: "Peridia spreading, vein-like, with many abruptly reticulated branchings; capillitium 4μ, branches numerous, free ends, the ends equal to the diameter of the capillitium, or somewhat longer; spiral bands 3–4, smooth, armed with numerous long spines, spaces between 3 or 4 times the width of the bands; spores yellow 9–11μ."

Macbride says in part: "Fructification plasmodiocarpus, often covering several square centimeters in extent, terete, rusty, tawny or bright yellow; the peridium thin, transparent, with irregular dehiscence; hypothallus none; capillitium variable, sparingly branched, free everywhere, the free tips spinose, acuminate.....traces of longitudinal striae; spore-mass golden yellow, spores globose, delicately reticulate, about 10μ in diameter."

Lister says the sporangium-wall is of two layers; capillitium threads are 5 to 6μ thick; spores 10 to 12μ in diameter, their border being from 0.5 to 1μ wide.

Massee makes this species *Arcyria serpula.* His description does not differ materially from the others. He speaks of a form collected in Cuba which was subglobose, scattered, and seated on a broad base.

The specimens which I have show the same structure and habits of growth as already described. I find the sparingly branched capillitium threads 5–6μ thick, some free ends which are acuminate, spinose; spores reticulate with narrow bands, 9–12μ.

We have two specimens, both from Blue Mounds, growing on much-decayed wood and bark, collected August 18, 1902, and April 29, 1904, respectively, the latter evidently the fruit of the previous year.

Hemitrichia vesparium (Batsch) Macbr.

1786. *Lycoperdon vesparium* Batsch, *Eleuch. Fung.*, pp. 255–6, fig. 172.

1899. *Hemitrichia vesparium* (Batsch) Macbr., *N.-A. S.-M.* p. 203.

Saccardo: "Sporangia fascicled, with short connate stipes, cylindrical-turbinate, with a metallic lustre, dark red; spores and capillitium cinnamon- or ruby-red; capillitium threads 4–5μ thick, rarely branched, free ends acute, smooth, or inflated and ending with a short spine, rarely obtuse; spiral bands 2–4, armed with numerous spinules, the spaces between twice the width of the bands; spores smooth, 10–11μ in diameter."

Macbride's description in part: "Sporangia rarely single, clavate or subcylindric, stipitate or sessile, dark wine-red or red-black; stipes solid, concolorous; capillitium marked by three or four spiral ridges; spores by transmitted light reddish orange, very distinctly warted, subglobose, 10–12μ. A most common species on rotten wood, everywhere, especially in forests. Recognized generally at sight by its color and fasciculate habit. The peridium often shows a tendency to circumscissile dehiscence, and persists long after the contents have been dissipated, in this condition suggesting the specific name applied by Batsch, *vesparium*, wasp-nest. Rostafinski describes the spores as smooth; they seem to be uniformly distinctly warted. The plasmodium

is deep red and a plasmodicarpous fructification occasionally appears."

Massee speaks of the capillitium mass as elongating at maturity and carrying the apical portion of the sporangium at its apex, where it remains in the form of a cap. I think this characteristic is not universal in this species. He says the capillitium tips are usually marked by from one to three short, smooth spines. This, too, I find not common. He says the spores vary from almost perfectly smooth to minutely but distinctly warted.

Lister gives the length of the capillitium spines as 2–5μ. He says the capillitium is rarely nearly smooth, and that sporangia are occasionally found with a few free elaters pointed at each end, in addition to the continuous network of threads of the usual type.

I find no essential points in which my specimens differ from the above descriptions. I have failed to find plasmodiocarpous forms. The spores are distinctly warted, from 9–12μ in diameter.

This species is very common here. It was found in great abundance late in October 1903, in the cemetery woods, in Vilas woods, and in the university campus woods. We have specimens also from Blue Mounds, collected October 4, 1902. A few collected at Blue Mounds April 14, 1904, were evidently the fruit of the previous year. Others are from Blue Mounds, July 1, 1908, and from Sturgeon Bay, on dead wood, August 19,1905.

Hemitrichia stipata (Schw.) Macbr.

1834. *Leangium stipatum* Schw., *N. A. F.*, p. 258, No. 2304.
1899. *Hemitrichia stipata* Schw. Macbr. *N.—A. S.—M.*, p. 204.

Of the four authorities whom I have before quoted, only Macbride and Lister mention this species.

Macbride: "Sporangia distinct, crowded, cylindric or irregular, overlying one another, rich copper-colored, metallic, shining, becoming brown, stipitate; the peridium thin, the upper portion early evanescent, the base persistent as a cup, as in *Arcyria;* capillitium concolorous, the thread abundantly branched to form a loose net, with many free and bulbous ends, pale under the lens, marked by three or four somewhat obscure spiral bands, and a few wart-like or plate-like thickenings; stipe very short; spore-

mass reddish, spores by transmitted light pale, nearly or quite smooth, 6–8μ. This species is known at sight by its peculiar beautiful tint when fresh, as by the crowded prolix habit of the singular overlying sporangia. .... It is a boundary form unquestionably."

From Lister I add the following: "Copper-colored or deep brown with a carmine tinge; membranous hypothallus; capillitium marked with a border of broad-based spines, or blunt cogs, sometimes covered with minute spines in addition; with many free clavate ends."

For the three groups of sporangia which I have, Macbride's description of manner of growth and general characteristics is accurate. The capillitium illustrated on his "Plate I," is, however, entirely different from that which I find. In Lister's *Mycetozoa,* Plate LXX, A, figs. *f.* and *b.* are like what I find. The capillitium has a border of broad-based spines, turning from one side to the other of the thread. The free ends are very few, but they all terminate in large globular swellings from 13 to 18μ in diameter. These same globose enlargements are occasionally found along the course of the thread, which is 3–4μ thick; there are no loops or rings in the thread. I find no difference in threads taken from different parts of the capillitium mass.

My three specimens were collected in the cemetery and Vilas woods in October 1903. They are on both wood and bark of decayed poplar.

Hemitrichia clavata (Pers.) Rost.

1794. *Trichia clavata* Pers., *Rom. N. Bot. Mag.,* I., p. 90
1873. *Hemitrichia clavata* Pers., *Rost.. Versuch,* p. 14.

Saccardo: "Sporangia simple gregarious, stipitate, more or less clavate, yellow, shining; stipe rather long, attenuate below, wrinkled; concolorous or with the base reddish; spores and capillitium yellow or olive, or dusky yellow; capillitium 4μ thick, sparingly branched, with free ends obtuse or frequently sightly enlarged; spiral bands 5, slender, spaces between two or three times the width of the bands; spores warted 8–9μ in diameter."

Macbride describes the sporangia as clavate or turbinate, color yellow, olivaceous, or brownish; peridium generally thin, evanescent above, breaking away so as to leave a more or less definite

cup beneath; stipe about one-half the total height, reddish, reddish-brown, or blackish, hollow about one-half way down; spirals on the capillitium four or five, regular, even, and projecting sharply; capillitium variable in the number of free ends, degree of smoothness, and amount of branching. Spores pale yellow, minutely but distinctly warted, 8–9μ in diameter.

Lister describes the plasmodium as watery white in dead wood; "total height 1 to 3 mm.; sporangia rarely globose; sporangium wall minutely papillose on the inner side; capillitium 5–6μ in diameter, with 5–6 spiral bands 1μ wide with intervals of 1 to 1.5μ, sometimes spinose in parts in imperfect developments; spores 8-10μ in diameter."

Massee names this species an *Arcyria*. He describes the stem as filled with large, gobose or sub-angular cells which pass upward into normal spores; he calls the capillitium 4–5μ thick; spores reticulated, 8–10μ, but, he says, that ridges are sometimes short and distinct or even wart-like.

The many specimens which we have vary from light yellow, shining, to brownish, dull; some forms are nearly sessile, while in others the stipe is more than half the total height. The long-stiped forms are clavate or turbinate, the short-stiped ones more nearly globose. The capillitium is centrally attached to the cup, and when set free by the evanescence of the upper part of the peridium it usually hangs from the cup in a long ragged mass. In such cases the cup in quite deep and the edge irregular. But I have several forms gathered at different times and places, which have short stipes and in which the peridium breaks away at the top, the lower part becomes distinctly reflexed and leaves a small shallow cup upon which the capillitium-mass remains quite permanently as a little globose mass. The capillitium and spores of these specimens show no variations from the other specimens. The capillitium is 6–7μ wide, with four or five spirals, smooth, even; the spores are minutely warted.

In April and May, 1904, many of this species appeared in the Science Hall greenhouse, upon decaying logs, mostly oak and poplar, which had been brought in the fall previous. These forms have unusually long stipes and the sporangia are rather smaller than the average. The plasmodium is within the wood and is watery white; it begins to pile up in milky-white drops as soon as it comes to the surface. Then it elongates upward,

the top at once becoming larger than the bottom. Its typical form is shown early. The sporange does not reach its normal size until some time ofter the stipe has grown to its full length. It is still milky-white. In about thirty-six hours after its first appearance, the stipe begins to turn reddish inside, the outside being translucent. In about forty-eight hours the whole body is dark red-brown; then it turns light yellow, the top turning first; the top then breaks away in fragments. The process is hastened by an increase of temperature.

These specimens in the greenhouse show the reflexed peridium and globose sporangium such as I have described above. Lister pictures such a fruit in Plate LXXIV of his *Mycetozoa,* and says it is a United States specimen.

Our specimens are from Dead lake, cemetery woods, Vilas woods, and university woods, Madison; from opposite Fond du Lac gathered July 1897, and from Blue Mounds. The most were gathered late in the fall, one lot in May. A few are on bark, but the most are on decayed poplar wood.

Trichia varia (Pers.) Rost.

1791. *Stemonitis varia* (Pers.) Gmel., *Syst. Nat.,* II., p. 1470.
1875. *Trichia varia* (Pers.) Rost., *Mon.,* p. 251.

Saccardo: "Peridia sessile, globose, but the mass having an irregular surface, there often being some reniform sporanges intermixed; yellow, approaching brownish- or reddish-yellow, scattered or crowded; elaters cylindric, with a thin membrane, toward the ends regular or slightly enlarged, slightly curved, the ends 2–3 times as long as the diameter of the elater; spiral bands 2, spaces between, 3 or 4 times as wide as the band; spores warted, dull yellow, 10–14μ."

Macbride says of the sporangia that they are shining, sessile, or with short black stipe; hypothallus none. He says that the capillitium is of rather long, simple, or more rarely branched elaters, 4–5μ wide. He finds two spiral bands, prominent and narrow and in places remote, the apices acute. The spore-mass he calls yellow, the spores 12–14μ in diameter, delicately verruculose, guttulate. He calls this a common species, variable in form. "The two spiral bands are loose and irregular, unlike anything

else in the group except the same structure in *T. contorta*, but here the elater is narrow and the sculpture obscure."

Lister speaks of the sporangia as sometimes forming short plasmodicarps, and speaks of the wall as membranous, pale yellow, marked with ring-shaped or crescentic thickenings. He gives the diameter of the spores as 11–16μ.

Massee describes the spores as turbinate or subglobose, the elaters as rarely branched, and sometimes swollen at the commencement of the tapering tips.

The abundant material which I have varies from crowded to scattered, from short-stipitate to sessile forms, from dark orange to shining bronze-brown, from globose to plasmodiocarpous forms, and varies considerably in size even in the same group. One of my groups has a distinct hypothallus. The elaters are generally simple, sometimes branched, 3–5μ thick, the spirals smooth, 2 or 3 projecting boldly, continuing to near the end of the tip. With but one or two exceptions, all the elaters I have seen have been swollen just at the beginning of the apex, generally on one side, giving the end a bent or unsymmetrical appearance at once noticeable and determinative. The tip is curved, often twisted like a corkscrew. The spores I find to be globose, delicately warted, 12–16μ.

Many specimens I found in the cemetery woods late in October 1903. Some were found in Vilas woods and in the campus woods in 1903, and in two other localities in Madison in 1899. They were mostly on dead poplar wood and bark.

Trichia scabra. Rost.

1875. *Trichia scabra* Rost., *Mon.*, p. 258.

Saccardo: "Typical sporangia gregarious, sessile on a common membranous hypothallus; elaters cylindrical, apices acute, straight, or slightly curved; spiral bands 3 to 4, bearing numerous short acute spines; spaces between, wide, smooth; spores 8–11μ; epispore thick, with numerous obtuse warts."

Macbride: "Sporangia closely crowded, regular, globose or turbinate-globose, orange or golden-brown, smooth, shining; capillitial-mass clear golden yellow, or sometimes rusty orange, the elaters simple, long, 4–5μ in width, spirals closely wound, even and regular; spore-mass concolorous, under the lens spores

yellow, covered by a delicate fine-meshed network, or simply spinulose under low power, 10–12μ. Fructifications two or more inches in length and half as wide are not infrequent on the lower side of fallen stems in forests of deciduous trees."

Lister's description varies but little from the above. He says the elaters are 4–6μ thick, with four or five bands arranged in somewhat irregular spirals, with spines, or nearly smooth, the ends acutely conical or with the bands produced at the apex in more or less diverging points, longitudinal striae rarely evident. He finds the spores minutely reticulated .... or irregularly warted, the spore border being reduced to a spinulose margin 9–12μ wide.

Massee says the color varies from pale yellow through dirty orange to brown. He finds the elaters to be 6–8μ thick, and that the spores have a fine network of raised lines.

My specimens might easily be mistaken from their general appearance for some of those of *T. persimilis*. The color of the most of the *T. scabra* however, approaches nearer to orange than does that of *T. persimilis*. The manner of growth, closely crowded in circular patches, is similar to that of *T. persimilis, T. favoginea*, and even of some of our specimens of *T. varia*. Under the lens the distinction between this species and the others named is quite marked. The elaters are generally long, but in one group I find many that are quite short. They are 4–6μ wide, the apices short, acuminate, or with one or two spines divergent. The spiral bands are 3–4, spinulose, closely, sometimes irregularly wound. The spores are globose, regular, with fine reticulations, 10–12μ in diameter. In one of my specimens the capillitium hangs in a woolly mass above the empty calyculi, as described by Macbride for *T. favoginea*.

We have specimens gathered at five different times in October 1903, three from the cemetery woods, and two from Blue Mounds. One specimen from Blue Mounds, collected in April 1904, was evidently the fruit of the year before. All were growing on dead bark.

Trichia persimilis Karst.

1868. *Trichia persimilis* Karst., *Not Saellsk Fenn. Fork.*, IX., p. 353.

Saccardo: "Sporangia aggregated, nearly or quite spherical, brownish, with a bronze-lustre, sessile; elaters cylindric, yellow, 4–6μ, apices smooth, generally curved, twice as long as the diameter of the elater; spiral bands 3–4, prominent, spaces between twice the width of the bands; bands armed with scanty, prominent, curved, hyaline spines, 8–10μ long, 4–6μ thick; spores warted, yellowish, globose, 12–14μ."

Macbride says, in part: "The sporangia are golden yellow to tawny, anon iridescent with metallic lustre; hypothallus thin, but usually very distinct; capillitial mass ochraceous or tawny yellow, the elaters long, even, about 4μ wide, the spirals four, more or less spinulose, generally joined by longitudinal ridges, the apices short, tapering regularly, anon bifurcate; spore-mass concolorous, spores marked by an irregular or fragmentary banded reticulation, the bands broad, flat, and pitted, 10–12μ. Plasmodium said to be white. .... It never shows at maturity the brilliant golden yellow fluff that hangs in masses about the open and empty peridia of *T. favoginea.*"

Lister calls the elaters 4–6μ thick, with the bands sometimes produced at the apex into two or three diverging points, longitudinal striae inconspicuous. He finds the spores to be 11 to 14μ in diameter, with the reticulation broken, or represented by regular pitted warts, border interrupted. He says also: "The occurrence of the long spinous processes on the elaters, noted in the original description of *T. persimilis,* is not a constant character."

Massee adopts the name *T. affinis* De Bary. His description is scanty and does not differ from those quoted above excepting that he says that this species is distinguished by the presence of pits on the raised bands of the epispore, and by the absence of raised ridges running parallel to the long axis of the elater.

I found considerable difficulty at first in distinguishing this species from *T. favoginea,* from the descriptions as given above The color is not markedly different from that of *T. favoginea* nor from that of *T. scabra;* the manner of growth is the same; the

color varies from dark golden to light yellowish brown, generally iridescent, shining; sporanges opening by jagged cracks on top; the statement that "it never shows at maturity the brilliant golden yellow fluff that hangs in masses about the open and empty peridia of *T. favoginea,*" is somewhat misleading, for in a large percentage of the specimens the most noticeable feature is the woolly fluff, and the empty peridia under and around the margins of it. After a short exposure to air, light, and dust, the difference in the shade of yellow of the two species is scarcely distinguishable. Then again the description of the spores of *T. favoginea* by Macbride as being "in form irregularly globose," the irregularity in the form of the spores of *T. persimilis* not being mentioned caused difficulty. Under a low-power lens, the spores of *T. persimilis* show such irregularity that one might easily think them to be dried, or shrunken, or otherwise distorted. The oil-immersion lens shows the bands which cause the irregularity to be fragmentary, unequal in width and pitted, giving a much interrupted margin to the spores, which I find to be 10–12μ in diameter. The capillitium is 4–5μ wide, never as wide as 6μ, except in specimens gathered in Port Wing July 12, in which the capillitium is 7–8μ thick; none of the spores of this specimen were as small as 10μ; the longitudinal striae were also evident in this specimen. In the other specimens which I have, the striae are quite inconspicuous; I found spines on all the capillitium, though more abundant on some than on others; the ends of the elaters often have 2 to 3 spines, the end sometimes enlarged.

This species seems quite abundant in this locality. We have specimens from the cemetery and Vilas woods, from Elmside, from Blue Mounds, and from Port Wing. One group an inch long and three-quarters inch wide, is growing on weather-worn bits of wood almost as fine as sawdust, these lying upon a piece of dead leaf. Other specimens are on decayed wood, mostly poplar, or on the inside or outside of bark. All our specimens excepting the one from Port Wing were collected in October.

Trichia favoginea (Batsch) Pers.

1786. *Lycoperdón favogineum* Batsch, *Eleuch. Fung.*, p. 257, Fig. 173, *a*, *b*.

1794. *Trichia favoginea* (Batsch) Pers., *Rom. N. Mag. Bot.*, I., p. 90.

Macbride: "Sporangia closely crowded, cylindric or prismatic by mutual pressure, obovoid, sessile, olivaceous yellow, smooth and shining; the peridium thin, opening above somewhat stellately, persistent; capillitium golden yellow, escaping entirely from the peridia, and forming large woolly masses above them, the threads long, even, beautifully sculptured, bearing spirals about four, usually smooth and connected by light longitudinal ridges, the apices short tapering, about equal to the width of the elater, 6–7μ; spores concolorous, by transmitted light paler, but still bright yellow, the epispore net conspicuous, the bands narrow and high, not pitted nor fragmentary, in form irregularly globose, 12–14μ. Plasmodium yellow. A common and beautiful species recognizable at sight, after the peridia break. by the aggregate capillitium constantly in evidence above the abandoned vasiform peridia."

Lister calls the capillitium and spore-mass orange yellow and the sporangium-wall membranous, minutely thickened with irregular striae. He says a stalk is rarely present. He finds the elaters to be 7–8μ thick, smooth or with scattered spines, and the points of the elaters 3–8μ long. The spore diameter he gives as 13–15μ, including the border which is 1.6 to 2μ wide. He further says: "Between *T. affinis* and *T. persimilis*, and between *T. persimilis* and *T. scabra*, intermediate forms frequently occur where it is often difficult to decide under which head to place them."

Massee adopts the name *T. chrysosperma* Rost. He calls the color yellow or ochraceous cinnamon. He finds sometimes a few scattered spinules on the elaters. He terms this "a rare species characterized by the deep narrow ridges forming a network on the epispore and the surface of the bands not being punctate, and by the narrow raised lines running parallel to the long axis of the elaters."

Saccardo gives the spore diameter as 10μ, or including projections, 12–15μ.

The specimens which we have show the same small, densely crowded sessile sporangia as *T. persimilis* and *T. scabra*. The color is yellow, rather lighter and somewhat nearer orange than the majority of the specimens of *T. persimilis*. The capillitium escapes from the peridia, forming a woolly mass above. So far the description is not distinctive. But I find the capillitium smooth, or with a few scattered, very minute spinules, 6–8μ thick, with the ends 6μ long. There are four spirals closely wound. The spores are more regular in outline than those of *T. persimilis*, the border is 1–2μ wide, not interrupted. The bands are reticulated, more even and narrower than in *T. persimilis*, and are neither pitted nor fragmentary; and the spores are larger, being 12–15μ in diameter.

The smoother capillitium, the larger, regular spores with their even bands not fragmentary, render this species not difficult to distinguish from those of similar general appearance, when they have once been studied.

We have specimens collected in Wisconsin in 1897, locality not given, and one from Star Lake, August 4, 1901; growing on dead poplar wood and bark.

Trichia decipiens (Pers.) Macbr.

1795. *Arcyria decipiens* Pers., *Ust. Ann. Bot.*, XV., p. 35.
1796. *Trichia fallax* Pers., *Obs. Myc.*, I., p. 59, etc.
1899. *Trichia decipiens* (Pers.) Macbr., *N.-A. S.-M.*, p. 218.

Saccardo: "Sporangia clustered, stipitate, crowded, turbinate, from dull yellow to olive yellow; stipe plicate, the tube continuous with the sporangial cavity; elaters spindle-shaped, simple or branched, 4–5μ in the widest part, tapering equally toward each end, the ends from four to six times as long as the diameter of the smooth thread; spiral bands 3, smooth, prominent; spores warted, 10–12μ."

Macbride's description differs but little from that given above. He calls the color shining olive or olivaceous brown. He says of the stipe that it is generally elongate, concolorous above, dark brown below, hollow, i. e. filled with spore-like cells. He speaks of the elaters as having long, smooth, unwound tips. The spores under the lens he finds to be pale, minutely delicately reticulate, 10–12μ in diameter.

Lister states that the plasmodium is rose-colored or white, the sporangium wall membranous and of two layers. He finds the spores minutely warted or more or less distinctly reticulated on one side and 9–12μ in diameter.

Massee finds some of the sporangia to be subsessile. He describes the spores as covered with a very fine irregular network.

The specimens which I have vary in color from a medium yellow which closely resembles the color of some of the *Hemitrichia clavata,* to dark olive brown. The size also varies. These variations are quite marked sometimes in material gathered at the same date and place. Some of the elaters carry their spiral bands nearly or quite to the tip. The spores I find to be finely and equally reticulated, and 10–12μ in diameter.

Several groups of sporangia on a piece of poplar bark found at Blue Mounds, April 29, 1904, are distinctly sessile, the sporangia being attached to the substratum by their attenuated bases. From their general appearance they might easily be mistaken for *T. varia* or *T. persimilis,* but under the microscope the elaters and spores show the characteristics of *T. decipiens* perfectly. These specimens are evidently of the last year's growth, and the variations may have come about by its fruiting very late in the fall under unfavorable conditions.

Another set of dried specimens from East Madison, August 5, 1903, vary from light red, semi-transparent, to dull black, opaque: from subsessile to stipitate. Many are wrinkled, roughened, very hard and brittle. A very few of the sporangia are soft and light colored at the top. In this softer portion I found the characteristic capillitium and spores of *T. decipiens.* It was impossible to crush most of these sporangia in such a manner as to learn the character of the contents. These are evidently immature fruiting bodies which have been arrested in their development. Occasionally similar brittle black sporangia are found mingled with ripe, perfect sporangia of *T. decipiens.* Such imperfect forms as these may have been sometimes named as new species. Lister mentions specimens of *T. botrytis* in the Strassburg herbarium which he says have "sessile, black, and brittle sporangia associated with others of brown and bright nut color." They may have been immature specimens arrested in development.

We have specimens from Blue Mounds, October 4, 1902; many

from the cemetery woods, October 1903; from the university campus woods, October 1903; and from East Madison, August 5, 1903. All of these were growing on dead poplar wood. The sessile form from Blue Mounds was found April 29, 1904. It is on poplar bark.

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