A STUDY OF THE TAXONOMY AND ECOLOGY OF MICHIGAN DESMIDS

Thesis for the Degree of Ph. D.

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Wilbert Ernest Wade

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This is to certify that the

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Wilbert Ernest Wade

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A STUDY OF THE TAXONOMY AND ECOLOGY OF MICHIGAN DESMIDS

By

Wilbert Ernest Wade

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Botany and Plant Pathology

Year 1952

Approved G. W. Prescott
per G. O. Steinhaus

Wilbert Ernest Wade

This is a study of the distribution and classification of Michigan desmids. The term desmid is applied to algal organisms belonging to several families of the Order of Zygnematales in the Division Chlorophyta (green algae). Their great range of cell architecture and their usually calciphobic nature offer many phycologists an interesting field for study. The state of Michigan with its large number of bodies of water, as well as its varied physiography and soils, provides an excellent area for the study of the ecology and taxonomy of these organisms.

The primary objectives of this study have been: (1) the collection and identification of desmids from various regions of the state, particularly from the areas of the southern lower peninsula and western upper peninsula where only a few reports are available; (2) the determination, if possible, whether desmid abundance in various regions of the state is correlated with major geological or soil features; (3) the assembling of previous distribution records of the desmids in the state together with those of the writer's into a unified volume.

Two main portions comprise the report of this investigation. The first portion consists of chapters dealing with the general morphology, classification and distribution of desmids. Brief discussions of the major physiographic and soil regions of the state are also included. The second por-

tion deals with the distribution and systematics of desmids in Michigan. The systematic section is based in part upon more than two hundred fifty samples made by the writer from seventy five stations throughout the state. The assembling of this data together with previous published records results in a total of seven hundred fifty one species, varieties and forms (including previous records) being considered. Artificial keys to genera and species are provided in addition to a standard reference, brief diagnostic comments, measurements and distributional data (in Michigan) for each species, variety or forma. Thirty-five plates and three maps supplement the written text. Nineteen new species, varieties or formas are reported for the first time.

A discussion of desmid distribution in the state in relation to major physiographic and soil regions is presented. On the basis of available distributional records, it generally appears that the greatest abundance of desmids is correlated with regions of the state where the lithologic composition of the surface deposits has the least limestone influence, whereas the poorest representation occurs in regions where the limestone influence is greatest.

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A THESIS

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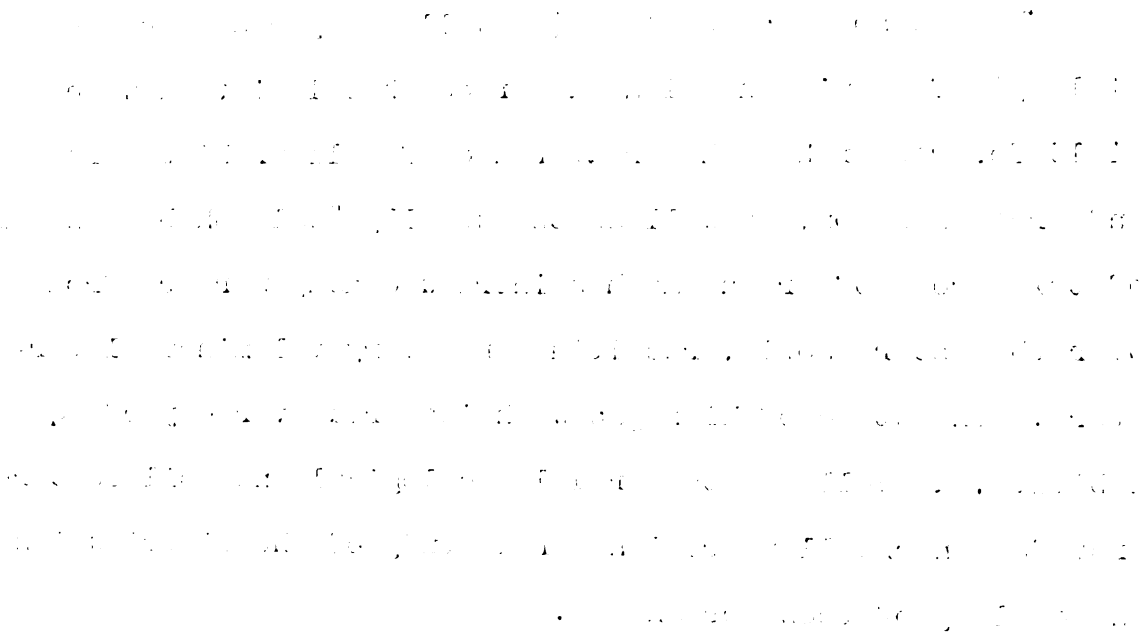
I. INTRODUCTION

The taxonomy and ecology (as well as cytology and physiology) of desmids has long afforded phycologists a wide field for research. The great range of cell architecture and ornamentation, as well as the usually "calciphobic" nature of this group of organisms has intrigued many workers from over the entire world, resulting in a very voluminous literature. The State of Michigan with its great variety of aquatic habitats, as well as its variable geological and soil features, provides an excellent region for a study of the distribution and ecology of these organisms.



II. HISTORY OF THE STUDY OF DESMIDS IN MICHIGAN

Most of the previous reports of desmids from the state have been part of general algal surveys, either of the entire state, or of some particular lake or region. Limnological surveys, systematic lists of species, and one taxonomic-ecological study comprise the remainder. The earliest publication (Campbell 1886) includes forty-one species from the Detroit River. A similar listing of fifty-eight species was made by Pieters from Lake St. Clair in 1894. Johnson, a professor at the University of Michigan, published two lists of desmids found in the southeastern part of the state in 1894 and 1895. West and West added more distribution records from the same region in 1898. Transeau (1917) in his study on the algae of Michigan, included desmids from both upper and lower peninsulas. Nichols and Ackley (1932) were the first to discuss the ecology and distribution of the desmids in the state, in addition to listing three hundred twenty five species (including previous records), mainly from the Douglas Lake region. Ackley also described two forms of desmids from Michigan in 1929. Several limnological papers by Welch (1936a, 1936b, 1938a, 1938b) on the bog lakes of the northern lower peninsula include desmid species (some are records of Nichols and Ackley). The desmid population of Isle Royale in Lake Superior was thoroughly covered by a series of papers by Taylor on plankton

(1935), and Prescott on nonplankton (1937, 1938, 1940, 1941). Prescott also was senior author of a paper with Magnotta (1935) upon desmid collections from Marquette and Calhoun Counties. Taft included about fifty new records in 1939. Gustafson (1942) published a complete bibliography of articles on Michigan algae (exclusive of those concerned solely with diatoms) and also included a numerical census of the species of various taxonomic groups of algae reported previously from Michigan (of which five hundred seventy five species, varieties or forms, or about 40% were desmids). Neal (1948) in his study of the psammon of Douglas Lake, and Wade (1949) in his study of a hard-water lake of southern Michigan, have also included a few species of desmids.

III. HISTORY AND OBJECTIVES OF PROBLEM

The writer first became interested in the study of desmids while a student at the University of Michigan Biological Station at Douglas Lake in the summer of 1946. There, as a member of a class on fresh-water algae, taught by Dr. G. W. Prescott, he had the opportunity to examine many samples of algae, collected in part from numerous bog lakes in that vicinity which contained a very rich representation of desmid species. Collections made several years later as a graduate student at Michigan State College, from bogs and acid lakes in the southern part of the state, revealed a somewhat variable number of desmids represented. The writer then became interested in determining whether desmids occurred in the southern part more commonly than previously indicated. Early workers (such as Johnson, Campbell, West and West) had reported desmids from the southeastern part of the state, and Prescott (in Prescott and Magnotta, 1935) stated that collections from Winnipeg Lake (Calhoun Lake) in Calhoun County had a very rich desmid flora, but otherwise, records from the southern part of the state were very few except for Transeau's report (1917) from Muskegon County. The contention of Nichols and Ackley (1932) that the "richest growths in both variety and quantity" coincides with the region of the greatest bog development (Douglas Lake region) did not agree with Dr. G. W.

Prescott's observations and collections from the western upper peninsula, and probably reflected a somewhat irregular sampling, or at least an overlooking of available habitats in that region of the state by Nichols and Ackley. It was then thought advisable also to include this region in the comparison of the desmid flora of various regions of the state. Thus the writer in the Spring of 1949 began a study of the desmid flora of the state with the following objectives:

1. The collection and identification of desmids from samples representative of the various physiographic regions of the state with emphasis on those regions from which reports of the desmid flora had been few in number, especially the southern lower peninsula and the western upper peninsula.
2. The use of simple field chemical tests to determine the general chemistry (pH, carbonates, bicarbonates and dissolved CO_2) of the water of habitats represented by the collections.
3. The determination, if possible, of whether a general correlation might exist between the desmid distribution (both in variety and quantity) and the major physiographic regions (including geological bedrock and the major soil regions) of the state.
4. The assembling of previous records, reports and lists of desmid species from the state, with additional information obtained from the writer's collections, into

a unified volume. This project would include writing of systematic keys to genera and to species, as well as brief descriptive or diagnostic comments, measurements, and distributional (in Michigan) data for each genus and each species.

5. The preparation of plates of illustrations of those desmids in the writer's collections which were new records for the state or new to science.

IV. GENERAL MORPHOLOGY AND CLASSIFICATION OF DESMIDS

The term "desmids" is applied to certain unicellular or filamentous algae belonging to the Zygnematales, a large order in the Chlorophyta. Primary characteristics of the division Chlorophyta include the presence of a thalloid structure (lack of true roots, stems and leaves), the predominance of chlorophyll A and B pigment over xanthophyll and carotin, food storage in the form of starch, cellulose walls, unicellular sexual cells or sexual organs, and the possession usually of two equal flagella on motile reproductive elements. The Order Zygnematales (in which the desmids are included) is sharply defined and delimited primarily from the other orders comprising the Division Chlorophyta by the lack of flagellated reproductive cells and by the occurrence of a special type of sexual process in which a fusion of amoeboid gametos (usually vegetative protoplasts) is involved and which usually is spoken of as conjugation. The desmids (about 4000 spp.) generally comprise two or three families of this order.

Two genera (Gonatozygon and Genicularia) with a total number of twenty species, the components of the Family Gonatozygonaceae, are often considered desmids and included with them. The other two families, comprising the desmids proper, are the Mesotaeniaceae (saccoderm desmids) and the Desmidiaceae (plac-

oderm desmids). The former, consisting of six genera (about 41 spp.) and the latter consisting of twenty-four genera (3900 spp.) compose two distinct series of forms whose relationship to one another is not completely understood.

Several major characteristics that distinguish them are listed below in tabular form:

		Mesotaeniaceae	Desmidiaceae
1.	Cell arrangement	usually unicellular; (one genus with short filaments)	majority solitary; some colonial or united in long filaments
2.	Cell shape	commonly rod-shaped or oblong and without a median constriction	variable from cylindrical (with rounded, truncate or attenuated ends), to flattened disciform or polyradiate, usually with a median constriction (sinus) partially dividing the cell into two symmetrical halves which are joined together by a connecting zone (isthmus)
3.	Cell wall pores	pores absent	pores absent
	Segmentation	not transversely segmented	transversely segmented
	Construction	layered	layered
	Layers	2	3
		inner-cellulose	inner-cellulose
		outer-pectose	middle-cellulose and pectic compounds (sometimes Fe)
			outer-pectic compounds
4.	Formation of new cell walls after cell division	elongation throughout the entire length of wall of daughter cells	regeneration of new sections of semicell walls

	Mesotaeniaceae	Desmidiaceae
5. Behavior of protoplasts (gametes) in conjugation	protoplasts rarely escape from conjugation tube	protoplasts usually escape from conjugation tube
6. Chloroplasts	variable spiral bands parietal stellate	variable 1 per semicell - axial 2 per semicell - axial and lateral to each other 4 or more per semicell - parietal
7. Nuclei	single - usually centrally located	single - centrally located

The evolutionary position of these organisms in relation to one another and other members of the division Chloroplyta is little-understood. Several hypotheses (Fritsch 1935, e.g.) deal with evolution of the desmids in general, from forms similar to certain species of the Chaetophoraceae in which motile gametes lose their flagella and become amoeboid before fusion, or from forms similar to certain species of the Volvocales such as Chlamydomonas eugametos in which there is a type of conjugation in sexual reproduction. Other theories dealing with relation of the two groups of desmids to each other, have the more complex placoderm desmids (varied shape, constricted, three cell layers, without pores, etc.) evolving from the saccoderm type (such as Mesotaenium with simple unconstricted rounded cells which possess two cell layers and lack pores). Teiling (1950) however, believes that many of the simpler forms have evolved by reduction of the forms similar to polyradiate species belonging to the saccoderm desmids. Still other theories

deal with the question of whether filamentous forms of desmids have evolved from unicellular ancestral forms or whether the reverse is true. These various theories are thoroughly and critically discussed by Prescott (1948) and will not be further considered here.

V. THE DISTRIBUTION OF DESMIDS

In general, aquatic plants, especially algae, have a much more nearly world-wide distribution than do terrestrial plants. Some species often occur on all continents, having been distributed by various agencies such as wind, interconnecting bodies of water, animals and man. Desmids are distributed over the entire world except on the Antarctic continent. A certain number of species appear to be cosmopolitan (Strom (1926) believes that two-thirds are cosmopolitan), but many are components of somewhat poorly defined regional floras (such as the Arctic, African, etc.) or have a very irregular or disjunctive distribution. Irénee-Marie (1938) has studied the various agencies which are important in the dispersal of desmids. According to him, the principal agents responsible for dispersion in a local territory are seasonal floods, winds and animals (including insects). Aquatic birds, terrestrial insects and wind, however, appear to be more important agents in dispersal over a large region.

There have been attempts also to arrange groups of species mainly on the basis of physical habitats. Thus La Porte (1931) after analyzing taxomonic lists of European desmids has listed ten types of associations. Examples include the Aerial association wherein species of Mesotaenium occur in moist surfaces of soils and trees, the Subaerial association (Desmidiacetum aerophilum) wherein a few forms live on moist, acid

soil around Sphagnum cushions in alpine regions near melting snow, and the Closterietum commune wherein species primarily of Closterium, and many species of diatoms inhabit newly formed ditches or dripping banks. Others include the Cosmarietum transitorium, a mixture of desmid and diatoms species which inhabit slightly acid mossy bogs, and some of which are components of the previously mentioned Closterietum commune and the Euastro-Micrasterietum. This latter group is composed of eight genera of desmids associated with Carex rostrata and C. fusca in Sphagnum bogs with a low pH of 5.0-6.0. The Closterium-lineati-Pinnularietum-stauropterae association is a poorly defined group based on lists of species associated with Carex rostrata and Carex limosa in Swiss marshes. As assemblage of various species, mainly of Cosmarium and Staurastrum, usually found free floating or attached to aquatic plants in the deep water of bog lakes is considered the Cosmarietum-Staurastrietum. Another poorly defined association (Desmidiacetum-benticum) is the number of species of all genera found in shallow water of bogs and the benthon. The planktonic association (Micrasterias-Staurastretum-planctonicum) is composed of a collection of species usually found in open water. Lastly, those species of desmids (usually of Cosmarium and Closterium) which are adapted to water on the alkaline side of neutrality, are included in the Calcophilic desmids. Although somewhat poorly understood, there is a corresponding change of these desmid associations with stages in the hydrogeographic evolution of bogs and lakes.

VI. FACTORS DETERMINING THE OCCURRENCE AND DISTRIBUTION OF DESMIDS

It was previously mentioned above, that desmids as a group have a world-wide distribution. Within limited areas however, the occurrence of this group appears to be determined by ecological factors, primarily water chemistry. West and West, as early as (1906) attributed the distribution of desmids in the British Isles to certain geological formations. They pointed out that where lake waters overlay ancient Precambrian rock, the richest development of desmids occurred, whereas in waters overlying Carboniferous, Secondary or Tertiary geological formations, desmid occurrence was considerably reduced. They further stated, that the abundance of individuals is correlated with the lack of lime and the presence of humic acids. In a later paper (1909), they re-emphasize the necessity of two factors for an abundant desmid-flora; a geological formation older than the Carboniferous and an abundant rainfall, and show the correlation between the abundance of desmids and the geological regions, and distribution of rainfall in Great Britain. Although not fully understanding the reason of the correlation, they suggested that a chemical analysis of the water might give the necessary information. Wesenberg-Lund (1905) agreed with the Wests in respect to the chemical factors (absence of lime and presence of humic acids) but claimed

that the antiquity of the region did not influence the abundance of desmids because the glaciation in many regions had completely modified the terrain of the older geological bedrock.

More recent workers are now of an agreement that the chemical nature of the water is the primary limiting factor in desmid distribution. Smith (1924), although agreeing that a geological correlation similar to that of the Wests has been found in his studies of the plankton in Wisconsin, Ontario and New York, admits that "the factor governing the distribution of desmids is not the antiquity of the lake, but the chemical nature of the water". Strom (1926) also emphasizes the water chemistry (and its relation to geological formations) as important in algal distribution. The importance of water chemistry has further been shown in the determination of two main types of planktonic algal associations, the Caledonian with a conspicuous desmid content, and the Baltic with a rich blue-green algal content. The water chemistry which favors either the development of one association or the other, is markedly different. Although the chemical content of bodies of fresh-water varies greatly, the Caledonian (desmid) type of plankton occurs where the water is low in nitrogen and phosphorous, low in calcium and magnesium, but often relatively high in sodium and potassium, whereas the Baltic type is present in waters of higher alkalinity (with a pH of 7.2-9.8) characterized by larger amounts of calcium, magnesium, nitrogen

and phosphorous. Pearsall (1923, 1932) has pointed out the value of the sodium-potassium / calcium-magnesium ratio in the determination of the type of planktonic flora present in a body of water. He also presents in tabular form (1923) the correlation of plankton types with the chemical contents (hardness, Na-K / Ca-Mg ratio) in bodies of water from all over the world. A rich desmid flora is thus found in waters where the Na-K / Ca-Mg ratio is high. Similar results have been reported by Smith (1924b), Welch (1935, 1936a, 1936b, 1938a, 1938b) and Prescott (1939, 1951) in the United States.

Many other ecological factors (both climatic and edaphic) without a doubt play an important role in the presence of desmids. Prescott (1948) questions the possibility of the presence of growth-promoting or other undetermined chemical substances as being of critical importance. Strom (1926) lists four essential factors determining alga-flora. They are temperature, aeration, salt content (i.e. principally lime) and contaminating organic nitrogen. Certainly, all of the complex factors that go to make up aquatic habitats have some bearing upon the organisms that live in those habitats. The role of light, temperature, currents, etc., in plankton production (and thus in a desmid production) is extremely complicated, and as yet is not clearly understood. Welch (1935), Rawson (1939), Prescott (1939, 1951), and Pennak (1946) and others have all attempted to classify and discuss these factors, their interrelationship and their effect upon aquatic organisms.

A complete repetition of voluminous published data cannot be made here, although one can emphasize that the desmids as aquatic organisms clearly reflect the many factors of their environment with the primary determiner in occurrence (both in quality and quantity) appearing to be a chemical one as stated above.

VII. METHODS AND PROCEDURES

In order to obtain desmid samples representative of the major physiographic regions of the state, several problems were involved. The general calciphobic nature of the desmids required the location of soft-water habitats. Such habitats, at least in the southern lower peninsula, it appeared from observation, were usually restricted to bog lakes. In order to locate these lakes the writer used several methods. Bog lakes are generally surrounded by some type of a vegetational mat, (Carex, Sphagnum, various members of the Ericaceae, Sarracenia (pitcher plant), Decodon (water willow) and others). Parts of such mats over a period of years, through natural change, become converted into organic peat deposits. Thus, through the location of peat deposits surrounding lakes, with the use of available county and soil maps, obtained through the courtesy of the Soil Science Department of Michigan State College, the writer was able to locate various bog lakes. Many of these provided excellent desmid habitats. Soil maps of some counties were not available, or were of such a general survey nature that they were of little value in locating soft-water habitats. In those counties, the writer depended upon information supplied by various persons, including staff members and students in the Botany Department of Michigan State College. Bog lakes in general are used very little by man for fishing and other

recreational purposes, and thus in many areas, especially in the upper peninsula, they and other habitats (marshes and swamps) are often located in regions not accessible by road. Collections of the open water in many bog lakes was also impossible because of the dangerous condition of the mat. Various ponds, sloughs, swamps and marshes were also sampled.

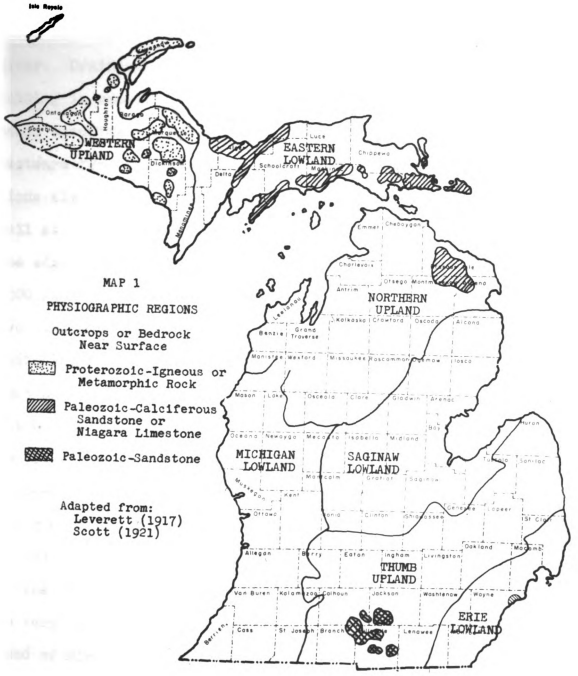
In general, most collections were made from squeezings of Sphagnum, Utricularia and other plants, scrapings from culms of submerged higher aquatic plants, and by plankton tow. They were preserved in Transeau's Solution, known as 6-3-1 (6 parts water, 3 parts ethyl alcohol and 1 part commercial formalin). A total of two hundred fifty or more vials of material from seventy three different stations (as shown in Map 3) were available for examination. The majority of the collections were made by the writer, but several from Berrien County were kindly furnished by Dr. M. L. Britton of Northwestern University. Dr. G. W. Prescott also graciously made available the use of his extensive collections from Northern Michigan. The methods of chemical water analysis for pH, methyl-orange alkalinity and dissolved CO_2, which were performed in the field, are given in Theroux, Eldridge and Mallman (1943). Examination of the material was made in the laboratory. Species determined for each collection were listed on a collection card. In addition, a separate card record for each species was maintained in order that distribution data for that species

could be assembled. A drawing of at least one specimen each of the majority of species identified by the writer was made with the use of a camera lucida.

VIII. GENERAL PHYSIOGRAPHY OF MICHIGAN*

The state of Michigan has been divided into a number of physiographic regions (See Map 1). The upper peninsula is divided into such regions, a western and an eastern, the boundary being near the meridian passing through Marquette. The western uplands is an uplifted peneplain, averaging 1600-1800 feet above sea level (1000-1200 feet above Lake Superior) with the local relief, which is not more than 500 feet, averaging 100-300 feet. The precambrian bedrock which is composed of igneous material such as granites, gneisses, schists or metamorphic sedimentary rocks of quartzite, dolomite, slate, etc., is irregularly covered in about three-fourths of the region by glacial drift composed of Palezoic sandstone, shale and limestone. The main areas where the bedrock occurs (as hills, rock, knobsand, sharp ridges) above or near the surface include (as shown in Map 1) regions of the Keweenaw Peninsula, the Huron and Porcupine Mountains, the Gogebic range between Ironwood and Lake Gogebic, and the extreme southern portion of the western peninsula near Iron Mountain. Other areas occur in the vicinity of the towns Republic and Crystal Falls, and in the Marquette-Ishpeming region. The surface drainage of this region, which is controlled both by glacial formations and preglacial topography, is into Lake Superior and Lake Michigan except for a small area in southern region of Gogebic County

* Adapted from Leverett 1917 and Scott 1921



MAP 1

PHYSIOGRAPHIC REGIONS

Outcrops or Bedrock Near Surface

Proterozoic-Igneous or Metamorphic Rock

Paleozoic-Calciferous Sandstone or Niagara Limestone

Paleozoic-Sandstone

Adapted from:
Leverett (1917)
Scott (1921)

which is drained by the Wisconsin River into the Mississippi River. Drainage is incomplete in many morainic areas, resulting in numerous small lakes and swamps. The Eastern Lowlands occupies primarily that region of the upper peninsula eastward from the meridian passing through Marquette. Extensions also occur southward into Wisconsin and Minnesota as well as northward and westward in a narrow coastal strip along the edge of the Western Highlands. Generally this region is 1000 feet lower than the Western Highlands, averaging about two hundred fifty feet above the Great Lakes. The unequal weathering of the younger Paleozoic bedrocks has resulted in what has been termed a belted lowland, with some formations in tablelands and others in low areas between the tablelands. Two examples are the Niagara limestone formation along the northern border of Lake Michigan and Lake Huron, and the calciferous Cambrian sandstone tableland overlooking Lake Superior or the plain below it in Alger and Marquette Counties. Most of the region is irregularly covered with a glacial drift that is very variable in its composition and its depth. The tableland of Niagara limestone along the southern boundary is the most thinly covered. In addition to the long moraine at the junction of Mackinac, Luee and Schoolcraft Counties, the other notable physiographic features are the swampy, sandy plains, the two major ones occupying much of the drainage basins of the Manistique and the Tahquamenon Rivers. The former drains some 1400 square miles of territory in the western part, whereas

in the central part, the drainage takes place by the Tahquamenon River to the north and the Carp River to the south. The drainage of the eastern part is mostly into St. Mary's River and Lake Huron. Despite these extensive river systems mentioned, the drainage is relatively poor with large areas covered by swamps and lakes.

The altitude of the southern lower peninsula compares more favorably with that of the eastern than with the western upper peninsula. The average elevation is about 800 feet above sea level, with about 96% of this region below 1200 feet. The main physiographic regions (as shown on Map 1), are the Erie lowland, the Thumb upland, the Michigan lowland, the Saginaw lowland and Northern upland. Both the Thumb upland, which extends in a northeasterly direction from Hillsdale County to the Thumb and the Northern upland which is composed primarily of 1500 square miles largely in Crawford, Otsego, Wexford, Osceola and Missaukee Counties, constitutes the regions of highest elevation. The former ranges from 1100 feet in Hillsdale County to about 700 feet at the end of the Thumb area, whereas the Northern upland is about 1200 feet in elevation.

The bedrock in this area is primarily of Paleozoic age, with Upper Silurian, Devonian and Carboniferous deposits of limestone, shale and sandstone arranged in a nearly horizontal position but dipping slightly to the center of the peninsula. Except for outcrops of thinly covered areas of Marshall sand-

stone of early Carboniferous Age in parts of Hillsdale, Jackson and Calhoun Counties and Palezoic deposits of limestone in Presque Isle County, the southern peninsula is covered with glacial drift of variable depth and composition. Leverett (1917) states that there are areas near the border of Lake Michigan where the drift is known to exceed six hundred feet, although the average depth is about three hundred feet. The drainage of this region is determined chiefly by the physiography of the different areas within it. In general, the sources of most of the major streams (which empty into either Lake Michigan or Lake Huron) are found in the upland areas.

In the Northern uplands (as shown in Map 1) arise the headwaters of the Muskegon, Manistee, Au Sable and Cheboygan Rivers. The Thumb upland is the source of tributaries (such as Huron River) to Lake St. Clair and Lake Erie. In the Southern upland near Hillsdale and Jackson Counties, are located the sources of three major streams, the St. Joseph, the Kalamazoo and the Grand, which drain also part of the Michigan lowland before flowing into Lake Michigan. The Saginaw River and its tributaries which constitutes the largest river system in Michigan, drains the major portion of the Saginaw lowlands, although one branch arises in Southern upland and another in the Northern upland. The Grand River also drains part of the Saginaw lowland. According to Scott (1921), the great number of lakes, both large and small, especially in the northern and southern interlobate areas, and in the mor-

ainic regions within Calhoun, Barry and Kent Counties, is indicative of the incompleteness of the drainage.

IX. SOIL REGIONS OF MICHIGAN

The wide range of soils of Michigan have a close relation to the surface formations of glacial origin. Veatch (1937), discusses the general relationship of geological formations to soil, but emphasizes that other factors such as the lithological character of the drift, the age of the land surface, details of relief or topography, the climate and the vegetative cover, must be considered as well as the soil-forming processes in the differentiation of soil types. He further presents a map of Michigan (which is reproduced here as Map 2) showing the various divisions based on the lithologic composition of the surface deposits. The great diversity of soils (and thus also of the surface drift) is even more apparent when one observes the sixty-seven natural land divisions discussed, and also shown in map form by Millar (Michigan State College Extension Bulletin 290). Even smaller subdivisions of the natural land divisions are discussed by Veatch (1941) in reference to the characteristics of individual soil types, and their land character, agricultural value and use, and to their distribution in Michigan. Because of the enormous variety of soil types thus exhibited in Michigan, and because they have been thoroughly described and discussed by the authors mentioned above, no attempt will be made here to discuss them individually. A summary of the major land

types, however, which are found within the state (Veatch, 1941) can be briefly mentioned.

1. The lake bed clay plains type, representing old lake beds formed during the high or glacial stages of the present Great Lakes, occupy primarily level or flat regions, underlain by clay or silt, along the shores of the Great Lakes. There are very few lakes or peat swamps in the land division.
2. The rolling clay plains type, represent a somewhat diverse group of gently rolling lands occupying till plains or ground moraines, similar in some respects to the type mentioned above, but with a greater range of difference in local elevation, and with a greater proportion of well-drained soils and associated peat and muck land.
3. The dry sandy plains type, which covers the largest area of the state, is composed of five subtypes. They include level and pitted plains associated with numerous lakes, peat and muck land in several counties (Kalamazoo, Jackson, Oakland, etc.) in the southern part of the state, dry sandy pine and oak plains in both the northern part and southern part of the peninsula, dry gravelly and sandy hardwood plains and valleys in the northern part of the state, valley plains associated with ridges and rock knobs in highly elevated parts of the western upper penin-

sula, and the dark-colored prairie lands of the southwestern part of the state.

4. The sandy hills land type, represents hilly, sandy uplands which arise above clay plains and sand plains. Irregular topographic features such as knobs, basins, sharp ridges and broad long slopes as well as numerous lakes, are characteristic of this type which is represented by subtypes in hilly regions of Barry, Jackson and Washtenaw Counties, pine and oak hills in Newaygo, Roscommon, Oscodao Counties, etc., and sandy hardwood hills of the northern part of the state.

5. The wet sandy plains type, represents wet, waterlogged and hard pan sands associated with flat areas or low, narrow, linear ridges of dry sands, occupying areas on old lake-bed plains. Variable amounts of peat, muck and wet clay land as well as clay plains are associated with this type in parts of Ottawa, Muskegon, Saginaw and Tuscola Counties.

6. The sandy plateau type, is represented by level, sandy plateau highlands which are cut by broad deep valleys at wide intervals. Slopes of such highlands may be sharp escarpments; valley slopes with broken topography or a succession of separate terraces or benches. Areas represented by this type occur in high sandy hardwood hill regions of some northern

lower peninsula counties (Antrim, Charlevoix, Emmet, etc.). One subtype represented by level, dry, sandy pine plains occurs in the plateau south of Newberry in Luce County, while another subtype composed of high bench land borders Keweenaw Bay and Lake Superior in Baraga, Houghton and Keweenaw Counties.

7. Rock plains type, is represented by level or gently rolling plains, plateaus or benches where bedrock lies very close to the surface. Only a few streams and lakes, but often numerous swamps, are associated with the numerous stones, slabs of bedrock, and boulders that are characteristic of this type. The subtypes are classified on the type of underlying rock and vegetation-soil relationship. One subtype comprises limestone-underlain regions with forests of sugar maple, beech, elm and basswood as well as a large proportion of conifers in the eastern upper peninsula (Delta, Alger, Schoolcraft, Mackinac Counties). One other subtype includes the sandstone plateaus and benches principally along Lake Superior in Alger County, forested by balsam, fir, spruce, cedar, hemlock, aspen and white birch. The land underlain by slates and crystalline rocks, and associated with a large proportion of wet land in shallow swales or held in hollows in bedrock and occurring in high elevated regions of the western upper

peninsula (Baraga, Marquette, Iron, Gogebic Counties) comprise the third subtype. A mixed forest of sugar maple, yellow birch, balsam, fir, spruce, etc., densely cover this latter region.

8. Rock knob type, is represented by areas in the Huron mountains and the northern part of Marquette County, Porcupine Mountains, Copper Range from Ontanagon County through the Keweenaw Peninsula as well as smaller areas near Ishpeming, Iron Mountain, Crystal Falls, Republic and Ironwood. Here the land is characterized by rugged topography with rock outcrops of domes, knobs or cliffs and coarse drift in the valleys. Swamps, bogs and streams are numerous.

9. The swamp plain type, comprises large extensive areas of wet peat and muck land located in: the Tahquamenon River drainage region of Luce County; marsh and forested swamps near Seney in Schoolcraft County, and swampland in lections of Menominee, Marquette and Delta Counties.

10. The lake shore type, is represented by narrow bands of land occupied by dunes, wave washed beaches and floors of bedrock, parallel sand ridges with intervening swampy depressions and lakes, marshes and sluggish streams which border the Great Lakes. Principal areas are located in the various counties of the western lower peninsula bordering Lake Michigan

and near Grand Marais (Alger County), Deer Park (Luce County), as well as several places upon the Lake Michigan shore between St. Ignace and Manistique in the upper peninsula.

X. DISCUSSION AND RESULTS

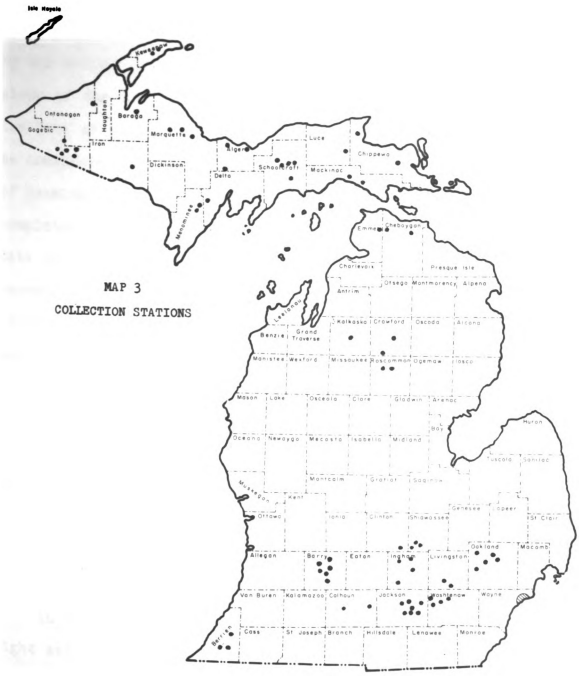
A. General Data

The collections from seventy-three habitats (as shown on Map 3) yielded over two thousand determinations of which about eight hundred were from the southern lower peninsula, three hundred from the northern lower peninsula, four hundred from the eastern upper peninsula, and about five hundred from the western upper peninsula. Records for individual species, variety or forms are located in the systematic section of this paper, and will not be discussed here. However, aggregate statistics are listed below.

New species, varieties or forms	19
New records for the state	192
Previously reported but also found by the writer	343
Previously reported but not found by the writer	198
Total species, varieties and forms in the state	752

The distribution of the seven hundred fifty two species, varieties or forms (including previous reports) in the various regions of the state are as follows:

Southern lower peninsula (below Bay City to Ludington line)	415
Northern lower peninsula	425
Eastern upper peninsula (east of Marquette and Menominee Counties)	280
Western upper peninsula	241
Isle Royale	191



MAP 3

COLLECTION STATIONS

Although the numbers of determinations of species made by the writer are unequal from the respective four major regions of the state, such determinations were made from collections of widely spaced stations in the state and thus must be considered as representative of the state-wide distribution of desmids. No claim is made that the entire state has been completely covered, but it is thought by the writer that the data from his widespread collections give a more accurate representation of certain regions of the state, such as the Southern lower peninsula and Western upper peninsula, than has been known previously. Many counties still lack a report of single desmid from within their boundaries, but the location of satisfactory habitats, chance collections, and the enormous number of aquatic habitats to be sampled, all provide difficulty in obtaining equal representative samples of every county in the state.

B. Desmid Distribution in Relation to Geological Features and Soil Types

In attempting to determine whether a general correlation might exist between the abundance of desmids and the geological and soil characteristics of the major physiographic regions, one is confronted with many factors that must be considered.

It is an accepted fact, that desmids are generally calciphobic, and thus occur most abundantly in soft-water habitats. The question that then arises, is whether previous distribution records necessarily reflect the relative number of such habi-

tats (or abundance of desmids) in the various regions of the state. The writer believes that the answer must be in the negative, because the concentration of the majority of previous investigations have been primarily directed toward two centers; the Douglas Lake region (Nichols and Ackley 1932, Taft 1939) and Isle Royale (Taylor 1935b, Prescott 1937, 1938, 1940, 1941). The large number of species reported from these two centers certainly reflect the fact that desmids are abundant in these two regions, but obviously cannot be used for comparison with other regions where desmid reports are few despite the fact that numerous soft-water habitats are present in many cases. The possession of a considerable number of additional distribution records from not only the writer's collections, but from other reports since 1932, perhaps gives a much more complete picture than available to Nichols and Ackley, but still does not completely represent necessarily the relative abundance of desmid habitats (and thus desmid abundance) in the various regions of the state. Another factor that must be considered when discussing correlations between physiographic regions and the abundance of desmids in those regions, is that soft-water habitats although generally favorable for desmid growth, do not always show equal abundance of desmids. Although desmid abundance appears correlated with the abundance of soft-water habitats, there is great variation in the number and kinds of species present in individual soft-water habitats. Certain regions of the state may have a

greater abundance of desmid habitats, but by no means is the distribution or abundance of desmids uniform throughout these regions. Thus, such local variation may have had an important influence upon our present distribution records, thereby modifying any broad general correlation to some degree. This is even more apparent if one refers to Welch (1935), Rawson (1939), Prescott (1939, 1951) and Pennak (1946) who discuss the great number of complexly inter-related edaphic and climatic factors which operate in producing an aquatic habitat. If only the chemistry of the water is considered as the primary factor in controlling desmid distribution, there remains a very complex problem. Unfortunately chemical analysis of the Na-K / Ca-Mg ratio (which has been discussed previously as important in desmid distribution) for various desmid habitats in Michigan are not available except as comparable chemical data for a few bog lakes in the northern lower peninsula, (Jewell and Brown 1929). The use of available but much simpler chemical data (such as pH and methyl-orange alkalinity) of soft-water habitats, creates other objections. Such simple chemical analyses are not only mere indices of a general nature, but also do they reflect only the value for that sample of water at the time it was determined (it being known (Welch 1935) that pH and other chemical components may change daily as well as seasonally). Collections of algae are likewise only representative of the time of collection, and in the immediate area of collection, and do not reflect either a total seasonal

picture of species present or the total number of species present in an entire pond, lake or ditch or whatever habitat is collected. Thus the number of samples, the number of habitats in one station, the time of sampling, as well as the thoroughness and accuracy of examination, also create variables. If one can assume, however, that one can compare the simple chemical (pH, methyl-orange of various soft-water habitats) indices taken during the day in the summer months with the number of species of desmids found in the collection obtained in those soft-water habitats at the same time and place, we will find noticeable contrasts. Listed below are the pH and methyl-orange alkalinity determinations as well as the number of species determined in those samples from a number of stations selected at random.

	pH	Bicarbonate (p.p.m.)	Acidity (in terms of $CaCO_3$ p.p.m.)	No. species of desmids
#65	5.5	9	23	10
#67	6.0	11	5	94
#68	5.8	15	6	50
#70	5.9	18	20	70
#72	5.6	25	60	4

Thus it is apparent from these few stations, that although desmids occur in soft-water habitats with similar pH and methyl-orange alkalinity values, they occur in much greater abundance in some of these habitats than others. Even in a single lake, the habitats may be so different that the desmid representation

is changed considerably. Collections from an unnamed bog lake four miles south and east of Howell in Livingston County, were made in August and October. Collections made from Utricularia sp. squeezings in the open water contained about the same number of species (30-35) as squeezings from Sphagnum sp. in the mat, but the majority of species in one habitat were not present in other habitat. That this difference is probably attributable to species preference, not only for certain types of physical habitats, but also for different chemical factors, can be shown by data collected from an unnamed bog lake near Quimby Road in Barry County. Here the Sphagnum mat not only offered a different physical habitat, but also a sharply different chemical one from the open water.

	Species Number	pH	Bicarbonates (p.p.m.)	Acidity (in terms of $CaCO_3$ p.p.m.)	CO_2 (p.p.m.)
Sphagnum Mat	25	4.2	12	54	42
Open Water	60	6.7	30	6	4

Not only was the species number much greater in the open water, but also the kinds of species was sharply different. Strom (1926) also found a great difference in numbers of species in various habitats in Norway, and states that acid bogs contain a far richer desmid population than any other type of habitat, but are most abundant in those moderately aerated with a reaction approaching the neutral. It thus appears very obvious that many variables do exist and that only certain broad gen-

eralities can be discussed, with the full knowledge that many exceptions probably do exist. Correlations between desmid distribution and the geological and soil characteristics of the various physiographic regions of the state must therefore be only of a general nature. Such correlations, must of necessity, be based upon the following sources of information:

1. The present available reports of desmids from Michigan.
2. The results of similar studies in other states and countries.
3. The very meager chemical data of the waters of Michigan.
4. The understanding of at least the major physiographic or soil regions of the state and their relationship to desmid distribution in the state.

With such considerations understood, one can proceed to a discussion of the desmid distribution in the state of Michigan.

Desmids, as previously mentioned, are calciphobic and therefore should have their greatest abundance in those regions of the state where there are the most suitable habitats (soft-water). Of the many factors that influence the creation of such habitats, the geological bedrock has been considered of paramount importance by several investigators. As previously mentioned, West (1906, 1909) found the greatest abundance of desmids in bodies of overlying prepaleozoic igneous bedrock (which is low in limestone and thus theoretically determines the low calcium content of the waters). Smith (1924b) in

studies of lakes in Wisconsin, Ontario and New York, also claims a correlation between the type of bedrock and the richness of desmids, the pre-Paleozoic igneous rock favoring (by exerting an effect on the chemical composition of the drainage water) the production of soft-water habitats and a corresponding abundance of desmids, whereas the younger Paleozoic deposits of sandstone and limestone favor the development of more alkaline lake water with a corresponding decrease in desmids. Strom (1926), in his work on the Norwegian mountain algae, has greatly enlarged upon the conclusions of the Wests, but emphasizes it is not the age of the bedrock, but the effect of the bedrock on the chemistry of the water.

If we apply such a criterion to the state of Michigan, we find (Map 1), that although the western upper peninsula is underlain by older and mostly lime-poor pre-Paleozoic formations, and the rest of the state, by younger and mostly lime-rich Paleozoic formations, there is only a relatively small area in which the bedrock is exposed as outcrops or present near the surface. It is thus obvious that the bedrock (whether pre-Paleozoic or Paleozoic), can influence the chemistry of surface waters only in this small area, whereas the nature of the glacial drift which covers the vast majority of the state must have a much more influential role in determining water-chemistry (and thus desmid habitats) in the state. Nichols and Ackley (1931) have stated essentially the same conclusion, although they were interested only in the influence of the

bedrock. The influence of glacial drift and soils developed from the drift in the determination of surface water chemistry, cannot be fully analyzed here, although the writer believes that in general it plays a vital part. Brown (1930) at least states that "the abundance of desmids in the coastal plain (southeastern Atlantic) seems to correlate well with the wide distribution of acid sand and clay soils". McInteer (1938) reports similarly that there is a greater desmid abundance (numbers of species) in the regions of more acid soils (with lower total phosphorous) in Kentucky. Shoup (1947) states that the waters of various regions of Tennessee reflect the influence of the various geological strata underlying the various regions (and the influence of the soil, the writer believes, which have for the most part been derived from the bedrock in that state). Strom (1926), also states that "in smaller bodies of water, especially, it is not exclusively the underground which determines the reaction of the water, but also the respiration and assimilation of plants and animals, as well as the aeration or stagnation, and last but not least, the qualities of the soil proper". It thus may be inferred that the nature of the exposed bedrock, the glacial drift and the soils derived from both, collectively exercise some general influence over the water chemistry of the various regions of Michigan.

Previous mention has been made in the section on soils, of not only the great variability in the depth, but also in

the composition of the glacial drift. The comparison of the sixty seven individual natural land divisions listed by Millar (Michigan State College Extension Bulletin 290) with the desmids reported from these divisions, appears to be a too complicated and unnecessary undertaking. However, the use of Veatch's (1937) eight divisions of the state, which are classified upon the basis of the lithologic composition of the surface deposits (thus combining not only the drift but also the bedrock at or near the surface), appears to be sufficiently simplified so that general comparisons can be made. The relative influence of limestone which is included for each division, would also seem to be of practical value in the comparison of desmid distribution in the different regions.

Veatch's lithologic divisions of the state do not conform to county boundaries, so that in many instances previous county records are not sufficient enough information to determine from which lithologic division the individual species have been reported. It is thus necessary to use only the distributional records obtained by the writer for purposes of comparison.

Lithologic Division (See Map 2)	Number of Desmid Species
1	177
2	381
3	---
4	340

Lithologic Division (See Map 2)	Number of Desmid Species
5	260
6	278
7	506
8	10

No collections were made from division three and only a very few from section eight, so that a strict comparison cannot be made in these two regions. Consideration must also be given for the fact that the number of samples as well as the number of stations were somewhat unequal in the different regions. The numerous other variables that may enter into such a comparison have also been previously discussed. If, however, an examination is made upon the basis of the available distribution records of species as well as observations made by the writer, the following general comparison can be made.

Division 1 (see Map 2) which exhibits the greatest limestone influence (and which has numerous limestone outcrops in certain regions) has the smallest number of species represented. Division 7 which has the least limestone influence (with numerous outcrops if igneous rock in certain areas) has the largest number of species represented. This information thus largely corroborates Prescott's (1951) views on the greater desmid distribution in the western upper peninsula with a corresponding decrease in the eastern upper peninsula. Although bog lakes are present in the eastern upper peninsula, the des-

MICHIGAN

GEOLOGIC–PEDOLOGIC RELATIONSHIPS

By J. O. VEATCH

Map 2

1 Drift generally exhibits strongest limestone influence, but noncalcareous deposits are associated; more clayey drift pale reddish; bedrock at shallow depths; bouldery. *1A*, red mixed limestone and sandstone. *1B*, red mixed limestone, sandstone, and crystalline rocks

2 Strong sandstone influence, moderate shale and limestone; gray and yellow; high proportion coarse texture; bedrock at shallow depths common

3 Red, diversity of rock influence, with strong to moderate limestone influence. *3A*, minimum limestone influence. *3B*, chocolate-colored or pale red, less coarse material

4 Gray and yellowish drift, locally chocolate-colored and red till clay northern part; great diversity of rocks with strong to moderate limestone and shale influence. *4A*, slate color, strong influence of shale and limestone. *4B*, chocolate to slate color, strong influence of shale, less coarse drift. *4C*, chocolate to slate color, strong shale influence

5 Pale red, great diversity of rock, strong to weak influence of limestone. *5A*, dominant sandy deposits and minimum influence from limestone. *5B*, pale red or chocolate color in clayey drift, more strongly calcareous; less coarse drift

6 Pale red and gray drift dominantly sandy; diversity of rocks; slight limestone influence. *6A*, pale reddish lacustrine silts and clays highly calcareous

7 Reddish drift, sandy, stony; sandstone and crystalline rock influence dominant; limestone slight and purely local; stony; locally small thickness and rock outcrop

8 Grayish to red drift producing dark red clay and loam soils; strong influence of basic rocks; coarse-textured drift; no limestone or purely local influence. *8A*, darker red moderately calcareous silt and clay. *8B*, gray and yellow drift; thin covering over bedrock; not calcareous; coarse. *8C*, darker red drift and soils; strong influence from iron-bearing rocks; coarse rock outcrop.

NOTE — The heavy boundary extending from Oceana to Alcona County marks approximately the southern limit of hardwood podsol soils which exhibit a marked limestone influence.

mid flora is usually less productive in a number of species than comparable stations in the western upper peninsula. A few habitats in this region were exceptions to the general picture and exhibited a moderately rich population of desmids. Strom (1926) reports similar findings in the Norwegian mountain algae, and states that "in the lime-rich districts they (desmids) only occur in any real qualitative abundance in the localities which are more or less self-contained, and directly influenced by the geologic strata, i.e., in the acid peaty bogs, though they are never so richly represented there as in clear waters". The other lithologic regions of the state are represented by a somewhat variable number of species records. Division 2 which has a strong sandstone but only a moderate limestone and shale influence is represented by the second largest number (381) of species varieties and forms. Division 4 (not including 4A, 4B which were not sampled because of the apparently few bog lakes) which has a strong to moderate limestone influence, is represented also by a fairly high number of species (340). The writer believes, however, that the high numbers of species represented in the latter two divisions are not true indications of the general lithologic characteristics of the divisions. Rather, they reflect mainly the reports from a very few rich desmid habitats located in a generally desmid-poor region. Observations of the numerous collections made from portions of these divisions by the writer, reveal that although bog lakes occur in these

generally hard-water regions, the vast majority are generally poor, in desmid species. Division 5 has a strong to weak influence of limestone. In division 5A, however, the dominant sandy deposits have a minimum influence from limestone. This division, although represented by only two hundred sixty species from the writer's collections, (because of the concentration of previous investigations in this region, the writer made only a few collections) should probably have a much higher number because of the frequency of acid bogs at least, in the Douglas Lake region. The vast majority of species reported by Nichols and Ackley (1932) and Taft (1939) from Cheboygan County, have probably come from this region, although about half the county is in Division 1 (strong limestone influence). It is impossible, however, to distinguish from what portion of the county the species records were made. General observations made by the writer (as a student in Douglas Lake region for two summers) may be used to substantiate the fact that many rich desmid habitats do exist in this region. Division 6 possesses a dominant sandy drift with slight limestone influence, and occurs in the northern half of the eastern upper peninsula, although the extreme eastern portion has more calcareous material. A fairly strong representation of desmid species (278) in this region is generally correlated with the large peat deposits, swamp and marsh land areas in Schoolcraft, Luce and West Chippewa Counties.

C. Summary of Discussion

1. The general distribution of desmids in the state of Michigan is determined largely by the presence of soft-water habitats.

2. The abundance and distribution of soft-water habitats (and thus abundance and distribution of desmids) is determined in general by several primary factors. They are:

a. Nature and distribution of geological bedrock. Drainage water from lime-poor formations (such as pre-Paleozoic deposits in regions of the western upper peninsula) appear to produce more favorable habitats (more acid habitats), whereas drainage water derived from more calcareous formations (such as Palezoic deposits in sections of the eastern upper peninsula) appear to produce less favorable habitats (more alkaline habitats). However, this factor of geological bedrock influences the presence of suitable habitats only in the relatively small areas of the state where bedrock occurs near the surface or as outcrops.

b. Nature and distribution of glacial drift. Waters draining acid sands and clay soils are more favorable for desmid production (more acid) than water draining soils with high calcareous content. This factor of glacial drift

appears to be more important in influencing desmid distribution in the state than geological bedrock because the vast majority of the bedrock in the state is covered by glacial drift.

c. Local habitat characteristics. Many factors such as type of drainage, physiographic features, vegetation, accumulation of organic remains of plants as well as the numerous climatic and edaphic features that influence aquatic habitats may so operate as to provide favorable desmid habitats in an otherwise unfavorable region.

3. Desmids are widely distributed over the state, but are more abundant in certain regions where there are more suitable habitats. These regions which are very generally correlated with areas of slight limestone influence (see Map 2) are:

a. The western upper peninsula (regions 7 and 8B) where surface waters are largely influenced by outcrops of sandstone and crystaline rocks, as well as acid, (generally none or only slight amounts of limestone) stony and sandy drift. The irregular, rugged terrain and poor drainage of this region are also influential in providing many soft-water habitat.

b. The dominant sandy regions (section 5 and

and 5A), especially in the upper central region of the lower peninsula where a minimum influence of limestone and poor drainage makes possible a rich development of acid bogs.

c. Parts of Chippewa, Luce, Alger and Schoolcraft Counties (section 6) where great areas of swamps, marshes and peat deposits associated with the Manistique and Tahquamenon River drainage systems, as well as the slight limestone influence of the dominantly sandy drift permits a fair development of suitable desmid habitats.

d. The irregular morainic area, extending from Oakland County, south and west through Washtenaw, Jackson, Calhoun and Barry Counties, in which the topography, poor drainage and other local conditions permit development of a few acid bogs, or other suitable habitats in a generally hard-water lake region. Many of these bogs are only slightly acid and have a poor desmid flora, but others have a conspicuous and rich desmid population.

XI. SYSTEMATIC ACCOUNT

A. Introduction

In the following taxonomic portion of this paper, artificial keys to both genera and species of Michigan desmids are presented. Each species, variety or form in the key possesses a number which corresponds to the same entry in the descriptive portion following each key. For each entry the following information is provided:

1. A standard reference.
2. Brief diagnostic comments.
3. Measurements. Those of the writer are always enclosed in brackets. Abbreviations used in this part are:

   L. - Length

   Lssp. - Length without spines

   Lcsp. - Length with spines

   Lsp. - Length without processes

   Lcp. - Length with processes

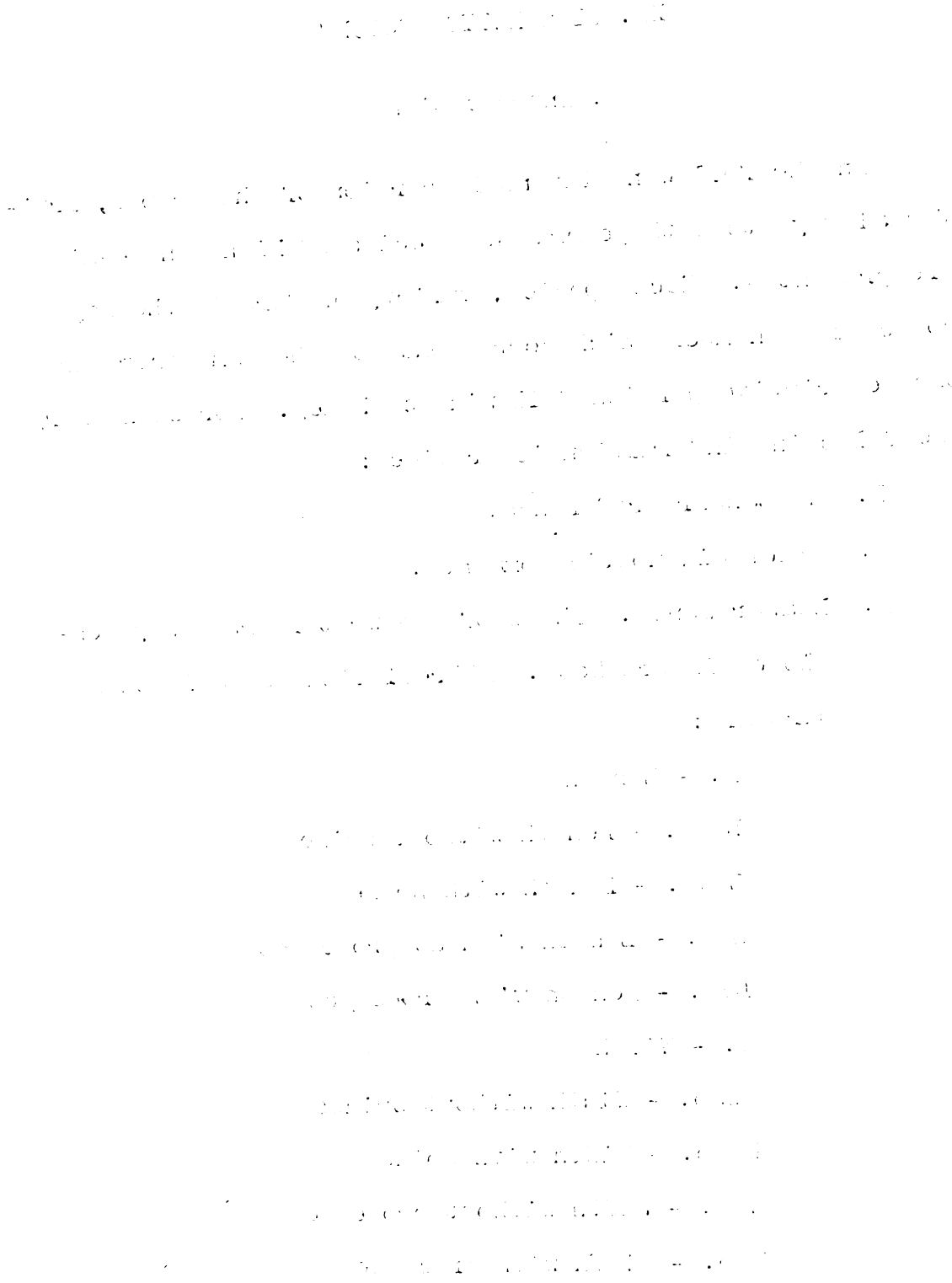
   W. - Width

   Wssp. - Width without spines

   Wcsp. - Width with spines

   Wsp. - Width without processes

   Wcp. --Width with processes



I. - Isthmus

A. - Apex

B. - Base

Sp. - Spines

4. Distribution records for Michigan. The following symbols are used in this section:

SLP - Southern Lower Peninsula (south of Bay City to Ludington line).

NLP - Northern Lower Peninsula

EUP - Eastern Upper Peninsula (east of Marquette and Menominee Counties).

WUP - Western Upper Peninsula.

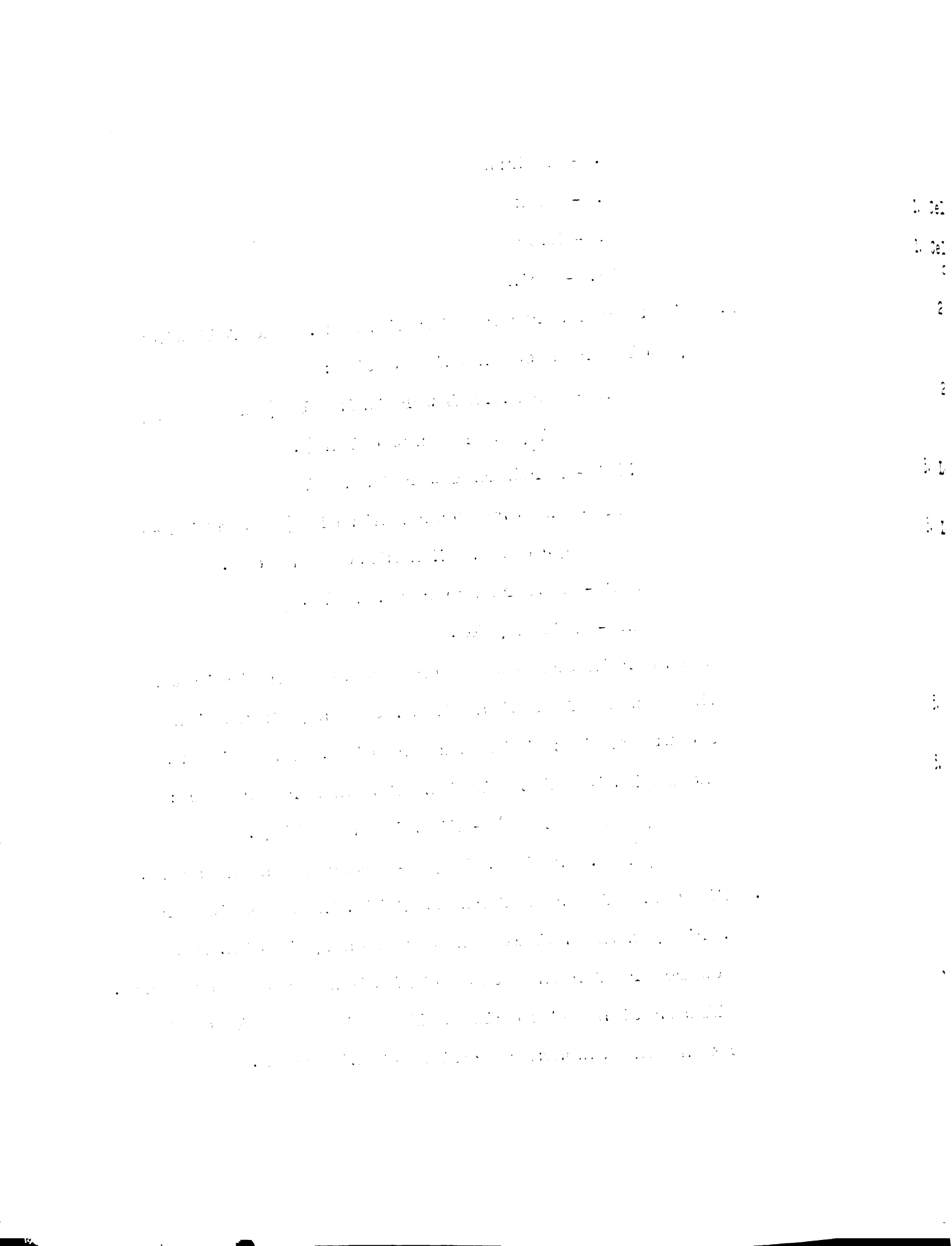
IR - Isle Royale.

A number in brackets after a county name indicates the number of stations in that county from which the writer identified the organism. In addition, the following abbreviations for authors are used:

(N and A 1932) - Nichols and Ackley.

(Pres. and Mag. 1935) - Prescott and Magnotta.

5. Plate and figure references following a species or variety name indicate that such entry is either a new record for the state of Michigan or new to science. Illustrations of species will be found on plates following the taxonomic section of this paper.



B. Key to the Genera of Michigan Desmids

1. Cells solitary 2

1. Cells either in filaments or in colonies 24

2. Cell with a median constriction dividing the cell into symmetrical halves 3

2. Cell without a median constriction dividing the cell into symmetrical halves 14

3. Length of cell over three times the width 4

3. Length of cell not over three times the width 7

4. Apical portion of the semicell with a vertical incision . . 5

4. Apical portion of the semicell without a vertical incision . 6

5. Semicell wall ornamented with transverse rows of spines or verrucae . (12) Triploceras

5. Semicell wall not ornamented with transverse rows of spines or verrucae . . . . . (13) Tetmemorus

6. Semicell base ornamented with a row of vertical plications . (11) Docidium

6. Semicell base not ornamented with a row of vertical plications . . . . . (10) Pleurotaenium

7. Cells compressed, biradiate in vertical view 8

7. Cells not compressed; three to twelve radiate in vertical view (rarely certain forms of Arthrodesmus or Xanthidium). . . . . (21) Staurastrum

8. Apical portion of the semicell with a vertical incision . . 9

8. Apical portion of the semicell without a vertical incision . 10

9. Lateral margins deeply incised nearly to the midregion . . . . . (20) Micrasterias

9. Lateral margins not deeply incised . (14) Euastrum

10. Lateral margins deeply incised, nearly to the midregion . . . (20) Micrasterias

10. Lateral margins not deeply incised . . 11

11. Apical angles of semicells continued into two diverging processes . . . (21) Staurastrum

11. Apical angles of semicells not continued into two diverging processes 12

12. Semicell wall with spines . . . 13

12. Semicell wall without spines. . (15) Cosmarium

13. Semicell wall thickened in median portion . . . . . (19) Xanthidium

13. Semicell wall not thickened in median portion 36

14. Cells elongate, straight or lunate 18

14. Cells more or less ovoid . . . 15

15. Two stellate chloroplasts present in each cell . . . . . (3) Cylindrocystis

15. Two stellate chloroplasts not present in each cell 16

16. Chloroplasts axial 17

16. Chloroplasts parietal, spirally twisted . . . . . (6) Spirotaenia

17. A single plate-like chloroplast extending the entire length of the cell . . . . . (2) Mesotaenium

17. Two chloroplasts present in each cell; each chloroplast with longitudinal ribs . . . . . (9) Penium

18. Poles of cells acute 19

18. Poles of cells broadly rounded or truncate 20

19. Two chloroplasts present in each cell and not touching each other in center of cell . . . . . (7) Closterium

19. A single chloroplast present in each cell and interrupted in center of cell . . . . . (5) Roya

20. Poles of cells truncate . . . . (1) Gonatozygon

20. Poles of cells broadly rounded. 21

21. Chloroplasts axial 22

21. Chloroplasts parietal spiral bands . (6) Spirotaenia

22. A single chloroplast present in each cell and not interrupted in center of the cell . . . . (5) Roya

22. Two chloroplasts present in each cell and not touching each other in center of cell. 23

23. Cells straight . . . . . (4) Netrium

23. Cells curved 35

24. Cells united in filaments . . . 25

24. Cells arranged in a more or less globose gelatinous colony and connected to each other by gelatinous strands . (16) Cosmocladium

25. Length of cell over three to four times the width . . . . . (11) Pleurotaenium

25. Length of cell not over three to four times the width 26

26. Apical portion of semicell incised . . . . . (20) Micrasterias

26. Apical portion of semicell not incised 27

27. Cells united by apical processes . . 28

27. Cells not united by apical processes 29

28. Processes short and interlocking often tuberculate . . . . . (23) Sphaerozosma

28. Processes long and overlapping adjacent cells . . . . . (22) Onychonema

29. Vertical view elliptical or circular 30

29. Vertical view triangular or quadrangular 33

30. Vertical view elliptical . . . 31

30. Vertical view circular 32

31. Cells strongly compressed, narrow in thickness as seen in side or end view . . . . . (24) Spondylosium

31. Cells not thus strongly compressed . (27) Desmidium

32. Semicell wall ornamented with longitudinal striae near the poles . . . . . (28) Gymnozyga

32. Semicell wall not ornamented with longitudinal striae . . ... . (25) Hyalotheca

33. Apices of young semicells infolded . (27) Desmidium

33. Apices of young semicells not infolded 34

34. Vertical view triangular . . . (24) Spondylosium

34. Vertical view quadrangular . . (26) Phymatodocis

35. Apices with stout spine . . . . . (8) Spinoclosterium

35. Apices without a spine . . . . . (7) Closterium

36. Semicell with spines present at each angle; semicell wall without tubercles and a supra-isthmial granule . . . . . (17) Arthrodesmus

36. Semicell with a single large spine at each basal angle; occasionally one at each apical angle; semicell wall with tu-

C. Systematic List

Division Chlorophyta

Class Chlorophyceae

Order Zygnematales

1. Family Gonatozygonaceae

1. GONATOZYGON De Bary 1856

Cells cylindrical or narrowly subfusiform, many (up to 40) times longer than wide, without a median constriction; lateral margins parallel, sometimes slightly tapering to the truncate or subcapitate, sometimes dilated apices. Cell wall smooth or covered with granules or spines. Chloroplasts axial, usually irregular bands, one or two in each cell; numerous pyrenoids regularly spaced in a linear series. Cells sometimes remaining attached in filaments of variable length after cell division, but separating when disturbed or prior to conjugation.

Zygospore spherical with walls smooth.

Key to Species of Gonatozygon

1. Cell wall ornamented with granules or spines 2
1. Cell wall smooth . . . . . (1) G. Kinahani
2. Cell wall with short spines (less than 4.5u) or with granules 3
2. Cell wall with long spines (5-10u) . . . . . (2) G. aculeatum

3. Cell wall with granules (sometimes sharp or papilliform) 4

3. Cell wall with short spines . . . . (6) G. pilosum

4. Cells long, narrow cylindrical-fusiform (usually 10-16, often 30-40 times longer than wide), lateral margins tapering towards sub-capitate apices; granules variable, often sharp . . . . . (3) G. Brebissonii

4. Cells cylindrical (10-25 times longer than wide) with apices very slightly dilated; granules variable, often sharp or papilliform . . . . . (5) G. monotaenium

1. Gonatozygon Kinahanii (Archer) Rabenh

West and West, 1904. Monogr. Brit. Desm., 1:35. Pl. 2, Figs. 1-3.

This species is easily differentiated from other species of Gonatozygon by the smooth cell wall.

Measurements: L. 145-(234)-375u; W. 10.5-(10.6)-17u.

Distribution: NLP, Cheboygan (Taft 1939); EUP, Mackinac: WUP, Gogebic.

2. Gonatozygon aculeatum Hastings

Smith, 1924. Bull. Wis. Geo. & Nat. Hist. Surv. 57(2):5. Pl. 52, Fig. 3.

The presence of long, sharp spines (L. 4.5-9.5u) which are broader at their bases, easily distinguishes this from other Michigan species.

Measurements: L. (116)-125-300u; W. (10.6)-12-20u.

Distribution: NLP, Cheboygan (N &A 1932, fa. minor, West and West); EUP, Chippewa.

3. Gonatozygon Brebissonii De Bary

West and West, 1904. Monogr. Brit. Desm., 1:31. Pl. 1, Figs. 8-11.

This species is characterized by the long, narrow, nearly cylindrical subfusiform cells which are 10-16, sometimes 30-40 times longer than wide. The lateral margins taper distinctly towards the subcapitate apices. The granules on the cell wall may be strongly developed and sharp.

Measurements: L. 94-(140)-288u; W. 3.5-(5.2)-10.8u.

Distribution: SLP, Barry; NLP, Cheboygan (Taft 1939); WUP, Houghton.

4. var. minutum West and West

West and West, 1904. Monogr. Brit. Desm., 1:33. Pl. 1, Figs. 15, 16.

This variety is much smaller than the typical.

Measurements: L. 47.5-67.5u; W. 4.2-7u.

Distribution: NLP, Cheboygan (Taft 1939).

5. Gonatozygon monotaenium De Bary

West and West, 1904. Monogr. Brit. Desm., 1:30. Pl. 1, Figs. 1-7; Pl. 5, Fig. 5.

This cylindrical species has the cell wall ornamented with small granules which may be sharp or even papilliform. The cell is 10-25 times longer than wide, the apices slightly dilated with rounded angles. Specimens from Roscommon had well-developed granules that were sharply pointed.

5. **Measurements:** L. 82-(218)-284u; W. 7.5-(8.7)-11.5u; A. 8.6-12.5u.

Distribution: SLP, Macomb (West and West 1898); NLP, Roscommon.

6. Gonatozygon pilosum Wolle

Smith, 1924, Bull. Wisc. Geo. & Nat. Hist. Surv. 57(2):5. Pl. 52, Fig. 2

This species has cells 12-20 times longer than wide. The lateral margins are somewhat variable, sometimes straight and parallel, at other times slightly attenuated outwardly to the dilated, truncate apices that have rounded angles. The cell wall is densely covered with short, straight and fine spines. The writer does not believe that Gonatozygon monotaenium var. pilosellum Nordst. can be accurately separated from this species, and thus all forms with short thin spines (under 4.5u long) are placed here.

Measurements: L. 100-(211)-300u; W. 6-(9.6)-15u.

Distribution: SLP, Calhoun, also Calhoun (Pres. & Mag. 1935, G. monotaenium var. pilosellum); NLP, Cheboygan, Emmet (Taft 1939); WUP, Gogebic.

2. Family Mesotaeniaceae

2. MESOTAENIUM Naeg.1849

Cells often cylindrical, longer than wide, usually straight, with truncate or rounded apices, free floating or

aggregated in gelatinous masses or mosses or wet rocks. Chloroplasts, one or two in each cell, axial, flattened plates with marginal notches; pyrenoids one or two in each chloroplast. Nucleus is sometimes excentrically located and the cell sap may be colorless or purplish.

Key to Species of Mesotaenium

1. Cells over 3 times longer than wide. (1) M. Endlicherianum

1. Cells under 3 times longer than wide 2

2. Apices of cells truncately rounded . . . . . (2) M. macrococcum

2. Apices of cells rounded . . . . (3) M. De. Greyi var. breve

1. Mesotaenium Endlicherianum Naeg. Pl. 1, Fig. 1. Krieger, 1933. Rabh. Krypt. Flor. 13(1):193. Pl. 3, Fig. 5.

This species is over three times longer than wide, is mostly straight and has rounded apices. The cell sap may be colorless or purplish. The chloroplast may be single or there may be one in each semicell. A single specimen from Berrien County agreed well with the description of this species. The chloroplast structure was slightly disintegrated, although there was a distinct pyrenoid in each semicell. The cell sap was purple. The width (below 15u) places it here.

Measurements: L. (23)-24-50u; W. 7-(11.5)-12u.

Distribution: SLP, Berrien. New record for Michigan.

2. Mesotaenium macrococcum (Kuetz.) Roy and Biss.

Krieger, 1933. Rabh. Krypt. Flor. 13(1):198. Pl. 4, Figs. 1-3.

This species is about 2 - 2 1/2 times longer than wide. The cells are cylindrical and the apices are truncately rounded. The chloroplast is a central plate, often with a notched margin.

Measurements: L. 22-38u; W. 11-20u.

Distribution: SLP, Washtenaw (West and West 1898).

3. Mesotaenium De Greyi var. breve W. West

Krieger, 1933. Rabh. Krypt. Flor. 13(1):192. Pl. 3. Fig. 2.

This organism (rarely curved) is usually two to three times longer than wide. The apices are rounded. The Goebic County specimens were intermediate in proportions between the typical and the variety breve, but are assigned here because of the small size.

Measurements: 32-(42)-65u; W. (13.5)-16-22u.

Distribution: NLP, Cheboygan (Taft 1939); WUP, Gogebic.

3. CYLINDROCYSTIS Menegh. 1838

Cells elliptical or cylindrical with broadly rounded apices and without median constriction. The cell wall is smooth. Each semicell has a somewhat stellate chloroplast with a central spherical or rod-shaped pyrenoid. The nucleus is central in position and between the two chloroplasts.

Zygospores spherical to rectangular, the wall smooth or with sharp angular projections.

Key to Species of Cylindrocystis

1. Cells elliptical . . . . . (1) Cyl. crassa

1. Cells cylindrical with broadly rounded apices . . . . . (2) Cyl. Brebissonii

1. Cylindrocystis crassa De Bary Pl. 1, Fig. 2.

Krieger, 1933. Rabh. Krypt. Flor. 13(1): Pl. 6, Figs. 16,17.

This species is broadly elliptical (about 1 1/2 - 2 times longer than wide).

Measurements: L. 22-(29.8)-72u; W. 14-(15)-48u.

Distribution: EUP, Schoolcraft. New record for Michigan.

2. Cylindrocystis Brebissonii Menegh.

Krieger, 1933. Rabh. Krypt. Flor. 13(1):207. Pl. 6, Figs. 4-7.

This species is cylindrical with broadly rounded apices, and is about 2 - 4 times longer than wide. A single chloroplast in each semicell has a central pyrenoid.

Measurements: L. 30-87u; W. 14-35u.

Distribution: SLP, Barry; NLP, Cheboygan (Taft 1939); EUP, Chippewa, Schoolcraft; Isle Royale (Prescott 1941).

3. var. minor West and West

Krieger, 1933. Rabh. Krypt. Flor. 13(1):209. Pl. 8, Figs. 8, 9.

This variety is smaller than the typical.

Measurements: L. 20-30-(rarely up to 41u); W. 8-13u.

Distribution: NLP, Presque Isle (Taft 1939).

4. NETRIUM Naegeli 1849 (Emend. Luetkem. 1902)

Cells straight, always longer than wide, cylindrical or fusiform with non-constricted lateral margins gradually attenuated to apices, or parallel and then strongly tapered to broadly rounded or conically rounded apices. Cell wall non-segmented, smooth and without pores. Chloroplasts axial, one or two in a semicell; each with 6 - 12 radiating longitudinal plates that are often notched at the edges. Pyrenoids, when single in each chloroplast, rod-shaped, when more than one, spherical or irregularly shaped. Terminal vacuole with gypsum crystals in several species.

Zygospore spherical with smooth thickened walls.

Key to Species of Netrium

1. Cells cylindrical or elongate- cylindric 2

1. Cells spindle-shaped . . . . . (1) N. digitus

2. Semicells with two chloroplasts . . . . . (4) N. interruptum

2. Semicells with a single chloroplast . . . . . (5) N. oblongum

1. Netrium digitus (Ehrenb.) Itzigs. and Rothe

Krieger, 1935. Rabh. Krypt. Flor. 13(1):215. Pl. 7, Fig. 1; Pl. 8, Fig. 1.

This large species is three to four times longer than wide. The cells are spindle-shaped with the convex lateral margins tapering to the rounded truncate

apices. The cell wall is smooth and the axial chloroplasts are lobed, the lobes turning alternately to the left and right throughout the length of the chloroplast. A single central pyrenoid is present in each cell.

Measurements: L. 100-130-(194)-(205)-400u; W. 30-(43)-(60)-80u.

Distribution: Very widely distributed according to the writer's collections. SLP, Shiawassee, Barry (2), Washtenaw, Livingston, Oakland, Berrien; NLP, Cheboygan, Crawford, Presque Isle, also Cheboygan (N & A 1932); Welch (1936b, 1938a), Emmet (N & A 1932); EUP, Delta, Chippewa, Alger, Schoolcraft (3), also Mackinac and Chippew (N & A 1932); WUP, Gogebic (2), Marquette (2), Houghton; Isle Royale (Prescott 1937).

2. var. lamellosum (Bréb.) Gronbl.

Kriegar, 1933. Rabh. Krypt. Flor. 13 (1):219. Pl. 7, Fig. 6.

This variety has the lateral margins slightly retuse in the mid-region of cell.

Measurements: L. 90-(200)-(334)-400u; W. 22-(45)-(59)-75u.

Distribution: SLP, Washtenaw, Livingston, Barry; NLP, Cheboygan (Taft 1939); EUP, Schoolcraft, Delta; WUP, Marquette; Isle Royale (Pres. 1941).

3. var. Naegelii (Bréb.) Krieger

Krieger, 1933. Rabh. Krypt. Flor. 13(1):218. Pl. 8, Figs. 4, 5.

This variety is usually smaller than the typical. The cell is four to five times longer than wide, and the apices are broadly rounded. The cell sap sometimes has a red-violet color.

Measurements: L. 90-(124)-300u; W. 21-(23.3)-60u.

Distribution: SLP, Livingston; NLP, Cheboygan (N & A 1932, N. Naegelii); Isle Royale (Prescott 1941).

4. Netrium interruptum (Bréb.) Luetkem.

Krieger, 1933. Rabh. Krypt. Flor. 13(1):222. Pl. 8, Fig. 8.

This species has two chloroplasts in each semicell. The apices are conical, rounded, and almost truncate. The Michigan specimens are not as long as measurements given by Krieger (1933).

Measurements: L. (123)-(128)-400u; W. (30)-30-(39)-80u.

Distribution: SLP, Berrien; NLP, Cheboygan (Welch 1936b); WUP, Gogebic.

5. Netrium oblongum (De Bary) Leutkem.

Krieger, 1933. Rabh. Krypt. Flor. 13(1):220. Pl. 8, Fig. 6.

This species has a characteristic oblong cylindrical form, is three to four times longer than wide, and has broadly rounded apices.

Measurements: L. 90-160u; W. 27-39u.

Distribution: SLP, Kalamazoo; NLP, Cheboygan. Both records (N & A 1932).

6. var. cylindricum West and West

Krieger, 1933. Rabh. Krypt. Flor. 13(1):221. Pl. 8, Fig. 7.

This cylindrical variety is usually smaller than the typical. The apices are broadly rounded.

Measurements: L. (49)-53-(53)-150u; W. (15)-17-34u.

Distribution: NLP, Roscommon, Emmet, also Cheboygan (N & A 1932).

5. ROYA West and West 1896, emend. Hodgetts 1920

Cells cylindrical or subcylindrical, unconstricted, straight or slightly curved. Lateral margins very slightly tapered to the rounded or truncate apices. Cell wall smooth and colorless. The axial chloroplast, single in each cell, the edges sometimes recurved, and sometimes exhibiting sharp ridges, extending often the entire length of the cell, rarely one in each half of the cell. Pyrenoids 2-14, arranged in linear series. A terminal vacuole present in one variety.

Zygospores spherical to oval, with smooth walls.

Key to Species of Roya

1. Cells 4-10 times longer than wide 2

1. Cells over 10 times longer than wide . . . . . (1) R. cambrica fa.

2. Width of cell 7.5-9u . . . . . (2) R. obtusa var. anglica

2. Width of cell 4.5-7u . . . . . (3) R. obtusa var. montana

1. Roya cambrica West and West fa. Pl. 1, Fig. 3.
Krieger, 1933. Rabh. Krypt. Flor. 13(1):206. Pl. 5, Fig. 9.

This species is typically 25-27 times longer than wide, slightly curved and very slightly attenuated near the apices. A few specimens from Gogebic County are about one-half the size of the typical, the measurements being only 20 times longer than wide. The apices are also more truncate than the typical.

Measurements: L. (91.5)-173-195u; W. (4.3)-6.2-7.5u.

Distribution: WUP, Gogebic. New record for Michigan.

2. Roya obtusa var. anglica (G. S. West) Krieger
Krieger, 1933. Rabh. Krypt. Flor. 13(1):205. Pl. 5, Figs. 7, 8.

This organism can be separated from other species of Roya by the width (7.5-9u) of the cell and the proportions of the cell (4-10 times longer than wide). This is the only form with terminal vacuoles.

Measurements: L. 35-80-112u; W. 7.5-9u.

Distribution: SLP, Ingham (N & A 1932).

3. Roya obtusa var. montana West and West Pl. 1, Fig. 4.
Krieger, 1933. Rabh. Krypt. Flor. 13(1):205. Pl. 5, Figs. 5, 6.

This variety can be separated from the variety anglica by the narrow width (4.5-7u).

Measurements: L. 16-(36)-93u; W. 4.5-(5.3)-7u.

Distribution: WUP, Gogebic. New record for Michigan.

6. SPIROTAENIA Breb. 1844

Cells, unconstricted, fusiform elliptical or cylindrical, straight or slightly curved, with acute or rounded apices. Cell wall colorless, smooth and without pores. Chloroplasts, either axial with sharp spiral ridges, or parietal laminate bands, spirally twisted to the left (one-half to sixteen turns per cell), the ends sometimes colored red. The nucleus is excentric, internal to chloroplast in cells with a parietal chloroplast, external to the chloroplast in cells with an axial chloroplast.

Zygospores single or in pairs, generally spherical with smooth, short spiny or areolate walls.

Key to Species of Spirotaenia

1. Cells small, less than 30u long . . (1) Sp. minuta
1. Cells large, over 60u long . . . . . (2) Sp. condensata

1. Spirotaenia minuta Thuret

Krieger, 1933. Rabh. Krypt. Flor. 13(1):186. Pl. 2, Fig. 8.

This small fusiform species is 6-10 times longer than wide.

Measurements: L. 15-27u; W. 3-4u.

Distribution: NLP, Cheboygan (N & A 1932).

2. Spirotaenia condensata Breb.

Krieger, 1933. Rabh. Krypt. Flor. 13(1):181. Pl. 2, Fig. 1.

This long cylindrical species with rounded apices shows from 7-16 turns of the spiral parietal chloroplast. **Measurements:** L. 60-(113)-334u; W. 10-(11.5)-30.4u. **Distribution:** SLP, Livingston; NLP, Cheboygan (N & A 1932); EUP, Schoolcraft; WUP, Gogebic; Isle Royale (Prescott 1937, 1941).

3. Family Desmidiaceae

7. CLOSTERIUM Nitzsch 1817

Cells always longer than wide, generally greatly elongated; lateral margins attenuated to the apices, mostly curved, rarely straight; without a median constriction; apices acute, obtuse, truncate or rostrate. Cell wall smooth, striated, costate, striate-punctate, or punctate; colorless to brownish, sometimes transversely subdivided into girdle bands. Chloroplasts, single in each semicell, margins entire or with longitudinal ridges radiating from a slender central axis, usually with an axial row of pyrenoids. Cell contents with a terminal vacuole at each pole containing one or more vibrating gypsum crystals.

Zygospores quadrangular, ovoid, spherical or ellipsoid; with a thick, smooth, or scrobiculate wall.

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Key to Species of *Closterium*

(Modified in part after Krieger, 1935)

1. Cells with girdle bands (sections of new wall interpolated, forming transverse bands) 2

1. Cells without girdle bands 16

2. Cell wall smooth (very old empty semicells may show sculpturing under very high magnification 3

2. Cell wall not smooth 6

3. Cells sharply curved, lunate 5

3. Cells slightly curved 4

4. Cell 9-14 times longer than wide . . . . . (36) *Cl. abruptum*

4. Cell 25-35 times longer than wide . . . . . (40) *Cl. macilentum*

5. Lateral margins parallel for about 1/3 the distance from the middle of the cell to the apex; apices bluntly rounded; cell lunate-bacilli-form . . . . . (74) *Cl. cynthia* var. *robustum*

5. Lateral margins tapering gradually from middle of cell to the apex; apices less bluntly rounded than above; cell lunate . . . . . (73) *Cl. cynthia* var. *Jenneri*

6. Cell wall striated (with longitudinal low ridges, but not short irregular longitudinal stria-like strips or punctations 7

6. Cell wall costate (with well-defined longitudinal rib-like thickenings) or otherwise marked or smooth 13

7. Length of cells usually over 180u; cell 10-11 times longer than broad, the apices rounded and gradually tapered . . . . . (75) Cl. Archerianum

7. Length of cells less than 180u; cell 6-10 times longer than broad, the apices broadly rounded and only slightly tapered . . . . (72) Cl. Cynthia

8. Lateral margins tapering very slightly toward broadly rounded apices . . . . . (58) Cl. Ulna

8. Lateral margins tapering distinctly toward apices 9

9. Apices broadly truncate (sometimes obliquely) 10

9. Apices otherwise 12

10. Cell width over 26u . . . . . (57) Cl. striolatum

10. Cell width under 26u 11

11. Cell width 6-14u . . . . . (54) Cl. juncidum var. elongatum

11. Cell width 15-25u . . . . . (55) Cl. intermedium

12. Poles angularly rounded . . . . (51) Cl. turgidum

12. Poles truncate . . . . . (41) Cl. acerosum

13. Cell wall with costae (ribs) 14

13. Cell wall with other type of marking or smooth 15

14. Cells 4-10 times longer than wide . . . . . (68) Cl. costatum

14. Cells more than 12 times longer than broad . . . . . (71) Cl. angustatum

15. Cells 13-26 times longer than broad. (53) Cl. subscoticum

15. Cells up to 10 times longer than broad . . . . . (47) Cl. didymocotum

16. Cells strongly curved 17

16. Cells slightly curved or not curved 25

17. Cell wall smooth 18

17. Cell wall striated . . . . . (24) Cl. Ehrenbergii var. malinvernianum

18. Apices narrowly and obliquely truncate 19

18. Apices not obliquely truncate. 20

19. Width of cells 5-11u, middle of cell never tumid . . . . . (27) Cl. calosporum var. brasilliense

19. Width of cell more than 10u, mid-region of cells often tumid . . . (28) Cl. Dianae

20. Apices rounded 21

20. Apices somewhat pointed . . . 24

21. Pyrenoids scattered . . . . . (23) Cl. Ehrenbergii

21. Pyrenoids arranged in a longitudinal linear series 22

22. Cell 4-5 times longer than wide, apices usually very broadly rounded, midregion of cell slightly tumid . . . (21) Cl. eboracense

22. Cell more than 5 times longer than wide, apices rounded , middle of cell tumid 23

23. Apices acutely rounded, cell strongly curved (dorsal margin 135°-190° of arc) . . . . . (22) Cl. Leibleinii

23. Apices obtusely rounded, cell less strongly curved (dorsal margin 100°-110° of arc) . . . . . (26) Cl. moniliferum

24. Each chloroplast with 1 or 2 pyrenoids; dorsal margin with curvature of 150°-180° of arc; cell length 30-85u; cell width 6-14u . . . . . (15) Cl. venus

24. Each chloroplast with 2-5 pyrenoids; dorsal margin with curvature of less than 150° of arc; cell length 57-205u, cell width 8.5-28u (5-11u in var. angustum which is 12-15 times longer than wide); apical thickening often present. (18) Cl. parvulum

25. Cell straight, the dorsal and ventral sides not differentiated . . 26

25. Entire cell not straight, at least the apices curved; dorsal and ventral sides differentiated 27

26. Cell 3-5 times longer than wide usually small (L. 24-93u; W. 7.5-22u) . . . . . (4) Cl. Navicula

26. Cell 5-8 times longer than wide usually larger (L. 75-450u; W. 15-55u) . . . . . (1) Cl. Libellula

27. Lateral margins tapering sharply from a broad midregion into seta-like extremities 28

27. Lateral margins usually tapering from sometimes tumid midregion, but not into seta-like extremities 30

28. Midregion of cell body tapering abruptly into long seta-like extremities . . . . . (67) Cl. setaceum

28. Midregion of cell body tapering gradually into long seta-like extremities 29

29. Cell 11-16 times longer than wide . (66) Cl. rostratum

29. Cell 20-30 times longer than wide . (65) Cl. Kuetzingii

30. Lateral margins tapering gradually to acuminate or acutely rounded apices (rarely truncately and narrowly rounded) 31

30. Lateral margins tapering gradually to truncate apices or to truncate apices with rounded angles 35

31. Width of cell over 12u (rarely 10u). (31) Cl. strigosum

31. Width of cell up to 12u (rarely 12.5) 32

32. Length of cell less than 200u (rarely up to 215u) 33

32. Length of cell more than 200u . 34

33. Midregion of the cell tumid . . . . (9) Cl. subulatum

33. Midregion of the cell not tumid . . (6) Cl. acutum

34. Cell more than 60 times longer than wide . . . . . (11) Cl. aciculare

34. Cell less than 60 times longer than wide . . . . . (10) Cl. pronum

35. Apices truncate 36

35. Apices rounded, angularly rounded or truncately rounded 46

36. Apices abruptly narrowed, somewhat conical (usually large species) 37

36. Apices gradually narrowed . . . 38

37. Cell wall striated . . . . . (60) Cl. attenuatum

37. Cell wall with paired longitudinal rows of coarse punctations, cell wall finely punctate between rows. (59) Cl. Braunii

38. Cell wall smooth 39

38. Cell wall striated, costate or strongly punctate 43

39. Midregion of cell tumid 40

39. Midregion of cell not tumid 41

40. Cell 6-13 times longer than wide . . . . . (12) Cl. tumidum

40. Cell 20-23 times longer than wide . . . . . (14) Cl. idiosporum

41. Cell gradually narrowed, uniformly and slightly curved towards apices . . . . . (13) Cl. cornu

41. Cell straight in midregion, the slightly narrowed apices inwardly curved 42

42. Width of cell 8-20 u . . . . . (37) Cl. toxon

42. Width of cell up to 8u . . . . (38) Cl. gracile

43. Cell wall striated 44

43. Cell wall not striated 45

44. Cell tumid in midregion . . . . (61) Cl. Ralfsii

44. Cell not tumid in midregion . . (63) Cl. lineatum

45. Cell wall punctate, the apical area darker brown, and more strongly punctate . . . . . (49) Cl. Baillyanum

45. Cell wall costate (with ribs) . . . (64) Cl. lineatum var. costatum

46. Apices broadly angularly rounded . . . . . (51) Cl. turgidum

46. Apices narrow and truncately rounded, or apices rounded . 47

47. Apices sharply narrowed, then truncately rounded 48

47. Apices gradually narrowed, then rounded 51

48. Apices recurved 49

48. Apices not recurved (sometimes slightly) 50

49. Width of cell less than 27u . . . . (46) Cl. praelongum

49. Width of cell more than 27u . . . . (45) Cl. Pritchardianum

50. Cell almost straight, ventral margin straight or convex; 5-10 times longer than wide . (44) Cl. lanceolatum

50. Cell somewhat curved, ventral margin mostly concave, rarely straight, 7-33 times longer than wide . . . . . (41) Cl. acerosum

51. Pyrenoids scattered . . . . . (33) Cl. Lunula

51. Pyrenoids in a single linear longitudinal series . . . . . (30) Cl. littorale

1. Closterium Libellula Focke

Krieger, 1935. Rabh. Krypt. Flor. 13(1):254. Pl. 12, Figs. 1, 2.

This species is 5-8 times longer than wide. The shape is fusiform with the lateral margins tapering gradually to the broadly rounded, truncate apices. The terminal vacuoles have 6-20 gypsum crystals and each chloroplast has 3-6 pyrenoids.

Measurements: L. 170-(233)-450u; W. 30-(42)-52u.

Distribution: SLP, Berrien; NLP, Cheboygan (N & A 1932); WUP, Gogebic (2); Isle Royale (Prescott 1937).

2. var. intermedium Roy and Biss.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):255. Pl. 12, Figs. 3, 4, 5.

This variety is separated from the typical by its smaller size. The cells are usually about 5 times longer

than wide.

Measurements: L. 75-170u; W. 15-36u.

Distribution: EUP, Schoolcraft; WUP, Gogebic, also Marquette (Pres. & Mag. 1935, Penium libellula var. intermedium Roy & Biss.); Isle Royale (Prescott 1937).

3. var. interruptum (West and West) Donat

Krieger, 1935. Rabh. Krypt. Flor. 13(1):256. Pl. 12, Fig. 6.

This variety has four axial chloroplasts arranged in a longitudinal series. This form may be only a typical Cl. Libellula in which the chloroplasts normally may be subdivided in older cells.

Measurements: L. 90-400u; W. 16-55u.

Distribution: NLP, Cheboygan (N & A 1932, Welch 1938a).

4. Closterium Navicula (Bréb.) Luetk.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):257. Pl. 12, Figs. 8-10.

This small species is about 3 1/2 - 5 times longer than wide. The cell is fusiform with the apices broadly or truncately rounded. The cell wall is smooth and colorless. The terminal vacuoles usually have a single gypsum crystal, and each chloroplast has a single pyrenoid.

Measurements: L. 24-(32)-93u; W. (7.5)-8-22u.

Distribution: SLP, Berrien; NLP, Cheboygan (N & A 1932, Welch 1938a); EUP, Schoolcraft; WUP, Houghton, Gogebic; Isle Royale (Prescott 1941).

5. var. crassum (West and West) Gronbl.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):258. Pl. 12, Figs. 11, 12.

This variety is more robust than the typical, being about three times longer than wide. The apices are truncately rounded.

Measurements: L. 22-52u; W. 8-17u.

Distribution: NLP, Emmet, Cheboygan (N & A 1932)

6. Closterium acutum Bréb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):259. Pl. 13, Figs. 10-13

This species is 20-30 times longer than wide. The lateral margins taper very gradually to the acute apices. The curvature of the cell is slight. The cell wall is colorless and smooth, the chloroplasts have 2-4 pyrenoids, and the terminal vacuoles have either one or two gypsum crystals.

Measurements: L. 90-155-(161)u; W. 4-(5.3)-6u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Chippewa; WUP, Houghton, Baraga, Gogebic.

7. var. variable (Lemmermann) Krieger Pl. 1, Fig. 6.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):262. Pl. 13, Figs. 18-22.

This variety is somewhat more stout than the typical (14-19 times longer than wide). It is very variable in the degree of curvature exhibited, and sometimes only a half

cell will have a curvature. Sigmoid forms were found in Barry County.

Measurements: L. 43-(60)-140u; W. 2.5-(3.5)-5u.

Distribution: SLP, Barry. New record for Michigan.

8. var. linea (Perty) West and West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):261. Pl. 13, Fig. 15.

This variety is usually more slender and more elongate than the typical, and is not curved or is very slightly curved.

Measurements: L. 100-168u; W. 3-3.5u.

Distribution: NLP, Cheboygan (N & A 1932).

9. Closterium sublatum (Kuetz.) Bréb. Pl. 1, Fig. 7.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):262. Pl. 13, Figs. 7, 8.

This species is typically 15-21 times longer than wide. The cell is slightly tumid in the middle, and the lateral margins taper gradually to the acutely rounded, slightly incurved apices. The cell wall is colorless and smooth. Each chloroplast has 3-5 pyrenoids, and the terminal vacuoles have about four gypsum crystals.

Measurements: L. 102-(163)-215u; W. 5-(7.5)-12.5u.

Distribution: SLP, Washtenaw. New record for Michigan.

10. Closterium pronum Bréb. Pl. 1, Figs. 8, 9.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):263. Pl. 13, Figs. 5, 6.

This slightly curved species is typically 35-50 times longer than wide. The lateral margins taper gradually to the inwardly turned, very narrow but truncately rounded apices. The cell wall is colorless and smooth. The chloroplasts each have 5-10 pyrenoids, and the terminal vacuoles have 1-6 gypsum crystals. Specimens from Chippewa County appeared somewhat intermediate between Cl. pronum and Cl. subulatum (Kuetz.) Bréb. The cells are about 35 times longer than broad. The midregion of the cells are slightly tumid, and the apices are slightly more incurved, and almost seta-like. Specimens from Berrien County were found in reproductive stages.

The zygospore is unknown according to Krieger (1935). The one specimen observed by the writer was transversely rectangular with the dorsal and ventral margins sharply convex, and with the angles forming short, rounded lobes projecting into each semicell. The wall was colorless and smooth.

Measurements: L. 220-(230)-(290)-480u; W. 5-(6.3)-(6.5)-12u; A. 2u. Zygospore: Transverse measurements: 36.6u; Longitudinal measurement: 19.4u.

Distribution: SLP, Berrien; EUP, Chippewa. New record for Michigan.

11. Closterium aciculare T. West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):265. Pl. 13, Figs. 1, 2.

This species is 65-144 times longer than broad. The lateral margins taper very gradually to the slightly incurved, acute or acutely rounded apices. The cell wall is colorless and smooth, the chloroplasts have up to 20 pyrenoids in each semicell, and the terminal vacuoles have 1-3 gypsum crystals.

Measurements: L. 390-800u; W. 4-8u; A. 1.5-2u.

Distribution: NLP, Presque Isle (Taft 1939, Cl. aciculare var. subpronum West and West).

12. Closterium tumidum Johnson

Krieger, 1935. Rabh. Krypt. Flor. 13(1):267. Pl. 14, Figs. 10, 11.

This species is 6-9 times longer than wide. The lateral margins (dorsal slightly curved, ventral broadly tumid or almost straight) taper gradually toward the roundly truncate apices that are variable in width. The cell membrane is smooth and colorless, the terminal vacuoles each usually have one compound gypsum crystal, and the chloroplasts each have 1-4 pyrenoids.

Measurements: L. 60-(134)-160u; W. 7-(17)-20u.

Distribution: Washtenaw, Barry also Ionia (N & A 1932); NLP, Cheboygan, Newaygo (N & A 1932); WUP, Gogebic.

13. Closterium Cornu Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):269. Pl. 15, Figs. 5-9.

This small slightly curved species is 12-21 times longer than wide. The dorsal margin is convex and the

ventral margin is slightly concave or straight. The apices are truncately rounded. The cell wall is smooth and colorless, and the terminal vacuoles each have a single gypsum crystal. The chloroplasts contain four pyrenoids in a linear series in each semicell.

Measurements: L. 95-(108)-(161)-180u; W. 5-(5.2)-(8.6)-11u; A. 2.5-3.5u.

Distribution: SLP, Calhoun, Barry; NLP, Cheboygan (N & A 1932); WUP, Gogebic.

14. Closterium idiosporum West and West Pl. 2, Fig. 3.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):271. Pl. 15, Figs. 1, 2.

This species is 20-23 times longer than wide. The lateral margins taper gradually from the slightly tumid midregion of the cell to the slightly incurved truncate apices. The cell wall is colorless and smooth. The terminal vacuoles contain numerous gypsum crystals. The chloroplasts each have 3-5 pyrenoids arranged in a linear series. This species was collected in reproductive state from Chippewa County.

Measurements: L. 221-(258)-260u; W. 10-14u; A. 2u. Zygospore: L. 55-58-(60)u; W. 29-(30)-30u.

Distribution: EUP, Chippewa. New record for Michigan.

15. Closterium Venus Kuetz.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):272. Pl. 16, Figs. 1-5.

This small species is 8-9 times longer than wide. The curvature is strong and the midregion is not tumid. The apices are acute or sharply rounded. The cell wall is colorless, (rarely brown), and smooth. The terminal vacuoles have a single large gypsum crystal or several small ones, and the pyrenoids (-2) in each chloroplast are in a linear series.

Measurements: L. 48-(65)-85u; W. 6-(9)-11u.

Distribution: SLP, Calhoun, Barry (2), Washtenaw (2), Oakland, Jackson, Livingston, also Wayne (Campbell 1886) and Macomb (Pieters 1894); NLP, Cheboygan (N & A 1932); EUP, Schoolcraft; WUP, Marquette, Menominee, Gogebic; Isle Royale (Prescott 1941).

16. var. incurvum (Bréb.) Krieger

Krieger, 1935. Rabh. Krypt. Flor. 13(1):273. Pl. 16, Figs. 16, 17.

This variety is somewhat stouter (5-7 times longer than wide) and more strongly curved than the typical.

Measurements: L. 30-(70)-80u; W. 6-(13)-14u.

Distribution: SLP, Oakland; NLP, Cheboygan (N & A 1932).

17. var. verrucosum (Roll) Krieger Pl. 3, Fig. 5.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):274. Pl. 16, Fig. 8.

This variety is characterized by the presence of small granules, arranged irregularly upon the cell wall. Krieger (1935) states that the granules may represent

the outer part of the pore apparatus. Only a single specimen was seen by the writer and it may have been the typical Cl. Venus in some unknown physiological condition.

Measurements: L. 57-61-(62)u; W. (8.5)-10.8u.

Distribution: SLP, Livingston. New record for Michigan.

18. Closterium parvulum Naeg.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):275. Pl. 16, Figs. 14-17.

This species is 7-10 times longer than wide (9-15 according to West and West 1904). The cell wall is smooth and colorless. The curvature is strong with the ventral margin concave and without any tumidness in the midregion. The apices are usually acutely pointed but sometimes acutely rounded, and often show an apical thickening (endpore). The terminal vacuoles each have 2-8 gypsum crystals and the 2-5 pyrenoids are in a linear series. This species is similar to Cl. Dianae (10-12 times longer than wide) but is usually much smaller (7-10 times longer than wide).

Measurements: L. 60-(96)-(108)-160u; W. 9-(11.5)-(15)-17u.

Distribution: SLP, Calhoun, Washtenaw, Barry, also Ionia (Wade 1949), also Branch, Wayne (N & A 1932); NLP, Cheboygan (N & A 1932, Welch 1936a); EUP, Schoolcraft, Alger; WUP, Marquette, Gogebic; Isle Royale (Prescott 1941).

19. var. angustum West and West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):277. Pl. 16, Figs. 20-21.

This variety is separated from the typical by the greater length-width ratio (12-15 times longer than wide). The apices are sharply pointed and the curvature is variable.

Measurements: L. 75-(97)-132u; W. 5-(7)-11u.

Distribution: SLP, Barry; NLP, Emmet (N & A 1932).

20. var. majus West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):277. Pl. 16, Fig. 18.

This variety is larger than typical.

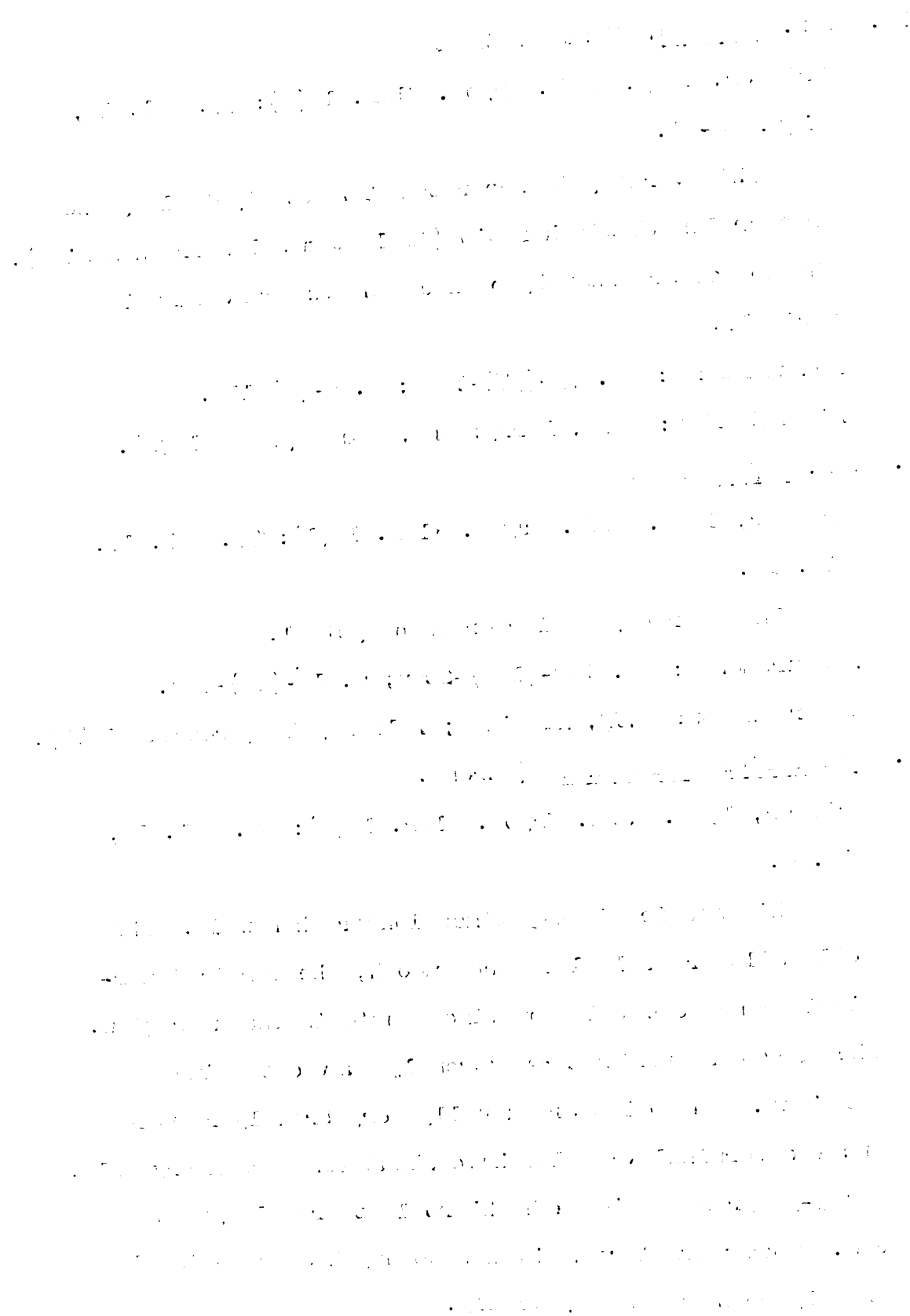
Measurements: L. 160-(166)-205u; W. 17-(23)-28u.

Distribution: EUP, Mackinac; Isle Royale (Prescott 1941).

21. Closterium eboracense (Ehrenb.)

Krieger, 1935. Rabh. Krypt. Flor. 13(1):282. Pl. 17, Fig. 4.

This species is 4-5 times longer than wide. The cell walls are colorless and smooth, the vertical margin is concave but is sometimes tumid in the midregion. The curvature varies from strongly curved to almost straight. The poles are usually very broadly rounded and the terminal vacuoles have about ten gypsum crystals. The 3-5 pyrenoids in each chloroplast are always in a row. Specimens from Washtenaw County had the poles less broadly rounded than typically.



Measurements: L. 140-(234)-294u; W. 35-(55)-69u.

Distribution: SLP, Washtenaw, also Wayne (Campbell 1886); NLP, Cheboygan (N & A 1932).

22. Closterium Leibleinii Kuetz.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):284. Pl. 17, Figs. 5-7.

This species is 6-8 times longer than wide. The wall is smooth and colorless, rarely yellow-brown. The dorsal margin is variable but the ventral margin is concave and characteristically tumid in the midregion. The apices are acutely rounded, sometimes almost subacuminate. The terminal vacuoles have 8-12 gypsum crystals and the 4-8 pyrenoids in each chloroplast are in a linear series. This species resembles Cl. moniliferum, from which it can be separated by the greater curvature and the more strongly attenuated apices.

Measurements: L. 90-(180)-(187)-260-(261)u; W. 14-(30)-(34)-(43)-45u.

Distribution: SLP, Calhoun, Barry, also Allegan, Barry, Branch, Lapeer, Saginaw, Sanilac (N & A 1932), Macomb (Pieters 1894), Van Buren (Transeau 1917), Wayne (Campbell 1886); NLP, Presque Isle, also Cheboygan (N & A 1932, Neal 1948); Isle Royale (Prescott 1941).

23. Closterium Ehrenbergii Menegh.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):285. Pl. 17, Fig. 1; Pl. 18, Fig. 1.

This species is 4-6 times longer than broad, with a fairly sharp curvature. The ventral margin in the mid-region is distinctly tumid, and the dorsal margin is strongly convex. The margins taper gradually to the rounded apices. The cell wall is colorless and smooth, and the terminal vacuole has a large number of gypsum crystals. The pyrenoids are numerous and scattered. This latter feature easily distinguishes this organism from many other species of Closterium.

Measurements: L. 230-(298)-880u; W. 44-(61)-172u.

Distribution: SLP, Allegan, Genesee, Hillsdale, Ingham, Ionia, Lenawee, also Macomb (Pieters 1894), Saginaw (N & A 1932), Allegan and Oakland (Transeau 1917); NLP, Cheboygan N & A 1932); EUP, Mackinac (N & A 1932, Transeau 1917); WUP, Marquette.

24. var. Malinverianum (De Not.) Rab.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):287. Pl. 18, Fig. 2.

This variety is separated from the typical on the basis of a brownish cell wall which is finely striated (12-20 per 10u).

Measurements: L. 220-(419)-620u; W. 32-(75)-148u.

Distribution: SLP, Washtenaw, also Macomb (Johnson 1894, Cl. Malinvernianum); NLP, Cheboygan (N & A 1932, Cl. Malinvernianum).

25. var. immane Wolle

Krieger, 1935. Rabh. Krypt. Flor. 13(1):288. Pl. 18, Fig.4.

This variety listed by Krieger (1935) as var. percrassum (Borge) Gronblad is more robust and wider than the typical. It is 3-5 times longer than wide. The ventral margin in the midregion is usually tumid and the dorsal lateral margin is strongly curved.

Measurements: W. 150-208u.

Distribution: Reported only from Wayne (Campbell 1886).

26. Closterium moniliferum (Bory) Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):289. Pl. 18, Figs. 6, 7.

This species is 6-8 times longer than wide. The cell wall is colorless and smooth. The curvature is slight to moderate with the ventral margin slightly tumid in the midregion of the cell. The lateral margins taper gradually to the obtusely rounded apices. The terminal vacuoles have about ten rounded gypsum crystals and the 4-8 pyrenoids are always in a row. This species can be separated from Cl. Leibleinii by the more bluntly pointed apices and the lesser curvature.

Measurements: L. 170-(185)-(225)-(264)-450u; W. 28-(35)-(37)-(40)-72u.

Distribution: SLP, Barry, Calhoun, Clinton, Ingham, Oakland, Jackson, also Ionia (Wade 1949), Wayne (Campbell 1886), Macomb (Pieters 1894) and St. Clair (N & A 1932); NLP, Cheboygan (N & A 1932, Welch 1938a), Emmet (N & A 1932); EUP, Chippewa (N & A 1932); WUP, Houghton, Gogebic (2) Marquette, also Houghton (N & A 1932).

27. Closterium calosporum var. brasiliense Boerges. Pl. 3, Fig.2.
Krieger, 1935. Rabh. Krypt. Flor. 13(1):294. Pl. 19, Fig. 8.

This variety is typically 12-16 times longer than wide. The cell wall is smooth, cclorless or brown, and the curvature is well marked. The midregion of the cell is not tumid and the lateral margins taper gradually to the obliquely truncate apices which have an apical thickening (endpores). Specimens from Washtenaw County are placed here reservedly as they seemed somewhat intermediate between the typical and the variety. The length was only 11.4 times longer than the width, but the general configuration of the cells agrees more closely with the variety. They also resembled Cl. Dianae generally, but the narrow width (11u) distinguishes them from this species.

Measurements: L. 90-(126)-195u; W. 5-(11)-11u.

Distribution: SLP, Washtenaw. New record for Michigan.

28. Closterium dianae Ehrenb.
Krieger, 1935. Rabh. Krypt. Flor. 13(1):294. Pl. 19, Figs. 9-11; Pl. 20, Fig. 1.

This species is about 9-12 times longer than wide. The cell is strongly curved with the ventral margin in the midregion straight, or slightly swollen. The lateral margins taper sharply to the obliquely truncate apices where the wall has a distinct polar thickening.

The cell wall is smooth when young, brownish when older. The terminal vacuoles have 7-20 small gypsum crystals, and each chloroplast has 5-9 pyrenoids.

Measurements: L. 150-(157)-(333)-380u; W. 15-(19)-(26)-40u.

Distribution: SLP, Calhoun, Livingston, Washtenaw, Oakland, Barry, Berrien, also Washtenaw (West and West 1898) Macomb (Pieters 1894) and Wayne (Campbell 1886); NLP, Crawford, also Cheboygan (N & A 1932); EUP, Alger, Mackinac, also Delta (N & A 1932); WUP, Gogebic (5), Marquette; Isle Royale (Taylor 1935, Prescott 1941).

29. var. pseudodianae (Roy) Krieger

Krieger, 1935. Rabh. Krypt. Flor. 13(1):297. Pl. 19, Figs. 16, 17.

This variety is relatively longer (14-21 times longer than wide), and much more slender near the apices than the typical. The midregion of the cell is somewhat tumid in some specimens.

Measurements: L. 160-(161)-(176)-312u; W. 10-(10.7)-(15)-18u.

Distribution: SLP, Washtenaw, Livingston, also Oakland (Transeau 1917); NLP, Cheboygan, also Emmet (N & A 1932); EUP, Alger, Mackinac, Schoolcraft, Delta; WUP, Houghton; Isle Royale (Prescott 1937, 1941). All records except the writer's are for Cl. pseudodianae, but the writer follows Krieger (1935) in considering it a variety of Cl. Dianae.

30. Closterium littorale Gay

Krieger, 1935. Rabh. Krypt. Flor. 13(1):298. Pl. 20, Figs. 3-5.

This slightly curved species is 9-11 times longer than wide. The ventral margin is straight or somewhat tumid. The margins taper gradually to the rounded or subtruncate apices. The cell wall is smooth and colorless (rarely striated). The terminal vacuoles usually contain a single compound gypsum crystal, and the chloroplasts each have 3-10 pyrenoids. Specimens from Mackinac County agree rather well with the description of this species, although the appearance was somewhat more slender and the apices were distinctly narrowly truncate. There is some resemblance to Cl. tumidum but the latter is much smaller. The Michigan specimens are almost identical with Irénee Marie's (1938) illustration of Cl. siliqua, West and West (this species is considered synonomous with Cl. littorale by Krieger (1935).

Measurements: L. 130-(247)-270u; W. 15-(21.5)-25u.

Distribution: NLP, Emmet (N & A 1932, Cl. siliqua); EUP, Mackinac.

31. Closterium strigosum Bréb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):299. Pl. 20, Figs. 8-10.

This species is 12-20 times longer than wide. The curvature is slight, and the lateral margins taper grad-

ually from a non-tumid midregion to the sometimes incurved, sharply pointed, or slightly rounded apices. The cell wall is colorless and smooth. The terminal vacuoles have several gypsum crystals, and the chloroplasts each have 3-11 pyrenoids in linear series.

Measurements: L. 150-410u; W. 10-20u.

Distribution: SLP, Wayne (Campbell 1886), Barry (N & A 1932, Cl. peracerosum).

32. var. elegans (G. S. West) Krieger

Krieger, 1935. Rabh. Krypt. Flor. 13(1):300. Pl. 20, Fig. 12.

This variety is separated from the typical by the greater tumidness of the ventral margin in the midregion, and the more obtuse or truncate apices. The chloroplasts each have 5-8 pyrenoids in linear series, and the terminal vacuoles contain one or two gypsum crystals.

Measurements: L. 150-390u; W. 11-21u; A. 2-3u.

Distribution: SLP, Barry (N & A 1932, Cl. peracerosum var. elegans); Isle Royale (Prescott 1941).

33. Closterium Lunula (Muell.) Nitszch.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):301. Pl. 21, Fig. 1; Pl. 22, Fig. 1.

This large, almost straight, species is 5-8 times longer than wide. The dorsal margin which is curved, and the ventral margin which is almost straight or slightly convex or concave, taper gradually to the broadly rounded

or truncate apices. The cell wall is smooth and colorless or rarely striated or punctate, and the terminal vacuoles each contain 10-30 gypsum crystals. The pyrenoids are numerous and scattered.

Measurements: L. 248-400-409-(598)-1000u; W. 47-(56)-(64)-(81)-120u.

Distribution: SLP, Washtenaw, Livingston, Barry, also Ionia (Wade 1949); NLP, Crawford (2), also Cheboygan (N & A 1932, Welch 1938a); WUP, Gogebic (2), Houghton (2).

34. var. minus West and West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):304. Pl. 21, Fig. 5.

This variety is smaller than the typical and the cell wall has a faint straw color.

Measurements: L. 305-(361)-403u; W. (53)-54-58u.

Distribution: SLP, Barry; Isle Royale (Prescott 1937).

35. var. intermedium Gutw.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):303. Pl. 21, Fig. 3.

This variety has a distinctly tumid midregion and is 5-6 times longer than wide. The apices may be somewhat angular and recurved.

Measurements: L. 300-660u; W. 47-140u.

Distribution: Isle Royale (Prescott 1941).

36. Closterium abruptum West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):306. Pl. 21, Fig. 9; Pl. 22, Fig. 5-7.

This species is 9-14 times as long as wide, has a girdle band, smooth cell wall, a very slight curvature, and a slight tapering of the lateral margins toward the broadly truncate apices. The terminal vacuoles usually have a single compound gypsum crystal, and the chloroplasts each have 4-6 pyrenoids in a single series. Some forms resemble Cl. tumidum which has a stouter appearance (6-9 times longer than wide) and characteristic swelling in the midregion of the cell.

Measurements: L. 100-(124)-(128)-240-246u; W. 11-(13)-(15)-(17.4)-19u; A. 5-8.6u.

Distribution: SLP, Livingston; NLP, Roscommon, Presque Isle, also Presque Isle (Taft 1939); WUP, Gogebic (3).

37. Closterium toxon West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):310. Pl. 23, Figs. 4, 5.

This species is 13-30 times longer than wide. The lateral margins are subparallel and straight for about two-thirds the length in the midregion, and then taper gradually into slightly incurved subtruncate apices. The dorsal margin is often slightly concave in the midregion. The cell wall is smooth and colorless (sometimes brownish). The terminal vacuoles contain several gypsum crystals and the chloroplasts each have 5-7 pyrenoids arranged in a linear series.

Measurements: L. 163-(277)-(321)-330u; W. 8-(10.5)-(12-20u; A. 6-(6.5)-9u.

Distribution: SLP, Calhoun; NLP, Cheboygan (N & A 1932); EUP, Delta, Schoolcraft; WUP, Houghton, Gogebic.

38. Closterium gracile Bréb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):310. Pl. 30, Figs. 7-9.

This very slim species is 20-50 times longer than wide. The lateral margins are parallel in the midregion of the cell, but taper near the poles into truncate, inwardly curved apices. The cell wall is usually colorless and smooth. The pyrenoids (5-7) are arranged in a linear series in each chloroplast, and the terminal vacuoles have from 1-4 gypsum crystals.

Measurements: L. 90-(250)-275u; W. 4-(5)-8u; A. 2.5-3.5u.

Distribution: SLP, Barry, Berrien also Macomb (Pieters 1894); NLP, Cheboygan (N & A 1932); EUP, Chippewa; WUP, Houghton, Gogebic.

39. var. elongatum West and West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):311. Pl. 30, Figs. 10, 11.

This variety is 50-75 times longer than wide.

Measurements: L. 275-(277)-(336)-485u; W. 3-(4.2)-5-(6)u.

Distribution: SLP, Barry, Calhoun, also Ionia (Wade 1949); NLP, Crawford, also Macosta (N & A 1932); Isle Royale (Taylor 1935).

40. Closterium macilentum Bréb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):312. Pl. 23, Figs. 6-8.

This species is 25-35 times longer than broad, has a girdle band, a slight curvature (especially in the terminal region), and lateral margins which are parallel in the middle third of the cell, but which above taper to the slightly obliquely truncate or obtusely rounded apices. The terminal vacuole has two to ten gypsum crystals, and the chloroplasts each have 6-12 pyrenoids in a linear series.

Measurements: L. 260-800u; W. 11-25u; A. 5-7u.

Distribution: SLP, Macomb (West and West 1898); NLP, Cheboygan (N & A 1932).

41. Closterium acerosum (Schrank) Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):314, Pl. 23, Figs. 11, 12; Pl. 24. Fig. 1.

This species is 7-13 times as long as wide, very slightly curved or almost straight. The dorsal margin which is slightly curved, and the ventral margin which is almost straight or slightly convex, taper gradually to the broadly or truncately rounded apices. The cell wall often appears colorless and smooth, but examples with brownish and finely striated walls have been found. The terminal vacuoles have numerous gypsum crystals and each chloroplast has 6-16 pyrenoids arranged in a regular or irregular longitudinal linear series.

Measurements: L. 250-(320)-(336)-790u; W. (22)-25-60u.

Distribution: SLP, Shiawassee, also Ionia (Wade 1949),

Macomb (Pieters 1894) and Branch, Hillsdale, Jackson, Lenawee (N & A 1932), Wayne (Campbell 1886), Van Buren (Transeau 1917); EUP, Chippewa (N & A 1932); WUP, Houghton (N & A 1932).

42. var. angolense West and West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):317. Pl. 24, Fig. 2.

This variety is longer than the typical (16-23 times longer than wide). The cell wall is smooth and colorless, and the apices are rounded.

Measurements: L. 650-915u; W. 30-40u.

Distribution: NLP, Cheboygan (N & A 1932, Welch 1938a).

43. var. elongatum Bréb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):318. Pl. 24, Fig. 5.

This variety is relatively longer (15-33u) than the typical. The cell wall may be colorless or brownish, striated or punctate.

Measurements: L. (498)-500-(563)-1000u; W. (28-29-(30)-54u.

Distribution: SLP, Calhoun, also Ionia (Wade 1949); NLP, Cheboygan, Mecosta (N & A 1932).

44. Closterium lanceolatum Kuetz.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):319. Pl. 24, Figs. 9, 10.

This species, which is slightly or not at all curved,

is 5-10 times longer than wide. The dorsal margin which is convex, and the ventral margin, which is straight or slightly convex, taper gradually to the acutely rounded apices. The cell wall is smooth and colorless, and the terminal vacuoles have about ten gypsum crystals. There are 6-8, sometimes up to 12, pyrenoids in each chloroplast.
Measurements: L. 200-540u; W. 28-79u.
Distribution: SLP, Ionia, Newaygo; NLP, Cheboygan, Emmet, Newaygo; all records by Nichols and Achley 1931; also Cheboygan (Welch 1938a).

45. Closterium Pritchardianum Archer
Krieger, 1935. Rabh. Krypt. Flor. 13(1):321, Pl. 25, Figs. 1-4.

This species is 8-25 times longer than wide. The general curvature of the cell is slight, with the dorsal margin slightly curved, and the ventral margin concave or almost straight. The apices are narrowly truncate, and often recurved. The cell wall is finely striated, the striae being composed of fine punctations. The terminal vacuoles each have many gypsum crystals, and each chloroplast has 7-16 pyrenoids in linear series.
Measurements: L. 300-(452)-810u; W. 27-(34)-54u; A. 6-8u.
Distribution: SLP, Washtenaw, also Jackson (N & A 1932); NLP, Cheboygan (N & A 1932).

46. Closterium praelongum Bréb. Pl. 2, Fig. 2.
Krieger, 1935. Rabh. Krypt. Flor. 13(1):234, Pl. 25, Figs. 7, 8.

This slender species is 25-45 times longer than wide. The general curvature is slight. The dorsal margin which is slightly convex, and the ventral margin which is parallel or slightly concave, taper gradually to the obtuse or truncately rounded apices that are slightly recurved. The cell wall is colorless or brownish, and may be smooth or striated (15 per 10u). Each chloroplast has 8-23 pyrenoids, and each terminal vacuole has 1-2 compound gypsum crystals.

Measurements: L. 380-(623)-885u; W. 11-(17)-26u; A. 4-6.5u.

Distribution: SLP, Washtenaw; WUP, Iron, Marquette, Menominee, Houghton. New records for Michigan.

47. Closterium didymocotum Corda

Krieger, 1935. Rabh. Krypt. Flor. 13(1):325. Pl. 26, Figs. 1, 2.

The limits of this species are somewhat poorly defined. West and West (1904) indicate that the walls may be striated but are usually smooth. Gronblad (1919) includes only those organisms that possess striae and girdle bands. Krieger (1935) follows Gronblad's ideas but his illustrations and description of this species indicate a somewhat more stout and less tapered cell than Taylor's (1935) specimens which are very much attenuated toward the apices.

The writer includes here, under Cl. didymocotum, those Michigan specimens which are 8-10 times longer than

This slender species is 25-45 times longer than wide. The general curvature is slight. The dorsal margin which is slightly convex, and the ventral margin which is parallel or slightly concave, taper gradually to the obtuse or truncately rounded apices that are slightly recurved. The cell wall is colorless or brownish, and may be smooth or striated (15 per 10u). Each chloroplast has 8-23 pyrenoids, and each terminal vacuole has 1-2 compound gypsum crystals.

Measurements: L. 380-(623)-885u; W. 11-(17)-26u; A. 4-6.5u.

Distribution: SLP, Washtenaw; WUP, Iron, Marquette, Menominee, Houghton. New records for Michigan.

47. Closterium didymocotum Corda

Krieger, 1935. Rabh. Krypt. Flor. 13(1):325. Pl. 26, Figs. 1, 2.

The limits of this species are somewhat poorly defined. West and West (1904) indicate that the walls may be striated but are usually smooth. Gronblad (1919) includes only those organisms that possess striae and girdle bands. Krieger (1935) follows Gronblad's ideas but his illustrations and description of this species indicate a somewhat more stout and less tapered cell than Taylor's (1935) specimens which are very much attenuated toward the apices.

The writer includes here, under Cl. didymocotum, those Michigan specimens which are 8-10 times longer than

wide, and which possess short, irregular, longitudinal striae-like strips. Girdle bands were not seen, probably because the cells were young and had not divided. Measurements: L. 391-(397)-628u; W. 44-(48)-(50)-61u; A. 21-25u.

Distribution: Undoubtedly most of the records here are those of Cl. Baillyanum (in sensu Krieger). SLP, Barry, Livingston, also Muskegon (Transeau 1917); NLP, Crawford, Emmet, also Cheboygan (N & A 1932, Welch 1936b): EUP, Chippewa, also Chippewa (N & A 1932).

48. var. glabrum Borge Pl. 1, Fig. 12.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):326. Pl. 26, Fig. 4.

This variety has the same proportions as the typical (8-10 times longer than wide) but the cell wall is smooth. Measurements: L. (355)-382-(386)-626u; W. (44)-(46)-48-60u.

Distribution: NLP, Roscommon; EUP, Schoolcraft. New records for Michigan.

49. Closterium Baillyanum Breb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):327. Pl. 26, Figs. 7, 8.

This slightly curved species has often been confused with Cl. didymocotum (see discussion under the latter). According to Krieger, (1935), this species is 9-12 times longer than wide. The dorsal margin is convex, the ven-

tral margin mostly straight, sometimes concave. The apices are broadly truncate (with rounded angles), and occasionally slightly recurved. The cell wall is colorless when young, brownish when older. The punctations in the cell wall are more distinct on the darker brown, thickened apices. The chloroplasts each have 5-8 pyrenoids, and the terminal vacuoles each have several gypsum crystals.

Measurements: L. 250-(462)-607u; W. 24-(44)-58u; A. 17-23u.

Distribution: WUP, Houghton, Gogebic, Marquette; Isle Royale (Prescott 1941).

50. var. alpinum (Viret) Gronbl. fa. Pl. 1, Fig. 11. Krieger, 1935. Rabh. Krypt. Flor. 13(1):328. Pl. 26, Fig. 9.

This variety is characteristically more slender (12-14 times longer than wide) than the typical. The ventral margin is slightly concave, and the cell wall is clearly punctate. A few specimens from Schoolcraft County were relatively longer (about seventeen times longer than wide) than either the typical or var. alpinum. It is placed here questionably, because of the agreement in greater curvature and the proportionately narrow and longer cells, although this variety has only been reported from mountainous areas of Europe.

Measurements: L. 380-(500)-48u; W. (30)-32-48u; A. (16)-19u.

Distribution: EUP, Schoolcraft. New record for Michigan.

51. Closterium turgidum Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):330. Pl. 27, Figs. 1, 2.

This large, slightly curved species is 10-13 times longer than wide. The dorsal lateral margin, which is slightly curved, and the ventral lateral margin, which is straight or slightly concave in the midregion of the cell, taper gradually to the angularly rounded, usually distinctly recurved apices. The cell wall is brownish in color, and finely striated (8-14 per 10u). The striae are often reduced into rows of punctations especially near the apices. The chloroplasts each have 10-15 pyrenoids, and the terminal vacuoles each have numerous gypsum crystals.

Measurements: L. 560-(684)-940u; W. 45-(64)-86u; A. 15-19u.

Distribution: NLP, Crawford; Isle Royale (Prescott 1937).

52. var. giganteum Nordst.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):332. Pl. 27, Figs. 5, 6.

This variety is 7-12 times longer than wide, and usually much longer than the typical. The pyrenoids are more numerous (80-90 in each semicell) and are usually seattered.

Measurements: L. 590-1500u; W. 58-138u; A. 18.5-33u.

Distribution: NLP, Cheboygan (N & A 1932, Cl. subturgidum).

53. Closterium subscoticum Gutw. Pl. 1, Fig. 10.
Krieger, 1935. Rabh. Krypt. Flor. 13(1):333. Pl. 27, Figs. 10-12.

This species typically is 17-26 times longer than wide. The girdle bands are present and the cell wall which is punctate-striate, may be either colorless or brownish. The curvature of the cell is slight, with the lateral margins parallel in the midregion of the cell, but above are very slightly tapered towards the truncate apices. The terminal vacuoles each have a single compound gypsum crystal and the chloroplasts each have 8-11 pyrenoids. A few specimens from Livingston County were only 12-13 times longer than wide, but the striations were very fine and interrupted. They agree with the measurements of Cl. intermedium but the type of cell wall markings place them questionably in Cl. subscoticum. Cl. striolatum may have reduced striolations but is always much wider.

Measurements: L. (174)-182-(192)-400u; W. 11-(15)-15u; A. 8-11u.

Distribution: SLP, Livingston. New record for Michigan.

54. Closterium juncidum var. elongatum Roy and Biss. Pl. 2, Fig. 1.
Krieger, 1935. Rabh. Krypt. Flor. 13(1):335. Pl. 28, Fig. 4.

This organism is 35-45 times longer than wide, and has a pale yellow to brown cell wall that is striated

(14-20 per 10u). The lateral margins are parallel in the midregion of the cell, but taper gradually to the truncate apices which have slightly rounded angles, and apical thickenings. The curvature is especially reflected by the inward bending near the poles. The terminal vacuoles contain one large gypsum crystal or several small ones, and the chloroplasts each have 4-9 pyrenoids. The Michigan specimens from Calhoun County had a less obvious polar curvature and a more slight curvature of the entire cell.
Measurements: L. 295-(370)-473u; W. 8.5-(10.5)-13u.
Distribution: SLP, Calhoun. New record for Michigan.

55. Closterium intermedium Ralfs.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):335. Pl. 28, Figs. 5, 6; Pl. 29, Fig. 8.

This slightly curved species is 6-15 times longer than wide, and possesses a girdle band. The cell walls are yellow to yellowish brown, and are distinctly striated (6-10 per 10u); the lateral margins are parallel in the middle part of the cell, but taper above gradually to the slightly incurved broadly truncate apices. The apices usually have an apical thickening and the terminal vacuoles have either a single large or several small gypsum crystals. There are 5-7 pyrenoids in each chloroplast.
Measurements: L. 76-(370)-470u; W. 14-25-(26)u; A. 6-8u.
Distribution: SLP, Barry, Washtenaw (2), Berrien; NLP, Crawford, also Cheboygan (N & A 1932); EUP, Alger, Delta,

Schoolcraft, Mackinac, also Mackinac (Transeau 1917); WUP, Houghton, Gogebic; Isle Royale (Prescott 1937).

56. var. hibernicum West

Krieger, 1935. Rabh. Krypt. Flor. 13(1):336. Pl. 28, Fig. 7.

This variety is separated from the typical by the shape of the cell. The lateral margins are parallel and straight in the midregion of the cell, but become rather suddenly incurved in the more apical portions.

Measurements: L. 200-(340)-384u; W. 14-(23.5)-26u.

Distribution: EUP, Mackinac; Isle Royale (Prescott 1941).

57. Closterium striolatum Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):337. Pl. 28, Figs. 8, 9; Pl. 29, Fig. 9.

This species is 8-12 times longer than wide, has a girdle band, and a cell wall that is variably striated (5-10 per 10u, often anastomosing or becoming punctate near apex), and lateral walls that are parallel or slightly concave in the midregion part of cell, but tapering gradually to the apices which are truncate with rounded angles. The end walls and angles of the apices may be thickened, causing the apices to appear slightly swollen. The terminal vacuoles usually have one large compound gypsum crystal, although there can be several smaller additional crystals. Each chloroplast has 5-9 pyrenoids. This species can be separated from C. intermedium by the proportionately wider cells.

Measurements: L. 180-(234)-(262)-540u; W. (26)-(27)-52u; A. 10-15u.

Distribution: SLP, Barry, Washtenaw (2), also Berrien (Transeau 1917); NLP, Cheboygan (N & A 1932); EUP, Mackinac (Transeau 1917, N & A 1932); WUP, Marquette, Houghton; Isle Royale (Prescott 1941).

58. Closterium ulna Focke Pl. 2, Fig. 5.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):341. Pl. 29, Figs. 1-4.

This slightly curved species is 16-25 times longer than wide, has a girdle band, a colorless or pale yellow striated cell wall (10-12 per 10u), and with lateral margins almost parallel, but very slightly attenuated to broadly rounded truncate apices. The terminal vacuoles generally have one large gypsum crystal, and the chloroplasts each have 6-19 pyrenoids.

Measurements: L. 170-(240)-500u; W. 10-(15)-23u; A. 7.5-13.5u.

Distribution: NLP, Roscommon, EUP, Alger. New records for Michigan.

59. Closterium Braunii Reinsch Pl. 2, Figs. 7, 8.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):343. Pl. 30, Figs. 1, 2.

This species is 16-22 times longer than wide. The dorsal margin is slightly curved, the ventral margin slightly concave. The lateral margins are parallel in

the midregion and taper almost inperceptibly for the greater length of the cell, then taper sharply to the truncate, often slightly recurved apices. The brownish cell wall is distinctly marked by 4-6 longitudinal double rows of punctate striations. In between each double row, the cell wall is irregularly punctate. The chloroplasts each have 14-16 pyrenoids, and the terminal vacuoles each have about twenty gypsum crystals. The Michigan specimens from Houghton County appear identical with Cl. attentuatum var. sculptum Nordst. which Krieger (1935) places under Cl. Braunii.

Measurements: L. 450-(666)-800u; W. 25-(44)-61u.

Distribution: WUP, Houghton. New record for Michigan.

60. Closterium attentuatum Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):344. Pl. 30, Figs. 3, 4; Pl. 31, Fig. 1.

This species is 11-16 times longer than wide, and slightly curved. The lateral margins taper gradually from the non-tumid midregion to below the apices where there is an abrupt narrowing to form apices that are truncately obtuse, but conical. The cell wall is brownish, and finely striated (8-9 per 10u), the striae sometimes reduced to punctations near the apices. The terminal vacuoles have many gypsum crystals and there are 6-9 pyrenoids arranged in a linear series in each chloroplast.

Measurements: L. 360-580u; W. 28-67u; A. 6-8u.

Distribution: NLP, Newaygo (N & A 1932).

61. Closterium Ralfsii Breb. fa. Pl. 3, Fig. 5.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):345. Pl. 31, Figs. 2, 3.

This species is 6-10 times longer than wide. The dorsal lateral margin is slightly curved throughout, whereas the ventral margin is convex in the midregion of the cell. The lateral margins taper sharply to the truncate poles that have an apical thickening in the wall. The cell wall is brownish and striated (7-9 per 10u). The striae become reduced into conspicuous pores near the apices. The terminal vacuoles have about ten gypsum crystals and each chloroplast has 6-9 pyrenoids. A few specimens from Delta County were slightly narrower than the typical measurements. The middle tumidness did not occupy as much of the cell length as in most typical expressions.

Measurements: L. 300-(368)-610u. W. (37)-40-62u; A. 9-10u.

Distribution: EUP, Delta. New record for Michigan.

62. var. hybridum Rabh.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):347. Pl. 31, Figs. 4,5.

This variety is proportionately narrower than the typical (11-18 times longer than wide). The cell wall is more finely striated (9-10 per 10u), and the chloroplasts each have up to twenty one pyrenoids.

Measurements: L. 300-(513)-(517)-770u; W. 24-(36)-40-(45)u; A. 5-10u.

Distribution: SLP, Livingston, Washtenaw, Barry, also Macomb (West and West 1898), and Washtenaw (N & A 1932, Cl. decorum Bréb.); NLP, Cheboygan (N & A 1932, Cl. decorum Bréb); EUP, Delta; WUP, Gogebic, Houghton, also Houghton (N & A 1932, Cl. decorum Breb.); Isle Royale (Prescott 1941).

63. Closterium lineatum Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):349. Pl. 32, Figs. 1, 2.

This narrow species is 16-26 times longer than wide. The lateral margins are straight and parallel in the mid-region of the cell, but taper gradually beyond into slightly incurved truncate apices. The color of the cell wall is brown, and the striae number 6-10 per 10u. The terminal vacuole contain 4-10 (rarely 1) gypsum crystals, and the chloroplast has 9-12 (rarely up to 15) pyrenoids in a linear series.

Measurements: L. 300-(516)-768u; W. 13-(20)-36u; A. 4-10u.

Distribution: SLP, Barry (2), also Macomb (Pieters 1894) and Allegan (Transeau 1917); NLP, Cheboygan (N & A 1932); EUP, Delta.

64. var. costatum Wolle Pl. 2, Fig. 4.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):351. Pl. 32, Figs. 4, 5.

Typically, this variety is 25-28 times longer than wide. The possession of distinct costae (3 per 10u) separates this organism from the typical. Specimens from Barry and Schoolcraft Counties were only about seventeen times longer than wide, and agree well with similar specimens reported by Irénee-Marie (1938) from Canada.

Measurements: L. 420-(559)-770u; W. 19-32-50u.

Distribution: SLP, Barry; EUP, Schoolcraft. New record for Michigan.

65. Closterium Kuetzingii Bréb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):351. Pl. 32, Figs. 8, 9.

The cells of this species are 20-30 times longer than wide. The median part of the cell is fusiform with the almost equally convex lateral margins converging gradually into long setaceous extremities that posses slightly incurved and swollen apices. The cell wall is brownish with 8-11 striae per 10u. The terminal vacuoles contain 2-10 gypsum crystals, and the chloroplasts each have 4-7 pyrenoids in a linear series.

Measurements: L. 270-(426)-540u. W. 14-(17)-27u.

Distribution: SLP, Barry (3), Calhoun, Washtenaw (2), also Hillsdale, Washtenaw (N & A 1932); NLP, Crawford, also Macosta (N & A 1932); EUP, Schoolcraft, Delta, also Mackinac (N & A 1932, Transeau 1917), Luce (N & A 1932), and Schoolcraft (Transeau 1917); WUP, Gogebic, also Houghton (N & A 1932).

66. Closterium rostratum Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):354. Pl. 33, Figs. 1-3.

This species is 11-16 times longer than wide. The median region of the cell is fusiform with the ventral lateral margin much more strongly convex than the dorsal lateral margin. The lateral margins taper gradually into relatively short setaceous extremities which possess slightly incurved obtuse, slightly dilated apices. The cell wall is brownish and striated (about 10 per 10u). The terminal vacuoles possess 6-14 gypsum crystals, and 3-5 pyrenoids are arranged linearly in each chloroplast. Measurements: L. 190-(330)-530u; W. 18-(21)-32u; A. 3-5u. Distribution: SLP, Barry, Washtenaw, also Wayne (Campbell 1886), Macomb, Lake St. Clair Pieters (1894) and Oakland (Transeau 1917); NLP, Cheboygan (N & A 1932); EUP, Delta, Mackinac; WUP, Gogebic.

67. Closterium setaceum Ehrenb.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):356. Pl. 33, Figs. 8-10.

This species is 25-40 times longer than wide. The median part of the cell body is fusiform with both lateral margins converging relatively abruptly into long narrow setaceous extremities that are slightly incurved near the obtuse apices. The cell wall is colorless or brownish, and finely striated (11-12 per 10u). The terminal vacuoles

contain three or four gypsum crystals, and the two to three pyrenoids are in linear series in each chloroplast. The body of the cell is relatively small in proportion to the length of the setaceous extremities. Cl. Nostratum and Cl. Kuetzingii are similar to this species, but have relatively larger bodies in proportion to the length of the setaceous extremities.

Measurements: L. 150-(310)-600u; W. 6-(10)-13u; A. 1.4u.

Distribution: SLP, Ingham, Barry (2), Washtenaw; NLP, Cheboygan, Emmet; EUP, Chippewa, Alger, Mackinac; WUP, Gogebic (3); Isle Royale (Prescott 1937).

68. Closterium costatum Corda

Krieger, 1935. Rabh. Krypt. Flor. 13(1):358. Pl. 34, Figs. 1-3.

This species is about 6-10 times longer than wide and possesses girdle bands which are not always recognizable. The cell wall has well-developed, widely spaced costae (1-2 per 10u) and the lateral margins taper gradually to the sharply truncate apices. The walls at the apices are thickened so that the poles appear angularly rounded. The terminal vacuoles possess usually one large gypsum crystal, but occasionally there may be numerous small ones. The cell wall is brownish with the poles often more darkly colored. There are 6-12 pyrenoids in each chloroplast.

Measurements: L. 200-(305)-550u; W. 28-(37)70u.

Distribution: SLP, Barry (2), Livingston, also Wayne (Campbell 1886); NLP, Roscommon, Emmet, also Cheboygan (N & A 1932); EUP, Delta, Schoolcraft (2); WUP, Gogebic, Marquette; Isle Royale (Prescott 1937).

69. var. subcostatum (Nordst.) Krieger Pl. 3, Fig. 3.
Krieger, 1935. Rabh. Krypt. Flor. 13(1):360. Pl. 34, Fig. 6.

This variety is separated from the typical by the smaller length-width ratio (4-7 times longer than wide). The midregion of the semicell may be slightly swollen, the apices are roundly truncated and the costae may be more closely arranged (4-5 per 10u). Michigan specimens were slightly broader than the original measurements of this variety.

Measurements: L. 232-(365)-377u; W. 31-49-(54).

Distribution: SLP, Barry; EUP, Schoolcraft. New records for Michigan.

70. var. Westii Cushman Pl. 2, Fig. 6.
Krieger, 1935. Rabh. Krypt. Flor. 13(1):361. Pl. 34, Fig. 8.

This variety is more slender (10-11 times longer than wide) than the typical and the curvature is slightly greater.

Measurements: L. 230-400u; W. 23-41u.

Distribution: WUP, Gogebic (2). New record for Michigan.

71. Closterium angustatum Kuetz.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):363. Pl. 35, Figs. 2-4.

This species is usually about 12-18 times longer than broad. The girdle bands or transverse wall markings are present and the cell wall has well-developed (ribs) costae (2 per 10u) that may be somewhat spirally arranged. The curvature is slight with the lateral margins parallel in the midregion of the cell and tapering very slightly to the usually subcapitate apex. The terminal vacuoles have numerous (13-20) gypsum crystals, and the chloroplasts each have 5-10 pyrenoids.

Measurements: L. 250-(559)-650u; W. 16-(17)-(23)-35u.

Distribution: SLP, Barry; NLP, Cheboygan (N & A 1932); EUP, Schoolcraft, also Mackinac (Transeau 1917); WUP, Houghton; Isle Royale (Prescott 1941).

72. Closterium Cynthia De Not. Pl. 3, Fig. 1.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):265. Pl. 35, Figs. 6-10.

This species is about 8-10 times longer than wide, has a girdle band, a pale yellow or light brown cell wall that is striated (6-9 per 10u), a marked curvature, and lateral margins gradually tapering toward the rounded apices. The terminal vacuoles usually contain one large gypsum crystal. This species has a general resemblance to Cl. Archerianum but is usually smaller, and has more broadly rounded apices.

Measurements: L. 73-(122)-180u; W. 9-(15)-22u.

Distribution: WUP, Houghton. New record for Michigan.

73. var. Jenneri (Ralfs.) Krieger

Krieger, 1935. Rabh. Krypt. Flor. 13(1):366. Pl. 36, Fig. 2.

This variety is separated from the typical on the basis of the colorless or brown cell wall. The girdle band has not been shown in many illustrations according to Krieger (1935). All the Michigan specimens from Schoolcraft County did not possess a girdle band, and were slightly longer than originally described.

Measurements: L. 43-110-(124)u; W. 7-(11.5)-18u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Schoolcraft (2).

74. var. robustum (G. S. West) Krieger Pl. 1, Fig. 13.

Krieger, 1935. Rabh. Krypt. Flor. 13(1):368. Pl. 36, Figs. 5, 6.

This variety is separated from the typical on the basis of the stouter proportions, the cells being only 5-6 times longer than wide, and having the apices very broadly rounded.

Measurements: L. 42-(70)-80u; W. 8.8-(11)-14u.

Distribution: SLP, Calhoun. New record for Michigan.

75. Closterium Archerianum Cleve

Krieger, 1935. Rabh. Krypt. Flor. 13(1):368. Pl. 36, Figs. 7-8.

This species is about 10-11 times longer than wide, has a girdle band, a brown or yellow cell wall that is striated (5-6 per 10u), a marked curvature and lateral margins gradually tapering toward the rounded apices. The terminal vacuoles have single large gypsum crystals and the chloroplasts each have 5-7 pyrenoids.
Measurements: L. (169)-175-(234)-300u; W. 16-(23.4)-30u.
Distribution: SLP, Barry; NLP, Emmet, also Cheboygan (N & A 1932); Isle Royale (Prescott 1941).

8. SPINOCLOSTERIUM

(Closterium cuspidatum Bailey) Bernard 1909

Cells broadly crescent-shaped with a strong curvature; lateral margins, tapering gradually to the broadly rounded apices each of which bear a single strong spine. Each semicell with a terminal vacuole and a longitudinal ridged chloroplast; pyrenoids arranged in three or four irregular series.

Zygospore unknown.

1. Spinoclosterium cuspidatum (Bailey) Hirano

Irenee-Marie, 1952, Le. Nat. Canad. 79(1):33, Pl. 1, Figs. 14-15.

This is the only species of the genus Spinoclosterium and possesses the characteristics named above. Transeau (1917) reported the occurrence of this organism (as Closterium cuspidatum Bailey) from Muskegon County. Krieger (1935) considers Bailey's original form as a Peridinium cyst, although Wolle considers it a species of Tetraedron

and Rabenhorst, a species of Ophiocytium (Wolle 1887). The writer believes that the presence of the terminal spines is sufficient evidence to separate this organism from the genus Closterium as has Hirano (1949). Bernard's (1909) use of the name Spinoclosterium is thus the proper designation of the genus. However, Bailey's species name cuspidatum must be used because of the International Rules of Botanical Nomenclature.

Measurements: L. 150-165u; W. 50u. Sp. 15u.

Distribution: SLP, Muskegon (Transeau 1917).

2. var. spinosum Prescott

Prescott, 1937. Pap. Mich. Acad. Sci., Arts and Letters. 22:203, Pl. 19, Figs. 1-3.

This variety can be separated from the typical by the slight dilation of the poles, especially upon the dorsal margins. The original specimens also possessed scattered concretions on the older cell wall. The shape of the cell is also different with the width of the variety being proportionately greater than in the typical (as shown by Wolle 1887).

Measurements: L. 140-148u; W. 58-62u; Sp. 4.5-11.5u.

Distribution: SLP, (Unknown locality by Taft according to Prescott (1940); NLP, (Unknown locality by the writer); Isle Royale (Prescott 1937).

9. PENIUM Bréb. 1844

Cells usually cylindrical, of variable length, always longer than wide, sometimes with a median constriction, usually attenuated near the apices which are mostly broadly rounded, truncate, or truncately rounded. Cell wall colorless to brownish, ornamented with longitudinal striae or punctate, and with a demarcation line between the two semicells. Chloroplasts, axial, one or more in each semicell, with radiating plates that extend to the cell wall. Pyrenoids, when single, centrally placed, when more than one, in an axial linear series.

Zygospores spherical to rectangular, with walls generally smooth.

Key to Species of Penium

1. Cell wall with longitudinal striae 5

1. Cell wall with irregularly arranged rows of punctations or with irregular punctations 2

2. Cell walls with irregular rows of punctations . . . . . (1) P. margaritaceum

2. Cell wall irregularly and densely punctate 3

3. Lateral margins somewhat invaginate a short distance below the apex causing the apices to appear slightly dilated; L. 19-69u; W. 6-14u . . . . . (2) P. exiguum

3. Lateral margins not invaginate a short distance below the apex . . 4

4. Cell width 8-21u; cell wall not medianly constricted . . (3) P. cylindrus

4. Cell width 20-31u; cell wall usually with a light median constriction . . . . . (4) P. rufescens

5. Cell wall punctate between longitudinal striae, cell length over 77u. (5) P. spirostriolatum

5. Cell wall not punctate between longitudinal striae, cell length under 79u 6

6. Girdle band never present; longitudinal striae often difficult to see . . . . . (6) P. phymatosporum

6. Girdle band usually present; longitudinal striae usually distinct . . . . . (7) P. polymorphum

1. Penium margaritaceum (Ehrenb.) Bréb.

Krieger 1935. Rabh. Krypt. Flor. 13(1):230. Pl. 10, Figs. 2-4.

This species is characterized by cylindrical cells, three to thirteen times longer than wide, with broadly rounded or almost truncate poles. The cell wall is ornamented with punctations arranged in slightly irregular longitudinal rows. West and West (1904), G. M. Smith (1924), Irénee-Marie (1938) state the surface is granular but the writer agrees with Krieger (1935) that the wall is punctate and the "granules" are merely extrusions of mucilage. The cell wall is reddish-brown and also usually constricted in median portion. The chloroplasts of which there are one or two in each semicell, have the longitudinal ridges radiating to the cell walls. The py-

renoids (one or two per chloroplast) are placed in a linear central row.

Measurements: L. 60-(65)-(127)-230u; W. 13-(19.3)-(21)-30u.

Distribution: SLP, Berrien, also Berrien (Transeau 1917), and Macomb (Pieters 1894); EUP, Schoolcraft, also Luce (N & A 1932); WUP, Gogebic.

2. Penium exiguum W. West

Krieger, Rabh. Krypt. Flor. 13(1):233. Pl. 10, Figs. 7-10.

This species is small of a very variable length, usually three to six times longer than wide. The cylindrical cell, often dilated at the apices, commonly has a median constriction. The cell wall is irregularly punctate. One to three pyrenoids are present in each semicell and frequently terminal vacuoles with gypsum crystals are present.

Measurements: L. 19-69u; W. 6-14u.

Distribution: NLP, Cheboygan (Taft 1939).

3. Penium cylindrus (Ehrenb.) Breb.

Krieger 1935. Rabh. Krypt. Flor. 13(1):234. Pl. 9, Figs. 9-12.

This small species is cylindrical, without a median constriction, and usually two to four (rarely six) times longer than wide. The lateral margins are not tapered except at the apices which are broadly rounded to truncate. The cell wall is irregularly but densely punctate,

with older cell walls becoming brownish. One or two chloroplasts, each with one or two central pyrenoids are present in each semicell.

Measurements: L. 30-58u; W. 8-21u.

Distribution: NLP, Presque Isle, also Cheboygan (N & A 1932, Welch 1936b); WUP, Baraga (N & A 1932).

4. Penium rufescens Cleve.

Krieger 1935. Rabh. Krypt. Flor. 13(1):240. Pl. 10, Figs. 13, 14.

This species is broadly cylindrical and about two to two and one-half times longer than wide. The cell wall is reddish brown or colorless, and densely but irregularly and finely punctate. The apices are usually broadly rounded, the lateral margin has a slight median constriction and sometimes a slight compression above the median constriction. A central pyrenoid is present in each half cell.

Measurements: L. 50-(59)-81u; W. 20-24.5)-31u.

Distribution: EUP, Schoolcraft; WUP, Marquette (Pres. & Mag. 1935); Isle Royale (Prescott 1937, P. chrysoderma Borge).

5. Penium spirostriolatum Barker

Krieger 1935. Rabh. Krypt. Flor. 13(1):227. Pl. 9, Figs. 1-6.

This large cylindrical species is five to eleven times longer than wide. The cell walls are brownish and

ornamented by a series of longitudinal striae that are irregularly spirally arranged and which often anastomose or become replaced by linear series of punctations, especially in the apical regions. The cell wall is punctate between the striae. A slight median constriction is present, and the apices are rounded or truncately rounded (rarely slightly dilated). Usually there are two chloroplasts in a semicell, each with a central pyrenoid.

Measurements: L. 77-(250)-325u; W. 15-(30)-30u.

Distribution: SLP: Washtenaw, also Muskegon (Transeau 1917); NLP, Cheboygan (N & A 1932); EUP, Schoolcraft; WUP, Gogebic (2), Houghton.

6. Penium phymatosporum Nordst.

Krieger 1935. Rabh. Krypt. Flor. 13(1): 237. Pl. 11, Figs. 14-17.

This small species is cylindrical and about two times longer than wide. The cell wall is colorless and ornamented with delicate striolations (11 per 10u). The lateral margins are often slightly constricted in the midregion and taper very slightly to the broadly rounded apices. Each semicell contains one chloroplast, each with a central pyrenoid.

Measurements: L. 24-49u; W. 11-27u.

Distribution: NLP, Cheboygan (N & A 1932); Isle Royale (Prescott 1941).

7. Penium polymorphum Perty Pl. 1, Fig. 5.
Krieger 1935. Rabh. Krypt. Flor. 13(1):229. Pl. 11, Figs. 18-20.

This small species is cylindrical or subcylindrical and two to two and one-half times longer than wide. The lateral margins usually have a slight median constriction and taper very slightly to the broadly, sometimes truncately rounded apices. The cell wall has very delicate but very closely arranged (about 18 per 10u) longitudinal striolations. Each semicell has one chloroplast with a central pyrenoid.

Measurements: L. 34-(50)-(60)-79u; W. (19.5)-(20.5)-36u.

Distribution: SLP, Barry; EUP, Chippewa; WUP, Houghton, Baraga. New record for Michigan.

10. PLEUROTAENIUM Naegeli 1849

Cells, solitary or rarely in short filaments, usually relatively large, with length at least more than two times the width; generally cylindrical with lateral margins straight undulate, parallel or slightly convex and tapering toward apex; median constriction distinct but not deep; apex of semicell truncate, angles usually rounded; the poles either smooth or ornamented with a crown of granules or spines; semicell bases usually swollen and without plications. Cell wall smooth, punctate, granulate or rarely of uneven thickness, which creates transverse rings of irregular ploygonal or quadrangular

areas. Chloroplasts extending the length of semicell, usually parietal straight or undulate bands with numerous pyrenoids, or more rarely an axial plate with a central row of pyrenoids.

Zygospore spherical with smooth walls.

Key to Species of *Pleurotaenium*

1. Cell wall smooth or punctate 2

1. Cell wall with numerous (12-15) transverse rings of irregularly polygonal or quadrangular areas formed by thin areas in the wall . (1) *Pl. verrucosum*

2. Pole of semicell smooth 3

2. Pole of semicell with spines, granules or warts 5

3. Chloroplast solitary in each semicell, an axial plate with longitudinal ridges . . . . . (2) *Pl. minutum*

3. Chloroplasts, many parietally placed narrow bands 4

4. Lateral margins undulate for more than half the length of semicell from the base . . . (17) *Pl. coronatum* var. *nodulosum*

4. Lateral margin with one to three slight undulations above basal swelling of semicell, undulations never extending to half the length of semicell . . . . . (5) *Pl. trabecula*

5. Pole of semicell bearing short spines 6

5. Pole of semicell bearing granular warts 8

6. Lateral walls bearing regularly spaced whorls of mammillate protuberances . . . . (10) Pl. nodosum

6. Lateral walls otherwise 7

7. Lateral margins broadly undulate, undulations (not including basal swelling) usually four. Apex with more than three small granular spines . . . . . (11) Pl. constrictum

7. Lateral margins straight except for basal swelling, apex bearing three short, sharp spines . . . . (12) Pl. tridentulum

8. Lateral margins with a distinct constriction just below apex, cells usually joined end to end in filaments . . . . . (13) Pl. subcoronulatum var. detum

8. Lateral margins lacking a constriction just below apex, cells usually not joined end to end in filaments 9

9. Basal swelling very slight; lateral margins never undulate, slightly convex or straight, semicells tapering markedly towards apex . . (14) Pl. truncatum

9. Basal swelling distinct, lateral margins straight or undulate or both straight and undulate in different portions, sometimes tapering gradually towards apex 10

10. Width of semicell base 30-75u; robust form with thick cell walls; number of lateral margin undulations above basal swelling variable, often reaching to middle or past middle of the semicell . . . (16) Pl. coronatum (inc. p.p. var. nodulosum)

10. Width of semicell base 15-35u; slighter form with cell walls not thickened; often with single undulation above basal swelling, undulations very rarely reaching to middle of semicells . . . . . (18) Pl. Ehrenbergii

1. Pleurotaenium verrucosum (Bail.) Lund. Pl. 4, Fig. 5. Krieger 1937. Rabh. Krypt. Flor. 13(1);438. Pl. 51, Fig. 3.

This species is characterized by the twelve to fifteen rings of irregular polygonal or quadrangular areas in the cell wall where the wall is thin. The presence of apical tubercles easily separates it from the somewhat similar Pl. trochiscum (not reported as yet for Michigan).

Measurements: L. 200-(335)-516u; W. at base, 25-(32)-45u; A. 16-(21.5)-30u.

Distribution: WUP, Gogebic. New record for Michigan.

2. Pleurotaenium minutum (Ralfs.) Delp. Krieger, 1937. Rabh. Krypt. Flor. 13(1):390. Pl. 39, Figs. 2, 3.

Characteristically, this species has either a very slight swelling or none at all at the base of the semicells. Apical tubercles are lacking and the chloroplast is an axial plate with longitudinal ridges. The writer follows Krieger (1937) by not separating fa. major from the typical.

Measurements: L. 60-(188)-(250)-270 at base; W. 7-(14)-(16)-18u.

Distribution: SLP, Washtenaw, Livingston, Berrien; NLP, Emmet, Presque Isle, Roscommon, also Cheboygan and Presque Isle (Taft 1939, Penium minutum) and Cheboygan (N & A

1932 Cosmarium docidioides); EUP, Chippewa, Schoolcraft; WUP, Gogebic, Houghton, Baraga.

3. var. elongatum (West and West) Cedergren Pl. 4, Fig. 6.
Krieger, 1937. Rabh. Krypt. Flor. 13(1):393. Pl. 39, Fig. 9.

This variety is separated from the typical (8-12 times as long as wide) by the much elongated cell (30-40 times as long as wide). Pl. trabecula var. elongatum resembles this variety but differs distinctly in the possession of pronounced swellings at the base of the semicells, and by having a smaller length-width ratio (19-28 times longer than wide).

Measurements: L. 257-(352)-550u; W. 8-(16)-18u.

Distribution: EUP, Alger. New record for Michigan.

4. var. gracile (Wille) Krieger Pl. 4, Fig. 4.
Krieger, 1937. Rabh. Krypt. Flor. 13(1):394. Pl. 39, Fig. 10.

This variety is intermediate between the typical and var. elongatum in length-width proportions (14-20 times as long as wide).

Measurements: L. 110-(219)-220u; W. 6.5-(13)-14.5u.

Distribution: EUP, Chippewa. New record for Michigan.

5. Pleurotaenium trabecula (Ehr) Naeg.
Krieger, 1937. Rabh. Krypt. Flor. 13(1):395. Pl. 40, Figs. 1-4.

Except for Pl. minutum and Pl. coronatum var. nodulosum, Pl. trabecula is the only Michigan species that

lacks apical tubercles in the typical form. The former has either a very slight basal swelling or none. Semicells of Pl. trabecula usually have a single distinct basal inflation (occasionally 1-3 undulations which do not extend to half the length of semicells) while Pl. coronatum var. nodulosum when lacking apical tubercles,has a distinct basal inflation and above it numerous undulations extending to half the length of the semicells. The writer follows Krieger (1937) in retaining fa. clavata within the typical.

Measurements: L. 260-(384)-(402)-(408)-660u; W. at base (23)-24-(32)-40.

Distribution: A very common and widespread species in Michigan. SLP, Calhoun, Ionia, Shiawassee, Washtenaw (2), Livingston, Oakland, Jackson, Berrien, Barry, Ingham, also Kalamazoo, Muskegon, Lapeer (N & A 1932), Ionia (Wade 1949), Wayne (Campbell 1886) and Macomb (Pieters 1894); NLP, Cheboygan, Emmet, Newaygo (N & A 1932, Welch 1938b) also Cheboygan (Pl. trabecula fa. clavata, N & A 1932); EUP, Chippewa, Alger, Mackinac, Delta, Schoolcraft, also Chippewa (N & A 1932), Schoolcraft (Transeau 1917); WUP, Gogebic (2), Iron, Menominee, also Baraga, Houghton, Ontanagon (N & A 1932); Isle Royale (Taylor 1935b, Prescott 1937).

6. var. hirsutum (Bail.) Krieger

Krieger 1937. Rabh. Krypt. Flor. 13(1):399. Pl. 41, Fig. 3.

This variety possesses short mucilaginous papillae on the surface of the cell wall. No other variety of Pl. trabecula possesses this feature.

Measurements: L. 245-500u; W. at base, 23-48u.

Distribution: NLP, Emmet (N & A 1932).

7. var. maximum (Reinsch.) Roll.

Krieger 1937. Rabh. Krypt. Flor. 13(1):400. Pl. 40, Fig. 8.

This variety is separated from the typical on the basis of its larger size. There are usually one to three slight undulations above the distinct basal swelling of the semicells.

Measurements: L. 350-(830)-1120u; W. at base, 48-(62)-65u.

Distribution: SLP, Barry; NLP, Cheboygan (N & A 1932).

8. var. rectum (Delp.) West and West

Krieger 1937. Rabh. Krypt. Flor. 13(1):402. Pl. 41, Fig. 2.

This variety is separated from the typical on the basis of its smaller size, primarily in the smaller width at the base of semicell.

Measurements: L. 180-400u; W. at base, 14-23u.

Distribution: SLP, Barry, also Muskegon (Transeau 1917, N & A 1932); NLP, Crawford, Emmet, also Cheboygan (Welch 1936b); EUP, Alger; WUP, Gogebic.

9. var. rectissimum West and West Pl. 4, Fig. 2.

Krieger 1937. Rabh. Krypt. Flor. 13(1):401 Pl. 41, Fig. 1.

This variety is separated from var. rectum by its greater length and the slightly greater length to width ratio (19-24 times longer than wide) than the typical (11-18). It also has a much greater width at the base of the semicell. An additional characteristic of this variety is the presence of slightly dilated apices. Specimens from Barry County agreed well with the measurements for this variety but lack the distinct dilated apices noted by West and West (1904). The writer therefore places these forms here questionably.

Measurements: L. 400-(505)-628u; W. at base, 21-(24)-26u.

Distribution: SLP, Barry. New record for Michigan.

10. Pleurotaenium nodosum (Bail.) Lund

Krieger 1937. Rabh. Krypt. Flor. 13(1):436. Pl. 47, Fig. 1.

This species is easily distinguished by the transverse whorls of mammillate protuberances.

Measurements: L. 250-(340)-520u; W. 40-(51)-82u; A. 24-50u.

Distribution: SLP, Berrien, also Muskegon (Transeau 1917); NLP, Emmet, also Cheboygan (Welch 1938b); Isle Royale, (Prescott 1937).

11. Pleurotaenium constrictum (Bail.) Wood Pl. 4, Fig. 1.

Krieger 1937. Rabh. Krypt. Flor. 13(1):421. Pl. 45, Fig. 8.

This species characteristically has four broad undulations (not including basal swelling) of the lateral

margins in each semicell, the undulations extending throughout the greater length of the semicell. Four to five granular spines are visible at the apex in front view.

Measurements: L. 415-(502)-580u; W. at base, 40-(44.7)-50u.

Distribution: SLP, Berrien; EUP, Chippewa. New record for Michigan.

12. Pleurotaenium tridentulum (Wolle) West

Krieger 1937. Rabh. Krypt. Flor. 13(1):408. Pl. 43, Figs. 12-14.

This species is easily separated from other Michigan species by the pronounced basal swelling, the distinct tapering of the lateral margins to the blunt rounded apex which bears three or four spines (usually three seen in front view).

Measurements: L. 160-(217)-320u; W. at base, 12-(15)-18u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Chippewa.

13. Pleurotaenium subcoronulatum var. detum West and West Pl. 4, Fig. 3.

Krieger 1937. Rabh. Krypt. Flor. 13(1):424. Pl. 46, Fig. e.

Distinctive features of this variety include the dilated truncate apex with a transverse ring of elliptic tubercles, the constriction of the lateral margins of the semicells at about one-tenth of the distance from the apex and the usually evident habit of remaining united end to end to form filaments.

Measurements: L. (372)-385-690u; W. at base, (23.5)-24-45u; W. at apex, (23.5)-24-28u.

Distribution: WUP, Gogebic, New record for Michigan.

14. Pleurotaenium truncatum (Bréb.) Naeg.

Krieger 1937. Rabh. Krypt. Flor. 13(1):430. Pl. 49, Figs. 2, 3.

One of the most distinct features that separates this species from others of the genus found in Michigan, is the short stout appearance (6-9 times as long as wide). In addition, the slight swelling at the base of the semicell and the convex lateral walls which taper sharply to the apex help distinguish this species.

Measurements: L. 230-(372)-762u; W. at base, 40-(54)-85u; W. at apex, 24-42u.

Distribution: SLP, Muskegon (Transeau 1917); EUP, Schoolcraft.

15. var. Farquharsonii (Roy) West and West

Krieger 1937. Rabh. Krypt. Flor. 13(1):433. Pl. 49, Figs. 5, 6.

This variety differs from the typical only in the presence of a slight but conspicuous concavity in the lateral margins just below the apex.

Measurements: L. 288-429u; W. at base, 44-62.4u.

Distribution: Isle Royale (Prescott 1940).

16. Pleurotaenium coronatum (Bréb.) Rabh.

Krieger 1937. Rabh. Krypt. Flor. 13(1):427. Pl. 48, Figs. 1, 2.

This species is often mistaken for Pl. Ehrenbergii from which it differs by having a more robust form, thicker cell walls and a usually greater width at the base of the semicells. The lateral undulations can also extend to the middle of the semicells whereas Pl. Ehrenbergii usually has only one to three undulations (sometimes none) which do not extend to the midregion of the semicells. The tapering of the lateral margins to the apex is very slight in both species.

Measurements: L. 360-(521)-680u; W. 30-(51)-75u.

Distribution: SLP, Muskegon (Transeau 1917), Kalamazoo (N & A 1932); NLP, Cheboygan (N & A 1932); EUP, Schoolcraft; WUP, Marquette; Isle Royale (Prescott 1937).

17. var. nodulosum (Bréb.) West

Krieger 1937. Rabh. Krypt. Flor. 13(1):429. Pl. 48, Fig. 4.

This variety is separated from the typical by a combination of characteristics. The tapering of the semicells to the apex is much sharper than in the typical. The number and extent of the undulations of the lateral margins are variable (often extending through almost the entire length of the semicell); the apical granules may either be completely lacking, strongly reduced, or present as normal granules.

Measurements: L. 335-(460)-(516)-670u; W. at base, 36-(43)-(53.7)-65u; W. at apex, 23-(32.5)-44u.

Distribution: SLP, Barry, Washtenaw, also Wayne (Campbell 1886, Pl. crenulatum); NLP, Cheboygan (N & A 1932, Pl. crenulatum); WUP, Houghton, also Marquette (Pres. & Mag. 1935, Pl. nodulosum); Isle Royale (Prescott 1937).

18. Pleurotaenium Ehrenbergii (Bréb.) De Bary

Krieger 1937. Rabh. Krypt. Flor. 13(1):410. Pl. 42, Figs. 4-8.

This species is very variable in size, in proportions of length to width, and in the degree of tapering of the lateral margins to the apex. The features that distinguish it from Pl. coronatum and Pl. coronatum var. nodulosum have been discussed previously. Some of the general characteristics are: fifteen to twenty times as long as wide, distinct basal swelling with sometimes a single undulation on the lateral margin above the basal swelling, middle lateral margins parallel, usually slightly tapering to the apex.

Measurements: L. 220-(349)-700u; W. at base, 15-(30.4)-35u.

Distribution: Very widely distributed in the writer's collections. SLP, Calhoun, Barry (3), Ingham, Jackson; NLP, Roscommon, Crawford, also Cheboygan (N & A 1932, Neal 1948); EUP, Schoolcraft, Delta; WUP, Houghton, Gogebic (3), also Isle Royale (Prescott 1940).

19. var. elongatum (W. West) West and West

Krieger 1937. Rabh. Krypt. Flor. 13(1):414. Pl. 43, Fig. 3.

This variety is twenty to twenty-five times longer than broad whereas the typical is fifteen to twenty times longer than broad.

Measurements: L. 390-575u; W. at base, 18-26u.

Distribution: SLP, Oakland (Transeau 1917); NLP, Crawford.

11. DOCIDIUM Bréb. 1844

(Emend. Lundell 1871)

Cells straight, solitary, always longer than broad, cylindrical, with a slight median constriction; semicells with lateral margin undulate or straight, and with apices truncate and smooth; base of semicells always inflated and with longitudinal plications. Cell wall smooth, punctate or finely striated. Chloroplast axial with irregular longitudinal ridges, single in each semicell; pyrenoids (6-8) in a linear series.

Zygospore unknown.

Key to Species of Docidium

1. Lateral margins undulate throughout the entire length of the semicell . . . . . (2) D. undulatum

1. Lateral margins with a single undulation at the base of the semicell . . . . . (1) D. baculum

1. Docidium baculum Bréb.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):379. Pl. 38,

The longitudinal plications and the single swelling at the base of each semicell clearly differentiates this

species. The width of the cell is always below 20u.

Measurements: L. 150-(185)-(267)-430u; W. 9.5-(13)-20u; A. 5-8-12u.

Distribution: SLP, Barry; NLP, Cheboygan (Taft 1939); EUP, Delta.

2. Docidium undulatum Bailey

Krieger, 1937. Rabh. Krypt. Flor. 13(1):380. Pl. 38, Figs. 9-12.

The undulate margins separate this species easily from any other reported from Michigan.

Measurements: L. 165-(265)-300u; W. 12-(13)-17u; A. 11-(15)-15u.

Distribution: NLP, Cheboygan (Taft 1939); EUP, Chippewa.

12. TRIPLOCERAS Bailey 1850

Cells large, straight, always much longer than wide, with a slight but well defined median constriction. Semicells cylindrical with lateral margins slightly tapered to apices. Apices flattened with two or three long, upwardly turned obliquely placed lobes or projections with truncate ends that bear two to three short, sharp spines; sometimes with one or two secondary protuberances each with one or two spines, located between two apical processes. Lateral margins strongly undulate with the undulations produced by transverse whorls of protuberances, each protuberance bearing simple spines or emarginate two to nine parted verrucae. Chloroplast axial,

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one in each semicell, with longitudinal plates extending from median axis to the lateral walls, pyrenoids in an axial row.

Zygospores unknown.

Key to Species of Triploceras

1. Lateral margins bearing whorls of protuberances which have in the midregion of the semicell, emarginate verrucae . . . . . (1) T. verticillatum

1. Lateral margins bearing whorls of protuberances all of which possess simple spines . . . . . (2) T. gracile

1. Triploceras verticillatum Bailey Pl. 5, Fig. 1

Krieger, 1937. Rabh. Krypt. Flor. 13(1):446. Pl. 52, Figs. 19-22.

This species has the semicells bearing transverse whorls of elevations or protuberances with two types of projections. The upper whorls have protuberances with short, upwardly directed spines, whereas the median and lower whorls have the protuberances with two-to-nine-parted projections.

Measurements: L. (300)-380-506u; W. csp. 30-(50)-50u.

Distributions: SLP, Berrien; NLP, Emmet. New record for Michigan.

2. Triploceras gracile Bailey

Krieger, 1937. Rabh. Krypt. Flor. 13(1):442. Pl. 52, Figs. 1-7.

This species with apical spines and the transverse whorls of protuberances with simple spines cannot be confused with any other species.

Measurements: L. 206-(398)-668u; W. csp. 21-(32)-53u; A. 24-40u.

Distribution: NLP, Emmet (N & A 1932); EUP, Chippewa.

13. TETMEMORUS Ralfs. 1844

Cells straight, always longer than wide, median constriction relatively shallow with an open sinus. Semicells subfusiform, cylindrical, lateral margins usually tapering to apices which have a distinct deep vertical incision. Cell wall smooth, punctate, scrobiculate or with longitudinal rows of elongated, flattened thickenings. Chloroplast, axial, single in each semicell, with longitudinal radiating plates that are entire or cleft at their margins. Pyrenoids fairly numerous and linear along the axis.

Zygospores, spherical to rectangular (sometimes with arms) with walls that are smooth.

Key to Species of Tetmemorus

1. Cell walls with longitudinal rows of flattened wall thickenings (considered punctulations or scrobiculations by West and West 1904, and many others) . . . . . (1) T. Brebissonii

1. Cell walls with irregularly arranged punctations or scrobiculations . . 2

2. Semicells very slightly tapered to the apices; apices only slightly less in diameter than at their bases . . . . . (3) T. laevis

2. Semicells gradually and regularly tapered from the base to apex; apices distinctly less in diameter than at their bases . . . . . (5) T. granulatus

1. Tetmemorus Brebissonii (Menegh.) Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):452. Pl. 54, Figs. 1-5.

This species is distinguished by the longitudinal rows of elongate, flattened wall thickenings (scrobiculations or punctulations according to many authors) on the cell walls.

Measurements: L. 100-(117)-264u; W. 19-(23.5)-39u; I. 21-(21.3)-32u.

Distribution: SLP, Barry, Livingston; NLP, Presque Isle (Taft 1939); WUP, Gogebic (2).

2. var. minor De Bary

Krieger, 1937. Rabh. Krypt. Flor. 13(1):454. Pl. 54, Figs. 6, 7.

This variety is separated from the typical by smaller size. The semicells are scarcely tapered near the apices, and the lateral margins are slightly concave in the middle of the semicells. The Roscommon County specimens were intermediate between the typical and variety.

Measurements: L. 57-(98)-100u; W. 15-21-(21.8)u; I. 12-15-(17)u.

Distribution: SLP, Barry, Livingston, also Calhoun (Pres. & Mag., 1935, fa. minutus); NLP, Roscommon, also Cheboygan (N & A 1932); EUP, Chippewa.

3. Tetmemorus laevis (Kuetz) Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):455. Pl. 54, Figs. 9-12.

This species has the semicells very slightly tapered to the apices. The width of the apices is only slightly less than at the median constriction. The cell wall has minute irregularly arranged punctations.

Measurements: L. 60-(93)-145u; W. 17-(22)-30u; I. 16-(19)-27u.

Distribution: NLP, Roscommon, also Cheboygan (N & A 1932; Welch 1938a); EUP, Chippewa, Schoolcraft (2); WUP, Houghton, Gogebic; Isle Royale (Prescott, 1937, 1941).

4. var. minutus (De Bary) Krieger

Krieger, 1937. Rabh. Krypt. Flor. 13(1):457. Pl. 55, Figs. 8, 9.

This variety differs from the typical in the smaller size. The lateral margins of the semicells are slightly convex.

Measurements: L. 42-(58)-65u; W. 12-(19)-24u.

Distribution: SLP, Livingston; NLP, Cheboygan (N & A 1932, T. minutus).

5. Tetmemorus granulatus (Bréb.) Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):458. Pl. 55, Figs. 1-5.

This species has an irregularly scrobiculate cell wall. The lateral margins are gradually and regularly

attenuated toward the apices.

Measurements: L. 80-(183)-260u; W. 20-(32)-50u; I. 25-(28)-37u.

Distribution: SLP, Livingston; NLP, Crawford (N & A 1932); EUP, Chippewa (N & A 1932); Isle Royale (Prescott 1941).

6. var. attenuatus West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):459. Pl. 55, Fig. 6.

This variety differs from the typical by the lateral margins being slightly and abruptly attenuated a slight distance below the apices. The lateral margins, however, are gradually tapering from the base of the semicells to the apices.

Measurements: L. 160-260u; W. 30-48u.

Distribution: NLP, Cheboygan (Taft 1939).

14. EUASTRUM

Ehrenb. 1832, emend. Ralfs. 1844

Cells of variable size, usually longer than wide, deeply constricted, sinus usually linear; the semicells generally truncate-pyramidate, the apex with a vertical median incision of variable length or the apex slightly emarginate or broadly retuse. The cell wall smooth, punctate or scrobiculate with facial swellings variously disposed, often ornamented with various patterns of granules, papillae; lateral margins often

bearing spines. Cells in vertical view generally elliptic with rounded poles and lateral swellings. Chloroplasts in large species axial with lobes (to each cell face) that end in massive parietal plates; in small species, the chloroplasts axial with simple lobes; rarely two chloroplasts in each semicell. Pyrenoids one to many.

Zygospore spherical to globose; wall smooth, mammillate or with spines.

Key to Species of Euastrum

1. Apical incision deep or moderately deep, linear or narrowly v-shaped. 15

1. Apical incision shallow, apex appearing slightly emarginate, or apical incision lacking, apex either entire or broadly retuse .. 2

2. Apex bearing a crown of granules . . . . . (28) E. attenuatum

2. Apex otherwise 3

3. Cells over 40u long 4

3. Cells under 40u long 6

4. Cell wall smooth punctate, scrobiculate . . . . . (23) E. pectinatum

4. Cell wall granulate 5

5. Cell more than 70u long and more than 50u wide . . . . . (61) E. verrucosum

5. Cell less than 70u long and less than 50u wide . . . . . (60) E. gemmatum

6. A granule present above the isthmus near the base of the semicell 7

6. No granules present as above 8

7. Central face of semicell with a papillate protrusion . . . . . (39) E. bipapillatum

7. Central face of semicell with a mucillage pore . . . . . (33) E. validum

8. Semicell with a single large swelling in the central facial area and with four small wart-like swellings distributed on the basal and apical lobes . . . . . (32) E. crassangulatum

8. Cell otherwise 9

9. Cell about 1 1/4 times longer than wide. Lateral and apical lobes with spines; two short spines at apex, one on either side of the emargination; central face of semicell with a papillate protrusion . . . . . (40) E. sibiricum

9. Cell not having the above combination of characters 10

10. One or more lateral undulations between apical and basal lobes 12

10. No lateral undulations between apical and basal lobes . . . 11

11. Apical angles usually rounded or obtuse, cell 1 1/2 times longer than wide . . . . . (30) E. sublobatum

11. Apical angles usually acuminate, cuspidate or sharp angled, cells 1 1/5-1 1/4 times longer than wide (35) E. binale

12. Lateral margins of semicell with a single undulation between the apical and basal angles (lobes) 13

12. Lateral margins of semicell with two undulations between the apical and basal angles (lobes) . . . . . (37) E. binale var. Gutwinskii

13. Cell 1 3/4-2 times longer than wide . . . . . (42) E. crassicolle var. bicrenatum

13. Cell less than 1 3/4 times longer than wide 14

14. Cells bearing granules, sometimes greatly reduced, either on lobes or on central facial protuberances of semicell or on both . . . . . (41) E. dubium

14. Cells not bearing granules, central facial region of semicell wall thickened . . . (38) E. insulare

15. Spines located upon some part of semicell margin 16

15. Spines not located upon some part of semicell margin 31

16. Upper lateral lobe present, either slightly or well exserted 21

16. Upper lateral lobe not present . 17

17. Upper margins of apical lobes converging to mid-region of semicell. (49) E. elegans

17. Upper margin of apical lobes horizontally truncate or nearly so . . 18

18. Cell length more than 34u . . . 19

18. Cell length less than 34u . . . 20

19. Lateral margin just above basal angle, bearing a single long horizontally directed spine . . . . . (50) E. divaricatum

19. Lateral margin above basal angle otherwise . . . . . (54) E. Ciastonii

20. Central area of face with a ring of five circular granules . . . . . (46) E. trigibberum

20. Central area of the face with 3-4 oblong granules disposed in an irregularly triangular or quadrangular pattern; usually two additional semi-circular granules located between the central group and the isthmus . . . . . (44) E. denticulatum

21. Upper margins of apical lobe converging toward the apex . . . . . (51) E. bidentatum

21. Upper margins of apical lobe horizontally or almost horizontally truncate 22

22. Lateral margins bearing a horizontal protrusion or projection a short distance below the apical spines 23

22. Lateral margins smooth just below the apical spines 25

23. Length of cell more than 50u (rarely under 50u) . . . . . (55) E. evolutum

23. Length of cell less than 50u 24

24. Width of cell more than 25u . . (46) E. trigibberum

24. Width of cell less than 25u . . (48) E. Turneri

25. Lateral margin a short distance above basal angle bearing a single long horizontally directed spine . . . (50) E. divaricatum

25. Lateral margin above basal angle otherwise 26

26. Central area of the semicell wall with a single thickened protrusion 27

26. Central area of semicell wall with granules 28

27. Apical spines divergent . . . . . (59) E. oculatum var. tonsum

27. Apical spines horizontal . . . . . (52) E. lapponicum fa.

28. A pair of mucilage pores located above facial granulation 30

28. A pair of mucilage pores not present above facial granulation 29

29. Length of cell 38.5-57u . . . . . (54) E. Ciastonii

29. Length of cell 25-38u . . . . . (41) E. dubium

30. Length of cell over 40u, width over 28u, semicell width at lateral lobes usually greater than at basal lobe . . . . . (53) E. abruptum

30. Length of cell under 41u, width under 30u, semicell width at lateral lobes never greater than at basal lobe . . . . . (47) E. pulchellum

31. Upper lateral lobes well developed, exserted and distinct 32

31. Upper lateral lobes either not present or if present, forming marginal undulations 38

32. Face of semicell with a pattern of at least 11 swellings, each with a mucilage pore . . . . (9) E. Jenneri

32. Cell wall otherwise 33

33. Polar lobe separated from lateral lobes by a narrow sinus 34

33. Polar lobe separated from lateral lobes by a widely open sinus . . . 36

34. Lateral lobes truncate . . . . (19) E. oblongum

34. Lateral lobes bluntly rounded or bluntly pointed 35

35. Cells about 1.6-1.7 times longer than wide, lateral lobes in side view entire . . . . . (13) E. ventricosum

35. Cells about 1.75-2 times longer than wide, lateral lobes in side view two parted . . . . . (10) E. crassum

36. Basal swellings thickened at margin, those lateral in position rectangular and obliquely placed; sinus between lateral and basal lobes often very broad and shallow . . . . . (18) E. humerosum

36. Basal swelling sometimes thickened at margin, none rectangular or obliquely placed; sinus between the lateral and basal lobes always deep . . . 37

37. Apex and polar lobes broadly rounded; upper lateral lobe exserted slightly; sinus between polar and lateral lobes broadly open and with a broadly rounded apex . . . . . (16) E. affine

37. Apex more anvil-shaped, angles of polar lobes bluntly pointed; upper lateral lobes exserted strongly; sinus between polar lobe and lateral lobe open and with a sharply rounded apex . . . . . (17) E. pinnatum

38. Semicell wall containing at least five facial swellings, each with a mucilage pore . . (6) E. sinuosum

38. Semicell wall with a variable number of facial swellings, never a mucilage pore within each swelling 39

39. Entire length of lateral margins a series of undulations . . . . . (43) E. incrassatum

39. Lateral margins not undulate or undulate only in small portion . . . 40

40. Lateral margins without undulations between basal lobes and apical lobe 41

40. Lateral margins with some undulations (sometimes very slight) between basal lobes and apical lobe 44

41. Apex capitate 42

41. Apex not capitate 44

42. Both apical and basal lobes broadly rounded . . . . . (21) E. intermedium fa.

42. Both apical and basal lobes bluntly pointed 43

43. Semicell wall with two basal and median submammillate downward projecting swellings . . . . . (20) E. insigne

43. Semicell wall with two somewhat broadly rounded swellings . . . . (22) E. intermedium var. longicolle

44. Cell length less than 58u, less than twice the width . . . . (5) E. pingue

44. Cell length more than 58u, at least twice the width . . . . (2) E. ansatum

45. Apex and apical lobes broadly rounded 46

45. Apex anvil-shaped, apical lobes bluntly pointed . . . . . (20) E. insigne

46. A single slight undulation present on the lateral margin less than halfway above the basal angle 47

46. A single slight undulation present on the lateral margin about half-way between the basal and apical angles . . . 48

47. A central mucilage pore present in the face of the semicell . . . . . (3) E. ansatum fa. Scottii

47. No mucilage pore present . . . . . (1) E. cuneatum var. subansatum fa.

48. Cell 1.5 times longer than wide, three mucilage pores in central area of semicell . . . . (14) E. ampullaceum

48. Cell 1.6-2 times longer than wide, a single mucilage pore or none in central region of semicell 49

49. A mucilage pore present in central region of semicell . . . . . (15) E. didelta

49. A mucilage pore absent in central region of semicell . . . . . (4) E. ansatum var. submaximum

1. Euastrum cuneatum var. subansatum Kossink. fa. Pl. 5, Fig. 2.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):481. Pl. 57, Fig. 1.

This variety differs from the typical in the smaller size and the greater development of the lateral margin undulation. A single specimen from Marquette County agrees with the description closely. In addition, this specimen had three very slight facial swellings, one basal and two above. Krieger (1937) does not mention facial swellings nor does his illustration (taken from original author) indicate their presence. There are three basal facial swellings in the typical and from 1-5 in other varieties. The Michigan form should be compared with E. ansatum var. suprapositum Nordst. which has a distinct mucilage pore above the two middle facial swellings.

Measurements: 72-(86)-89u; W. 37-(43)-43u; I. 10-(10.7)-14u; A. 18-20u.

Distribution: WUP, Marquette. New record for Michigan. Krieger (1937) reports that this variety has been reported only from the Arctic (Greenland, etc.).

2. Euastrum ansatum Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):484. Pl. 58, Figs. 1-3.

The triangular shape of the semicells, the truncate polar lobes with the subparallel lateral margins diverging to a broad base, help distinguish this species. The lateral margins may be slightly undulate above the basal region. The semicell wall has five facial swellings, three in the basal region, two above, arranged transversely.

Measurements: L. 61-(105)-110u; W. 32-(49)-51u; I. 8-(13)-15u; A. 16-24u.

Distribution: SLP, Barry, also Muskegon (Transeau 1917); NLP, Emmet; Isle Royale (Prescott 1937).

3. fa. Scottii fa. nov. Pl. 5, Fig. 3.

Prescott and Scott, 1945. Am. Mid. Nat. 34:233. Pl. 3, Fig. 2. (E. ansatum fa.).

This form differs from the typical in the presence of only a single basal swelling of the semicell wall in the presence of a central mucilage pore. The Michigan specimens show a slight undulation of the lateral margin above the basal angle.

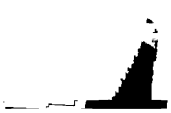
Measurements: L. (105)-110u; W. 33-(47)u; I. (13)u.

Distribution: EUP, Schoolcraft. New record for Michigan.

4. var. submaximum Borge Pl. 5, Fig. 4.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):491. Pl. 59, Figs. 4-6.

This variety is separated from the typical by the slight undulation of the lateral margin about half-way



between the basal and apical angles. In side view, there is only a single slight middle swelling and in vertical view, the facial swelling appears as two slightly projected undulations on the margin. Specimens from Schoolcraft County fit this variety, except for the slightly deeper apices. The writer believes that E. obesum var. crassum Prescott and Scott (1942) should also be placed here although this variety is somewhat broader in side view.

Measurements: L. (97)-108-117u; W. (53.7)-64u; I. 13-13.5-16u.

Distribution: EUP, Schoolcraft. New record for Michigan.

5. Euastrum pingue Elfv. Pl. 5, Fig. 5.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):497. Pl. 61, Figs. 19-22.

This small species is less than two times longer than broad, has trapeziform semicells, the basal lobes broadly rounded, and the apical lobes divided by open shallow median incision. The cell wall is scrobiculate, the markings larger at the lobes and at the center of the semicells. In addition, there is a large excentric mucilage pore and a basal papilla at the isthmial region in each semicell.

Measurements: L. 52-(58)-58u; W. 35-(41)-45u; I. 10-(10.7)-12u; A. 18-20u.

Distribution: NLP, Cheboygan. New record for Michigan.

6. Euastrum sinuosum Lenorm.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):499. Pl. 62, Figs. 9-11.

The five facial swellings (three basal and two central) each with a mucilage pore are the distinguishing characteristics of this species. The lateral marginal undulation is variable.

Measurements: L. 52-87u; W. 28-50u; I. 8-15u; A. 19-21u.

Distribution: NLP, Cheboygan (N & A 1932, Welch 1938a).

7. var. reductum West and West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):502. Pl. 62, Fig. 25.

This variety is ssparated from the typical by the somewhat smaller size, the non-dilated poles, and the reduced lateral margin undulation. In vertical view, the facial swellings are less pronounced.

Measurements: L. 46-(60)-74; W. 24-(43)-44u; I. 8-15u.

Distribution: NLP, Crawford (Taft 1939); WUP, Gogebic.

8. var. aboense (Elfv.) Cedr. Pl. 6, Fig. 5.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):500. Pl. 62, Figs. 12-15.

This variety has five facial swellings (three upper, two lower) each with a mucilage pore upon each semicell. In addition, there are two pores placed between the upper facial swellings and each lateral basal swelling making a total of eleven pore in semicell wall.

In the Michigan specimens the facial swellings and the apical and basal lobes are much more conspicuously punctate than the rest of the semicell wall. This variety should be compared with E. sinuosum var. subjenneri West and West which has eleven facial swellings, each with a pore, and a more exserted polar lobe.

Measurements: L. 52-(68)-70u; W. 30-(40.4)-42u; I. 10-13u; A. 16-18u.

Distribution: EUP, Schoolcraft. New record for Michigan.

9. Euastrum Jenneri Arch.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):505. Pl. 63, Fig. 8.

The rounded subrectangular shape of the lower part of the semicell and the presence of eleven facial swellings each with a mucilage pore, distinguishes this species.

Measurements: L. 72-76u; W. 45-48u; I. 15u.

Distribution: NLP, Cheboygan (N & A 1932).

10. Euastrum crassum (Bréb.) Kuetz.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):510. Pl. 66, Fig. 1.

This large species (about 1 3/4-2 times longer than broad) has capitate apices, lateral lobes usually separated from apical lobes by deep or slightly linear incision and a strongly punctate cell wall. The cell wall has three basal swellings (rarely two additional middle swellings) in a transverse plane. This organism is

closely related to E. ventricosum but differs from it in the possession of a larger length-width ratio and in the lateral lobes being two parted when seen in lateral view.

Measurements: L. 125-(126)-275u; W. 63-(71)-118u; I. 18-(21.3)-35u; A. 42-65u.

Distribution: SLP, Muskegon (Transeau 1917); NLP, Emmet, also Emmet (Transeau 1917).

11. var. scrobiculatum Lund,

Krieger, 1937. Rabh. Krypt. Flor. 13(1):512. Pl. 65, Figs. 2-5.

This variety is distinguished from the typical primarily by the presence of one to four mucilage pores arranged in various patterns in the central region of semicell wall.

Measurements: L. 134-(144)-170u; W. 65-(75)-88u; I. 18-(21.8)-26u.

Distribution: SLP, Livingston, also Calhoun (Pres. & Mag. 1935); NLP, Emmet, Roscommon; WUP, Gogebic; Isle Royale (Prescott 1940).

12. var. michiganense Prescott

Prescott and Magnotta, 1935. Pap. Mich. Acad. Sci, Arts and Letters. 20:165. Pl. 126, Fig. 1, 2.

This variety is separated from the typical by the presence of only a single basal swelling of the semicell wall.

Measurements: L. 156-159.5u; W. 87-89.7u; I. 23-25.5u.

Distribution: WUP, Marquette (Pres. & Mag. 1935).

13. Euastrum ventricosum Lund.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):513. Pl. 64, Figs. 1-3; Pl. 65, Fig. 1.

This species is similar to E. crassum from which it differs in possession of a smaller length-breadth ratio and the entire lateral lobes in lateral view.

Measurements: L. 80-173u; W. 49-103u; I. 14-28u; A. 35-43u.

Distribution: NLP, Cheboygan (Taft 1939); Isle Royale (Prescott 1940).

14. Euastrum ampullaceum Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):515. Pl. 64, Figs. 6-8.

The somewhat cuneate polar lobe with rounded angles and the three mucilage pores in the central region of the semicell wall easily distinguish this species.

Measurements: L. 66-124u; W. 45-75u; I. 10-20u; A. 22-42u.

Distribution: NLP, Cheboygan (N & A 1932).

15. Euastrum didelta Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):517. Pl. 66, Fig. 6; Pl. 67, Figs. 1-3.

This very variable species has trapeziform-pyramidate semicells with five facial swellings in semicell wall. Three are placed transversely in the basal region, and two transversely above. Between the latter, a mucilage pore is often located. The lateral margins usually have a broad undulation about half-way between the basal and apical angles. The apex has a deep linear incision, and

the apical lobes are usually broadly rounded. Some specimens from Barry and Marquette Counties generally resembled a new forma illustrated by Irenee-Marie (1938). The two upper facial swellings were much more pronounced than the basal swellings. The middle basal swelling was somewhat reduced in size but very distinct. According to Irenee-Marie (1938), this form has granular cell walls, while the Michigan forms were definitely scrobiculate. They agree more closely with the organism illustrated by Hirn (1903) as E. didelta fa. scrobiculata Nordst. which is considered by Krieger to be synonomous with the typical.
Measurements: L. (98)-102-(111)-(124)-150u; W. 52-(53)-(64)-(66)-82u; I. 12-(13)-(17.2)-27u; A. 20-24u.
Distribution: SLP, Barry, Calhoun, Berrien; NLP, Emmet, also Cheboygan (N & A 1932, Welch 1938a) and Emmet (Transeau 1917); EUP, Schoolcraft, also Chippewa (N & A 1932); WUP, Gogebic, Marquette; Isle Royale (Prescott 1937).

16. Euastrum affine Ralfs.
Krieger, 1937. Rabh. Krypt. Flor. 13(1):524. Pl. 68, Figs. 2-4.

This species is very close to E. pinnatum from which it differs in the longer but more shallow sinus between the lateral and basal lobes. The lateral lobes are thus less exserted horizontally.
Measurements: L. 92-(115)-(129)-140u; W. 50-(64)-(68)-81u; I. 12-(15)-(17)-24u; A. 24-31u.

Distribution: SLP, Calhoun, Barry, Livingston; NLP, Roscommon, also Cheboygan (N & A 1932, Welch, 1938a); EUP, Schoolcraft, also Chippewa (N & A 1932); WUP, Gogebic; Isle Royale (Prescott 1937, 1940).

17. Euastrum pinnatum Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):522. Pl. 68, Figs. 5-7.

This species is closely related to E. affine and E. humerosum. It is separated from the former by the more exserted lateral and apical lobes, and from the latter by the more horizontal lateral lobes; the often more deep incision between the lateral lobes and basal lobes and the facial swellings of semicell wall not being thickened as greatly at the margins and not placed obliquely.

Measurements: L. 110-156u; W. 58-80u; I. 17-30u; A. 26-42u.

Distribution: NLP, Emmet, also Cheboygan (N & A 1932); EUP, Mackinac (Transeau 1917); WUP, Gogebic; Isle Royale (Prescott 1937).

18. Euastrum humerosum Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):524. Pl. 69, Figs. 4-6.

This species is very variable in respect to the depth of interlobular incision, the shape of the polar lobe and the amount of projection of the upper lateral lobe. It can be distinguished from E. pinnatum and E. affine by the more shallow and broader sinuses between

the lateral and basal lobes and the more pronounced basal angles that are thickened at their margins and obliquely placed. A single specimen from Roscommon County appears somewhat intermediate between E. humerosum and E. pinnatum.

Measurements: L. 104-(148)-160u; W. 60-(74)-90u; I. 14-(19.5)-29u; A. 27-42u.

Distribution: SLP, Barry; NLP, Roscommon, Crawford, Emmet, also Cheboygan (N & A 1932, Welch 1938a); EUP, Chippewa.

19. Euastrum oblongum (Grev.) Ralfs.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):526. Pl. 70, Figs. 3-6.

This species can be distinguished readily by the oblique truncate shape of the lateral lobes. The variety cephalophorum West, is included here.

Measurements: L. 107-(161)-(164)-205u; W. 48-(68)-(72)-107u; I. 13-(21.5)-31u; A. 34-53u.

Distribution: SLP, Washtenaw, Barry; NLP, Crawford, Roscommon, also Cheboygan (N & A 1932, also as var. cephalophorum); EUP, Schoolcraft, alger; WUP, Houghton; Isle Royale (Prescott 1937).

20. Euastrum insigne Hass.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):529. Pl. 71, Figs. 1-3.

The elongate triangular shape of the semicells, the submammillate basal lobes, the capitate polar lobe and

the two sub-mammillate downward projecting swellings of the semicell wall partly characterize this species. Some specimens from Chippewa County were intermediate between the typical and E. insigne var. lobulatum Prescott and Scott.

Measurements: L. 80-(100)-144u; W. 43-(56)-76u; I. (10.5)-11-20u; A. 22-42u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Chippewa(2).

21. Euastrum intermedium Cleve. fa. Pl. 6, Fig. 2. Krieger, 1937. Rabh. Krypt. Flor. 13(1):532. Pl. 71, Figs. 6-8.

Characteristically, this species has trilobed semicell, the basal lobes obtusely conical or broadly rounded, and the polar lobe somewhat anvil-shaped with acutely rounded angles. Two facial swellings of the semicell wall arranged transversely between the basal lobes and two small facial swellings upon the polar lobe are also typical. Krieger (1937) states that the cell wall is porous whereas West and West (1905) state that it is smooth. Specimens from Schoolcraft County have the apical poles less capitate with the angles more broadly rounded; and lacked the two facial swellings. The cell wall punctation was more pronounced upon the lobes and upon the facial swellings, the latter placed much higher up on the semicell than in the typical. It should be compared with E. intermedium var. verrucosum Krieger, and E. inter-

medium var. scrobiculatum Schmidle (not found in Michigan).

Measurements: L. 54-(76.6)-80u; W. 31-(40.4)-45u; I. 8-(10.6)-12u.

Distribution: EUP, Schoolcraft. New record for Michigan.

22. var. longicolle Borge Pl. 6, Fig. 1.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):533. Pl. 71, Figs. 9-11.

The basal lobes of this variety are not as broad and are more pointed than the typical. The polar lobe is more elongate, and the apical lobes are rather sharply pointed.

Measurements: L. 60-(70.5)-79u; W. 38.5-(43)-43u; I. 7-10u; A. 18.5-20u.

Distribution: WUP, Gogebic. New record for Michigan.

23. Euastrum pectinatum Bréb.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):537. Pl. 72, Figs. 4-7.

Some of the more prominent characteristics of this species are the convex truncate apex that is slightly retuse in the middle, the subquadrate basal lobes, the three facial swellings across the widest part of the semicell, and the two facial swellings on the polar lobe.

Measurements: L. 48-84u; W. 30-49u; I. 8-16u; A. 32-35u.

Distribution: NLP, Emmet; Isle Royale (Prescott 1940 fa.).

24. var. brachylobum Wittr.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):537. Pl. 72, Figs. 8, 9.

This variety has the lateral and polar lobes less developed than the typical. There is only one single facial swelling on the apical lobes, in contrast to two in the typical.

Measurements: L. 55-(64)-84; W. 37-(47)-56u; I. 9-(9)-15u; A. 21-32u.

Distribution: NLP, Cheboygan (Taft 1939); EUP, Delta; WUP, Iron.

25. var. rostratum Taylor

Krieger, 1937. Rabh. Krypt. Flor. 13(1):539. Pl. 73, Figs. 4,5.

This variety has the margins of the reduced lateral lobe converging towards the sinus and the basal lobe rostrate in a median lateral line.

Measurements: L. 70u; W. 44.8-52u; I. 12u; A. 22u.

Distribution: EUP, Alger, Delta; WUP, Menominee; Isle Royale (Prescott 1940, var. brachylobum fa. rostratum).

26. var. inevolutum West and West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):538. Pl. 72, Figs. 12, 13.

This variety appears to be a reduced form of the typical. The cells are smaller, the basal lobes are more quadrate, and the polar lobe is relatively broader and shorter with the apex more convex and retuse in central portion, and with the apical angles more rounded. In the vertical view, the facial swellings are reduced from the size of the typical.

Measurements: L. 42-68.4u; W. 33-45.6u; I. 6-15.5u; A. 24-30u.

Distribution: Isle Royale (Prescott 1937).

27. var. scrobiculatum Prescott

Prescott, 1940. Pap. Mich. Acad. Sci. Arts and Letters. 25:98. Pl. 1, Fig. 22.

This variety has a very short polar lobe with a convex apex. The wall is coarsely scrobiculate, and there is a single facial swelling within the margin of each lateral and basal lobe.

Measurements: L. 73-76.4u; W. 47-49.4u; I. 15.2u.

Distribution: Isle Royale (Prescott 1940).

28. Euastrum attentuatum Wolle

Krieger, 1937. Rabh. Krypt. Flor. 13(1):541. Pl. 73, Figs. 15-17.

The apical crown of granules separates this from other Michigan species of Euastrum.

Measurements: L. 61-67u; W. 35-45u; I. 12-13u; A. 11-13u.

Distribution: NLP, Cheboygan (N & A 1932); Isle Royale (Prescott 1937).

29. var. lithuanicum Wolosz. fa.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):542. Pl. 73, Figs. 18, 19.

This variety has a less exserted and broader apical lobe than the typical. In addition, it has in side view, a 2-3 parted facial swelling, whereas the typical has a greatly reduced facial swelling that is two parted.

Measurements: L. 59.5-65u; W. 35.1-40u; I. 11.7-14u.

Distribution: Isle Royale (Prescott 1940).

30. Euastrum sublobatum Naegli. Pl. 5, Fig. 7.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):544. Pl. 74, Figs. 1-3.

This variety is about 1 1/2 times longer than wide. This characteristic and the truncate apex (in side view) separate it from E. binale. The apical angles are usually broadly rounded whereas in E. binale they are usually sharply angled.

Measurements: L. 18-30u; W. 13-21.5u; I. 3-8u.

Distribution: WUP, Gogebic. New record for Michigan.

31. var. obtusatum (Gutw.) Krieger Pl. 5, Fig. 6.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):545. Pl. 74, Figs. 9-11.

This variety is relatively longer than the typical. The apex is slightly emarginate and the central facial swelling is lacking.

Measurements: L. 18-26u; W. 8-17u; I. 3-5u; A. 8.4u.

Distribution: WUP, Marquette. New record for Michigan.

32. Euastrum crassangulatum Boerg.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):546. Pl. 74, Figs. 12-14.

This species can be distinguished by the large central facial swelling of the semicell wall, and by a smaller swelling on each of the apical and basal lobes.

Measurements: L. 25-28u; W. 17-19u; I. 5-6u; A. 12u.

Distribution: Isle Royale (Prescott 1937).

33. Euastrum validum West and West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):54 . Pl. 74, Figs. 18-20.

The presence of a pore in the central region of the semicell wall and the isthmial papillae easily separates this species from E. binale and E. bipapillatum. A small papilla within each basal angle is also characteristic of this species.

Measurements: L. 25-(25.8)-(28)-30u; W. 18-(19.3)-22u; I. 3.6-(4.2)-6u; A. 13.5-14.5u.

Distribution: SLP, Calhoun, Berrien; EUP, Schoolcraft; WUP, Gogebic (2); Isle Royale (Prescott 1937).

34. var. glabrum Krieger Pl. 5, Fig. 8.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):547. Pl. 74, Figs. 21, 22.

This variety is separated from the typical by the lack of papillae in the angles of the basal lobes. Our specimens were slightly shorter and narrower than the typical measurements.

Measurements: L. (23.6)-29u; W. (17.2)-19u; I. (3.8)-4.8u.

Distribution: SLP, Calhoun; EUP, Schoolcraft. New records for Michigan.

35. Euastrum binale (Turp.) Ehrenb. Pl. 6, Fig. 3.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):548. Pl. 75, Figs. 1-3.

E. binale is very closely related to E. sublobatum. It differs from this species in relative smaller length, being about 1 1/5 - 1 1/4 times longer than wide. The basal angles are much broader and the apical angles are usually sharply angles. The apex is slightly emarginate, whereas E. sublobatum has the apex broadly and shallowly retuse. In addition, the lateral view of the semicell is elliptic in contrast to the irregular rectangular shape of E. sublobatum.

Measurements: L. 10-(21.5)-23u; W. 10-(15)-23u; I. 3-(3.5)-9u; A. 10-12u.

Distribution: EUP, Chippewa; WUP, Gogebic. New record for Michigan.

36. var. hians W. West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):551. Pl. 75, Fig. 16.

The basal angles of this variety are obliquely truncate toward the sinus.

Measurements: L. 11-17.5u; W. 10-15.5u; I. 2.5-5u.

Distribution: NLP, Cheboygan (Taft 1939).

37. var. Gutwinskii Schmidle

Krieger, 1937. Rabh. Krypt. Flor. 13(1):551. Pl. 75, Figs. 13-15.

This variety is generally somewhat larger than the typical. There are also two undulations in the lateral margin between the apical and basal angles.

Measurements: L. 16-(25.8)-30u; W. 12-(19.2)-21u; I. 3-(4.3)-6.5u; A. about 11u.

Distribution: SLP, Ingham (N & A 1932); EUP, Chippewa, Schoolcraft; WUP, Gogebic (2), Baraga (2), Houghton.

38. Euastrum insulare (Wittr.) Roy

Krieger, 1937. Rabh. Krypt. Flor. 13(1):555. Pl. 76, Figs. 11-14.

The cell of this species is about 1 1/2 times longer than broad; the basal portion of the semicell is rectangular and the lateral margin has a single undulation between apical and basal angles. The apex is slightly emarginate and the apical angles are rounded or slightly cuspidate. The semicell wall has a smooth central swelling.

Measurements: L. 17.5-(23)-31u; W. 11.5-(17)-22u; I. (3)-3-6u.

Distribution: SLP, Livingston, Barry, also Macomb (Johnson 1894, Pieters 1894, E. binale var. insulare); NLP, Cheboygan (N & A 1932); EUP, Chippewa, Alger; WUP, Menominee, Houghton, Marquette, Gogebic.

39. Euastrum bipapillatum Gronbl. Pl. 6, Fig. 8.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):562. Pl. 80, Figs. 13, 14.

Characteristically, this species has trapeziform semicells, base wide, apex slightly emarginate, a single marginal undulation between the basal and apical angles, a single papilla in the central region of the semicell,

and another at the isthmus. Michigan specimens are slightly smaller than typical measurements.

Measurements: L. (25.5)-28-30u; W. (19)-21u; I. 4.2u.

Distribution: NLP, Emmet. New record for North America.

40. Euastrum sibiricum Boldt. Pl. 6, Fig. 4.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):566. Pl. 77, Figs. 1-3.

The following characteristics separate this species from other Michigan species. It is slightly longer than broad, the apical and lateral lobes possess short spines, the central facial region of the semicell wall is ornamented with a papilla and two short spines are inserted within margin at the apex, one on each side of the slight apical emargination. Michigan specimens are slightly larger than typical measurements.

Measurements: L. 15.6-20-(21.5)u; W. 11-16-(19.3)u; I. 3-(4.3)-6u; A. 10-11u.

Distribution: SLP, Barry. New record for Michigan.

41. Euastrum dubium Naeg.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):571. Pl. 79, Figs. 1-5.

This extremely variable species is about 1 1/2 times longer than wide. The semicells are elongate-trapeziform with the apex either emarginate or with a moderately deep linear sinus. The lateral margins have a single undulation between the apical and basal lobes. The semicells

have a granule within each apical angle, sometimes within each lateral and basal angle. The central facial area of the semicell may have three granules or be smooth. The variety Snowdoniense is included as part of the typical here.

Measurements: L. 25-(28)-38u; W. 17-(21.5)-26u; I. 3-(4.3)-8u; A. 11.5-15u.

Distribution: SLP, Calhoun, Barry (3); NLP, Crawford, also Cheboygan, Emmet (N & A 1932), Cheboygan (N & A 1932, var. Snowdoniense); EUP, Schoolcraft, Mackinac.

42. Euastrum crassicolle var. bicrenatum de Toni

Krieger, 1937. Rabh. Krypt. Flor. 13(1):576. Pl. 78, Figs. 15, 16.

This variety cannot be confused with any other species reported from Michigan. Characteristically, this species has cells 1 3/4 - 2 times longer than wide, the semicells being somewhat truncate pyramidate in shape. The polar lobe is rounded and the apex is slightly retuse. The lateral margin has a single undulation between the basal and apical angles.

Measurements: L. 26-34u; W. 13.8-18u; I. 4.5-8.8u; A. 8-12u.

Distribution: EUP, Marquette (Pres. & Mag. 1935, E. Chickeringii Prescott).

43. Euastrum incrassatum Nordst.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):582. Pl. 85, Figs. 16-18.

This species is sharply differentiated from other Michigan species by the entirely undulate lateral margins.
Measurements: L. 29-40u; W. 19-26u; I. 6-11.4u.
Distribution: Isle Royale (Prescott 1940).

44. Euastrum denticulatum (Kirchn.) Gay
Krieger, 1937. Rabh. Krypt. Flor. 13(1):80. Pl. 80, Figs. 15-17.

This species has cells about 1 1/5 times longer than broad. The semicell is trapeziform with the apex possessing a short median incision and short lateral spines. The lateral lobe is absent. The central region of the semicell wall has a circle of three elongated granules. Sometimes there are two semicircular granules between the central granules and the isthmus. The basal and apical lobes also have a number of granules within the margin. Some of Michigan specimens have five central granules and lack the supra isthmial papilla.
Measurements: L. 19-(30)-32u; W. 14-(24.5)-25u; I. 3-(4.3)-8u; A. 12-16u.
Distribution: SLP, Livingston, Calhoun, Berrien, also Muskegon (Transeau 1917); NLP, Cheboygan (N & A 1932), Emmet (Transeau 1917).

45. var. angusticeps Gronbl. Pl. 6, Fig. 7.
Krieger, 1937. Rabh. Krypt. Flor. 13(1):584. Pl. 80, Figs. 18, 19.

This variety has a narrower apex than the typical. The apex is scarcely dilated. The central facial swelling

in the semicell wall may be smooth or bear (usually) four elongate granules in a circular pattern. The Michigan specimens have three granules, and one specimen has two supra isthmial granules.

Measurements: L. 19-(21.3)-25u; W. 15-(19)-20u; I. (4.3)-4.5-5.3u.

Distribution: EUP, Schoolcraft; WUP, Gogebic. New record for Michigan.

46. Euastrum trigibberum West and West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):585. Pl. 80, Figs. 24-26.

This small species is about 1 1/5 times longer than wide. The semicell is trapeziform with deep median incision. The lateral margin has the basal lobe separated from the apical lobe by a deep semicircular incision. In the writer's Michigan specimens, the basal lobe is subdivided into two smaller lobules giving the semicell an almost trilobed appearance. The apical lobes each have a slight subapical marginal projection and a pair of granules. The central facial area has a circle of five small granules, and the basal areas each have four to six granules arranged in a somewhat elliptical pattern.

Measurements: L. 23-29-(32)u; W. 19-23-(23.5)u; I. (6.3)-6.5-7u; A. 14-15.5u.

Distribution: NLP, Cheboygan (N & A 1932); WUP, Gogebic (fa.).

47. Euastrum pulchellum Breb.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):587. Pl. 81, Figs. 8-11.

This species resembles E. abruptum but never has the basal width greater than the width of the semicells at the lateral lobes.

Measurements: L. 30-41u; W. 20-30u; I. 4-7.3u; A. 15-20u.

Distribution: NLP, Cheboygan (Taft 1939).

48. Euastrum Turneri W. West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):589. Pl. 82, Figs. 20, 21.

This species superficially resembles E. trigibberum from which it can be easily separated by its relatively greater length-width ratio, and by the presence of two mucilage pores above the central granular region of the semicell wall. The basal and lateral lobes are always distinct in this species although they are not greatly exserted.

Measurements: L. 33-(44.6)-50u; W. 25-(30.5)-33u; I. 6-(6.7)-11u; A. 18-23u.

Distribution: SLP, Barry, also Kalamazoo, Washtenaw (N & A 1932).

49. Euastrum elegans (Bréb.) Kuetz.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):591. Pl. 81, Figs. 14-18.

This species can be differentiated easily by the obliquely truncate apical lobes, and the truncate, slightly

retuse basal lobes. It is closest to E. bidentatum from which it is easily distinguished by the lack of a lateral lobe.

Measurements: L. 23-(30)-44u; W. 14-(21)-29u; I. 4-(4.3)-8u; A. about 15-16u.

Distribution: SLP, Washtenaw, also Wayne (Campbell 1886) and Macomb (Pieters, 1894); NLP, Emmet; WUP, Menominee, Gogebic (2); Isle Royale (Prescott 1937).

50. Euastrum divaricatum Lund.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):598. Pl. 84, Figs. 1-5.

This species is sharply distinguished by the triangular-trapeziform shape of the semicell, and the single large horizontally directed spine at each supra basal margin.

Measurements: L. 35-(43)-46.8u; W. 27-(36.5)-37u; I. 5-(6.4)-10u; A. 14-20u.

Distribution: WUP, Gogebic; Isle Royale (Prescott 1937).

51. Euastrum bidentatum Naeg.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):601. Pl. 85, Figs. 1, 2.

This species has a resemblance to E. elegans but is sharply differentiated from it by the presence of a (sometimes slight) lateral lobe. The ornamentation on the semicell wall is highly variable. Krieger (1937) states that the typical has (in the central region of

the semicell face) three long granules lying parallel to each other and to the long axis of cells. These are above a single long granule lying in transverse position. The writer believes that because of the great variability of the central granulation found in his Michigan specimens and because of the similar observations made by West and West (1905), it is more satisfactory to include under the typical forms which agree with other typical characteristics, but which have a different central granulation. E. elegans var. bidentatum (Naeg.) Jacobson, and E. rostratum Ralfs., also should be included here.

Measurements: L. (45)-45-(60)-(62.5)-64u; W. (26)-27-(38)-41u; I. 6.9-(8.5)-13u.

Distribution: SLP, Calhoun, Ingham, Oakland, Barry (2), Washtenaw; NLP, Emmet, Crawford, also Cheboygan (N & A 1932); EUP, Delta, Alger, also Schoolcraft (N & A 1932, also as E. rostratum), also Schoolcraft (Transeau 1917); WUP, Marquette, Iron, Houghton, Menominee; Isle Royale (Prescott 1937).

52. Euastrum lapponicum Schmidle fa. Pl. 6, Fig. 10. Krieger, 1937. Rabh. Krypt. Flor. 13(1):604. Pl. 85, Figs. 8, 9.

This species typically has a trapeziform semicell with the lateral lobe forming a distinct undulation on the lateral margin. The apex has a medium deep, slightly open median incision, and the apical angles bear small

horizontally directed spines. Typically the lateral and basal lobes bear small granular spines on the margin, and single, larger, semicircular granules within the margin. The central area of the semicell face has two elongate granules which may be subdivided once or twice. The few Michigan specimens from Schoolcraft County, agree favorably with the forma illustrated by Prescott and Scott (1945) from Mississippi. This forma has a deeper apical incision and the central facial region has only a single large granule. In addition, the lobular granulation is relatively more reduced, and the plant is slightly smaller than the typical. This forma should be compared with E. dubium.

Measurements: L. (33)-36-43u; W. (21.3)-24-30u; I. (4.2)-8u.

Distribution: EUP, Schoolcraft. New record for Michigan.

53. Euastrum abruptum Nordst. Pl. 6, Fig. 9.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):605. Pl. 83, Figs. 1-3.

This species has trapeziform semicells with the semicell width at the lateral lobes usually larger than the width at the basal lobes. The only specimens examined were from Oakland County and agree more favorably with illustrations of Prescott and Scott (1945), than with those of Krieger (1937).

Measurements: L. 37-(42)-60u; W. (25.5)-27-40.5u; I. (4.5)-7-9u; A. 31-36u.

Distribution: SLP, Oakland. New record for Michigan.

54. Euastrum Ciastonii Racib. Pl. 6, Fig. 11.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):607. Pl. 84, Figs. 14, 15.

Typically, this species has semicells that are almost rectangular with the lateral lobular undulations (sometimes lacking) possessing 3-4 granules. The deep linear apical incision and the characteristic granular decoration of the semicell wall also distinguish this species easily. Michigan specimens from several counties exhibit a more pronounced undulation on the lateral margin than shown in Krieger's (1938) illustration, and agree more favorably with illustrations of this species by Irenee-Marie (1938), and Prescott and Scott (1945).

Measurements: L. 38-(45)-57u; W. 21-(25)-29u; I. 4.5-(5)-10u; A. 17-22u.

Distribution: SLP, Barry (2); EUP, Schoolcraft; WUP, Gogebic (3). New records for Michigan.

55. Euastrum evolutum (Nordst.) West and West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):614. Pl. 87, Figs. 15, 16.

This species is very characteristic and cannot be confused with other species of Euastrum. The presence of an accessory lobe with spines on the lateral margin a short distance below the apical angle, separates it

from most species. The middle-sized cell (over 50u), is about 1 1/2 times longer than wide, with the semicell elongate-trapeziform. The apex has a deep linear to slightly open median incision, and the apical angles bear single spines. The lateral margins have the lobes separated by open (sometimes deep and narrow) sinuses. The central facial area of the semicell wall has three elongate granules arranged in a somewhat circular pattern with two mucilage pores a short distance above. The three lateral lobes bear small granular teeth.

Measurements: L. 58.5-75u; W. 37-58u; I. 10-15u; A. 30-32u.

Distribution: Isle Royale (Prescott 1937).

56. var. integrius West and West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):616. Pl. 88, Figs. 4-6.

This variety is separated from the typical by the lack of a distinct lateral lobe, and by the presence on the subapical margin of a large horizontally directed spine instead of an accessory lobe.

Measurements: L. 46-(54.2)-61u; W. 31-(38.3)-41u; I. (6.4)-7-10u; A. 24-31u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Schoolcraft; WUP, Houghton.

57. var. **Glaziovii** (Boerges.) West and West Pl. 7, Fig. 3.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):615. Pl. 88, Figs. 1-3.

This variety, like var. integrius has the accessory subapical lobe replaced by a spine. The lateral lobe is less sharply separated than the typical. The apical sinus is almost closed at the outer margin, but opens widely internally to form an elliptic space between the apical lobes. The central facial area of semicell wall may be smooth or bear three granules as in the typical.
Measurements: L. 55-(64)-68.5u; W. 34-(36)-43u; I. 6.5-(10.6)-11u; A. 35-40u.
Distribution: NLP, Emmet; EUP, Schoolcraft. New records for Michigan.

58. var. guianense (Raab.) West and West Pl. 7, Fig. 2. Krieger, 1937. Rabh. Krypt. Flor. 13(1):615. Pl. 87, Fig. 21.

This variety is somewhat smaller than the typical. The accessory subapical lobe is reduced either to a slight marginate protuberance, or a less exserted lobe. The lateral and basal lobes are less exserted and the granular teeth are reduced. It appears essentially to be a slightly smaller, reduced form of the typical.
Measurements: L. 42-(45)-47u; W. 23-32-(32)u; I. 5-(6.4)-8u.
Distribution: EUP, Schoolcraft. New record for Michigan.

59. Euastrum oculatum var. tonsum West and West Pl. 6, Fig. 6. Krieger, 1937. Rabh. Krypt. Flor. 13(1):618. Pl. 87, Figs. 12-14.

This organism characteristically has cells which are almost twice as long as wide, the semicells being elongate

trapeziform in shape. The apex has a medium-deep incision, opened or linear, and the apical angles each bear a large divergent spine. The lateral margin has the lateral lobe slightly exserted and bear short granular spines. The basal lobes have similar spines at the angles. The semicell wall has several granules within the lateral margin at each pole and also a large single (rarely several) central one. Typically, there are two mucilage pores above the central granule.

Measurements: L. 38.5-(45)-48u; W. 24-(29.2)-30u; I. (5.5)-5.6-8u.

Distribution: WUP, Gogebic (3). New record for Michigan.

60. Euastrum gemmatum Bréb.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):639. Pl. 92, Figs. 5-8.

This species cannot be confused with any other Michigan species of Euastrum. The cell wall granulation easily separates it from E. pectinatum and varieties, and the quadrate shape of the lower half of the semicell and the smaller size distinguishes it from E. verrucosum.

Measurements: L. 43-(56.6)-72u; W. 37-(39)-52u; I. 8-(10.9)-15u; A. 15-21u.

Distribution: SLP, Barry, also Muskegon (Transeau 1917); NLP, Roscommon also Cheboygan (Neal 1948); EUP, Alger.

61. Euastrum verrucosum Ehrenb.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):643. Pl. 94, Figs. 1-3.

Some of the more prominent characteristics of this species are the trapeziform shape of the semicell, the three lobes on the margin that are separated by deep and open sinuses and the cuneate apex which is broadly retuse. The facial area of semicell wall is furnished with a transverse row of three protuberances, each ornamented with granules arranged in concentric circles. The semicell wall is granulate, especially so in the angles where the granules are often sharp and conical.

Measurements: L. 74-115u; W. 65-103u; I. 17-30u; A. 25-42u.

Distribution: SLP, Berrien (Transeau 1917), also Wayne (Campbell 1886 and Macomb Pieters 1894); NLP, Roscommon, also Cheboygan (N & A 1932); EUP, Alger, also Chippewa (N & A 1932); Isle Royale (Prescott 1937).

62. var. alatum Wolle Pl. 7, Fig. 1.

Krieger, 1937. Rabh. Krypt. Flor. 13(1):645. Pl. 94, Fig. 4.

This variety differs from the typical in having the inner portion of the median sinus linear and closed, and the outer portion widely open.

Measurements: L. 72-(78.8)-110u; W. 60-(61.7)-108u; I. 14-(19)-22u; A. 22-38u.

Distribution: SLP, Washtenaw; EUP, Schoolcraft; WUP, Houghton, Gogebic (2). New records for Michigan.

63. var. planctonicum West and West

Krieger, 1937. Rabh. Krypt. Flor. 13(1):649. Pl. 95, Fig. 7.

This variety differs from the typical and from var. alatum by having a widely open sinus. The lateral lobes are also lacking.

Measurements: L. 90u; W. 91u; I. 19.5u.

Distribution: SLP, Berrien (Transeau 1917).

64. var. vallesiacum Véret

Krieger, 1937. Rabh. Krypt. Flor. 13(1):653. Pl. 96, Fig. 8.

This variety is distinguished from the typical by the more nearly semicircular shape of the semicells and the shorter lobes which are broadly rounded. The sinus between the semicells is linear and then widely open outwardly.

Measurements: L. 73-88u; W. 57-69u; I. 12-15u.

Distribution: EUP, Chippewa (Ackley 1929, N & A 1932, var. sublongum Ackley).

15. COSMARIUM Corda 1834

Cells variable in size, usually with the length not more than twice the width, rarely with the width greater than the length, median constriction usually deep and linear. Semicells of variable shape, often circular, semicircular, elliptic trapeziform, reniform, or subquadrate in front view (usually compressed but rarely with lateral protuberances in side view). Cell wall smooth, punctate, or ornamented with granules or verrucae (never with spines), the ornamentation often ar-

ranged in definite patterns. In vertical view, cells generally elliptic, rarely with lateral protuberances. Chloroplast generally single and axial and with form radiating plates in each semicell, rarely two axial or four-parietal chloroplasts in each semicell; pyrenoids usually single and central in each chloroplast.

Zygospores usually spherical or ellipsoidal, more rarely angular with walls that are smooth or ornamented with papillae or spines.

Key to Species of *Cosmarium*

A. Cell wall smooth, punctate or scrobiculate; margins usually entire, sometimes crenate, but never with granules; papillae sometimes present on face or on isthmus . . . . . .Section A

B. Cell wall ornamented with granules, verrucae or papillae . . . . . .Section B

Section A

1. Semicells semicircular or subsemicircular 2

1. Semicells not semicircular or subsemicircular 14

2. Semicells with blunt submammillate thickenings at the basal angles 3

2. Semicells without blunt submammillate thickenings at the basal angles 4

3. Width of isthmus more than 15u . . . (1) *C. obsoletum*

3. Width of isthmus less than 15u . . . (143) *C. taxichondrum* var. *nudum* (142) and var. *unigranulatum*

4. Margins of semicells undulate or crenate 5

4. Margins of semicells not undulate or crenate 6

5. Intramarginal crenations present . . (2) C. cyclicum

5. Intramarginal crenations not present (4) C. undulatum

6. One or more scrobiculations present in central area of semicells 7

6. No scrobiculations present in central area of semicells . . 8

7. Cells large, length more than 50u; scrobiculations numerous, more than 10 . . . . . (9) C. perforatum

7. Cells small, length less than 50u; scrobiculations less than 10 . . . (8) C. ocellatum fa.

8. Walls of semicells very thick (2.5-3u) 9

8. Walls of semicells not conspicuously thickened 10

9. Width of isthmus usually less than 27u; lateral margin slightly undulate-crenate; wall with conspicuous pores . . . . . (16) C. tuddalense

9. Width of isthmus more than 28u; lateral margin entire; wall with conspicuous punctations . . . . . (10) C. pachydermum

10. Cell length more than 100u . . (11) C. Ralfsii

10. Cell length less than 100u . . 11

11. Semicells semicircular . . . . . (13) C. circulare

11. Semicells subsemicircular or pyramidate-semicircular 13

12. Apices retuse . . . . . (124) C. laeve

12. Apices not retuse 13

13. Constriction very deep, more than one half the distance to center of semicell, sinus linear . . . . (14) C. Lundelli var. ellipticum

13. Constriction less deep, less than one half the distance to center of semicell, sinus acute . . . . . (15) C. canadense

14. Semicells semi-elliptic, constriction well-defined and deep 15

14. Semicells not semi-elliptic, constriction variable 19

15. Lateral margins undulate . . . . . (17) C. subundulatum

15. Lateral margins not undulate 16

16. Cell length more than 75u . . . (16) C. tuddalense

16. Cell length less than 75u . . . 17

17. Cell width more than 20u 18

17. Cell width less than 20u . . . . . (23) C. moniliforme fa. elongata

18. Semicell with 6-8 parietal chloroplasts . . . . . (19) C. cucumis

18. Semicell with a single axial chloroplast . . . . . (18) C. subcucumis

19. Semicells circular or subcircular, rarely subelliptic 20

19. Semicells otherwise 27

20. Constriction conspicuous and fairly deep . . . . . (20) C. moniliforme

20. Constriction slight 21

21. Cell length more than 45u 25

21. Cell length less than 45u 22

22. Semicell elliptical in vertical view 24

22. Semicell circular or subcircular in vertical view 23

23. Cell wall with sparsely scattered punctations . . . . . (27) C. subtile

23. Cell wall without sparsely scattered punctations . . . . . (32) C. globosum

24. Length of cell 15-21u, width of cell 12-17u . . . . . (31) C. subarctoum

24. Length of cell 10.5-14.6u, width of cell 9-12u . . . . . (38) C. inconspicuum

25. Length of semicell 65u or more . . . 26

25. Length of semicell less than 65u ... (35) C. pseudoconnatum

26. Cell wall finely scrobiculate with minute punctations between the scrobiculations, constriction moderate . . . . (36) C. connatum

26. Cell wall finely punctate, constriction slight . . . . . (37) C. alpestre

27. Semicells cylindrical, subcylindrical or fusiform-cylindrical; constriction very slight 28

27. Semicells otherwise 33

28. Cell length more than 20u . . . 29

28. Cell length less than 20u . . . (27) C. subtile

29. Cell length more than 75u 30

29. Cell length less than 75u 31

30. Semicell wall thickened at apices . . . . . (26) C. diplospora var. major

30. Semicell wall not thickened at apices . . . . . (30) C. elongatum (cf. (29) C. cucurbitinum fa. major)

31. Semicell wall thickened at apices. . (25) C. diplospora

31. Semicell wall not thickened at apices 32

32. Cell length more than 50u . . . (29) C. cucurbitinum var. minor

32. Cell length less than 50u . . . (28) C. cucurbita

33. Semicells transversely elliptic, oblong elliptic, reniform or subhexagonal-elliptic 34

33. Semicells otherwise 43

34. Semicells transversely and narrowly elliptical-oblong or subhexagonal elliptic 35

34. Semicells transversely elliptical or elliptical-reniform . 37

35. Sinus closed 36

35. Sinus open . . . . . (40) C. depressum var. reniforme

36. Cells small, length less than 25u . . . . . (41) C. subdepressum

36. Cells larger, length more than 30u . . . . . (39) C. depressum var. achondrum

37. Sinus closed 38

37. Sinus open 39

38. Cell length more than 30u . . . (44) C. tumidum

38. Cell length less than 30u . . . (42) C. phaseolus var. minor and (43) var. elevatum

39. Cell length more than 30u 40

39. Cell length less than 30u 41

40. Semicell with three lateral undulations in vertical view . (45) C. sulcatum

40. Semicell without three lateral undulations in vertical view. (46) C. contractum

41. Width of semicells up to 12u 42

41. Width of semicells 13u or more . . . (49) C. bioculatum

42. Apex of sinus obtuse . . . . . (cf. (31) C. subarctoum) C. inconspicuum

42. Apex of sinus acute . . . . . (48) C. tinctum

43. Semicells pyramidate or subpyramidate, apices usually truncate 44

43. Semicells not pyramidate or subpyramidate, apices variable 74

44. Lateral margins sharply constricted a short distance below and causing a dilation of the apex(51) C. Holmiense

44. Lateral margins otherwise . . . 45

45. Lateral margins crenate or undulate. 46

45. Lateral margins not crenate or undulate; either straight, retuse or biundulate in upper part only, or convex 53

46. Semicell with a supraisthmial granule or papilla 47

46. Semicells without a supraisthmial granule or papilla . 48

47. Semicells more than 35u . . . . . (53) C. tetragonum var. Lundelli

47. Semicells less than 35u . . . . . (61) C. trilobulatum var. basichondrum

48. Middle area of semicell wall with a distinct scrobiculation . . 51

48. Middle area of semicell wall without a distinct scrobiculation 49

49. Each lateral margin with about eight undulations . . . . . (55) C. obtusatum

49. Each lateral margin with three or four undulations (including apical and basal angle) 50

50. Lateral undulations 3 . . . . . (56) C. venustum

50. Lateral undulations 4 . . . . . (58) C. impressulum

51. Width of semicell below 20u 52

51. Width of semicell above 20u . . . . (57) C. venustum var. excavatum fa. duplo-major

52. Length of cell under 25u . . . (62) C. trilobulatum var. retusa

52. Length of cell over 25u . . . . (63) C. subreinschii var. ocellatum

53. Upper lateral margins retuse, subretuse or biundulate 54

53. Upper lateral margins not retuse or subretuse 61

54. Basal angles rectangular . . . 56

54. Basal angles broadly rounded . 55

55. Cell length more than 35u . . . . . (64) C. Hammeri

55. Cell length less than 35u . . . . . (66) C. retusiforme

56. Apical lobes distinctly retuse. (67) C. Pokornyanum

56. Apical lobes flattened or very slightly concave 57

57. Lower lateral margins slightly divergent 58

57. Lower lateral margins not divergent. 59

58. Upper lateral margin with one or two undulations . . . . . (69) C. granatum var. subgranatum

58. Upper lateral margin retuse . . (cf. (79) C. scopulorum) (60) C. trilobulatum

59. Upper lateral margin straight . . . (68) C. granatum

59. Upper lateral margin retuse or subretuse 60

60. Lateral margin with two sides . (cf. (79) C. scopulorum) (60) C. trilobulatum

60. Lateral margin with three sides . . . . . (96) C. angulare var. octangulare

61. Semicells pyramidate-semicircular . (70) C. subtumidum

61. Semicells not pyramidate-semicircular 62

62. Cell as long as wide or slightly (up to 1 1/4 times) longer than wide 63

62. Cells distinctly (1 1/3-1 3/4 times) longer than wide . . . 66

63. Length of cell more than 50 u . . . 64

63. Length of cell less than 50u 65

64. Width of apices 15-17u . . . . (73) C. galeritum

64. Width of apices 20-28u . . . . (75) C. pseudonitidulum var. validum

65. Two pyrenoids present in each semicell . . . . . (74) C. pseudonitidulum

65. A single pyrenoid present in each semicell . . . . . (76) C. nitidulum

66. Cells small, less than 35u . . 67

66. Cells larger, more than 35u . . 69

67. Apices flat . . . . . (68) C. granatum

67. Apices retuse 68

68. Semicell wall coarsely scrobiculate . . . . . (78) C. variolatum fa.

68. Semicell wall finely punctate or punctate-scrobiculate . . (124) C. laeve

69. Central area of semicell wall with a large pore . . . . . (77) C. variolatum fa. var. cataractarum

69. Central area of semicell without a large pore 70

70. Sinus shallow 71

70. Sinus deep 72

71. Width of semicells greater than the length of the semicell . . . . . (72) C. capense fa. minor

71. Width of semicells about equal to or less than the length of the semicell . . . . . (80) C. maculatum

72. Lower lateral margin perpendicular to base, upper lateral margin strongly convergent to apex . . . . . (68) C. granatum

72. Lateral margins convex and gradually converging to the apex. 73

73. Semicells with a single pyrenoid . . (83) C. pseudopyramidatum

73. Semicells with two pyrenoids . . . . (81) C. pyramidatum

74. Semicells rectangular or subrectangular in outline . . . 75

74. Semicells elliptic hexagonal, subhexagonal or polygonal . . 85

75. Apices of semicells with about six undulations between each of which there is a short vertical linear thickening of the wall . . . . . (113) C. humile var. striatum

75. Apices of semicells with entire or crenulate-undulate margins but never with wall thickenings as above 76

76. Margins of semicells entire . . 77

76. Margins of semicells crenate or undulate . . . . . (cf. (128) C. Regnesii var. tritum) (169) C. novae-semliae var. sibericum

77. Constriction very slight . . . . . (86) C. arctoum var. tatrica

77. Constriction fairly deep 78

78. Semicells distinctly longer than wide 82

78. Semicells as long as wide or wider than long 79

79. Cell length 8-10.5u . . . . . (87) C. minimum

79. Cell length more than 10.5u 80

80. Cell small, length less than 30u 81

80. Cell larger, length more than 30u . . . . . (108) C. rectangulare

81. Lateral margins slightly retuse . . (88) C. norimbergense fa. depressa

81. Lateral margins not retuse . . . . . (89) C. exiguum

82. Cell length more than 100u . . (90) C. Debaryi

82. Cell length less than 100u . . 83

83. Lateral margins concave in some part 84

83. Lateral margins straight or convex . (93) C. plicatum

84. Basal angles rounded and slightly protruding, apices broadly rounded . . . . . (91) C. quadratum

84. Basal angles rounded, but not protruding, apices angularly rounded . . . . . (94) C. plicatum var. hibernicum

85. Semicells hexagonal-elliptic (including base as one side) 86

85. Semicells not hexagonal-elliptic, but polygonal 98

86. Semicells with one or three sharp lateral median projections in vertical view . . . 87

86. Semicells without sharp projections in vertical view . . 90

87. Semicell with 2 or 3 sharp projections in vertical view 88

87. Semicell with a single lateral projection in vertical view 89

88. Cell minute, 7-12u long . . . . (99) C. pygameum

88. Cell larger, more than 20u long (95) C. angulare

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89. Lower lateral margins convex, lateral angle broadly rounded . . . . (cf. (98) C. bireme) (100) C. geometricum var. suecium

89. Lower lateral margins retuse, lateral angle slightly produced . . . (97) C. podygonum

90. Cell more than 28u long 95

90. Cell less than 28u long 91

91. Lateral walls thickened in vertical view . . . . . (111) C. pseudoprotuberans

91. Lateral walls not thickened in vertical view 92

92. Sinus very shallow . . . . . (cf. (128) C. Regnesii var. tritum) (102) C. Sphagnicolum fa.

92. Sinus deep 93

93. Sinus gradually and regularly opened (101) C. subcapitulum

93. Sinus linear 94

94. Cells as wide as long, or wider than long . . . . . (103) C. abbreviatum

94. Cells longer than wide . . . . (cf. (123) C. repandum var. minor) (107) C. sexangulare fa. minima

95. Lateral walls thickened in vertical view 97

95. Lateral walls not thickened in vertical view 96

96. Lower lateral margin sharply convergent towards the isthmus . (106) C. sexangulare

96. Lower lateral margin not at all or very slightly convergent towards the isthmus . . . . . (108) C. rectangulare

97. Poles broadly rounded in vertical view . . . . . (110) C. refringens

97. Poles acutely rounded in vertical view . . . . . (111) C. pseudoprotuberans

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98. Semicells with 6-8 equal marginal undulations . . . . . (58) C. impressulum

98. Semicells without 6-8 equal marginal undulations 99

99. Semicells with two subapical tumors. (112) C. Moerlianum var. brasiliense

99. Semicells otherwise 100

100. Semicells rhomboidal with concave lateral margins in vertical view . . . . . (114) C. clepsydra

100. Semicells not rhomboidal with concave lateral margins in vertical view 101

101. Semicells longer than wide or as long as wide 102

101. Semicells wider than long 106

102. Cell length 28u or more 103

102. Cell length less than 28u . . . 104

103. Semicells rounded-polygonal . . . . (124) C. laeve

103. Semicells subrectangular with elevated apex . . . . . (115) C. difficile

104. Upper lateral margin straight . 105

104. Upper lateral margin retuse . . (118) C. meneghini

105. Apical margin flat . . . . . (119) C. angulosum

105. Apical margin retuse 106

106. Lateral margins convex . . . . (124) C. laeve

106. Lateral margins retuse . . . . (125) C. quadratulum

107. Apical margin flat . . . . . (121) C. Regnelli var. minimum

107. Apical margin retuse 108

108. Lateral margin convex . . . . . (124) C. laeve

108. Lateral margin angular 109

109. A sharp indentation present just above the lower lateral margin . . (127) C. quadratulum var. applanatum

109. A sharp indentation not present above the lower lateral margin . . . . . (125) C. laeve var. octangularis

1. Cosmarium obsoletum (Hantzsch) Reinsch

West and West, 1905. Monogr. Brit. Desm. 2:133. Pl. 56, Figs. 1-3.

The semicircular to subsemicircular semicells of this species has thickened and submammillate basal angles. The vertical view is elliptic and the cell wall is punctulate or finely scrobiculate. The semicells are much more depressed, the width is usually greater, and the vertical view is more tumid than C. taxichondrum var. nudum.

Measurements: L. 34-46u; W. 42-54u; I. 15.5-20u.

Distribution: NLP, Cheboygan (T ft 1939).

2. Cosmarium cyclicum Lund.

West and West, 1905. Monogr. Brit. Desm. 2:145. Pl. 58, Figs. 8, 9.

The semicircular semicells of this species are regularly undulate-crenate. The two or three intramarginal rows of small undulations easily distinguishes this species from C. undulatum. There is also a superficial resemblance to C. obtusatum which has truncate-pyramidate semicells.

Measurements: L. 49-52u; W. 52-58u; I. 17-27.5u.

Distribution: SLP, Washtenaw (Johnson 1894); NLP, Emmet (Transeau 1917).

3. var. Nordstedtianum (Reinsch) West and West Pl. 15, Fig. 1.

West and West, 1905. Monogr. Brit. Desm. 2;146. Pl. 58, Fig. 12.

This variety has cells which are distinctly hexagonal and which have truncate apices that are less crenate than the lateral margins.

Measurements: L. 48-50-(53)u; W. (53)-54-66u; I. 19-(19)-21u.

Distribution: NLP, Crawford, New record for Michigan.

4. Cosmarium undulatum Corda

West and West, 1905. Monogr. Brit. Desm. 2:148. Pl. 59, Figs. 1, 2, 3, 5.

The subsemicircular (at least the greater upper part) semicells with 10-12 marginal undulations (counting apical and basal angles) are characteristic of this species. C. impressulum has more pyramidate semicells which have only eight marginal undulations. This latter species is also much larger.

Measurements: L. 54-64u; W. 39-52u; I. 12.5-17u.

Distribution: SLP, Ionia, Jackson, Lapeer, Muskegon, Livingston, Monroe, Muskegon; EUP, Chippewa, Luce; WUP, Baraga. All records by N & A (1932).

5. var. crenulatum (Naeg.) Wittr.

West and West, 1905. Monogr. Brit. Desm. 2:150. Pl. 59, Figs. 11, 12.

This variety is smaller than the typical. The semicells are semicircular-quadrate, and have only eight mar-

ginal undulations. It resembles C. impressulum very closely, but the lower lateral margins which are convergent towards the base and the shape of the semicells easily distinguish it from this species. Specimens from Calhoun and Gogebic Counties agree more favorably with typical measurements of var. minutum Wittr. but have the eight marginal undulations of var. crenulatum.

Measurements: L. (21.8)-29-30u; W. (17)-22.5-23u; I. (6)-7-8.5u.

Distribution: SLP, Calhoun; NLP, Cheboygan, Emmet (N & A 1932); WUP, Gogebic, also B-raga (N & A 1932).

6. var. minutum Wittr.

West and West, 1905. Monogr. Brit. Desm. 2:149. Pl. 59, Figs. 6, 7.

This variety is distinguished from the typical by the smaller size. The margin has 12-14 undulations. (See discussion on var. crenulatum for similar small forms).

Measurements: L. 21-28u; W. 18-21u; I. 8.5-10u.

Distribution: NLP, Cheboygan; EUP, Chippewa; WUP, Houghton. All records by N & A (1932).

7. var. Wollei West

West and West, 1905. Monogr. Brit. Desm. 2:150. Pl. 59, Figs. 8-10.

This variety is intermediate in size between the typical and var. crenulatum, and the semicell margins have thirteen or fourteen crenations.

Measurements: L. 32-43u; W. 27-36u; I. 10-13.5u.

Distribution: SLP, Ionia; EUP, Delta; WUP, Houghton. All records by N & A 1932.

8. Cosmarium ocellatum Eichl. and Gutw. fa. Pl. 15, Fig. 2. West and West, 1905. Monogr. Brit. Desm. 5:144. Pl. 58, Fig. 6.

Typically C. ocellatum has subsemicircular-pyramidate semicells with a large central scrobiculation. The variety incrassatum West and West has a more pyramidate semicell in which a ring of 2-5 lesser scrobiculations surround a large scrobiculation in a central thickened area. The variety rotundatum Fritsch and Rich has a widely open linear sinus, a more depressed semicell than the typical, but a similar single central scrobiculation. A few specimens from Barry County do not agree perfectly with either the typical or the variety. The semicell shape (although more angular) and the sinus, are close to var. rotundatum, but the central scrobiculation is irregularly surrounded by two or three smaller scrobiculations similar to that in the var. incrassatum, although the central region was not thickened as in this latter variety.

Eichler and Gutwinski's original illustrations show a variability of the semicell shape and the degree of the sinus opening, and thus the Michigan specimens are assigned here as a form of the typical.

Measurements: L. 20-(28)-30u; W. 17-(23)-23u; I. 4-(4.3)-6u

Distribution: SLP, Barry. New record for Michigan.

9. Cosmarium perforatum Lund.

West and West, 1905. Monogr. Brit. Desm. 2:143. Pl. 58, Figs. 4, 5.

The subpyramidate-semicircular semicells of this species have the central region of the cell wall ornamented with about twenty scrobiculations. The more angular basal angles and the open sinuses distinguish this species from C. Lundellii var. corruptum (Turn.) West and West. The numerous central scrobiculations separate it from C. canadense Irenee-Marie.

Measurements: L. 60-(61)-75u; W. (55)-57-63u; I. 26-(32)-36u.

Distribution: SLP, Barry; WUP, Houghton; Isle Royale (Prescott 1938).

10. Cosmarium pachydermum Lund.

West and West, 1905. Monogr. Brit. Desm. 2:139. Pl. 57, Fig. 7.

The subsemicircular shape of the semicells and the very thick walls are distinctive features of this species. The vertical view is broadly elliptic, and the cell wall is densely punctate. It resembles C. tuddalense Strom, which has numerous definite pores in the cell wall, and a narrower isthmus.

Measurements: L. 78-117u; W. 60-87u; I. 29-40u.

Distribution: SLP, Barry (2), Livingston; NLP, Cheboygan (N & A 1932, Welch 1938a); EUP, Alger, Schoolcraft, also Schoolcraft (Transeau 1917); Isle Royale (Prescott 1937, 1938).

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11. Cosmarium Ralfsii Breb.

West and West, 1905. Monogr. Brit. Des. 2:141. Pl. 57, Fig. 10; Pl. 58, Figs. 1, 2.

This species has subpyramidate-semicircular semicells. The vertical view is rhomboid-elliptic, and the cell wall is finely punctate or scrobiculate. It resembles C. Lundellii, from which it can be distinguished by the usually larger size, the more narrow isthmus, and the parietal chloroplasts.

Measurements: L. 112-120u; W. 95-104u; I. 21-25u.

Distribution: SLP, Wayne (Campbell 1886).

12. var. aethiopicum West and West

West and West, 1905. Monogr. Brit. Desm. 2:140. Pl. 57, Figs. 8, 9.

This variety is separated from the typical by the thinner cell wall, The cell wall also is scrobiculate with minute punctations between the scrobiculations.

Measurements: L. 69-(81)-(96)-107u; W. 61-(66)-(77)-80u; I. 28-(32)-33-34u.

Distribution: SLP, Ingham, Clinton; NLP, Cheboygan (N & A 1932); EUP, Delta, Alger; WUP, Menominee.

13. Cosmarium circulare Reinsch

West and West, 1905. Monogr. Brit. Desm. 2:136. Pl. 56, Figs. 11, 13, 14.

The semicircular semicells of this species have rounded basal angles. The vertical view is narrowly el-

liptic and the cell wall is punctulate. The semicircular front view and the narrowly elliptic vertical view separate this species from C. Lundellii.

Measurements: L. 47-(47)-95u; W. 46-(46)-90u; I. (13)-14-28u.

Distribution: SLP, Barry, Washtenaw; NLP, Cheboygan (Welch 1938a); EUP, Mackinac; WUP, Gogebic, also Houghton (N & A 1932).

14. Cosmarium Lundellii var. ellipticum West

West and West, 1905. Monogr. Brit. Desm. 2:138. Pl. 57, Figs. 3, 4.

This organism has pyramidate-semicircular semicells. The vertical view is elliptic and the cell wall is punctate. It has a superficial resemblance to C. capense De Toni, but the deeper constriction and large size easily distinguish it.

Measurements: L. 68-73u; W. 53-55u; I. 16-21u.

Distribution: SLP, Ottawa (N & A 1932).

15. Cosmarium canadense Irenée-Marie Pl. 15, Fig. 6.

Irenee-Marie, 1938. Flor. Desm. de la Reg. Mont. :164. Pl. 32, Figs. 3, 4.

This species resembles some expressions of C. perforatum Lund. except for the lack of scrobiculations in the central region of the semicell wall. The semicells are subsemicircular-pyramidate, and the sinus is short and open. The vertical view is more broadly elliptic

than the above species, and the punctate semicell wall is slightly thickened in the central region.

Measurements: L. 59-65-(69)-(71)u; W. 58-61-(62)-(67)u; I. (31)-35-37u.

Distribution: SLP, Washtenaw, Barry; EUP, Alger; WUP, Marquette. New records for Michigan.

16. Cosmarium tuddalense Strom

Strom, 1919. Nyt. Mag. f. Natur. 57:29. Pl. 4, Fig. 8.

The semicells of this species are transversely (rarely sub-semicircular-pyramidate) semi-elliptic in front view, and elliptic in vertical view. The very thick semicell walls have numerous pores. There is a general resemblance to C. pachydermum Lund., but the distinct pores in the semicell walls and the usually greater size, as well as the smaller isthmus distinguish it from this species.

Measurements: L. 94-(95)-150u; W. 65-(70)-101u; I. 15-(22)-28u.

Distribution: EUP, Delta; WUP, Marquette; Isle Royale (Prescott 1938).

17. Cosmarium subundulatum Wille

West and West, 1905. Monogr. Brit. Desm. 2:151. Pl. 59, Figs. 13, 15.

The semi-elliptic semicells of this species have margins that are twelve undulate. In addition, there are two intramarginal rows of undulations. The vertical view

is elliptic with broad lateral protuberances. The semicell wall is punctate and sometimes has several scrobiculations near the margins. The semi-elliptic shape of the semicells and the central protuberance distinguish this species from C. undulatum Corda.

Measurements: L. 45-60u; W. 32-39u; I. 15-16u.

Distribution: Isle Royale (Prescott 1938).

18. Cosmarium subcucumis Schmidle

West and West, 1905. Monogr. Brit. Desm. 2:155. Pl. 60, Figs. 1-3.

This species has semi-elliptic (withlong axis vertical) semicells in front view which are broadly elliptic in transverse view. The sinus is linear, closed or open at the base. The semicell wall is finely punctate. The two pyrenoids in each semicell separates this species from C. cucumis (Corda) Ralfs.

Measurements: L. 60 (60)-(64)-87u; W. 36-(39)-(42)-54u; I. 14-(19)-19-21u.

Distribution: SLP, Calhoun, Ingham, Livingston, Washtenaw; NLP, Crawford, Roscommon, also Emmet (N & A 1932); WUP, Gogebic, also Marquette (Pres. and Mag. 1935).

19. Cosmarium cucumis (Corda) Ralfs. Pl. 15, Fig. 3.

West and West, 1950. Monogr. Brit. Desm. 2:152. Pl. 59, Figs. 18-20.

The semicells of this species are semi-elliptic (long axis vertical) in front view, and broadly elliptic or el-

liptic-oblong in vertical view. The cell wall is smooth. The parietal band-shaped chloroplasts, each with several pyrenoids distinguish this species from C. subcucumis Schmidle.

Measurements: L. (54)-59-102u; W. (30)-34-56u; I. 15-(17)-38u.

Distribution: SLP, Barry; EUP, Schoolcraft (2); WUP, Houghton, Gogebic. New records for Michigan.

20. Cosmarium moniliforme (Turp.) Ralfs.

West and West, 1908. Monogr. Brit. Desm. 3:20. Pl. 67, Figs. 1-3.

This species has cells constricted by a deep, widely open sinus into two circular or subcircular smooth walled semicells. The vertical view is circular.

Measurements: L. 21-37u; W. 11-23u; I. 3-9u.

Distribution: NLP, Cheboygan (N & A 1932).

21. fa. punctata Lagerh. Pl. 15, Fig.

West and West, 1908. Monogr. Brit. Desm. 3:22. Pl. 67, Fig. 4.

This form is separated from the typical by the punctate semicell wall which sometimes becomes yellow.

Measurements: 24-(42)-43u; W. 14-(21)-25u; I. 3.5-(6)-6.5u.

Distribution: NLP, Emmet. New record for Michigan.

22. fa. panduriformis Heimerl. Pl. 15, Fig. 5.

West and West, 1908. Monogr. Brit. Desm. 3:22. Pl. 67, Figs. 8, 9.

This form is distinguished from the typical by a proportionately broader isthmus and an obtusely rounded sinus. Measurements: L. 17-(25)-27u; W. 10-(15)-15u; I. 6-(9)-16u.

Distribution: SLP, Barry. New record for Michigan.

23. fa. elongata West and West Pl. 15, Fig. 8.

West and West, 1908. Monogr. Brit. Desm. 3:23. Pl. 75, Fig. 10.

The semicells of this form are broadly elliptic. (Vertical axis the long axis).

Measurements: L. (35)-38-42-(43)u; W. 17-(17)-(18)-20u; I. 4-(5)-(7)-7u.

Distribution: SLP, Barry; NLP, Emmet; EUP, Schoolcraft. New records for Michigan.

24. var. subpyriforme West and West Pl. 15, Fig. 7.

West and West, 1908. Monogr. Brit. Desm. 3:23. Pl. 67, Fig. 5.

This variety has angularly obovate semicells. The apices and lower lateral margins may be slightly flattened.

Measurements: L. 40-(43)u; W. 20-(23)u; I. (7.5)-7.7u.

Distribution: EUP, Delta. New record for Michigan.

25. Cosmarium diplospora (Lund.) Luetk.

West and West, 1904. Monogr. Brit. Desm. 1:61. Pl. IV, Figs. 40, 41.

This species has moderately large subcylindrical cells that have a very slight constriction. The cell wall which

is slightly thickened at the apex, is smooth. Each semicell has a central pyrenoid and a chloroplast with numerous radiating processes. The zygospore is double.

Measurements: L. 32.5-66-(70)u; W. 22.5-53-(36)u.

Distribution: NLP, Roscommon; EUP, Delta; Isle Royale (Prescott 1937).

26. var. major West

West and West, 1904. Monogr. Brit. Desm. 1:61. Pl. 4, Figs. 42, 43.

This variety is almost twice the size of the typical and may lack a constriction at times.

Measurements: L. 102-121u; W. 48-54u.

Distribution: Isle Royale (Prescott 1937).

27. Cosmarium subtile (West and West) Luetk.

West and West, 1904. Monogr. Brit. Desm. 1:92. Pl. 8, Figs. 27-29.

The small subcylindrical cells of this species have a slight, almost imperceptible median constriction. The cell wall is sparsely and indistinctly punctate according to West and West (1904) but Borge (1936) illustrates and describes Swedish specimens in which the "porenapparate" protrudes slightly on the lateral margins, perhaps indicating that the punctulations of West and West are really pores. The "porenapparate" referred to above may have been mucilage threads.

Measurements: L. 14-15.7u; W. 10-11.4u.

Distribution: NLP, Cheboygan (N & A 1932).

28. Cosmarium cucurbita Breb.

West and West, 1908. Monogr. Brit. Desm. 3:106. Pl. 73, Figs. 31-33; Pl. 74, Fig. 3.

The subcylindrical-subquadrate semicells of this species have a very slight median constriction. The lateral margins are subparallel and the apices are convex or convex-truncate. The vertical view is circular, and the cell wall is punctate. This species appears to be very similar to C. cucurbitinum (Biss.) Luetken, from which it can be separated by the smaller size and the less attenuated lateral margins. The writer does not feel that fa. minutum of C. cucurbitinum can be separated distinctly from this species and so it is included here.

Measurements: L. 25-(34)-(38)-40-51u; W. 12-(15)-(17)-(19)-25u.

Distribution: SLP, Ingham, Livingston, Oakland, Berrien; NLP, Cheboygan, also Cheboygan (N & A 1932); EUP, Chippewa, Delta, Schoolcraft; WUP, Gogebic (3), Houghton, Baraga, also Marquette (Pres. and Mag. 1935).

29. Cosmarium cucurbitinum fa. minor (West and West) Luetk.

West and West, 1904. Monogr. Brit. Desm. 1:94. Pl. 9, Figs. 13, 14.

Typically C. cucurbitinum fa. minor has subcylindrical cells with a very slight median constriction. The cell wall is minutely punctate. This species has a great similarity to some expression of C. cucurbita, but has more attenuated lateral margins, more broadly rounded apices and a smaller size.

Measurements: L. 50-58u; W. 22-25u.

Distribution: NLP, Cheboygan (N & A 1932, Taft 1939).

30. Cosmarium elongatum Racib. fa. Borge.

Borge, 1923. Arkiv. f. Bot. K. Sv. Vets. Akad. 18(10); 8. Pl. 1, Fig. 4.

This large species has subcylindrical cells with a slight but very distinct constriction. The lateral margins are slightly convex and taper gradually to rounded or convex-truncate apices. The wall is punctate. Specimens from Chippewa County resembled very closely the organism illustrated and identified by Whelden (1943) as C. subturgidum (Turn.) Schmidle fa. They were also similar to specimens of C. Clevei (Lund.) Luetk. shown by Irenée Marie (1949). In all cases, the apical region was coarsely punctate or scrobiculate. According to West and West (1904), C. Clevei has small granules in the apical region. Consequently, the Michigan specimens are assigned questionably to Borge's form of C. elongatum which does not have pronounced punctations in the apical region. The figure of Cosmarium (Penium) cucurbitinum fa. majus West and West, reported by Prescott and Magnotta (1935), from Marquette County, should probably also be placed here.

Measurements: L. 94-106-(129)u; W. 36-(38)-39u; I. 31.5-(36)-36u.

Distribution: EUP, Chippewa; WUP, Marquette (Pres. & Mag. 1935); Isle Royale (Prescott 1938).

31. Cosmarium subarctoum (Lagerh.) Racib.

West and West, 1908. Monogr. Brit. Desm. 3:31. Pl. 68, Figs. 6-8.

This small species has transversely subelliptic semicells. The sinus is open and subacute at the apex. The convex apex is slightly flattened. The vertical view is elliptic. It can be separated from C. subarctoum by the smaller size and the more elliptic semicells, and from C. subtile and C. globosum by the elliptic shape in vertical view.

Measurements: L. 15-(21.5u); W. 12-17u; I. 8.5-11.5u.

Distribution: NLP, Cheboygan (N & A 1932, Welch 1936b).

32. Cosmarium globosum Bulnh.

West and West, 1908. Monogr. Brit. Desm. 3:29. Pl. 168, Figs. 1, 2.

The semicells of this small species are subcircular. The sinus is widely open and has a subacute apex. The vertical view is circular and the cell wall is punctate.

Measurements: L. 30-36u; W. 22-25u; I. 17-19u.

Distribution: NLP, Cheboygan (N & A 1932, Welch 1938a).

33. fa. minor Boldt.

West and West, 1908. Monogr. Brit. Desm. 3:30.

This form is similar to the typical in cell shape but is smaller.

Measurements: L. 16.8-24u; W. 12-15u; I. 10.8-12u.

Distribution: SLP, Oakland; NLP, Cheboygan (Taft 1939).

34. var. Wollei West and West

West and West, 1896. Trans. Linn. Soc. Bot. 5(5):252. Pl. 15, Fig. 17.

This variety has a slighter constriction, a more semi-elliptic-shaped semicell and is slightly larger than typical.

Measurements: L. 38.5u; W. 24u; I. 21u.

Distribution: NLP, Cheboygan (N & A 1932, Welch 1938a).

35. Cosmarium pseudoconnatum Nordst.

West and West, West, G. S. 1908. Monogr. Brit. Desm. 3:27. Pl. 67, Figs. 19-21.

The semicells of this species are semi-elliptic (subcircular for about 2/3 of the margin). The constriction is slight and the sinus is broad and very shallow. The vertical view is circular or subcircular and the cell wall is punctate. This species can be separated from C. connatum Bréb. by the smaller size, the non-scrobiculate cell wall, and the smaller constriction. Some specimens from Gogebic County are much smaller than typically.

Measurements: L. (40)-47-57.5-59u; W. (29)-33-(43.5)-45u; I. (26)-30-(38)-41.

Distribution: SLP, Barry (2), Calhoun, Livingston; NLP, Emmet, also Cheboygan (Taft 1939); WUP, Gogebic.

36. Cosmarium connatum Breb.

West and West, 1908. Monogr. Brit. Desm. 3:25. Pl. 67, Figs. 15-17.

The semicells of this species are transversely subelliptic (circular for about 2/3 of margin). The constriction is very slight, the sinus being widely open and with an obtuse apex. The vertical view is subcircular and the cell wall is scrobiculate with fine punctations between the scrobiculations. This species is larger, has a more pronounced constriction and less rounded semicells than C. pseudoconnatum.

Measurements: L. 65-(79)-100u; W. 46-(58)-74u; I. 40-(41)-54u.

Distribution: SLP, Barry (2) also Ionia (Wade 1949) and Macomb (Pieters 1894); NLP, Presque Isle, also Cheboygan (N & A 1932); EUP, Delta; WUP, Marquette; Isle Royale (Prescott 1937, 1938).

37. Cosmarium alpestre Roy and Biss.

West and West, 1908. Monogr. Brit. Desm. 3:24. Pl. 67, Fig. 14.

The semicells of this species are subsemicircular. The constriction is very slight and the isthmus is broad. The vertical view is broadly elliptic and the cell wall is thickly and finely punctate, the punctae along the isthmus being larger. The very slight constriction distinguishes this species from C. connatum Bréb.

Measurements: L. 78-105u; W. 58-90u.

Distribution: Isle Royale (Prescott 1938).

38. Cosmarium inconspicuum West and West

West and West, 1905. Monogr. Brit. Desm. 2:164. Pl. 61, Figs. 1, 2.

The transversely elliptic semicells of this species have broadly convex apices. The sinus is open and subrectangular. The vertical view is elliptic and the cell wall is smooth. It resembles C. subarctoum (Lagerh.) Racib. but the smaller size, the convex apices and the broader sinus clearly differentiates it from this species.

Measurements: L. 13.5-14.6u; W. 9.5-12u; I. 4.8-6.5u.

Distribution: EUP, Schoolcraft; WUP, Houghton. Both records by Nichols and Ackley (1932).

39. Cosmarium depressum var. achondrum (Boldt) West and West Pl. 15, Fig. 9.

West and West, 1905. Monogr. Brit. Desm. 2:177. Pl. 62, Figs. 6-9.

The semicells of this organism are subhexagonal-elliptic. The apices are flat and the sinus is linear but opens outwardly. The vertical view is elliptic and the cell wall is finely punctulate.

Measurements: L. 37-(38)-51u; W. 40-(40)-51u; I. (10.5)-12-17u.

Distribution: NLP, Presque Isle; EUP, Alger, Mackinac; WUP, Marquette. New records for Michigan.

40. Cosmarium depressum var. reniforme West and West

West and West, 1905. Monogr. Brit. Desm. 2:178. Pl. 62, Fig. 10.

This organism has narrowly elliptic-reniform semicells. The sinus is open and the cell wall is smooth. The vertical view is elliptic. It can be distinguished

from C. subdepressum by the open sinus and the smooth cell wall.

Measurements: L. 21u; W. 26u; I. 6.5u.

Distribution: Cheboygan (Taft 1939).

41. Cosmarium subdepressum West and West Pl. 16, Fig. 1.

West and West, 1896. Trans. Linn. Soc. of Lon. Bot., 25(5):247. Pl. 15, Fig. 15.

This species has narrowly elliptic-reniform semicells which are finely granulate-punctate. The constriction is deep, the sinus being linear and slightly closed in some part. The vertical view is elliptical. The Michigan specimens were somewhat larger than typical.

Measurements: L. 15-(22)u; W. 21-(26)u; I. (3.5)-3.7u.

Distribution: SLP, Oakland. New record for Michigan.

42. Cosmarium phaseolus fa. minor Boldt. Pl. 16, Fig. 2.

West and West, 1905. Monogr. Brit. Desm. 2:159. Pl. 60, Fig. 15.

The semicells of this organism are hexagonal elliptic. The constriction is deep and the sinus narrow and is opened outwardly. The vertical view is elliptic with a small protuberance on each lateral margin. The cell wall is minutely punctate. The central protuberance on each semicell separates this from C. subtumidum Nordst.

Measurements: L. (20.4)-21u; W. 18-(21.5)u; I. (4.5)-5.5-6u.

Distribution: WUP, Gogebic. New record for Michigan.

43. Cosmarium phaseolus var. elevatum Nordst. Pl. 16, Fig. 3. West and West, 1905. Monogr. Brit. Desm. 2:159. Pl. 60, Figs. 16, 17.

This variety has hexagonal-elliptic semicells with truncate-convex apices. Specimens from Houghton and Barry Counties are somewhat intermediate between this variety and var. rectangulare Insam and Krieger (1936). The latter has more subrectangular semicells.

Measurements: L. (25)-25.5-28.8u; W. (21.5)-23.5-30u; I. (5)-7-(8)-10u..

Distribution: SLP, Barry; WUP, Houghton. New record for Michigan.

44. Cosmarium tumidum Lund.

West and West, 1905. Monogr. Brit. Desm. 2:160. Pl. 60, Fig. 18.

The subsemicircular-elliptic semicells of this species have broadly convex apices. The constriction is deep and the sinus is narrow but open outwardly. The vertical view is elliptic with strong tumid lateral margins. The cell walls are punctate, the punctations often much larger and distinct in the central region of the semicells.

Measurements: L. (28)-(30)-31-(32)-37u; W. (22)-23-(24)-(26)-32u; I. 6-(6)-(8)-9.5u.

Distribution: SLP, Barry, Calhoun, Oakland; NLP, Emmet, also Emmet (N & A 1932); EUP, Chippewa; WUP, Gogebic.

45. Cosmarium sulcatum Nordst.

Nordstedt. 1878. De. Alges aquae dulcis et de Characeis ex insulis Sandvicensibus a Sv. Berggren 1876 reportatis :13. Pl. 1, Fig. 18.

This species has hexagonal elliptic semicells, with bluntly pointed lateral angles. The vertical view is elliptic with obtuse poles and with three undulations on the middle of each lateral margin.

Measurements: L. 36-42u; W. 28-34u; I. 8-10u.

Distribution: SLP, Macomb (Johnson 1894, Pieters 1894).

46. Cosmarium contractum Kirchn.

West and West, 1905. Monogr. Brit. Desm. 2:170. Pl. 61, Figs. 23-25, 34.

The semicells of this species are subelliptic to almost sub-semicircular in shape with the ventral margins more convex than the dorsal. The constriction is deep with the sinus widely open. The isthmus is narrow with parallel walls. The vertical view is elliptic and the cell wall is finely punctate.

Measurements: L. 29-(40)-56u; W. 22-(22)-(25)-40u; I. 5-(6.5)-12.5u.

Distribution: SLP, Oakland, Washtenaw, also Lapeer (N & A 1932) and Macomb Pieters 1894); EUP, Alger; WUP, Gogebic (2).

47. var. ellipsoideum (Elfv.) West and West

West and West, 1905. Monogr. Brit. Desm. 2:172. Pl. 61, Figs. 28, 35.

This variety is separated from the typical by the proportionately wider and the more perfect elliptic semicells. The cell wall is smooth.

Measurements: L. 31-(34)-(38)-55u; W. 24-(28)-(30)-42; I. 7-(7)-15u.

Distribution: SLP, Barry, Berrien, Livingston; NLP, Emmet (N & A 1932); Isle Royale (Prescott 1938).

48. Cosmarium tinctum Ralfs.

West and West, 1905. Monogr. Brit. Desm. 2;168. Pl. 61, Figs. 16-18.

This small species has elliptic semicells with smooth cell walls of a reddish brown color. The constriction of the cell is fairly deep, the sinus narrow but opening in the outer part.

Measurements: L. 10-15u; W. 7.5-11.6u; I. 4.5-8.4u.

Distribution: NLP, Cheboygan (Taft 1939).

49. Cosmarium bioculatum Bréb.

West and West, 1905. Monogr. Brit. Desm. 2:165. Pl. 61, Figs. 3-7.

The semicells of this species are oblong-elliptic. The constriction is deep with the sinus narrowly open. The vertical view is oblong elliptic. This species has a general resemblance to C. tumidum Lund. and C. phaseolus Bréb. but is smaller than the former and lacks the central protuberance of the semicells of the latter.

Measurements: L. 15-(25)-30u; W. 15-(25)-30u; I. 4.3-(8)-11u.

Distribution: SLP, Oakland, also Wayne (Campbell 1886), and Lapeer (N & A 1932); WUP, Gogebic.

50. var. hians West and West Pl. 16, Fig. 4.

West and West, 1905. Monogr. Brit. Desm. 2:166. Pl. 61, Figs. 10, 11.

This variety has a more open sinus and the apices of the semicell are straight or slightly retuse.

Measurements: L. 17-(17)-19u; W. (14)-15-17u; I. 3.5-(4.5)u.

Distribution: WUP, Gogebic. New record for Michigan.

51. Cosmarium Holmiense Lund.

West and West, 1908. Monogr. Brit. Desm. 3:1. Pl. 65, Figs. 1, 2.

The pyramidate-truncate semicells of this species have the lateral margins (a short distance below the apex), sharply constricted giving a dilated appearance to the apices. The upper parts of the lateral margins are also characteristically undulate and the apical margins are slightly biundulate.

Measurements: L. 43-66u; W. 26-40u; I. 14-21u.

Distribution: Isle Royale (Prescott 1938).

52. var. integrum Lund.

West and West, 1908. Monogr. Brit. Desm. 3:2. Pl. 65, Figs. 3-5.

This variety is separated from the typical by the convex apices and the lack of undulations in the upper lateral margins.

Measurements: L. 45-(53)-(57)-62u; W. 28-(34)-40u; I. 15-(17)-22u.

Distribution: SLP, Calhoun, also Ionia (N & A 1932); NLP, Crawford, also Cheboygan (N & A 1932); Isle Royale (Prescott 1938).

53. Cosmarium tetragonum var. Lundellii Cooke

West and West, 1908. Mongr. Brit. Desm. 3:18. Pl. 66, Figs. 23, 24.

The subquadrate semicells of this species have the triundulate (including apical and basal angles) lateral margins slightly convergent towards the apex. The apices are convex and undulate. The sinus is linear and closed. The vertical view is elliptic and the cell wall is smooth.

Measurements: L. 38-50u; W. 22-29u; I. 8-10u.

Distribution: Isle Royale (Prescott 1938).

54. fa. Schmidlei Gutw.

Schmidle, 1893. Ber. d. Deutsch. Bot. Gesell. 11:(10):549. Pl. 28, Fig. 6.

This form is identical with var. Lundellii except for the presence of supraisthmial granules on each semicell.

Measurements: L. 47-(47)u; W. 25.4-(28)u; I. (6.5)-7.8.

Distribution: WUP, Menominee, Marquette, also Marquette (Pres. and Mag. 1935).

55. Cosmarium obtusatum Schmidle

West and West, 1908. Monogr. Brit. Desm. 3:7. Pl. 65, Figs, 13, 14.

The semicells are truncate-pyramidate with convex lateral margins, each of which has 8-9 undulations. In

addition, there are several secondary rows of undulations just within the margin. The vertical view is oblong-elliptic and the cell walls are punctate. Specimens from Houghton County have slightly convex apices, so that the semicells are almost semicircular.

Measurements: L. (42)-44-(60)-60-64u; W. 37-(42)-(50)-52-(53)u; I. 13-(13)-(15)-(17)-18u.

Distribution: SLP, Livingston, Washtenaw; also Tuscola (N & A 1932); EUP, Mackinac; WUP, Houghton.

56. Cosmarium venustum (Bréb.) Arch.

West and West, 1908. Monogr. Brit. Desm. 3:8. Pl. 66, Figs. 1-3.

The lateral margins of the truncate-pyramidate semicells have a single median undulation. The basal and apical angles are rounded, and the apical margin is slightly retuse. The vertical view is elliptic and the cell wall is finely punctate. A single specimen from Chippewa County had the lateral undulations greatly reduced and the wall coarsely punctate.

Measurements: L. 24-(30)-(32)-43u; W. 18-(22)-32.5u; I. (5)-5.5-13.4u.

Distribution: NLP, Roscommon, also Emmet (N & A 1932); EUP, Chippewa; Isle Royale (Prescott 1938).

57. var. excavatum fa. duplo-major Gutw.

Gronblad, 1921, Acta. Soc. pro. Faun. et Flor. Fenn. 49:37. Pl. 7, Figs. 18-19.

This forma is separated from the typical Cosmarium venustrum (Breb.) Archer by the presence of a central scrobiculation in each semicell. Scrobiculations in specimens from Emmet County were excentrically placed.
Measurements: L. 36-(36)-41.5u; W. 25-(25)-27.5u; I. 4.5-(4.5)-5.8u.
Distribution: NLP, Emmet; Isle Royale (Prescott 1937, 1938).

58. Cosmarium impressulum Elfv.
West and West, 1908. Monogr. Brit. Desm. 3:86. Pl. 72, Figs. 14-18.

This species has semi-elliptic or subcircular (vaguely polygonal) semicells in which each lateral margin possesses four undulations (including apical and basal angles). This characteristic and the different cell shape distinguish this species from C. undulatum Corda. The rectangular basal angles differentiates it from C. undulatum var. crenulatum (Naeg.) Wittr.
Measurements: L. 20-(26)-(36)-36-(43)u; W. 14.5-(19.5)-(21)-(26)-26u; I. 3.5-(5)-(6)-(9)u.
Distribution: SLP, Barry (2), Calhoun, Shiawassee, Clinton, Jackson, Oakland, also Macomb (Johnson 1894 Pieters 1894) and Lapeer (N & A 1932); NLP, Presque Isle also Cheboygan, Emmet (N & A 1932); EUP, Alger, Mackniac, Schoolcraft; WUP, Marquette, Gogebic (2).

59. fa. suborthogonum (Racib.) West and West
Taylor, 1934. Pap. Mich. Acad. Sci. Arts and Letters. 19:255. Pl. 58, Fig. 20.

This organism differs only from the typical in the presence of a slight protuberance in the center of each lateral margin in vertical view.

Measurements: L. 25-28-(30)u; W. 19-(21)-22u; I. 6u.

Distribution: SLP, Washtenaw; Isle Royale (Prescott 1938).

60. Cosmarium trilobulatum Reinsch

West and West, 1905. Monogr. Brit. Desm. 2:185. Pl. 62, Figs. 28-30.

This species has semicells that are tri-lobed. The lateral margins between the basal lobes and the apical lobe are concave. The apices are straight or slightly convex. The vertical view is elliptic and the cell wall is smooth.

Measurements: L. 20-23u; W. 13-20u; I. 3.8-4.4u.

Distribution: Isle Royale (Prescott 1938).

61. var. basichondrum Nordst. Pl. 16, Fig. 5.

Nordsted. 1888. Kongl. Sv. Vet. Akad. Handl. 22(8):57. Pl. 6, Fig. 11.

This variety can be distinguished from the typical by the triundulate lateral margins (including apical and basal angles) and by the supraisthmial papilla at the base of each semicell. The Michigan specimens resemble (in shape) var. majus Taylor (1934) which is different from var. basichondrum only in the larger size.

Measurements: L. 26-31-(32)u; W. 17-21-(22)-(23)u; I. (4.5)-6-7u.

Distribution: SLP, Barry; EUP, Alger, New records for Michigan.

62. fa. retusa Reinsch Pl. 16, Fig. 8.

Insam and Krieger, 1936. Hedwigia, 76:110. Pl. 3, Fig. 19.

This variety has a small pore in the central region of each semicell. This form should be compared with C. subreinschii var. ocellatum West and West from which it can be separated by the slightly divergent lower lateral margin and the lack of an undulation on the upper lateral margin.

Measurements: L. 19-(21.8)u; W. 13.3-(15)u; I. (3)-4.2u

Distribution: NLP, Crawford. New record for Michigan.

63. Cosmarium subreinschii var. ocellatum West and West

West, W. and West, G. S. 1902. Trans. Linn. Soc. Bot., 2nd Ser., 6:165. Pl. 20, Fig. 33.

This species has truncate-pyramidate semicells. The lateral margins are triundulate (including basal and apical angles). The central region of the semicell wall is ornamented with a large scrobiculation, the rest of the semicell wall being punctate. The vertical new is elliptic with central protuberance on each lateral margin.

Measurements: L. 26-28.5u; W. 17-19u; I. 4-5u.

64. Cosmarium Hammeri Reinsch

West and West, 1905. Monogr. Brit. Desm. 2:181. Pl. 62, Figs. 20, 21.

This species has truncate-pyramidate semicells in which the basal angles are broadly rounded and the upper

lateral margins and the apical margins are slightly concave. The vertical view is elliptic and the cell wall is smooth.

Measurements: L. 40-50u; W. 27-35u; I. 11-13u.

Distribution: NLP, Cheboygan (N & A 1932, Welch 1938a).

65. var. protuberans West and West

West and West, 1905. Monogr. Brit. Desm. 2:183. Pl. 62, Figs. 24, 25.

This variety is smaller than the typical and in vertical view has an inflation of the lateral margins.

Measurements: L. 24-35u; W. 18.5-21.5u; I. 7-7.5u.

Distribution: SLP, Calhoun (Pres. and Mag. 1935).

66. Cosmarium retusiforme (Wille) Gutw.

West and West, 1905. Monogr. Brit. Desm. 2:180. Pl. 62, Fig. 19.

The semicells of this species are truncate-pyramidate. The basal angles are broadly rounded, the upper lateral margins slightly retuse and the apices straight and sharply truncate. The vertical view is elliptic, with lateral margins inflated in the median region. This species can be separated from C. retusum (Perty) Rabh. by the lack of granules on the semicell wall and from C. Hammeri Reinsch by the smaller size and the sharper apical angles.

Measurements: L. 22.5-24u; W. 19-19.5u; I. 6-7u.

Distribution: SLP, Macomb (West and West 1898).

67. Cosmarium pokornyanum (Grun.) West and West Pl. 16, Fig.6.

West and West, 1905. Monogr. Brit. Desm. 2:190. Pl. 63, Figs. 11-15.

Characteristics of this species are the somewhat trilobed or truncate-pyramidate semicells. The basal angles are rectangular and slightly retuse. The upper lateral margins are strongly convergent and concave and the apical lobe is narrowly truncate and slightly retuse in the median region. The vertical view is rhomboid-elliptic and the cell wall is smooth.

Measurements: L. 23-(25)-39u; W. 14-(17)-22u; I. (5)-6.5-11u.

Distribution: EUP, Delta; WUP, Menominee. New records for Michigan.

68. Cosmarium granatum Bréb.

West and West, 1905. Monogr. Brit. Desm. 2:186. Pl. 63, Figs. 1-3.

The truncate-pyramidate semicells of this species have rectangular basal angles. The upper lateral margins are straight or slightly convex and converge sharply to the narrowly truncate apex. The vertical view is elliptic and the cell wall is finely punctate. Some of the specimens from Calhoun County have distinctly inflated semicells in which the lateral margins are distinctly convex and the apex is not as clearly truncate as typically.

Measurements: L. 26-(38)-(43)-47u; W. 19-(28)-(30)-30-(32)u; I. 3.8-4.4-(7.5).

Distribution: SLP, Calhoun (2), Barry (2), Washtenaw, Jackson, also Lapeer, Livingston (N & A 1932) and Macomb

(pieters 1894); NLP, Cheboygan, Emmet (N & A 1932) also Cheboygan (Neal 1948); EUP, Alger, also Mackinac (N & A 1932); WUP, Marquette, Menominee.

69. var. subgranatum Nordst.

West and West, 1905. Monogr. Brit. Desm. 2:188. Pl. 63, Figs. 5-8.

This variety is separated from the typical by the different semicell shape. The lower lateral margins are slightly divergent (occasionally slightly retuse medianly) and the upper lateral margins are sharply convergent (and 1-2 undulate) to the narrowly truncate apex. The vertical view is narrowly elliptic with the lateral margins slightly tumid.

Measurements: L. 24-(29)-30u; W. 17-(21)-22u; I. (4.5)-6-9u.

Distribution: Oakland, also Washtenaw (Johnson 1895); Isle Royale (Prescott 1938).

70. Cosmarium subtumidum Nordst.

West and West, 1905. Monogr. Brit. Desm. 63, Figs. 18-20.

This species has pyramidate-semicircular semicells. The basal angles are broadly rounded, the lateral margins convex and the apices broadly truncate and straight. The vertical view is elliptic and the cell wall is minutely punctate.

Measurements: L. 30-42-(44)u; W. 24-34-(39)u; I. 7.5-(10.5)-10.5u.

Distribution: NLP, Roscommon, also Cheboygan, Emmet

(N & A 1932) and Cheboygan (Neal 1948); EUP, Schoolcraft, Alger; Isle Royale (Prescott 1938).

71. var. Klebsii (Gutw.) West and West

West and West, 1905. Monogr. Brit. Desm. 2:193. Pl. 63, Figs. 21-23.

This variety has more broadly rounded basal angles than the typical and the lateral margins are more convergent with a resulting narrower apex.

Measurements: L. 32-41u; W. 29-35u; I. 7-11u.

Distribution: Calhoun (Pres. and Mag. 1935).

72. Cosmarium capense fa. minor West and West

West, W. and West, G. S. 1898. Jour. Linn. Soc. Bot. 33:301. Pl. 17, Fig. 3.

This species has truncate, pyramidate semicells with convex lateral margins and broadly rounded basal angles. The apical margins are straight. The constriction is moderately deep with the sinuses closed inwardly. The vertical view is elliptical.

Measurements: L. 64u; W. 46u; I. 16u.

Distribution: SLP, Washtenaw (West and West 1898).

73. Cosmarium galeritum Nordst. Pl. 16, Fig. 16.

West and West, 1905. Monogr. Brit. Desm. 2:194. Pl. 63, Figs. 24, 25.

The pyramidate-trapeziform or truncate-pyramidate semicells of this species have rounded basal and apical angles. The lateral and apical margins are straight or slightly convex. The vertical view is elliptic and the

semicell wall is punctate. This species resembles C. Lundelli var. ellipticum but is smaller and has more pyramidate semicells.

Measurements: L. (50)-51-(60)u; W. 42-(44)-50u; I. (13.5)-15-18u.

Distribution: NLP, Presque Isle. New record for Michigan.

74. Cosmarium pseudonitidulum Nordst.

West and West, 1905. Monogr. Brit. Desm. 2:195. Pl. 63, Fig. 26.

The subtrapezoid or truncate-pyramidate semicells have rounded basal and apical angles. The slightly convex lateral margins are suberect near the basal angles and sharply convergent above to the broadly truncate and slightly convex apex. The vertical view is elliptic and the cell wall is punctate. The smaller size separates this species from C. galeritum Nordst. and the single pyrenoid in each semicell distinguishes it from C. nitidulum De Not.

Measurements: L. 42-46.8u; W. 33-35u; I. 10-15.6u.

Distribution: SLP Macomb (Pieters 1894); Isle Royale (Prescott 1938).

75. var. validum West and West Pl. 17, Fig. 1.

West and West, 1905. Monogr. Brit. Desm. 2:196. Pl. 63, Figs. 27-30.

This variety is larger than the typical and has less rounded basal angles.

Measurements: 56-(64)-(76)-78u; W. 42-(44)-(48)-50u; I. 15-(15)-(17)-18u.

Distribution: EUP, Chippewa; WUP, Gogebic. New records for Michigan.

76. Cosmarium nitidulum De Not.

West and West, 1905. Monogr. Brit. Desm. 2:197. Pl. 64, Figs. 1-3.

The truncate-subsemicircular semicells of this species have convex lateral margins which converge gradually from broadly rounded basal angles to the small truncate convex apex which may be straight or slightly retuse. The vertical view is elliptic and the cell wall is very minutely punctate. This species can be distinguished from C. pseudonitidulum Nordst. by the presence of two pyrenoids in each semicell.

Measurements: L. 30-41u; W. 23-33u; I. 8-10u.

Distribution: SLP, Wayne (Campbell 1886).

77. Cosmarium variolatum var. cataractarum Racib. fa.

Pl. 16, Fig. 7.

Messikomer, 1938. Hedwigia. 78:173. Pl. 3, Figs. 35, 36.

The semi-elliptic semicells have convex lateral margins which converge upwardly from broadly rounded basal angles to a narrow convex truncate apex. The vertical view is elliptic with each lateral margin possessing a central biundulate protuberance. The semicell wall is coarsely scrobiculate, slightly thickened at the apices

and ornamented with a prominent central mucilage pore. Specimens from Delta County possess a more inflated upper semicell than usually present in var. catacactarum, and thus resemble var. rotundum Messikommer which possesses an apical rather than a central pore. The presence of the central pore, the writer believes, is of sufficient importance to assign these organisms as a forma of var. cataractarum. Other specimens from Barry County have more angular and pyramidate semicells, and have larger measurements. The area around the central pore has a highly refractive surface similar to that found in C. pseudopyramidatum var. lentiferum Taylor.

Measurements: L. (43)-53u; W. (29)-(30)u; I. 7-7.5u.

Distribution: SLP, Barry; EUP, Delta. New records for Michigan.

78. Cosmarium variolatum . Lund. fa. Pl. 16, Fig. 13. West and West, 1905. Monogr. Brit. Desm. 2:2-3. Pl. 64, Figs. 14-16.

The semicells of this species are semi-elliptic. The slightly convex lateral margins converge very gradually from the slightly rounded basal angles to the very narrow, truncate and subretuse apex. The cell wall is coarsely and conspicuously scrobiculate. The semicells are elliptic in vertical view. Specimens from Emmet County are somewhat shorter and more robust than typical figures.

Measurements: L. (30)-32-35u; W. 18-(19)-21u; I. (4.5)-5-6.5u.

Distribution: NLP, Emmet. New record for Michigan.

79. Cosmarium scopulorum Borge.

Borge, 1923. Arkiv. f. Bot. 18:12. Pl. 1, Fig. 9.

This species has truncate-pyramidate to hexagonal semicells. The lower lateral margins are straight and usually slightly divergent, whereas the upper lateral margins are straight or retuse and sharply convergent to the narrowly truncate apex. The vertical view is elliptic with the lateral margins slightly tumid in mid-region. The cell wall is smooth.

Measurements: L. 16-23.4u; W. 14-19.5u; I. 3.9-6u.

Distribution: Isle Royale (Prescott 1938).

80. Cosmarium maculatum Turner.

Turner, W. B., 1893 Kongl. Sv. Vets. Akad. Handl. 25 (5):49. Pl. 7, Fig. 31; Pl. 8, Fig. 68.

This species has vertical semi-elliptic to truncate pyramidate semicells. The incision is shallow with a corresponding wide isthmus. The cell wall is strongly and thickly punctate. The semicell is elliptic in vertical view. This species has a superficial resemblance to Cosmarium pyramidatum Bréb. but has more shallow sinuses and a much larger size.

Measurements: L. 145-160u; W. 75u; I. 47u.

Distribution: NLP, Cheboygan (N & A 1932).

81. Cosmarium pyramidatum Breb.

West and West, 1905. Monogr. Brit. Desm. 2:199. Pl. 64, Figs. 5-7.

This large species has truncate pyramidate semicells. The convex lateral margins taper gradually towards the truncate apices. The vertical view is elliptic and the cell wall is finely and densely scrobiculate. This species can be separated from C. pseudopyramidatum Lund. by the usually larger size and the two pyrenoids in each semicell. Measurements: L. 58-(76)-(82)-(94)-100u; W. 41-(51)-(52)-63u; I. 13.5-(17)-(21)-21u; A. 15-24u.

Distribution: SLP, Calhoun, Barry (2), Livingston, Washtenaw; NLP, Crawford, Emmet, Cheboygan, also Cheboygan (N & A 1932); EUP, Chippewa, Schoolcraft (2), Delta; WUP, Gogebic (3); Isle Royale (Prescott 1937, 1938 fa.).

82. var. angustatum West and West

West and West, 1905. Monogr. Brit. Desm. 2:200. Pl. 64, Fig. 8.

This variety has less convex sides than the typical and is proportionately longer and narrower.

Measurements: L. 90-94-(96)u; W. 48-(53)-54.5u; I. 13.5-18-(21.5)u.

Distribution: SLP, Calhoun (Pres. and Mag. 1935); WUP, Gogebic, also Marquette (Pres. and Mag. 1935).

83. Cosmarium pseudopyramidatum Lund.

West and West, 1905. Monogr. Brit. Desm. 2:201. Pl. 64, Figs. 9-12.

The semicells of this species are truncate-pyramidate or truncate-semi-elliptic in outline. The basal angles

are rounded and the convex lateral margins taper gradually to narrowly truncate apices which have rounded angles. The vertical view is elliptic and the cell wall is punctate. This species is usually smaller than C. pyramidatum Bréb. and has only one pyrenoid per semicell.

Measurements: L. (40)-43-(43)-(47)-65u; W. 25-(27)-(28)-(30)-40u; I. (6.5)-(7)-(9)-14u.

Distribution: SLP, Livingston; NLP, Cheboygan, also Cheboygan and Emmet (N & A 1932); EUP, Alger, Schoolcraft, Chippewa; WUP, Marquette, Gogebic; Isle Royale (Prescott 1938).

84. var. stenonotum Nordst. Pl. 16, Fig. 12.

West and West, 1905. Monogr. Brit. Desm. 2:202. Pl. 64, Fig. 13.

This variety is much larger than the typical and has slightly retuse lateral margins just below the apex.

Measurements: L. 78-80-(90)u; W. 46-48-53u; I. 16-17-(17)u.

Distribution: EUP, Alger. New record for Michigan.

85. var. carniolicum Luetk. Pl. 17, Fig. 2.

Insam and Krieger, 1936. Hedwigia. 76:106. Pl. 2, Fig. 11.

This variety has slightly concave lateral margins. Michigan specimens are slightly smaller than those listed by Insam and Krieger (1936).

Measurements: L. (44)-54.2-54.6u; W. (28)-31.4-32u; I. (9)-12.7-13u.

Distribution: County records lost. New record for Michigan.

86. Cosmarium arctoum var. tatrica Racib. Pl. 16, Fig. 9.
West and West, 1908. Monogr. Brit. Desm. 3:42. Pl. 69, Fig. 4.

This very minute species has cells that are subquadrate in outline with retuse lateral margins which are very slightly constricted. The semicells are subcuneate with slightly diverging lateral margins. The vertical view is elliptic and the cell wall is smooth.
Measurements: L. 9-(10.5)-14u; W. 8-(8.5)-10.5u; I. 5.2-(6.5)-7u.
Distribution: EUP, Schoolcraft. New records for Michigan.

87. Cosmarium minimum West and West Pl. 16, Fig. 10.
West and West, 1908. Monogr. Brit. Desm. 3:66. Pl. 71, Fig. 1, 2.

This minute species has transversely rectangular semicells with slightly rounded angles. The vertical view is elliptic and the cell wall is smooth.
Measurements: L. 8.4-(9)-10.5u; W. (7)-7.2-9u; I. 3-(4)-5u.
Distribution: SLP, Calhoun. New record for Michigan.

88. Cosmarium norimbergense fa. depressum West and West
West and West, 1908. Monogr. Brit. Desm. 3:53. Pl. 69, Figs. 28, 29.

This organism has transversely rectangular semicells with retuse lateral margins. The apical and basal angles are broadly rounded. The vertical view is elliptic and the cell wall is smooth.

Measurements: L. 11-(12.5)-15.6u; W. 11-(11.5)-15.6u; I. 3.5-(5)-5u.

Distribution: SLP, Barry; WUP, Marquette (Pres. and Mag. 1935).

89. Cosmarium exiguum Archer

West and West, 1908. Monogr. Brit. Desm. 3:63. Pl. 70, Figs. 17, 19.

This species has subquadrate semicells with rounded angles. The margins are straight or very slightly convex. The vertical view is elliptic and the cell wall is smooth.

Measurements: L. 14.5-29u; W. 9.5-15u; I. 3-6u.

Distribution: SLP, Washtenaw (West and West 1898).

90. Cosmarium De Baryi Arch.

West and West, 1908. Monogr. Brit. Desm. 3:61. Pl. 70, Figs. 14-16; Pl. 93, Fig. 2.

This large species has the cell moderately constricted, the sinus being open and acute. The semicells are subquadrate with lateral margins that are straight, slightly retuse or convex. The basal angles are angularly rounded and the apical angles broadly rounded. The apices are convex-truncate or convex. The vertical view is almost circular with slightly compressed margins. The cell wall is minutely punctate.

Measurements: L. 100-112-122u; W. 46-(53)-54u; I. 27.5-(38)-30u.

Distribution: NLP, Crawford; WUP, Houghton; Isle Royale (Prescott 1938).

91. Cosmarium quadratum Ralfs.

West and West, 1908. Monogr. Brit. Desm. 3:57. Pl. 70, Figs. 6-8.

This species has subquadrate (vertically subrectangular) semicells which are broadly rounded at the apices. The constriction is moderate with the sinus narrow at the apex, but open outwardly. The basal angles are broadly rounded and slightly protruding and the lateral margins are slightly retuse in some part. This species can be distinguished from C. cucumis (Corda) Ralfs by the axial chloroplasts, the open sinus and the protruding basal angles.

Measurements: L. 48-(65)-65u; W. 25-(34)-40u; I. 12-(21.5)-25u.

Distribution: SLP, Barry(2), Livingston; NLP, Crawford, Emmet, also Cheboygan (N & A 1932); EUP, Alger, Mackinac; WUP, Gogebic.

92. fa. major Irenee-Marie

Irenee-Marie, 1938. Flor. Desm. de la Reg. Mont. 175. Pl. 29, Figs. 3, 4.

This form differs from the typical only in its larger size.

Measurements: L. 71-(85)u; W. 40-(44)-46u; I. 23.5-(25)-34u.

Distribution: SLP, Washtenaw; Isle Royale (Prescott 1938, C. quadratum).

93. Cosmarium plicatum Reinsch

West and West, 1908. Monogr. Brit. Desm. 3:60. Pl. 70, Figs. 9, 10.

This species has truncate-pyramidate to vertically subrectangular semicells. The constriction is fairly deep with the sinus linear and closed inwardly but open outwardly. The lateral margins are straight or slightly convex. The vertical view is elliptic and the cell wall is minutely and densely punctate. Specimens from Ingham County have the apical angles more rounded and the apices more convex than those shown by West and West (1908). This species should be compared with C. quadratum Ralfs from which it can be separated by the closed sinus and convex side, and with C. cucumis (Corda) Ralfs. and C. subcucumis Schmidle which have proportionately deeper constrictions, less rectangular semicells and a usually longer length.

Measurements: L. 48-(49)-62u; W. 26-(27)-35u; I. (14)-16.5-20u.

Distribution: SLP, Ingham, also Calhoun (Pres. and Mag.1935).

94. var. hibernicum W. West

West and West, 1908. Monogr. Brit. Desm. 3:61. Pl. 70, Figs. 12, 13.

This variety is usually larger than the typical and has a slightly different semicell shape. The apices are strongly convex in the median part and the lateral margins are slightly concave below the apical angles.

Measurements: L. 62.4-96u; W. 35-52u; I. 17-21u.

Distribution: Isle Royale (Prescott 1938).

95. Cosmarium angulare Johnson

Johnson, 1894. Bull. Torr. Bot. Club. 21 (7):290. Pl. 211, Fig. 14.

This species has hexagonal-elliptical semicells. The lower lateral margins are slightly divergent and the upper lateral margins are strongly convergent. The apical margin is straight. The angles (except the apical angles) are thickened and often acutely pointed. The vertical view is elliptic with two small sharp projections on each lateral margin and sometimes one at each end. The cell wall is minutely punctate.

Measurements: L. (28)-30-32u; W. 20-(26)-30u; I. 6-(6.5)-10u.

Distribution: SLP, Calhoun, Barry, Oakland, also Macomb (Johnson 1894); NLP, Roscommon, Crawford; EUP, Schoolcraft; Isle Royale (Prescott 1938).

96. var. octangulare var. nov. Pl. 16, Fig. 11.

This variety is separated from the typical by the eight-sided semicell, the more exserted apices, and the slightly retuse upper lateral margin. Intermediate forms between the typical form and this variety have been shown in illustrations of Prescott (1938) and Irenee-Marie(1938) in which some of the semicells have three sides in each lateral margin. The vertical view is elliptic with each

lateral margin possessing two sharp projections as in the typical. The angles may or may not be conspicuously thickened and sharply pointed as in the typical.
Measurements: L. (21.5)-(26)u; W. (19)-(24)u; I. (7)-(8.7)u.
Distribution: SLP, Calhoun.

97. Cosmarium polygonum (Naeg.) Arch.
West and West, 1908. Monogr. Brit. Desm. 3:76. Pl. 71, Figs. 32-34.

This small species has hexagonal semicells in which the lateral angles are slightly rounded and produced. Both upper and lower lateral margins are slightly retuse and the apical margin is either slightly retuse or straight. The vertical view is elliptic with a single conical protuberance on each lateral margin. The cell wall is smooth or very finely punctate. The conical lateral protuberances in vertical view and the more produced lateral angles separate this species from C. abbreviatum Racib.
Measurements: L. 15-21u; W. 14-18u; I. 3-7u.
Distribution: EUP, Schoolcraft, also Luce (N & A 1932); WUP, Marquette.

98. Cosmarium bireme Nordst. Pl. 16, Fig. 14.
West and West, 1908. Monogr. Brit. Desm. 3:77. Pl. 71, Figs. 36, 37.

This small species has subellipsoid-hexagonal semicells in which the lateral and basal angles are obtuse. The vertical view is elliptic with a more or less long

papilla in the center of each lateral margin. The cell wall is smooth. This species is very similar to C. polygonum from which it can be distinguished by the smaller size, the less produced lateral angles and the straight lateral margins.

Measurements: L. 12-(12.9)-13.5u; W. 10-(10.7)-14.5u; I. 2.5-4-(4.3)u.

Distribution: SLP, Calhoun. New record for Michigan.

99. Cosmarium pygmaeum Arch.

West and West, 1908. Monogr. Brit. Desm. 3:73. Pl. 71, Figs. 22-31.

This small species has variably shaped semicells. Usually they are transversely oblong-rectangular, but often transversely oblong-hexagonal. The basal angles are obtuse and the apical angles are obtuse or obliquely truncate. There is a median swelling of each lateral margin. In addition, there is a minute papilla on each lateral margin near the poles. The cell wall is smooth. The three projections on each lateral margin in vertical view clearly distinguishes this small species.

Measurements: L. 7-12u; W. 7-12.5u; I. 2-5.5u.

Distribution: SLP, Macomb (West and West 1898).

100. Cosmarium geometricum var. suecium Borge. Pl. 16, Fig. 15.

Borge, 1921. Sjon. Takerns Fauna och Flora. 4:21. Pl. 2, Fig. 21.

This small species has hexagonal semicells. The basal angles are broadly rounded (lower lateral margin is convex)

and the upper lateral margin is slightly retuse as in the apical margins. The vertical view is elliptic with the lateral margins somewhat tumid, and the middle portion bearing a single conical protuberance. The broadly rounded basal angles and the small size distinguish this species from C. polygonum (Naeg.) Arch. and C. bireme Nordst.

Measurements: L. 9-(10.5)-12u; W. 9-(10.5)-11u; I. 3-(3)-4.5u.

Distribution: SLP, Calhoun. New record for Michigan.

101. Cosmarium subcapitulum West. Pl. 17, Fig. 5.

West and West, 1908. Monogr. Brit. Desm. 3:73. Pl. 71, Fig. 17.

This species has transversely elliptical-hexagonal semicells. The upper and lower lateral margins converge to form a bluntly rounded angle. The apex is straight or slightly retuse. The vertical view is elliptic or fusiform-elliptic with subacute poles. The cell wall is smooth.

Measurements: L. (16.5)-17u; W. (17)-19u; I. 4-(4.3)u.

Distribution: SLP, Livingston. New record for Michigan.

102. Cosmarium sphagnicolum West and West fa. Pl. 17, Fig. 6.

West and West, 1908. Monogr. Brit. Desm. 3:71. Pl. 71, Figs. 11-14.

This small species has subtrapeziform to transversely hexagonal semicells. The constriction is moderately deep with the sinus short and broadly open. The apical margin

is straight or slightly retuse. Each upper angle is furnished with a small intramarginal granule. The vertical view is elliptic with a small papilla on each side of the bluntly rounded poles. Specimens from Schoolcraft County agree well with the semicell shape, but the constriction was less pronounced and the facial papillae were lacking.

Measurements: L. (10)-10.5-11u; W. (10)-11-13.5u; I. 5-5.5-(6.5)u.

Distribution: EUP, Schoolcraft. New record for Michigan.

103. Cosmarium abbreviatum Racib. Pl. 17, Fig. 3.

West and West, 1908. Monogr. Brit. Desm. 3:84. Pl. 72, Figs. 9-11.

This species has elongate-hexagonal semicells in which the angles are slightly rounded and the apices are straight and broadly truncate. The vertical view is narrowly elliptic and the cell wall is smooth.

Measurements: L. 14-22-(23.5)u; W. 13-22-(28)u.

Distribution: SLP, Inhgam. New record for Michigan.

104. var. minor West and West Pl. 17, Fig. 4.

West and West, 1908. Monogr. Brit. Desm. 3:85. Pl. 72, Fig. 12.

This variety is typically about half the size of the typical. The writer chooses to include here, extremely small forms (up to 13u long) although the Wests (1908) indicate the length of this variety to be 8u.

Measurements: L. 8-(13)u; W. 9-(13)u; I. (4.5)u.

Distribution: SLP, Barry. New record for Michigan.

105. var. planctonicum West and West Pl. 17, Fig. 10.

West and West, 1908. Monogr. Brit. Desm. 3:85. Pl. 72, Fig. 13.

This variety has the upper angles more broadly rounded than the typical.

Measurements: L. 19-(19)-29u; W. (19)-22-30u; I. 5.5-(6)-8u.

Distribution: WUP, Gogebic. New record for Michigan.

106. C. sexangulare Lund.

West and West, 1908. Monogr. Brit. Desm. 3:81. Pl. 22, Fig. 3.

This moderately large species has transversely-elliptic-hexagonal semicells in which the angles are rounded and the upper lateral margins are sometimes slightly concave. The constriction is deep, the sinus closed inwardly but open outwardly. The vertical view is elliptic and the cell wall is minutely punctate.

Measurements: L. (40)-42u; W. 33-36-(38)u;I. 7-(8)-12u.

Distribution: SLP, Barry; NLP, Cheboygan (N & A 1932), (Neal 1948); EUP, Mackinac; WUP, Menominee, Houghton; Isle Royale (Prescott 1938).

107. fa. minima Nordst.

West and West, 1908. Monogr. Brit. Desm. 3:82. Pl. 72, Figs. 4, 5.

Typically this forma is about 1/3 the size of the typical. The upper lateral margins and the apical margins

are retuse. Specimens from Calhoun County agree well with the characteristics of this forma except for the straight lateral margins.

Measurements: L. 13.5-15-(15.2)u; W. 11-12-(12)u; I. 3-(4)u.

Distribution: SLP, Calhoun; Isle Royale (Prescott 1938).

108. Cosmarium rectangulare Grun.

West and West, 1908. Monogr. Brit. Desm. 3:54. Pl. 70, Figs. 1, 2.

Typically this species has subrectangular semicells with basal angles that are subrectangular and rounded. The apical margin is straight and the upper lateral margin is obliquely truncate. The vertical view is subelliptic and the cell wall is finely punctate. Specimens from Calhoun County have the basal angles more broadly flattened and rounded than illustrations shown by West and West (1908).

Measurements: L. 37-(38)-(43)-47u; W. 30-(32)-(34)-36u; I. 9-(9.5)-(10.5)-12.

Distribution: SLP, Barry, Calhoun; NLP, Roscommon, also Cheboygan (N & A 1932); EUP, Mackinac; Isle Royale (Prescott 1938).

109. var. hexagonum (Elfv.) West and West

West and West, 1908. Monogr. Brit. Desm. 3:56. Pl. 70, Fig. 4.

This variety is usually smaller than the typical and generally is about as long as wide. The upper lateral

margins are longer than in the typical and give the semicells a more equally hexagonal appearance. The measurements are considerably different than those given by West and West (1908) and agree better with measurements of Prescott (1938).

Measurements: L. 28-30-(38)-(41)-43u; W. 24-27-(29)-(32)-32u; I. 7-8-9.7-(10.5)u.

Distribution: SLP, Washtenaw; Isle Royale (Prescott 1938).

110. Cosmarium refringens Taylor. Pl. 17, Fig. 7.

Taylor, W. R., 1934. Pap. Mich. Acad. Sci. Arts and Letters. 19:265. Pl. 50, Fig. 10.

This species has semicells that are hexagonal-oval in outline. The semicell walls are conspicuously thickened, especially in the regions of the lateral angles which are more or less broadly rounded. The vertical view is elliptic with the lateral walls greatly thickened and somewhat tumid. The cell wall is sparsely and finely punctate. This species is very difficult to separate from C. pseudoprotuberans Kirchm. The latter has less broadly rounded lateral angles in front view, and more acutely rounded poles in vertical view.

Measurements: L. 38-(41)u; W. (34)-35u; I. 8-(9)u.

Distribution: Presque Isle. New record for Michigan.

111. Cosmarium pseudoprotuberans Kirchn.

West and West, 1908. Monogr. Brit. Desm. 3:82. Pl. 72, Figs. 6-8.

The semicells of this species are transversely sub-elliptic or hexagonal-elliptic. The lateral angles are obtuse (usually with somewhat thickened walls) and the lower lateral margins are as long or longer than the upper lateral margins. The vertical view is elliptical with slightly tumid and thickened walls in the middle of the lateral margins. The cell wall is punctate. The less rounded lateral angles in front view, and the more broadly rounded poles in vertical view distinguish this species from C. refringens Taylor. C. Sexangulare Lund. is usually slightly larger, more angular and without thickened walls in the regions of the lateral angles.

Measurements: L. 20-(34)-(40)-41u; W. 18-(25)-(32)-36u; I. 8-(10)-(10.5)-10.5u.

Distribution: SLP, Barry, Washtenaw, Livingston, Oakland, also Macomb (Johnson 1895); NLP, Crawford; EUP, Schoolcraft; WUP, Marquette, Houghton; Isle Royale (Prescott 1938).

112. Cosmarium Moerlianum var. brasiliense Borge fa. Pl. 17,Fig.8.

Borge, 1918. Arkv. f. Bot. 15(13):36. Pl. 3, Fig. 13.

This organism has unequally polygonal semicells. The basal angles of the semicells are two-sided and the upper lateral margins are slightly retuse and convergent toward the straight and narrowly truncate apices. The semicell wall is unornamented except for two subapical granules. A single specimen from Calhoun County agrees well with this variety although the subapical ornamentation was not clearly granular, but merely slight protuberances from the wall.

Measurements: L.(25)-28-29u; W.(19)-22u; I. 7-(7)u.

Distribution: SLP, Calhoun. New record for Michigan.

113. Cosmarium humile var. striatum (Boldt.) Schmidle

West and West, 1908. Monogr. Brit. Desm. 3:223. Pl. 85, Figs. 21, 22.

This small organism has trapeziform-rectangular semicells in which the lower lateral margins are slightly biundulate and perpendicular to the base and the upper lateral margins are retuse and convergent to the apices. The apical margin is broadly truncate with 2-4 undulations. Between the undulations, the semicell wall is slightly thickened and forms short vertical strips. The vertical view is elliptic.

Measurements: L. 12.5-15-16u; W. 12-(13)-17u; I. 4-(4.3)-5u.

Distribution: SLP, Oakland; NLP, Cheboygan (Taft 1939).

114. Cosmarium clepsydra Nordst. Pl. 17, Fig. 16.

West and West, 1908. Monogr. Brit. Desm. 3:98. Pl. 73, Figs. 6, 7.

This small species has angularly subsemicircular or broadly subtriangular semicells. The lower lateral margins are two-sided with a blunt angle, and the upper lateral margins are retuse, straight or convex and convergent to the truncately rounded apices. The vertical view is elliptical with a broad central protuberance from each lateral margin (Rhomboid with concave lateral margins and obtuse angles). The cell wall is smooth.

Measurements: L. 18-21-(21.5)u; W. 18-(21.5)-22u; I. 4.5-(6)-6.5u.

Distribution: EUP, Schoolcraft. New record for Michigan.

115. Cosmarium difficile Luetkm. Pl. 17, Fig. 9.

West and West, 1908. Monogr. Brit. Desm. 3:96. Pl. 73, Figs. 1-3.

This species has subrectangular or polygonal semicells with rounded angles and retuse lateral and apical margins. The semicell wall is thickened slightly in the regions of retuseness. The semicell wall is finely punctate and usually decorated with three transverse rows of minute scrobiculations. Several authors (Taylor 1934, Irenee-Marie 1938) have pointed out that these scrobiculations are often only weakly or not at all visible. This was true of many of the Michigan specimens examined by the writer.

Measurements: L. (23)-25-(25)-38u; W. (15)-16.5-(17)-24u; I. 4-(4)-6u.

Distribution: SLP, Barry; EUP, Delta. New record for Michigan.

116. var. sublaeve Luetkm.

West and West, 1908. Monogr. Brit. Desm. 3:97. Pl. 73, Figs. 4, 5.

This variety has less produced apices than the typical and the upper lateral margins are not retuse. The lateral margins may also be straight.

Measurements: L. 31-(35)-39u; W. (17)-20-24u; I. 5-6-(6.5)u.

Distribution: SLP, Calhoun; WUP, Marquette (Pres. and Mag. 1938).

117. var. dilatatum Borge

Borge, 1925. Arkiv. f. Bot. 19:4. Pl. 1, Fig. 38.

This variety has semicells that are unequally polygonal in outline and wider at the upper portion than at the base.

Measurements: L. 23-(36)-36u; W. 17.5-(22)-22u; I. 5-(5)-7u.

Distribution: NLP, Roscommon, Emmet; Isle Royale (Prescott 1938).

118. Cosmarium meneghinii Breb.

West and West, 1908. Monogr. Brit. Desm. 3:90. Pl. 72, Figs. 29-32.

This small species has semicells that are subrectangular in the lower part and pyramidate in the upper part. The lower lateral (sometimes slightly retuse) margins are perpendicular or slightly divergent to the base. The upper lateral retuse margins are convergent to the broadly retuse apices which have rounded angles. The vertical view is elliptic and the cell wall smooth.

Measurements: L. 12.5-(22)-24u; W. 9.5-(15)-17u; I. 3-6-(6.5)u.

Distribution: SLP, Calhoun, Clinton, also Macomb (Pieters 1894) and Ingham (N & A 1932); EUP, Houghton; Isle Royale (Prescott 1938).

119. Cosmarium angulosum Bréb.

West and West, 1908. Monogr. Brit. Desm. 3:93. Pl. 72, Figs. 35, 36.

This small species has subquadrate or subrectangular semicells. The lower lateral margins are straight and perpendicular to the base, and the upper lateral margins are straight and convergent to the straight apical margin. The vertical view is elliptic and the cell wall smooth.

Measurements: L. 14.5-(19.5)-28u; W. (10.5)-(13)-13.5-18u; I. 3.2-(4.3)-6u.

Distribution: SLP, Barry, Calhoun, Washtenaw, also Ionia Wade (1949); WUP, Gogebic..

120. var. concinnum (Rabh.) West and West

West and West, 1908. Monogr. Brit. Desm. 3:94. Pl. 72, Figs. 37, 38.

This variety is somewhat smaller than the typical and has the upper angles of the semicells obliquely truncate or retuse.

Measurements: L. 10.5-(13)-13u; W. 8-(12)-12u; I. 2.6-(4)-4.5u.

Distribution: SLP, Barry, also Ionia (Wade 1949).

121. Cosmarium Regnellii var. minimum Eichl. and Gutw.

Pl. 17, Fig. 11.

Taft, 1945. Ohio. Jour. of Sci. 45:199. Pl. 3, Fig. 28.

This small apices has trapezoid-hexagonal (almost rectangular in outline) semicells. The lower lateral margins are slightly divergent and much longer than the upper lateral margins which are deeply retuse. The apical margin is straight and wide. The vertical view is elliptic and the cell wall is smooth.

Measurements: L. 11-(12)-14u; W. 11-(11)-12u; I. 3-(4)-4u.

Distribution: SLP, Calhoun; WUP, Gogebic. New records for Michigan.

122. fa. basigranulatum Magnotta

Prescott and Magnotta, 1935. Pap. Mich. Acad. Sci. Arts and Letters, 20:161. Pl. 27, Fig. 7.

This organism has hexagonal semicells in which the retuse and divergent lower lateral margins and the retuse and convergent upper lateral form broadly rounded lateral angles. The apices are straight and possess rounded angles. Several tubercular thickenings are present at each basal angle.

Measurements: L. 18-22u; W. 14-16u; I. 4u.

Distribution: SLP, Calhoun (Pres. and Mag. 1935).

123. Cosmarium repandum fa. minor West and West

West and West, 1908. Monogr. Brit. Desm. 3:54. Pl. 69, Figs. 31, 32.

This organism has transversely trapezoid-oblong semicells which are widest above the middle. The slightly retuse lower lateral margins are very slightly divergent and the upper lateral margins are convex and convergent to the flat apices. This organism resembles C. rectangulare Grun. but the slight retuseness of the lower lateral margins and the greatest width of the semicell above the middle, and the smaller size clearly distinguish it.

Measurements: L. 15-22u; W. 14-20u; I. 5.5-8u.

Distribution: NLP, Cheboygan (Taft 1939).

124. Cosmarium laeve Rabh.

West and West, 1908. Monogr. Brit. Desm. 3:99, Pl. 73, Figs. 8-19.

The semi-elliptic or semi-oblong elliptic (sometimes almost pyramidate with convex lateral margins) semicells of this species have a narrowly truncate and retuse apices. The vertical view is elliptic and the cell wall is punctate or punctate-scrobiculate.

Measurements: L. 15-(17)-34u; W. 11.5-(13)-23u; I. 2.8-(3.3)-6.7u.

Distribution: SLP, Barry; NLP, Emmet, also Emmet (N & A 1931).

125. var. octangularis (Wille) West and West Pl. 17, Fig. 15.

This small organism has angular semicells which are about eight-sided. The lateral margins have three straight or slightly curved sides. The apices are retuse. The vertical view is elliptic. Specimens from Calhoun County agree well with the description of this organism, although they are shorter and stouter and have broader and less retuse apices than those illustrated by West and West (1908). They appear identical with Irenee-Marie's (1938) illustration of C. repandum var. minor West and West, and superficially similar to C. Meneghini var. nanum Wille (as illustrated by Taylor 1934) and C. laeve Rabh. as illustrated by Insam and Krieger (1936). The measurements of the specimens above except for Irenee-Marie's, were slightly

greater than the Michigan specimens. The writer believes that the slightly retuse apices and angular expression sometimes found in C. laeve, necessitates the assigning of these specimens to the var. octangularis.

Measurements: L. (17)-21u; W. (12.5)-17-19u; I. (4.5)-6.5-7.5u.

Distribution: SLP, Calhoun. New record for Michigan.

126. Cosmarium quadratulum (Gay) De Toni Pl. 17, Fig. 14. West and West, 1908. Monogr. Brit. Desm. 3:121. Pl. 72, Fig. 33; Pl. 93, Fig. 4.

This small species typically has transversely sub-rectangular semicells with the lateral margins and apices, retuse and the basal and upper angles obliquely-truncate. The vertical view is elliptic, and the cell wall is smooth. Collections from several counties are very similar to those illustrated by West and West (1908). However, other specimens appear somewhat intermediate with C. Regnelli Wille. These specimens are roughly octangular in outline, with the lower lateral margins slightly divergent and extending about half the length of the semicells. Just above the lower lateral margins, there is a sharp constriction so that a small shoulder is formed, above which the lateral margin is perpendicular or slightly convergent. They appear closest to individuals of C. quadratulum illustrated by Insam and Krieger (1938).

Measurements: L. 12-(17)-20u; W. 10-(13)-(15)-17u; I. 2-(3.5)-6u.

Distribution: SLP, Barry, Calhoun; EUP, Chippewa; WUP, Gagebic. New record for Michigan.

127. var. applanatum Insam and Krieger Pl. 17, Fig. 12.

Insam and Krieger, 1936. Hedwigia. 76:107. Pl. 3, Fig.17.

This small organism has trapezoid semicells. The basal angles are broadly rounded and slightly produced, and the lateral margins are slightly concave. The apical margins are straight. Michigan specimens from Barry County are similar to this variety, although the apices are slightly retuse.

Measurements: L. (12)-12.6-17u; W. (10.5)-11.8-14.5u; I. 3.7-(4)-4.2u.

Distribution: SLP, Barry. New record for Michigan.

128. Cosmarium Regnesii var. tritum West Pl. 17, Fig. 13.

West and West, 1908. Monogr. Brit. Desm. 3:38. Pl. 68, Figs. 35, 36.

This very small organism has semicells which are irregularly hexagonal. The convex and divergent lower lateral margins form a broadly rounded lateral angle with the deeply retuse and convergent upper lateral margin. The apices are straight and broadly truncate. The sinus between the semicells is open and obtuse at the apex. Specimens from Barry County are assigned here, although the lateral angles are more broadly rounded than figures shown by West and West (1908). They should be compared with C. polygonum Naeg. from which they differ in the

shorter and open sinus and the lack of central protuberances on the semicell, and with C. Regnellii Wille which has a deep linear sinus.

Measurements: L. 6.6-8.5-(10.5)u; W. 6.6-8.5-(10.5)u; I. 3.7-5-(5.5)u.

Distribution: SLP, Barry. New record for Michigan.

Key to Species of Cosmarium

Section B. Semicells with Granulate or Verrucose Walls

1. Outline of semicells circular, semicircular, subcircular or subsemicircular 2

1. Outline of semicells otherwise . . . 8

2. Outline of semicells circular or subcircular . . . . . (129) C. praegrande

2. Outline of semicells semicircular or subsemicircular . . 3

3. Margin of semicells crenate . . . . (130) C. caelatum

3. Margin of semicells not crenate, but entire 4

4. Semicells with a large supraisthmial granule (1 or more) . . 5

4. Semicells without large conspicuous supraisthmial granules . 6

5. Semicells with an intramarginal series of verrucae . . . . . (141) C. taxichondrum

5. Semicells without an intramarginal series of verrucae . . . . . (131) C. monomazum var. polymazum and (132) var. tristichum

6. Sinus deep and linear . . . . . (133) C. intermedium

6. Sinus shallow and open 7

7. Width of isthmus 15-17u . . . . . (134) C. excavatum var. duplo-major

7. Width of isthmus 11-14u . . . . . (135) C. isthmium

8. Semicells circular in transverse view 9

8. Semicells not circular in transverse view 11

9. Cell length over 65u . . . . . (136) C. tesselatum

9. Cell length less than 65u 10

10. Cell wall ornamented with transverse rows of nodules . . . . (139) C. annulatum

10. Cell wall ornamented with transverse rows of rounded warts (granules) . . . . . (cf. (137) C. cylindricum) (138) C. elegantissimum var. simplicius

11. Semicells transversely elliptic, subelliptic, oblong-elliptic or reniform (rarely rhomboid-elliptic) . . 12

11. Semicells otherwise 29

12. Semicells distinctly reniform . 13

12. Semicells not distinctly reniform 17

13. Apices of semicells elevated . . . . (157) C. ornatum

13. Apices of semicells not elevated . . 14

14. Cell length below 15u, cell wall minutely punctate-granulate . . . . . (41) C. subdepressum

14. Cell length above 15u, cell wall with well developed granules. 15

15. Cell length below 40u 16

15. Cell length above 40u . . . . . (146) C. reniforme

16. Central area of semicell above isthmus with five vertical series of granule . . . . . (148) C. subreniforme

16. Central area of semicell not as above . . . . . (149) C. Netzerianum

17. Semicells elliptic, broadly elliptic or subelliptic, (rarely rhomboid elliptic) 18

17. Semicells otherwise 29

18. Semicells rhomboid-elliptic (sometimes with a slight apical retuseness) 19

18. Semicells not rhomboid elliptic 20

19. Cell length below 25u . . . . . (151) C. Wittrockii var. quasidepressum

19. Cell length above 25u . . . . . (150) C. Raciborskii

20. Semicells ornamented with granular teeth 21

20. Semicells ornamented with granules 22

21. Granules restricted to or just within lateral margin . . . . . (158) C. dentatum

21. Granules present upon lateral and within apical margin . . . . . (152) C. Eloiseanum var. depressum

22. Semicells narrowly oblong-elliptic 23

22. Semicells not narrowly oblong-elliptic 24

23. Apices slightly elevated . . . . . (159) C. commissurale var. crassum

23. Apices not slightly elevated . . . . (160) C. trachypleurum var. minus

24. Granules arranged in pairs . . (154) C. ordinatum

24. Granules not arranged in pairs. 25

25. Length of cells more than 50u . . . 26

25. Length of cells less than 50u . . . 27

26. Length of cells more than 80u . (164) C. Brebissonii

26. Length of cells less than 80u . (163) C. logiense

27. Upper central region of the semicell wall with two strongly developed warts . . . . . (155) C. bimamillatum

27. Upper central region of the semicell wall without warts 28

28. Central region of semicell wall with granules arranged in some pattern . . . . . (cf. (156) C. pseudornatum) (157) C. ornatum

28. Central region of semicell wall without granules arranged in a pattern, granules arranged regularly in vertical series upon entire semicell wall . . (161) C. portianum

29. Semicells more or less rectangular or subrectangular (occasionally with convex apices) 30

29. Semicells more or less pyramidate, truncate-pyramidate, subpyramidate, trapeziform, or trapeziform-like with slightly rounded lateral margins 44

30. Semicells vertically rectangular or subrectangular (with convex apices) 31

30. Semicells transversely rectangular or subrectangular 32

31. Lateral margins nearly parallel, except near apices; constriction often sublinear . . . . . (165) C. amoenum

31. Lateral margins subparallel; constriction a slight notch . . . . . (167) C. pseudoamoenum

32. Margin of semicells crenate-undulate . . . . . (206) C. crenatum

32. Margin of semicells not crenate-undulate 33

33. Semicells uniformly granulate . . . 37

33. Semicells not uniformly granulate . 34

34. Length of semicells above 60u . (168) C. ungerianum var. subtriplicatum

34. Length of semicells below 60u . 35

35. Cells small, less than 40u long, with a sharp papilla-like protuberance in the central area of the semicell wall . . . . . (169) C. novae-semilae var. sibericum

35. Cells large, more than 40u. long, without sharp papilla-like protuberance as above 36

36. Semicells with two transverse linear series of granules which are separated by scrobiculations . . . . . (171) C. triplicatum

36. Semicells with numerous granules, but not arranged in two linear series and not separated by scrobiculations . . . (170) C. nudiceps

37. Lateral margins of semicells in vertical view strongly tumid; granules small . . . . . (cf. (182) C. biretum var. minus) (177) C. subbroomei

37. Lateral margins of semicells in vertical view not tumid, granules larger 38

38. Semicell wall punctate between granules 39

38. Semicell wall not punctate between granules 41

39. Apices slightly retuse in median portion . . . . . (176) C. quadrum var. sublatum

39. Apices straight or slightly convex . 40

40. Lateral margins parallel . . . (172) C. margaritatum

40. Lateral margins slightly divergent . . . . . (178) C. conspersum var. latum

41. Lateral margins parallel 42

41. Lateral margins slightly divergent . (178) C. conspersum var. latum

42. Cell length more than 50u . . . 43

42. Cell length less than 50u . . . (180) C. pseudobroomei

43. Apical margins convex . . . . . (179) C. conspersum var. rotundatum

43. Apical margins slightly retuse . . . (175) C. quadrum

44. Cells as long as wide, or slightly longer than wide . . 45

44. Cells 1 1/4 times longer than wide, or longer 75

45. Upper central region of semicell with granules in a transverse row, semicell hexagonal with strongly punctate wall . . . . . (181) C. mediogemmatum

45. Semicells without the above combination of characteristics 46

46. Width of semicell greatest at upper lateral angle . . . . . (182) C. biretum fa. minus

46. Width of semicell not greatest at upper lateral angle . . . 47

47. Cell length usually less than 42u . 57

47. Cell length usually more than 42u . 48

48. Apex of semicell truncate and elevated 49

48. Apex of semicell not elevated . 53

49. Semicell with two inflations on each lateral margin (in vertical view). (183) C. Turpinii

49. Semicell with a single inflation or none on each lateral margin (in vertical view) 50

50. Central region of semicell wall smooth 52

50. Central region of semicell wall not smooth 51

51. Lateral margins with a subrectangular incision between apical and basal lobes; cell length 34-45u . (184) C. protractum

51. Lateral margins undulate between apical and basal angles; cell length 55-80u . . . . . (186) C. quasillus

52. Cell length usually less than 48u; basal angles broadly rounded . . . . . (187) C. vexatum

52. Cell length usually more than 48u; basal angles subrectangular . . . . . (188) C. sportella var. subnudum

53. Semicell wall with a reticulat network formed by six triangular depressions around each granule . . (189) C. cosmetum

53. Semicell wall not as above 54

54. Semicell without lateral inflations in vertical view . . . (190) C. margaritiferum

54. Semicells with lateral inflations in vertical view . . . 55

55. Lateral intramarginal granules arranged in pairs 56

55. Lateral intramarginal granules not arranged in pairs . . . . . (191) C. radiosum

56. Semicells subtrapeziform, lower lateral margins subparallel, upper lateral margins slightly convergent . . . . . (210) C. costatum

56. Semicells trapeziform-semicircular; lateral margins convex and convergent . . . . . (192) C. formosulum

57. Semicells without lateral inflations in vertical view . . . . . (194) C. furcatospermum

57. Semicells with lateral inflation in vertical view 58

58. Semicells almost semicircular, with lateral margins slightly angular . . . . . (195) C. pseudotaxichondrum var. Foggii

58. Semicells otherwise 59

59. Lateral inflation (in vertical view) papilla-like . . . . . (196) C. Blytii

59. Lateral inflation (in vertical view) not papilla-like 60

60. Central region of semicell wall not as [illegible] 61

60. Central region of semicell wall with two transverse rows of large granules (3 upper, 2 lower), the granules interspersed with punctations . . (197) C. quinarium

61. Lateral margins crenate and/or emarginate, with distinct sinuses between granules or pairs of granules 66

61. Lateral margins entire or slightly undulate-crenulate, with very shallow sinuses between granules or pairs of granules 62

62. Central area of semicell with about five vertical series of granules 63

62. Central area of semicell without five vertical series of granules 64

63. Cell length less than 30u . . . . . (198) C. Kjellmanii

63. Cell length more than 30u . . . . . (148) C. subreniforme

64. Supraisthmial region of semicell wall with either a single granule, or if more than one granule, then with one granule much larger than others . . . (199) C. Boeckii

64. Semicell otherwise 65

65. Granules of the same size, or if of two sizes, larger granules restricted to central area of semicell wall . . . . . (cf. (202) C. cruciatum) (200) C. punctulatum

65. Granules of two different sizes, the larger granules extending vertically from the apex to near isthmus . (203) C. anisochondrum

66. Each lateral margin with four minute basal crenations and one large upper crenation . . (204) C. calcareum

66. Each lateral margin otherwise . 67

67. Central area of semicell ornamented with three elongate granules, one of which, at least, is divided into a short and a long part . . . . (205) C. sexnotatum var. tristriatum

67. Central area of semicell ornamented otherwise 68

68. Crenations, especially upper lateral ones, sharply angular, often emarginate 72

68. Crenations with broadly rounded angles 69

69. Outline of semicell nearly rectangular . . . . . (206) C. crenatum

69. Outline of semicell trapeziform-semicircular or trapeziform-pyramidate 70

70. Central area of semicell with vertical series of granules . 71

70. Central area of semicell without vertical series of granules . . . . . (207) C. modestum

71. Lateral crenations (counting apical and basal angles) 5-6. . . . . (208) C. subcrenatum

71. Lateral crenations four (counting apical and basal angles) . . . . . (209) C. subprotumidum

72. Central area of semicell wall with 5-7 vertical granulate ridges . . . . . (210) C. costatum

72. Central area of semicell wall with 3-5 subvertical series of granules 73

73. Cell length over 25u . . . . . (211) C. subcostatum

73. Cell length below 25u 74

74. Cell width 18-21u . . . . . (212) C. subcostatum var. minor

74. Cell width 21.5-23.5u . . . . . (213) C. norvegicum

75. Lateral margins entire, usually ornamented with granules 82

75. Lateral margins crenate, crenations sometimes finely granulate 76

76. Crenations bigranulate 77

76. Crenations not bigranulate . . 79

77. Twelve or more crenations in each semicell 78

77. Less than twelve crenations in each semicell . . . . . (214) C. nasutum

78. A single basal transverse row of granules distinctly isolated from upper transverse rows of granules (in central ornamented region of semicell wall . . . (215) C. binum

78. A single basal transverse row of granules not isolated from upper transverse rows of granules . . . . . (216) C. subspeciosum

79. Lower central region of semicell wall with at least five vertical series of granules 80

79. Lower central region of semicell wall without five vertical series of granules 81

80. Cell length more than 65u . . . (218) C. supraspeciosum

80. Cell length less than 65u . . . (219) C. speciosum

81. Granules on semicell wall simple . . (220) C. speciosum var. simplex

81. Granules on semicell wall not simple, but flattened warts . . . . . (224) C. ochthodes

82. Semicell decorated with triangular thickenings of the wall; thickenings arranged in series around a single large scrobiculation so that the wall appears to have reticulate linear grooves with a coarse scrobiculation at each intersection . . . . . (223) C. decoratum

82. Semicell wall otherwise 83

83. Lateral margins deeply concave in central part . . . . . (227) C. retusum

83. Lateral margins straight or convex . 84

84. Granules restricted to marginal region, sometimes with several transverse rows near base of semicells 85

84. Granules distributed over entire semicell, except in some cases where the central region of the semicell wall will be smooth or have greatly reduced granules 86

85. Base of semicells with 1-4 short transverse rows of granules . . . (cf. (230) C. ovale var. Prescottii) (228) C. denticulatum fa. Borgeii

85. Base of semicells without short transverse rows of granules . . . (229) C. ovale

86. Central region of semicell wall smooth 87

86. Central region of semicell wall granulate (sometimes faintly) 88

87. Cell length more than 85u . . . . . (231) C. Gayanum var. eboracense

87. Cell length less than 85u . . . . . (233) C. Botrytis var. mediolaeve

88. Semicell with slight or well defined lateral inflations (in vertical view) 89

88. Semicell without lateral inflations (in vertical view) . . 91

89. Length of cell less than 50u . . . . (197) C. quinarium

89. Length of cell more than 50u 90

90. Width of isthmus 10-15u . . . (234) C. Botrytis var. subtumidum

90. Width of isthmus over 16u . . . (235) C. Botrytis var. tumidum

91. Cell length usually more than 90u . (237) C. tetraophthalmum

91. Cell length usually less than 90u . (232) C. Botrytis

129. Cosmarium praegrande Lund.

West and West, 1908. Monogr. Brit. Desm. 3:150. Pl. 77, Fig. 19.

This large species has semicells that are almost circular. The sinus opens widely from an acute apex. The cell wall is ornamented with conical warts over the entire surface, except for a small apical region. The wall is punctate between the conical warts.

Measurements: L. 91-(101)-104u; W. 56-61-(64)u; I. 20-23.4-(26u).

Distribution: EUP, Delta; Isle Royale (Prescott 1938).

130. Cosmarium caelatum Ralfs.

West and West, 1908. Monogr. Brit. Desm. 3:134. Pl. 76, Figs. 5-7.

The subsemicircular semicells of this species have strongly crenate margins. The lateral margins are bi-crenate (rarely tricrenate) the lower crenations larger than the upper, and the apical margins are quadri-crenate. The apical and upper lateral crenations are ornamented with two or three marginal granules which are components of four transverse linear series of granules (some of which may be larger and in the distinct linear series) extending across the lower part of the semicell face. The vertical view is elliptic with tumid lateral margins. The margin is evenly granulate and the intramarginal regions have short vertical series of granules.

Measurements: L. 40-51u; W. 36-42u; I. 12-15u.

Distribution: WUP, Marquette (Pres. and Mag. 1935).

131. Cosmarium monomazum var. polymazum Nordst. Pl. 17, Fig. 17. West and West, 1908. Monogr. Brit. Desm. 3:140. Pl. 76, Fig. 12.

The subsemicircular semicells of this species have the intramarginal region ornamented with 16-20 flat emarginate warts. Three prominent granules form a transverse series in the central region of the semicell wall and a single larger granule occurs just above the isthmus. The vertical view is elliptic with three granules in the middle of each lateral margin, and with two longitudinal (long axis) intramarginal linear series of flat emarginate warts.

Measurements: L. 32-(32)-39u; W. 32-(34)-39u; I. 9-(10.5)-14u.

Distribution: SLP, Barry; NLP, Cheboygan; EUP, Schoolcraft. New record for Michigan.

132. Cosmarium monomazum var. tristichum West and West

West and West, 1893. Journ. Linn. Soc. Bot. 33:305. Text Fig. 4.

This variety is similar to var. polymazum except for the central region of the semicell where nine granules are arranged in three transverse series.

Measurements: L. 32u; W. 36u; I. 11u.

Distribution: SLP, Washtenaw (West and West 1898).

133. Cosmarium intermedium Delp.

West and West, 1908. Monogr. Brit. Desm. 3:138. Pl. 76, Fig. 10.

This species has pyramidate-semicircular semicells with broadly rounded apices and basal angles. The vertical view is elliptic. The cell wall is ornamented uniformly and in concentric series by granules. The limits of this species are poorly defined and various authors have extremely different measurements.

Measurements: L. 45-50u (79u according to West and West 1908); W. 33-35u (61u according to West and West 1908); I. 12-14u (19u West and West 1908).

Distribution: SLP, Wayne (Campbell 1886); NLP, Emmet (N & A 1932).

134. Cosmarium excavatum var. duplo-major Lund. Pl. 17, Fig. 18. West and West, 1908. Monogr. Brit. Desm. 3:148. Pl. 94, Fig. 3.

The semicells of this species are subsemicircular to subcircular. The semicells are separated by a shallow, broad sinus, the isthmus being broad and somewhat elongated. The lateral margins are convex, although sometimes slightly flattened. The vertical view is circular. The semicell walls (in front view) are ornamented with 5-7 transverse rows of granules so that the semicell margin has about 13-15 granules.

Measurements: L. 39-(44)-47u; W. 21.5-(22)-25u; I. 15-(15)-17u.

Distribution: SLP, Calhoun. New record for Michigan.

135. Cosmarium isthmium West

West and West, 1908. Monogr. Brit. Desm. 3:145. Pl. 77, Figs. 7-10; Pl. 94, Fig 2.

This species has semicircular semicells with subrectangular basal angles. The sinus between the semicells is broadly open and of a semicircular or semielliptic outline. The cell wall is ornamented with 7-10 vertical series of granules, in each one of which there are 6-7 granules. Each lateral margin has 15-20 granules. The vertical view is almost circular with 25-28 granules around the margins. This species can be distinguished from C. excavatum var. duplo-major Lund. by the wider

cells, and the deeper sinus, and from C. portianum Arch. by the semicell shape.

Measurements: L. 40-(42)-(45)-48u; W. 25-(25)-(26)-28u; I. (10.5)-11-(13)-13.5u.

Distribution: SLP, Calhoun, Oakland; NLP, Presque Isle, also Cheboygan (Taft 1939); EUP, Schoolcraft; WUP, Houghton.

136. Cosmarium tesselatum (Delp.) Nordst.

Irenee-Marie, 1948. Le. Nat. Canad. 75(5-7):171. Pl. 3, Fig. 4.

This large species has subcylindrical cells that are very slightly constricted. The lateral margins are subparallel and the apices convex. The semicell wall is ornamented with 13-17 horizontal (also oblique) series of granules. The vertical view is circular.

Measurements: L. 132-149.7u; W. 67.6u; 74u; I. 54-61u.

Distribution: SLP, Washtenaw (Johnson 1894).

137. Cosmarium cylindricum Ralfs.

West and West, 1912. Monogr. Brit. Desm. 4:43. Pl. 94, Fig. 7. (Pl. 94 in Vol. 3., 1908).

This species has small subcylindrical cells which are very slightly constricted. The semicells are subquadrate or subrectangular in outline with slightly divergent lateral margins and convex-truncate apices. The vertical view is circular. The semicell walls are ornamented densely with small granules.

Measurements: L. 38-57u; W. 19-24u; I. 15-17u.

Distribution: NLP, Emmet (N & A 1932).

138. Cosmarium elegantissimum var. simplicius West and West, Pl. 18, Fig. 1

West and West, 1898. Journ. Linn. Soc. Bot. 33:308. Pl. 17, Fig. 7.

This organism has cells which are cylindrical with convex apices. The constriction is very slight so that the sinus is distinguished only by the lack of granules. The cell wall is ornamented by seven vertical series of large rounded warts (granules). There are about seven warts in each vertical series. The vertical view is circular.

Measurements: L. 54-(63)-64u; W. 22-(25)-28u; I. 21-(23)-24u.

Distribution: SLP, Calhoun; NLP, Roscommon; WUP, Gogebic. New record for Michigan.

139. Cosmarium annulatum (Naeg.) De Bary

West and West, 1912. Monogr. Brit. Desm. 4:39. Pl. 102, Figs. 13-15.

This species has subcylindrical cells which are very slightly constricted. The semicells are rectangular (with convex-truncate apices) with 4-5 undulations on each lateral margin corresponding to the 4-5 transverse rows of small nodules upon the cell wall. The vertical view is circular, with fourteen marginal undulations.

Measurements: L. 36-54u; W. 16-23u; I. 14.5-21u.

Distribution: NLP, Cheboygan (N & A 1932).

140. var. elegans Nordst. Pl. 18, Fig. 2.

West and West, 1912. Monogr. Brit. Desm. 4:40. Pl. 102, Figs. 16-18.

This variety is distinguished primarily from the typical by the bigranulate crenations. Specimens from Delta County have the subapical row (of each semicell) of crenations possessing short vertical ridges, the next lowest row made up of single granules and the bottom three rows possessing the typical two granules on each crenation. This expression appears identical with specimens of Taylor (1934) from New Foundland.

Measurements: L. 40-(49)-57.5u; W. 17-(19)-29u; I. (17)u.

Distribution: EUP, Delta. New record for Michigan.

141. Cosmarium taxichondrum Lund.

West and West, 1912. Monogr. Brit. Desm. 4:45. Pl. 103, Figs. 11-13.

The semicircular semicells of this species have the basal angles conspicuously thickened and sometimes slightly convergent. The apices are slightly flattened or subtruncate. The cell wall is punctate. Additional ornamentations of the semicell wall are the single large supraisthmial granule and the two (occasionally one) transverse arcuate series of granules in the upper median region. Usually there are 3-5 granules in the upper row and three in the lower row in the specimens examined by the writer. West and West (1912) however, state that

there are three in the upper series and five or six in the lower series. The vertical view is elliptic with a variable mumber of granules on each lateral margin.

Measurements: L. 36-(44)-50u; W. 32-(46)-46u; I. 9-(10)-14u.

Distribution: SLP, Muskegon (Transeau 1917); NLP, Emmet, also Cheboygan (N & A 1932); Isle Royale (Prescott 1938).

142. var. unigranulatum Prescott

Prescott and Magnotta, 1935. Pap. Mich. Acad. Arts, Sci. and Letters. 20:162. Pl. 25, Figs. 5, 6.

The presence of only the single supraisthmial granule separates this variety from the typical and other varieties. Specimens taken by the writer from the same lake from which Prescott described this variety have only the single supraisthmial granule, but agree more favorably with the semicell shape of the typical than those illustrated by Prescott. The measurements are also smaller than the var. unigranulatum.

Measurements: L. (42)-53-54.3u; W. (42)-45-46.8u; I. (10.5)-17-17.5u.

Distribution: SLP, Calhoun, also Calhoun (Pres. and Mag. 1935).

143. var. nudum Turner Pl. 18, Fig. 8.

Irénee-Marie, 1949. Le. Nat. Canad. 76:(8-10); Pl. 5, Fig. 6.

This variety is separated from the typical by lack of any granular ornamentation upon the semicell wall...

This variety is very close to C. obsoletum (Hantzch) Reinsch from which it can be separated by the less depressed and more angular semicells, the usually smaller width, and the lack of a lateral swelling in vertical view.

Measurements: L. (32)-(36)-40u; W. (30)-(38)-43u; I. (10.5)-13u.

Distribution: Delta; WUP, Marquette. New records for Michigan.

144. var. obsoletumiforme var. nov. Pl. 18, Fig. 7.

This variety differs from the typical and from the varieties of the typical in the possession of greatly thickened basal angles which are submammillate and convergent (including possible mucilage pores). The semicell wall granulation is similar only to var. unigranulatum Prescott in the possession of single supraisthmial granules. It should be compared with C. smolandicum Lund. which lacks the supraisthmial granule and possesses papillae at the basal angles, and with C. smolandicum var. angustatum (Hantzsch) Reinsch which has a different semicell shape and which lacks the supraisthmial granule.

Measurements: L. 34u; W. 34u; I. 7u.

Distribution: NLP, Presque Isle; WUP, Gogebic.

145. var. Irénee-Marie nob. Pl. 18, Fig. 6.

Irenee-Marie, 1938. Flor. Desm. de la Reg. Mont. 186. Pl. 27, Figs. 6-8.

This variety differs from the typical and other varieties by the possession of a series of small granules

upon or just within the apical margin. Irenee-Marie (1938) illustrates several individuals (Figs. 7, 8) that possess a median transverse row of three granules on the semicell wall but the Michigan specimens from Crawford County lack these granules as does Fig. 6 of Irénee-Marie's. This organism was described by Irénee-Marie as a new variety of C. taxichondrum, but without a name. The writer believes that the discovery of this organism in Michigan corroborates Irenee-Marie's original finding and therefore necessitates the addition of a variety name.

Measurements: L. 30-(32)-36u; W. 29-(32)-33u; I. 7-(7.5)-8u.

Distribution: NLP, Crawford. New record for Michigan.

146. Cosmarium reniforme (Ralfs) Arch.

West and West, 1908. Monogr. Brit. Desm. 3:157. Pl. 79, Figs. 1, 2; Pl. 82, Fig. 15.

This species has reniform semicells. The sinus is deep, narrow and closed, although dilated at the apices. The vertical view is elliptic. The cell wall is ornamented by round granules arranged in oblique (sometimes irregularly vertical) series. There are about 25-33 granules along the lateral margin of each semicell in front view and approximately 38 in vertical view. Specimens from Barry County are much smaller than typical measurements. The writer has been unable to find any reference in the literature to a small expression of this species.

Measurements: L. (36)-44-67u; W. (32)-36-60u; I. 9-(10.5)-20u.

Distribution: SLP, Barry, also Macomb. (Campbell 1898), Ionia (Wade 1949) and Livingston (N & A 1932); NLP, Presque Isle, also Cheboygan (N & A 1932, Welch 1938a); WUP, Marquette.

147. var. elevatum West and West

West and West, 1908. Monogr. Brit. Desm. 3:159. Pl. 79, Fig. 6.

This variety is separated from the typical by the less reniform semicells, the subrectangular basal angles and the subparallel lower lateral margins. A few specimens from Mackinac County were intermediate between the typical and this variety. The semicells were slightly reniform but more elevated and with less rounded angles. It agrees favorably with Fig. 7, Pl. 79 (West and West 1912) which is identified as a form approaching var. elevatum.

Measurements: L. (48)-52-54u; W. 36-(38)-46u; I. (10.5)-14u.

Distribution: SLP, Washtenaw (West and West 1898); NLP, Emmet (N & A 1932); EUP, Mackinac fa.

148. Cosmarium subreniforme Nordst.

West and West, 1908. Monogr. Brit. Desm. 3:243. Pl. 88, Fig. 6.

The subreniform semicells of this species have truncate apices. The crenulate lateral (7-8) and apical (4-5)

margins are ornamented with fine granules. Within the margin, there are additional small granules which are irregularly arranged. A central protuberance above the isthmus possesses five vertical series of granules. The elliptic semicell (in vertical view) has a broad central granulate protuberance on each lateral margin, the remaining portion of the semicell walls, except for the central part, has curved transverse rows of small granules. Measurements: L. 36-37u; W. 31-33u; I. 10-11u. Distribution: SLP, Ionia (Wade (1949); NLP, Cheboygan (N & A 1932).

149. Cosmarium Netzerianum Schmidle fa. Pl. 18, Fig. 3. Schmidle, 1895. Oest. Bot. Zeit. 45:20. Pl. 15, Fig. 19.

This species has elliptic semicells with convex lateral margins and convex apices. The sinus is fairly deep, open and inwardly sharply rounded. The semicell wall is ornamented with rounded granules in transversely oblique series. The wall is smooth between the granules. The vertical view is elliptic. A single specimen from Oakland County is assigned here questionably. The specimen is distinctly more rectangular-reniform than Schmidle's (1895) illustration, and the sinus is almost closed. The semicell wall wall is ornamented with deep subcircular-elliptic depressions so that the semicell margin appears to be granulate although it is the cell wall projections between adjacent depressions which appear to be granules.

Insam and Krieger (1936) show a form of C. Netzerianum similar to Schmidle's but it is impossible to determine whether the wall is pitted or granulate. Punctations also are present in the cell wall.

Measurements: L. (32)-48u; W. (28)-42u; I. (18)u;

Distribution: SLP, Oakland.

150. Cosmarium Raciborskii Lag.

Homfeld, 1929. Pflanzen. 12:53. Pl. 7, Fig. 74.

This species has rhomboid-elliptic semicells with obtusely rounded lateral angles and convex apices. The semicell is ornamented with fine, irregularly disposed granules. The vertical view is elliptic, the middle lateral margins straight and the poles obtusely rounded.

Measurements: L. 54.6-(55)u; W. (55)-55u; I. (23)-25u.

Distribution: EUP, Delta; Isle Royale (Prescott 1938).

151. Cosmarium Wittrockii var. quasidepressum Skuja Pl. 17, Fig. 19.

Skuja, 1930. Act. Hort. Bot. Univ. Lat. 4:67. Pl. 3, Fig. 30.

This organism has cuneate (unequally hexagonal) semicells which are constricted by a deep and gradually opening sinus. The apical margins are slightly retuse and both the upper and lower lateral margins are convex, the latter margin longer, so that the greatest width is in the upper half of the semicell. The semicell wall is ornamented with vertical series of small round granules. The vertical view is elliptic. Specimens from Menominee

and Marquette Counties agree well with the description of this organism although the granules are not as large as specimens illustrated by Skuja (1930).

Measurements: L. (18)-19-(19)-23u; W. 16-(19)-21u; I. (6)-7-(8)-9.5u.

Distribution: WUP, Menominee, Marquette. New records for Michigan.

152. Cosmarium Eloiseanum var. depressum West and West West and West, 1896. Trans. Linn. Soc. Bot. Ser. 2., 5 (5):248, Pl. 15, Fig. 23.

The semicells of this organism are broadly elliptic, with convex lateral margins and flattened apices. The ornamentation of the semicell consists of large conical granules arranged (about 25) along the lateral margins, (about 6) within the apical margin and (about 6) within each lower lateral margin and (2-6) occasionally above the isthmus. The semicell wall is punctate except for the central region which is conspicuously scrobiculate.

Measurements: L. 77-95-(96)u; W. 54-(66)-75; I. 15-(21)-26u.

Distribution: NLP, Emmet; Isle Royale (Prescott 1937, 1938, C. Eloiseanum).

153. Cosmarium ordinatum (Boerg.) West and West Pl. 17, Fig. 20. Krieger, 1932. Archiv. f. Hydrobiol. Suppl. 11:181, Pl. 13, Fig. 2.

This small species has elliptic semicells with broadly rounded lateral margins and straight or slightly convex

apical margins. The semicell wall is ornamented with 4-5 transverse rows of granules (warts), the central nine granules being emarginate and appearing as paired granules. The vertical view is elliptic with sharply truncate granules on the lateral margins and the rest of the semicell is ornamented with transverse rows of granules.

Measurements: L. 19-(21.5)-22u; W. 19-(19)-21u; I. (5)-6-8u.

Distribution: SLP, Calhoun; EUP, Chippewa. New records for Michigan.

155. Cosmarium bimamillatum Krieger

Krieger, 1932. Archiv. f. Hydrobiol. Suppl. 11:171, Pl. 13, Fig. 3.

This species has elliptic semicells with broadly rounded lateral angles and flattened apices. The ornamentation consists of two large granules (warts) upon the upper middle semicell wall, two short rows of large punctae, one below the two granules, the other in the supraisthmial region, three concentric rows of small granules arranged within each lateral margin, and a single row of similar granules subapically placed. The vertical view is elliptic with two large granules in the middle of each lateral margin. The rest of the semicell has transverse rows of granules except the central part which is smooth.

Measurements: L. 32-40u; W. 30-33u; I. 11-20u.

Distribution: Isle Royale (Prescott 1938).

156. Cosmarium pseudoornatum Eichl. and Gutw. Pl. 18, Fig. 5. Eichler and Gutwinski, 1894. Rospr. Wydz. Matem. orz. Akad. Umiej. Cracovie 28:170, Pl. 5, Fig. 25.

This species has elliptic semicells with convex lateral margins and straight or slightly convex apices. Granular ornamentation consists of about 17-23 granules along each semicell margin, about four curved vertical series within each lateral margin and one or two transverse series within the apical margin. The central region of the semicell has a protuberance upon which are arranged 4-6 central granules surrounded by 10-14 others in a concentric series. This species is close to C. ornatum Ralfs. but lacks the elevated apices. The Michigan specimens from Menominee County are considerably larger than original typical measurements and are assigned here questionably as they may represent specimens of C. ornatum with reduced apices, although they agree very favorably with illustrations of Messikommer (1927).

Measurements: L. 26-(41)-u; W. 29-(41)u; I. 9-(10.5)u.

Distribution: WUP, Menominee. New record for Michigan.

157. Cosmarium ornatum Ralfs.

West and West, 1908. Monogr. Brit. Desm. 3:151, Pl. 78, Figs. 1-10.

This species has reniform semicells with truncate apices that are slightly elevated. The lateral margins which are broadly rounded, except below the apices where

they are slightly retuse, are ornamented with 6-9 granules on the margin and a variable number with the margin. The apices have about seven prominent granules. The central part of the semicell wall possesses a protuberance upon which are arranged granules of variable size and number in short vertical or concentric series. The vertical view is elliptic with broadly rounded poles and conspicuous lateral granular protuberances. The central area of the semicell is smooth in this view.

Measurements: L. 32-(32)-(38)-41u; W. 32-(33)-(38)-41u; I. (9)-9.5-(13)-13u.

Distribution: SLP, Barry (2), Livingston, Oakland also Macomb (Pieters 1894); NLP, Presque Isle; EUP, Chippewa, Delta; WUP, Gogebic (2); Isle Royale (Prescott 1938).

158. Cosmarium dentatum Wolle

Wolle, F. 1892. Desm. of the U.S., 83. Pl. 16, Fig. 15.

This large species has broadly elliptic semicells in which each broadly rounded lateral margin is ornamented with 6-10 dentate granules. The apex is slightly flattened and the sinus is gradually opened from an acute apex. The cell wall is punctate. Specimens from Presque Isle County are considerably smaller than Wolle's (1892), measurements.

Measurements: L. (113)-145-160u; W. (74)-90-100u.

Distribution: SLP, Wayne (Campbell 1886), Washtenaw West and West 1898); NLP, Presque Isle, also Cheboygan (Welch 1938a).

159. Cosmarium commissurale var. crassum Nordst. Pl. 19, Fig.3. West and West, 1908. Monogr. Brit. Desm., 3:155, Pl. 78, Figs. 15-16.

This organism has narrowly oblong-elliptic semicells with truncate and very slightly produced apices. The sinus is linear and narrowly open. The broadly rounded lateral angles possess 6-8 granules on the margin and 8-10 within the margin. The apices have about seven granules. The central region of the semicell possesses a broad protuberance which has a variable number of granules arranged in an irregular concentric pattern. The vertical view is elliptic with broadly rounded poles and with broad lateral granulate protuberances. The lateral margins are strongly constricted below the poles which are also granulate.

Measurements: L. 28-(28)-37u; W. 31-(32)-43u; I. 9-(10)-13u.

Distribution: SLP, Barry (2), Calhoun, Livingston; EUP, Schoolcraft; WUP, Gogebic (2). New records for Michigan.

160. Cosmarium trachypleurum var. minus Racib. West and West, 1908. Monogr. Brit. Desm. 3:173, Pl. 81, Figs. 4-5.

This species has narrowly oblong-elliptic semicells with the margins (apical and lateral) bearing small acute

granules. The granules within the lateral margins are arranged in several oblique and irregular rows and within the apical margin in a single transverse and slightly curved row. The central region of the semicell wall has a center granule surrounded by a circle of 5 or 6 more. The vertical view is elliptic with granulate, rounded poles and with slight lateral, tri-granulate protuberances. This species is easily separated from C. commissurale var. crassum Nordst. by the lack of elevated apices.

Measurements: L. 31-34.5u; W. 26.5-33u; I. 8-5-12u.

Distribution: NLP, Cheboygan (N and A 1932).

161. Cosmarium Portianum Arch.

West and West, 1908. Monogr. Brit. Desm. 3:165, Pl. 80, Figs. 4-7.

This species has elliptic semicells which are separated by a deep sinus opening gradually from a broadly rounded (occasionally subrectangular) apex, the isthmus thus being slightly elongated. The semicell wall is ornamented with 10-12 vertical series of granules which number about twenty along the margin. The vertical view is elliptic.

Measurements: L. 30-(38)-40u; W. 22-(28)-36u;
I. 8-(10.5)-13u.

Distribution: SLP, Barry (2), Calhoun, Livingston, Oakland, Washtenaw, also Wayne (Campbell 1886), Macomb (Pieters 1894), Muskegon (Transeau 1917), and Calhoun (Pres. and Mag. 1935 fa.); NLP, Cheboygan, Presque Isle, Crawford,

Emmet, Roscommon; also Cheboygan (N and A 1932); EUP, Delta (2), Alger, Schoolcraft; WUP, Houghton, Isle Royale (Prescott 1938).

162. var. nephroideum Wittr. Pl. 18, Fig. 4.

West and West, 1908. Monogr. Brit. Desm. 3:167, Pl. 80, Figs. 10, 11.

This variety is smaller than the typical; the granules are somewhat smaller and the semicells have a subreniform or semicircular-elliptic outline.

Measurements: L. 25-(27)-31u; W. (21)-22-27u; I. 7-(8)-10u.

Distribution: SLP, Livingston; EUP, Schoolcraft. New records for Michigan.

163. Cosmarium longiense Biss.

West and West, 1908. Monogr. Brit. Desm., 3:163. Pl. 80, Figs. 1, 2.

This species has elliptic-subreniform semicells with the basal angles somewhat rounded and slightly subrectangular. The apical margin may be somewhat flattened or slightly retuse in the central part. The vertical view is elliptic. The semicell wall is ornamented with about seventeen vertical series of granules with 28-33 of the granules along the margin. The proportionately greater length, the smaller granules and the different cell shape separate this species from C. reniforme (Ralfs) Archer.

Measurements: L. 61-65u; W. 48-50u; I. 16-18u.

Distribution: SLP, Lapeer. (N and A 1932).

164. Cosmarium Brebissonii Menegh.

West and West, 1908. Monogr. Brit. Desm., 3:161. Pl. 79, Figs. 10, 11.

The semi-elliptic semicells of this species have broadly rounded basal angles and a flattened and subtruncate apex. The sinus is narrowly linear but closed only in the central position. The vertical view is elliptic with broadly tumid lateral margins. The semicell wall is irregularly covered with large conical granules which are reduced in size or completely lacking in the central region of the semicell (in vertical view).

Measurements: L. 88-100u; W. 67-79u; I. 22-26u.

Distribution: EUP, Schoolcraft (N & A 1932).

165. Cosmarium amoenum Bréb. Pl. 19, Fig. 2.

West and West, 1912. Monogr. Brit. Desm. 4:29, Pl. 102, Figs. 1-4; Pl. 103, Fig. 9.

The semicells of this species are rounded-quadrate with slightly convex lateral and apical margins. The constriction is moderate with the sinus slightly open or nearly linear. The semicell wall is ornamented with 6-9 vertical (somewhat irregular) series of granules. There are 8-10 granules in each series and about 20-25 along each semicell margin. The vertical view is broadly elliptic (almost circular). Zygospores were found in Schoolcraft County and as the writer has been unable to find references to this reproductive structure of this

species, the description is included here. Zygospore spherical, outer wall smooth, inner wall regularly and uniformly ornamented by deep circular depressions; diameter 46u.

Measurements: L. 42-(53)-56u; W. 24-(28)-30u; I. 11-(15)-17u.

Distribution: SLP, Barry (2), Berrien, Ingham, Livingston; NLP, Crawford, Emmet; also Cheboygan (N and A 1932, Welch 1938b); EUP, Chippewa, Schoolcraft (4); WUP, Gogebic (3), Houghton.

166. var. mediolaeve Nordst. Pl. 18, Fig. 11.

West and West, 1912. Monogr. Brit. Desm. 4:31, Pl. 102, Figs. 5, 6.

This variety is separated from the typical by the lack of granules in the central part of the semicell wall and the two transverse rows of granules across the base of the semicells.

Measurements: L. 39-(43)-(48)-76u; W. 21-(23)-(26)-(28)-40u; I. 9-(11)-(15)-20u.

Distribution: SLP, Calhoun, Barry (2); NLP, Emmet. New records for Michigan.

167. Cosmarium pseudoamoenum Wille

West and West, 1912. Monogr. Brit. Desm. 4:31, Pl. 102, Figs. 7-9.

The small, almost cylindrical cells of this species are slightly constricted with the sinus only a small and

open indentation. The semicells are more or less oblong with straight or slightly convex lateral margins, and a broadly rounded apex. The cell wall is ornamented with granules that are either arranged in vertical series or in an irregular pattern. The vertical view is subcircular-elliptic. The writer has not seen this species which appears very similar to C. amoenum Breb. West and West (1912) report that C. pseudoamoenum Wille is proportionately narrower and the sinus is not as deep. The typical presence of only a single pyrenoid in each semicell is questioned.

Measurements: L. 44-59u; W. 18-29u; I. 15-24u.

Distribution: NLP, Cheboygan (N and A 1932).

168. Cosmarium Ungerianum var. subtriplicatum West and West

West and West, 1908. Mon. Brit. Desm., 3:196. Pl. 91, Fig. 7.

This organism has oblong-rectangular semicells with rounded upper angles. The constriction is deep and the sinus is linear. The semicell wall is partly ornamented with granules of somewhat variable size. The upper lateral angles have four short oblique rows (four granules in outer row, two in inner row) of granules just within the margin and two somewhat smaller granules upon the margin. There is also a single granule just within apical margin. The basal angles have two small intramarginal and three small marginal granules, whereas the cen-

tral region of the semicell has a few scattered ones. The larger size and the different arrangement of granules separates this species from C. triplicatum Wolle.

Measurements: L. 67u; W. 54; I. 22u.

Distribution: NLP, Cheboygan (N and A 1932).

169. Cosmarium novae-semiliae var. sibericum Boldt.

West and West, 1908. Monogr. Brit. Desm., 3:36, Pl. 68, Figs. 17, 18.

This small organism has the cells deeply constricted by a broad and open sinus. Each semicell is rectangular in general outline with the central region of the apices retuse. The rest of the apical margin and the lateral margins are denticulate (about five per half of semicell). The semicell wall has 2-3 denticulations within each lateral margin and the central region has a sharp papilla-like protuberance. The vertical view is elliptic with a papilla-like protuberance on each lateral margin and two transverse rows of denticulations (one within margin and one upon margin).

Measurements: L. 17-18u; W. 15-15.5u; I. 6.5-7u.

Distribution: Isle Royale (Prescott 1938).

170. Cosmarium nudiceps Johnson

Johnson, 1894. Bull. Torr. Bot. Club. 21(7):289. Pl. 211, Fig. 12.

This species has rectangular semicells with strongly convex apices. Each lower lateral margin has two small

granules, one above the other, occasionally with one or two more in the series. The upper central region of the semicell wall is ornamented with nine oblique (divergent) rows of large granules, 2-4 granules in each row. The vertical view is elliptic with the lateral margins granulate.

Measurements: L. 48-50u; W. 36-40u; I. 12-14u.

Distribution: SLP, Macomb (JOhnson 1894); NLP, Cheboygan (N and A, 1932).

171. Cosmarium triplicatum Wolle

Wolle, 1892. Desm. of the U.S.:79. Pl. 22, Figs. 3-6.

This species has subrectangular semicells with rounded angles. The basal angles each have three flattened granules on the margin and 2-3 within the margin. Each of the apical angles, which are more rounded than the basal angles, possesses three flattened granules upon the margin and three within the margin. Usually there are two or three additional granules of the same size within the apical margin. The upper central region of the semicell wall possesses two transverse rows of similar granules, each granule separated from the adjacent one by conspicuous scrobiculations.

Measurements: L. 44-(58)-58u; W. 34.5-(40)-44u; I. 10-(10.5)-14u.

Distribution: SLP, Washtenaw, Oakland, Barry, Jackson, also Washtenaw (Johnson 1894, West and West 1898). WUP, Houghton.

172. Cosmarium margaritatum (Lund.) Biss.

West and West, 1912. Monogr. Brit. Desm. 4:18, Pl. 99, Figs. 8, 10.

This species has subrectangular semicells with slightly convex apical and lateral margins and with rounded basal and apical angles. The sinus between the semicells is deep, narrowly linear, closed but open at the base. The semicell wall is ornamented by oblique series of granules, about twelve granules in a series and about 28-32 of the granules arranged around the semicell margin. Distinct punctations occur between the granules. The vertical view is oblong-elliptic with convex lateral margins.

Measurements: L. 60-105u; W. 56-82u; I. 19-31u.

Distribution: SLP, Barry; NLP, Cheboygan; also Cheboygan (N and A 1932); EUP, Alger, Mackinac; Isle Royale (Prescott 1937, 1938).

173. var. minor (Boldt) West and West. Pl. 20, Fig. 1.

West and West, 1912. Monogr. Brit. Desm. 4:19. Pl. 99, Fig. 9.

This form is separated from the typical by the smaller size.

Measurements: L. 44-(52)-60u; W. 38-(48)-51u; I. 12.5-16-(19)u.

Distribution: SLP, Barry, Calhoun, Oakland, Washtenaw; NLP, Emmet; EUP, Delta; WUP, Menominee, Marquette. New records for Michigan.

174. var. ridibundum Taylor. Pl. 19, Fig. 8.

Taylor Pap. Mich. Acad. Sci., Arts, and Letters, 19:257. Pl. 52, Fig. 8.

This variety can be separated from the typical by the hollowness of the granules and the especially strong development of the isthmial row of granules. Specimens from Emmet County are slightly smaller than typical measurements.

Measurements: L. (75)-85-88u; W. (60)-64u; I. 18-(19)u.

Distribution: NLP, Emmet. New record for Michigan.

175. Cosmarium quadrum Lund.

West and West, 1912. Monogr. Brit. Desm. 4:20. Pl. 100, Figs. 3-6.

This species has subrectangular semicells with straight or slightly convex lateral margins and with rounded angles. The apical margin is straight or slightly retuse. The semicell wall is ornamented with numerous vertical series of solid granules, the margin of the semicell showing about 34-37 of the granules. The vertical view is oblong-elliptic with straight parallel sides. The lack of punctations between the granules easily separates this species from C. margaritatum (Lund.) Biss. The slightly retuse or straight apices separates it from C. conspersum var. latum (Breb.) West and West and the larger size from C. pseudobroomei Wolle.

Measurements: L. 60-83u; W. 54-74u; I. 18-29u.

Distribution: NLP, Emmet (Taft 1939).

176. var. sublatum (Nordst.) West and West. Pl. 21, Fig. 1. West and West, 1912. Monogr. Brit. Desm. 4:21. Pl. 100, Fig. 2.

This variety is separated from the typical by the hollow granules and the intergranular punctations. It resembles C. margaritatum (Lund.) Biss. but can be easily distinguished by the different shape of the semicell and the hollow granules.

Measurements: L. (85)u; W. (77)u; I. 21u.

Distribution: NLP, Presque Isle. New record for Michigan.

177. Cosmarium subbroomei Schmidle fa. West and West Pl. 19, Fig. 1.

West and West, 1912. Monogr. Brit. Desm. 4:23, Pl. 100, Fig. 11.

Typically, this species has oblong-rectangular (slightly trapeziform) semicells with slightly rounded angles and slightly convex apical and lateral margins. The semicell wall is finely granulate. The central region of the wall has the granules more conspicuous, but more irregularly arranged. The vertical view is elliptic with a very slightly granulated protuberance in the middle of each lateral margin. A few specimens from Barry County agree well with the description of West's form but the lateral margins are slightly divergent (but not as sharp as in C. biretum Bréb.) and the upper lateral margins are more angularly rounded.

Measurements: L. (32)-42u; W. (30)-38u; I. (9)-12u.

Distribution: SLP, Barry. New record for Michigan.

178. Cosmarium conspersum var. latum (Breb.) West and West

West and West, 1912. Monogr. Brit. Desm., 4:15. Pl. 99, Figs. 5, 6.

This large organism has subrectangular semicells with distinctly divergent lateral margins and usually convex apical margins. The semicell wall is uniformly granulate, the granules arranged in about 13-15 vertical (often somewhat irregular) rows. The vertical view is elliptic.

Measurements: L. 88-107u; W. 76-88u; I. 27.5-34u.

Distribution: SLP, Macomb (West and West 1898); NLP, Emmet.

179. Cosmarium conspersum var. rotundatum Wittr.

West and West, 1912. Monogr. Brit. Desm. 4:16. Pl. 99, Fig. 3.

This variety has semicells with subparallel lateral margins and less convex apical margins than var. latum (Breb.) West and West. The semicell shape is thus more perfectly rectangular than var. latum. The semicell wall has the typical (as in var. latum) arrangement of granules in vertical and transverse rows. The vertical view is elliptic.

Measurements: L. 86-110u; W. 66-80u; I. 25-33u.

Distribution: NLP, Cheboygan (N and A 1932).

180. Cosmarium pseudobroomei Wolle

West and West, 1912. Monogr. Brit. Desm., 4:22. Pl. 100, Figs. 7, 8; Pl. 103, Fig. 7.

This species has transversely oblong-rectangular semicells with straight or slightly convex lateral and apical margins. The angles are slightly rounded. The semicell wall is ornamented with about 9-12 vertical rows of small solid granules, the semicell margin showing 23-32 of these granules. The vertical view is oblong with subparallel lateral margins and broadly rounded poles.
Measurements: L. 33-38u; W. 29-36u; I. 8.5-12u.
Distribution: SLP, Wayne (N and A 1932); NLP, Cheboygan, (N and A 1932, Welch 1938a); Isle Royale, (Prescott 1938).

181. Cosmarium mediogemmatum West and West

West and West, 1897. Jour. Bot., 35(412):118. Pl. 367, Fig. 11.

This species has hexagonal semicells. Typically, the central region of the semicell wall is decorated with three transverse rows of large granules (two in upper, three in middle, two in lower) surrounded by scrobiculations. There is also a single granule at each basal angle. The semicell wall is also coarsely punctate. The vertical view is elliptic with several granules in the middle of each lateral margin. A single specimen from Oakland County resembled this species except for the presence of only a single transverse row of three granules.
Measurements: L. 36-(36)-38u; W. (28)-29-31u;
I. (8.5)-9.5u.
Distribution: SLP, Oakland. New record for Michigan.

182. Cosmarium biretum var. minus Hansgirg. Pl. 19, Fig. 4. West and West. Monogr. Brit. Desm. 4:26. (Pl. 101, Figs. 1-8 typical).

This organism has subrectangular trapeziform semicells with straight or slightly convex lateral margins which diverge upwardly. Thus, the widest part of the semicell is just below the convex apical margin. The semicell wall is ornamented with small granules arranged either in vertical series or irregularly. The vertical view is elliptic.

Measurements: L. 38-(38)-52u; W. (32)-35-52u; I. 13-(14)-19u.

Distribution: SLP, Barry; NLP, Roscommon. New records for Michigan.

183. Cosmarium Turpinii Breb.

West and West, 1909. Monogr. Brit. Desm. 3:189. Pl. 82, Figs. 16 and 17; Pl. 83, Fig. 1.

This species has truncate-pyramidate semicells. The basal angles are broadly rounded and the lateral margins are very slightly concave and distinctly convergent to the truncate apex. The semicell wall is ornamentdd with granules that are irregularly arranged and usually somewhat reduced in size towards the center. The central region has two slight protuberances upon which larger granules are irregularly disposed. The vertical view is narrowly elliptic with two granulate protuberances on each lateral margin.

Measurements: L. 60-(75)-77u; W. 50-64-67u; I. 14-(17)-18u.

Distribution: SLP, Jackson; also Gratiot (West and West 1898) and Ionia (Wade 1949); NLP, Newaygo (N and A 1932); EUP, Mackinac, also Delta (N and A 1932); WUP, Menominee.

184. Cosmarium protractum (Naeg.) De Bary

West and West, 1908. Monogr. Brit. Desm. 3:181. Pl. 82, Fig. 8; Pl. 94, Figs. 4, 5.

This species has trilobed semicells with a subrectangular sinus between the apical and basal lobes. The lateral lobes are broadly rounded and the apical lobes are truncate with rounded angles and with slightly retuse margins. The lobes are ornamented with irregular rows of granules and the central region of the semicell possesses a protuberance upon which are granules arranged in several concentric series.

Measurements: L. 34-45u; W. 33-47u; I. 8.5-12u.

Distribution: SLP, Oakland, also Wayne (Campbell 1886), and Washtenaw (N and A 1932); NLP, Cheboygan (N and A 1932); WUP, Houghton (N and A 1932); Isle Royale (Taylor 1935, Prescott 1938).

185. fa. basigranulatum fa. nov. Pl. 18, Fig. 9.

This new form is identical with the typical except for the presence of a large supraisthmial granule upon each semicell.

Measurements: L. (42)u; W. (42)u; I. (10.5)u.

Distribution: NLP, Presque Isle.

186. Cosmarium Quasillus Lund.

West and West, 1908. Monogr. Brit. Desm. 3:188. Pl. 92, Fig. 3.

The trapeziform to pyramidate-truncate semicells of this species have lateral margins converging from rounded basal angles to the slightly produced apices. The basal angles are finely crenate and the lateral margins are undulate with the undulations increasing in size upwardly. The apical margin is slightly biundulate but not granulated. The central region of the semicell has a protuberance upon which several concentric series of granules are arranged. Two of the granules near the base are often distinctly larger than others. The rest of the semicell is ornamented with granules arranged in radiating and concentric series, except a small smooth area around the central protuberance. The vertical view is elliptic with a central granulate protuberance upon each lateral margin.

Measurements: L. 55-80u; W. 50-74u; I. 15-21u.

Distribution: SLP, Wayne (Johnson 1894, N and A, 1932), Washtenaw (Johnson 1894); NLP, Emmet (N and A 1932).

187. Cosmarium vexatum West.

West and West, 1908. Monogr. Brit. Desm. 3:187. Pl. 92, Fig. 4.

This truncate-pyramidate semicells of this species have convex and convergent lateral margins arising from bluntly rounded basal angles to the truncate and slightly

produced apex. The lateral margins are undulate with 6-7 undulations increasing in size upwardly. The apices are straight or slightly subundulate. The semicells walls are ornamented with small granules arranged in a somewhat irregularly radial and subconcentric pattern. The granules gradually decrease in size inwardly toward the center which is smooth. The vertical view is oblong-elliptic with granulate poles and smooth central lateral protuberances.

Measurements: L. 41-43u; W. 36-38u; I. 13.5-14u.

Distribution: NLP, Emmet (N and A 1932).

188. Cosmarium Sportella var. subnudum West and West.

West and West, 1908. Monogr. Brit. Desm. 3:186, Pl. 82, Fig. 14.

The semicells of this variety are truncate-pyramidate. The lateral margins which are granulate, converge gradually from slightly rounded basal angles to the truncate apex which also has a granulate margin. The semicell wall is punctate in the center but ornamented within the margins with several irregularly concentric and radial series of small granules.

Measurements: L. 50-53u; W. 39-41u; A. 22u; I. 14.5-24u.

Distribution: Isle Royale (Prescott 1938).

189. Cosmarium cosmetum West and West.

West and West. Trans. Linn. Soc. Bot. 2nd Ser. 5 (5):250. Pl. 15, Fig. 4.

The oblong-trapeziform semicells of this species have a very characteristic ornamentation. The convex lateral margins possess 7-8 granules and the apical margin is smooth. The semicell wall has one or two granules within each basal angle. The upper part of the semicell has numerous equally spaced granules around each of which there are about six triangular depressions in the wall. This arrangement thus creates a very conspicuous reticulate pattern.

Measurements: L. (49)-51-(52)-57u; W. 42-44-(44)-48.5u; I. (10.5)-12.5-(13)-15u.

Distribution: SLP, Barry; NLP, Emmet, also Emmet (N and A 1932).

190. Cosmarium margaritiferum Menegh.

West and West, 1908. Monogr. Brit. Desm. 3:199. Pl. 83, Figs. 4-11.

The broadly-pyramidate-truncate (somewhat trapeziform) semicells have slightly convex lateral margins (each with 7-9 granules) which converge from rounded basal angles towards the straight or slightly convex apical margin. The semicell walls are granulate with the granules in the center and within the basal angles and lateral margins somewhat larger than others, the former being surrounded by fine scrobiculations. Fine and dense punctations occur between all the granules. The vertical view is elliptic with granules in the middle of each lateral margin larger and with the central area smooth.

Measurements: L. 47-59u; W. 41-56u; I. 13-16u.

Distribution: SLP, Wayne (Campbell 1886) and Macomb (Pieters 1894); Isle Royale (Prescott 1937).

191. Cosmarium radiosum Wolle

Wolle, 1892. Desm. of the U.S.:97. Pl. 22, Figs. 21,22.

The species has trapeziform semicells with convex lateral margins and flattened apices. The semicell margin is ornamented with numerous granules which continued in about thirty-five radiating series inwardly to the middle of the semicell. There is a protuberance above the isthmus upon which there are about eight vertical or slightly divergent short series of granules. The vertical view is elliptic with a central protuberance upon each lateral margin.

Measurements: L. 56-58u; W. 50u.

Distribution: EUP, Delta. (N and A 1932).

192. Cosmarium formosulum Hoff.

West and West, 1908. Monogr. Brit. Desm. 3:241. Pl. 88, Figs. 1-3.

The trapeziform semicells of this species have convex lateral margins that are 6-7 crenate, the three upper crenations bigranulate and the lower crenations entire. The apices are truncate, usually four crenulate, with the angles obtuse or faintly bigranulate-emarginate. Granules within the semicell margin are arranged in concentric or radiating series, usually binate except for

the innermost series. The central region has a broad protuberance upon which there are 5-7 vertical series of granules. The vertical view is narrowly elliptic, with rounded and crenulate poles and with a broad crenulate protuberance on each lateral margin.

Measurements: L. 40-50u; W. 34-40u; A. 12-17u; I. 10-15.5u.

Distribution: SLP, Washtenaw, Jackson; NLP, Cheboygan and Emmet. All records by Nichols and Ackley (1932) except for Washtenaw.

193. var. Nathorstii (Boldt) West and West

West and West, 1908. Monogr. Brit. Desm., 3:242. Pl. 88, Figs. 4,5.

This variety is separated from the typical by the greater width of the semicells and the larger granules upon the central protuberance.

Measurements: L. 44-53-(60)u; W. 42-(51)-52u; I. 11-(13)-15u.

Distribution: SLP, Calhoun, also Macomb (West and West 1898).

194. Cosmarium furcatospermum West and West

West and West, 1908. Monogr. Brit. Desm. 3:206, Pl. 81, Figs. 10, 11; Pl. 84, Figs. 8-10.

The truncate-semicircular or trapeziform-semicircular semicells of the species have crenate-granulate lateral margins (4-5 crenations per margin). The truncate and sometimes slightly exserted apices have 4-6 slight undu-

lations. Just within the margin of the semicell there are one or two rows of granules, the rest of the semicell being smooth or minutely punctate. The vertical view is elliptic with undulate-granulate poles.

Measurements: L. 18-(21.5)-26u; W. 16.5-(19)-22u; I. 5.7-(6.5)-7.5u.

Distribution: SLP, Calhoun; NLP, Crawford; EUP, Mackinac; Isle Royale (Prescott 1938).

195. Cosmarium pseudo-taxichondrum var. Foggii Taylor fa. Pl. 18 Fig. 10

Taylor, 1934. Pap. of Mich. Acad. Arts, Sci., and Letters, 19:262. Pl. 54, Figs. 9 and 11.

This fairly small species has truncate-triangular (almost subsemicircular with angular lateral margins) semicells which are at least 2 1/2 times wider than long. Typically, the basal angles are thickened, convergent and ornamented with divergent, rounded teeth. In addition, there is a single granular tooth just within the basal margin. The semicell wall is otherwise ornamented with three widely spaced granules, the central one larger than the laterals. Occasionally there is an additional granule within each basal angle. The vertical view is narrowly elliptic with three widely separated granules on each lateral margin, and with acute poles. Specimens from Chippewa County agree favorably with the characteristics of this variety although the granular ornamentation is somewhat reduced and the size of the semicells somewhat smaller.

Measurements: L. (21.5)-24-26u; W. (28)-32-34u; I. 5.5-(6)u.

Distribution: EUP, Chippewa. New record for Michigan.

196. Cosmarium Blytii Wille.

West and West, 1908. Monogr. Brit. Desm. 3:225. Pl. 86, Figs. 1-4.

This small species has trapeziform semicells with lateral margins that have four crenations (including basal and apical angle). The upper crenations may be emarginate. One or two series of small granules are located just within the lateral margins and the central region of the semicell possesses a single subpapillate granule. The vertical view is elliptic with a single conspicuous granule in the middle of each lateral margin.

Measurements: L. 10-(15)-19u; W. 7-(13)-16u; I. 2.8-(3)-5.5u.

Distribution: SLP, Barry, Calhoun, Livingston, also Kalamazoo (N and A 1932); EUP, Alger, Schoolcraft.

197. Cosmarium quinarium Lund.

West and West, 1908. Monogr. Brit. Desm. 3:216. Pl. 85, Figs. 9-10.

The broadly pyramidate-truncate semicells have convex lateral margins converging from the obtusely rounded bases to the rounded angles of the truncate apices. Each lateral margin is ornamented with 7-8 granules (the margin thus appearing undulate) and the apical margin

has about four undulations. The intramarginal granulation consists usually of a single series of large rounded or acute granules. The central region of the semicell possesses two transverse rows of the large granules (3 in upper, 2 in lower), interspersed with at least three punctations.

Measurements: L. 38-(42)-42u; W. 32-(32)-(34)-36-38u; I. (9)-9.5-11u.

Distribution: SLP, Calhoun (Pres. and Mag. 1935, not Fig. 4, Pl. 26 which is C. Boeckii); NLP, Emmet; EUP, Alger, Schoolcraft; WUP, Gogebic.

198. Cosmarium Kjellmanii Wille

West and West, 1908. Monogr. Brit. Desm. 3:219. Pl. 85, Fig. 13.

The truncate-pyramidate or trapeziform-subsemicircular semicells of this species have convex lateral margins converging upwardly from obtusely rounded bases to the narrow truncate apex. The semicell wall is granulate, the granules upon each lateral and margin numbering about 5-6, the granules within the margin arranged in radial series and those in the center of the semicell in five vertical rows. The vertical view is elliptic with granulate poles. A single protuberance with five granules occurs on each lateral margin.

Measurements: L. 28u; W. 28u; I. 9u.

Distribution: NLP, Cheboygan (N and A 1932).

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200. Cosmarium punctulatum Bréb.

West and West, 1908. Monogr. Brit. Desm. 3:206. Pl. 84, Figs. 13, 14; Pl. 102, Fig. 22.

The semicells of this species are oblong-trapeziform, with basal angles rounded, and with the convex lateral margin converging slightly to the broadly truncate (with straight or slightly convex margin) apex. The semicell wall is granulate, the granules arranged in somewhat irregular vertical and oblique series. The vertical view is elliptic.

Measurements: L. 28-40u; W. 27-38u; I. 7.5-12u.

Distribution: SLP, Barry, also St. Clair (N & A 1932); NLP, Crawford, also Emmet (N & A 1932); WUP, Gogebic.

199. Cosmarium Boeckii Wille

West and West, 1908. Monogr. Brit. Desm. 3:234. Pl. 86, Figs. 26-32.

The trapeziform-semicircular semicells of this species have convex lateral margins which are 4-5 crenate. Each crenation is usually entire but dentate, occasionally the lower and upper are emarginate. The apical margin is undulate-crenate. Within the margins there are about twelve relatively large granules arranged in two series. The central region of the semicell is occupied by a broad but slight protuberance, which is ornamented by five or six diversely arranged granules, the lower granule above the isthmus usually larger than the others. The vertical view is elliptic with granulate poles and slightly tumid tri-granulate lateral margins.

Measurements: L. 28-40u; W. 27-38u; I. 7.5-12u.

Distribution: SLP, Barry, also St. Clair (N and A 1932); NLP, Crawford, also Emmet (N and A 1932); WUP, Gogebic.

201. var. subpunctulatum (Nordst.) Boerg.

West and West, 1908. Monogr. Brit. Desm. 3:209. Pl. 84, Figs. 15-20; Pl. 85, Figs. 1-3.

This variety is separated from the typical by the presence of central protuberance in each semicell, upon which the granules may be more or less regularly arranged.

Measurements: L. 24-(28)-(32)-36u; W. 23-(26)-(30)-36u; I. (6.5)-7-(7)-16u.

Distribution: SLP, Barry (2), Livingston, Washtenaw, Jackson; NLP, Crawford, Roscommon, Presque Isle, also Cheboygan (N and A 1932); EUP, Alger, Schoolcraft; WUP, Marquette, Menominee, Houghton, Gogebic.

202. Cosmarium cruciatum Breb.

Wolle, 1892. Desm. of the U.S.; 89. Pl. 21, Figs. 23,24.

This small species has deeply constricted cells with the sinus narrow and enlarged outwardly. The semicells are trapezoid-reniform (truncate-pyramidate) with the lateral margins convergent to the truncate apices. The margins are slightly crenate and the semicell wall is finely granulate or punctate. The vertical view is elliptic, with a small submamillate protuberance in the middle of each lateral margin. West and West (1912) believe that this species is synonomous with some form of C. punctulatum Breb. The writer has seen no specimens that agree with this description.

Measurements: L. 22-24; W. 22-24u.

Distribution: SLP, Wayne (Campbell 1886).

203. Cosmarium anisochondrum Nordst.

West and West, 1908. Monogr. Brit. Desm. 3:212, Pl. 85, Fig. 5.

The subsemicircular (trapeziform-semicircular) semicells have convex lateral margins converging upwardly to the truncate apices. The lateral margins are ornamented with seven or eight granules, whereas the apical margins

are smooth. Within the lateral margins there are several rows of granules, within the apical margin a single row, The central region of the semicell wall possesses several slightly curved or irregular transverse rows of granules. The vertical view is elliptic with 3-4 large granules on each lateral margin and with the rest of semicell granulate except for the middle part. Specimens from Oakland County had slightly elevated apices.

Measurements: L. 28-30-(34)-u; W. 25-27-(28)u;I5.3-(6.5)-9.5u.

Distribution: SLP, Oakland, also Macomb (Johnson 1894).

204. Cosmarium calcareum Wittr.

West and West, 1908. Monogr. Brit. Desm. 3:235. Pl. 87, Figs. 1, 2.

The trapeziform-semicircular semicells have convex lateral margins that have four minute crenulations in the lower part and a single emarginate crenation above. The apices are truncate, and minutely 6-7 crenulate. Granular ornamentation consists of several radiating series of minute granules extending from margin to the central region of the semicell where 8-11 peripheral granules surround 1-4 central ones. The vertical view is elliptic with a granulate (3-4) tumor in the middle of each lateral margin.

Measurements: L. 78-30u; W. 17-27u; I. 5-7.2u.

Distribution: NLP, Cheboygan (N and A 1932, Welch 1938a) Emmet, (N and A 1932).

205. Cosmarium sexnotatum var. tristriatum (Luetkm) Schmidle. Pl. 19, Fig. 6.

West and West, 1908. Monogr. Brit. Desm. 3:228. Pl. 87, Figs. 8, 9.

This small organism has truncate-pyramidate semicells. The lateral margins of the semicells are convex, 4-5 undulate and slightly convergent to the apical margin which is undulate or almost straight. Granular ornamentation on the semicell wall consists of two series within the lateral margin. In addition, there are three elongated central granules each of which are divided into short and a long part. The vertical view is elliptic with three granules in the middle of each lateral margin.

Measurements: L. 16-(19)-26u; W. 14-(15)-22u; I. 4-4.5-8u.

Distribution: SLP, Calhoun. New record for Michigan.

206. Cosmarium crenatum Ralfs.

West and West, 1912. Monogr. Brit. Desm. 4:35. Pl. 98, Figs. 9-12.

The pyramidate-quadrate semicells of this species have margins that are crenate (3-4 on lateral, 4 on apical). Within each marginal crenation there are several smaller secondary crenations that are smooth or ornamented with one or two minute granules. Three to six vertical costae (ridges) occupy the center. The elliptic vertical view shows a broad 3-6 undulate inflation on each lateral margin and subtruncate, finely granulate poles.

Measurements: L. 27-(28)-43u (rarely up to 59u); W. (21.5)-

(22)-31u (rarely to 44u); I. (6.5)-9-13u.

Distribution: SLP, Barry; NLP, Cheboygan, Emmet (N and A 1932); Isle Royale (Prescott 1937, 1938).

207. Cosmarium modestum West and West

West and West, 1898. Jour. Linn. Soc. Bot., 33:304. Pl. 17, Fig. 12.

The semicells of this species are pyramidate-trapeziform with rectangular basal angles, convex lateral margins (each with four crenations) and truncate apices (very slightly emarginate). The semicell wall is ornamented with small granules arranged in concentric and radiating series. The vertical view is elliptic with a central protuberance upon each lateral margin.

Measurements: L. 21.4-33u; W. 19.5-26u; I. 5-8-7u.

Distribution: SLP, Washtenaw (West and West 1898); Isle Royale (Prescott 1938).

208. Cosmarium subcrenatum Hantzsch.

West and West, 1908. Monogr. Brit. Desm. 3:228. Pl. 86, Figs. 10-14.

The truncate-pyramidate (subsemicircular with a truncate apex) semicells have crenate (4-6) lateral margins which converge to the truncate apices which are 4-5 crenate. Each crenation is ornamented with minute granules. Within the marginal crenations there are one or two series of minute granules concentrically and radially arranged. The central area of the semicell wall is occupied by a broad, slightly elevated protuberance upon

which there are 4-7 vertical series of small granules (3-6 granules in each series). The vertical view is elliptic with a broad granulate protuberance on each lateral margin and with rounded or truncate poles.

Measurements: L. 23-(32)-(34)-37u; W. 18-(26)-(30)-32u; I. 7-(10)-16u.

Distribution: SLP, Calhoun, Washtenaw; also Macomb (Pieters 1894); WUP, Dickinson (N and A 1932); Isle Royale (Prescott 1933).

209. Cosmarium subprotumidum Nordst.

West and West, 1908. Monogr. Brit. Desm. 3:231. Pl. 87, Figs. 19-21.

This species has trapeziform-subsemicircular semicells. The basal lateral margins are perpendicular to base and are biundulate, and the upper lateral margins are convergent (with a crenation between two hollows) to the apex which is truncate and 2-4 undulate. The granular ornamentation consists of one or two series of paired (single inwardly) granules within each marginal crenation and a central tumor with 3-4 vertical series (outer series sometimes slightly curved) of granules with 4-5 granules in each series. The vertical view is elliptic with a broad-three-crenulate tumor on each lateral margin.

Measurements: L. 24-30u; W. 22-27u; I. 6-10u.

Distribution: NLP, Cheboygan (N and A 1932, Neal 1948).

210. Cosmarium costatum Nordst.

West and West, 1908. Monogr. Brit. Desm. 3:239. Pl. 87, Figs. 13-16.

The semicells of this species are subtrapeziform with convergent lateral margins. The lower lateral margins have one or two small and entire crenations, the upper lateral margins 2-3 emarginate crenations. The apex is truncate and possesses four emarginate crenations. Within the lateral margins small paired granules (single inwardly) are arranged in radiating and concentric series. The central region of the semicell is ornamented with 5-7 vertical granular ridges. The elliptic vertical view shows a broad crenulate inflation upon each lateral margin. Measurements: L. 27-57u; W. 25-39.6u; I. 10.5-21u. Distribution: Isle Royale (Prescott 1938).

211. Cosmarium subcostatum Nordst

West and West, 1908. Monogr. Brit. Desm. 3:236. Pl. 87, Figs. 3-5.

The semicells of this species are subtrapeziform-reniform. The convex lateral margins possess 6-7 crenations, of which the lower 2 or 3 are entire and the upper are emarginate. The apices are slightly produced and slightly undulate. Within each marginal crenation or undulation there are 2-4 series of paired granules (single in innermost series) radially and concentrically arranged. The central area of the semicell (surrounded by a small clear area) possesses a broad tumor upon which there are 4-5 subvertical series of granules (each series with about four granules).

Measurements: L. 24.6-(30)-38u; W. 23-(25)-43u; I. 6.4-(6.4)-12u.

Distribution: NLP, Presque Isle, also Emmet (Transeau 1917, N and A 1932).

212. fa. minor West and West.

West and West, 1908. Monogr. Brit. Desm. 4:238. Pl. 87, Figs. 6-9.

This form is separated from the typical by the smaller size and the presence of only 2-3 emarginate crenations. A specimen from Barry County agrees well with the description of this form except for the central tumor which has about nine peripheral granules around a single central granule and a slightly smaller width.

Measurements: L. 19-(19)-(22)-24u; W. (15)-(17)-18.5-21u; I. 4.2-(5)-5.5u.

Distribution: SLP, Barry, also Macomb (Johnson 1894, C. calcareum); NLP, Cheboygan (N and A 1932); WUP, Menominee.

213. Cosmarium norvegicum Strom. Pl. 19, Fig. 7.

Taylor, 1934. Pap. Mich. Acad. Sci., Arts and Letters, 19:258. Pl. 53, Fig. 3.

This small species has truncate-pyramidate (pyramidate sub-semicircular) semicells. Each of the convex lateral margins has 3 or 4 crenations whereas the apical margins possess two crenations and two middle undulations. The intramarginal ornamentation consists of several concentric series of small granules opposite each marginal

crenation or undulation, the outer series with paired granules, the inner series with single granules. The central region of the semicell wall has 3-5 vertical series of granules, usually 3-4 granules in each series. The vertical view is elliptic, with a granulate protuberance on each lateral margin and with several transverse rows of granules.

Measurements: L. (24)-24u; W. (22)-22u; I. (4.4)-6.5u.

Distribution: SLP, Calhoun, Barry. New records for Michigan.

214. Cosmarium nasutum Nordst.

West and West, 1908. Monogr. Brit. Desm., 3:259. Pl. 90, Figs. 9-10.

The trapeziform-semi-circular semicells of this species have convergent lateral margins that are slightly convex and sharply crenate (three per lateral margin). The apical margin has two crenations, each of which are 3-4 granulate (almost subpapillate), whereas the crenations on the lateral margins are bigranulate. Granular ornamentation within the margins consists of several concentric radiating series of paired granules (inner often single). The central region of semicell has a tumor which is smooth except for an emarginate granule just above the isthmus. The vertical view is elliptic with single small lateral protuberances and with transverse rows of granules upon the poles (smooth in center).

Measurements: L. 35-42u; W. 28-33u; I. 8.5-13u.

Distribution: NLP, Cheboygan (Taft 1939).

215. Cosmarium binum Nordst. Pl. 19, Fig. 5.

West and West, 1908. Monogr. Brit. Desm. 3:246. Pl. 88, Figs. 10-14.

The semicells of this species are pyramidate-trapeziform with convex lateral margins and truncate apices. The margins are crenate (6-10 in lateral, 4-6 in apical), the crenations bigranulate and more or less emarginate. The intramarginal ornamentation consists of radial and concentric series of paired granules (innermost single). The central region of the semicell has a tumor upon which there are located 6-8 granular ridges, and beneath each ridge a single granule. The vertical view is elliptic with a broad granulate central protuberance upon each lateral margin, and with transverse rows of granules except in center of semicell.

Measurements: L. 41-(62)-90u; W. 30-(42)-59u; I. 12-(18)-21u.

Distribution: SLP, Oakland; NLP, Presque Isle; EUP, Schoolcraft. New record for Michigan.

216. Cosmarium subspeciosum Nordst.

West and West, 1908. Monogr. Brit. Desm. 3:252. Pl. 89, Fig. 11.

This species has pyramidate-subsemicircular semicells with convex lateral margins which are slightly

divergent near base and then strongly convergent above to the subtruncate apices. The margins are crenate (four apical, 6-7 on each lateral) with each crenation bigranulate except those at basal angles. Intramarginal ornamentation consists of concentric and radial series of minute granules (granules, in outer series, paired, in inner series single). The central region of the semicell possesses a tumor upon which are arranged 5-6 somewhat irregularly subvertical series of granules. The elliptic semicells in vertical view have broad lateral protuberances and rounded poles.

Measurements: L. 41-58u; W. 28.8-43.9u; I. 12-16.2u.

Distribution: SLP, Macomb (Johnson, 1894); Isle Royale (Prescott 1938).

217. var. validus Nordst.

West and West, 1908. Monogr. Brit. Desm. 3:253. Pl. 89, Figs. 12-13.

This variety is separated from the typical by the larger size and the 7-9 vertical series of granules in the central region of the semicell.

Measurements: L. 62-85u; W. 47-53u; I. 17.5-22u.

Distribution: SLP, Washtenaw (Johnson 1895).

218. Cosmarium supraspeciosum Wolle.

Wolle, 1892. Desm. of the U.S.:95. Pl. 61, Figs. 5-9.

This species has truncate pyramidate semicells. The convex lateral margins and the flattened apical margins are crenate (each of the former with about sixteen and

each of the latter with 4-5 crenations). The intramarginal ornamentation consists of large undivided granules arranged in concentric and radial series extending about half-way to the central region which is smooth except for 5-6 vertical series of smaller granules. The vertical view is elliptic with a granulate central protuberance on each lateral margin.

Measurements: L.90-95u; W. 65-70u.

Distribution: Washtenaw (Johnson 1894).

219. Cosmarium speciosum Lund.

West and West, 1908. Monogr. Brit. Desm., 3:247. Pl. 89, Figs. 1-3.

The semicells of this species are truncate pyramidate (almost subrectangular). The lateral margins, which possess about seven crenations, converge very gradually and slightly to the truncate apices, each of which has four crenations. The intramarginal granules are arranged in regular concentric and radial series (about four granules in each radial series). The lower part of the semicell just above the isthmus has 6-9 vertical series of granules with about 4-5 granules in each series. The vertical view is elliptic with granules arranged in curved transverse rows.

Measurements: L. 48-(51)-64u; W. 31-(38)-41;
I. 14-(21)-26u.

Distribution: NLP, Emmet, also Cheboygan (N and A 1932).

220. var. simplex Nordst.

West and West, 1908. Monogr. Brit. Desm., 3:250. Pl. 89, Fig. 6.

The semicells of this variety have more attenuated lateral margins than the typical. The vertical series of granules at the base of the semicell is usually indistinct or absent.

Measurements: L. 42-60u; W. 26.5-40u.

Distribution: Isle Royale (Prescott 1937).

221. var. simplex fa. intermedia Wille

West and West, 1908. Monogr. Brit. Desm. 3:251. Pl. 89, Fig. 7.

This form is slightly smaller than var. simplex Nordst.

Measurements: L. 38-40u; W. 27-29u; I. 14-21u.

Distribution: Isle Royale (Prescott 1938).

222. var. Rostafinskii fa. americana West and West.

West and West, 1898. Jour. Linn. Soc. Bot. 33:279. Pl. 17, Fig. 13.

This form is distinguished from the typical species and from var. Rostafinski (Gutw.) West and West by the lack of vertical series of granules in the lower central region of the semicell wall. It resembles var. simplex Nordst. but the semicell is more pyramidate and the size is smaller.

Measurements: L. 40.5u; W. 26.6u; I. 17.2u.

Distribution: Isle Royale (Prescott 1938).

223. Cosmarium decoratum West and West

West and West, 1895. Trans. Linn. Soc. Bot. Ser. 2, 5:61. Pl. 7, Fig. 21.

This species has truncate-pyramidate semicells with the slightly convex lateral margins converging gradually to the flattened apices. The semicell wall is ornamented with triangular thickenings, six of which surround a single scrobiculation. The semicell wall thus appears to have a reticulate network composed of linear grooves with a coarse scrobiculation at each intersection. The vertical view is elliptic (almost rhomboid) with tumid lateral margins, and with the same wall decoration as described above.

Measurements: L. 70-86u; W. 52-63u; I. 23-32.5u.

Distribution: NLP, Cheboygan (Taft 1939).

224. Cosmarium ochthodes Nordst.

West and West, 1912. Monogr. Brit. Desm. 4:10. Pl. 98, Figs. 1-3.

This species has truncate-pyramidate semicells (ovate-pyramidate from a flat base) with convex lateral margins converging to a narrow and truncate apices. The lateral margins are crenate or undulate (11-13 per semicell). The intramarginal granulation consists of irregular radial and concentric series which become reduced or are completely lacking in the middle of the semicell. The semicell wall is also punctulate.

Measurements: L. 70-(82)-94u; W. 51-(62)-67u; I. 17.5-(21.5)-27u.

Distribution: NLP, Cheboygan (N and A 1932); EUP, Delta, Isle Royale (Prescott 1938).

225. var. amoebum West.

West and West, 1912. Monogr. Brit. Desm. 4:11. Pl. 98, Figs. 4-6.

This variety is separated from the typical by the pyramidate-trapeziform semicells (broader apices), the very much depressed granules which are sinuate in outline and the faintly undulate margin.

Measurements: L. 82-(87)-113u; W. (54)-60-75u; I. 19-24u.

Distribution: SLP, Barry, Oakland; Isle Royale (Prescott, 1937, 1938).

226. var. Novae-terrae Taylor. nob. Pl. 20, Fig. 2.

Taylor, 1934. Pap. Mich. Acad. Sci., Arts and Letters, 19:258, Pl. 52, Fig. 8.

This variety which was unnamed by Taylor (1934) has somewhat shorter and more stout semicells which are pyramidate-truncate (to sub-semicircular) in outline. The convex lateral margins are slightly crenate and the apical margins are straight or slightly undulate. The intramarginal ornamentation consists of 3-5 crenations radially arranged within each marginal crenation (about 7-9 per lateral margin). The intramarginal crenations are lacking within the apices. The semicell wall is closely

and densely punctulate, the punctae in the polar areas forming blocks of transverse rows. The vertical view is elliptic with crenate poles and with the cell wall punctate as described above. Specimens from Barry and Shiawassee Counties are assigned here although neither the polar punctation nor the scrobiculate semicell wall in the Shiawassee County specimens agree with typical characteristics. They should be compared with var. subcirculare Wille which has uniformly undulate margins and a smaller size.

Measurements: L. (64.5)-65-(65)u; W. 50-(50)-(54)u; I. 12-(15)-(17)u.

Distribution: SLP, Barry, Shiawassee. New records for Michigan.

227. Cosmarium retusum (Perty) Rab.

West and West, 1908. Monogr. Brit. Desm. 3:264. Pl. 91, Figs. 1, 2.

The semicells of this species have retuse lateral margins converging from broadly rounded basal angles to truncate apices which may be straight or slightly convex. The granular ornamentation consists of 4-8 granules at each basal angle (3 or 4 of which are upon the margin), 3-6 granules irregularly disposed in the center of the semicell, and sometimes 3-4 granules in an subapical row. Specimens from Alger, Schoolcraft and Gogebic Counties lack granules in the central region of the semicells. As

West and West (1908) state that the granulation is exceedingly variable and not infrequently scarcely visible, the author has included these forms here. Also included is Prescott's (1938) record of C. columbianum G. S. West.

Measurements: L. 28-39-(42)u; W. 24-31-(33)u; I. 8-10-(10.5)u.

Distribution: EUP, Alger, Schoolcraft; WUP, Gogebic; Isle Royale (Prescott 1938).

228. Cosmarium denticulatum fa. Borgei Irénee-Marie

Irénee-Marie 1938. Hor. Desm. de la Reg. Mont.:209. Pl. 28, Figs. 1 and 3-6; Pl. 68, Fig. 4.

This organism has truncate-pyramidate semicells with convex lateral margins converging gradually to the truncate apices which have straight or slightly rounded margins. The lateral margins are ornamented with numerous (32-44) wart-like granules and the apical margins are smooth. Within the margins there are 4-5 concentric series of granules similar to those on the margins but diminishing in size inwardly. The base of each semicell above the isthmus is ornamented with 2-4 transverse rows of granules. This latter characteristic distinguishes this species from C. ovale Ralfs. The semicell wall is finely scrobiculate.

Measurements: L. 168-(192)-208u; W. 95-(97)-109u; I. (32)-35-44u.

Distribution: SLP, Barry, Washtenaw, also Calhoun (Pres. and Mag. 1935).

229. Cosmarium ovale Ralfs.

West and West, 1908. Monogr. Brit. Desm. 3:267. Pl. 92, Fig. 1; Pl. 93, Fig. 1; Pl. 94, Fig. 1.

This very large species has truncate-pyramidate (ovate from a broad flat base according to the Wests(1908)) semicells with the lower lateral margins convex and very slightly convergent and with the upper lateral margins almost straight and convergent to rounded truncate apices. Large conical granules are arranged in series upon or just within the lateral margins. The apical margin is smooth but with one or two irregular series of granules just within the margin. The cell wall is finely scrobiculate. The vertical view is elliptic with granules (arranged in 4-5 irregular rows) forming a broad band from pole to pole.

Measurements: 166-(168)-222u; W. 90-(97)-136u; I. 30-(30)-48u.

Distribution: SLP, Barry (2); NLP, Cheboygan (N and A 1932); EUP, Schoolcraft.

230. var. Prescottii Irénee-Marie.

Irénee-Marie 1938. Flor. Desm. de la Reg. Mont:208. Pl. 68, Figs. 1, 2.

This variety is separated from the typical by the presence of one or two transverse rows of granules across the base of the semicell. It resembles C. denticulatum fa. Borgei Irenee-Marie but one or two intramarginal

series of granules distinguished it (var. Prescottii) from this form.

Measurements: L. 163-(192)-212u; W. 93-(107)-116u; I. (32)-36-40u.

Distribution: SLP, Barry; WUP, Houghton; Isle Royale (Prescott 1937, 1938).

231. Cosmarium Gayanum var. eboracense G. S. West. Pl. 20, Fig. 3. West and West, 1912. Monogr. Brit. Desm., 4:3. Pl. 93, Figs. 6-8 (Pl. and Figs. in Vol. 3, 1908).

The semicells are truncate-pyramidate (ovate-pyramidate from a flat base) with convex lateral margins converging from rectangular-rounded bases to the truncate apices. Each lateral margin possesses about twenty-four minute granules to which of each there is corresponding series (7-9 granules) radiating inwardly within the margin. The granules progressively decrease in size inwardly to the central region of the semicell wall which is punctate.

Measurements: L. 85-(91)-110u; W. 51-(55)-68u; I. (19)-20-22.5u.

Distribution: NLP, Roscommon; EUP, Chippewa. New records for Michigan.

232. Cosmarium Botrytis Menegh.

West and West, 1912. Monogr. Brit. Desm., 4:1. Pl. 96, Figs. 1, 2, 5-15.

The semicells of this species are truncate-pyramidate (ovate-pyramidate from a broad flat base according to

West and West 1912) with convex lateral margins converging gradually to the narrowly truncate or subtruncate apices. The semicell wall and margin is ornamented with granules either irregularly or in slightly concentric series. The vertical view is elliptic without lateral protuberances.

Measurements: L. 60-(83)-111u; W. 51-(56)-85u; I. 14-(17)-26u.

Distribution: SLP, Ionia (Wade 1949), Wayne (Campbell 1886), Macomb (Pieters 1894); NLP, Emmet (Transeau 1917 and N and A 1932), Cheboygan (Transeau 1917, Welch 1936a, 1938b)(Neel 1948); WUP, Menominee; Isle Royale (Taylor 1935, Prescott 1937, 1938).

233. var. mediolaeve West.

West and West, 1912. Monogr. Brit. Desm., 4:6. Pl. 97, Fig. 5.

This variety is separated from the typical by the smooth and faintly concave apex, by the intramarginal granules arranged in concentric and radiating series and by the smooth central area of the semicell.

Measurements: L. 54.5-70u; W. 47-59u; I. 15-15.5u.

Distribution: NLP, Cheboygan (N and A 1932); Isle Royale (Prescott 1938 fa.).

234. var. subtumidum Wittr. fa. Irénee-Marie nob. Pl. 20,Fig. 4.

Irenee-Marie, 1938. Flor. Desm. de la Reg. Mont.:211; Pl. 31, Fig. 14; Pl. 32, Figs. 5-6.

This organism is separated from the typical by the proportionately wider cells and the larger size of the

granules in the central region. Specimens from Oakland County agree favorably with Irénee-Marie's (1938) unnamed forma in which some of the intramarginal granules above the central region of the semicell are very strongly developed and a few are emarginate.

Measurements: L. 55-(59)-65u; W. 45-47-(59)u; I. 10-12-14u.

Distribution: SLP, Oakland. New record for Michigan.

235. var. tumidum Wolle.

West and West, 1912. Monogr. Brit. Desm. 4:5. Pl. 97, Figs. 2, 3.

This variety is separated from the typical by the possession of a central tumor on each semicell. The granules on the central tumor are larger than other granules and are irregularly disposed. Occasionally there is a large granule adjacent to the base.

Measurements: L. 65-85u; W. 50-68u; I. 17-20u.

Distribution: Isle Royale (Prescott 1938).

236. fa. nudum fa. nov. Pl. 21, Fig. 2.

Collections from Menominee County were rich in number of individuals of an organism which agrees favorably with most characteristics of C. Botrytis var. tumidum Wolle. Granules on the central tumor in each semicell were not larger than other granules as in the variety but were either poorly developed or lacking. A large supra-isthmial granule was present on each semicell. This

characteristic which is present sometimes in the variety plus the presence of a central protuberance which is characteristic of the variety seem valid proof for designating these organisms as a new form of this variety.

Measurements: L. (75)u; W. (59)u; I. 17u.

Distribution: WUP, Menominee.

237. Cosmarium tetraophthalmum Bréb.

West and West, 1908. Monogr. Brit. Desm. 3:270. Pl. 95, Figs. 4-7.

This plant has pyramidate-ovate to truncate-pyramidate semicells. The lateral margins are convex and the apical margin flattened and somewhat truncate. The granular ornamentation consists of 10-14 granules along each lateral margin (apices smooth). Within the margins, the granules are arranged in concentric and radial series (or more or less scattered according to West and West 1908), becoming very much reduced in size near the middle of the semicells.

Measurements: L. 90-120u; W. 60-86u; I. 18-30u.

Distribution: NLP, Cheboygan and Emmet (N and A 1932); Isle Royale (Prescott 1937, 1938).

238. Cosmarium spinosporum Lag.

West and West, 1898. Jour. Linn. Soc. 33:309. Pl. 17, Fig. 89. Lagerheim, 1887. Ofvers. K. Sv. Vet. Akad. Forh. 8:538.

The writer has been unable to obtain the original description of this organism because the journal is un-

available. The only other reference known to the writer is that of West and West (1898) who merely report its occurrence in Washtenaw County.

16. COSMOCLADIUM Breb. 1856

Cells small, round in outline or with length slightly greater than width; medianly constricted and similar in shape to Cosmarium; inclosed in mucilage and united by gelatinous bands into spherical or ellipsoidal few-celled colonies that are attached or free-floating. Semicells subpyramidate, subreniform or elliptic in front view, circular or elliptic in transverse view, and subcircular in side view; sometimes with a median facial swelling or tubercle. Chloroplast axial, usually one in each semicell, and each with a central pyrenoid.

Zygospores spherical with short spines or broadly angular projections.

Key to Species of Cosmocladium

1. Cells with a median facial swelling or tumor 2

1. Cells without a median facial swelling or tumor 3

2. Semicells hexagonal elliptic; L. 9u; W. 8u. . . . . (1) C. tumidum

2. Semicells subreniform; L. 14.5-15u; W. 11.5-12u. . . . . (2) C. tuberculatum

3. Semicells subpyramidate in front view, circular in transverse view; median constriction very slight . . . (3) C. constrictum

3. Semicells oblong-elliptic, elliptic, or subreniform in front view; elliptic in transverse view; median constriction well defined and linear 4

4. Semicells oblong elliptic; length equal to breadth (10-12u) . . . . . (5) C. pusillum

4. Semicells elliptic or subreniform; length always somewhat greater than width (10.5)-12-24u x (8.5)-11-16u . . . . . (4) C. pulchellum

1. Cosmocladium tumidum Johnson

Johnson, 1895. Bull. Torr. Bot. Club. 22(7):296. Pl. 240. Fig. 23.

This small species has transversely hexagonal-elliptic semicells, a median facial inflation and is slightly longer than wide.

Measurements: L. 9u; W. 8u; I. 2u.

Distribution: SLP, Washtenaw (Johnson 1895, N & A 1932).

2. Cosmocladium tuberculatum Prescott

Prescott and Magnotta, 1935. Pap. Mich. Acad. Sci. Arts, Letters: 20:163. Pl. 25, Fig. 11.

This species has a median facial tubercle, subreniform semicells, and cells longer than wide.

Measurements: L. 14.5-15u; W. 11.5-12u.

Distribution: SLP, Calhoun (Pres. & Mag. 1935).

3. Cosmocladium constrictum Arch.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:198. Pl. 158, Figs. 1-3.

The characteristic subpyramidate semicells (circular in transverse view) and the very slight median constriction easily distinguishes this species.

Measurements: L. 16-20u; W. 10-12u; I. 8.5-9u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Schoolcraft (Transeau 1917).

4. Cosmocladium pulchellum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm.:200. Pl. 158, Figs. 11, 12.

This species is characterized by elliptic or subreniform semicells, with the cells always being longer than wide.

Measurements: L. (10.5)-12-24; W. (8.5)-11-16u; I. 4-4.5u.

Distribution: SLP, Oakland, also Muskegon (Transeau 1917).

5. Cosmocladium pusillum Hilse

West, West and Carter, 1923. Monogr. Brit. Desm. 5:201. Pl. 158, Figs. 8-10.

This species has elliptic or subreniform semicells and the cell length is always somewhat greater than width.

Measurements: L. 10-12u; W. 10-12u; I. 2-3u.

Distribution: Barry, also Calhoun (Pres. & Mag. 1935).

17. ARTHRODESMUS Ehrenb. 1838

Cells relatively small, and as broad as long; usually compressed, and bilaterally symmetrical; in front view the semicells generally obversely triangular, more rarely transversely

elliptic, subtrapeziform, subrectangular, or subquadrate; median constriction relatively deep with the sinus widely open to linear (closed in A. Bulnheimii); cell wall without ornamentation except for single spines (paired spines at apical angles in A. tenuissimus and A. trispinatus fa.) inserted at each angle. Cells in vertical view usually elliptic, rarely fusiform or triangular, with single spines at pole (one spine on each side near pole in A. tenuissimus, and A. trispinatus fa.). Chloroplast axial, usually one in each semicell; pyrenoids usually single and arranged centrally in each chloroplast.

Zygospore smooth or with simple spines.

Key to Species of Arthrodesmus

1. Semicells bearing two spines 6
1. Semicells bearing more than two spines 2
2. Semicells bearing four spines . 3
2. Semicells bearing six spines . 5
3. Semicells hexagonal depressed with straight sides . . . . . (1) A. bifidus var. truncatus
3. Semicells rectangular, with retuse sides 4
4. Length of cells up to 27u (without spines) . . . . . (2) A. octocornis
4. Length of cells over 30u (without spines); angles extended to form lobes . . . . . (3) A. impar
5. Apical angles with minute granular spines, lateral angles with short spines . . . . . (4) A. tenuissimus

5.	Apical angles with well-defined spines; lateral angles with spines of the same length	(5) A. trispinatus
	6. Apex highly elevated and broadly truncate	(6) A. michiganensis
	6. Apex otherwise	7
7.	Semicells transversely elliptic . .	8
7.	Semicells not transversely elliptic.	9
	8. Spines convergent	(7) A. convergens
	8. Spines horizontal or slightly divergent	(8) A. subulatus
9.	Semicell subrectangular, sinus closed or nearly so at the apex .	(10) A. Bulnheimii var. subincus
9.	Semicell not subrectangular	10
	10. Spines less than 4u long, usually about 2u	11
	10. Spines more than 4u long . . .	12
11.	Width without spines, 12.9-17u . . .	(11) A. crassus
11.	Width without spines, 10.5-11.7u . .	(12) A. controversus var. brasiliense
	12. Spines convergent	13
	12. Spines horizontal or divergent.	14
13.	Spines straight	(13) A. Ralfsii
13.	Spines twisted	(15) A. crispus var. minor
	14. Apex retus	(16) A. phimus
	14. Apex not retuse	15
15.	Apex flat or concave	(18) A. incus
15.	Apex slightly elevated, often with a median indentation	(26) A. triangularis

1. Arthrodesmus bifidus var. truncatus West

West and West, 1912. Monogr. Brit. Desm. 4:114. Pl. 117, Fig. 14.

This small variety is characterized by the subhexagonal form with a single minute spines at each angle.

Measurements: L. 10-15.5u; W. 10-14.4u; I. 4.5-5.7u.

Distribution: NLP, Cheboygan (N & A 1932).

2. Arthrodesmus octocornis Ehrenb.

West and West, 1912. Monogr. Brit. Desm. 4:111. Pl. 117, Figs. 6-10.

This species characteristically has transversely trapeziform-rectangular semicells, the margins retuse between the angles. It is easily separated from A. impar (Jacobs) Gronbl. by its smaller size, and by the angles not being extended into lobes.

Measurements: L. ssp. (14)-21.5-24-(27)u; L. csp. (30)-30-(42)u; W. ssp. (10)-14-(20)u; W. csp. 20-(22)-44u; I. (4)-5.5-(10u.

Distribution: SLP, Berrien, Calhoun; NLP, Emmet, Cheboygan (N & A 1932); EUP, Chippewa, Schoolcraft; WUP, Houghton, Gogebic (2).

3. Arthrodesmus impar (Jacobs) Gronbl. Pl. 7, Fig. 4.

Gronblad, 1921. Acta. Soc. pro Faun. and Flor. Fenn. 49(7):55. Pl. 3, Figs. 58-60.

This species resembles A. octocornis Ehrenb. superficially but is easily separated by its greater size and

by the lobes which are formed by the extension of the angles.

Measurements: L. ssp. 29.7-(33)-40u; L. csp. 65-(67)-80u; W. ssp. 26.4-(33)-42u; W. csp. 59.4-(65)-80u; I. 10-(10.5)-13u.

Distribution: NLP, Roscommon; EUP, Chippewa. New record for Michigan. The only other reports of this species in North America are those of Taylor (1934), for New Foundland and Prescott (1935) for Massachusetts.

4. Arthrodesmus tenuissimus Archer Pl. 7, Fig. 5.

West and West, 1912. Monogr. Brit. Desm. 4:116, Pl. 117, Figs. 18, 19.

This small species can be confused easily with A. bifidus var. truncatus West. The latter, however, bears only four spines on a semicell, whereas A. tenuissimus bears six, four of which are not more than small granules upon the apical angles.

Measurements: L. 8-(8.5)-10u; W. ssp., Spines (8.5)-11.5u; W. csp. (10)-13.6u; I. (5)-5.5u.

Distribution: WUP, Houghton. New record for Michigan.

5. Arthrodesmus trispinatus West and West Pl. 7, Fig. 6.

West and West, 1912. Monogr. Brit. Desm. 4:115. Pl. 117, Fig. 17.

The typical form of this species shows, in vertical view, three superimposed spines at each pole. The specimens examined from Barry County show three spines at each

pole not superimposed. The typical form in front view has three equal undulations on each lateral margin with a spine on each crest. The Barry County specimens have, on each side, one spine inserted upon each lateral angle, and two spines inserted on the apical angles. These agree well with forms shown by Skuja (1928). The equal size of the spines and the shape of the semicells easily distinguish this form from A. tenuissimus Archer. This should also be compared with Xanthidium Smithii Arch.

Measurements: L. ssp. (10.5)-11.5u; L. csp. 17-(19)u; W. ssp. (8)-11u; W. csp. 17-(17)u; I. (4.5)-6.2u.

Distribution: SLP, Barry. New record for North America.

6. Arthrodesmus michiganensis Johnson

Johnson, 1895. Bull. Torr. Bot. Club. 22(7):296. Pl. 239, Fig. 12.

The elevated truncate apex separates this species from others. Specimens from Barry County are proportionately narrower than Johnson original figures, and agree more favorably with those illustrated by Smith (1924).

Measurements: L. (32)-26-40u; W. ssp. (22)-24-30u; W. csp. (44)-65u; I. 5.5-(8.5)-9u.

Distribution: SLP, Barry, Oakland, also Washtenaw (Johnson 1895). This alga is quite rare, having been reported only from Wisconsin (Smith 1924), Michigan and New York, (Burkholder 1931).

7. Arthrodesmus convergens Ehrenb.

West and West, 1912. Monogr. Brit. Desm. 4:106. Pl. 116, Figs. 4-13.

The transversely elliptic semicells with convergent spines on each lateral margin easily distinguish this species, although there is some variation in form of semicells, and in the length of the spines.

Measurements: L. 33-(38)-54u; W. ssp. (38)-40-64u; W. csp. 50-(64)-90u; I. 10-(11)-17u.

Distribution: Well represented in the writer's collection. SLP, Calhoun, Barry (2), Washtenaw, Berrien, also Washtenaw (West and West 1898); NLP, Emmet, Crawford, also Cheboygan (N & A 1932); EUP, Chippewa, Alger, Schoolcraft; WUP, Marquette, Houghton.

8. Arthrodesmus subulatus Kuetz.

West and West, 1912. Monogr. Brit. Desm.4:109. Pl. 16, Fig. 14; Pl. 117, Fig. 1.

The elliptic obsemicircular shape of the semicells and the elevated apices characterize this species.

Measurements: L. 27-50u; W. ssp. 18-54u; W. csp. 52-100u; I. 6-13.5u.

Distribution: SLP, Berrien; NLP, Cheboygan (N & A 1932, Welch 1938a); EUP, Schoolcraft.

9. var. subaequalis West and West

West and West, 1912. Monogr. Brit. Desm. 4:110. Pl. 117, Figs. 2, 3.

This variety has a greater proportionate width of the semicells and less difference in convexity between the upper and lower margins of the semicells when compared

with the typical plants. The only specimens that the writer has examined appear somewhat intermediate between the typical and var. subaequalis but are placed in the latter category because of the similar convexity of the dorsal and ventral margins of the semicells, although the measurements are closer to those of the typical. This intermediate form approaches very closely the organism figured by Irénee-Marie (1938) as the typical plant.
Measurements: L. (28)-31-38u; W. csp. (27)-31-42u; W. csp. (47)-52-65u; I. (6)-8-12u.
Distribution: NLP, Presque Isle, also Cheboygan (N & A 1932).

10. Arthrodesmus Bulnheimii var. subincus West and West
West and West, 1912. Monogr. Brit. Desm. 4:105. Pl. 116, Fig. 3.

The distinguishing features of A. Bulnheimii are the subrectangular shape of the semicells, and the closed linear sinus, Smith (1924); however, does not recognize the latter as being characteristic of Wisconsin forms, nor do his figures indicate such a condition. The writer has observed specimens from several counties which show either a closed or a slightly closed sinus, but which must be designated as var. subincus because of the rounded basal angles of the semicells. These specimens are larger than those reported by Taylor (1934) from New Foundland or by West and West (1912) from Great Britain.

Measurements: L. ssp. 23-(33)-28-(36)u; L. csp. 44-54-(56)u; W. ssp. 24-(29)-28-(35.5)u; W. csp. 45-(52)-54-(57)u; I. 4.5-8-(8.5)u.

Distribution: NLP, Emmet, also Cheboygan (Taft 1939); EUP, Schoolcraft.

11. Arthrodesmus crassus West and West fa. Borge Pl. 7, Fig. 7. Borge, 1930. Arkiv. f. Botanik. 23A(2):40. Pl. 2, Fig. 36. West and West, 1912. Monogr. Brit. Desm. 4:102. Pl. 115, Figs. 8, 11.

There is some difficulty in determining the limits of A. crassus and A. controversus. West and West (1912), who are the authors of both species, separates them on the basis of size and the shape of the semicell in vertical view. A. crassus has a length of 19.5-24u; and is broadly elliptic-fusiform (West and West use the term rhomboid in their analytical key) in vertical view. A. controversus is much smaller, being 10.5-12u long, and is broadly elliptic in vertical view. Borge (1930) described a new form which he places in A. crassus (probably upon the basis of the appearance in front view). This form however, has a length of 14.3-16u (intermediate between A. crassus and A. controversus), and the broadly elliptic shape of A. controversus in vertical view. The shape of specimens from Berrien County are closer to Borge's form than to either of the typical plants of both species, although the measurements are closer to A. controversus. Perhaps both Borge's form and the Berrien County

specimens could be better considered forms of A. controversus than of A. crassus.

Measurements: L. (12.9)-14.3-16u; W. ssp. (12.9)-14-17u; W. csp. (15)-15.5-20u; I.(6.5)-7-8.5u.

Distribution: SLP, Berrien. New record for North America.

12. Arthrodesmus controversus var. brasiliense Borge. Pl. 7, Fig. 8.

Borge, 1918. Ark. f. Bot. 15(13):40. Pl. 2, Fig. 21.

West and West, 1912. Monogr. Brit. Desm. 4:103. Pl. 115, Figs. 12, 14.

The characteristics of both A. controversus and A. crassus were mentioned previously under A. crassus. Borge (1918) described the variety brasiliense from Sao Paulo, Brazil as a slightly larger form with a less rotund apex. The writer has observed specimens from Schoolcraft County that are similar to this variety in shape and measurements. These specimens differ from the variety, however, by having a slight retuseness in the median portion of the apex. The lateral view compares favorably with A. crassus fa. Zachariasii Gronb. (= A. Zachariasii Schroder) (see Gronb. 1926), which is probably identical with A. controversus var. brasiliense although no measurements are given.

Measurements: L. 12-(12.9)-14.5u; W. ssp. 10.5-11.5-(11.7)u; W. csp. 13.5-(14.9)-16.5u; I. (6.5)-7-8u.

Distribution: EUP, Schoolcraft. New record for North America.

13. Arthrodesmus Ralfsii W. West

West and West, 1912. Monogr. Brit. Desm. 4:95. Pl. 114, Figs. 2-4.

West originally described this species, and later transferred it to A. incus as a variety. The writer follows Smith (1924a) in considering this alga a distinct species. The most distinctive character is the convergent spines. In addition to this, the length-width ratio separates it from A. incus (Breb.) Hass.

Measurements: L. 16-33u; W. ssp. 16-20u; W. csp. 28-47u; I. 7.5-8.5u.

Distribution: NLP, Cheboygan (N & A 1932).

14. var. Brebissonii (Racib.). Smith Pl. 8, Fig. 2.

Smith, 1924. Wisc. Geo. Nat. Hist. Surv. Bull. 57(2):130. Pl. 85, Figs. 13-17.

This variety is separated from the typical by the triangular semicells, the greater length, and the degree of convergence of the spines.

Measurements: L. (19)-21-27u; W. ssp. (19)-25u; W. csp. (43)-47-60u; I. (4.5).

Distribution: NLP, Presque Isle. New record for Michigan.

15. Arthrodesmus crispus Turner var. minor var. nov. Pl. 8, Fig. 1.

Cells small, median constriction moderately deep, sinus widely open and with a rounded apex. Isthmus narrow and elongate, semicells obversely subtriangular with

convex sides and very slightly convex apices which are somewhat retuse in the median part. Upper angles with fairly long spines that are convergent and slightly twisted. Vertical view elliptic with each pole armed with a long, slightly twisted spine.

Nordstedt (1895) transfers A. crispus, A. curvatus, and A. gangensis (all described by Turner 1892) to A. gibberulus Joshua. This transfer, however, has not been held valid, or at least recognized, by several authors (Gronbl. 1921, Krieger 1932). Although the writer has been unable to locate any descriptions of A. crispus or A. gangensis, other than the original descriptions of Turner (1892), a variety of A. curvatus has been described by Gronbl. (1921). It is the writer's opinion that A. crispus must be considered a valid species (at least distinct from A. gibberulus) because it differs from A. gibberulus in the lack of lateral inflations In vertical view, in the less elevated apices, and in the more slender spines. The Michigan specimens differ from the typical in the smaller size, the presence of a more elongated isthmus, broadly open sinuses, and less convergent spines. A. curvatus and A. gangensis Turner, are at least closely related forms, and probably are identical with A. crispus.

Measurements: L. 30u; W. ssp. 29u; W. csp. 59u; I. 8.5u.

Distribution: WUP, Gogebic.

16. Arthrodesmus phimus Turner

Turner, 1892. Kongl. Sv. Vet. Akad. Handl. 25(5):136. Pl. 12, Fig. 9.

This species is distinguished by the marked concavity of the apex of the semicell.

Measurements: L. csp. 19.5-26u; L. csp. 36u; W. ssp. 20-35u; W. csp. 42u; I. 6.5-7.6u.

Distribution: NLP, Cheboygan (Taft 1939).

17. var. occidentalis West and West

West and West, 1912. Monogr. Brit. Desm. 4:104. Pl. 115, Fig. 17.

This variety is smaller than typical, with cells broader than long. The sinus is less open and the angles are less produced.

The writer's specimens from Roscommon County agree with measurements of the variety very closely, except for the presence of longer spines which, on the other hand, are characteristic of the typical.

Measurements: L. (14)-14-14.6; W. ssp. 16.3-(17)-17.3u; W. csp. 19-19.4u(30u); I. (5)-5.7-6.2u.

Distribution: NLP, Roscommon, also Cheboygan (Taft 1939).

18. Arthrodesmus incus (Breb.) Hass.

West and West, 1912. Monogr. Brit. Desm. 4:90. Pl. 113, Figs. 13-15.

Smith (1924), and West and West (1912), consider the typical A. incus of the early investigators as follows:

(cell about as long as broad, semicells obversely triangular with a straight or slightly convex apex, narrow isthmus, broadly open sinus with an acute apex, acute angles bearing long divergent or subparallel spines, vertical view elliptical. Numerous varieties and forms have been described in the past, making it difficult to delimit the exact form of this species.

Measurements: L. ssp. 21-27u; L. csp. 27-50u; W. ssp. 18-26u; W. csp. 56-71u; W. 7-9u.

Distribution: SLP, Berrien; NLP, Cheboygan (N & A 1932, Welch 1936b).

19. forma isthmosa Heimerl.

Heimerl, 1891. Ver. K. K. Zool. Bot. Ges. 41:603. Pl. 5, Fig. 18.

A small variety characterized by a narrow trapeziform semicells with angular bases, widely open sinuses, semicircular apices and horizontal to slightly divergent spines. The vertical view is fusiform. There is a resemblance to the variety extensus from which it differs primarily in the presence of a shorter isthmus, and a greater breadth to length ratio.

Measurements: L. 13-18-(19)u; W. 13-29u; W. csp. 32u; I. (5)-6u.

Distribution: SLP, Calhoun; NLP, Cheboygan (N & A 1932).

20. forma minor West and West

West and West, 1912. Monogr. Brit. Desm. 4:92. Pl. 113, Figs. 16-19.

A small variety about 1/2 the size of the typical, with the semicells slightly inflated.

Measurements: L. ssp. 12.5-16.5; L. csp. 19-25u; W. ssp. 12.5-13.5u; W. csp. 19-26u; I. 5.5-7.

Distribution: NLP, Cheboygan (N & A 1932).

21. forma semilunaris Schmidle Pl. 7, Fig. 10.

Schmidle, 1895. Oest. Bot. Zeit. 45: Pl. 16, Fig. 9.

A small variety characterized by the decidedly convex apex of the semicell, the broadly open sinus with an acute apex, and the acute angles terminated by sharply divergent spines.

Measurements: L. ssp. (13)-u; L. csp. (19.5)u; W. ssp. 10.5u; W. csp. 15.2u; I. 5.3u.

Distribution: WUP, Chippewa. New record for North America.

22. fa. triquetra West and West

West and West, 1912. Monogr. Brit. Desm. 4:99. Pl. 118, Fig. 16.

This variety is triangular in vertical view, and has retuse sides.

Measurements: L. ssp. 21u; W. ssp. 21u; W. csp. 48u; I. 6.5u.

Distribution: SLP, Muskegon (Transeau 1917).

23. var. extensus Anderson

Smith, 1924. Wis. Geo. & Nat. Hist. Surv. Bull. 57(2):132. Pl. 85, Figs. 23-26.

This variety is characterized by the trapeziform shape of the semicells and the elongate isthmus. It should be compared with fa. isthmosa from which it differs in a greater breadth-length ratio, and a more elongate isthmus.

Measurements: L. 20-(23.5)-25; W. ssp. 15-17u; W. csp. 45-62u; I. 5-6-(7.5)u.

Distribution: SLP, Berrien; NLP, Schoolcraft; WUP, Gogebic; Isle Royale (Prescott 1937; A. triangularis var., 1940; A. triangularis var. inflatus West and West).

24. var. indentatus West and West

West and West, 1912. Monogr. Brit. Desm. 4:94. Pl. 113, Figs. 20-24.

The slight constriction of the basal part semicell just above the isthmus is the distinctive feature of this variety. It results in a transversely rectangular portion of the upper half of the semicell, and a cup-shaped portion in the lower half of the semicell. The spines are usually divergent but may rarely be horizontal. The latter characteristic is present in specimens from Calhoun County. These specimens are also slightly smaller in width of semicell and isthmus than measurements given in West and West, (1912).

Measurements: L. 18-(21.8)-22u; W. ssp. (15.2)-18-22u; W. csp. 35-(43.6)-48u; W. (4.3)-7-9u.

Distribution: SLP, Calhoun; NLP, Cheboygan (N & A 1932).

25. var. longspina Eichl. and Racib. Pl. 7, Fig. 9.

Eichler and Racib., 1893. Akad. Umiej. w. Krakow. 2 Ser. 6:120. Pl. 3, Fig. 21.

A small variety which is characterized by its size, slight retuseness of apex of semicells and the sharply diverging long spines. The figure used by West and West (1912) to illustrate this variety lacks the retuse character of the semicell apex. The measurements are slightly smaller than the British forms.

Measurements: L. ssp. (11)-14u; L. csp. (18.5)u; W. ssp. (8.8)-11.5u; W. csp. (18.5)u; I. (4.5)u.

Distribution: SLP, Ingham. New record for North America.

26. Arthrodesmus triangularis Lagerheim Pl. 7, Fig. 10.

Lagerheim, 1885. Ofvers. Kgl. Sv. Vet. Akad. Forh. 42(7):244. Pl. 27, Fig. 22.

The distinguishing features of this species are the obversely triangular semicells with shallow retuseness of the slightly elevated apex, the widely open sinus with bluntly flattened apex, and the narrow and elongate isthmus. Specimens from Calhoun County have measurements in the lower range for the species.

Measurements: L. 15-(17.4)-30u; W. ssp. 14-(15)-25u; W. csp. (34)-52-65u; I. (4.3)-5-7u.

Distribution: SLP, Calhoun. New record for Michigan.

27. var. rotundatus (Racib.) Smith

Smith, 1924. Wisc. Geo. & Nat. Hist. Surv. Bull. 57(2): 133. Pl. 86, Figs. 2-4.

Smith has combined var. inflatus of West and West, and Raciborski's var. rotundata. These forms are distinguished from the typical by the larger size, and the more convex apex of the semicells in which the median indentation may be reduced or wanting. The semicells are angular-elliptic in shape, being slightly inflated in appearance. This form approaches A. subulatus fa. americana (Turner) West and West, from which it differs in the more elongated and narrower isthmus, the narrower elliptic semicell in vertical view, and the slightly smaller maximum width. Specimens observed from Barry County are wider than measurements given by West and West (1912) or Smith (1924), but otherwise agree with the description of fa. rotundatus. Prescott's figures of A. triangularis Lag. var. (1937) and of A. triangularis var. inflatus (1940) do not appear to belong to this form.
Measurements: L. 24-(33)-38u; W. ssp. 19-25-(31)u; W. csp. 57-(62)-76u; I. 5.8-(7)-7.5u.
Distribution: SLP, Barry; NLP, Cheboygan (Taft 1939, A. incus var. inflatus).

18. SPINOCOSMARIUM Prescott and Scott 1942

Cells of medium size, compressed in lateral view, with a deep median constriction. Semicells in front view suborbiculate, generally subhexagonal to suboctagonal, with each lower lateral margin bearing a single, long, straight or slightly

recurved, simple or bifurcate horizontally projecting spine; each apical angle with a pair of granules or spines. Cell wall with irregularly arranged granules or verrucae, a single granule always in a median supra-isthmial position in each semicell, sometimes wall devoid of granules except for isthmial granule and a central facial projection. Semicell in vertical view elliptic, with poles bearing long, stout, simple or bifurcate spines, sometimes accessory divergent spines placed on each side of the centrally placed polar spine.

Zygospore unknown.

1. Spinocosmarium quadridens (Wood) Prescott and Scott. Pl.11, Fig. 3.

Prescott and Scott, 1942. Trans. Amer. Microsc. Soc. 61(1):16. Scott and Prescott, 1949. Trans. Amer. Microsc. Soc. 68(4): Pl. 1, Figs. 1-3.

This compressed species has each lower lateral margin of the semicell bearing a long, stout, straight or slightly divergent simple or bifurcate spine. The apical angles may have short, single or paired spines. The cell wall has irregularly arranged granules and/or verrucae, a single granule always placed in a median supra-isthmial region in each semicell.

Measurements: L. 32-(34)-36u; W. ssp. 30-(30)-38u; W. csp. (42.6)-44-53u; I. 8-13u.

Distribution: NLP, Emmet. New record for Michigan.

19. XANTHIDIUM Ehrenb. 1837

Cells of variable size, frequently longer than broad in front view; usually compressed and narrowed in side view, and bilaterally symmetrical; semicells generally polygonal, sometimes transversely elliptic or hexagonal-elliptical; median constriction deep with the sinus linear to acute-angled; cell wall smooth or punctate, bearing simple, or rarely, furcate spines disposed asymmetrically in reference to a vertical plane and a thickened protuberant central facial area which is often scrobiculate; cells in vertical view usually elliptic, rarely triangular. Chloroplasts, four in each semicell when parietal, two in each semicell when axial; pyrenoids usually one in each chloroplast.

Zygospore spherical, either spineless and scrobiculate or with simple or furcate spines.

Key to Species of Xanthidium

1. Cells somewhat elliptic in vertical view 2

1. Cells triangular in vertical view . (22) X. antilopaeum var. triquetrum

2. Margins of semicells with mucronate projections . . . . . (1) X. obsoletum

2. Margins of semicells with spines 3

3. Spines in the form of broad furcate processes . . . . . (2) X. armatum

3. Spines simple 4

4. Lateral margins bearing a single pair of spines 5

4. Lateral margins bearing more than a single pair of spines. 7

5. Some portion of the face of semicell wall thickened and scrobiculate . 6

5. Some portion of the face of semicell wall thickened but not scrobiculate . . . . . (5) X. Torreyi

6. Spines on lateral margins inserted in different vertical planes . . . . . (6) X. tetracentrotum var. intermedia

6. Spines on lateral margins inserted in same vertical plane (7) X. subhastiferum var. Johnsonii

7. Lateral margins with a pair of spines on each apical and lateral angle, and with a single spine on the basal angle 8

7. Lateral margins otherwise 9

8. Central area of semicell face with three-quarter circular row of scrobiculations . . . (17) X. antilopaeum fa. Michiganensis

8. Central area of semicell face smooth or with granules or scrobiculations, the scrobiculations never arranged in a three-quarter circular row . (9) X. cristatum

9. Lateral margins with three spines . 10

9. Lateral margins with more than three spines 11

10. Semicells elliptic-hexagonal . (19) X. antilopaeum var. oligacanthum

10. Semicells irregularly rectangular, with angles exerted to form lobes . . . . . (5) X. Torreyi

11. Lateral margins with two pairs of spines 12

11. Lateral margins without two pairs of spines 14

12. Apex broadly truncate, spines inserted horizontally on apical angles . . . . . (15) X. Tylerianum

12. Apex not broadly truncate, spines inserted on apical angles divergent or almost erect 13

13. Supra-median region of the facial cell wall with an arcuate thickened band in which are two irregular rows of scrobiculations . . . (8) X. subhastiferum var. Johnsonii fa. Smithii

13. Face of cell wall ornamented in various ways but never as above . . . (16) X. antilopaeum

14. Lateral margins with three pairs of spines . . . . . (23) X. fasciculatum

14. Lateral margins with more than three pairs of spines, may be somewhat scattered . . . . . (24) X. Brebisonii

1. Xanthidium obsoletum Taylor. Pl. 8, Fig. 3.

Taylor, 1934. Pap. Mich. Acad. Sci. Arts and Letters. 19:275. Pl. 17, Fig. 12.

This species is characterized by the short incrassate projections at the upper and suprabasal angles. Specimens observed from Washtenaw County are questionably placed here because the projections from the angles were short, usually blunt, knob-like spines. They resemble the organism illustrated by Irenee-Marie(1938). Both his form and the specimens from Washtenaw County are possible undeveloped specimens of an unknown species of Xanthidium.

Measurements: L. 52-65-(84)u; W. 52-(61)-67u;
I. (9.5)-18-(21)u.

Distribution: SLP, Washtenaw. New record for Michigan.

2. Xanthidium armatum (Bréb.) Rabenh.

West and West, 1912. Monogr. Brit. Desm. 4:51. Pl. 104, Figs. 1-5.

The possession of furcate spines separates this species from others reported from Michigan. The central protuberance is a large wart bearing simple or emarginate teeth.

Measurements: L. csp. (107)-114; W. csp. (78)-127u;
I. (28)-46u.

Distribution: NLP, Roscommon, also Cheboygan (N & A 1932, Welch, 1936b); EUP, Chippewa; WUP, Gogebic.

3. var. fissum Nordst.

West and West, 1912. Monogr. Brit. Desm. 4:54. Pl. 105, Figs. 1, 2.

This variety differs from the typical by the more elongated spines and by the central protuberance being similar to the marginal spines.

Measurements: L. csp. 135-172u; W. csp. 104-214u; I. 28-40u.

Distribution: NLP, Cheboygan (Taft 1939); WUP, Gogebic.

4. var. irregularis West.

West and West, 1912. Monogr. Brit. Desm. 4:55. Pl. 105, Figs. 3, 4.

This variety is separated from the typical primarily on the basis of the variable disposition and character of

the spines. The spines are often reduced to emarginate or tridentate warts, but may be simple with obtuse ends.

Measurements: L. csp. 172-181u; W. csp. 110-126u; I. 41-50u.

Distribution: NLP, Cheboygan (Taft 1939).

5. Xanthidium Torreyi Wolle

Taylor, 1934. Mich. Acad. Sci., Arts and Letters, 19:277, Pl. 56, Figs. 13-14.

The Michigan specimens from Chippewa County are very similar to those illustrated by Taylor (op. cit) from New Foundland. He believes that the irregular placement and deflection of spines necessitates the retention of this form in Xanthidium. There is some resemblance to A. impar (Jacobs) Gronblad and A. octocornis, Ehrenb. but the closed linear sinus and the different form of semicells readily distinguishes it.

Measurements: L. ssp. 32-34u; L. csp. 67-71u; W. ssp. 28-35u; W. csp. 54-67u.

Distribution: NLP, Cheboygan (Taft 1939); EUP, Chippewa.

6. Xanthidium tetracentrotum Wolle var. intermedia var. nov. Pl. 8, Fig. 3.

Semicells, elliptic hexagonal, with an elliptical section of central area of semicell wall thickened and scrobiculate, lateral margins bearing a pair of simple spines which curve upward. Vertical view rhomboid-elliptical with poles bearing two simple curved spines which

are inserted in different planes, the arrangement of spines at one pole being alternate with those at the other pole; cell wall punctate in a narrow median band extending from pole to pole.

This organism seems to be intermediate between X. tetracentrotum fa. protuberans West and West, and X. tetracentrotum var. quadricornutum (Roy and Biss.) West and West. The Michigan specimens from Oakland County have the shape of the semicells and spines similar to the type exhibited by the former but have the irregularly disposed spines and the size of the latter. In vertical view, they are similar to the fa. protuberans, but lack the small lateral protuberances. The band of punctations in the dorsal cell wall is characteristic of only the Michigan specimens. This variety should be carefully compared with X. subhastiferum var. Johnsonii fa. Smithii.

Measurements: L. 53u; W. ssp. 46u; W. csp. 70u; I. 12.5u.

Distribution: SLP, Oakland.

7. Xanthidium subhastiferum var. Johsonii (West and West), G. M. Smith.

Smith, 1924. Wisc. Geo. Nat. Hist. Surv. Bull. 57(2):61. Pl. 67, Figs. 4-6.

X. subhastiferum West, which has not been reported as yet from Michigan is a very distinctive species. The semicells are transversely elliptic or sub-elliptic with each truncate lateral margin bearing two divergent, straight or slightly curved spines that lie in the same vertical plane.

The variety Johnsonii was first described by West as a variety of X. hastiferum Turner, but has been transferred to X. subhastiferum by Smith on the basis of similar shape and because the occurrence of accessory spines in this form is rare. The prrsence of the subapical row of pores and the two regularly placed spines on the lateral margin are the distinctive characteristics of this variety.

Measurements: L. ssp. 48-(50)-57u; L. csp. 52-(52)-63u; W. ssp. 48-(48)-53u; W. csp. 75-(79)-95u; I. 12.5-(13)-15u.

Distribution: SLP, Oakland, also Washtenaw (West and West 1898) and Macomb (Johnson 1895); NLP, Presque Isle.

8. fa. Smithii fa. nov. Pl. 10, Fig. 2.

Xanthidium subhastiferum var. Johnsonii(West&West)G.M.Smith fa. Smith, 1924. Wisc. Geo. and Nat. Hist. Surv. Bull. 57(2):61, Pl. 67, Fig. 7.

Semicells subsemicircular with two pairs of spines borne on lateral margins, the lower pair slightly curved and inserted a slight distance apart and in a different vertical plane on the lateral margins, the upper pair inserted close together at the apical angles; the upper central region of the face of the cell wall thickened and scrobiculate, the scrobiculations arranged regularly or irregularly in two arcuate rows. Vertical view elliptic with each pole bearing four spines arranged in different planes.

This form differs from var. Johnsonii (West and West) G. M. Smith in possessing four spines irregularly dis-

posed upon the lateral margin whereas the variety has two spines that are arranged in the same plane on the lateral margin. The scrobiculations are arranged about half-way between the apex and the face of the semicells, and thus lower than in variety. In addition, the scrobiculations are arranged in a double irregular row in a subarcuate band, in contrast to the single irregular row found just below the apex in the variety. The organism figured by Taylor (1934) as X. antilopaeum var. hebridarium West and West is closely related to this form because of shape of semicells and the number and arrangement of spines, although the arrangement of scrobiculations on the face of the semicell is different. The writer believes Smith's (1924) X. subhastiferum var. Johnsonii fa. and the Michigan form from Mackinac County are distinctive enough (as discussed above) to qualify as a separate forma.

Measurements: L. ssp. (64)u; L. csp. (70)u; W. ssp. (55)u; W. csp. (72)u; I. 12-(22)u.

Distribution: EUP, Mackinac.

9. Xanthidium cristatum Bréb.

West and West, 1912. Monogr. Brit. Desm. 4:70. Pl. 110, Fig. 1.

This species is distinguished by the single convergent spine at the basal angles of the semicells and by the central protuberance which is usually not ornamented.

Measurements: L. ssp. 44-55u; L. csp. 60-77; W. ssp. 34.5-48u; W. csp. 42-68u; I. 13-17u.

Distribution: SLP, Barry; NLP, Cheboygan (N & A 1932); EUP, Alger, also Schoolcraft (N & A 1932); WUP, Gogebic, also Isle Royale (Prescott 1937).

10. var. leiodermum (Roy and Biss.) Turner

West and West, 1912. Monogr. Brit. Desm. 4:72, Pl. 110, Fig. 11.

The lack of any ornamentation or modification in the central area of the semicell is characteristic of this variety. X. cristatum var. Hipparqui Irenee-Marie has the same characteristic but has truncate pyramidate shaped semicells, retuse lateral margins and a punctate cell wall which easily separates it from the var. leiodermum. Specimens from Berrien County agree favorably with this variety except for a slight retuseness of the upper lateral margins. The insertion of the long spines on the lateral margins in the semicells of specimens is much closer than in the variety. This characteristic, the presence of long spines and the slight retuseness of the upper lateral margins approach X. cristatum var. longispina Gronblad (1921) which is a much larger variety.

Measurements: L. ssp. (47)-48-54u; L. csp. 65-(66.5)-74u; W. ssp. (32)-36-39u; W. csp. 53-55-(60)u; I. (9.5)-11-13u.

Distribution: SLP, Berrien; NLP, Cheboygan (N & A, 1932).

11. var. Hipparqui Irénee-Marie. Pl. 8, Fig. 4.

Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont.:244. Pl. 43, Fig. 6.

This variety is characterized by the absence of any ornamentation or modification in the central area of the semicells. It is separated from X. cristatum var. leiodermum (Roy and Biss.) Turner by the truncate-pyramidate shape of the semicells, and by the punctation of the cell wall.

Measurements: L. ssp. 46-(54)-60u; L. csp. 65-(67)-70u; W. ssp. 35-38-(39)u; W. csp. 50-(54)-56u; I. (10.7)-13-14u.

Distribution: SLP, Calhoun. New record for Michigan.

12. var. papilliferum Irénee-Marie Pl. 9, Fig. 2.

Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont.:243. Pl. 43, Fig. 13.

The distinguishing characteristics of this variety are the single basal isthmial papilla and the mucronate projections that close the sinus.

Measurements: L. ssp. 57-59-(60u; L. csp. 71-(72)-75u; W. ssp. 45-47-(50u; W. csp. 45-47-(48)u; I. (13.3)-14-15u.

Distribution: SLP, Washtenaw, Jackson; WUP, Marquette. New records for Michigan.

13. var. uncinatum Breb.

West and West, 1912. Monogr. Brit. Desm. 4:73. Pl. 111, Figs. 2-4.

This variety is distinguished from the typical by the more pyramidate semicells, the erect curved spines

and by the central area of semicell wall in which granules are irregularly disposed.

Measurements: L. ssp. (53.7u); L. csp. 60-(64)-(74)-91u; W. ssp. (34)-36u; W. csp. (47)-51-(55)-83u; I. (10.5)-12-20u.

Distribution: SLP, Calhoun Barry (2), also Macomb (Taft 1939); NLP, Crawford, also Cheboygan, Presque Isle, Ostego (Taft 1939); EUP, Chippewa; WUP, Iron, Houghton, Gogebic(2); Isle Royale (Prescott 1937, 1940).

14. fa. mucronata West and West Pl. 9, Fig. 1.

Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont.:242. Pl. 43, Figs. 10, 11.

This form is distinguished by the spines being inflated at their bases, thus appearing to be inserted upon a protuberance of the cell wall. The semicell has a general trilobed appearance.

Measurements: L. csp. 58-(74)-76u; W. ssp. (40)u; W. csp. 42-(54)-69u; I. 9-(10.5)-16u.

Distribution: NLP, Emmet; WUP, Gogebic. New records for Michigan.

15. Xanthidium Tylerianum West

West, W., 1889. Journ. Roy. Microsc. Soc. 5:19, Pl. 2, Figs. 1-4, Pl. 3, Fig. 14.

The insertion of the spines in a horizontal plane at the apical angles and the broad truncate appearance of the semicell apex are characteristics which easily distinguish this specie.

Measurements: L. 66.3-70u; W. 62.4-80u; I. 20-25u.

Distribution: WLP, Marquette (Pres. and Mag. 1935).

16. Xanthidium antilopaeum (Bréb.) Kuetz.

West and West, 1912. Monogr. Brit. Desm. 4:63. Pl. 118, Figs. 7-18.

The hexagonal semicells with a pair of spines at both the apical angles and lateral angles distinguishes this species. X. Tylerianum has the same characteristics but differs in the spines at apical angles being horizontally placed whereas in X. antilopaeum, the spines at the apical angles are either divergent or almost erect. The spines may be variable in length and curvature as can the number and arrangement of the scrobiculations in the central area of the semicells.

Measurements: L. ssp. 42-(44)-76; L. csp. 50-(54)-114u; W. ssp. 42-(44)-72u; W. csp. 57-(60)-108u; I. (13)-14-26u.

Distribution: SLP, Barry, also Wayne (Campbell 1886) and Muskegon (Transeau 1917); NLP, Emmet, also Emmet (N & A 1932) Cheboygan, (Welch 1938b and Neal 1948); EUP, Chippewa (2), Schoolcraft, Delta; WUP, Marquette (2), Houghton; Isle Royale (Prescott 1937, 1940).

17. fa. michiganensis fa. nov. Pl. 11, Fig. 1.

Semicell hexagonal with a pair of long divergent spines at each apical and lateral angle, a single shorter convergent spine at each basal angle; central area of the cell wall with a three-quarter circular row of scrobiculations.

Specimens of this forma collected in Roscommon County appear to be intermediate between X. antilopaeum var. Crameri Gronbl. (Gronbl. 1921) and X. mauricianum (Irénee-Marie 1949b). The single spine at the basal angle is characteristic of X. cristatum Breb. The shape of the semicells and the single convergent spine at the basal angle are similar to X. mauricianum although the semicell outline is definitely hexagonal, Irenee-Marie's species being almost rectangular. The central facial area of the semicell wall has a three-quarter circular row of scrobiculations that is also found in X. antilopaeum var. Crameri Gronblad. The paired spines on the lateral angles, however, easily separate the Michigan form from this variety. The general semicell shape and the sharp convergence of the suprabasal margins towards the basal angles distinguishes this form from X. cristatum. The hexagonal shape of the semicell and the similarity of the facial scrobiculations with var. Crameri makes retention of this form in X. antilopaeum necessary despite the occurrence of a single basal spine in both X. cristatum and X. mauricianum.

Measurements: L. ssp. (50)-u; L. csp. (70)u; W. ssp. (42)u; W. csp. (65)u; I. (10.5)u.

Distribution: NLP, Roscommon.

18. var. basiornatum Eichl. and Racib. Pl. 9, Fig. 3.

Eichler and Raciborski, 1893. Akad. Umiej. w. Krakow. Ser 2(6):125. Pl. 3, Fig. 31.

Gronblad, 1921. Acta. Soc. pro. Fenn. et Flor. Fenn. 49(7):46 Pl. 4., Figs. 17-18.

This variety is characterized by the angles being extended into short mammillate processes, each of which is terminated by a straight spine. A row of basal scrobiculations and a papilla in the central region of the semicell are also distinctive.

Measurements: L. ssp. (50)-53u; L. csp. (85)u; W. ssp. (55)-60u; W. csp. (87)u; I. (25)-31u.

Distribution: EUP, Schoolcraft. New record for North America.

19. var. oligacanthum Schmidle Pl. 10, Fig. 1.

West and West, 1912. Monogr. Brit. Desm. 4:68. Pl. 109, Fig. 5.

This variety is distinguished from the typical and other varieties reported from Michigan by the presence of a single spine at apical angles. West and West (1912) report that there is no central differentiated area, although Gronblad (1921) indicates that Finnish specimens always have a thickened (smooth or scrobiculate) central area. The few Michigan specimens observed were smooth. They were also longer than measurements given by West and West (1912).

Measurements: L. ssp. 46-50-(59)u; L. csp. 70u; W. ssp. 46-(57)-58u; W. csp. 83u; I. (15.5)u.

Distribution: NLP, Emmet. New record for Michigan.

20. var. minneapoliense Wolle

Wolle F., 1892. Desm. of the U.S., 2nd Ed.:10. Pl. 63, Fig. 16.

This variety has the same cell shape, subapical row of verrucae, and arrangement of spines as var. polymazum Nordst. but differs in the presence of a small erect spine either below or above the verrucae.

Measurements: L. ssp. 50-(54)-72u; L. csp. (71)-75-138u; W. ssp. (50)-52-64u; W. csp. 72-(73)-126u; I. (13)-15-20u.

Distribution: SLP, Livingston; NLP, Crawford, also Cheboygan (N & A 1932); EUP, Schoolcraft; WUP, Marquette, Houghton, Gogebic.

21. var. polymazum Nordst.

West and West, 1912. Monogr. Brit. Desm. 4:67. Pl. 108, Fig. 19.

The subapical arc of verrucae easily distinguishes this variety. West and West (1912) state that there may be a third spine partially or fully developed in addition to the usual typical pair of spines at each lateral angle. No specimens observed by the writer demonstrated this characteristic.

Measurements: L. ssp. (55)u; L. csp. 62-(73)-90u; W. ssp. 53u; W. csp. 58-(75)-90u; I. 12-(12.5)-22u.

Distribution: SLP, Barry (2), Berrien, Calhoun, Livingston, Oakland, also Calhoun (Pres. and Mag. 1935); EUP, Delta; WUP, Menominee, Marquette, Gogebic, also Isle Royale (Taylor 1935, Prescott 1937, 1940).

22. var. triquetrum Lund. Pl. 11, Fig. 1.

West and West, 1912. Monogr. Brit. Desm. 4:66. Pl. 109, Fig. 1.

The triangular shape in vertical view easily distinguishes this variety. West and West (1912) state that the central facial area of the cell wall between the arms is thickened, but does not mention, nor do their figures indicate whether this area is scrobiculated as in the typical plant. The Michigan specimens from Delta County have the central facial area thickened and scrobiculate. Okada (1934) illustrates the same characteristic. Measurements for the Michigan specimens are smaller than those given by West and West (1912).

Measurements: L. ssp. (61)-81-90u; L. csp. (73)-116-126u; W. ssp. (52)-65-82; W. csp. (71.5)-97-125; I. (15)-26.5-28u.

Distribution: EUP, Delta. Except for a report of this variety by Wailes (1933) this is the only record for North America.

23. Xanthidium fasciculatum Ehrenb.

West and West, 1912. Monogr. Brit. Desm. 4:75. Pl. 111, Figs. 6-8.

This species, sometimes confused with X. antilopaeum (Breb.) Kuetz. is characterized by the presence of six pairs of equidistantly placed spines upon each semicell. The shape of the semicell is angular-reniform and the central area is always slightly protuberant and usually granulate.

Measurements: L. ssp. 44-66u; L. csp. 65-74u; W. ssp. 44-59u; W. csp. 62-72u; I. 12-21u.

Distribution: SLP, Wayne (Campbell 1886).

24. Xanthidium Brebissonii Ralfs.

West and West, 1912. Monogr. Brit. Desm. 4:77. Pl. 112, Figs. 1, 2.

This species is characterized by the presence of 8-10 spines upon each lateral margin of the semicell. These spines may be in pairs or irregularly disposed.

Measurements: L. ssp. 61-80u; L. csp. 79-101u; W. ssp. 62-76u; W. csp. 80-104u; I. 18-27u.

Distribution: NLP, Cheboygan (N & A 1932).

20. MICRASTERIAS Agardh. 1827

Cells usually solitary, very often of large size, nearly circular in outline but with the length generally slightly greater than width, bilaterally symmetrical (transverse and front view) and greatly compressed in lateral view, very deeply constricted with the isthmus never broad and the sinus usually linear or sublinear but open widely in some species. Semicells semicircular to hexagonal either with three primary lobes (polar and two lateral lobes) or with five primary lobes (polar, two lateral and two basal lobes); polar lobe generally broadly cuneate and emarginate, sometimes with secondary (polar) lobules, often with accessory projections; primary lateral (and basal lobes if present) sometimes entire but

mostly subdivided into secondary lobes and lobules, the ultimate lobes or lobules generally with emarginate apices or spines. Cell wall rarely granulate, occasionally entirely covered with spines but usually smooth or with rows of spines within the wall margins adjacent to the incisions. Chloroplast on axial plate with the general contour of the semicell; often with small ridges and containing numerous fairly well distributed pyrenoids.

Zygospores spherical, covered with radially disposed spines that are simple to quadrified at their apices.

Key to Species of Micrasterias

1. Semicell with a single undivided lateral lobe present on each side 2

1. Semicell with more than one lateral lobe present on each side 6

2. Polar lobe bearing a single spine on each angle 3

2. Polar lobe bearing more than a single spine on each angle . 5

3. Lateral lobe bearing a single spine. 4

3. Lateral lobe bearing more than a single spine . . . . . (2) M. laticeps

4. Polar lobe convex . . . . . (6) M. oscitans var. mucronata

4. Polar lobe retuse . . . . . (1) M. arcuata var. expansa

5. Cell more than 100u long . . . . . (5) M. oscitans

5. Cell less than 100u long . . . . . (4) M. pinnatifida

6. Lateral margin divided only into a basal and a lateral lobe . . . 7

6. Lateral margins otherwise . . . 13

7. Polar lobe without accessory projections (in addition to polar lobules) 8

7. Polar lobe with accessory projections (in addition to polar lobules) 11

8. Cell wall just within margins ornamented with small spines. (10) M. mahabuleshwarensis var. ringens

8. Cell wall otherwise 9

9. Incision between polar and lateral lobes narrow and linear . . . . . (18) M. truncata var. quadrata

9. Incision between polar and lateral lobes wide and broadly open . . . 10

10. Basal and lateral lobes very short and broad, about as long as wide . . . . . (7) M. depauperata var. Kitchellii

10. Basal and lateral lobes very long, about six times longer than wide . . . . . (23) M. radiata var. gracillima

11. Polar lobe with two to four upright projections between the polar lobules . . . . . (8) M. mahabuleshwarensis

11. Polar lobe with projections in same plane as polar lobes 12

12. Lateral margin of the polar lobe with accessory projections; both basal and lateral lobes entire . . . . . (11) M. Nordstedtiana

12. Lateral margin of the polar lobe without accessory projections; both lateral and basal lobe bearing accessory projections in same plane . . (12) M. muricata

13. Lateral margins divided into lateral and basal lobes, each of which are subdivided into secondary lobes that are either poorly developed or exserted into long processes, very rarely showing slight subdivisions. 14

13. Lateral margins otherwise 18

14. Polar lobe with accessory projections (in addition to polar lobules) . . . . . (13) M. americana

14. Polar lobe without accessory projections 15

15. Incisions usually narrow and linear. 16

15. Incisions widely open 17

16. Cell wall covered with flattened granules . . . . . (15) M. Jenneri

16. Cell wall otherwise . . . . . (16) M. truncata

17. Lateral and basal secondary lobes long and narrow . . . . . (21) M. radiata

17. Lateral and basal secondary lobes short and broad . . . . . (20) M. crux-melitensis

18. Lateral incisions very deep, more than two-thirds the distance to the mid-axis, the ultimate lobules slender . . 19

18. Lateral incisions less deep, less than two-thirds the distance to the mid-axis, the ultimate lobules not slender. 20

19. A single spine on each side of the apical emargination (not polar lobule spines) . . . . . (24) M. sol

19. No spines on each side of apical emargination . . . . . (28) M. Torreyi

20. Cell under 170u long 21

20. Cell over 170u long (sometimes (30) M. papillifera var. speciosa) 25

21. Polar lobules reflexed or reclinate, each with three to several apines. (32) M. conferta

21. Polar lobules upright, each with two spines 22

22. Rows of spines within the margins of the lobes which are separated by the deeper incisions . . . . . (29) M. papillifera

22. Rows of spines not present within the margins of lobes which are separated by the deeper incisions 23

23. Width of isthmus 15-23u . . . . . (31) M. papillifera var. glabra

23. Width of isthmus 10-12u . . . . . (34) M. novae-terrae

24. Polar lobules without spines . (35) M. denticulata

24. Polar lobules with spines . . . 25

25. Ends of lateral and basal lobules armed with strong spines 26

25. Ends of lateral and basal lobules acute, or right-angled, sometimes with small projections but never with strong spines 29

26. Almost entire surface of semicell wall covered with strong spines; middle area of semicell wall with a small projection ornamented with spines (37) M. apiculata

26. Semicell wall with or without spines; spines if present more or less restricted to the margins of lobes; middle area of semicell wall never with a projection ornamented with spines 27

27. A single spine placed on each side of apical emargination (not polar lobules) 28

27. A single spine not placed on each side of apical emargination . . . (42) M. rotata

28. Polar lobe broad, almost quadrangular . . . . . (40) M. apiculata var. brachyptera

28. Polar lobe not as broad, tapering distinctly towards base . (38) M. apiculata var. fimbriata

29. The upper margins of the apical incisions sharply pointed . . . . . (41) M. Thomasiana var. notata

29. The upper margins of the apical emargination not sharply pointed, but broadly rounded . . . . . (42) M. rotata

1. Micrasterias arcuata var. expansa (Bail.) Nordst.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):11. Pl. 97, Fig. 4.

This species has single, large, somewhat parallel lateral lobes which are tipped with a single spine and which are separated from the polar lobe by a large open sinus. The apices are retuse and the polar lobules are slightly divergent and tipped with a single spine. Measurements: L. 49-(75)-105u; W. 49-(79)-103u; I. 8-(11.5)-13u; A. 31-42-(43)u.

Distribution: NLP, Presque Isle; also Cheboygan (Taft 1938).

2. Micrasterias laticeps Nordst.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):13. Pl. 98, Fig. 1.

This species differs from M. pinnatifida (Kuetz.) Ralfs in its much greater size and from M. oscitans Ralfs in the narrower lateral lobes and in the greater width of the polar lobe.

Measurements: L. 112-(116)-221u; W. 122-(135)-265u; I. 15-(21)-37u; A. 110-250u.

Distribution: SLP, Shiawassee, Barry (2), Washtenaw, also Wayne (Campbell 1886); NLP, Presque Isle; EUP, Alger, Schoolcraft; Isle Royale (Taylor 1935, Prescott 1937, 1940).

3. var. crassa Prescott

Prescott and Magnotta, 1935. Pap. Mich. Acad. Arts, Sci., and Letters, 20:166. Pl. 25, Fig. 7.

This variety is separated from the typical by the greater thickness of the base of the lateral lobes. The polar lobe is broadly conical with the spines directed slightly downward.

Measurements: L. 111-117u; W. 121-125u; I. 19u.

Distribution: SLP, Calhoun, Washtenaw (both, Pres. and Mag. 1935).

4. Micrasterias pinnatifida (Kuetz.) Ralfs.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):16. Pl. 99, Figs. 6-9.

The small size and the greater width of the incisions between the lobes readily distinguish this organism.

Measurements: L. 40-(60)-80u; W. 37-(69)-84u; I. 9-(13)-20u; A. 31-59u.

Distribution: SLP, Calhoun, Barry (2), Jackson, also Muskegon (Transeau 1917); NLP, Crawford, Emmet, also Cheboygan (N & A 1932); EUP, Alger; WUP, Houghton; Isle Royale (Prescott 1937, 1940).

5. Micrasterias oscitans Ralfs.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):23. Pl. 101, Figs. 8, 9.

This species is much larger than M. pinnatifida (Kuetz.) Ralfs. and has wider lateral lobes and narrower polar lobes than M. laticeps Nordst.

Measurements: L. 125-163u; W. 100-148u; I. 23-30u; A. 77-95u.

Distribution: SLP, Muskegon; NLP, Cheboygan (both Transeau, 1917).

6. var. mucronata (Dix) Wille

Krieger, 1939. Rabh. Krypt. Flor. 13(2):24. Pl. 101, Figs. 10-12.

This variety may have slight angular projections in the middle of the upper margin of the lateral lobes. The polar lobe is not as broad and the spines at the tip are directed more or less downward.

Measurements: L. 125-160u; W. 102-140u; I. 23-33u; A. 74-87u.

Distribution: NLP, Emmet (Transeau, 1917).

7. Micrasterias depauperata var. Kitchelii (Wolle) West & West

Krieger, 1939. Rabh. Krypt. 13(2):39. Pl. 106, Figs. 3,4.

This variety is distinct but has a general resemblance to M. truncata (Corda) Breb. from which it can be distinguished by the division of the lateral margin into a basal and a lateral lobe both of which are very short. M. truncata has the basal and lateral lobes divided into secondary lobes.

Measurements: L. 125-(129)-150u; W. (123)-125-150u; I. 21-(21.5)-27u; A. 75-100u.

Distribution: SLP, Berrien; NLP, Cheboygan (N & A 1932).

8. Micrasterias mahabuleshwarensis Hobs.

Krieger, Rabh. Krypt. Flor. 13(2):49. Pl. 107, Figs. 7-10.

The possession of upright accessory apical processes distinguishes this form from other species except M. americana (Ehrenb.) Ralfs. The latter has the basal and lateral lobes further subdivided into secondary lobes.

Measurements: L. 100-220u; W. 85-190u; I. 15-31u; A. 55-100u.

Distribution: SLP, Calhoun, Washtenaw (Pres. & Mag. 1935); NLP, Presque Isle.

9. var. dichotoma G. M. Smith

Krieger, 1939. Rabh. Krypt. Flor. 13(2):51. Pl. 110, Fig. 4.

This variety is distinguished from the typical by the development of a secondary process from the side of either or both the lateral and basal lobes. This process may be only slightly developed or may be entirely lacking in one of the semicells.

Measurements: L. 150-(150.5)-165u; W. 115-(117)-160u; I. 20-(21.5)-31u; A. 72u.

Distribution: SLP, Barry, also Calhoun (Pres. & Mag. 1935).

10. var. ringens (Bailey) Krieger

Krieger, 1939. Rabh. Krypt. Flor. 13(2):52. Pl. 110, Fig. 9.

This variety is readily distinguished from the typical by the lack of upright accessory processes.

Measurements: L. 125-(137.6)-150u; W. 115-(118)-130u; I. (15.5)u.

Distribution: SLP, Barry, also Calhoun (Pres. & Mag. 1935; M. mahabuleshwarensis var. serrulata).

11. Micrasterias Nordstedtiana Wolle Pl. 12, Fig. 1.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):75. Pl. 120, Figs. 3-7.

This species has several characteristics which readily distinguish it from M. muricata (Bailey) Ralfs. The polar lobe has accessory processes in the same plane, as does the latter species, but they are much shorter. In addition, M. Nordstedtiana has similar accessory processes developed from neck of lateral lobes. These may be greatly reduced. The basal and lateral lobes are always entire.

Measurements: L. 134-(178.5)-203u; W. 115-(150.5)-180u; I. 14-(25.8)-28u; A. 138u.

Distribution: SLP, Barry. New record for Michigan.

12. Micrasterias muricata (Bailey) Ralfs.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):74. Pl. 119, Figs.4-6.

The semicells of this species appear to have the lobes in three whorls. The polar lobes each bear two asymmetrically disposed secondary processes, the lateral lobes are subdivided into two secondary processes and the basal lobes possess two accessory projections in the same vertical plane as the lobes.

Measurements: L. 150-200; W. 100-155u; I. 18-31u; A. 78-140u.

Distribution: NLP, Presque Isle, also Cheboygan (Welch, 1938b).

13. Micrasterias americana (Ehrenb.) Ralfs.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):45. Pl. 108, Figs. 5-8.

This species resembles M. mahabuleshwarensis in a general way but has the lateral and basal lobes further subdivided into secondary lobes.

Measurements: L. 104-160u; W. 86-145u; I. 17-19u; A. 50-81u.

Distribution: SLP, Oakland, also Berrien (Transeau 1917); NLP, Cheboygan; EUP, Delta; WUP, Houghton (N & A 1932).

14. var. Boldtii Gutw.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):47. Pl. 109, Figs. 1-3.

This variety has the polar lobe separated from the lateral margin by a shorter and narrower incision. The apex is plane or very slightly concave and the apical accessory processes are greatly reduced.

Measurements: L. 110-143u; W. 93-128u; I. 19-28u; A. 53-83u.

Distribution: Isle Royale (Prescott 1940).

15. Micrasterias Jenneri Ralfs.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):113. Pl. 135, Figs. 1, 2.

The granulate cell wall of this species as well as the greater length to breadth ratio separates this species from M. truncata var. crenata (Breb.) Reinsch with which it might be possibly confused.

Measurements: L. 127-188u; W. 80-130u; I. 22-34u; A. 60-81u.

Distribution: WUP, Marquette (Pres. & Mag. 1935).

16. Micrasterias truncata (Corda) Breb.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):25. Pl. 102, Figs. 1-4.

This very common species has the cells about as broad as long. The lateral and basal lobes (themselves separated by a short incision) are each divided by a short incision into secondary lobes each of which bears two short spines. The slightly convex apical lobe is very wide (about three-fourths the width of semicell) and is separated from the lateral lobe by a short incision.

Measurements: L. 75-(100)-144u; W. 74-(93)-135u; I. 10-(17.5)-30u; A. 55-97u;

Distribution: SLP, Ingham, Jackson, Livingston, Oakland,

Barry (2), also Wayne (Campbell 1886) and Macomb (Pieters 1894); NLP, Roscommon, Crawford, Cheboygan, Presque Isle, Cheboygan (N & A 1932),(Welch 1936b, 1938b and Neel 1948) and Emmet (Transeau 1917): Eup, Chippewa (2), Schoolcraft (3), also Mackinac, Schoolcraft (Transeau 1917); WUP, Marquette, Houghton, Gogebic (2).

17. var. crenata (Breb.) Reinsch.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):29. Pl. 103, Fig. 3.

This form is chiefly separated from the typical because it lacks spines on the secondary lobes. Krieger (1939) states that this variety may be a reduction form of the typical.'

Measurements: L. 75-(94.6)-125u; W. (71)-74-102u; I. 15-(16)-30u; A. 46-65u.

Distribution: SLP, Barry, also Calhoun (Pres. & Mag. 1935, M. crenata); NLP, Cheboygan (N & A 1932, M. crenata); WUP, Baraga.

18. var. quadrata Bulnh. fa. Pl. 13, Fig. 2.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):31. Pl. 104, Figs. 1, 2.

This variety characteristically does not have the lateral lobes and basal lobes divided into secondary lobes as in the typical. The lateral and basal lobes each have a row of three to seven small granular projections at the end of the lobe. The specimens from Roscommon County

have the lateral lobe slightly divided by a very slight emargination into secondary lobes and five granular projections at the tips. This latter combination is characteristic of M. truncata var. tridentata Benn., so that the Michigan specimens can be considered intermediate between the two varieties.

Measurements: L. 85-(87)-131u; W. (75)-76-130u; I. 19-(22)-29u.

Distribution: NLP, Roscommon. New record for Michigan.

19. var. semiradiata (Naeg.) Cleve. Pl. 13, Fig. 1. Krieger, 1939. Rabh. Krypt. Flor. 13(2):32. Pl. 103, Fig. 9.

This variety is difficult to separate from the typical. The cell shape is sometimes semicircular or the cell width is greater than the length. The apex is shallowly arched and the secondary lobes have longer spines than the typical.

Measurements: L. 64-(85)-128u; W. 60-(91.4)-124u; I. 13-(15)-19u; A. 55-76u.

Distribution: NLP, Presque Isle. New record for Michigan.

20. Micrasterias crux-melitensis (Ehrenb.) Hass. Krieger, 1939. Rabh. Krypt. Flor. 13(2):62. Pl. 114, Figs. 5-8.

The basal and lateral lobes of this species are each subdivided into short, broad secondary lobes. The polar lobes are each exserted into two short, stout di-

vergent polar lobes giving the apex a broadly retuse margin.

Measurements: L. 85-(120)-164u; W. 78-(113)-153u; I. 11-(17.4)-28u; A. 35-60u.

Distribution: SLP, Shiawassee, Washtenaw, Jackson also Macomb (Pieters 1894); NLP, Cheboygan (Transeau 1917, N & A 1932, Welch 1936a); EUP, Alger; WUP, Menominee; Isle Royale (Prescott 1937, 1940).

21. Micrasterias radiata Hass.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):68. Pl. 116, Figs. 4-6; Pl. 117, Figs.1-4.

Although there is considerable variation in the size of the polar lobules and the secondary lobes, the greater length and slimness of these lobes and the semicell shape readily separates this species from others.

Measurements: L. 127-(159)-(198)-250u; W. 110-(138)-(189)-208u; I. 12-(17)-(22)-30u; A. 48-94u.

Distribution: SLP, Wayne (Campbell 1886), Muskegon (Transeau 1917); NLP, Presque Isle; WUP, Alger; Isle Royale (Prescott 1937, 1940).

22. var. pseudocrux Gronbl. fa. Pl. 12, Fig. 2.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):72. Pl. 118, Figs. 4, 5.

This variety differs from the typical in the lateral incisions being less deep and in the secondary lobes being shorter. The polar lobe is wider at the base than

in typical. It approaches M. crux-melitensis but has longer polar lobules and basal and lateral lobes. The Michigan specimens are intermediate between the typical and this variety, the base of the polar lobe being more typical and the lateral lobes being shorter as in the variety. It is placed here because of the stouter appearance of the entire cell. The measurements are slightly larger than the original.

Measurements: L. 137-142-(157)u; W. 124-125-(139)u; I. 21; A. 57-61.

Distribution: EUP, Schoolcraft. New record for North America.

23. var. gracillima Smith

Krieger, 1939. Rabh. Krypt. Flor. 13(2):71. Pl. 118, Fig. 1.

This variety is distinguished from the typical by the lateral and basal lobes not being subdivided into secondary lobes.

Measurements: L. 135-190u; W. 130-170u; I. 15-18u; I. about 65u.

Distribution: NLP, Presque Isle (Taft 1939).

24. Micrasterias sol (Ehrenb.) Kuetz.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):93. Pl. 131, Fig. 1.

Krieger (1939) has placed M. radiosa Ralfs. into synnonomy with M. sol. He considers these characteris-

tics as typical. The cell is medium-sized, about as long as wide, and divided into semicells by a linear incision that is slightly open at the end. The width of the lateral lobe is greater than the basal lobe, the former having the secondary lobes subdivided twice so that there are eight lobules on each lobe, the latter having the secondary lobes usually subdivided once so that there are four lobules on each lobe. All incisions are narrow and deep, the polar lobe is slim with parallel walls at the base and the apex has a spine on each side of a shallow emargination. The polar lobules are short with two spines each.

Measurements: L. 140-220u; W. 125-215u; I. 16-26u; A. 25-38u.

Distribution: SLP, Kalamazoo (N & A 1932) and Muskegon (Transeau 1917); NLP, Cheboygan (N & A 1932, Welch 1936b); Isle Royale (Prescott 1937, 1940).

25. var. ornata Nordst.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):96. Pl. 131, Figs. 3-5.

This variety has rows of spines along the margins of the lobes which are separated by the deeper incisions (between the basal lobes of adjacent semicells, between lateral and basal lobes, and between the lateral and polar lobes).

Measurements: L. 116-228u; W. 110-245u; I. 15-26u; A. about 28u.

Distribution: NLP, Cheboygan (Taft 1939).

26. var. elegantior G. S. West.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):94. Pl. 132, Figs. 3, 4.

Krieger (1939) raises this organism to varietal status although G. S. West originally considered it a form of var. ornata Nordst. The distinctive features are the very narrow and elongate polar lobe, the very deep and wider sinuses (except between semicells) than in the typical and the irregular undulate margins of the incisions. There are also rows of spines along the margins of the major incisbns as in var. ornata. The writer believes that if this organism has varietal rank, then the organism illustrated by Prescott and Magnotta (1935) and identified as M. radiosa var. ornata Nordst. should have been placed under the var. elegantior by Krieger, rather than under var. ornata.

Measurements: L. 150-(166)-248; W. 151-258u; I. 12-28u; A. 32-39u.

Distribution: SLP, Barry, also Calhoun (Pres. & Mag. 1935).

27. var. Murrayi (West and West) Allorge

Krieger, 1939. Rabh. Krypt. Flor. 13(2): Pl. 131, Fig. 6; Pl. 132, Fig. 1.

This variety has the basal sinus widely open. The incisions are all more open than in the typical. The lobes are somewhat shorter and bear rows of spines along the major incisions as in var. ornata Nordst.

Measurements: L. 116-158u; W. 104-157u; I. 16-20u; A. 30-44u;

Distribution: NLP, Cheboygan, (N & A 1932, M. Murrayi).

28. Micrasterias Torreyi (Bail.) Ralfs.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):97. Pl. 133, Figs. 2, 3.

The large size and the palmate appearance of the semicell lobes are distinguishing features of the species.

Measurements: L. 250-410u; W. up to 450u; I. about 27u; A. about 74u.

Distribution: SLP, Muskegon (Transeau 1917).

29. Micrasterias papillifera Breb.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):86. Pl. 129, Figs. 2-5.

This species has a resemblance to M. sol var. ornata Nordst. and M. apiculata var. fimbriata fa. spinosa (Biss.) West and West. It is easily distinguished from the former by the more shallow incisions, the proportionately wider polar lobe, the somewhat octagonal shape, and the almost equal width of the lateral and basal lobes. It can be separated from M. apiculata var. fimbriata fa. spinosa by the slightly less exserted and proportionately wider polar lobe and the almost equal width of lateral and basal lobes.

Measurements: L. 95-(132)-170u; W. 95-(121)-165u; I. 13-(19.3)-30u; A. 33-46u.

Distribution: SLP, Muskegon (Transeau 1917); EUP, Schoolcraft, Delta; WUP, Gogebic; Isle Royale (Prescott 1937, 1940).

30. var. speciosa (Wolle) Krieger Pl. 14, Fig. 1.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):90. Pl. 130, Fig. 3.

This variety is separated from the typical by the more open incisions, especially those between the polar lobes and the lateral lobes. The polar lobes are narrower and their margins are parallel at the base.

Measurements: L. 104-(129)-195u; W. 95-(116)-172u; I. (13)-15-20u; A. 45-58u.

Distribution: EUP, Chippewa. New record for Michigan.

31. var. glabra Nordst.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):89. Pl. 129, Figs. 6, 7.

This variety lacks the rows of spines on the margins along the major incisions.

Measurements: L. 84-160u; W. 84-135u; I. 15-23u; A. about 41u.

Distribution: SLP, Muskegon (Transeau 1917); NLP, Cheboygan (N & A 1932).

32. Micrasterias conferta Lund.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):91. Pl. 126, Figs. 3-5.

This species can be distinguished by the reflexed nature of the two polar lobules, each of which bears

three to several spines. There is also a single spine on each side of the apical emargination.

Measurements: L. (79)-80-100u; W. 70-(79)-90u; I. 14-(15)-18u; A. 36-44u.

Distribution: NLP, Cheboygan (Welch 1938a); EUP, Schoolcraft; Isle Royale (Prescott 1937).

33. var. hamata Wolle

Krieger, 1939. Rabh. Krypt. Flor. 13(2):92. Pl. 126, Figs. 6-8.

This variety has a wider incision between the polar lobe and the lateral lobes than the typical. This wider incision is a result of the different downward curvature of the lateral margin of polar lobe.

Measurements: L. 75-128u; W. 73-107u; I. 11-19u; A. 34-53u.

Distribution: NLP, Cheboygan (Taft 1939).

34. Micrasterias novae-terrae (Cush.) Krieger

Krieger, 1939. Rabh. Krypt. Flor. 13(2):91. Pl. 127, Figs. 6, 7.

Krieger (1939) has elevated this organism to species rank from a variety of M. conferta Lund. It is near M. papillifera Breb. and the var. speciosa (Wolle) Krieger, but lacks spines on the cell wall and has a wider lateral lobe and deeper incisions.

Measurements: L. 102-150u; W. 93-116u; I. 10-12u; A. 35-57u.

Distribution: NLP, Cheboygan (Taft 1939).

35. Micrasterias denticulata Breb.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):108. Pl. 137, Figs. 3-6.

This species can easily be separated from similar species (M. rotata (Grev.) Ralfs. and M. Thomasiana Archer) by the narrowly cuneate polar lobes with dilated apices and concave sides, and by the lack of spines upon the lateral and basal lobules.

Measurements: L. 180-(268)-350u; W. 165-(218)-300u; I. 20-(25)-42u; A. 50-76u.

Distribution: SLP, Washtenaw; NLP, Cheboygan (N & A 1932).

36. var. angulosa (Hantzsch) West and West

Krieger, 1939. Rabh. Krypt. Flor. 13(2):107. Pl. 138, Figs. 4-6.

This variety is separated from the typical by several features. They are the slightly deeper incisions, the shorter polar lobe with the nearly straight sides and the almost rhomboid shape in vertical view.

Measurements: L. 210-323u; W. 175-262u; I. 26-38; A. 42-70u.

Distribution: SLP, Muskegon (Transeau 1917); NLP, Cheboygan (N & A 1932).

37. Micrasterias apiculata (Ehrenb.) Menegh.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):78. Pl. 122, Figs. 3, 4.

Distinguishing characteristics of this species include the numerous spines placed irregularly over the cell

wall and the median protrusion ornamented with a few spines in the central region at each semicell.

Measurements: L. 170-300u; W. 140-250u; I. 29-40u; A. 53-90u.

Distribution: SLP, Muskegon (Transeau 1917); NLP, Cheboygan (N & A 1932); Isle Royale (Prescott 1937, 1940).

38. var. fimbriata (Ralfs.) Nordst.

Krieger, 1939. Rabh. Krypt. Flor. 13(2):81. Pl. 123, Figs. 3-5; Pl. 124, Fig. 1.

Krieger (1939) follows Ralfs in considering this organism to be of distinct specific rank. Many modern workers however, consider it to be merely a variety of M. apiculata (Ehrenb.) Ralfs because of the same recurving of the spines on the lateral lobules and the same recurving of apical spines (which are of different lengths). The variety differs in the polar lobe usually being less exserted, and less inflated, and the spines on the surface of the semicell wall usually being completely lacking. The writer believes that the similarity of cell shape, the characteristic of types and curvatures of the spines and the report of many intermediate stages (West and West 1905) is sufficient evidence for retention of this organism as a variety of M. apiculata.

Measurements: L. 196-(218)-293u; W. 180-(192)-252u; I. 25-(26)-40u; A. 40-68u.

Distribution: SLP, Calhoun, Crawford, Barry, also Wayne (Campbell 1886) and Macomb (Pieters 1894, M. fimbriata); Isle Royale (Prescott 1937).

39. fa. spinosa (Bissett) West and West

Krieger, 1939. Rabh. Krypt. Flor. 13(2):83. Pl. 124, Figs. 3, 4.

This forma of var. fimbriata is distinguished by the presence of rows of spines along the margins of the lobes which are separated by the apical-lateral incision and along the basal margins of the semicells. This organism was more common in the writer's collections than the typical, although it had only been reported once previously from Michigan.

Measurements: L. 198-(229)-270; W. 169-(207)-267; I. (24)-25-39u; A. about 70u.

Distribution: SLP, Calhoun, Barry, Washtenaw (2), Livingston; NLP, Presque Isle, also Cheboygan (Taft 1939); EUP, Schoolcraft; WUP, Menominee.

40. var. brachyptera (Lund) West and West

Krieger, 1939. Rabh. Krypt. Flor. 13(2):84. Pl. 125, Figs. 3-6; Pl. 126, Fig. 1.

This variety (considered a species by Krieger, 1939) differs from the typical in the shorter lateral and basal lobes, the fewer spines upon the semicell wall, and the relatively larger and wider polar lobe which is more exserted.

Measurements: L. 182-(210)-234u; W. 131-(161)-180u; I. (21.5)-24-37u; A. 54-80u.

Distribution: SLP, Calhoun (Pres. and Mag. 1935); EUP, Alger.

41. Micrasterias Thomasiana var. notata (Nordst.) Gronbl. Krieger, 1939. Rabh. Krypt. Flor. 13(2):111. Pl. 140, Figs. 1-4.

This organism can be easily distinguished by the three small sharply projecting facial swellings on each semicell just above the isthmus.

Measurements: L. 215-287u; W. 170-236u; I. 24-30u; A. about 42u.

Distribution: Isle Royale (Prescott 1937, M. denticulate var. notata).

42. Micrasterias rotata (Grev.) Ralfs. Krieger, 1939. Rabh. Krypt. Flor. 13(2):100. Pl. 136, Fig. 1.

This species has the lateral lobes almost twice as wide as the basal lobes. The former are subdivided so that there are about eight to twelve lobules per lateral lobe. The basal lobes usually have four to eight lobules. The polar lobe is usually well exserted, and has two spines on each polar lobe. It is easily distinguished from M. apiculata var. fimbriata (Ralfs) Nordst. by the absence of single spines on each side of the apical emargination. This latter organism also has long spines at the tip of the lobules whereas M. rotata has bidentate projections. Specimens from Barry and Livingston Counties have the secondary lateral lobes subdivided three times so that the lateral lobe has sixteen lobules. The basal lobes had eight lobules. A few specimens from Livingston

Counties approach the variety pseudo-quadridenta Gronbl., having the secondary lobes divided into only four lobules. A few of the lobules are tridentate as in the variety, but there is a slight emargination of others. These specimens have a similar appearance to M. papillifera var. glabra Nordst. (Krieger 1937, Pl. 129, Fig. 6.), but are relatively larger and lack the pair of small teeth on each side of the apical emargination. The scarcity of specimens makes necessary the questionable assigning of these forms under M. rotata.

Measurements: L. (191)-200-(226)-(294)-(301)-305u; W. (191)-165-(224)-(276)-(292)-305u; I. (25)-26-(32)-43; A. 48-72.

Distribution: SLP, Livingston, Barry, Shiawassee also Macomb (Pieters 1894); NLP, Crawford, also Cheboygan (Transeau 1917, N & A 1932, Welch 1936a, 1936b, 1938); EUP, Schoolcraft, Chippewa (N & A 1932), Mackinac (Transeau, 1917, N & A 1932) and Schoolcraft (Transeau 1931); WUP, Gogebic; Isle Royale (Prescott 1940).

21. STAURASTRUM Meyen 1829

Cells variable in size, usually longer than wide (without processes or wall ornamentations), median constriction, often deep, with the sinus usually acute-angled at the apex. Semicells of variable shape, often triangular, hexagonal, cyathiform, spherical, subcylindrical or transversely ellipsoidal in front view, the angles usually continued into processes of

variable length, the processes (arising in one or more transverse planes) often variably ornamented and terminated by spines or granules. Cell wall smooth, punctate or ornamented with granules, spines, mucros, denticulations or combinations of these structures. In vertical view, cells usually radially symmetrical (the triangular form most common), but sometimes showing bilateral symmetry. Chloroplast usually an axial mass (rarely parietal) with deeply incised lobes extending to each angle of the semicell, pyrenoid single in each axial mass or several in each lobe.

Zygospores usually spherical, more rarely angular, ornamented with conical elevations that are continued into long spines with simple or furcate apices.

Species of this genus with simple form are often impossible to separate from radiate species of Cosmarium. The biradiate, simple-spined species of Staurastrum are also difficult to differentiate from Arthrodesmus. This overlapping of characteristics in these genera has been partly eliminated by the establishment of a new genus, Staurodesmus by Teiling (1948) in which there is incorporated the biradiate, single-spined, smooth-walled species of Staurastrum with similar species of Arthrodesmus. The writer, however, has chosen to retain the older system of classification until the exact limits of the genera and species concerned have been accepted by desmid authorities.

Key to Species of *Staurastrum*

1. Angles of cells not extended into hollow processes 2

1. Angles of cells extended into hollow processes 66

2. Cells with a very slight constriction, semicells subcylindrical at base and angular at apex 3

2. Cells with a well marked constriction, the semicells 3-6 angled or rarely compressed . 4

3. Cell wall uniformly granulate . . (1) *St. Meriani*

3. Cell walls granulate only in upper part of semicells, with a row of verrucae at the base of the semicell . . . . . (2) *St. capitulum* var. *spetsbergense*

4. Cell wall smooth or punctate, sometimes with mucros, but never with spines at angles . 5

4. Cell walls either not smooth or punctate, or if smooth or punctate, then with spines at angles 15

5. Each angle with a mucro or mammilla. 6

5. Each angle without a mucro 7

6. Lateral margins convex in vertical view . . . . . (3) *St. tumidum*

6. Lateral margins slightly concave (in median part) in vertical view . . . . . (4) *St. brevispinum*

7. Sinus closed and linear 8

7. Sinus open 10

8. Apices very slightly retuse . . (7) *S. suborbiculare*

8. Apices not slightly retuse . . 9

9. Lateral margins broadly rounded in front view . . . . . (8) S. orbiculare

9. Lateral margins concave in median part in front view . . . . . (14) S. trihedrale

10. Isthmus elongate . . . . . (15) S. pseudopachyrynchum

10. Isthmus not elongate 11

11. Cell walls conspicuously thickened at angles . . . . . (16) S. pachyrynchum

11. Cell walls not conspicuously thickened at angles 12

12. Angles mammillate . . . . . (17) S. subpygmaeum

12. Angles not mammillate 13

13. Semicells obversely triangular . . . (18) S. clepsydra fa.

13. Semicells transversely elliptic . . 14

14. Cell length more than 50u . . . (20) S. grande

14. Cell length less than 50u . . . (19) S. muticum

15. Cell walls partially or wholly granulate, angles without spines . . . 16

15. Cells smooth, punctate, granulate, spinate or verrucose; if granulate the angles bearing spines 23

16. Granules restricted to angles . 17

16. Granules uniformly distributed. 18

17. Apices with slight projections . . . (23) S. Prescottii

17. Apices without projections . . . . . (22) S. trachytithophorum

18. Semicells angularly elliptic (sometimes rhomboid elliptic) 19

18. Semicells elliptic or oblong elliptic 20

19. Dorsal margin more convex than ventral margin . . . . . (24) S. dispar

19. Dorsal margin and ventral margins equally convex . . . . . (25) S. punctulatum

20. Sinuses widely open, minutely acuminate or obtuse at apex . 21

20. Sinuses gradually and regularly opened 22

21. Apices flattened or retuse . . . . . (27) S. striolatum

21. Apices convex . . . . . (28) S. dilatatum

22. Granules irregularly arranged upon cell wall; angles broadly rounded; cells not twisted at isthmus . . . . . (31) S. turgescens

22. Granules regularly arranged upon cell wall, especially upon angles; angles less broadly rounded; cells usually twisted at isthmus . . . . . (30) S. alternans

23. Cell wall smooth, punctate or granulate, spines present only at angles 24

23. Cell wall covered with spines, or spines restricted to angular regions; or cell wall with verrucae (that may be emarginate or reduced) and with the angles trispinate or bispinate 48

24. A single spine present at each angle 25

24. More than one spine present at each angle 40

25. Cell wall granulate 38

25. Cell wall smooth or punctate 26

26. Cells with a greatly elongated isthmus . . . . . (32) S. cuspidatum

26. Cells without a greatly elongated isthmus 27

27. Semicells obversely triangular or obversely sub-semicircular, sometimes almost transversely fusiform or semicircular 28

27. Semicells rhomboidal, transversely s sub-elliptic, or elliptic . . . . (37) S. Dickiei

28. Semicells semicircular . . . . (40) S. Dickiei var. circulare

28. Semicells obversely triangular or obversely sub-semicircular 29

29. Spines convergent 30

29. Spines divergent or parallel 31

30. Width of semicells without spines more than 30u . . . . (42) S. megacanthum

30. Width of semicells without spines less than 30u . . . . (41) S. glabrum

31. Semicells obversely triangular (sometimes almost fusiform) 34

31. Semicells obversely semicircular . . 32

32. Spines short, up to 6u long . . 33

32. Spines well developed, 8-13u long . . . . . (42) S. connatum

33. Spines divergent . . . . . (49) S. dejectum

33. Spines dorsally inserted, more or less erect . . . . . (44) S. apiculatum

34. Ventral margins of semicells indented in front view . ... (45) S. aristiferum

34. Margins not indented as above . 35

35. Apex of semicells concave (cf. (52) S. megacanthum var. scoticum). (46) S. curvatum

35. Apex of semicells straight or convex 36

36. Cells up to 17u long (without spines) . . . . . (47) S. O'Mearii

36. Cells more than 17u long (without spines) 37

37. Cells about as long as wide (without spines); length without spines up to 28u . . . . . (49) S. dejectum

37. Cells wider than long (without spines); length without spines rarely less than 30u . . . . . (51) S. megacanthum

38. Semicells obversely triangular. 39

38. Semicells transversely ovate or hexagonal . . . . . (91) S. cornutum

39. Apex convex . . . . . (53) S. granulosum

39. Apex straight or very slightly convex . . . . . (54) S. lunatum

40. Cell wall smooth or punctate . 41

40. Cell wall granulate 46

41. Cells hexagonal or pentagonal in vertical view . . . . . (55) S. Brasiliense var. Lundelli

41. Cell triangular or quadrangular in vertical view 42

42. Cell quadrangular in vertical view . . . . . (56) S. quadrangulare var. armatum

42. Cells triangular in vertical view 43

43. Three or four spines at each angle . 44

43. Two spines at each angle 45

44. Three spines at each angle . . (58) S. trifidum var. Inflexum

44. Four spines at each angle . . . (57) S. quadrispinatum

45. Cells large, over 90u long . . . . . (59) S. longispinum

45. Cells small, less than 30u long . . (61) S. aviculoides

46. Angles of the cells perceptibly continued into short cylindrical processes . . . . . (65) S. subcruciatum

46. Angles of the cells not perceptibly continued into short cylindrical processes 47

47. Semicells transversely oval, hexagonal; lateral margins in transverse view with at least two strongly developed granules . . . . . (91) S. cornutum

47. Semicells transversely subelliptic or subtriangular; lateral margins in transverse view with several small granules, especially near the angles . . . . . (cf. (66) S. subdenticulatum) (62) S. avicula

48. Cell wall ornamented with verrucae which may be either reduced, emarginate and bi- or trispinate 64

48. Cell wall ornamented with spines, which may entirely cover the cell wall or which may be restricted to the regions of the angles 49

49. Spines uniformly covering the cell walls 55

49. Spines not uniformly distributed over cell walls 50

50. Spines at the region of the angles of distinctly greater size than body spines, or spines present only near angles and often of two sizes 52

50. Spines at the region of the angles of the same size as body spines, or spines gradually becoming larger approaching the angles 51

51. Semicell with two spines at each angle, and with three pairs upon apex; semicell wall otherwise with small sharp granules . . . . . (67) S. Simonyii

51. Semicell wall otherwise . . . . . (84) S. gladiosum

52. Cell length more than 100u (without spines) . . . . . (68) S. minnesotense

52. Cell length less than 100u (without spines) 53

53. Cell length less than 30u (without spines). 54

53. Cell length more than 30u (without spines). . . . . (69) S. setigerum

54. Lateral angles truncate . . . . (73) S. spiculiferum fa.

54. Lateral angles broadly rounded. (74) S. hystrix

55. Semicell wall ornamented with short granular spines or emarginate verrucae with spines 56

55. Semicell wall ornamented with long distinct spines 59

56. Cell length more than 26u . . . 57

56. Cell length less than 26u . . . (78) S. Bohlinianum

57. Cells 42-62.5u long . . . . . (79) S. muricatum

57. Cells less than 40u long 58

58. Semicell width 28-36u . . . . . (75) S. Ravenelli

58. Semicell width up to 28u . . (76) S. echinatum

59. Spines few, about 10, restricted more or less to the region of the angles and apex . . . . . (77) S. teliferum

59. Spines more numerous, not restricted to region of angles and apex . . . 60

60 Cells over 84u long . . . . . (83) S. Brebissonii var. maximum

60. Cells shorter 61

61. Cells 77-79u long (without spines) . (80) S. saxonicum

61. Cells shorter 62

62. Cells 48-67u long (without spines) . . . . . (81) S. polytrichum

62. Cells smaller 63

63. Middle part of apex smooth (in transverse view) . . . . . (cf. (85) S. pilosum) (82) S. Brebissonii

63. Middle part of apex sparsely spinescent . . . . . (84) S. gladiosum

64. Verrucae restricted to the apex and the angles . . . . . (86) S. maamense

64. Verrucae not restricted to the apex and angles 65

65. A single large spine (sometimes bifid) at each basal angle of the semicell; semicell wall otherwise ornamented with verrucae that are not spinate . . . . . (91) S. cornutum

65. A bi-trifid or emarginate verruca present at each basal angle of the semicell; cell wall ornamented with same type of verrucae (88) S. spongiosum

66. Processes in one whorl 67

66. Processes not in one whorl . . 153

67. Processes smooth, extremities sometimes emarginate, spinate or furcate 68

67. Processes undulate, crenulate or variously ornamented 71

68. Processes borne in pairs at angles . . . . . (94) S. laeve

68. Processes borne singly at angles 69

69. Cell length more than 20u 70

69. Cell length less than 20u . . . . . (95) S. inconspicuum

70. Ends of processes subdivided . (96) S. brachiatum

70. Ends of processes not subdivided (98) S. sublaevispinum

71. Body of semicells (not including apex) ornamented with accessory spines or verrucae that are usually not uniformly distributed 72

71. Body of semicells (not including apex) not ornamented with accessory spines or verrucae 86

72. Semicells biradiate 73

72. Semicells not biradiate 74

73. Cells small, length with processes less than 20u . . . . . (99) S. irregulare

73. Cells larger, length with processes more than 20u . . . . . (104) S. natator

74. Semicells hexagonal (in vertical view) . . . . . (93) S. sexcostatum var. productum

74. Semicells not hexagonal (in vertical view) 75

75. Body of semicells ornamented with verrucae 82

75. Body of semicells ornamented with one or more spines 76

76. Lateral margins of semicell body between processes ornamented with more than two spines 78

76. Lateral margins of semicell body between processes ornamented with two spines each of which may be reduced to a large granule or bifurcately divided at the tip 77

77. Base of semicell inflated and ornamented with verrucae or granules . (140) S. quebecense var. ornatum

77. Base of semicell not inflated and not ornamented with verrucae . . .(136) S. vestitum

78. Processes of semicells twisted.(114) S. controversum

78. Processes of semicells not twisted 79

79. The base of each semicell ornamented with a transverse series of granules or spines 81

79. The base of each semicell not ornamented with a transverse series of spines or granules 80

80. Cell length less than 50u . . .(141) S. aculeatum

80. Cell length more than 50u . . .(132) S. Sebaldii

81. A single row of spines present on each lateral margin between processes . . . . . .(134) S. Pseudosebaldii

81. A double row of spines present on each lateral margin between processes . . . . . .(133) S. Sebaldii var. ornatum

82. Semicells quadrangular in vertical view . . . . . .(142) S. Cerastes

82. Semicells triangular in vertical view 83

83. Semicells twisted at base so that processes on upper semicell are in different plane than processes in lower semicell when seen in transverse view, or processes twisted . 84

83. Semicells or processes not twisted as above 85

84. Processes with long sharp spines at tip . . . . . .(114) S. controversum

84. Processes with small short spines at tip . . . . . .(130) S. proboscideum

85. Verrucae restricted to lateral margins just below processes . . . .(133) S. Sebaldii var. ornatum

85. Verrucae forming a lateral marginal series between the processes . . .(146) S. anatinum

86. Semicells biradiate 87

86. Semicells not biradiate 99

87. Semicells twisted at isthmus 97

87. Semicells not twisted at isthmus . . 88

88. Apices smooth . . . . . .(106) S. chaetoceras

88. Apices with ornamentation . . . 89

89. Apices with a single spine or verruca(100)S. leptocladum

89. Apices with more than a single spine or verruca 90

90. Spines on ends of processes of different length . . . . . .(103) S. grallatorium var. forcipigerum

90. Spines on ends of processes of about the same length 91

91. Semicells with lateral truncate projections when seen in vertical view 92

91. Semicells without lateral truncate projections when seen in vertical view 93

92. Central region of semicell wall ornamented with 6-8 granules or verrucae . . . . . .(104) S. natator

92. Central region of semicell wall smooth . . . . . .(100) S. leptocladum

93. Ornamentation present on cell wall below apical verrucae 95

93. Ornamentation not present on cell wall below apical verrucae 94

94. Seven to ten apical verrucae present in face view . . . .(199) S. anchora

94. Less than seven apical verrucae present in face view . . . .(102) S. grallatorium

95. Apical verrucae 4 . . . . . .(105) S. brachioprominens

95. Apical verrucae 5-8 96

96. Base of semicells with two transverse rows of granules or none, processes parallel or slightly divergent . . . . . .(107) S. Johnsonii

96. Base of semicells with one transverse row of granules or none, processes usually slightly convergent . . . . . .(110) S. bicorne

97. Central region of semicell wall granulate or verrucose . . . . . (99) S. irregulare

97. Central region of semicell wall not granulate or verrucose 98

98. Cells 18-31u long with processes(112)S. tetracerum

98. Cells 36-67u long with processes(111)S. contortum

99. Semicells with 5-9 processes, usually very long (in vertical view) . . . 137

99. Semicells with 3-4 processes, if more than 4, processes relatively short and stout(in vertical view) . . . 100

100. Apices with verrucae 120

100. Apices without verrucae 101

101. Processes poorly developed, the length of the processes not as great as width of cell body . . . 102

101. Processes more developed, the length at least as great as width of cell body 110

102. Processes with two long spines at tips 103

102. Processes without two long spines at tips 104

103. Processes of two semicells alternating when seen in end view . . . . (65) S. subcruciatum fa.

103. Processes not alternating when seen in end view . . . . . (65) S. subcruciatum

104. Processes strongly convergent .(113) S. crytocerum var. compactum

104. Processes slightly convergent, horizontal or divergent . . . 105

105. Dorsal and ventral margins of semicells about equal in curvature, the semicells subfusiform . . . . . .(115) S. hexacerum

105. Dorsal margin of semicell not as convex as ventral margins, the semicells not subfusiform 106

106. Processes divergent, each process with two rings of denticulations and four apical spines . . . . . .(116) S. affine fa.

106. Processes not divergent 107

107. Processes with denticulate undulate margins . . . . . .(125) S. crenulatum

107. Processes ornamented with minute granules 108

108. Cell length 34u or more . . . .(130) S. proboscideum

108. Cell length less than 34u . . . 109

109. Angles of semicells attenuated to form short blunt processes; base of semicells without a transverse row of granules . . . . . .(123) S. polymorphum

109. Angles of semicells projecting into short obtuse processes; base of semicells sometimes with a transverse row of granules . . . . . .(127) S. margaritaceum

110. Cells small, length less than 20u without processes 111

110. Cells larger, length more than 20u without processes 116

111. Semicells with very long slender parallel processes . . . . . .(117) S. subgracillimum

111. Semicells with shorter divergent processes 112

112. Length of cells without processes less than 12u 113

112. Length of cells without processes 12u or more 114

113. Semicells transversely subrectangular, basal angles not rounded . .(118) S. iotanum

113. Semicells cup-shaped or cuneate, basal angles rounded . . . . . (121) S. paradoxum var. parvum

114. Length of cell with processes 77-84u . . . . . .(122) S. paradoxum var. longipes

114. Length of cell with processes below 77u 115

115. Basal angles broadly rounded . . . .(121) S. paradoxum var. parvum.

115. Basal angles straight . . . . . .(119) S. pseudotetracerum

116. Processes distinctly divergent.(120) S. paradoxum

116. Processes horizontal or convergent 117

117. Processes with denticulate undulate margins . . . . . .(125) S. crenulatum

117. Processes ornamented with minute granules 118

118. Processes twisted laterally in the same direction so that a processes from one semicell project between two processes of other semicells in front view. Semicells with a distinct row of intramarginal granules (in transverse view)(124) S. inflexum

118. Processes not twisted as above. Semicells sometimes with granular ornamentation(in transverse view) 119

119. Angles of semicells projecting into short obtuse processes, base of semicell often with a transverse row of granules . . . . . .(127) S. margaritaceum

119. Angles of semicells attenuated into longer, stout processes. Base of semicell without a transverse row of granules . . . . . .(123) S. polymorphum

120. Semicell base distinctly inflated 121

120. Semicell base not inflated . . 124

121. Semicell base with at least one transverse row of granules or with two minute spines 122

121. Semicell base without at least one transverse row of granules or without two minute spines . . . . . .(143) S. longiradiatum

122. Lateral margins with 2 small granules or spines between processes . . . . . .(140) S. quebecense var. ornatum

122. Lateral margins otherwise . . . 123

123. Semicell base with 3 or 4 transverse rows of sharp granules . . . . . .(145) S. elongatum

123. Semicell base with 2 minute spines at each lateral margin . . . . . .(144) S. protractum

124. Processes slightly developed, usually not as long as cell body is wide 125

124. Processes more developed, as long or longer than cell body is wide 130

125. Processes twisted (in transverse view)(113)S. cytocerum var.compactum

125. Processes not twisted (in transverse view) 126

126. Processes with denticulate undulate margins . . . . . .(125) S. crenulatum

126. Processes ornamented with small granules 127

127. Angles with well-developed spines at tips 129

127. Angles with granular teeth at tips . 128

128. Verrucae in a linear series along lateral margin in transverse view . . . . . (131) S. proboscideum var. ornatum

128. Verrucae arranged in a circle or star-like arrangement, or placed singly on each side of the base of the processes . . (127) S. margaritaceum

129. Two spines at each angle . . . . . (129) S. protectum var. planctonicum

129. Three spines at each angle . . . . (135) S. rugosum

130. Each process with a bifurcate accessory projection above but near base . . . . . (184) S. bicoronatum

130. Bifurcate projections not present as above 131

131. Two verrucae present on each side of cell (in transverse view) . . . . (149) S. floriferum

131. More than two verrucae on each side of cell (in transverse view) . . . 132

132. Only apical verrucae present . 134

132. Apical and subapical verrucae present 133

133. Subapical verrucae two, or if more than two, the middle two with well developed simple or bifurcate spines and much larger . . . . . (136) S. vestitum

133. Subapical verrucae more than two, or lateral margins between processes ornamented with spines . . . . . (146) S. anatinum

134. Base of semicells with a transverse row of granules . . . (150) S. boreale

134. Base of semicells without a transverse row of granules . . . 135

135. Isthmus of cell more than 15u wide, usually more than 20u . . . . . (132) S. Sebaldii

135. Isthmus of cell less than 15u wide . . . 136

136. A linear series of verrucae within each lateral margin when seen in transverse view, cells 42-52u long . . . . . (151) S. Manfeldtii

136. A linear series of paired granules within each lateral margin when seen in transverse view, or if verrucae are present, the cells are less than 40u long . . . . . (152) S. gracile

137. Processes very long and slender . . . 145

137. Processes short and stout 138

138. Base of processes with small emarginate projections on each side, or sharply serrate, or with a single spine on one side 139

138. Base of processes not as above. 141

139. Base of processes with small bifid projections . . . . . (156) S. distentum var. Michiganensis

139. Base of processes otherwise 140

140. Base of processes with a single spine on one side . . . . . (155) S. gyrans

140. Base of processes not as above. (157) S. incisum

141. Semicells without apical ornamentation other than granules 144

141. Semicells with apical verrucae . . . 142

142. Cell wall ornamented with verrucae . . . . . (93) S. sexcostatum var. productum

142. Cell wall not ornamented with verrucae 143

143. Apices with 2 or 3 emarginate verrucae just within the lateral margin between processes (in transverse view) . . . . . .(125) S. crenulatum

143. Apices with verrucae in circle or star-shaped position, or with a single verrucae on each side at the base of the processes . . . .(127) S. margaritaceum

144. Processes at angles of semicell attenuated . . . . . .(123) S. polymorphum

144. Processes at angles of semicell obtuse and short . . . .(127) S. margaritaceum

145. The base of processes with a single spine on one side . . . . . .(155) S. gyrans

145. The base of processes otherwise . . 146

146. Base of processes separated by a narrow linear incision (in vertical view) . . . . . .(157) S. incisum

146. Base of processes not separated by a narrow linear incision (in vertical view) 147

147. Semicells with five processes (in vertical view) 148

147. Semicells with more than five processes (in vertical view) 150

148. Width of cell with processes 40-65u . . . . . .(161) S. Arachne

148. Width of cell with processes more than 65u 149

149. Inner or ventral margin of processes crenulate . . . . . .(160) S. ankyroides var. pentacladum

149. Inner margin of processes smooth . .(158) S. pentacerum

150. Semicells with 6 or 7 processes (in vertical view) 151

150. Semicells with 8 or 9 processes (in vertical view) 152

151. Base of semicells with a transverse row of conical verrucae . . . . .(162) S. Ophiura

151. Base of semicells without a transverse row of conical verrucae . .(158) S. pentacerum

152. Base of processes with verrucae(162) S. Ophiura

152. Base of processes without verrucae, processes with transverse rings of granules . . .(159) S. rotula

153. Vertical view (of semicell body) triangular or quadrangular 155

153. Vertical view (of semicell body) circular 154

154. Upper accessory whorl of four processes present . . . . . .(166) S. leptacanthum

154. Upper accessory whorl of six processes present . . . . . .(164) S. Arctiscon

155. All provesses smooth, not granulate nor undulate 156

155. Processes not all smooth 159

156. Each semicell with 15 processes, (also possibly S. Hantzschii, which has become confused in the literature . . . . . .(167) S. senarium

156. Each semicell with 9-12 processes 157

157. Each semicell with 12 processes . . (168)S. gemelliparum

157. Each semicell with 9 processes . . . 158

158. Cells less than 26u long without processes . . . . . .(169) S. furcatum

158. Cells more than 26u long without processes . . . . . .(177) S. tohopekaligense

159. Processes in lower whorl granulate, processes in upper whorl smooth . 160

159. Processes in both whorls granulate .(179) S. furcigerum

160. In transverse view, each lateral margin possessing two processes upon the margin and two processes within the margin . . . . . .(175) S. forficulatum

160. In transverse view, each lateral margin possessing two processes within the margin . . 161

161. Angles sharp in transverse view . . 163

161. Angles rounded or truncate in transverse view 162

162. Body of semicell granulate . .(173) S. arcuatum

162. Body of semicell not granulate, granules restricted to ends of lower whorl processes . .(172) S. furcatum var. pisciforme

163. Lateral margins straight or convex in transverse view . . . . . .(182) S. monticulosum

163. Lateral margins slightly concave . .(174) S. arcuatum var. pseudopisciforme fa. Irenee-Marie

1. Staurastrum Meriani Reinsch

West and West, 1912. Monogr. Brit. Desm. 4:122. Pl. 118, Figs. 4-6.

This species has the bases of the semicells subcylindrical, the apices of the semicells angular and the wall uniformly granulate.

Measurements: L. 36-46u; W. at base, 17-20u; W. at apex, 20-26u; I. 13-18u.

Distribution: SLP, Berrien (Transeau 1917), Lapeer (N & A 1932).

2. Staurastrum capitulum var. spetsbergense (Nordst.) Cooke

West and West, 1912. Monogr. Brit. Desm. 4:126. Pl. 118, Fig. 8.

This species has subcylindrical semicell bases and angular apices. The apices are granulate and the basal portion of the semicell has a transverse row of verrucae.

Measurements: L. 34-50.7u; W. at base 26-28u; W. at apex 31-33u; I. 12-20u.

Distribution: Isle Royale (Prescott 1937, 1940).

3. Staurastrum tumidum Bréb.

West and West, 1912. Monogr. Brit. Desm. 4:142. Pl. 122, Figs. 1-5.

This species (triangular or quadrangular in transverse view) has a mammilla at each angle of the semicell, and the lateral margins are convex in vertical view.

Measurements: L. 97.5-134u; W. 78-127u; I. 44-50u.

Distribution: WUP, Marquette (Pres. & Mag. 1935).

4. Staurastrum brevispinum Bréb. Pl. 22, Fig. 1.

West and West, 1912. Monogr. Brit. Desm. 4:145. Pl. 123, Figs. 1-3.

This species has transversely oblong elliptic semicells with a small mucro at each angle. The concave lateral margins in vertical view distinguishes it easily from S. tumidum.

Measurements: L. 27-(32)-50u; W. 27-(32)-49u; I. 8-17u.

Distribution: SLP, Oakland. New record for Michigan.

5. var. retusum (West and West) Borge Pl. 22, Fig. 3.

West and West, 1912. Monogr. Brit. Desm. 4:148.Pl. 123, Fig. 6.

This variety is separated from the typical by the slightly retuse apices.

Measurements: L. 35-52-(53)u; W. 36-40-(41)u; I. 11-(13)-14u.

Distribution: SLP, Barry. New record for Michigan.

6. var. Boldtii Lagerheim Pl. 22, Fig. 2.

Smith, 1924. Trans. Wisc. Geo. & Nat. Hist. Surv. 57(2):68. Pl. 67, Figs. 16-17.

This variety is proportionately longer than the typical.

Measurements: L. 40-(47)-47u; W. (34)-38u; I. 9-11-13.5u.

Distribution: NLP, Cheboygan. New record for Michigan.

7. Staurastrum suborbiculare West and West

West and West, 1912. Monogr. Brit. Desm. 4:159. Pl. 125, Figs. 3-5.

This species has pyramidate-sub-semicircular semicells with narrow and slightly retuse apices.

Measurements: L. 35-(38)-44u; W. (33)-34.2-38u; I. 7.5-9.5-(10.5)u.

Distribution: SLP, Livingston, also Calhoun (Pres. & Mag. 1935); EUP, Schoolcraft; WUP, Gogebic.

8. Staurastrum orbiculare Ralfs. Pl. 22, Fig. 4.

West and West, 1912. Monogr. Brit. Desm. 4:155. Pl. 124, Figs. 10, 11.

This species has sub-semicircular semicells with apices slightly depressed and the lateral margins broadly

rounded. The vertical view is triangular with slightly concave sides and broadly rounded angles.

Measurements: L. 25.5-(43)-56u; W. 23-(43)-49u; I. 8-16u.

Distribution: SLP, Oakland; WUP, Gogebic. New records for Michigan.

9. var. Ralfsii West and West Pl. 22, Fig. 6.

West and West, 1912. Monogr. Brit. Desm. 4:156. Pl. 124, Figs. 12, 13, 15, 16.

This variety is separated from the typical by the subtriangular shape of the semicells.

Measurements: L. 31-(32)-41u; W. 22-(29)-36u; I. 7-(8.5)-11u.

Distribution: SLP, Barry; EUP, Mackinac. New records for Michigan.

10. var. truncatum Prescott

Prescott, 1940. Mich. Acad. Arts. Sci. & Letters. 25:93. Pl. 3, Figs. 14 and 20.

This variety is often larger than the typical. The upper lateral margins are more nearly straight than in the typical and the apex is broadly truncate.

Measurements: L. (60)-(69)-70-74.5u; W. 60-63-(64)u; I. (15)-19.5u.

Distribution: EUP, Delta; Isle Royale (Prescott 1940).

11. var. extensum Nordst. Pl. 22, Fig. 5.

West and West, 1912. Monogr. Brit. Desm. 4:158. Pl. 125, Figs. 1, 2.

This variety has cells that have a greater length to width ratio than the typical. The smaller size separates it from St. cosmarioides Nordst. which has not been found in Michigan.

Measurements: L. 38-(40)-48u; W. 25.5-(28)-36u; I. 8-(10.5)-14u.

Distribution: SLP, Oakland; WUP, Gogebic (2). New records for Michigan.

12. var. hibernicum West and West

West and West, 1912. Monogr. Brit. Desm. 4:156. Pl. 125, Figs. 5-9.

This variety has more pronounced basal angles than the typical, and flattened apices.

Measurements: L. 42-(47)-65u; W. 36-(43)-57u; I. 9.5-(15)-20u.

Distribution: SLP, Washtenaw; NLP, Cheboygan (N & A 1932); EUP, Schoolcraft; WUP, Marquette; Isle Royale (Prescott 1941).

13. var. depressum Roy and Biss.

West and West, 1912. Monogr. Brit. Desm. 4:158. Pl. 124, Figs. 17-19.

This variety has much smaller cells than the typical. The semicells are depressed and the cell wall is smooth. There is some resemblance to S. muticum Breb. from which it can be separated by the closed sinus.

Measurements: (22)-22-(24)-27u; W. 20-(22)-27u; I. 6-(7)-7.5-(8.5)u.

Distribution: SLP, Oakland, Barry; NLP, Cheboygan (N & A 1932); EUP, Schoolcraft, also Schoolcraft (N & A 1932); WUP, Menominee, Marquette; Isle Royale (Prescott 1940).

14. Staurastrum trihedrale Wolle

Wolle, 1892. Desm. of the U. S.:136. Pl. 51, Figs. 12, 14.

This species has triangular semicells which have lateral margins distinctly concave medianly.

Measurements: L. (43)u; W. (27.5)u; I. 10.5u.

Distribution: NLP, Cheboygan (N & A 1932); WUP, Gogebic (2).

15. Staurastrum pseudopachyrynchum Wolle Pl. 22, Fig. 9.

Smith, 1924. Wisc. Geo. & Nat. Hist. Surv. 57(2):69. Pl. 68, Figs. 1-3.

This smooth-walled species has rhomboidal-elliptic semicells with the apices convex and more tumid in the median region. The isthmus is narrow and elongate. The vertical view is triangular with the lateral margins concave and the angles broadly rounded.

Measurements: L. 22-34-(40)u; W. 20-(23)-35u; I. (6.5)-10.5u.

Distribution: EUP, Alger. New record for Michigan.

16. Staurastrum pachyrynchum Nordst.

West and West, 1912. Monogr. Brit. Desm. 4:151. Pl. 121, Figs. 8, 9.

This species has subelliptic or elliptic-subtriangular semicells with the angles conspicuously thickened.

The vertical view is 3-5 angled with the lateral margin concave and the angles obtusely rounded.

Measurements: L. (21.5)-24-(40)-45u; W. 22-(23.5)-(37)-45u; I. 7.8-(8.5)-15u.

Distribution: SLP, Calhoun, Oakland; NLP, Presque Isle, also Cheboygan (N & A 1932, Welch 1936a); Isle Royale (Prescott 1937, 1940).

17. Staurastrum subpygmaeum West Pl. 22, Fig. 7.

West and West, 1912. Monogr. Brit. Desm. 4:162. Pl. 125, Figs. 13-16.

The semicells of this species are widely cuneate with the apices and lateral margins convex. The lateral angles are mammillate. The lateral margins are convex and the angles mammillate in the triangular end view.

Measurements: L. 42-(52)-53u; W. 39.5-(43)-52u; I. 16-22.5-(23)u.

Distribution: NLP, Emmet. New record for Michigan.

18. Staurastrum Clepsydra Nordst. fa. Pl. 22, Fig. 8.

West and West, 1912. Monogr. Brit. Desm. 4:152. Pl. 122, Fig. 6.

The apices of the obversely subtriangular semicells are straight or convex and the angles are very slightly exserted and sometimes submucronate. The semicells are triangular in vertical view, with the lateral margins somewhat concave and the angles slightly rounded and sometimes slightly mucronate. The specimens from Oakland

County are smaller than the typical.

Measurements: L. (18)-27-31u; W. (25)-27-36u; I. 6-8u.

Distribution: SLP, Oakland. New record for Michigan.

19. Staurastrum muticum Bréb.

West and West, 1912. Monogr. Brit. Desm. 4:133. Pl. 118, Figs. 16-20.

This species has elliptic, elliptic-sub-semicircular or subreniform semicells and an open sinus. The vertical view is triangular or quadrangular with concave lateral margins and broadly rounded angles.

Measurements: L. (22)-22-(26)-43.5u; W. (22)-22-(24)-41u; I. 7.5-(8.5)-12u.

Distribution: SLP, Calhoun, Barry (2), also Ingham (N & A 1932) and Macomb (Pieters 1894); NLP, Emmet, Crawford, also Cheboygan (N & A 1932).

20. Staurastrum grande Bulnh.

West and West, 1912. Monogr. Brit. Desm. 4:140. Pl. 119, Figs. 11-13; Pl. 120, Fig. 1.

This very large species has elliptic to subelliptic semicells that have the lateral angles acutely rounded. The ventral margins may be more convex than the dorsal margins, or about equal. The vertical view is triangular or quadrangular with the lateral margins slightly concave and with the angles acutely rounded.

Measurements: L. 84-100u; W. 80-111u; I. 21-25u.

Distribution: Cheboygan (N & A 1932).

21. var. parvum West Pl. 23, Fig. 1.

West and West, 1912. Monogr. Brit. Desm. 4:141. Pl. 120, Figs. 2, 3.

This variety is separated from the typical by the smaller size and the more broadly rounded angles. The Michigan specimens from Calhoun County are smaller than the typical.

Measurements:L.(56)-60-65u; W. 47-56-61u; I. (9)-13.5-17u.

Distribution: SLP, Calhoun. New record for Michigan.

22. Staurastrum trachytithophorum West and West

West and West, 1912. Monogr. Brit. Desm. 4:165. Pl. 126, Figs. 1, 2.

The widely cuneate semicells of this species have the angles slightly upturned and mammillate; each angle with two rings of granules. The vertical view is triangular with the lateral margins slightly convex and the angles slightly produced, mammillate and ornamented with two rings of granules. The Michigan specimens from Schoolcraft County have the angles less mammillate and the apices additionally ornamented with three pairs of granules, one pair just back of each second transverse ring of granules. The size is also much smaller.

Measurements: L. (25.5)-30-34u; W. (23)-29-32.5u; I. (10.5)-10.5-11.5u.

Distribution: EUP, Schoolcraft, also Chippewa (N & A 1932).

23. Staurastrum Prescottii sp. nov.

This small organism, collected in abundance in Roscommon County appears to be a new species. The cell is longer than broad, with elliptic semicells that are truncate at the apices. The sinus between the semicells is acute angled at the apex and gradually opening to the outside. The lateral margins are truncate with broadly rounded angles and ornamented with 3-4 concentric series of granules. The apices bear a row of very short bifid ridges. In vertical view the semicells are triangular with straight or very slightly concave lateral margins. The angles are truncate with broadly rounded apices and with 3-4 concentric series of granules. Across each angle and just within the concentric series of granules, there is a pair of lunate ridges, each ridge accompanied inwardly by a shallow depression which is conspicuously punctate.

Measurements: L. 20-21u; W. 16-17u; I. 6.5-7u.

Distribution: NLP, Roscommon.

24. Staurastrum dispar Bréb.

West and West, 1912. Monogr. Brit. Desm. 4:187. Pl. 127, Fig. 7.

This species has narrowly elliptic-rhomboid or elliptic-fusiform semicells which are uniformly granulate. The vertical view is triangular with the angles acute and alternate with angles of other semicell. The lateral

margins are convex. The writer has been able to examine only an illustration of a form shown by West and West (1912).

Measurements: L. 27.5u; W. 27-28u.

Distribution: NLP, Cheboygan (N & A 1932).

25. Staurastrum punctulatum Bréb.

West and West, 1912. Monogr. Brit. Desm. 4:179. Pl. 127, Figs. 8-11, 13, 14.

The sub-rhomboid-elliptic semicells of this species are uniformly granulate and the angles are acutely rounded. The vertical view is triangular (rarely four or five angular) with the angles of one semicell partly or completely alternating with angles of other semicell. The lateral margins are slightly retuse and the angles are uniformly covered with concentric series of flattened depressed granules. The granules are irregularly scattered at the apex.

Measurements: L. 26-40.5u; W. 23-36.5u; I. 8-16u.

Distribution: SLP, Wayne (Campbell 1886), Berrien (Transeau 1917), Washtenaw (N & A 1932); NLP, Cheboygan, Emmet, Mecosta (N & A 1932); Isle Royale (Prescott 1940).

26. var. pygmaeum (Bréb). West and West Pl. 23, Fig. 2.

West and West, 1912. Monogr. Brit. Desm. 4:184. Pl. 128, Figs. 1, 2.

This variety is distinguished from the typical by the more acute granules and the wider isthmus. This var-

iety sometimes also possess straight lateral margins in transverse view which are never found in the typical.

Measurements: L. 27-42-(43)u; W. 24-(39)-40u; I. 13.5-(15)-18u.

Distribution: SLP, Calhoun, New record for Michigan.

27. Staurastrum striolatum (Naeg.) Archer

West and West, 1912. Monogr. Brit. Desm. 4:177. Pl. 127, Figs. 1-5.

This species has oblong elliptic semicells with straight or slightly retuse dorsal margins. The angles are furnished with concentric series of granules, and the areas between the angles are also granulate. The vertical view is 3-4 angular, the granulate rounded or subtruncate angles sometimes alternating with angles of the other semicell. The lateral margins are concave.

Measurements: L. (19)-19-(22)-(24)-28u; W. 18-(22)-28-(30)u; I. 6-(8.6)-10u.

Distribution: SLP, Calhoun, Washtenaw; NLP, Cheboygan (N & A 1932); EUP, Schoolcraft.

28. Staurastrum dilatatum Ehrenb.

West and West, 1912. Monogr. Brit. Desm. 4:172. Pl. 126. Figs. 10-15.

This species has transversely elliptic-subfusiform semicells with a convex dorsal margin. The cell wall granulation is in concentric rows around the angles and in regular series between the angles. The vertical view

is 3-5 angled with the angles sometimes alternating with the angles of the other semicells.

Measurements: L. 21-(36)-46u; W. 22-32-46u; I. 7.5-(8.5)-13u.

Distribution: SLP, Barry, Livingston, Washtenaw, Oakland; NLP, Crawford, Emmet, also Cheboygan (N & A 1932); EUP, Alger, Schoolcraft (2); WUP, Marquette, Gogebic, Houghton.

29. var. hibernicum West and West

West and West, 1912. Monogr. Brit. Desm. 4:175. Pl. 126, Fig. 18.

This variety has the basal portion of the semicell more pronounced than the typical. The granules are irregularly scattered on the body of the cell, but arranged in concentric rings on the angles.

Measurements: L. 22.5-24u; W. 21-24u; I. 7-7.5u.

Distribution: Isle Royale (Prescott 1940).

30. Staurastrum alternans Bréb.

West and West, 1912. Monogr. Brit. Desm. 4:170. Pl. 126, Figs. 8, 9.

This species has narrowly transverse oblong-elliptic semicells with rounded angles. The sinus is widely open and acute at the apex. The cells are triangular in vertical view, the angles of one semicell alternating with the angles of the other semicell. The lateral margins are concave, and the cell wall is granulate with the granules in concentric rows around angles, but irregularly

scattered upon the apex. The writer does not believe that S. rugulosum Breb. can be separated from this species, and thus it is included here.

Measurements: L. 21-(32)-(34)-35u; W. 21-(32)-(34)-37u; I. 7-(10.5)-13u.

Distribution: SLP, Barry (3), Calhoun, Washtenaw, Oakland also Ionia (Wade 1949) and Macomb (Pieters 1894); NLP, Cheboygan (N & A 1932); EUP, Alger; WUP, Houghton (N & A 1932); Isle Royale (Prescott 1937 and 1940 S. rugulosum).

31. Staurastrum turgescens De Not.

West and West, 1912. Monogr. Brit. Desm. 4:167. Pl. 126, Figs. 5, 6.

This species has elliptic or elliptic-oblong semicells with broadly rounded angles. The lateral margins are concave, and the angles are broadly rounded in vertical view. The cell wall is granular, sometimes in a very irregular fashion, sometimes in concentric series around the angles.

Measurements: 28-(32)-38.5u; W. 25-(32)-32.5u; I. 10-12u.

Distribution: SLP, Oakland, also Branch (N & A 1932).

32. Staurastrum cuspidatum Bréb.

West and West, and Carter, 1923. Monogr. Brit. Desm. 5:23. Pl. 132, Figs. 13-15.

This species has obversely triangular semicells with a single convergent or divergent spine at each angle. The elongate isthmus easily distinguishes it from similar species.

Measurements: L. (17.5)-20-31u; W. ssp. (17.5)-18-28u; I. 5-7.8u.

Distribution: SLP, Calhoun, Barry, Oakland, also Washtenaw (N & A 1932); NLP, Crawford, also Cheboygan (N & A 1932), (Welch 1938a); EUP, Alger, Schoolcraft; WUP, Menominee, Gogebic (2); Isle Royale (Prescott 1937).

33. var. divergens Nordst.

West and West, and Carter, 1923. Monogr. Brit. Desm. 5:25. Pl. 132, Figs. 16, 17.

This variety is separated from the typical by the divergent spines and from var. canadense G. M. Smith by the lack of a distinct indentation at the point of union of the two semicells.

Measurements: L. ssp. 18-(21.8)-25u; L. csp. 34.8u; W. ssp. (15)-16-23.5u; W. csp. 34.8u; L. Sp. 5-(10)-10u; I. 4.5-(5.5)-6.6u.

Distribution: SLP, Calhoun, Barry, Oakland; NLP, Cheboygan (N & A 1932); EUP, Schoolcraft.

34. var. canadense G. M. Smith

Smith, 1924. Wisc. Geol. and Nat. Hist. Surv. 54(2):75. Pl. 69, Figs. 1-3.

This variety usually has divergent spines as in var. divergens Nordst. but can be distinguished from it by the distinct indentation at the point of union of the two semicells.

Measurements: L. ssp. (22)-26-32u; L. csp. (36)-37-39u;

W. ssp. (15)-21-33u; W. csp. (35)-54-58u; L. sp. 10u; I. (4.5)-5u.

Distribution: SLP, Calhoun; NLP, Cheboygan (Taft 1939).

35. var. maximum var. nov. Pl. 23, Fig. 3.

This variety differs from the typical and varieties of the typical, by the possession of greatly elongated spines, the slightly mammillate angles, and the slightly curved cell and spines in end view. It should be compared with S. curvatum var. elongatum, G. M. Smith, from which it differs by the indentation at the point of union of the semicells, the slightly mammillate angles, and in vertical view, the less retuse lateral margins and very slight curvature of the spines which are also longer than measurements given by Smith (1924).

Measurements: L. ssp. 38u; W. ssp. 23u; W. csp. 81u; I. 5-6u; L. sp. 32u.

Distribution: SLP, Barry.

36. var. coronulatum Gutw.

West and West, and Carter, 1923. Monogr. Brit. Desm. 5:26. Pl. 33, Fig. 1.

This variety has a circle of verrucae just below the insertion of the spines on the angles. Some authors believe that these are not verrucae but gelatinous threads from mucilage pores.

Measurements: L. 26u; W. csp. 36u; I. 5-6u.

Distribution: NLP, Cheboygan (Taft 1939).

37. Staurastrum Dickiei Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:3. Pl. 124, Figs. 14, 15.

This species has subelliptic semicells with a single convergent spine at each angle. The vertical view is triangular with concave lateral margins and with the broadly rounded angles bearing a single spine. The subelliptic semicells separates this species from St. megacanthum Lund.

Measurements: L. 35-(36)-(43)-46u; W. ssp. 29-(43)-48u; W. csp. 39-(47)-59u; I. 8-11-(12)u.

Distribution: SLP, Calhoun, Oakland also Macomb (Pieters 1894); NLP, Cheboygan (N & A 1932); EUP, Schoolcraft (2), Alger; WUP, Iron, Menominee; Isle Royale (Prescott 1937, 1940).

38. var. maximum West and West

Smith, G. M., 1924. Wisc. Geo. and Nat. Hist. Surv. 57(2):76. Pl. 70, Figs. 3-5.

This variety is usually larger than the typical, and the sinus is acutely angled.

Measurements: L. 40-69u; W. ssp. 42-73u; W. csp. 62-86u; I. 11-15u.

Distribution: Isle Royale (Prescott 1940).

39. var. rhomboideum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:5. Pl. 129, Fig. 17.

This variety has rhomboidal semicells in which the lateral margins are straight in front view. Specimens from Alger County approach the fa. depressa Irénee-Marie of this variety.

Measurements: L. 36-(37)-46u; W. ssp. 40-48u; W. csp. 52-55-70u; I. 8.5-10.5-13u.

Distribution: NLP, Crawford; EUP, Alger; Isle Royale (Prescott 1937).

40. var. circulare Turn.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:5. Pl. 129, Fig. 16.

This variety is separated from typical by the almost semicircular semicells.

Measurements: L. 24-(43)-50u; W. 26-(43)-45u; I. 8-(10.5)-17u.

Distribution: SLP, Calhoun, Washtenaw, Oakland, Jackson, also Calhoun (Pres. & Mag. 1935); EUP, Schoolcraft; WUP, Marquette; Isle Royale (Prescott 1937, 1940).

41. Staurastrum glabrum (Ehr.) Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:2. Pl. 129, Figs. 2-4.

This species has cuneate, or obversely triangular semicells with a large convergent spine at each angle. In vertical view the semicells are usually triangular (the writer's specimens were all quadrangular) with concave lateral margins. In addition, the spines are curved

(in vertical view), agreeing favorably with specimens illustrated by Prescott (1935) from Cape Cod.

Measurements: L. 16-(23.5)-25u; W. ssp. 15-19-30u; W. csp. 34.2-(43)u; I. 5-(9)-9.3u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Chippewa.

42. Staurastrum connatum (Lund.) Roy and Biss.

West and West and Carter, 1923. Monogr. Brit. Desm. 5:15. Pl. 130, Figs. 6-8.

This species is characterized by obsemicircular semicells with long (over 8u), erect or almost erect spines at the angles.

Measurements: L. ssp. 20-29.5-(30)u; W. ssp. 20-22.5u; I. 6.5-(6.5)-9.2u.

Distribution: SLP, Calhoun; NLP, Cheboygan (N & A 1932).

43. var. americanum West and West Pl. 23, Fig. 4.

West and West, 1896. Trans. Linn. Soc. Lond. 2nd. Ser. Bot. 5(5):255. Pl. 16, Fig. 7.

This variety is somewhat longer and narrower than the typical. The spines are long, slightly curved and very robust.

Measurements: L. ssp. 24u; L. csp. 48u; W. 19.5u; I. 6u.

Distribution: SLP, Calhoun. New records for Michigan.

44. Staurastrum apiculatum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:6. Pl. 129, Figs. 6-8.

This species has obversely subsemicircular semi-

cells with a small (under 6u), almost erect spine on each angle.

Measurements: L. 14-(19)-(21.5)-29u; W. (15)-15-(21.5)-29u; I. (4.5)-5-7u.

Distribution: SLP, Calhoun; NLP, Cheboygan (N & A 1932); EUP, Schoolcraft (2); WUP, Menominee, Gogebic.

45. Staurastrum aristiferum Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:22. Pl. 132, Figs. 10, 11.

This species has obversely triangular semicells that have the ventral margins indented slightly about halfway between the isthmus and the apex. The specimens from Chippewa County have stouter and shorter spines than in the typical plant.

Measurements: L. ssp. 21-(21.5)-30u; L. csp. (36)-40-58u; W. ssp. (21.5)-22-24-27u; W. csp. (30)-38-45u; I. 6-6.5-(9)u.

Distribution: SLP, Calhoun (Pres. & Mag. 1935); NLP, Cheboygan (N & A 1932, Welch 1936b); EUP, Chippewa.

46. Staurastrum curvatum West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:19. Pl. 130, Figs. 15, 16.

This species has obversely triangular to sublunate semicells with a long straight divergent spine at each angle. The apices are concave. In transverse view, the cells are triangular with the acute angles each bearing

a long, straight, sometimes slightly curved spine. The lateral margins are retuse in this view. This species resembles superficially S. megacanthum Lund. from which it can be easily distinguished by the concave apices and the smaller size of the cell body. The spines on specimens from Barry are considerably shorter than typical.

Measurements: L. ssp. 25-(26)-32.5u; W. ssp. 20-(26)-35u; W. csp. (45)-64-80u; I. 5-(6)-8.5u.

Distribution: SLP, Barry; NLP, Cheboygan (Taft 1939).

47. Staurastrum O'Mearii Arch.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:13. Pl. 132, Figs. 5-8.

This small species has obversely triangular semicells with a sharp spine at each angle. The triangular end view usually has straight sides. This latter feature and the smaller size help distinguish it from small expressions of S. dejectum Bréb.

Measurements: L. ssp. 12-17u; W. 10-18u; I. 5-8u; Sp. 4-10u.

Distribution: NLP, Presque Isle, also Cheboygan (N & A 1932).

48. var. minutum W. West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:14. Pl. 132, Fig. 9.

This variety is much smaller than the typical plant.

Measurements: L. ssp. 7-8u; W. ssp. 10u; I. 5u; Sp. 10u.

Distribution: Cheboygan (Welch 1938a, C. Taft, identification).

49. Staurastrum dejectum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:7. Pl. 129, Fig. 9-12.

This species has obversely subsemicircular or obversely triangular semicells. Each lateral angle has a short (2.5-5u long) divergent spine inserted as a continuation of the angle or rarely more in a horizontal position. The vertical view is triangular with concave lateral margins and with a single, short spine at each angle. The small expression of this species resembles S. O'Mearii Archer sometimes, but the latter is usually much smaller and has straight or slightly convex lateral margins in vertical view. The writer has observed no specimens from Michigan with an elongated isthmus which Smith (1924a) states is a variable characteristic of this species.

Measurements: L. ssp. 18-(19)-28u; W. ssp. 17-(19)-32u; I. 5-(6.2)-8u; Sp. 2.5-10u.

Distribution: SLP, Barry (3), Calhoun, Livingston also Macomb (Pieters 1894); NLP, Crawford, Cheboygan (N & A 1932, Welch 1938a); EUP, Chippewa.

50. var. inflatum West Pl. 23, Fig. 5.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:9. Pl. 139, Figs. 1, 2.

This variety is larger than the typical and has convex dorsal margins. The Michigan specimens agree more favorably with Smith (1924a) than with the Wests (1923).

Measurements: L. 31-(32)-43u; W. ssp. 31-(34)-52u; I. 6-(12)-12u.

Distribution: WUP, Gogebic, New record for Michigan.

51. Staurastrum megacanthum Lund.

West, West and Carter. Monogr. Brit. Desm. 5:20. Pl. 131, Figs. 7, 8.

This species has obversely triangular (sometimes almost fusiform) semicells with a stout straight or slightly convergent spine at each angle. The vertical view is triangular or quadrangular with concave lateral margins. This species has a resemblance to S. Dickiei Ralfs, S. curvatum West and S. dejectum Breb., but has a stouter spine at the angles and a different semicell shape.

Measurements: L. 24-(36)-50u; W. ssp. 35-(43)-57u; W. csp. 58-(64)-(70)-83u; I. 9-(10.5)-14.5u; Sp. 7-18u.

Distribution: SLP, Calhoun, Barry; NLP, Presque Isle, also Cheboygan (Welch 1938a).

52. var. scoticum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:21. Pl. 131, Figs. 9, 10.

The spines on this variety are relatively longer than the typical. Smith (1924) states that the apices are concave, although West, West and Carter (1923) state that they may be straight.

Measurements: L. ssp. 35-44u; W. ssp. 38-51u; W. csp. 67-111u; I. 8-10.5u; Sp. 19-34u.

Distribution: NLP, Cheboygan (Taft 1939).

53. Staurastrum granulosum (Ehrenb.) Ralfs. Pl. 23, Fig. 6.

Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont. 1938:287. Pl. 46, Fig. 9; Pl. 48, Fig. 9.

This species is very similar to S. lunatum Ralfs. but has distinctly convex dorsal margins in front view. The sinus is acute at the apices and widely open to the exterior. The apical and lateral margins are convex and each of the angles is tipped with a short, stout spine. The vertical view is triangular with the lateral margins slightly retuse, and with each of the angles terminated by a short, stout spine. The semicell walls are ornamented with granules which are irregularly disposed upon the apices and face of the wall, but in concentric series around the angles.

Measurements: L. 28-(28)-(30)-49u; W. 27-(32)-48u; I. 9-(10.5)-17u.

Distribution: NLP, Emmet; EUP, Chippewa. New records for Michigan.

54. Staurastrum lunatum Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:29. Pl. 33, Figs. 17-19.

This species has semicircular semicells with a small sharp divergent spine at each angle. The vertical view is triangular with the lateral margins concave and with each of the angles ornamented with a single spine. The cell wall is uniformly covered with small granules,

especially in regular concentric series around the angles. The almost straight dorsal margins (in front view) and the marked concavity of the lateral margins separates this species from S. granulosum (Ehrenb.) Ralfs.

Measurements: L. 25-(30)-39u; W. 28-(32)-43u; I. 6.5-(10.7)-13u.

Distribution: SLP, Calhoun; NLP, Emmet; Isle Royale (Prescott 1940).

55. Staurastrum Brasiliense var. Lundellii West and West
West, West and Carter, 1923. Monogr. Brit. Desm. 5:35. Pl. 135, Figs. 12, 13.

This large organism cannot be confused with any other species of Staurastrum. The semicells are broadly cuneate with each of the truncate angles ornamented with three long, stout divergent spines. The vertical view is 5-6 angled with the lateral margins deeply concave.

Measurements: L. ssp. 74-80u; L. csp. 120-145u; W. ssp. 63-92u; W. csp. 120-148u; I. 28-38u; Sp. 25-37u.

Distribution: Isle Royale (Prescott 1937).

56. Staurastrum quadrangulare var. armatum West Pl. 24, Fig.1.
Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont.:282. Pl. 47, Fig. 3.

This species (usually quadrangular in vertical view) has rectangular semicells with two simple spines at each apical angle. A pair of bifurcate projections occur at each basal angle with the lower part of the projections

often being more strongly developed. This should be compared with S. contectum var. inevolutum West, which has only a single bifurcate projection at each basal angle.

Measurements: L. 22-(25)-30u; W. 25-28-29u; I. (9)-10-12u.

Distribution: SLP, Oakland. New record for Michigan.

57. Staurastrum quadrispinatum Turner

West, West and Carter, 1923. Monogr. Brit. Desm. 5:38. Pl. 135, Figs. 5-7.

This species is characterized by two pairs of long robust spines at each angle of the triangular semicell (in vertical view). One pair of divergent spines is inserted at the apical angle, and the other pair of spines which is convergent is inserted on the lateral margins (in front view).

Measurements: L. ssp. (32)-33-39u; L. csp. (53)u; W. ssp. (25)-26-30.5u; W. csp. (43)u; I. 8-(10.5)-10.5u; Sp. about 10u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Chippewa.

58. Staurastrum trifidum var. inflexum West and West Pl. 24,Fig.2.

West and West, 1896. Trans. Linn. Soc. Lon. Bot. 2nd Ser. 5(5):258. Pl. 16, Fig. 22.

This organism is characterized by three (one apical, two subapical) spines at each angle. In vertical view, the triangular semicells have the angles slightly recurved with the spines at the angle slightly twisted.

Measurements: L. 28.5-(34)u; W. ssp. 30.5-(32)u. W. csp. (43)-44u; I. 9-(14)u.

Distribution: EUP, Schoolcraft. New record for Michigan.

59. Staurastrum longispinum (Bail.) Arch.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:34. Pl. 134, Fig. 1.

This large species is characterized by subelliptical or subtriangular semicells with each angle possessing two large, stout, divergent spines. The vertical view is triangular with slightly concave lateral margins and broadly rounded angles, each angle being ornamented with two stout spines.

Measurements: L. 90-120u; W. ssp. 73-100u; I. 36-41u; Sp. 9.5-32.5u.

Distribution: NLP, Cheboygan (Taft 1939).

60. var. bidentatum (Wittr.) West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:34. Pl. 134, Figs. 2, 3.

The spines are smaller and the apex is less convex than in the typical.

Measurements: L. 80-90u; W. ssp. 75-85u; I. 30-35u; Sp. 7-10u.

Distribution: NLP, Cheboygan (Taft 1939).

61. Staurastrum aviculoides Gronbl. fa. Pl. 24, Fig. 3.

Gronblad, 1938. Bot. Not.:59. Pl. 2, Fig. 11.

This species has subtriangular semicells with two small, almost erect, spines inserted at each of the apical

angles. In end view, the triangular semicells have concave lateral margins. The Michigan specimens from Oakland County have more robust and sharply curved apical spines, and were smaller than the typical. The lateral margins in front view were also undulate in contrast to the straight lateral margins shown by Gronbl. (1938).

Measurements: L. (28)-42u; W. (32)-53u; I. 17u.

Distribution: SLP, Oakland. New record for Michigan.

62. Staurastrum avicula Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:40. Pl. 133, Figs. 8-10, 12.

This species has subelliptical or subtriangular semicells with each apical angle possessing two short spines, one above the other. In vertical view, the semicells are triangular with concave lateral margins and with spines at each angle. The cell wall is finely granulate, the granules being arranged in concentric rings around the angles.

Measurements: L. 29-(30)-34.5u; W. ssp. (30)u; W. csp. 35u; I. 9-(10.9)-11u.

Distribution: SLP, Calhoun, also Wayne (Campbell 1886), Macomb (Pieters 1894), Branch (N & A 1932); NLP, Cheboygan (N & A 1932); EUP, Schoolcraft; Isle Royale (Prescott 1940), Alger (fa.).

63. var. subarcuatum (Wolle) West Pl. 24, Fig. 4.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:41. Pl. 133, Fig. 11.

This variety has obversely triangular semicells with a nearly straight apical margin.

Measurements: L. 20-(26)-(30)-32u; W. 30-(30)-40-(41)u; I. 8.5-(12)-(12.5)-14u.

Distribution: SLP, Barry, Washtenaw; NLP, Roscommon, Emmet, Presque Isle; EUP, Delta; WUP, Houghton (2). New records for Michigan.

64. var. coronulatum var. nov. Pl. 24, Fig. 5.

This variety differs from the typical in the possession of verrucae on the apices. In vertical view, there is a lateral series of four verrucae just within the lateral margin. In addition, there is a second lateral series of four verrucae within the first series, the secondary series forming a triangular pattern. This organism should be compared with S. rugosum Irénee-Marie from which it differs in the possession of two spines which are inserted subapically on the angles. S. rugosum has short lateral processes which are trifid at the ends. In addition, this variety has (in transverse view) a linear series of four verrucae just within each lateral margin, and the granules upon the angles are much smaller than those shown by Irénee-Marie.

Measurements: L. 32u; W. csp. 38u; I. 10.5u.

Distribution: WUP, Menominee.

65. Staurastrum subcruciatum Cooke and Wills Pl. 24, Fig. 6; Pl. 25, Fig. 1.

The obversely triangular to lunate semicells of this species have the angles developed very slightly

into short divergent processes which are terminated by two divergent spines that lie in the same plane. The cell wall is granulate, the small granules being arranged in concentric series around the angles. The vertical view is triangular with concave lateral margins, and with the angles slightly extended into short processes which are terminated by two large spines. Specimens from Barry County are similar but larger than the typical, but those from Marquette and Presque Isle Counties have the processes reduced or completely lacking and should probably be considered a distinct forma.

Measurements: L. (28)-30-(42)u; W. 33-(33)-35-46u; I. 7.5-(10.5)u.

Distribution: SLP, Barry; NLP, Presque Isle; WUP, Marquette, New records for Michigan.

66.. Staurastrum subdenticulatum Nordst. fa. Pl. 25, Fig. 2. Nordstedt, 1888. Kongl. Sv. Vet. Akad. Handl. 22(8):39. Pl. 4, Fig. 14.

This species has hexagonal semicells with the lateral margins bearing two stout spines (one convergent, the other divergent). In vertical view the triangular semicells have slightly concave margins and acutely rounded angles with one spine visible. Large granules are arranged in three concentric series around the angles, the remaining cell wall being smooth. Nordstedt (1888) illustrations show a triangular pattern of granules on

the apices which was lacking in the Michigan specimens. The spines in the writer's specimens are also more robust. Nordstedt (1895) questions this species as possibly being an expression of S. avicula.

Measurements: L. 40-(43)u; W. ssp. 40; W. csp. (49)u.

Distribution: EUP, Delta. New record for Michigan.

67. Staurastrum Simonyii Heimerl.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:45. Pl. 135, Figs. 1-4.

This small species has elliptic to subfusiform semicells. The truncate lateral margins and also the apices have 2-4 short spines. The angles sometimes have 2-3 concentric series of sharp granules or denticulations. The triangular apical view shows variable lateral margins and obtusely rounded angles with 2-4 spines. In addition, there is a series of 2-4 spines just within the lateral margin, the middle two the largest of the four present.

Measurements: L. csp. 18-(23)-26u; W. ssp. 18-(23)-24u; W. csp. 22-25u; I. 6-(6.5)-10u.

Distribution: SLP, Barry; NLP, Cheboygan (N & A 1932); EUP, Chippewa, Schoolcraft; WUP, Gogebic (2), Baraga (2), Houghton.

68. Staurastrum minnesotense Wolle

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):81. Pl. 71, Figs. 14, 15.

This very large species is characterized by the presence of two large spines at each angle which are

larger than the two subapical pairs.

Measurements: L. ssp. 84-(94)-104u; L. csp. 99-(118)-145u; W. ssp. 82-88-112; W. csp. 105-(105)-172u; I. 20-(42)-42.5u.

Distribution: SLP, Barry; Isle Royale (Prescott 1937, 1940.

69. Staurastrum setigerum Cleve. Pl. 25, Fig. 3.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:52. Pl. 136, Figs. 13, 14.

This species has elliptical semicells with the apices often flattened. The extreme angles have two (usually three) -5 stout spines in a vertical row. In addition, there are smaller, more slender spines arranged around the angles in concentric series which are not always distinct. In vertical view, the semicells are triangular, with three stout superimposed spines at the terminus of the angles. Smaller and more delicate spines are arranged obscurely around the angles in concentric series.

Measurements: L. ssp. 42-(47)-56u; W. ssp. 27-40-55u; L. (10.5)-11-20u; Sp. 5-(11)-20u.

Distribution: SLP, Oakland; WUP, Houghton. New records for Michigan.

70. var. brevispinum G. M. Smith Pl. 26, Fig. 1.

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):80. Pl. 71, Figs. 9-13.

This variety is slightly smaller than the typical,

and also has four stout spines quadrately arranged at the angles. In addition, there are one or two spines on the dorsal margin internally from the lateral spine. The body has two transverse rows of smaller spines.

Measurements: L. (38)-39-41u; W. ssp. 35-(38)-40u; W. csp. 42-(47)-53u; I. (10.5)-12-14u.

Distribution: SLP, Barry. New record for Michigan.

71. var. occidentale West and West
Smith, 1924. Bull, Wisc. Geo. and Nat. Hist. Surv. 57(2):80. Pl. 71, Figs. 1-4.

This variety has the semicells more compressed than the typical. In vertical view, there are only two marginal spines.

Measurements: L. ssp. 32-33u; L. csp. 41-45u; W. ssp. 41-42u; W. csp. 57-63u; I. 11.5-12.5u; Sp. (large stout) 10-12.5u, (short delicate) 4-9u.

Distribution: NLP, Cheboygan (N & A 1932).

72. var. pectinatum West and West Pl. 26, Fig. 2.
Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):80. Pl. 71, Figs. 5-8.

This variety differs from the typical in possession of longer spines. In vertical view, the marginal spines are restricted to regions of the angles.

Measurements: L. ssp. 34-(42)-54u; L. csp. 44-(52)-64u; W. ssp. 31-(46)-49u; W. csp. 46-(67)-67u; I. 6.5-17u.

Distribution: NLP, Presque Isle. New record for Michigan.

73. Staurastrum spiculiferum G. M. Smith fa. Pl. 26, Fig. 3.
Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):82. Pl. 71, Figs. 16-20.

This small species has hexagonal rectangular semicells with subconvex or subconcave apices. The lateral margins are truncate with either one or two spines at the basal angle, and one spine at the superior angle. In vertical view, the triangular semicell has two spines (one near each angle) on the margin, and two spines within the margin just behind the angle. The Michigan specimens from Livingston County resemble figures 19 and 20 on Pl. 71 shown by Smith (1924), but there are three long spines at the basal lateral angle, and three long spines at apical lateral angle. In addition, there is an apical linear series of short spines within each lateral margin (in vertical view). The writer's specimens were slightly smaller than the typical measurements.
Measurements: L. ssp. (21)-23-25u; L. csp. (25.5)-29-45u; W. ssp. 20-(21.3)-24u; W. csp. (24.5)-30-40u; I. 6.5-(6.5)-8.5u.
Distribution: SLP, Livingston. New record for Michigan.

74. Staurastrum hystrix Ralfs.
West, West and Carter, 1923. Monogr. Brit. Desm. 5:60. Pl. 136, Fig. 1.

This species has elliptic oblong semicells with 2-3 spines at the bluntly rounded angles. In addition, there

are 3-4 spines in a series just back from the angle. In the vertical view, the semicells are triangular, with slightly concave lateral margins and obtusely rounded angles. There are 3-4 spines at the apex of the angle, and about three on or within each side of the lateral margin just behind the apex of the angle.

Measurements: L. ssp. 25-(27)u; W. ssp. 20-(23)u; I. 6.5-(10.5)u; Sp. (3)-3-4u.

Distribution: NLP, Cheboygan (N & A 1932) (Welch 1938a); EUP, Chippewa.

75. Staurastrum Ravenelli Wood

West, West and Carter, 1923. Monogr. Brit. Desm. 5:70. Pl. 138, Figs. 7, 8.

This species has subelliptical to subpyramidate-truncate semicells. The vertical view is triangular with nearly straight lateral margins. The cell wall is covered with granules which are often emarginate and spinate.

Measurements: L. 28-36u; W. 28-32u; I. 18-24u.

Distribution: SLP, Wayne (Campbell 1894), Washtenaw (West and West 1898).

76. Staurastrum echinatum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:56. Pl. 137, Fig. 12.

The broadly elliptical semicells of this species are covered with short spines which have dilated bases.

Measurements: L 33u; W 27u; I 12.5u; L sp. about 2.5u.
Distribution: SLP, Macomb (Pieters 1894); NLP, Cheboygan (N & A 1932).

77. Staurastrum teliferum Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:58. Pl. 136, Figs. 2-6.

This species has broadly elliptic semicells with numerous stout spines arranged near the angles. The vertical view is triangular with concave lateral margins and broadly rounded angles. The stout spines are arranged mostly around the angles, being lacking in the middle of the lateral margin and in the center of the apex.

Measurements: L. ssp. 32-56u; L. csp. 40-64u; W. ssp. 27-(29)-37u; W. csp. (40)-40-45u; I. 15u.
Distribution: SLP, Macomb (Pieters 1894); NLP, Cheboygan (N & A 1932); EUP, Chippewa.

78. Staurastrum Bohlinianum Schmidle fa. Pl. 26, Fig. 5.

Schmidle, 1898. Bih. t. Kongl. Sv. Vet. Akad. Handl. 24:53. Pl. 3, Fig. 3.

This small species has elliptic semicells with broadly rounded angles. The semicell body, especially the region of the angles, is ornamented with concentric series of acute granules and the processes are terminated by four smallspines. In vertical view, the semicells are triangular with slightly concave lateral mar-

gins. The central portion of the apex is smooth. The sinus on the Michigan specimens have a less acute apex, and the lateral margins (in vertical view) have more strongly developed granules than the typical.

Measurements: L. 20-(21.5)-24u; W. 20-22-(25)u; I. (8.5)u.

Distribution: EUP, Chippewa. New record for North America.

79. Staurastrum muricatum Bréb. Pl. 26, Fig. 4.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:67. Pl. 138, Fig. 9; Pl. 139, Figs. 1, 2.

The subelliptical to subreniform (rarely truncate-pyramidate) semicells have the cell wall covered with minute conical granules. The semicells are triangular in end view, with straight or slight concave lateral margins.

Measurements: L. (45)-46-62.5u; W. (38)-40-55u; I. (10.5)-12-21u.

Distribution: EUP, Schoolcraft; WUP, Houghton, Gogebic. New record for Michigan.

80. Staurastrum saxonicum Bulnh.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:54. Pl. 137, Fig. 7.

The broadly oval semicells with broadly rounded angles of this species are covered regularly by short, acute spines except in the center of the apices. The vertical view is triangular (rarely 4-5 angular) with slightly convex lateral margins and broadly rounded angles. This

species is longer and has more broadly oval semicells than S. Brebissonii Archer.

Measurements: L. ssp. 77-79u; L. csp. 85-86u; W. ssp. 58-65u; W. csp. 72-74u; I. 21-22u; Sp. 3-8u.

Distribution: NLP, Cheboygan (N & A 1932).

81. Staurastrum polytrichum (Perty) Rabehn.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:53. Pl. 136, Figs. 8-10.

This species has elliptical or subelliptical semicells covered with fairly long acute spines which are arranged around the angles in irregular concentric series and in the longitudinal rows upon the cell body. S. senticosum Delp. cannot be clearly differentiated from S. polytrichum and therefore is included here.

Measurements: L. ssp. 48-67u; L. csp. 54-80u; W. ssp. 41-48u; W. csp. 50-70u; I. 15-22u; Sp. 5-11u.

Distribution: NLP, Cheboygan (N & A 1932, also Cheboygan and Emmet, S. senticosum); WUP, Houghton (N & A 1932); Isle Royale (Prescott 1940).

82. Staurastrum Brebissonii Arch.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:86. Pl. 137, Figs. 4, 5.

The elliptic or elliptic-fusiform semicells of this species have acutely rounded angles. The cell wall is covered with short acute spines which are in concentric series around the angle where they may be longer and more num-

erous. The vertical view is triangular with slightly concave lateral margins and acutely rounded angles. Spines are lacking in the central region of the semicell apices.

Measurements: L. ssp. 34-(41)-48u; W. ssp. 40-(45)-62u; I. (13)-13u; Sp. 2.5u.

Distribution: EUP, Schoolcraft, Delta; WUP, Houghton, Gogebic; Isle Royale (Prescott 1940).

83. var. maximum Cedercreutz

Cedercreutz, 1932. Mem. Soc. pro Faun. et Fenn. 7:245. Text Figures 14, 15.

This is much larger than the typical.

Measurements: L. 87u; W. 85.5u; I. 4u.

Distribution: Isle Royale (Prescott 1937).

84. Staurastrum gladiosum Turner

West, West and Carter, 1923. Monogr. Brit. Desm. 5:57. Pl. 137, Figs. 1, 2.

This species has elliptic-reniform semicells with the dorsal and ventral margins about equally convex. The wall is uniformly covered with short spines which are in vague concentric series around the angles. The apical view is triangular with slightly concave lateral margins and broadly rounded angles.

Measurements: L. ssp. 37.5-(41)-43u; L. csp. 44.8-(47)-52u; W. ssp. 35-40u; W. csp. 44-50u; I. 10-17.5u.

Distribution: SLP, Barry, Jackson; NLP, Cheboygan (N & A

1932, Welch 1936b); EUP, Chippewa; WUP, Houghton, Gogebic (2); Isle Royale (Prescott 1937, 1940).

85. Staurastrum pilosum (Naeg.) Archer Pl. 27, Fig. 1.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:63. Pl. 138, Figs. 1-3.

There is some question as to whether this species really exists, and if it does, as to what the distinguishing characteristics are. One specimen from Gogebic County agrees rather well with the organisms illustrated by West, West and Carter (1923), and Irénee-Marie (1938). According to the former, the semicells are subelliptic or subfusiform with acutely rounded angles, and the cell wall is covered by numerous delicate spines which are arranged in concentric rings around the angles. The vertical view is triangular with concave margins and acutely rounded angles.

Measurements: L. ssp. (39)-42.5-44u; W. 38-(39)-47u; I. 11-(12)u; Sp. 2u.

Distribution: WUP, Gogebic. New record for Michigan.

86. Staurastrum maamense Archer

West, West and Carter, 1923. Monogr. Brit. Desm. 5:75. Pl. 139, Fig. 10.

This species has semicircular or subpyramidate semicells with the lateral margins bearing 4-5 emarginate verrucae. The apical margins are flattened. The vertical view is triangular with smooth, concave lateral margins and broadly rounded or tricrenate angles.

Measurements: L. 33-(33)-42u; W. 28-(30)-33u; I. 10-(11)-13u.

Distribution: SLP, Barry (2), Oakland, also Calhoun (Pres. & Mag. 1935); Isle Royale (Prescott 1937, 1940).

87. var. atypicum Magnotta

Prescott and Magnotta, 1935. Pap. Mich. Acad. Sci. Arts and Letters. 20:164, Pl. 26, Figs. 7, 8.

This variety is distinguished from the typical in the possession of single or double spines (which are extensions of verrucae), at the basal angle of the semicells.

Measurements: L. (39)-40-41.8u; W. (34)-(37.5)-38.5u; I. (10.5)-13.5u.

Distribution: SLP, Calhoun, also Calhoun (Pres. & Mag. 1935).

88. Staurastrum spongiosum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:76. Pl. 140, Fig. 4.

This very characteristic species has subpyramidate-truncate to trapeziform semicells which are ornamented by 8-10 emarginate processes along the margins and about six similar processes across the face of the semicell. The vertical view is triangular with the straight or slightly convex lateral margins ornamented with four emarginate verrucae. The angles are provided with a verrucae at the apex. In addition, there are three pairs

of verrucae arranged across the angle and decreasing in size toward the apex.

Measurements: L. 45-(56)-65u; W. 42-(43)-55u; I. 12-(13.5)-19u.

Distribution: NLP, Roscommon, Crawford, Emmet, also Cheboygan (N & A 1932).

89. var. Griffithsianum (Naeg.) Lagerh.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:78. Pl. 140, Fig. 15.

This variety has the sinus open toward the extremities and has in vertical view, a deep, rounded and distinct concavity between the middle processes on each lateral margin.

Measurements: Same as typical.

Distribution: NLP, Cheboygan (N & A 1932).

90. var. perbifidum W. West fa. spinosa Irenee-Marie Pl. 27, Fig. 2.

Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont.:291. Pl. 51, Fig. 11.

This form is characterized by the verrucae being bifid spined. The basal angles of the semicells are slightly projected, each extension having several small spines in addition to a strong bifurcate projection. This forma may be merely within the range of environmental variation of the var. perbifidum.

Measurements: L. (44.5)-50u; W. (47)-53u; I. (11.5)-12.5u.

Distribution: NLP, Emmet. New record for Michigan.

91. Staurastrum cornutum Archer

West, West and Carter, 1938. Monogr. Brit. Desm. 5:31. Pl. 133, Fig. 16.

This species has oval or hexagonal semicells with a strong simple or bifid spine on each lateral margin. The apices are ornamented with a series of emarginate granules or verrucae as in the lower lateral margins. There may also be a subapical row of granules or verrucae between the processes. The transverse view is triangular with slightly concave lateral margins. The angles each have a stout spine and are also ornamented by 2-3 concentric rings of emarginate granules or verrucae. Within the lateral margin there are one or two linear series of granules or verrucae. In addition, there may be a series upon the lateral margin between the angles. This latter series is reduced to two granules, one each near the angles in the writer's specimens.

Measurements: L. 27-35-40u; W. ssp. 27-33u; W. csp. 44-50.7u; I. (6.5)-8-15.6u; Sp. 9-12u.

Distribution: EUP, Schoolcraft, Delta; Isle Royale (Prescott 1937).

92. fa. reductum fa. nov. Pl. 27, Fig. 3.

This organism can be separated from the typical by the presence of a single poorly developed convergent spine on each lateral margin. Otherwise the cell shape and ornamentation agree with the typical.

Measurements: L. 32u; W. ssp. 27u; W. csp. 33u; I. 10.5u.
Distribution: EUP, Schoolcraft.

93. Staurastrum sexcostatum var. productum W. West
West, West and Carter, 1923. Monogr. Brit. Desm. 5:148. Pl. 150, Fig. 15.

This species has elliptical semicells with short blunt processes which have a circle of six granules at their apices, and which are ornamented with concentric circles of granules. The apices are granulate and the base of the semicells has a transverse row of granules. The vertical view is hexagonal with short, truncate processes and concave lateral margins. The processes have several series of granules, and the apices have several series of emarginate granules or verrucae inside the lateral margin following the contour of the semicell.
Measurements: L. 36-(38)-43u; W. (38)-40-43u;
I. 12.5-(15)-17.5u;
Distribution: EUP, Gogebic, also Marquette (Pres. and Mag. 1935); Isle Royale (Prescott 1937, 1940).

94. Staurastrum laeve Ralfs.
West, West and Carter, 1923. Monogr. Brit. Desm. 5:92. Pl. 141, Figs. 1-3.

This species has elliptical or subsemicircular semicells with two smooth apically bifid processes lying in the same plane at each angle. The cell wall is smooth. The vertical view is 3-5 angled with the lateral margins

concave and with the angles lobed and ornamented with two short bifid processes.

Measurements: L. csp. 18-27.5u; W. 14-28u; I. 7-10u.

Distribution: SLP, Washtenaw (Johnson 1895).

95. Staurastrum inconspicuum Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:86. Pl. 141, Figs. 4-7; Pl. 142, Fig. 8.

This small species has approximately quadrangular semicells with small, short, outward, divergent processes that suddenly become narrowed and upward directed, ending in smooth truncate apices. The vertical view is 3-6 angular.

Measurements: L. ssp. 12-16u; L. csp. 15-(15)-26u; W. 12.5-(15)-26u; I. 5.5-(6.5)-9u.

Distribution: SLP, Calhoun; NLP, Cheboygan (N & A 1932).

96. Staurastrum brachiatum Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:88. Pl. 141, Figs. 14, 15; Pl. 142, Figs. 1-7.

This smooth-walled species has triangular semicells with stout, hollow, divergent processes which are bifid or trifid at the tips. In vertical view, the semicells are 3-5 angular with concave lateral margins and with a stout process arising at each angle. The two semicells may be twisted at the apices. This apecies is easily separated from S. laevispinum by the bifid or trifid processes.

Measurements: L. 27-(32)-55u; W. 15-(43)-57.5u; I. 5-8.5-14u.

Distribution: NLP, Cheboygan (N & A 1932, Welch 1936a, 1936b, 1938b); EUP, Chippewa, Schoolcraft; WUP, Gogebic.

97. var. major var. nov. Pl. 27, Fig. 4.

This variety is about twice as large as the typical, and has the trifid or quadrifid apices of the processes further subdivided.

Measurements: L. 75u; W. 75u; I. 17u.

Distribution: EUP, Chippewa.

98. Staurastrum sublaevispinum W. West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:91. Pl. 141, Fig. 19.

This species has semicells composed of three very stout smooth parallel-walled processes with conical apices arising from a very reduced semicell body. The processes with the conical apices easily distinguish this species from S. brachiatum Ralfs.

Measurements: L. 20-25u; W. 30-37u; I. 7-7.5u.

Distribution: NLP, Cheboygan (Taft 1939).

99. Staurastrum irregulare West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:150. Pl. 149, Fig. 7.

This very small, often twisted, biradiate species has inversely trapeziform semicells with short diverging processes. The cell wall has a truncate and scrobiculate

process in the middle of each semicell. This latter feature distinguishes it from S. tetracerum.

Measurements: L. ssp. 9.4-9.6u; L. csp. 15.3-18.2u; W. csp. 13.5-17.3u; I. 4.8-7.5u.

Distribution: SLP, Washtenaw (West and West 1898).

100. Staurastrum leptocladum Nordst.

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):102. Pl. 78, Fig. 1-7.

This biradiate species is characterized by a subcampanulate semicell with a tumid apex and an inflated base. The processes are very long and typically are first divergent and then upwardly curved. The apices have a single subapical spine and bases of the semicells usually have a transverse row of granules.

Measurements: L. ssp. 30-(32)-(43)-48u; L. csp. (54)-56-95u; W. ssp.11-21u; W. csp. 67-(84)-(97)-120u; I. 4.5-(8)-11u.

Distribution: SLP, Calhoun, Barry, Clinton; EUP, Schoolcraft; Isle Royale (Taylor 1935, Prescott 1940).

101. var. insigne West and West

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):103. Pl. 77, Fig. 15; Pl. 78, Figs. 8-11.

This variety differs from the typical in possessing crenulations or verrucae along the lateral margins between the basal swelling and the base of the process. The subapical spine of the typical is replaced by a trans-

verse row (4-6) of verrucae. Specimens from Calhoun County lack the transverse row, possessing one subapical elevation similar to the variety denticulatum G. M. Smith, and in addition several apical elevations.

Measurements: L. ssp. 36-42-(43)u; L. csp. 55-(60)-100u; W.ssp. 20-26u; W. csp. 86-(96)-110u; I. 6-8u.

Distribution: SLP, Calhoun; Isle Royale (Prescott 1940).

102. Staurastrum grallatorium Nordst. Pl. 28, Fig. 1. Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):100. Pl. 77, Figs. 3-5.

This biradiate species has narrowly campanulate semicells with truncate apices (with three emarginate verrucae). The parallel or slightly divergent processes have sharply crenulate slightly tapered margins and are bifurcate at apices. This species is easily separated from S. Johnsonii West and West by the parallel bifurcate processes and the lack of subapical verrucae.

Measurements: L. ssp. 32-(34)-34u; L. csp. 42-48u; W. ssp. 20u; W. csp. (65)-69-86u; I. 8.5-9u.

Distribution: NLP, Roscommon, Emmet; EUP, Schoolcraft (2). New records for Michigan.

103. var. forcipigerum Lagerh. Pl. 28, Fig. 2. Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):101. Pl. 77, Figs. 6, 7.

This variety has trapeziform semicells which possess two divergent spines upon the truncate apex. The lateral

processes have crenulate margins and are unequally bifurcate at the apices.

Measurements: L. ssp. 38-48u; L. csp. 45-57-(60)u; W. ssp. 21-33u; W. csp. 46-(65)-86u; I. 7.5-9-(9.5)u.

Distribution: EUP, Schoolcraft. New record for Michigan.

104. Staurastrum natator West Pl. 28, Fig. 3.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:149. Pl. 147, Fig. 7.

This biradiate species has subrectangular or subtrapeziform semicells with long, slightly curved and divergent processes. Ornamentation consists of three trispinate verrucae on the apices, 6-8 granules enclosing one or two other granules on the central region of the semicell wall and a transverse row of granules at the base of the semicells.

Measurements: L. ssp. 32-(32)-38.5u; L. csp. 53-(65)-75u; W. ssp. 11-25u; W. csp. 57-(86)-88u; I. 8-(10.5)-12.5u.

Distribution: SLP, Barry; EUP, Alger, Schoolcraft. New records for Michigan.

105. Staurastrum brachioprominens Boerg.

Boergesen, 1890. Vid. Medd. f. Nat. For.:952. Pl. 5, Figs. 52.

This biradiate species has obversely triangular semicells with undulate apices and biundulate lateral margins. The lateral angles projecting into long,

slightly attenuated, divergent processes which are denticulate and terminated by three small spines. The ornamentation consists of three transverse rows of granules at the base of the semicells and a subapical row of about seven granules and minute spines on the apical undulations. The latter feature is probably tridentate verrucae.

Measurements: L. 30u; W. 72u; I. 11u.

Distribution: NLP, Cheboygan (N & A 1932).

106. Staurastrum Chaetoceras (Schroeder) G. M. Smith

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):99. Pl. 76, Figs. 21-24; Pl. 77, Fig. 1.

This biradiate species has obversely triangular semicells with long, divergent processes which are ornamented with concentric rings of minute granules and terminated by four small teeth. The cell body usually has a few scattered subapical granules. The vertical view is narrowly elliptic (rarely triangular) with long processes.

Measurements: L. ssp. 19-22-(25)u; L. csp. 46-(65)-89u; W. ssp. 16-21-22u; W. csp. 65-(65)-89u; I. 5.5-6.5-7u.

Distribution: SLP, Ionia (Wade 1949).

107. Staurastrum Johnsonii West and West

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):104. Pl. 79, Figs. 1-6.

This biradiate species has subcampanulate semicells with inflated bases. The processes have crenulate margins,

are slightly attenuated, and terminate in three spines. The ornamentation consists of 5-7 subapical verrucae, a secondary transverse row of granules or verrucae just below the subapical row, and two transverse rows of granules at the inflated bases of the semicells.

Measurements: L. 38.5-49-85u; W. ssp. 13-30u; W. csp. 79-99-110u; I. 8-(10.5)-12u.

Distribution: SLP, Calhoun, Barry, Oakland, also Washtenaw (Johnson 1894, S. leptocladum, West and West 1898); NLP, Crawford; EUP, Alger; WUP, Marquette, Menominee, Gogebic.

108. var. depauperatum G. M. Smith Pl. 29, Fig. 4.
Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):105. Pl. 79, Figs. 7-11.

This variety differs from the typical in having a less pronounced basal swelling and a reduced secondary subapical row of granules, and by lacking a transverse row of granules at the base.

Measurements: L. ssp. 32-(38)-52u; L. csp. 40-86u; W. ssp. 16-30u; W. csp. 72-(93)-125u; I. 8-10.5u.

Distribution: SLP, Oakland, Barry; EUP, Schoolcraft.

New records for Michigan.

109. Staurastrum anchora West and West Pl. 29, Fig. 1.
Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):101. Pl. 77, Figs. 8, 9.

This biradiate species has campanulate semicells

with very slightly inflated bases. The parallel or slightly convergent processes have crenulate margins and are tipped by three divergent spines. The apices of the semicells are flattened and ornamented with a single subapical transverse row of 8-10 emarginate verrucae.

Measurements: L. 65-(75)-76u; W. ssp. 22-58u; W. csp. 113-(117)-162u; I. 12-15-(17)u.

Distribution: SLP, Barry, Oakland. New records for Michigan.

110. Staurastrum bicorne Hauptfl.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:117. Pl. 143, Fig. 17.

The subtriangular semicells of the species are biradiate with the parallel or convergent processes gradually tapered and terminated by three spines. The apices are flattened and bear two transverse rows of 8-10 emarginate verrucae.

Measurements: L. 52-(53)-71u; W. ssp. 19-27u; W. csp. (69)-72-93u; I. 10-13.4-(15)u.

Distribution: NLP, Emmet, also Cheboygan (N & A 1932).

111. Staurastrum contortum G. M. Smith

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):98. Pl. 76, Figs. 17-20.

This biradiate species has obversely triangular semicells which are twisted at right angles to each other. The processes are long, attenuated and divergent.

Measurements: L. ssp. 12u; L. csp. 36-67u; W. ssp. 10.5-12u; W. csp. 44-119u; I. 6u.

Distribution: NLP, Cheboygan (Taft 1939).

112. Staurastrum tetracerum Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:118. Pl. 149, Figs. 2, 3.

This small biradiate species has rectangular semicells with long divergent processes. The semicells are often twisted at the isthmus.

Measurements: L. ssp. 7-(8)-10u; L. csp. 18-(22)-28u; W. ssp. 7-(8.5)-9u; W. csp. 18-(18)-32u; I. 2.5-(3)-6u.

Distribution: SLP, Calhoun, Barry, Oakland; NLP, Emmet, also Cheboygan (N & A 1932); EUP, Schoolcraft, Mackinac; WUP, Menominee, Marquette; Isle Royale (Prescott 1940).

113. Staurastrum cyrtocerum var. compactum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:136. Pl. 149, Fig. 10.

This organism has cup-shaped semicells in which the lateral margins are much more convex than the apical margin. The processes are slightly attenuated, stout, convergent and tipped with short spines. The vertical view is triangular or quadrangular with concave lateral margins and with the angles projected into short, stout processes tipped with three short spines. The processes are usually twisted (all in same direction). The cell wall is granulate. The granules are arranged in concen-

tric series around the angles, and in longitudinal rows upon the body. The apices are ornamented with an intramarginal series of verrucae.

Measurements: L. 36; W. csp. 40u; I. 11u.

Distribution: WLP, Houghton (N & A 1932).

114. Staurastrum controversum Bréb. Pl. 28, Fig. 4.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:162. Pl. 154, Figs. 1-4.

This species is characterized by elliptic or fusiform semicells in which the angles are projected into laterally twisted and slightly convergent processes. The processes are ornamented with 3-4 concentric series of granules and tipped by 3-5 spines. The apical view is triangular (rarely more than 4-5 angular), with concave lateral margins and with processes twisted in the same direction. Within the lateral margin there is a linear series of bifid spines or emarginate granules which are often displaced by twisting of the cell. Sometimes there is secondary series upon the lateral margin.

Measurements: L. 26-(38)-(44)-65u; W. 28-(60)-(65)-75u; I. 6.8-(10.5)-12-(13)u.

Distribution: SLP, Barry; EUP, Schoolcraft; WUP, Marquette. New record for Michigan.

115. Staurastrum hexacerum (Ehrenb.) Wittr.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:138. Pl. 142, Figs. 11-14.

This species has fusiform or subtriangular semicells with short, tapering processes which are tipped with three spines. The transverse view is usually triangular with slightly concave lateral margins and short, attenuated processes. The cell wall is granulate, the granules in concentric series around the angles and somewhat reduced upon the apices and body. The processes are longer than typical in the Mackinac County specimens. A form from Menominee County is slightly longer and is more uniformly granulate than typically and has the semicells slightly twisted at the isthmus.

Measurements: L. 18-(25)-28-(32)u; W. csp. 20.5-34-(35)-(40)u; I. 4.5-8u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Mackinac; WUP, Gogebic (2); Menominee; Isle Royale (Prescott 1940).

116. Staurastrum affine West and West fa. Pl. 28, Fig. 5.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:128. Pl. 142, Fig. 23.

This species typically possesses the following characteristics. The semicells are elliptic-subsemicircular with both margins convex, the lateral ones especially so. The processes are short and divergent, and are terminated with four short spines. There are 2-3 concentric series of denticulations about the processes just within the apical spines. The semicells are triangular in vertical

view with slightly concave lateral margins and short denticulate processes. The cell wall is granulate. A single specimen from Gogebic County, for which the measurements are unfortunately unavailable, agrees well with this description but differs primarily in the much shorter processes, the less convex dorsal margin in front view, and the straight lateral margins in vertical view. In addition, the cell wall appeared smooth.

Measurements: (Typical) L. 36-40u; W. ssp. 28-33u; W. csp. 44-45u; I. 10-10.5u.

Distribution: WUP, Gogebic. New record for Michigan.

117. Staurastrum subgracillimum West and West Pl. 28, Fig. 6. West and West, 1896. Trans. Linn. Soc. of Lon. Bot. 2nd Ser. 5(5):263. Pl. 17, Figs. 3, 4.

This small species is characterized by broadly cuneate semicells with concave apices. The processes are very long, about horizontal, undulate, the same width throughout and terminated by three divergent spines. The vertical view is triangular with lateral margins straight or concave and with the long narrow processes terminated with three divergent spines. The angles of the one semicell may alternate with those of the other semicell.

Measurements: L. (9)-10.5-15.5u; W. ssp. 12-13u; W. csp. 40-44-60u; I. 4.8-(5)-6u.

Distribution: EUP, Schoolcraft. New record for Michigan.

118. Staurastrum iotanum Wolle

West and West and Carter, 1923. Monogr. Brit. Desm. 5:121. Pl. 149, Fig. 1.

This very small species has subrectangular semicells with angular bases. The processes are long and divergent, undulate and with emarginate apices. The vertical view is triangular with straight lateral margins and long undulate processes.

Measurements: L. ssp. 8-10u; L. csp. 12-(17.5)-22u; W. ssp. 6-10u; W. csp. 12-(22)-23u; I. 3-(5)-6u.

Distribution: SLP, Calhoun, Barry; NLP, Crawford, Emmet, also Cheboygan (N & A 1932); WUP, Iron; Isle Royale (Prescott 1940).

119. Staurastrum pseudotetracerum (Nordst.) West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:122. Pl. 149, Fig. 11.

This small species has cuneate semicells with short, strongly diverging processes. The processes are terminated by three spines; 2-3 concentric series of granules also occur around each process. The vertical view of the semicell is triangular or quadrangular with concave lateral margins and with the short processes ornamented with 2-3 concentric series of granules and terminated by three spines. This species has a stouter appearance than S. tetracerum.

Measurements: L. ssp. 12-19u; L. csp. 19-25u; W. csp. 19-30u; I. 5-6u.

Distribution: NLP, Cheboygan (N & A 1932).

120. Staurastrum paradoxum Meyen

West, West and Carter, 1923. Monogr. Brit. Desm. 5:101. Pl. 145, Figs. 1-5.

This very variable species has obversely triangular to subcampanulate semicells. The processes are usually long and somewhat attenuated, always divergent and ornamented by concentric series of granules (which may be developed into short spines at the base of the process), and terminated by three or four spines. The vertical view of the semicells is triangular or quadrangular with straight or slightly concave lateral margins and with the processes ornamented with concentric rings of granules and terminated by three or four spines. According to Smith (1924), and West, West and Carter (1923), the granules on the processes may be developed into spines under certain conditions. Specimens from Chippewa County agreed well with the typical description except for the basal regions of the processes which developed into single or bispinate projections. In accordance with the views of Smith (1924), and West, West and Carter (1923) above, they are retained here but should be compared with S. acestrophorum var. subgenuinum Gronbl. (Borge 1930).

Measurements: L. ssp. 21-22-36u; L. csp. (30)-35-65u; W. ssp. 18-25u; W. csp. 41-(43)-88u; I. 5-(8.5)-11u.

Distribution: SLP, Muskegon (Transeau 1917) and Ionia Wade (1949); NLP, Cheboygan (N & A 1932), Welch 1938a, 1938b); EUP, Chippewa.

121. var. parvum West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:106. Pl. 145, Fig. 6.

This variety differs from the typical in the smaller size.

Measurements: L. ssp. 9-16-(17)u; L. csp. 18-(33)-35u; W. 20-(32)-35u; I. 3.5-6-(7)u.

Distribution: EUP, Chippewa; Isle Royale (Prescott 1940).

122. var. longipes Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:103. Pl. 146, Figs. 2, 3.

This variety is distinguished from the typical by the small body of the semicell, and the longer and more graceful and often slightly curved processes.

Measurements: L. ssp. 26-29u; L. csp. 77-84u; W. ssp. 15-17u; W. csp. 84-139u; I. 8-9.5u.

Distribution: NLP, Cheboygan (Taft 1939).

123. Staurastrum polymorphum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:125. Pl. 142, Fig. 24; Pl. 143, Figs. 1-3.

This somewhat variable species has semicells which may be either subelliptical, subfusiform or subcuneate. The processes are fairly short and robust and are horizontal or slightly convergent. In addition, they are ornamented with 3-4 concentric series of granules and terminated by 3-4 short spines. In vertical view, the

semicells are 3-7 angular with the processes often of different number on the two semicells, and often alternating in different vertical planes. The apices are smooth in the center of the semicells. Many small specimens encountered during the study are assigned here, because of the variability of this species and because of the lack of good diagnostic features found in these specimens. Some of the specimens are somewhat larger than typical.

Measurements: L. 17-21-(26)-30-(34)-36u; W. 21-(21)-43-(44)-49u; I. (4)-5.5-(9)-10-(10.5)u.

Distribution: SLP, Calhoun, Washtenaw, Ingham, Livingston, Barry (2), also Wayne (Campbell 1886), Macomb (Pieters 1894) and Kalamazoo (N & A 1932); NLP, Roscommon, Crawford, also Cheboygan (N & A 1932 and Neel 1948); EUP, Mackinac; WUP, Gogebic (2), Houghton.

124. Staurastrum inflexum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:108. Pl. 143, Figs. 7, 8.

This somewhat variable, small species, has fusiform semicells with slender, slightly attenuated and convergent processes ornamented with several concentric series of denticulations and terminated by 2-3 small spines. The vertical view of the semicells is triangular with the denticulate processes often slightly twisted or the semicells twisted at the isthmus so that the processes of the

two semicells alternate. The lateral margins are concave and the apices often have an intramarginal linear series of granules.

Measurements: L. (17)-19-(19)-(21)-26-(28)u; W. ssp. 10.5u; W. csp. 30-(32)-(35)-(36)-(37)-40u; I. 4.5-(6.5)-(8)-8u.

Distribution: SLP, Barry, Calhoun, Oakland; NLP, Cheboygan (N & A 1932); EUP, Alger, Mackinac, Schoolcraft; WUP, Marquette, Gogebic.

125. Staurastrum crenulatum (Naeg.) Delp.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:110. Pl. 143, Figs. 9-13.

This small, somewhat variable species has broadly oval or subfusiform semicells with parallel or slightly convergent processes of variable length. The processes are undulate, denticulate and often become emarginate near the bases. The vertical view is 3-5 angular with usually two pairs of emarginate granules just within the concave lateral margin.

Measurements: L. 20-28-(32)-u; W. 20-(25)-33u; I. 5-8-(10)u.

Distribution: SLP, Ingham also Macomb (Pieters 1894); WUP, Houghton, Gogebic; Isle Royale (Prescott 1940).

126. var. britannicum Messikommer Pl. 29, Fig. 2.

Messikommer, 1927. Inaugr. Disser.:107. Pl. 5, Fig. 8; Pl. 6, Figs. 1, 2.

A few specimens from Barry County are assigned here questionably. Typically, this variety is 3-5 radiate with well developed processes which are ornamented with several concentric series of granules and terminated by three small spines. The apices are ornamented by a pair of emarginate verrucae placed intramarginally between the bases of the processes. Irénee-Marie (1938), illustrates a similar organism identified as S. crenulatum (Naeg.) Delp. The five-radiate Michigan specimens differ only in the presence of three intramarginal granules between the bases of each pair of processes.

Measurements: 17.5-28u; W. 22.5-33-(34)u; I. 6-8u.

Distribution: SLP, Barry. New record for Michigan.

127. Staurastrum margaritaceum (Ehrenb.) Menegh.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:131. Pl. 150, Figs. 5-9.

This species has variably shaped semicells, the usual expression being cyanthiform or subfusiform. The angles are projected into very short, truncate processes which may be either emarginate or ornamented with small granules at the apices. Small granules are arranged in concentric series around the processes and may occur in a transverse row around the base of the semicells. The vertical view is 3-9 angled with the central portion of the apices smooth. The lateral margins are concave. Sometimes the apical granules within the lateral margins are very well developed.

Measurements: L 24-(27.5)-35u; W. 24-(32)-48u; I. 6-10-(10.5)u.

Distribution: SLP, Berrien, Barry (2), also Ingham (N & A 1932) and Macomb (Pieters 1894); NLP, Roscommon, also Cheboygan (N & A 1932, Welch 1938a); EUP, Chippewa, Schoolcraft (3), also Schoolcraft (N & A 1932); WUP, Gogebic (3), Baraga (2); Isle Royale (Prescott (1937)).

128. var. robustum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:133. Pl. 150, Fig. 13.

This variety is somewhat more stout than the typical. In vertical view, there is an emarginate verruca on each side of the base of the process.

Measurements: L. 25.5u; W. 27u; I. 8u.

Distribution: Isle Royale (Prescott 1940).

129. Staurastrum protectum var. planctonicum G.M.Smith Pl.29, Fig. 3.

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):87. Pl. 74, Figs. 1-4.

This organism has broad, obversely triangular semicells with the angles continued into divergent processes of a short or medium length. Each process is tipped with two stout divergent spines, and ornamented with concentric series of granules. The apices have tridenticulate verrucae. The vertical view is triangular with concave lateral margins. The central portion of the apex has a circle of about five tridenticulate verrucae. The pro-

cesses on specimens from Calhoun County are shorter and somewhat less divergent than those illustrated by Smith (1924a).

Measurements: L. ssp. 23-31u; L. csp. 32-(34)-39u; W. ssp. 28-35u; W. csp. 40-(43)-57u; I. 6-9u.

Distribution: SLP, Calhoun. New record for Michigan.

130. Staurastrum proboscideum (Bréb.) Arch.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:129. Pl. 143, Figs. 14-16.

The semicells of this species are transversely subelliptic or subcuneate. The processes are short and stout, truncate, parallel or slightly convergent and terminated by a ring of small granules. In addition, there are several concentric rings of granules around each process as well as a single transverse row around the base of the semicells. The vertical view is triangular (sometimes quadrangular) with concave lateral margins and short, stout, truncate processes. The processes have several concentric rings of granules and the apical portion of the semicell body has two lateral series of granules along each lateral margin, the innermost often being composed of emarginate verrucae.

Measurements: L. 35-(43)-45u; W. 30-43-53u; I. 10-(11.5)-15u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Delta.

131. var. ornatum var. nov. Pl. 29, Fig. 6.

This organism differs from the typical in the pos-

session of well-developed linear series of verrucae along the lateral margin between the processes. Specimens from Gogebic County lacked the transverse row of granules around the base of the semicells found in the typical. An apparently somewhat reduced form was collected from Marquette County. In this latter expression, the organism has the transverse row of granules across the base of the semicell and the processes and cell are somewhat shorter.

Measurements: L. 29-36u; W. 32-42u; I. 10.5-12.5u.

Distribution: EUP, Gogebic, Marquette.

132. Staurastrum Sebaldii Reinsch

West, West and Carter, 1923. Monogr. Brit. Desm. 5:166. Pl. 148, Figs. 5, 6.

The cyathiform semicells of this species have short, stout converging processes which are ornamented by concentric series of denticulations and terminated by three or four spines. The convex apical margins possess a row of large simple or bifid-quadrifid spines. In addition, there may be a subapical row of similar structures along the lateral margin between the processes. The vertical view is triangular with straight or slightly convex lateral margins and short denticulate processes. A linear series of large spines is located within the lateral margin, and sometimes a secondary row will be found upon the margin itself.

Measurements: L. 50-85u; W. 55-100u; I. 17-24u.

Distribution: SLP, Kalamazoo (N & A 1932); NLP, Cheboygan (N & A 1932); WUP, Iron, Menominee.

133. var. ornatum Nordst. Pl. 29, Fig. 5.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:167. Pl. 148, Fig. 7.

This variety has longer processes than the typical. There also may be a group of verrucae on the lateral margin just below the base of the processes and a transverse row of granules or short spines across the base of the semicells.

Measurements: L. 50-(52)-(60)-81u; W. (60)-(68)-88-132u; I. 15-(17)-(18)-22u.

Distribution: SLP, Oakland; NLP, Emmet. New records for Michigan.

134. Staurastrum pseudosebaldii Wille

West, West and Carter, 1923. Monogr. Brit. Desm. 5:133. Pl. 146, Fig. 4.

This species has cyathiform semicells with stout, horizontal or convergent processes which are terminated by 3-4 spines. The granulation occurs in concentric series around the processes and in a single transverse row along the base of the semicells. The vertical view is triangular with concave lateral margins. The ornamentation consists of two linear series of bifid spines, one within and one upon the lateral margins.

Specimens from Oakland County are smaller than typical but have the characteristic bifurcate apical spines. The measurements are close to var. simplicius, West which lacks the bifurcate spines.

Measurements: L. (32)-43-55u; W. (43)-60-65u; I. (9)-9-13u.

Distribution: SLP, Oakland, Barry; EUP, Alger; Isle Royale (Prescott 1940).

135. Staurastrum rugosum Irénee-Marie Pl. 29, Fig. 7.

Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont. :311. Pl. 59, Figs. 4, 5.

The elliptic angular semicells have short processes which are trifid at the apices. The granulation is in concentric series around the processes. The vertical view is triangular, with slightly concave lateral margins and with a central ring of 10-12 large granules which may be emarginate or spinous. A few specimens from Oakland County resemble this species and are questionably assigned here because the apical ornamentation consisted of an outer linear series of 3-4 granules, and an inner series of four granules within each lateral margin.

Measurements: L. 35-36u; W. ssp. 35-40u; W. csp. 45-50u; I. 13-15u.

Distribution: SLP, Oakland. New record for Michigan.

136. Staurastrum vestitum Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:158. Pl. 151, Figs. 9-11; Pl. 162, Figs. 5, 6.

This characteristic species has subfusiform semicells with long parallel or somewhat divergent processes which are ornamented with several concentric rows of denticulations and terminated by three divergent spines. The lateral margin between the processes has either a linear series of simple spines in which the middle two are larger, or the series is reduced in number and only two granules or spines (bifurcate or simple) are present. The apices may be convex or straight with a crown of verrucae. The lateral view is triangular with concave lateral margins and denticulate processes. A linear series of verrucae which may be emarginate or spinous is present within each lateral margin and a secondary series (sometimes reduced to two) is present on the margin.

Measurements: L. 24-(38)-(43)-43u; W. 58-(64)-(74)-(87)-90u; I. 9-(10.5)-13-(14.5)u.

Distribution: SLP, Oakland, Barry (2), Calhoun, Barry; NLP, Cheboygan (N & A 1932, Welch 1936b); EUP, Chippewa (2); WUP, Gogebic (2).

137. var. tortum West

Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont.:326. Pl. 56, Figs. 4, 5.

This variety differs from the typical in possession of processes which are all curved in the same direction (in vertical view).

Measurements: L. 34-35u; W. 45-(59)-65u; I. 15-16u.

Distribution: SLP, Barry; NLP, Cheboygan(N & A 1932); EUP, Alger.

138. var. subanatinum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:159. Pl. 153, Fig. 5.

This variety has long and slightly divergent processes. The arrangement of the verrucae is similar to that of S. anatinum Cooke and Wills but the emarginate verrucae or spines on the lateral margins easily distinguishes it.

Measurements: L. 30-(32)-42u; W. ssp. 22-(30)-30u; W. csp. 60-66-72-102u; I. 10-(10.5)-(13)-13.5u.

Distribution: SLP, Calhoun, Barry; NLP, Cheboygan (N & A 1932); EUP, Schoolcraft.

139. var. semivestitum West fa. Pl. 30, Fig. 5.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:160. Pl. 152, Figs. 7, 8.

This variety is smaller than the typical and the processes in vertical view are sometimes twisted. Characteristically, the spines are much reduced with the entire dorsal series absent and the lateral series consisting of a single bifurcate spine on one side at the base of each process. Specimens from Chippewa County have the processes only slightly twisted and two bifurcate processes are present on each lateral margin.

Measurements: L. 20-(21.5)-28u; W. (28)-34-42.5u; I. 4-(6.5)-8u.

Distribution: EUP, Chippewa. New record for Michigan.

140. Staurastrum quebecense Irénée-Marie var. ornatum var. nov. Pl. 30, Fig. 2.

This organism very well might be related to many species, but is assigned here as a new variety for the reasons to be discussed below. The semicells of this variety as in the typical, are distinctly inflated at the bases, although the ornamentation in this region consists of three transverse rows of small granules or a single row of tridentate verrucae, rather than a single transverse row of large granules. A large sinus separates the basal inflation from the upper lateral margins which are continued into slightly attenuated processes which are terminated by short spines at their apices. The processes are ornamented by large spines along both margins, several spines near the base of the processes on the dorsal margin being replaced by small verrucae. The lateral margin between the processes bears two small granules or spines. The vertical view of the semicell is triangular with straight lateral margins (concave if considering the processes) that are ornamented with two minute spines or granules, and with the angles continued into long, undulate, marginal processes which are terminated by four spines at the apices. The apices possess a circle of emarginate verrucae composed of two pairs within each lateral margin. The base of the processes also has one or two pairs which are placed parallel with the process.

This organism should be compared with illustrations of one identified by Dick (1919) as S. gracile var. coronulatum Boldt. which differ greatly from the illustrations shown by West, West and Carter (1923), and with S. gracile var. splendidum Messikommer (Messikommer 1928). The Michigan specimens differ from the former in type of basal ornamentation, in the presence of the secondary apical verrucae on the dorsal base of the processes and in the presence of a pair of short spines or granules on the lateral margins between the processes (rather than tridentate verrucae). It differs from the latter (S. gracile var. splendidum) in the more pronounced basal inflation, in the basal ornamentation, in the secondary apical verrucae on the dorsal base of the processes and in the presence of a pair of short spines or granules on the lateral margins between the processes (rather than a pair of verrucae). S. pseudosebaldii var. gostyniense Racib. has both similar basal inflation and ornamentation, but the processes are markedly convergent, the lateral margins are verrucose and the apical ornamentation is different.

Measurements: L. 40-43u; W. csp. 49-55u; I. 10.5u.

Distribution: EUP, Alger, Delta.

141. Staurastrum aculeatum (Ehrenb.) Menegh.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:161. Pl. 153, Figs. 1-4.

The transversely subelliptical or subfusiform semicells of this species have the angles very slightly produced (sometimes scarcely at all) into processes which are ornamented with one or two series of denticulations and terminated by 3-4 sharp spines. The apical margin possesses a series of spines of which the middle few are often emarginate. In addition, the lateral margin possesses another series of spines between the angles. The vertical view is triangular or quadrangular with straight or slightly convex lateral margins and slightly produced processes which terminate in three or four spines. Ornamentation consists of a linear series of spines (the middle ones sometimes emarginate) within the margin and an additional series upon the lateral margin.

Measurements: L. 33-50-(52)u; W. csp. 38-(54)-60u; I. 12-16-(19)u.

Distribution: SLP, Washtenaw; NLP, Cheboygan (N & A 1932).

142. Staurastrum Cerastes Lund.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:141. Pl. 150, Fig. 16; Pl. 151, Fig. 1.

This very characteristic species cannot be easily confused with any other species of Staurastrum as yet reported from Michigan. The trapeziform-rectangular semicells have a strongly convex dorsal margin and strongly convergent processes. The apex has a row of

strongly developed verrucae which become reduced to conical verrucae when continuing upon the processes. In addition, there is a lateral row of simple verrucae upon the lateral margin, and also a transverse row of papillae or mucros upon the base of the semicells. The vertical view is triangular or quadrangular with concave and verrucose margins, and with an additional row of verrucae upon the lateral margin.

Measurements: L. 45-(54)-57u; W. 40-(66)-72u; I. 10-(13.5)-17.5u.

Distribution: SLP, Berrien; NLP, Cheboygan (N & A 1932); WUP, Gogebic.

143. Staurastrum longiradiatum West and West

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):90. Pl. 74, Figs. 5-11.

This species has campanulate semicells with cyathiform bases and with long, slightly attenuated, parallel or slightly convergent processes. The processes are crenulate upon both the upper and lower margins, but more shallow in the latter, and are terminated by four short, divergent spines. The vertical view is triangular with straight or slightly concave lateral margins and with long processes with undulate or crenulate margins which terminate in four short spines. The apices have two or three verrucae within each lateral margin.

Measurements: L. ssp. 41-49u; L. csp. 46-(89)-96u; W. ssp. 20-28u; W. csp. 73-(80)-108u; I. 8.5-(9)-10u.

Distribution: SLP, Barry; Isle Royale (Taylor 1935).

144. Staurastrum protractum (Wolle) Johnson

Johnson, 1895. Bull. Torr. Bot. Club. 22(7):295.

Pl. 2, Fig. 35.

This species has semicells (without processes) that are nearly rectangular. The base of the semicells is swollen and provided with two minute spines on the margin. The processes are short, ornamented by concentric series of denticulations and terminated by three spines. The vertical view is triangular with concave margins and the apices are ornamented with a circle of six bifid or trifid granular projections.

Measurements: L. 44u; W. 50-52u.

Distribution: SLP, Washtenaw (Johnson 1895).

145. Staurastrum elongatum Barker

West, West and Carter, 1923. Monogr. Brit. Desm. 5:156.

Pl. 151, Figs. 2-5.

This very characteristic species has cells that are about six times longer than broad (without processes). The semicells are cyathiform with inflated bases that are ornamented with three or four transverse rows of granules. The apex which is truncate in the middle is ornamented with several emarginate verrucae. The processes which are short and usually parallel, are ornamented by three concentric series of sharp denticulations and terminated by three small spines. The vertical view

is triangular with concave bi-verrucose lateral margins and short, stout processes. There are two additional verrucae within each lateral margin.

Measurements: L. (58)-60-77u; W. ssp. 14-15u; W. csp. 40-(43)-48u; I. 7.5-(8.5)-9u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Chippewa.

146. Staurastrum anatinum Cooke and Wills

West, West and Carter, 1923. Monogr. Brit. Desm. 5:142. Pl. 146, Fig. 7; Pl. 142, Fig. 1.

This species has broad cyathiform semicells with long, slightly attenuated, subparallel or divergent processes which are ornamented with several concentric series of denticulations and terminated by 2-3 divergent spines. The body ornamentation consists of an apical row of 6-7 emarginate verrucae and of a subapical row of similar verrucae. The vertical view is triangular with slightly concave to slightly convex lateral margins which are verrucose. The apices are smooth except for a linear series of verrucae within each lateral margin.

Measurements: L. ssp. 33-46u; L. csp. 50-65u; W. ssp. 40u; W. csp. 80-113u; I. 10-15.5u.

Distribution: NLP, Cheboygan (N & A 1932).

147. var. longibrachiatum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:146. Pl. 147, Fig. 5.

This variety lacks the subapical row of verrucae and

possesses much longer processes than the typical.

Measurements: L. ssp. 30-37u; L. csp. 37-80u; W. ssp. 28-37u; W. csp. 68-131u; I. 10.5-12u.

Distribution: NLP, Cheboygan (N & A 1932).

148. var. truncatum West Pl. 30, Fig. 1.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:145. Pl. 146, Fig. 8.

The semicells of this variety are more elliptical than the typical and the processes are inserted lower on the semicells and appear to arise rather abruptly.

Measurements: L. 50-(60)-68u; W. 75-(80)-100u; I. 15-(16)-20u.

Distribution: EUP, Schoolcraft. New record for Michigan.

149.. Staurastrum floriferum West and West. Pl. 31, Fig. 1.

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):91. Pl. 74, Figs. 12-18.

This species has obversely trapeziform semicells with long, parallel or divergent processes. The processes are tipped with three sharp divergent spines and the margins of the processes are ornamented with short spines. The apices have a row of emarginate verrucae. The vertical view is triangular with slightly concave lateral margins (without processes) and with two emarginate verrucae within each lateral margin.

Measurements: L. ssp. 22-26u; L. csp. 23-(38)-44-(52)u; W. ssp. 19-26u; W. csp. 52-(62)-(68)-(75)-86u; I. 6.5-8u.

Distribution: SLP, Barry, Oakland; NLP, Presque Isle. New record for Michigan.

150. Staurastrum boreale West and West Pl. 30, Fig. 3.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:112. Pl. 146, Fig. 5.

This species has cup-shaped semicells with long, slightly divergent processes which are ornamented with several concentric series of denticulations and terminated by three spines. The bases of the semicell have a transverse row of sharp granules, and the apices have a row of emarginate granules. The semicells are triangular in vertical view, with a single series of three granules and further within three emarginate, submarginal verrucae. Measurements: L. 27-31-(32)u; W. 43-46-(52)u; I. 7-8-9u. Distribution: EUP, Schoolcraft. New record for Michigan.

151. Staurastrum Manfeldtii Delp.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:114. Pl. 148, Fig. 2.

This species has subcuneate to cyathiform semicells with long parallel processes which are ornamented with several concentric series of denticulations and terminated by three small spines. The apices have a row of emarginate verrucae, and the body of the semicells may be irregularly covered with denticulations or have small groups of minute granules irregularly scattered or forming a band around the base of the semicells. The vertical

view is triangular with a linear series of emarginate verrucae just within the straight or slightly convex lateral margins.

Measurements: L. 42-57u; W. 55-100u; I. 9-13u.

Distribution: NLP, Cheboygan (N & A 1932).

152. Staurastrum gracile Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:96. Pl. 144, Figs. 3-7.

The concept of this species' characteristics is somewhat variable. Carter (West, West and Carter 1923) who monographed the genus Staurastrum with the use of the Wests critical notes and drawings, states that the processes are either horizontal or sometimes slightly convergent, and that this feature distinguishes this species from S. paradoxum Meyen. However, Smith (1924), after examining the original collection of the Wests, believes that the two species cannot be separated on the basis of the length and divergence of the processes, and notes that the presence of a linear series of paired granules (apical verrucae) within the lateral margin in end view, is the only characteristic which aptly separates them. The writer follows Smith in this matter. The semicells are broadly triangular to cyathiform, with the apices possessing a row of small emarginate verrucae. The processes may be parallel or divergent, and are ornamented with concentric series of granules, and terminated by

three or four small spines. The vertical view is triangular with slightly concave lateral margins, and with linear or intramarginal pairs of granules (sometimes with additional single row of granules between the lateral margin and the paired granules).

Measurements: L. 27-107u; W. 44-(45)-118u; I. 5.5-11u.

Distribution: SLP, Wayne (Campbell 1886), Macomb (Pieters 1894), Washtenaw (West and West 1898), Kent (N & A 1932) and Ionia (Wade 1949); NLP, Roscommon, also Cheboygan (N & A 1932)(Welch 1936a); EUP, Alger; WUP, Gogebic.

153. var. coronulatum Boldt. Pl. 30, Fig. 4.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:100. Pl. 144, Fig. 10.

This variety is often smaller than the typical, and possesses shorter processes. The apex has two emarginate verrucae on each side of the process. The vertical view is triangular or quadrangular with two emarginate verrucae within each lateral margin.

Measurements: L. 21-(33)-36u; W. 32.5-(42)-43u; I. 6-(9)-11u.

Distribution: EUP, Chippewa. New record for Michigan.

154. var. nanum Wille

West, West and Carter, 1923. Monogr. Brit. Desm. 5:100. Pl. 144, Figs. 8, 9.

This variety is separated from the typical on the basis of the smaller size. The apical view is 3-5 angu-

lar. Specimens from Emmet County appear identical with this variety except for a single transverse row of granules at the base of the semicell.

Measurements: L. 14-(24)-27.5u; W. 23-(32)-36u; I. 4-(8.5)-8.7u.

Distribution: NLP, Emmet, also Cheboygan (N & A 1932); Isle Royale (Prescott 1937).

155. Staurastrum gyrans Johnson Pl. 31, Fig. 2.

Johnson, 1894. Bull. Torr. Bot. Club. 21(7):290. Pl. 211, Fig. 4.

This species has cyathiform semicells with long, undulate, convergent processes which are ornamented with a median series of spines and terminated by three short spines. The vertical view is pentagonal with a single straight horizontal spine at the base of each of the processes. These spines are always on the same side (right in vertical view) of the processes. The apices usually have a single large verrucae or granule between the bases of the processes.

Measurements: L. 20-(23)-26u; W. ssp. 12-15u; W. csp. 40-(48)-50u; I. 10.5-(10.5)-11.5u.

Distribution: SLP, Barry. New record for Michigan.

156. Staurastrum distentum Wolle var. Michiganensis var. nov.

Pl. 31, Figs. 3, 4.

This 5-radiate organism compares favorably with S. distentum Wolle. However, the Michigan specimens have

a median linear row of small denticulations on the dorsal margins, the processes are less distended at their apices which are quadrifid, and the sinus between the bases of the processes (in vertical view) is larger and not linear. The processes in Wolle's organism have an acutely pointed basal inflation, whereas the Michigan specimens have a distinct bifid secondary process on each side of the base of the semicell. This variety should be compared with S. pinnatum var. subpinnatum West and West from which it differs in the lack of both the apical ornamentation and the transverse row of granules at the base of the semicells. It also resembles S. ornatum var. asperum (Perty) Schmidle, but this organism also has apical ornamentation and a transverse row of granules across the base of the semicells. The writer was fortunate to procure this variety in zygospore formation. The zygospores are spherical and covered by long, slender spines which are slightly bifurcated at their apices.

Measurements: L.23.7u; W. csp. 38.7u; I. 8.6u;
Zygospore: ssp. 23.6u; csp. 43u.

Distribution: SLP, Barry.

157. Staurastrum incisum Wolle

Wolle, 1892. Desm. of U. S.:146. Pl. 52, Figs. 12-14

This species (in vertical view) has 5-6-angled semicells with processes (which are toothed on the margins)

that are separated at their broad bases by an acute-angled or linear incision.

Measurements: Diameter 36-40u.

Distribution: Washtenaw (Johnson, 1894, West and West, 1898) and Macomb (Pieters, 1894).

158. Staurastrum pentacerum (Wolle) Smith

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):112. Pl. 80, Figs. 15-18.

This very characteristic species has trapeziform-quadrate semicells with subparallel, slightly attenuated processes which are crenulate upon the upper margin and which are terminated by three short spines. The apex bears a row of subapical verrucae. The vertical view is pentagonal (rarely hexagonal) with the processes of one semicell alternating with those of the other semicell, and with a large verrucae between the bases of each pair of processes (sometimes with a single smaller verrucae on each side of the major verrucae).

Measurements: L. 36-45u; W. ssp. 18-20u; W. csp. 82-105u; I. 10-13u.

Distribution: SLP, Calhoun; NLP, Cheboygan (Taft 1939); WUP, Gogebic (2); Isle Royale (Prescott 1940).

159. Staurastrum rotula Nordst.

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):116. Pl. 81, Figs. 5-8.

This species has subhexagonal semicells with long

processes arising about midway between the apex and the isthmus. The processes are ornamented by three or four concentric series of granules, and terminated by three short spines. The vertical view is 8- or 9-radiate with a single large granule or emarginate verruca at the base of each process.

Measurements: L. 40-(46.5)-48u; W. ssp. 22-30u; W. csp. 58-70-105u; I. 10.5-17u.

Distribution: SLP, Barry; NLP, Cheboygan (Taft 1939); EUP, Schoolcraft; Isle Royale (Prescott 1940).

160. Staurastrum ankyroides var. pentacladum G. M. Smith

Pl. 32, Fig. 1.

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):114. Pl. 81, Figs. 1, 2.

This species has cylindrical semicells in which the upper portion is projected into long convergent processes which are crenulate upon the margins, verrucose in the middle (especially near the base) and terminated by several small spines. The vertical view is five-angled with a semicircular verruca between the bases of the processes. The processes have lateral bifid verrucae near the bases and simple spines near the trispinate apices.

Measurements: L. 60-(60)-68u; W. ssp. 22-28u; W. csp. 96-(107)-150u; I. (13.5)-14u.

Distribution: SLP, Barry. New record for Michigan.

161. Staurastrum Arachne Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:151. Pl. 150, Fig. 1.

This species has broadly campanulate semicells with long convergent processes which are ornamented with concentric rings of granules and terminated by three small spines. The vertical view is five or six radiate with a few scattered granules or only a pair, between the bases of the processes.

Measurements: L. (24)-26-42u; W. ssp. 14-18u; W. csp. 40-(43.6)-65u; I. 7.5-(11)-16u.

Distribution: SLP, Barry (2), Calhoun, Berrien, Livingston; NLP, Crawford, also Cheboygan (N & A 1932); WUP, Gogebic; Isle Royale (Prescott 1937, 1940, var.).

162. Staurastrum Ophiura Lund.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:158. Pl. 153, Figs. 1, 2.

This large species cannot be confused with any other species of this genus reported from Michigan. The cyathiform semicells have long, convergent processes, a transverse row of stout, conical verrucae at the base of the semicell, and a row of apical verrucae. The semicells in vertical view are usually 7-rayed (rarely 8- or 6-) and possess two emarginate verrucae within the lateral margin between the processes in addition to a circle of bifid or conical verrucae.

Measurements: L. 47-(68)-91u; W. ssp. 34-46u; W. csp. 96-(125)-169u; I. 10.5-26u.

Distribution: SLP, Barry, Calhoun, Livingston; NLP, Cheboygan (Taft 1939), also Otsego (Taft 1939); EUP, Schoolcraft.

163. var. cambricum (Lund.) West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:154. Pl. 152, Figs. 3, 4.

This variety has relatively short processes and more convex apices.

Measurements: L. 75-80u; W. csp. 98-110u; I. 16-18.5u.

Distribution: Isle Royale (Prescott 1937).

164. Staurastrum arctiscon (Ehrenb.) Lund.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:193. Pl. 157, Fig. 5.

This large species with an accessory whorl of processes has subspherical semicells. In vertical view, the semicells are circular and possess nine straight marginal processes and six intramarginal processes. The only other species (reported as yet from Michigan) which is circular in transverse view and which has accessory processes is S. leptacanthum Nordst. This latter species possesses only four intramarginal accessory processes.

Measurements: L. ssp. 51-96u; L. csp. 90-(107)-155u; W. ssp. 40-68u; W. csp. 90-(107)-160u; I. 21-(30)-33u.

Distribution: SLP, Calhoun, also Muskegon (Transeau 1917)

and Macomb (Pieters 1894); NLP, Cheboygan (Welch 1938b); Isle Royale (Prescott 1940).

165. var. glabrum West and West

Smith, 1924. Bull, Wisc. Geo. and Nat. Hist. Surv. 57(2):125. Pl. 83, Fig. 15; Pl. 84, Figs. 3-5.

This variety is separated from the typical by the lack of granules on the processes. Intermediates between this variety and the typical have been reported by Smith (1924) and Irénee-Marie (1938).

Measurements: L. ssp. 60-65u; L. csp. 105-127u; W. ssp. 40-50u; W. csp. 101-115u; I. 21-26u.

Distribution: SLP, Oakland; NLP, Presque Isle; Isle Royale (Taylor 1935).

166. Staurastrum leptacanthum Nordst.

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):123. Pl. 83, Figs. 12-14.

In vertical view, this species is circular and possesses six marginal processes and four intramarginal processes. In front view, the semicells are subcircular to subhexagonal with a lower whorl of six processes arising midway between the isthmus and the apex, and an upper whorl of four processes arising at the apex. The processes are without ornamentation and bifurcate at the apices.

Measurements: L. ssp. 24-48u; L. csp. 44-(68)-110u; W. ssp. 20-28u; W. csp. (52)-54-114u; I. 11-(13)-14u.

Distribution: SLP, Livingston (N & A 1932); NLP, Cheboygan (Welch 1938b); EUP, Schoolcraft.

167. Staurastrum senarium (Ehrenb.) Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:176. Pl. 166, Fig. 3.

This species has elliptic to subfusiform semicells with nine lower whorl processes and six upper whorl processes. The smooth processes are bifid at their apices. In vertical view, the semicells are triangular with lower whorl processes appearing at each angle. There is also an additional lower whorl process on each side of the angle. The six intramarginal upper whorl processes are arranged singly on each side of the angle. Nichols and Ackley (1932) report S. Hantzchii Reinsch from Cheboygan County. The writer believes, after an examination of the original description and original figures, that this species cannot be separated from S. senarium. A specimen illustrated by Irenee-Marie (1938), and identified as S. tohopekaligense var. nonanum Turner, agrees well with the Michigan specimens, but Smith (1924) after examining collections from England, the East Indies and Africa, states that the var. nonanum is synonomous with var. trifurcatum West and West.

Measurements: L. csp. 42-46-48u; W. csp. (38)-46-58u; I. 11-(12)-15u.

Distribution: NLP, Cheboygan (N & A 1932, S. Hantzschii Reinsch); EUP, Schoolcraft.

168. Staurastrum gemelliparum Nordst. Pl. 33, Fig. 3.
West, West and Carter, 1923. Monogr. Brit. Desm. 5:177. Pl. 156, Fig. 5.

This species has subelliptical semicells with two short processes at each basal and apical angle. The processes are bifid, the short spines being in the same vertical plane. In vertical view, the semicells are triangular with each angle being truncate and bearing four processes, the lower pair of processes being visible under the upper pair.

Measurements: L. ssp. 17-25u; L. csp. 26-30-(33)u; W. csp. 20-26-(27)u; I. (5)-7.7-10u.

Distribution: SLP, Oakland, Barry. New records for Michigan.

169. Staurastrum furcatum (Ehrenb.) Bréb.
West, West and Carter, 1923. Monogr. Brit. Desm. 5:175. Pl. 155, Figs. 1-4.

This species is characterized by transversely elliptical-hexagonal semicells with three lower processes arising midway between the isthmus and the apex and six upper processes which are subapically inserted. The vertical view is triangular, with straight lateral margins and very short processes that merge gradually with the body of the semicells. Two intramarginal processes, one near each angle of the cell, arise from each side of the semicell. S. tohopekaligense Wolle has the same number

and arrangement of processes but the semicells are broadly oval to subglobose, the processes are much longer and the size of the semicells is much larger. Measurements: L. ssp. 20-(25)-30u; L. csp. 25-(39)-47u; W. ssp. 14-(21.5)-22u; W. csp. 20-(32)-40u; I. 6-(10.5)-11.5u.

Distribution: NLP, Cheboygan (N & A 1932); EUP, Chippewa (2), also Chippewa (N & A 1932); WUP, Gogebic.

170. var. Taylorii var. nov. Pl. 34, Fig. 1.

This variety is distinguished from the typical by the presence of very short lateral processes which are terminated by a very stout (bifurcate near tip) spine. Another distinctive characteristic is the insertion of two stout simple spines on the lateral margin between the processes, each spine being in the same vertical plane as the apical process. This organism is closely related to an un-named variety reported by Taylor (1935) in which some of the lateral processes are hollow throughout, and others are similar to the Michigan specimens wherein the process has become solidified into a stout spine. Taylor's variety also has a single spine on the periphery of the lateral margin, whereas the Michigan specimens have two on the lateral margin as described above. This variety should be compared with S. forficulatum subheteropol fa. simplex Gronblad (1920) and S. forficulatum var. subheterophorum Gronblad (1921) from

which it differs in the lack of body ornamentation except the spines, and the possession of distinct apical processes rather than spines.

Measurements: L. ssp. 33u; L. csp. 47u; W. ssp. 34u; W. csp. 57u; I. 8u.

Distribution: EUP, Chippewa.

171. fa. spinosa Gronblad Pl. 34, Fig. 2.

Gronblad, 1920. Acta. Soc. pro. Faun et Flor. Fenn. 47(1): Pl. 1, Figs. 31, 32, 37.

This form has very short processes which are bifurcate at their apices. Specimens from Gogebic and Houghton Counties resembe this form and also S. furcatum var. aculeatum Schmidle (1895). The general shape of the cells of both organisms are the same, but the bifurcate nature of the short processes necessitates placing them here. The processes, although bifid, were acutely pointed in some specimens, thus resembling the variety aculeatum. Irenee-Marie (1938), illustrates an organism identified as S. aciculiferum which is very similar to the Michigan specimens but which has few granules at the lateral angles.

Measurements: L. ssp. 21.5u; L. csp. 25-27u; W. ssp. 21.5u; W. csp. 25-27u; I. 6.5-10.5u.

Distribution: WUP, Gogebic, Houghton. New records for Michigan.

172. var. pisciforme Turner Pl. 31, Fig. 5.

Irenee-Marie, 1938. Flor. Desm. de la Reg. Mont. 329. Pl. 55, Figs. 9, 10.

This variety has granular ornamentation on the periphery of the lateral margins of the angles. The sinus is also less open than in the typical.

Measurements: L. ssp. 24-27-32u; L. csp. 32-(38)-40u; W. ssp. 24-(27)-36u; W. csp. 34-(42)-48u; I. 8-9-10.5u.

Distribution: EUP, Alger. New record for Michigan.

173. Staurastrum arcuatum Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:180. Pl. 155, Fig. 8.

This species has fusiform semicells in which the ventral margins, which are concave, and the dorsal margins, which are almost straight, are projected into short processes which terminate in two stout diverging spines. Granules are arranged in concentric series around the processes. The vertical view is triangular with concave lateral margins and sharp angles. A pair of bifid intramarginal projections are placed at each angle, one on each side of the terminal spines.

Measurements: L. ssp. 20-24u; L. csp. 32-36u; W. ssp. 26-28u; W. csp. 32-49u; I. 6.5-12u.

Distribution: Isle Royale (Prescott 1937).

174. var. pseudopisciforme fa. Irénee-Marie nob. Pl. 33, Fig.2.

Staurastrum pseudopisciforme Irenee-Marie non Eichl.&Racib. 1938 Flor. Desm. de la Reg. Mont.:330. Pl. 55, Fig. 11.

Staurastrum pseudopisciforme Eichl. and Racib. has been assigned as a variety of S. arcuatum Nordst. Thus

Irénee-Marie's (1938) report of an organism identified as S. pseudopisciforme must be considered as a variety of S. arcuatum. However, an examination of the original illustration of Eichl. and Racib. (1893) reveals an entirely different plant than the one shown by Irénee-Marie. The original figures have long, narrow, divergent lower whorl processes which are terminated by two stout, divergent spines. The bases of the processes have a few granules. In the upper whorl, the processes are bispinate. Specimens from Schoolcraft County are very similar to those illustrated by Irenee-Marie (1938). The processes are very slightly projected, only very slightly divergent and ornamented with three concentric series of granules. The apical whorl processes are 3-6 spinate with the spines being small. The writer believes that these two organisms are sufficiently the same and that they should be united under a new form name.

Measurements: L. ssp. 27-30u; L. csp. 34-(36)-42u; W. ssp. 25-30u; W. 34-40-(42)u; I. 8-(10.5)-117.

Distribution: EUP, Schoolcraft.

175. Staurastrum forficulatum Lund.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:187. Pl. 154, Figs. 14-16.

This species has subtrapeziform to subelliptical semicells with two emarginate spines or short bifid processes on the apices. The lateral margins each have a

short, stout process terminating in two sharply divergent spines. In vertical view, the semicells are triangular or quadrangular with short processes terminating in short spines and concave lateral margins. Each side has two spines or processes upon each margin and two spines or porcesses within each margin.

Measurements: L. ssp. 40-45u; L. csp. 48-64u; W. ssp. 37-60u; W. csp. 54-95u; I. 9-16u.

Distribution: NLP, Cheboygan (N & A 1932).

176. var. cornutiforme var. nov. Pl. 33, Fig. 1.

This organism, while closely related to S. forficulatum Lund., and varieties of this species, possesses a pattern of apical verrucae which is suggestive of S. cornutum Archer. In front view, the elliptical semicells are similar to the former. Also confirming the close relationship of this organism to S. forficulatum (as seen in vertical view) is the insertion on each lateral margin of a single spine or projection on each side of the angle. Two bifurcate processes are also placed within each lateral margin. The intramarginal linear rows of emarginate granules or verrucae within the bifurcate projections, however, is suggestive of S. cornutum, especially those specimens illustrated by Gronblad (1920).

Measurements: L. 48u; W. ssp. 44u; W. csp. 67u.

Distribution: NLP, Crawford.

177. Staurastrum tohopekaligense Wolle

West, West and Carter, 1923. Monogr. Brit. Desm. 5:178. Pl. 155, Fig. 12.

This species had broadly oval to subglose semicells with three lower parallel processes and six upper divergent processes. In vertical view, the triangular semicell has each angle projected into long processes which have two or three hollow spines at the apices. Two intramarginal accessory processes, one near each angle, arise from each side of the semicell. The different semicell shape and the longer processes separate this species from S. furcatum (Ehrenb.) Breb.

Measurements: L. ssp. 29-51u; L. csp. 48-91u; W. ssp. 23-28-40u; W. csp. 50-96u; I. 13-19u.

Distribution: Isle Royale (Prescott 1940).

178. var. brevispinum G. M. Smith Pl. 33, Fig. 4.

Smith, 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):121. Pl. 82, Figs. 8-11.

This variety is distinguished from the typical by the shorter processes and the much shorter spines terminating the processes.

Measurements: L. ssp. 26-(30)-32u; L. csp. (43)-46-53u; W. ssp. (21.8)-24-25u; W. csp. (34)-37-50u; I. 11-(13)-15u.

Distribution: NLP, Roscommon, Emmet; EUP, Schoolcraft. New records for Michigan.

179. Staurastrum furcigerum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:189. Pl. 156, Figs. 7, 8, 11.

This species has elliptic-hexagonal semicells with

two whorls of processes. The three processes in each whorl all have concentric series of granules. The vertical view is triangular with short truncate processes which are ornamented with several concentric series of granules. An additional intramarginal process is present at each angle.

Measurements: L. ssp. 30-48u; L. csp. 50-(55)-72u; W. ssp. 22-40u; W. csp. 45-(50)-80u; I. 12.5-(15)-19u.

Distribution: SLP, Barry, Washtenaw, Jackson also Macomb (Pieters 1894); NLP, Cheboygan (N & A 1932); EUP, Alger, Schoolcraft, also Delta, Manistique (N & A 1932); WUP, Iron; Isle Royale (Prescott 1937, 1940).

180. var. armigera (Bréb.) Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:191. Pl. 146, Fig. 10.

This form is separated from the typical by the longer processes which are crenulate-undulate rather than denticulate, and by the six processes in the upper whorl.

Measurements: L. ssp. 31-45u; L. csp. 49-80u; W. ssp. 25-35u; W. csp. 52-70u; I. 10-15u.

Distribution: NLP, Cheboygan (N & A 1932); WUP, Marquette.

181. fa. eustephana (Ehr.) Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:190. Pl. 157, Fig. 1.

This form has the six upper whorl processes as in

var. armigera, but they are ornamented with concentric series of granules as in the typical.

Measurements: L. ssp. 32-40u; L. csp. 40-(42)-58u; W. ssp. 28-30u; W. csp. 46-(56)-56u; I. 12-16u.

Distribution: SLP, Wayne (Campbell 1886); NLP, Crawford, also Cheboygan (N & A 1932); EUP, Schoolcraft, Delta, Alger; WUP, Menominee.

182. Staurastrum monticulosum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:183. Pl. 154, Fig. 8.

This species has subtrapeziform semicells with two whorls of processes. The six short conical processes in the upper whorl are not ornamented with concentric rings of granules and possess only single spines. The processes of the lower whorl are short and stout, ornamented with concentric rows of granules, and bear two divergent spines. The vertical view is triangular with straight or very slightly convex lateral margins. Two short intramarginal projections with simple spines occur at each angle which is bispinate (one spine above the other).

Measurements: L. csp. 40-57u; W. csp. 35-42u; I. 13-19u.

Distribution: WUP, Marquette. (Pres. and Mag. 1935).

183. var. bifarium Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:184. Pl. 154, Fig. 9.

This variety is separated from the typical by emar-

ginate apical processes and by the possession of bifid projections along the middle of the lateral margins of the semicells. Specimens from Barry County lack this latter characteristic but have bifid apical processes.
Measurements: L. ssp. 29-37u; L. csp. (49)u; W. ssp. 30-34u; W. csp. (45)u; I. 10-13-(15)u.
Distribution: SLP, Barry; NLP, Cheboygan (N & A 1932).

184. Staurastrum bicoronatum Johnson Pl. 34. Fig. 3.
Johnson, 1894. Bull. Torr. Bot. Club. 21(7):290. Pl. 211, Fig. 9.

This species has subhexagonal semicells. The angles are prolonged into processes, each of which have triserrate margins and a trifid apex. The vertical view is triangular with each process possessing a pair of short, bifid secondary processes at the base. A pair of bifid verrucae are located inside each lateral margin. Specimens from Oakland and Calhoun Counties are slightly larger than typical measurements.
Measurements: L. 14-16-(18)u; W. 22-25-(32u; I. 6-(10)u.
Distribution: SLP, Calhoun, Oakland. New records for Michigan.

185. Staurastrum erasum fa. espinulosa Lund.
West and West, 1898. Jour. Linn. Soc. 33:312.
Lundell, 1871 Nov. Act. Soc. Scient. Upsal. Ser. 3, 8(2):62.

This writer has been unable to obtain the original

description of this organism because the journal is unavailable. Nor are there any references (known to the writer) made to this form in any publication, except by West and West (1898) who merely report its occurrence in Washtenaw County.

22. ONYCHONEMA Wallich 1860

Cells usually small and somewhat wider than long, united in filaments by two capitate asymmetrically disposed apical processes on each semicell overlapping the adjacent semicell, and often enclosed in a mucilaginous covering. Cells compressed, with a deep median constriction and narrow sinus. Semicells elliptic in front view, sometimes with a single, long, convergent spine on each lateral angle. Cell wall finely punctate, smooth or with transverse rows of granules or pores. Cells in vertical view fusiform-elliptic with apical processes alternately inserted and the poles rounded or with a single spine. Each semicell with a single axial, plate-like chloroplast with a single pyrenoid.

Zygospores spherical with simple short spines.

Key to Species of Onychonema

1. Lateral angles of the semicell with a sharp projection or spine . . . O. laeve

1. Lateral angles of the semicell broadly rounded and without spines O. filiforme

1. Onychonema laeve Nordst.

West and West and Carter, 1923. Monogr. Brit. Desm. 5:218. Pl. 160, Figs. 15, 16.

This species is characterized by the convergence of the lateral margins into a long horizontally projecting spine.

Measurements: L. 16-(17)-17u; W. ssp. (20)-20.5-(24)-(25u; W. csp. (24)-25-(29)-46; I. 3.5-6.

Distribution: SLP, Calhoun, Oakland, Jackson; NLP, Cheboygan (N & A 1932).

2. var. micracanthum Nordst.

Irénee-Marie, 1938. Flor. Desm. de la Reg. Mont.:345. Pl. 61, Figs. 4-6.

This variety has the lateral margins of the semicells converging to a sharp point or a very short projection. The writer has observed filaments in which some cells had very reduced spines and other cells had much longer spines, thus indicating intermediate forms between the typical and this variety.

Measurements: L. 15-(15.2)-16u; W. ssp. 16-19-21u; W. csp. 20-(23.5)-26u; I. 3.5-(4)-4u.

Distribution: SLP, Barry, also Macomb (Johnson 1894 and Pieters 1894); NLP, Cheboygan (N & A 1932).

3. var. latum West and West Pl. 35. Fig. 4.

Smith, 1924. Bull. Wids. Geo. and Nat. Hist. 57(2):136. Pl. 86, Fig. 16.

This variety has a truncate elevation at the mid-region of the apical margin.

Measurements: W. sp. (13)-15.5-20u; W. cp. 20-29u; W. ssp. 15-(17)-28.5u; W. csp. (22)-23-36.5u; I. 3.8-6u.

Distribution: SLP, Calhoun; WUP, Gogebic, Houghton.

New record for Michigan.

4. Onychonema filiforme (Ehrenb.) Roy and Biss.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:216. Pl. 160, Figs. 13-14.

This species has semicells with rounded lateral margins without spines.

Measurements: L. sp. 8.5-(10.9)-13.5u; L. cp. 92-(15)-18u; W. 8.5-(13)-17u; I. 3.5-(5)-5.6u.

Distribution: SLP, Barry, Calhoun, Livingston, Oakland, also Kalamazoo (N & A 1932); NLP, Cheboygan (N & A 1932); EUP, Alger, Schoolcraft; WUP, Iron, Marquette, Menominee, Gogebic.

23. SPHAEROZOSMA Corda 1834

Cells generally small, often slightly wider than long, compressed, moderately constricted, with a linear, narrow or open sinus, united into filaments by apical processes or granules that are inserted on opposite sides of the semicells. Semicells in front view elliptic to oblong with lateral margins granulate or smooth. Semicells in transverse view elliptic. Cell wall smooth, punctate or granulate. Chloroplast axial, one with a single pyrenoid in each cell.

Zygospore variable, spherical to subrectangular; walls smooth or with simple spines.

Key to Species of Sphaerozosma

1. Cells joined together with interlocking elongate apical processes. 2

1. Cells joined together with interlocking granules 3

2. Cell wall smooth or punctate . (3) S. vertebratum

2. Cell wall with two transverse rows of granules . . . . . (1) S. Aubertianum var. Archeri

3. Cells with smooth walls 4

3. Cells with some granules on wall . . (8) S. granulatum

4. Lateral margins of cells smooth . . . . . (2) S. exiguum

4. Lateral margins of cells granular . . . . . (6) S. excavatum

1. Sphaerozosma Aubertianum var. Archeri (Gutw.) West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:208. Pl. 159, Figs. 14-17.

The much wider than long, transversely elliptical semicells with the two transverse rows of granules on the cell wall and the long interlocking apical processes clearly distinguish this organism.

Measurements: L. sp. 12-20u; L. cp. 22-27u; W. 19-35u; I. 5.5-12u.

Distribution: Isle Royale (Taylor 1935).

2. Sphaerozosma exiguum Turner Pl. 35, Fig. 3.

Smith 1924. Bull. Wisc. Geo. and Nat. Hist. Surv. 57(2):138. Pl. 86, Fig. 21.

This species has transversely elliptic semicells, and a broad, fairly deep sinus. Granules are not present on the cell wall and upon the lateral margins.

Measurements: L. (10.5)-14u; W. (10.5)-12.5u; I. 6.5u.

Distribution: WUP, Gogebic. New record for Michigan.

3. Sphaerozosma vertebratum (Bréb.) Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:209. Pl. 159, Figs. 9, 10.

This species has long interlocking apical processes, transversely, narrowly oblong or reniform semicells and a smooth cell wall.

Measurements: L. 19u; W. 21-24u; I. 9-10u.

Distribution: NLP, Cheboygan (N & A 1932).

4. fa. minor West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:210. Pl. 159, Fig. 12.

This variety has slightly more depressed cells, a relatively wider isthmus and a smaller size than the typical.

Measurements: L. 8-10u; W. 12-14u; I. 7.5-8u.

Distribution: NLP, Chebpygan (N & A 1932).

5. var. punctulatum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:210. Pl. 160, Fig. 12.

This variety differs from the typical in the possession of punctate cell walls and more angular cells.

Measurements: L. 14-16u; W. 17.5-20u; I. 8-9.5u.

Distribution: NLP, Cheboygan (N & A 1932).

6. Sphaerozosma excavatum Ralfs.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:211. Pl. 160, Figs. 1-3.

This species has oblong elliptic semicells. The constriction is large, resulting in a large semicircular sinus. The cell wall is usually smooth although the lateral margins possess two to three granules. Occasionally there may be as few granules within the lateral margins.

Measurements: L. 7.5-14u; W. 7-12.5u; I. 3.5-7.5u.

Distribution: SLP, Oakland, also Muskegon (Transeau 1917); NLP, Emmet, also Cheboygan (N & A 1932).

7. var. subquadratum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:212. Pl. 160, Figs. 4, 5.

This variety differs from the typical in having relatively wider cells with a narrow and apically obtuse sinus and oblong semicells.

Measurements: 7.8-10u; W. 9-10u; I. 2.5-4u.

Distribution: NLP, Cheboygan (Taft 1939).

8. Sphaerozosma granulatum Roy and Biss.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:213. Pl. 160, Figs. 6, 7.

This species has elliptical semicells with rounded lateral angles, a semicircular sinus and three to five granules on the lateral margin. The cell wall also has at least a single granule within the margin.

Measurements: L. 8-10-(10.5)u; W. 8-(8.5)-10u; I. 3.4-(4.2)-5u.

Distribution: SLP, Calhoun, Barry; NLP, Crawford, also Cheboygan (N & A 1932); EUP, Chippewa, Alger, Schoolcraft; WUP, Gogebic.

24. SPONDYLOSIUM Bréb. 1844

Cells, of variable size, often small, of a variable length-width ratio, deeply constricted, united end to end into filaments which may be twisted and enclosed in a mucilaginous sheet. Semicells transversely elliptic, or oblong, or pyramidate with the poles truncately flattened, the apical margin sometimes concave, or in some, with the poles elevated and the apical margin convex, never with apical processes. Cell wall rarely with granules in a definite pattern, usually punctate or smooth. Chloroplasts axial, usually with a single pyrenoid.

Zygospores spherical, with simple spines or smooth.

Key to Species of Spondylosium

1. Semicells transversely elliptical or subelliptical (may have slight truncate apices) 2

1. Semicells truncate pyramidate . . . (1) Sp. pulchellum

2. Lateral margins of semicells with three small granules . . (2) Sp. papillosum

2. Lateral margins otherwise . . . 3

3. Cells large, more than 40u long . . (3) Sp. pulchrum

3. Cells smaller, less than 40u long . 4

4. Cells 5-8u long, 4-8u wide . . (4) Sp. pygmaeum

4. Cells larger, more than 8u long and 8u wide 5

5. Semicells transversely elliptical, length of cell 19.6-24u . . . . . (6) Sp. ellipticum

5. Semicells transversely oblong, length of cell 9.5-19.5u . . . . . (7) Sp. planum

1. Spondylosium pulchellum Arch.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:227. Pl. 161, Figs. 1-3.

The truncate-pyramidate semicells easily distinguish this species.

Measurements: L. 12-(13)-15u; W. (9.6)-10-11u; A. 5u; I. 4.5-6u.

Distribution: SLP, Barry, also Muskegon (Transeau 1917); NLP, Cheboygan (N & A 1932); EUP, Mackinac (Transeau 1917); WUP, Gogebic.

2. Spondylosium pulchrum (Bail.) Arch.

Smith, 1924. Bull. Wis. Geo. and Nat. Hist. Surv. 57(2):140. Pl. 87, Figs. 3, 4.

The transversely oval (much elongated) semicells, the cells much wider than long, and the large size easily separate this species from all others in the genus. The apices are elevated and decidedly truncate.

Measurement: L. 40-54u; W. 70-85u; I. 18-22u.

Distribution: SLP, Muskegon (Transeau 1917); NLP, Cheboygan (Welch 1936b); EUP, Mackinac (Transeau 1917).

3. Spondylosium papillosum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:223. Pl. 161, Figs. 6, 7.

This small species has the lateral margins provided with three minute granules.

Measurements: L. 8-9.5u; W. 8.5-9.5u; I. 4.5-5u;

Distribution: NLP, Cheboygan (N & A 1932); EUP, Chippewa (Transeau 1917).

4. Spondylosium pygmaeum (Cooke) West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:220. Pl. 160, Figs. 18, 19.

This minute species is about as wide as long, and has transversely elliptic semicells which are united together by a relatively small portion of the apical surfaces.

Measurements: L. 5-8u; W. 5-8u; I. 2.5-3.2u.

Distribution: NLP, Cheboygan (N & A 1932).

5. var. monile (Turn.) West and West

West and West and Carter, 1923. Monogr. Brit. Desm. 5:221. Pl. 160, Figs. 20, 21.

This variety has cells that are relatively longer than the typical. The semicells are broadly oval.

Measurements: L. 7u; W. 4u.

Distribution: NLP, Cheboygan (N & A 1932).

6. Spondylosium ellipticum West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:222. Pl. 161, Fig. 15.

This species has elliptical semicells with convex apices. It resembles S. planum but the shape of the semi-

cells and the greater length of the cells easily distinguishes it from this species, which has transversely oblong semicells.

Measurements: L. 19.6-24u; W. 20-22u; I. 6.7-7u.

Distribution: SLP, Ingham (N & A 1932).

7. Spondylosium planum (Wolle) West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:222. Pl. 160, Figs. 23-25.

This species has transversely oblong semicells with the lateral angles broadly rounded. The constriction is deep with the sinus open but obtuse at the apex.

Measurements: L. (9)-9.5-(13)-19.5u; W. 9.5-(10)-(14)-17u; I. 5-11.5u.

Distribution: SLP, Barry (2), Calhoun, Livingston; WUP, Ontanagon (N & A 1932).

25. HYALOTHECA Ehrenb. 1841

Cells cylindrical or discoid, sometimes longer than wide, often wider than long; united in untwisted filaments, often covered by a mucilaginous sheath; median constriction either a slight indentation or notch or a broad shallow depression of the lateral margins; apices flattened and without projections, angles usually rounded. Cell wall smooth, or punctate, especially near apices, sometimes with two transverse rows of small granules near poles. Chloroplast axial with several radiating lobes, each chloroplast with a central pyrenoid.

Zygospores smooth and spherical.

Key to Species of *Hyalotheca*

1. Cells with two parallel transverse rows of granules just below apices . . . . . (1) *H. mucosa*

1. Cells without two parallel transverse rows of granules below apices . . 2

2. Cells about as wide as long (never over 1 1/4 times longer than wide) or wider than long . . . . . (3) *H. dissiliens*

2. Cells more than 1 1/4 times longer than wide 3

3. Length of cells less than 18u . . . (7) *H. undulata*

3. Length of cells more than 25u . . . (6) *H. neglecta*

1. *Hyalotheca mucosa* (Mert.) Ehrenb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:235. Pl. 162, Figs. 1-4.

The two transverse parallel rows of granules just below the apices clearly differentiate this species.

Measurements: L. 14-26u; W. 16-22u.

Distribution: SLP, Barry; NLP, Cheboygan (N & A 1932, Welch 1938b); EUP, Delta, Alger, Schoolcraft; WUP, Marquette, Gogebic; Isle Royale (Taylor 1935, Prescott 1937, 1940).

2. var. *minor* Roy and Biss.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:232. Pl. 162, Fig. 5.

This variety is distinguished from the typical by its smaller size.

Measurements: L. 12.5-14.5u; W. 9-12u.

Distribution: NLP, Cheboygan (N & A 1932).

3. Hyalotheca dissiliens (Smith) Breb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:229. Pl. 161. Figs. 16-27.

This somewhat variable species has the following characteristics: the cells are about 1 1/4 - 2 times wider than long; the cylindrical discoid cells have the constriction reduced to a slight concavity or indentation, and the apices are flattened. Cell wall smooth, or punctate, especially near the apices.

Measurements: L. 10-(17)-33; W.20-39u.

Distribution: Very common and widespread in the writer's collection. SLP, Barry (3), Calhoun, Washtenaw (2), Jackson; also Barry, Calhoun, Ingham, Kalamazoo (N & A 1932), Allegan, Muskegon (Transeau 1917) and Macomb (Pieters 1894); NLP, Crawford, Emmet, also Cheboygan (N & A 1932, Welch 1936a, 1936b); EUP, Delta, Alger, Schoolcraft (4), Mackinac, also Chippewa, Luce, Mackinac (N & A 1932) and Schoolcraft (Transeau 1917); WUP, Gogebic (3), Marquette (2), Houghton, Baraga, also Houghton, Onatanagon (N & A 1932); Isle Royale (Prescott 1937, 1940).

4. var. hians Wolle

West, West and Carter, 1923. Monogr. Brit. Desm. 5:234. Pl. 162, Figs. 16-18.

This variety is often conspicuously constricted at

the joints. The lateral margins are distinctly convex with a distinct median indentation or notch. The cells are also usually much longer than wide. The writer's specimens from Roscommon agree favorably with the form illustrated by Taylor (1935) from New Foundland.

Measurements: L. (11)-12-22u; W. 20-(28)-32u.

Distribution: SLP, Ingham, Saginaw (N & A 1932); NLP, Roscommon, also Cheboygan, Mecosta (N & A 1932); EUP, Chippewa.

5. var. tatrica Racib. Pl. 35, Fig. 2.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:234. Pl. 162, Fig. 19.

This variety is almost as long as wide, or longer than wide, the somewhat quadrangular cells having a distinct median constriction. The filaments are often without mucilanginous sheaths.

Measurements: L. 12-(13)-(15)-22; W. (15)-16-(17)-20u.

Distribution: NLP, Roscommon; WUP, Gogebic. New record for Michigan.

6. Hyalotheca neglecta Racib.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:238. Pl. 162, Figs. 11-15; Pl. 163, Figs. 1-4.

This species is about 2 1/2 - 3 times longer than wide, with the slightly tumid midregion of cells showing a slight median constriction.

Measurements: L. 26-(29)-42u; W. 11-(15)-18.5u.

Distribution: NLP, Cheboygan (N & A 1932); WUP, Gogebic.

7. Hyalotheca undulata Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:239. Pl. 162, Figs. 6-9.

This species is characterized by the cells being 1 1/2 - 2 times longer than wide, and having a broad, shallow lateral indentation. The length of the cells is under 18u, this feature separating the species from some forms of H. neglecta which also has a broad, shallow indentation. Two transverse rows of mucilage pores are found on each semicell.

Measurements: L. 8-(9)-(12)-17u; W. 5-(5.5)-(9)-9u.

Distribution: SLP, Barry, also Calhoun (Pres. & Mag. 1935); WUP, Gogebic.

26. PHYMATODOCIS Nordstedt 1877

Cells quadrangular in front view, about as long as wide, joined together end to end in straight or spirally twisted filaments; median constriction deep and the sinus linear to sublinear; apices and lateral margins flattened or slightly undulate. Semicells in transverse view quadrate, with angles extended to form arms which are broadly rounded at the apices. Chloroplast, axial and single in each semicell, with two radially laminate plates extending into each arm.

Zygospore irregularly quadrangular with irregularly thickened walls.

1. Phymatodocis Nordstedtiana fa. minor West and West Pl. 14, Fig. 2.

West and West, 1895. Trans. Linn. Soc. 5(5):230. Pl. 12,

This very rare genus has quadrangular cells arranged end to end to form straight or spirally twisted filaments. There is a deep median constriction and a linear to sublinear sinus. In vertical view, the cell is quadrate with the angles extended into broadly rounded arms.

Measurements: L. 33-35-38.5u; W. 27-34.5-(35u).
I. 11.5-15-(16u).

Distribution: EUP, Chippewa; WUP, Gogebic. New record for Michigan.

27. DESMIDIUM C. A. Agardh 1824

Cells united into filaments, which are usually twisted, sometimes enclosed in a broad mucilaginous sheath. Cells usually broader than long, and radially symmetrical, not markedly compressed; in front view semicells transversely semi-elliptical, trapeziform or narrowly oblong; median constriction usually distinct and moderately shallow; apices plane or when depressed, forming an opening between adjacent cells; cells in vertical view broadly elliptic, cylindrical, sub-cylindrical, oblong, tri-or quadrangular; chloroplast, axial, single and central in each semicell, with lobes or plates (each with a pyrenoid) projecting into each angle.

Zygospores spherical or ellipsoidal, wall smooth or with small flattened conical papilla.

Key to Species of *Desmidium*

1.	Vertical view broadly elliptical, cylindrical or subcylindrical, often with a nodule at each pole .		11
1.	Vertical view otherwise		2
2.	Vertical view angular		4
2.	Vertical view otherwise		3
3.	Filaments twisted	(11)	*D. pseudostreptonema*
3.	Filaments not twisted	(4)	*D. aptogonum* var. *Ehrenbergii*
4.	Vertical view quadrangular (symmetrical)	(9)	*D. Swartzii* var. *quadrangulatum*
4.	Vertical view triangular (very rarely quadrangular) or asymmetrically triangular		5
5.	Vertical view asymmetrically triangular	(1)	*D. asymmetricum*
5.	Vertical view symmetrically triangular		6
6.	Lateral margins convex in vertical view	(13)	*D. aequale*
6.	Lateral margins not convex in vertical view		7
7.	Apices plane or nearly so, area between apices of adjacent cells very small or none		9
7.	Apices with broad depressions, area between apices of adjacent cells large and distinct		8
8.	Median incision well defined .	(2)	*D. Aptogonum*
8.	Median incision not well defined	(5)	*D. Baileyi*

9. Semicells in front view transversely and narrowly oblong 10

9. Semicells in front view transversely oblong semi-elliptical . . . . . (6) D. occidentale

1 10. Spaces between apical adjoined processes transversely narrow-oblong or linear, often difficult to detect . . . . . (7) D. Swartzii

10. Space between apical adjoined processes transversely elliptical, distinct . . . . . (11) D. pseudostreptonema

11. Cells 19-22u long by 25-29u wide . . (12) D. quadratum

11. Cell measurements otherwise 12

12. Cells 17-22u long by 29-35u wide . . . . . (13) D. aequale

12. Cell measurements otherwise . . 13

13. Width of apex of semicells one-third or less of the width of the cell at its greatest diameter . . . . . (14) D. coarctatum

13. Width of apex of semicell more than one-third of the width of the cell at its greatest diameter 14

14. Apex of semicell 16-24u wide . (15) D. coarctatum var. cambricum

14. Apex of semicell 26-40u wide . (16) D. Grevillii

1. Desmidium asymmetricum Gronbl.

Gronblad, R., 1920. Acta. pro. Faun. et Flor. Fenn 47(4):85. Pl. 1., Figs. 5-7.

This species in vertical view has triangular semicells that are assymmetrical. In front view, the lobes of the semicells lie in different planes because the cells within the filament are turned at various angles.

Measurements: L. 15.6-23.4; W. 27-28u.

Distribution: Isle Royale (Prescott 1937, 1940).

2. Desmidium Aptogonum Bréb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:242. Pl. 164, Figs. 1-3.

This species is the only one except D. Baileyii that possesses a large elliptical cavity between adjacent cells. It can be separated easily from the latter by the marked constriction of the semicells.

Measurements: L. 12-(19.3)-20u; W. 21-(28)-43u; I. 14-(17)-35u.

Distribution: Well distributed throughout states in writer's collections. SLP, Barry (2), Berrien, Jackson, Ingham, Washtenaw, also Wayne (Campbell (1886), Kalamazoo, Kent (N & A 1932) and Macomb (Pieters 1894); NLP, Cheboygan, Roscommon, Crawford, Emmet, also Cheboygan (N & A 1932); EUP, Alger, Mackinac, Schoolcraft, Chippewa (2); WUP, Marquette, Menominee, Houghton, Gogebic (2), also Isle Royale (Prescott 1937, 1940).

3. var. acutius Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:244. Pl. 64, Fig. 6.

The lateral angles of this variety are not rounded as in the typical, but are slightly retuse in the upper part, thus producing a sub-acute angle pointing toward the apex. Otherwise, the variety conforms to the typical.

Measurements: L. 15-(15)-23u; W. (28)-32-43u; I. (21)-34u.
Distribution: SLP, Barry, Washtenaw, also Ingham (N & A 1932); NLP, Roscommon, Crawford; EUP, Chippewa, Schoolcraft.

4. var. Ehrenbergii Kuetz. Pl. 14, Fig. 3.
West, West and Carter, 1923. Monogr. Brit. Desm. 5:243. Pl. 164, Figs. 4, 5.

This variety is not triangular in vertical view like the typical, but is oblong-rectangular, with rounded poles and with concave lower and convex upper lateral margins. Also unlike the typical form, the filaments are not twisted.

Measurements: L. 14-(21)-22u; W. 25-(32)-32.5u; I. 22-(22)-24u.
Distribution: EUP, Alger; WUP, Menominie. New record for Michigan.

5. Desmidium Baileyi (Ralfs.) Nordst.
Smith, G. M., 1924. Wisc. Geo. and Nat. Hist. Surv. Bull. 57(2):145. Pl. 88, Figs. 5-7.

This species is sharply differentiated in front view by the rectangular shape of the cells, the almost straight (sometimes two very slight undulations) lateral margins with only a suggestion of a median constriction. It also has very pronounced elliptic cavities between adjacent cells that are also found in D. Aptogonum and its varieties. The variety minor Allorge and Allorge

appears to differ only in smaller size and is included here under the typical.

Measurements: L. 15-(21.5)-26u; W. 19-(21.5)-30u.

Distribution: SLP, Barry (2), also Kalamazoo (N & A 1932), Wayne (Campbell 1886) and Macomb (Pieters 1894); NLP, Cheboygan (N & A 1932); EUP, Alger, Delta, Schoolcraft (2), also Schoolcraft (Transeau 1917); WUP, Menominee, Gogebic; Isle Royale, (Prescott 1937, 1940 (D. Baileyi var. minor).

6. Desmidium occidentale West and West Pl. 35, Fig. 1.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:245. Pl. 164, Fig. 11.

This species is close to D. Swartzii from which it is separated by the semi-elliptic shape of the semicells. It is proportionately longer and the lateral angles are shorter and more rounded. The Michigan specimens are smaller than measurements given by West, West and Carter (1923).

Measurements: L. (21.5)-25.5-28u; W. (29)-32.5-38.5; I. (21.5)-23-38.5u.

Distribution: Eup, Delta. New record for Michigan.

7. Desmidium Swartzii C. A. Agardh

West, West and Carter, 1923. Monogr. Brit. Desm. 5:246. Pl. 163, Figs. 5-8.

Characteristically, this species has transversely narrow, long, trapeziform semicells with lateral margins obliquely truncate. The upper lateral margins are dis-

tinctly projected toward the apex and the lower lateral margin is generally rounded. The space between the apices of adjoined cells is often difficult to distinguish.

Measurements: L. 12-(17.5)-20.5; W. (34.3)-35-(39)-50u; I. 27-(34)-40u.

Distribution: One of the most common and wide-spread species in Michigan. SLP, Barry (3), Ingham, Washtenaw, also Ingham, Kalamazoo, Kent, Mecosta, Muskegon, Newaygo, Ottawa (N & A 1932). Muskegon (Transeau 1917 and Macomb (Pieters 1894); NLP, Roscommon, Crawford, Emmet, also Cheboygan N & A 1932), Cheboygan (Welch 1936b, 1938a); EUP, Chippewa, Mackinac, Alger, Delta also Chippewa, Mackinac, Schoolcraft, Luce (N & A 1932), Schoolcraft (Transeau 1917); WUP, Menominee, Gogebic (5), Marquette, Houghton, also Dickinson, Houghton, Ontanagon (N & A 1932); Isle Royale (Prescott, 1937, 1940).

8. var. amblyodon Rabenh.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:249. Pl. 165, Fig. 7.

This variety is separated from the typical form by its possession of rounded lateral margins.

Measurements: L. 15-21u; W. 30-50u; I. 25-45u.

Distribution: NLP, Newaygo (N & A 1932).

9. var. quadrangulatum (Ralfs.) Roy

West, West and Carter, 1923. Monogr. Brit. Desm. 5:248. Pl. 163, Figs. 9, 10.

This variety differs from the typical in being quadrangular in vertical view and in having a much greater width.

Measurements: L. 24.8u; W. 57.6-60u.

Distribution: NLP, Cheboygan, Presque Isle (Taft 1939).

10. var. spinuosum Ackley

Ackley A., 1929. Trans. Amer. Microsc. Soc. 48:304. Pl. 35, Fig. 13.

This variety has been described by Ackley (1929) as possessing numerous short spines at all the lateral angles. The writer has not seen such a form in his collections, although frequently some specimens were found to have mucilage threads extruded from the cells, simulating spinous-projections. More specimens of this organism must be collected and examined before it can be considered valid.

Measurements: L. 17-21u; W. 31-37u; I. 28-30u.

Distribution: Ackley (1929) reports having collected this variety from near Augusta, Michigan which is in Barry County. However, in (1932) she reports the same variety as occurring only from Newaygo County.

11. Desmidium pseudostreptonema West and West

West, West and Carter, 1923. Monogr. Brit. Desm. 5:244. Pl. 165, Figs. 5, 6.

Characteristically, this species has transversely and narrowly oblong semicells with rounded lateral mar-

gins. The cells are about one and one-half to two times wider than long. The apex is convex resulting in a small elliptical space between the apices of adjacent cell attachment regions. The vertical view is either triangular or oblong, the latter being bilobed with a slight constriction between each angle. This species resembles Spondylosium pulchrum (Bailey) Archer and D. Swartzii var. amblyodon,Rabehn. superficially. It is separated from the former by the connecting processes on the apices and from the latter by the shape and size of the space between the apices of adjacent cells. The triangular form was not found in the writer's collections.

Measurements: L. 17-(20.7)-21u; W. 31-(34.5)-35u; I. 13.5-22-(25u).

Distribution: NLP, Cheboygan (N & A 1932); EUP, Schoolcraft, Delta, Alger; WUP, Menominee.

12. Desmidium quadratum Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:254. Pl. 166, Figs. 6, 7.

This species is closely related to D. aequale West and West from which it is separated by the greater width. (See discussion under D. aequale for characteristics of this species.)

Measurements: L. 19-(22)-22u; W. 25-(27)-29u.

Distribution: SLP, Livingston, also Jackson (N & A 1932);

NLP, Roscommon, also Cheboygan (N & A 1932); EUP, Chippewa, also Chippewa (N & A 1932).

13. Desmidium aequale West and West

West and West, 1896. Trans. Linn. Soc. of Lon., Bot. 5(5):233. Pl. 12, Figs. 17, 26.

This species is closely related to D. quadratum Nordst. from which it is separated by the greater width of the semicells. In vertical view D. quadratum is subcircular whereas D. aequale may be subcircular or triangular (with convex margins). A nodule is at each pole in both species. The cell proportions give D. aequale, in front view, a transversely narrow oblong shape while D. quadratum has a short pyramidate truncate shape.

Measurements: L. 17-19u; W. 29-35u; I. 28u.

Distribution: NLP, Cheboygan (N & A 1932).

14. Desmidium coarctatum Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:252. Pl. 165, Figs. 1, 2.

Cells elliptical, from about one and one-half to two times broader than long, with a narrow apex about one-third the width, and with a slight median constriction. The vertical view is usually narrowly elliptical with a nodule at each pole. The cell wall has several longitudinal rows of minute punctae.

Measurements: L. 25-34u; W. 34-38-(42); I. 33-(35); A. 12-14-(15).

Distribution: SLP, Livingston; NLP, Roscommon, also Cheboygan (N & A 1932).

15. var. cambricum W. West.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:252. Pl. 165, Figs. 3, 4.

This variety differs from the typical in the different proportions of the cell, and in the greater width of the apex. It approaches D. Grevillii (Kuetz.) De Bary in general form but the apex is always shorter than the latter.

Measurements: L. 22.5-24u; W. 40-45u; I. 35-37u; A.16-24u.

Distribution: SLP, Calhoun (Pres. & Mag. 1935).

16. Desmidium Grevillii (Kuetz.) De Bary

West, West and Carter, 1923. Monogr. Brit. Desm. 5:249. Pl. 164, Figs. 7-10.

The use of Ralfs (1848) as a starting point for nomenclature necessitates the use of this name Grevillii although D. cylindricum antedates it.

Characteristically, this species has short pyramadate truncate cells, at least twice as wide as long, plane apical attachment and, in vertical view, an elliptical shape with a nodule at each pole. It is closest to D. coarctatum var. cambricum W. West from which it differs by the greater width of the apex.

Measurements: L. 20-(26.5)-(27.5); W. (40)-41-(44)-63; I. (34)-35-(37)-47u; A. 26-40u.

Distribution: Well-distributed throughout the state in the writer's collections. SLP, Barry (3) also Muskegon (Transeau 1917); NLP, Crawford, also Cheboygan (N & A 1932, Welch 1936b); EUP, Chippewa (2); WUP, Gogebic (3), Houghton; Isle Royale (Prescott 1937, 1940).

28. GYMNOZYGA Ehrenb. 1841

Cells cylindrical or barrel-shaped, always longer than wide, joined together in long, untwisted (rarely twisted) filaments, median constriction very slight, basal part of the semicells usually inflated; apices flattened and without protuberances. The cell wall is smooth or with longitudinal striae near the poles. Cells in transverse view circular with two opposite mammillae. Chloroplasts axial with radiating longitudinal plates; each chloroplast with a single centrally located pyrenoid.

Zygospore smooth, spherical to broadly ellipsoidal.

1. Gymnozyga moniliformis Ehrenb.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:255. Pl. 165, Figs. 8, 9.

This organism is the only species of Gymozyga reported as yet from Michigan. It is chiefly characterized by the barrel-shaped cells joined together in long untwisted filaments. A slight median constriction is present and the basal part of the semicells is inflated. The cell wall has a series of longitudinal striae near the pole.

Measurements: L. 20-(28)-37u; W. 16.5-(19)-(21.5)-26u.

Distribution: Very common and widespread in writer's collections. SLP, Barry (3), Calhoun, Livingston, also Kalamazoo (N & A 1932), and Muskegon (Transeau 1917); NLP, Cheboygan, also Cheboygan (N & A 1932, Welch 1936a, 1936b), Emmet (N & A 1932); EUP, Delta (2), Alger, Chippewa, Schoolcraft, also Mackinac (Transeau 1917); WUP, Gogebic (4), Marquette, Menominee, Baraga, Houghton (2), also Ontanagon (N & A 1932); Isle Royale (Prescott 1937).

2. var. gracilescens Nordst.

West, West and Carter, 1923. Monogr. Brit. Desm. 5:256. Pl. 165, Fig. 10; Pl. 166, Fig. 10.

This variety has a relatively smaller width than the typical.

Measurements: L. 24-(26)-30u; W. 13-(15)-17u.

Distribution: SLP, Barry; NLP, Crawford, also Cheboygan (N & A 1932); EUP, Alger.

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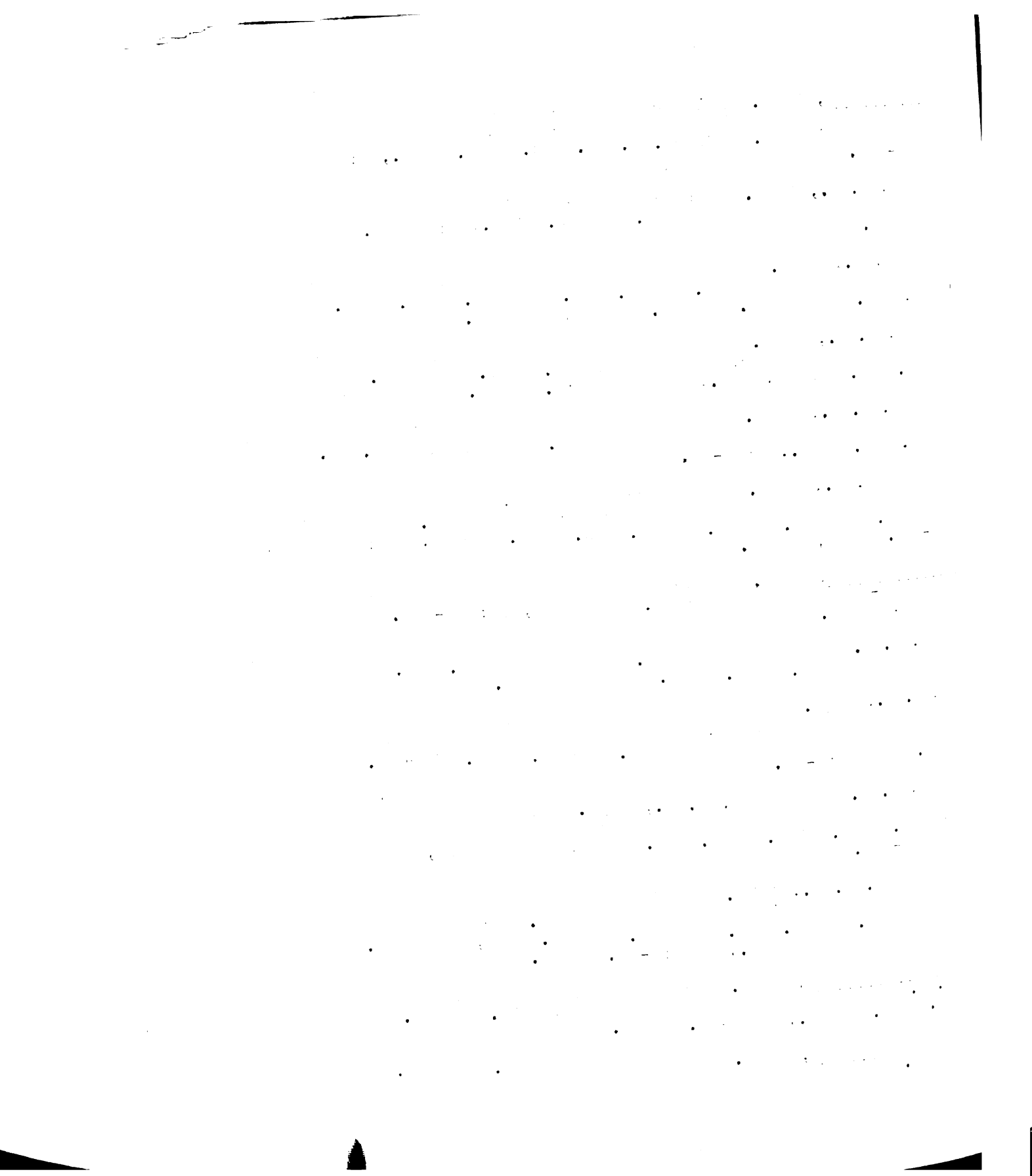

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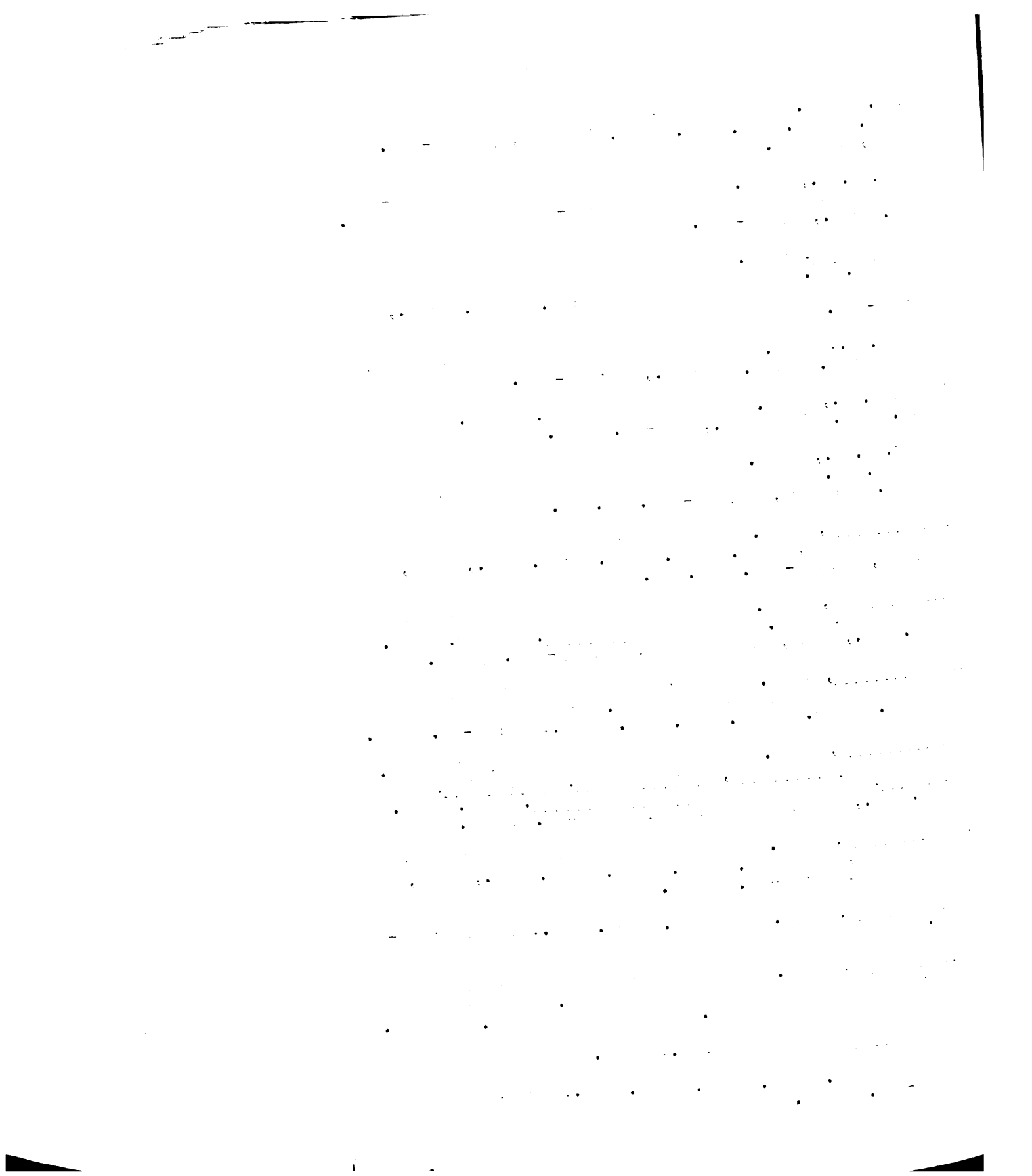

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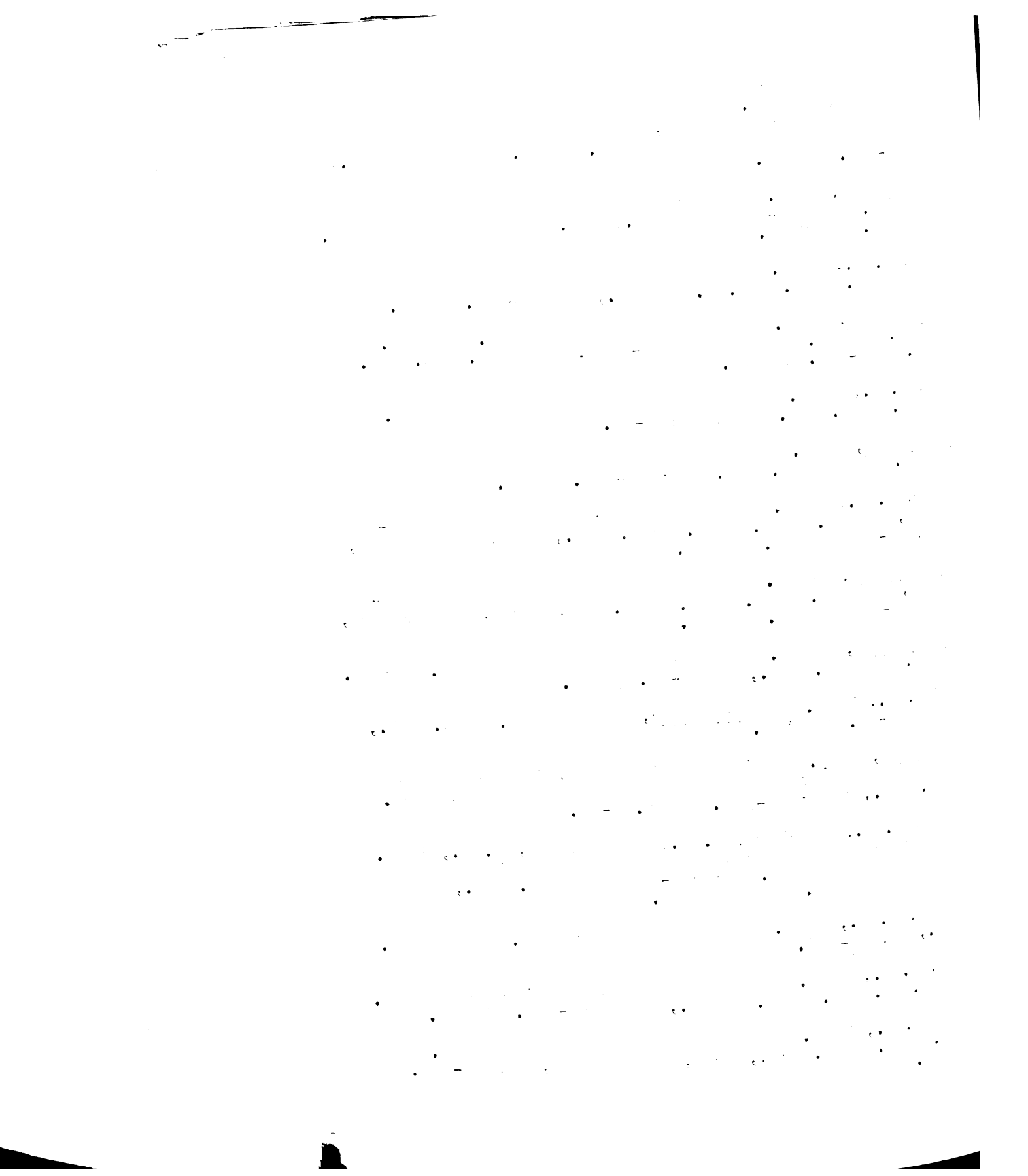

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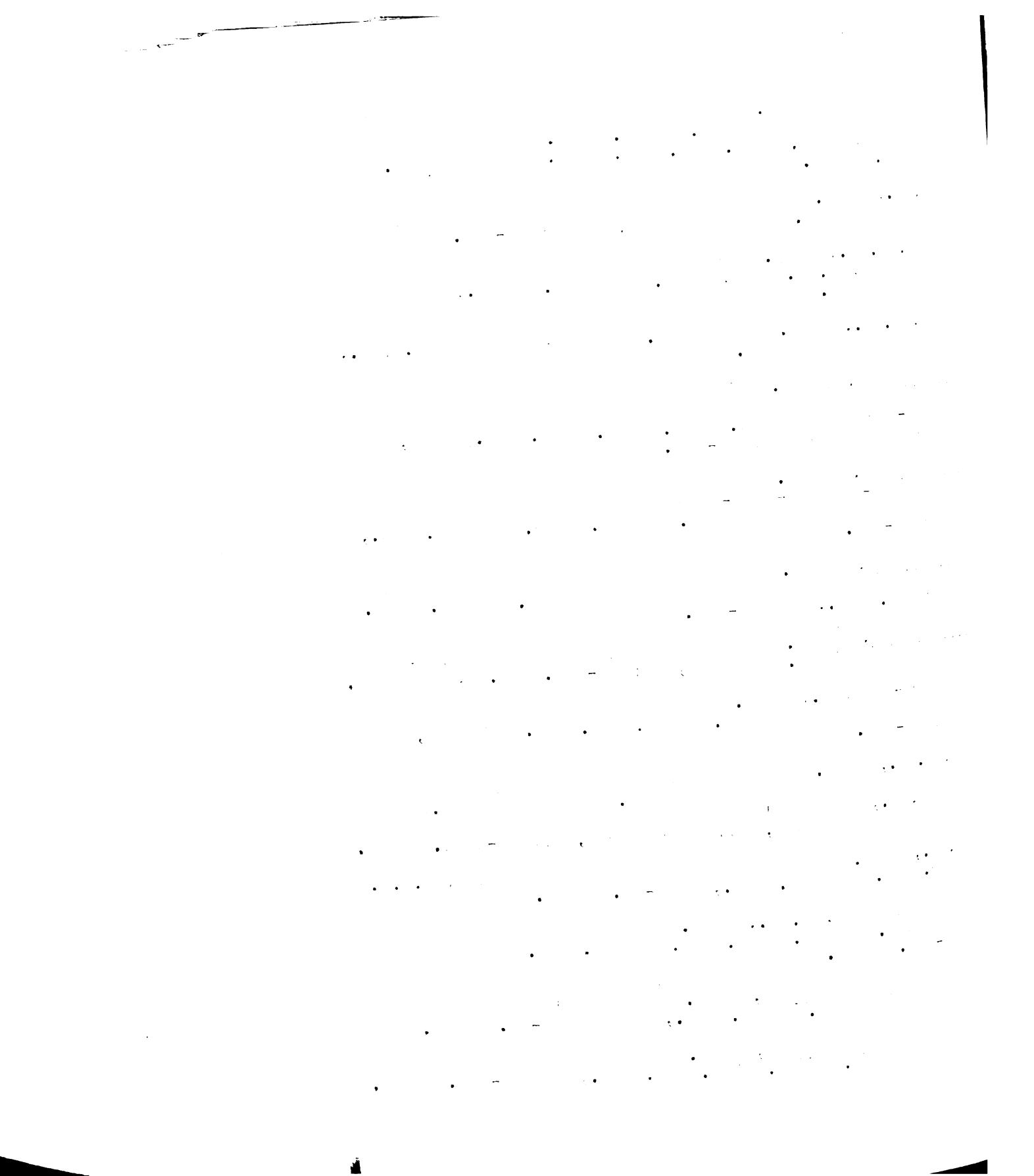

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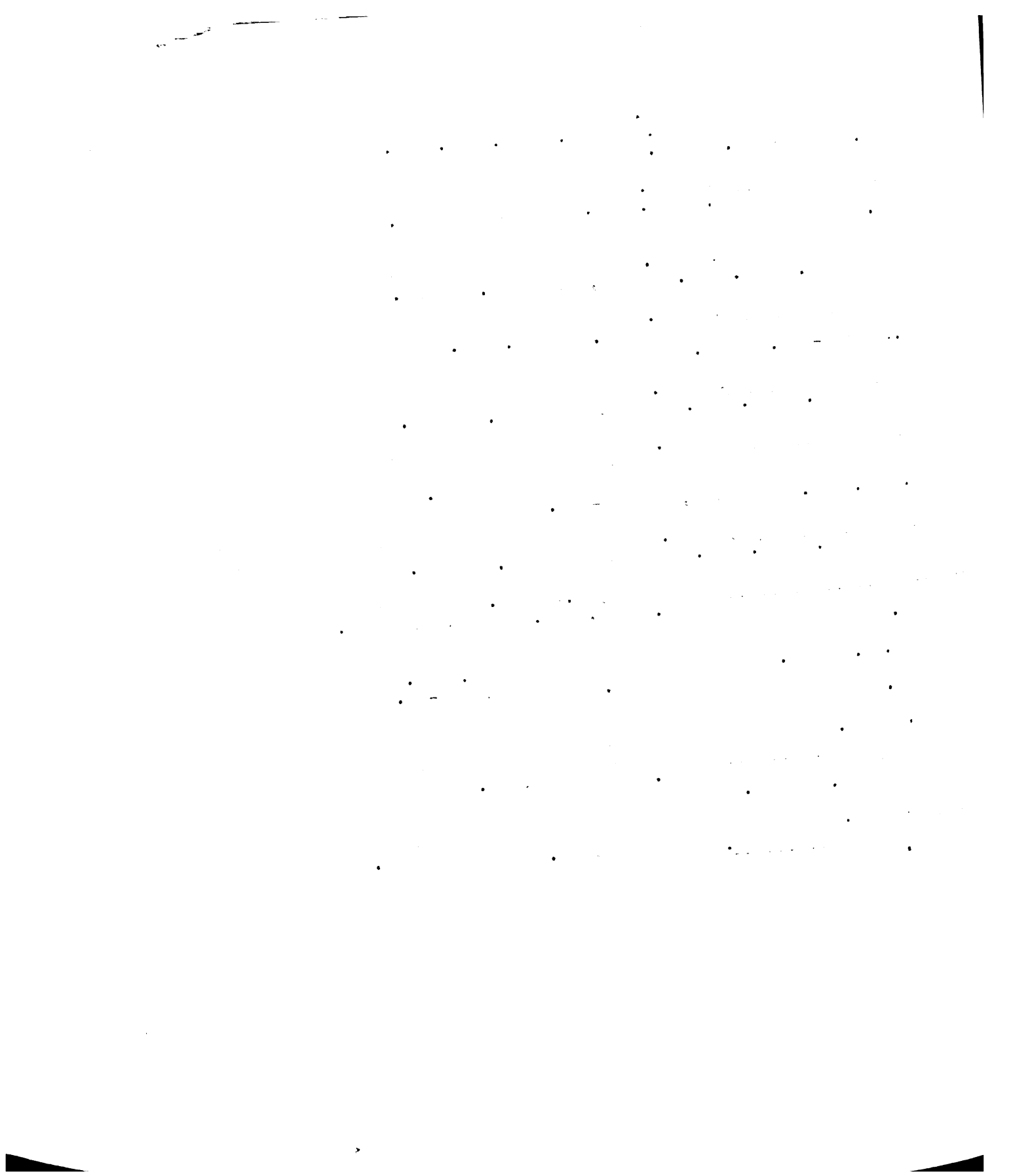

XIII. COLLECTION DATA

Southern lower peninsula

Barry county

Otis lake

Unnamed bog lake on Quinby Rd. South and west of Hastings

Small marshy pond on Whittemore Rd. East of Otis lake

Unnamed bog lake between Delton and Hickory corners

Perch lake

Berrien county

Mud lake bog (collections furnished by M. L. Britton)

Koenigshof lake (collected by Mr. Koenigshof)

Calhoun county

Winipeg lake (sometimes called Calhoun lake)

Swampy bog near Battle Creek (collected by G. W. Prescott)

Clinton county

Park lake (mat collections only)

Ingham county

Mud lake near Holt

Ewers lake

Huntoon lake

Bear lake

Three lakes

Jackson county

Squeezings from mosses in swale - Waterloo area

Brill lake

Little Pleasant (Weilch) lake

Huckleberry marsh south of Little Pleasant lake

Goose lake - Mat on west shore

Small unnamed lake near cloverleaf east of Jackson on U.S. #12

Livingston county

Old marsh east of Fowlerville on U.S. #16

Unnamed bog lake south and east of Howell

Oakland county

Softwater lake

Golfcourse pond - Webster

Walters lake

Pungs lake

Small lake east of Pungs lake

Shiawassee county

Burke lake

Shallow "pot-hole" between hills near Burke lake

Rose lake

Washtenaw county

Small "pot-holes" on both sides of Territorial Rd. west of Hudson Mills

Mud lake - Waterloo area

Small unnamed lake in Waterloo area

Cavanagh lake - Waterloo area

Whittemore lake bog - (Dead lake ?)

Northern lower peninsula

Cheboygan county

East Twin lake

West Twin lake

Little lake 16

Crawford county

In brush near Beaver Creek

Wakely lake east of Gaylord

Kalkaska county

Twenty One lake - On Michigan Rt. #66 south of Kalkaska

Roscommon county

Robinson lake

Roadside ditch near Robinson lake

Eastern upper peninsula

Alger county

Marshland by Munising county park

Chippewa county

Unnamed lake beside road from Paradise to Tahquamenon Falls

Mud lake on Rt. #2 near Rudyard

Delta county

Second lake

Unnamed bog lake north of Harris

Au Train swamp

Mackinac county

Old marshland on U.S. #2 west of St. Ignace

Cedar and Tammarack woods along U.S. #2 west of St. Ignace

Schoolcraft county

Cedar lake

Crane lake

Doyle lake

Marshland near Seney

Marsh along Rt. #94 north of Manistique (collected by G. W. Prescott)

Western upper peninsula

Gogebic county

Swamp along road north of Fuller

Baraga county

Vast Tammarack marsh between L'anse and Marquette on Rt. #28 & 41

Bog lake near fish hatchery at Fuller (collected by G. W. Prescott)

Marsh east of Watersmeet near Gum lake

Marshland along railroad tracks

Cloverleaf lake near Cisco lake

Small unnamed lake near Cloverleaf lake

Houghton county

Small unnamed lake on Rt. #26 south of Houghton and east of Baraga

Iron county

Beaver lake

Keweenaw county

Unnamed bog lake along Rt. #41 west of Copper Harbor

Low marshland adjacent to Objibway copper mine near Vaughnsville

Marquette county

Marshland along Rt. #41 west of Ishpeming

Swamp five miles west of Ishpeming (collected by G. W. Prescott)

Pond at base of Sugarloaf Mountain.

XIV. PLATES

Plate 1

1. Mesotaenium Endlicherianum Naeg.
2. Cylindrocystis crassa DeBary.
3. Roya cambrica West and West fa.
4. R. obtusa var. montana West and West.
5. Penium polymorphum Perty.
6. Closterium acutum var. variable (Lemm.) Krieger.
7. Cl. subulatum (Kuetz.) Breb.
8. Cl. prononum Breb.
9. Cl. prononum Breb.
10. Cl. Subscoticum Gutw.
11. Cl. Baillyanum var. alpinum (Viret) Gronblad fa.
12. Cl. didymocotum var. glabrum Borge.
13. Cl. cynthia var. robùstum (G. S. West) Krieger.

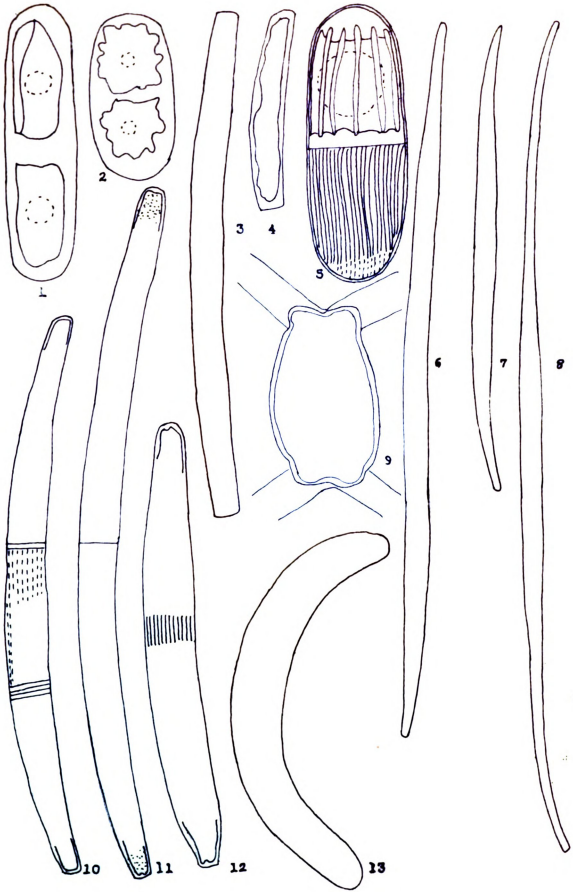
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Plate 2

1. Closterium juncidum var. elongatum Roy and Biss.
2. Cl. praelongum Breb.
3. Cl. idiosporum West and West
4. Cl. lineatum var. costatum Wolle
5. Cl. ulna Focke.
6. Cl. costatum var. Westii Cushman
7. Cl. Braunii Reinsch
8. Cl. Braunii Reinsch

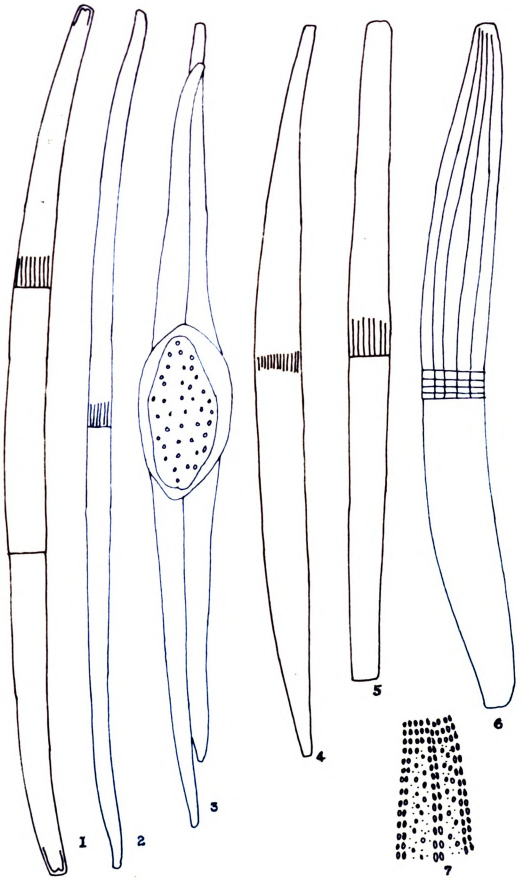
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Plate 3

1. Closterium cynthia DeNot.
2. Cl. calosporum var. brasiliense Boerg.
3. Cl. costatum var. subcostatum (Nordst.) Krieger
4. Cl. venus var. verrucosum (Roll) Krieger
5. Cl. Ralfsii Breb. fa.

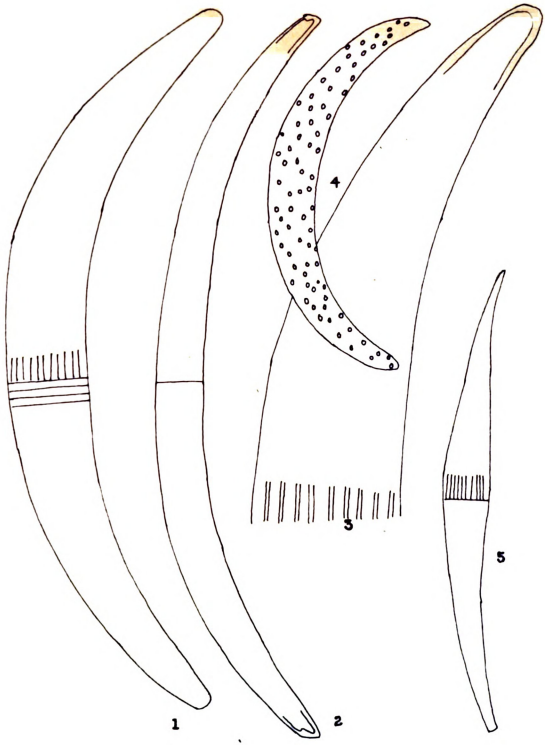
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Plate 4

1. Pleurotaenium constrictum (Bailey) Wood.
2. Pl. trabecula var. rectissimum West and West.
3. Pl. subcorunulatum var. detum West and West.
4. Pl. minutum var. gracile Wille.
5. Pl. verrucosum (Bailey) Lund.
6. Pl. minutum (Ralfs) Delp.

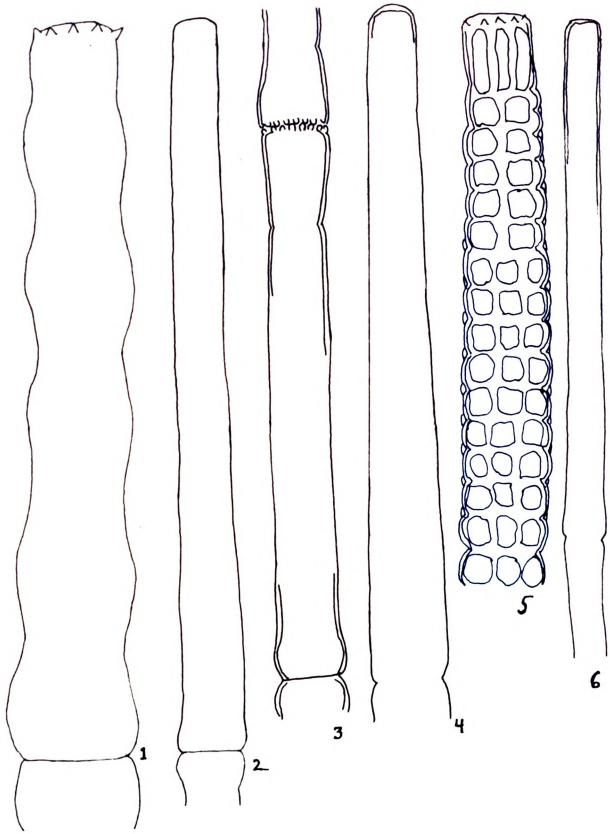
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Plate 5

1. Triploceras verticillatum Bailey
2. Euastrum cuneatum var. subansatum Kossinsk.
3. E. ansatum fa. Scottii nob.
4. E. ansatum var. submaximum Borge
5. E. pingue Elfv.
6. E. sublobatum var. obtusatum (Gutw.) Krieger
7. E. sublobatum Nordst.
8. E. validum var. glabrum Krieger

Plate 6

1. Euastrum intermedium var. longicolle Borge.
2. E. intermedium Cleve fa.
3. E. binale (Turp.) Ehrenb.
4. E. sibiricum Boldt.
5. E. sinuosum var. aboense (Elfv.) Cedegr.
6. E. oculatum var. tonsum West and West.
7. E. denticulatum var. angusticeps Gronblad.
8. E. bipapillatum Gronblad.
9. E. abruptum Nordst.
10. E. lapponicum Schmidle fa.
11. E. Ciastonii Racib.

Plate 7

1. Euastrum verrucosum var. alatum (Ehrenb.) Wolle.
2. E. evolutum var. Guianense (Racib.) West and West.
3. E. evolutum var. Glaziovii Borge.
4. Arthrodesmus impar (Jacobs) Gronbl.
5. A. tenuissimus Archer.
6. A. trispinatus West and West.
7. A. crassus West and West fa. Borge.
8. A. controversus var. brasiliense Borge.
9. A. incus var. longispina Eichl. and Racib.
10. A. incus fa. sèmilunaris Schmidle.
11. A. triangularis Lagerheim.

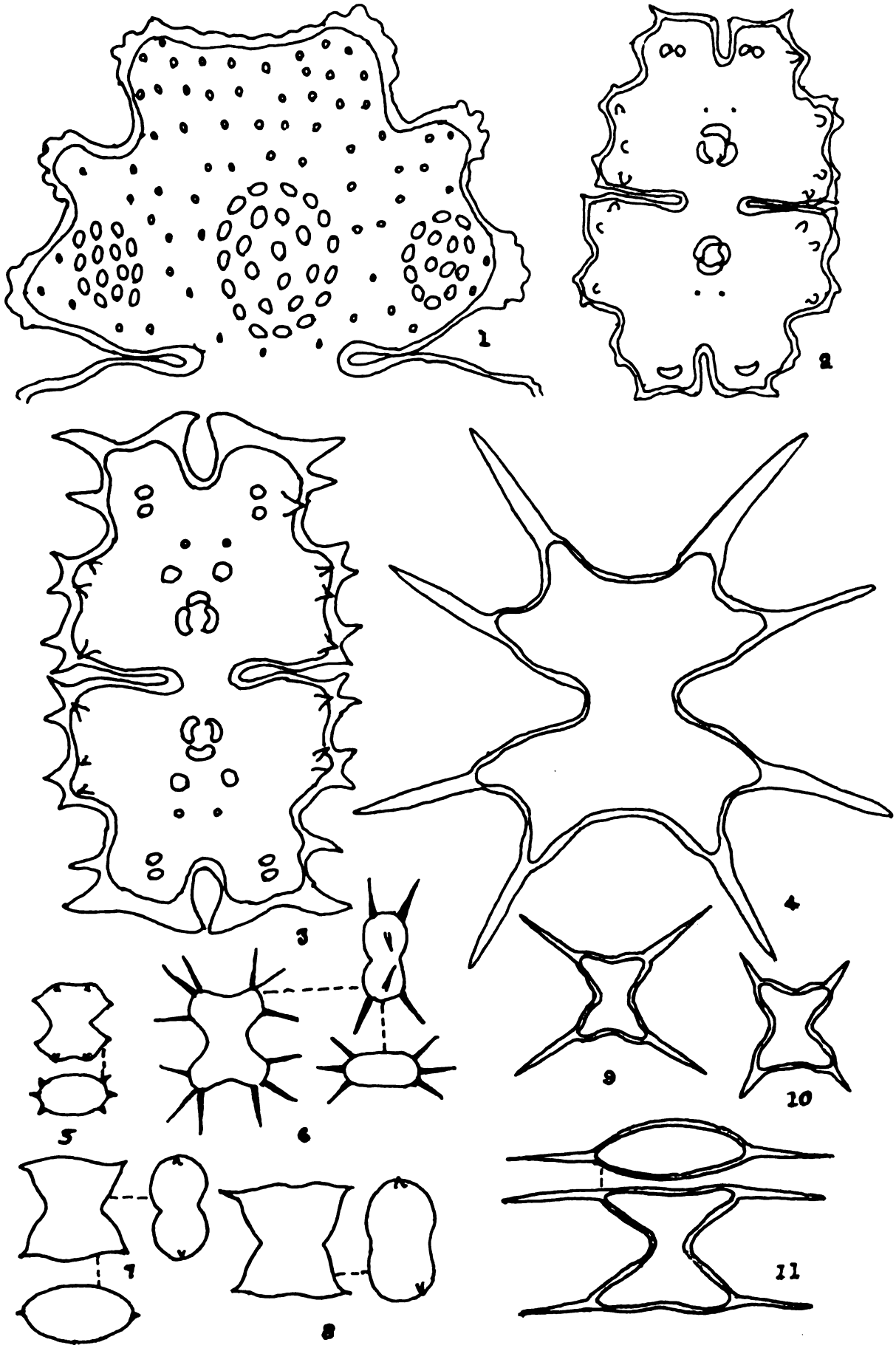
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Plate 8

1. Arthrodesmus curvatus var. minor var. nov.
2. A. Ralfsii var. Brebissonii (Racib.) Smith.
3. Xanthidium obsoletum Taylor.
4. X. cristatum var. Hipparqui Irenee-Marie.
5. X. tetracentrotum var. intermedia var. nov.

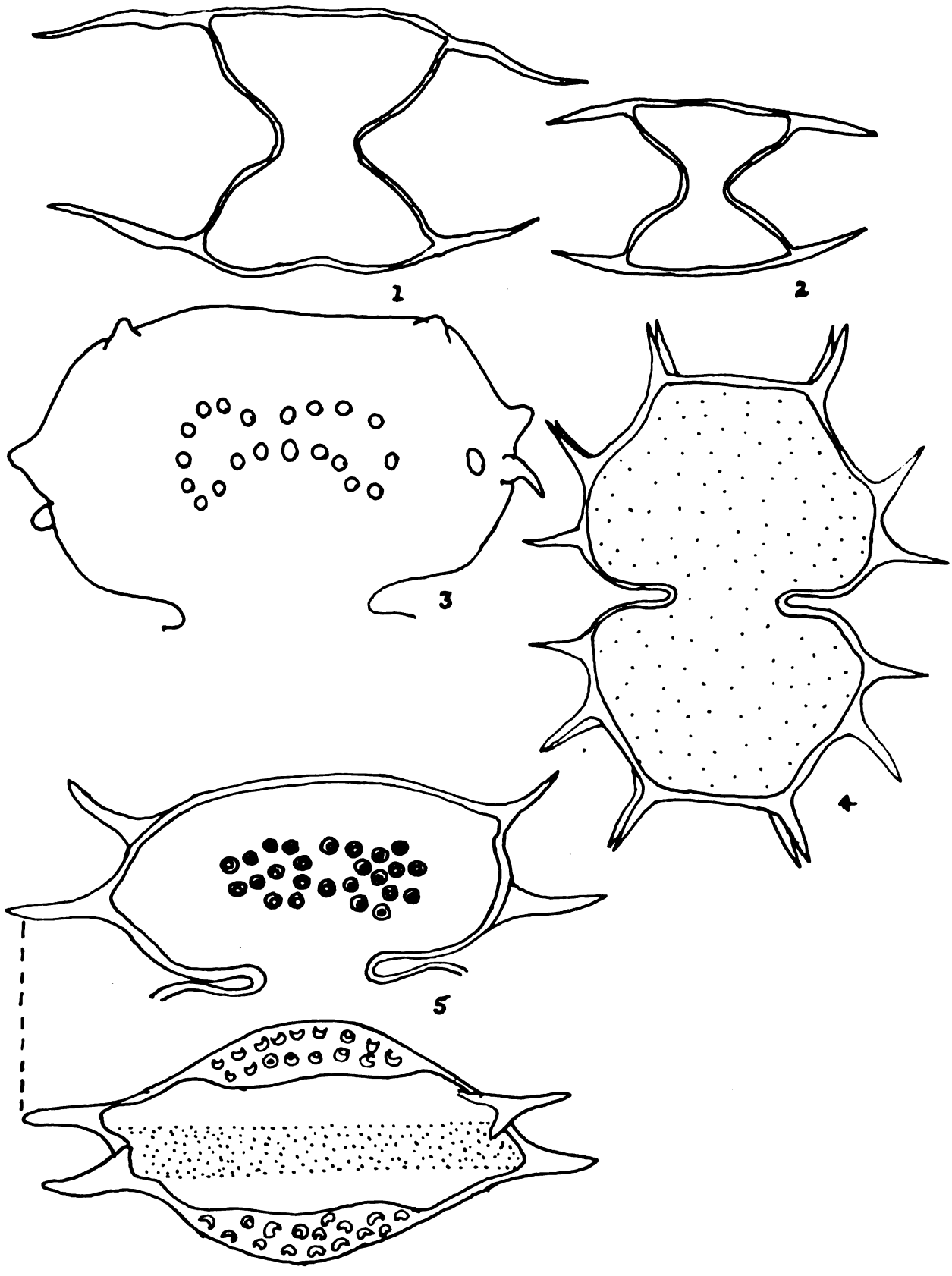
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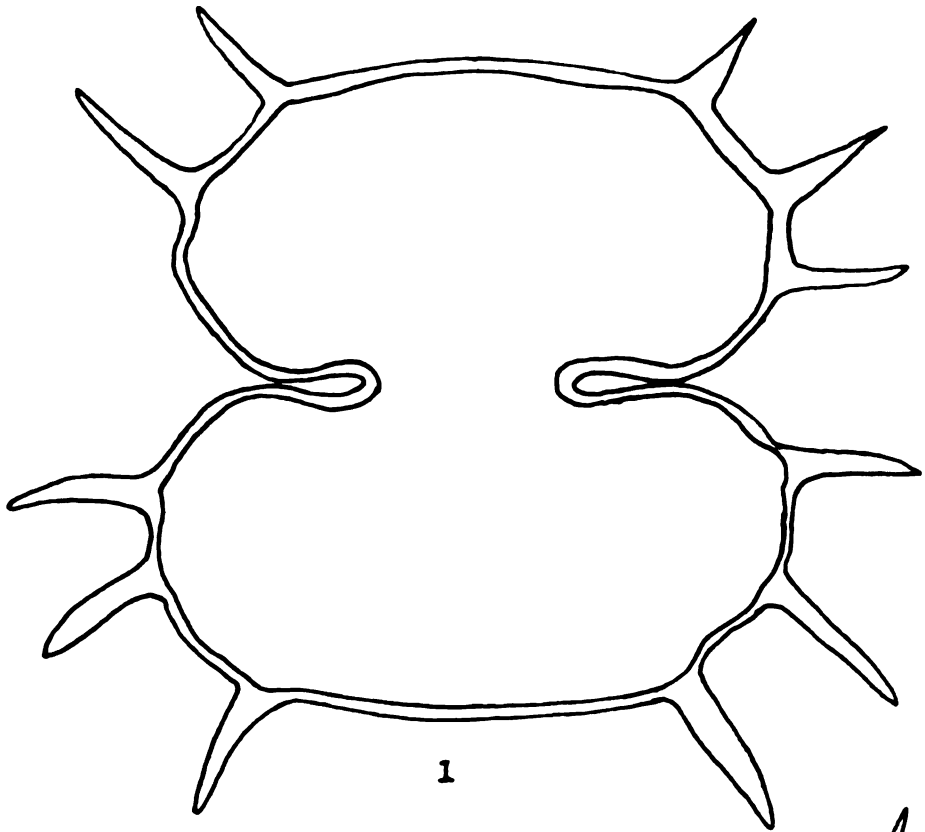
Plate 9

1. Xanthidium cristatum fa. mucronata West and West.
2. X. cristatum var. papilliferum Irenee-Marie.
3. X. antilopaeum var. basiornatum Eichl. and Racib.

Plate 10

1. Xanthidium antilopaeum var. oligacanthum Schmidle.

2. X. subhastiferum var. Johnsonii fa. Smithii fa. nov.



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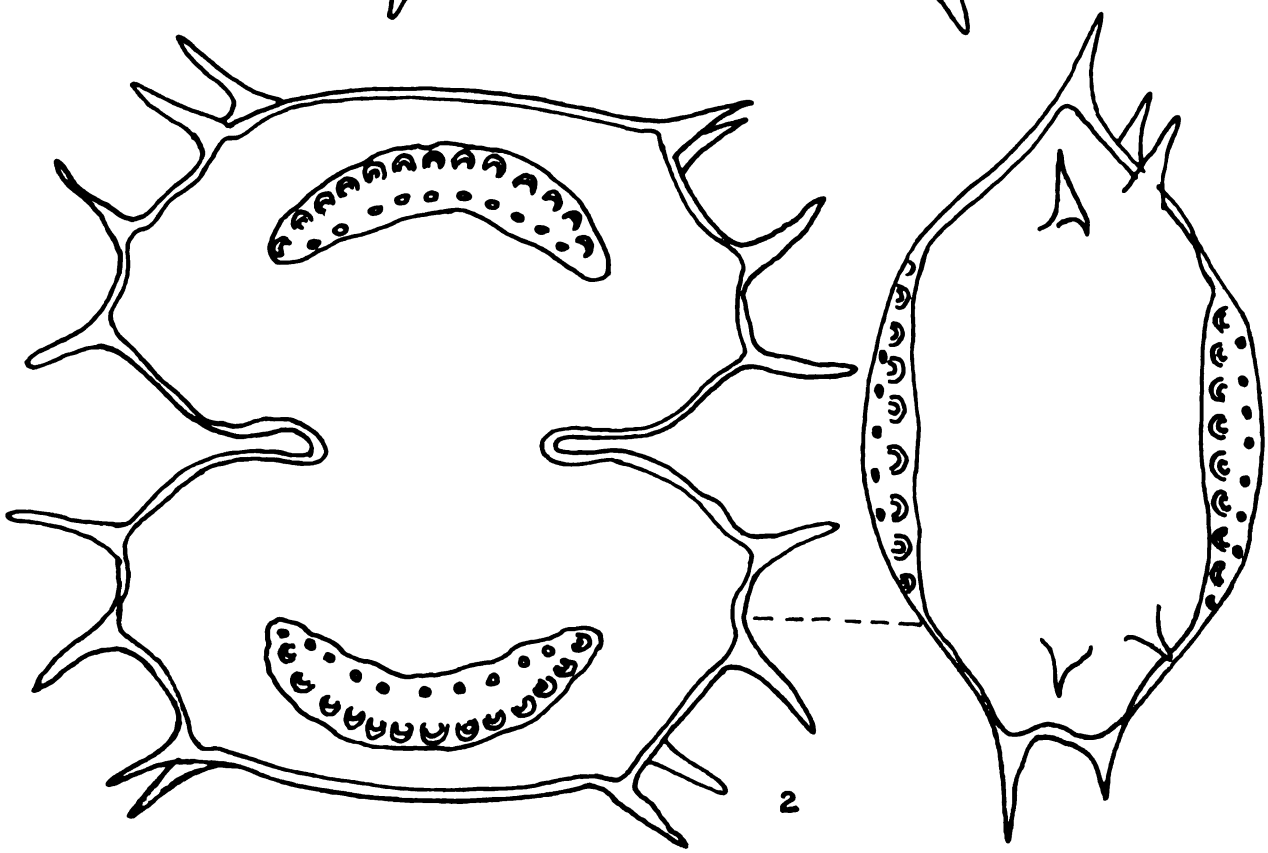

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Plate 11

1. Xanthidium antilopaeum fa. michiganensis fa. nov.
2. X. antilopaeum var. triquetrum Lund.
3. Spinocosmarium quadridens (Wood) Pres. and Scott.

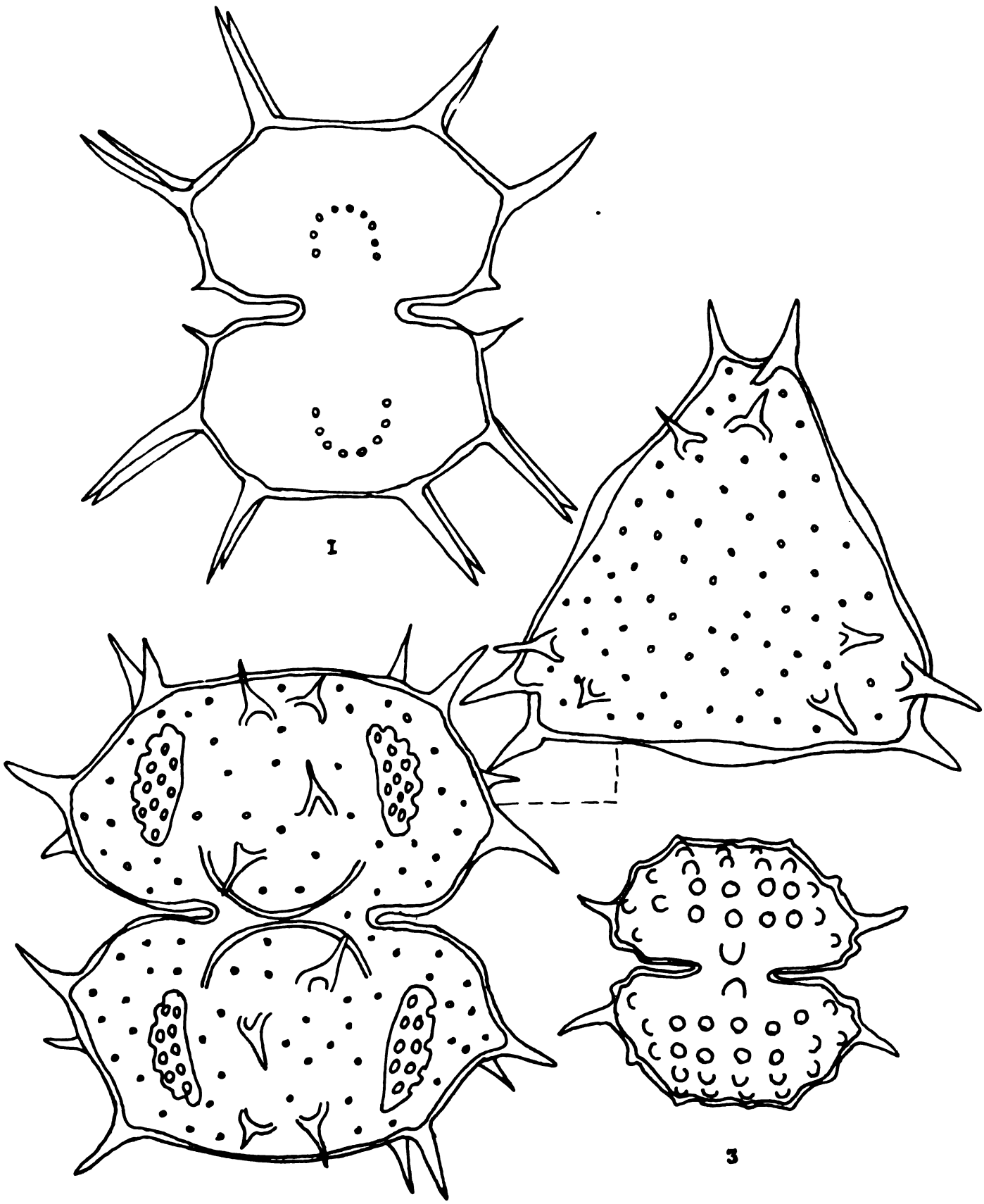
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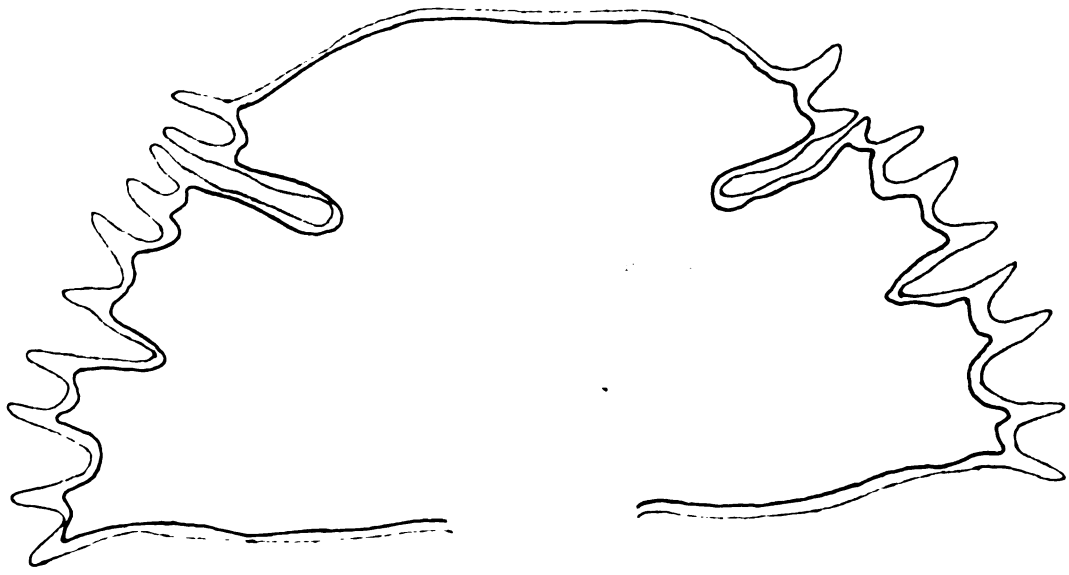
Plate 12

1. Micrasterias Nordstedtiana Wolle.

2. M. radiata var. pseudocrux Gronblad fa.

Plate 13

1. Micrasterias truncata var. semiradiata (Naeg.) Cleve.
2. M. truncata var. quadrata Bulnh.



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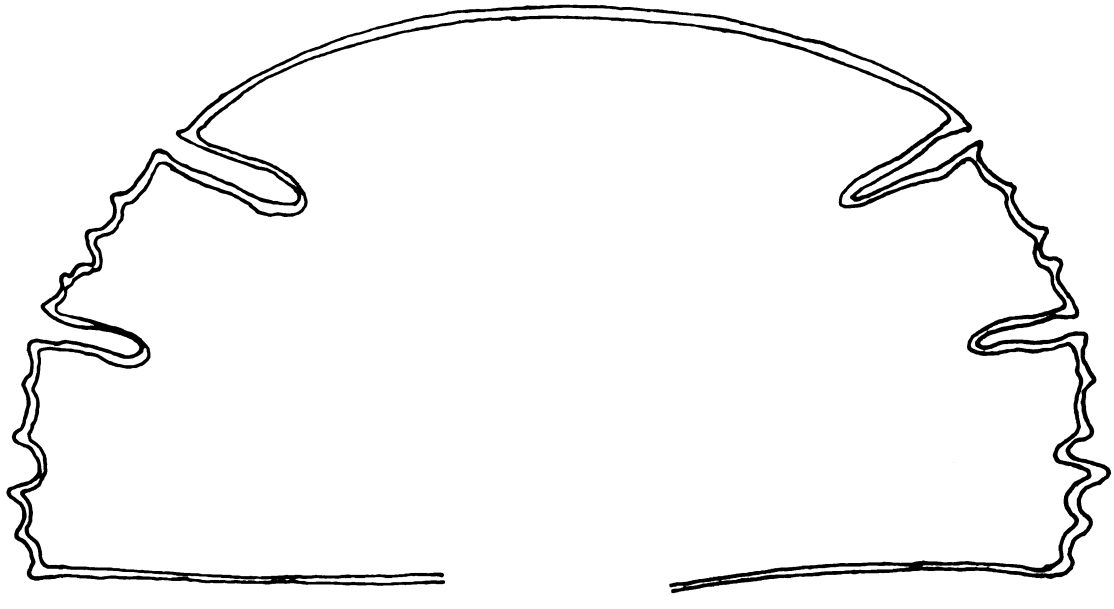

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Plate 14

1. Micrasterias papillifera var. speciosa (Wolle) Krieger.
2. Phymatodocis Nordstedtiana fa. minor West and West.
3. Desmidium Aptogonum var. Ehrenbergii Kuetz.

Plate 15

1. Cosmarium cyclicum var. Nordstedtianum (Reinsch) West and West.
2. C. ocellatum Eich. and Gutw. fa.
3. C. cucumis (Corda) Ralfs.
4. C. moniliforme fa. punctata Lagerh.
5. C. moniliforme fa. panduriformis Heimerl.
6. C. canadense Irenee-Marie.
7. C. moniliforme var. subpyriforme West and West.
8. C. moniliforme fa. elongata West and West.
9. C. depressum var. achondrum (Boldt) West and West.

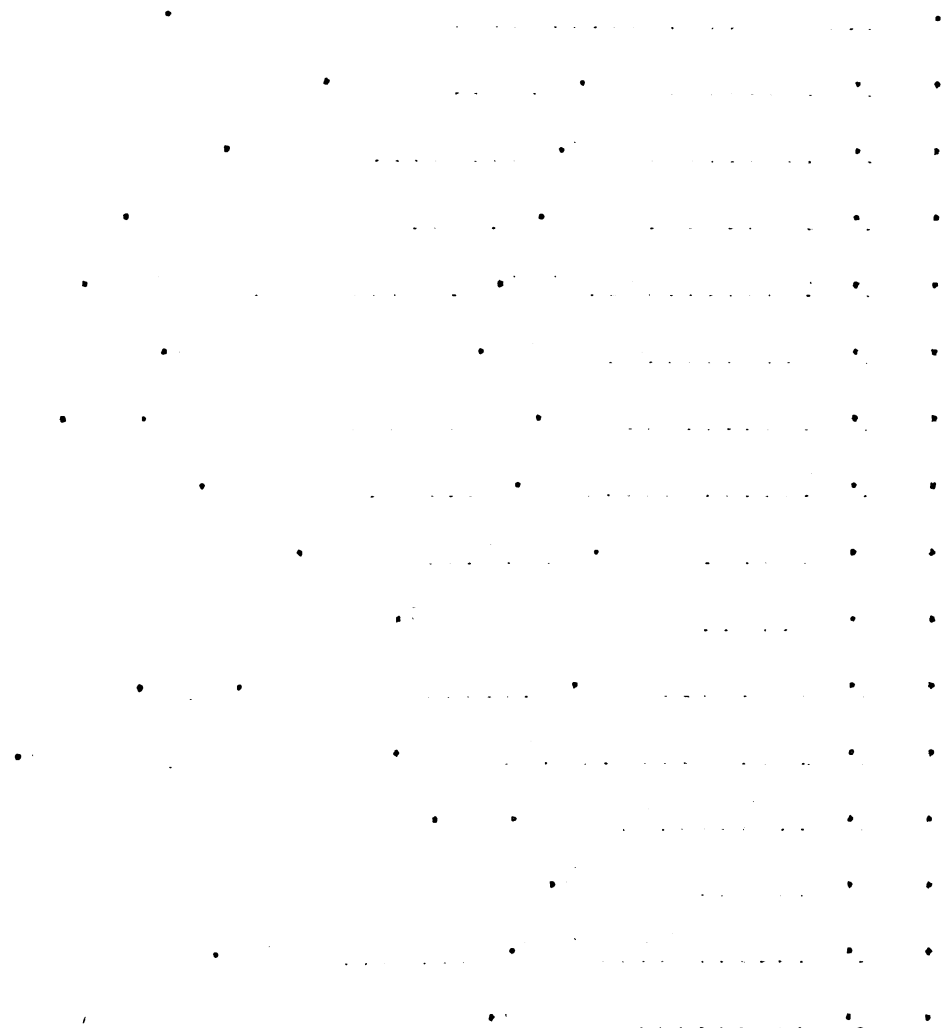

Plate 16

1. Cosmarium subdepressum West and West.
2. C. phaseolus fa. minor Boldt.
3. C. phaseolus var. elevatum Nordst.
4. C. bioculatum var. hians West and West.
5. C. trilobulatum var. basichondrum Nordst.
6. C. Pokornyanum (Grun.) West and West.
7. C. variolatum var. cataractarum Racib. fa.
8. C. trilobulatum fa. retusa Reinsch.
9. C. arctoum var. tatrica Racib.
10. C. minimum West and West.
11. C. angulare var. octangulare var. nov.
12. C. pseudopyramidatum var. stenonotum Nordst.
13. C. variolatum Lund. fa.
14. C. bireme Nordst.
15. C. geometricum var. suecium Borge.
16. C. galeritum Nordst.

Plate 17

1. Cosmarium pseudonitidulum var. validum West and West.
2. C. pseudopyramidatum var. carniolicum Luetk.
3. C. abbreviatum Racib.
4. C. abbreviatum var. minor West.
5. C. subcapitulum West.
6. C. sphagnicolum West and West fa.
7. C. refringens Taylor.
8. C. moerlianum var. brasiliense Borge fa.
9. C. difficile Luetk.
10. C. abbreviatum var. planctonicum West and West.
11. C. Regnellii var. minimum Eichl. and Gutw.
12. C. quadratulum var. applanatum Insam and Krieger.
13. C. Regnesii var. tritum West.
14. C. quadratulum (Gay) De Toni.
15. C. laeve var. octangularis (Wille) West and West.
16. C. clepsydra Nordst.
17. C. monomazum var. polymazum Nordst.
18. C. excavatum var. duplo-major Lund.
19. C. Wittrockii var. quasidepressum Skuja.
20. C. ordinatum (Boerg.) West and West.

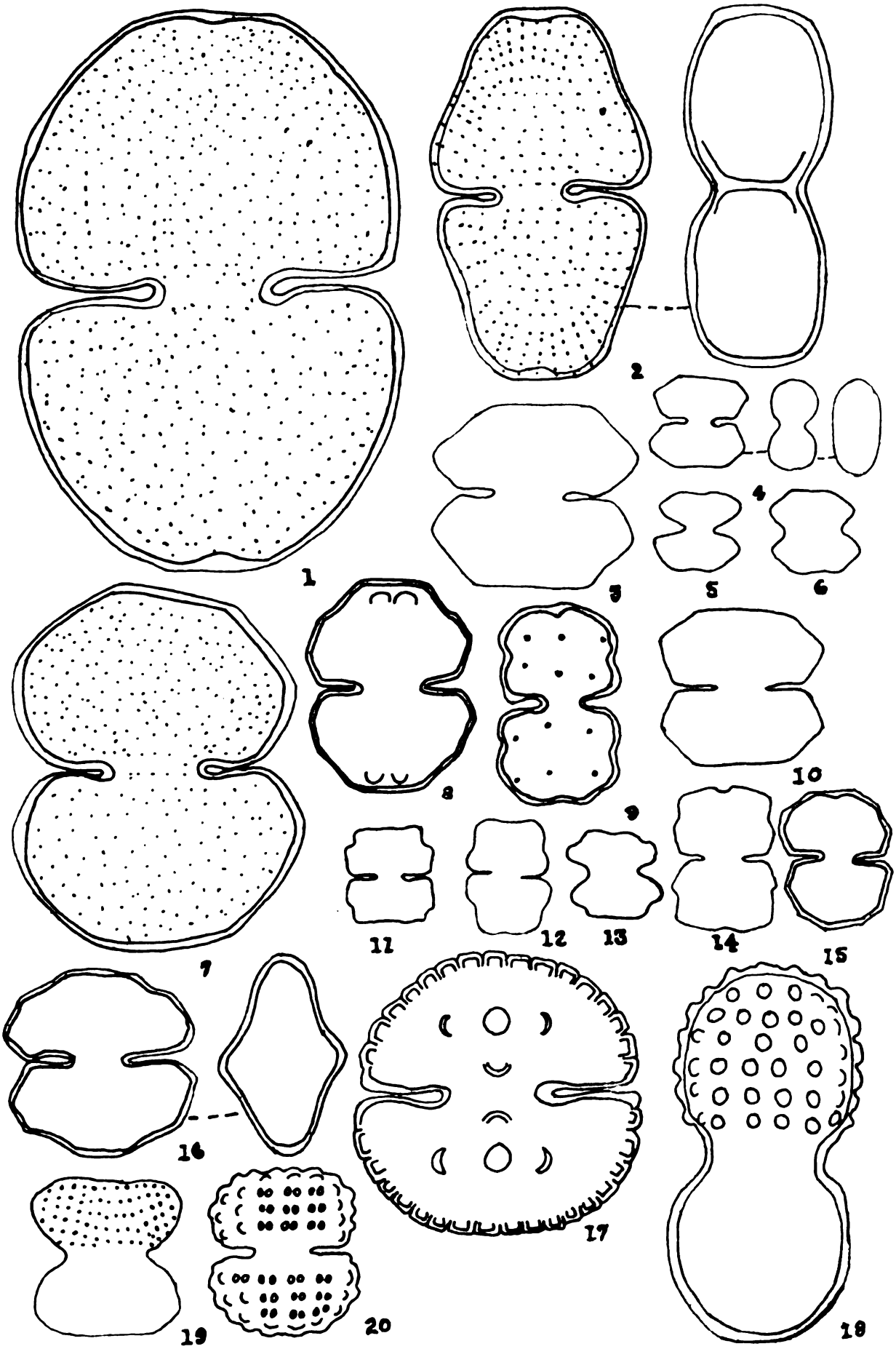
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Plate 18

1. Cosmarium elegantissimum var. simplicius West and West.
2. C. annulatum var. elegans Nordst.
3. C. Netzerianum Schmidle fa.
4. C. portianum var. nephroideum Wittr.
5. C. pseudoornatum Eichl. and Gutw.
6. C. taxichondrum var. Irenee-Marie nob.
7. C. taxichondrum var. obsoletumiforme var. nov.
8. C. taxichondrum var. nudum Turner.
9. C. protractum var. basigranulatum var. nov.
10. C. pseudotaxichondrum var. Foggii Taylor fa.
11. C. amoenum var. mediolaeve Nordst.

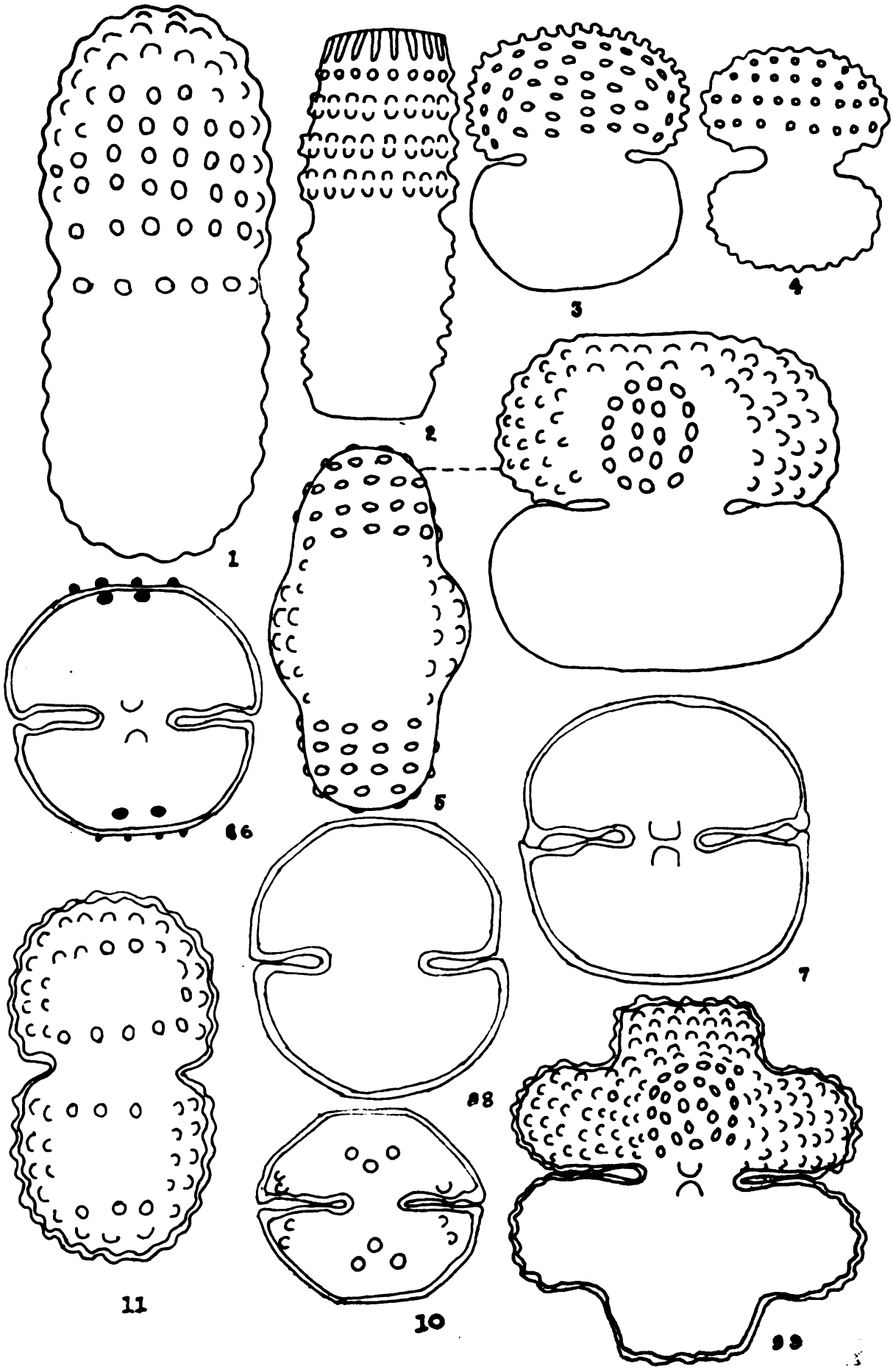
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Plate 19

1. Cosmarium subbroomei Schmidle fa. West and West.
2. C. amoenum Breb. zygospore.
3. C. commissurale var. crassum Nordst.
4. C. biretum var. minus Hansgirg.
5. C. binum Nordst.
6. C. sexnotatum var. tristriatum (Luetkm.) Schmidle.
7. C. novegicum Strom.
8. C. margaritatum var. ridibundum Taylor.

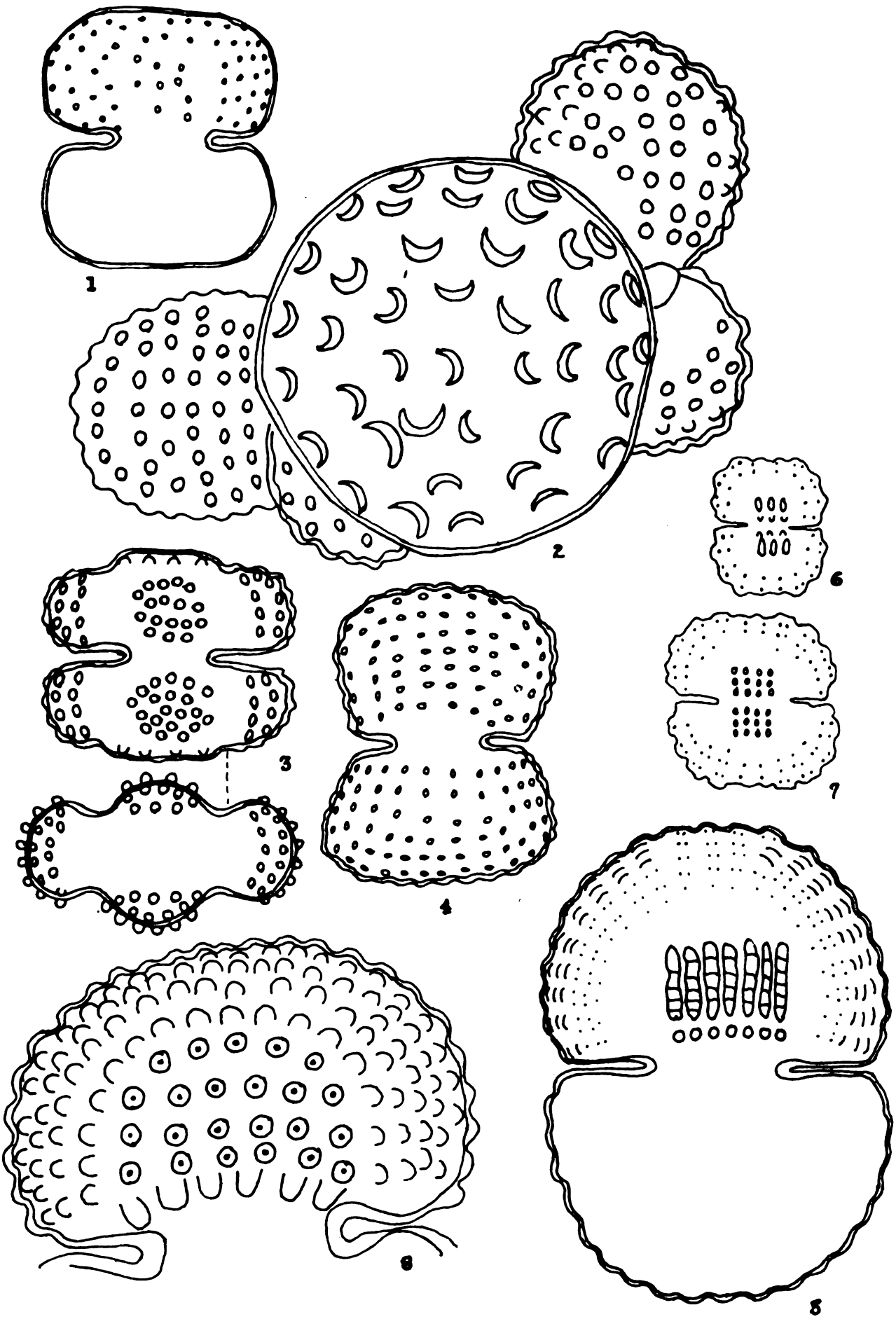
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Plate 20

1. Cosmarium margaritatum var. minor (Boldt) West and West.
2. C. ochthode var. navae-terrae Taylor nob.
3. C. gayanum var. eborascense G. W. West.
4. C. Botrytis var. subtumidum fa. Irenee-Marie nob.

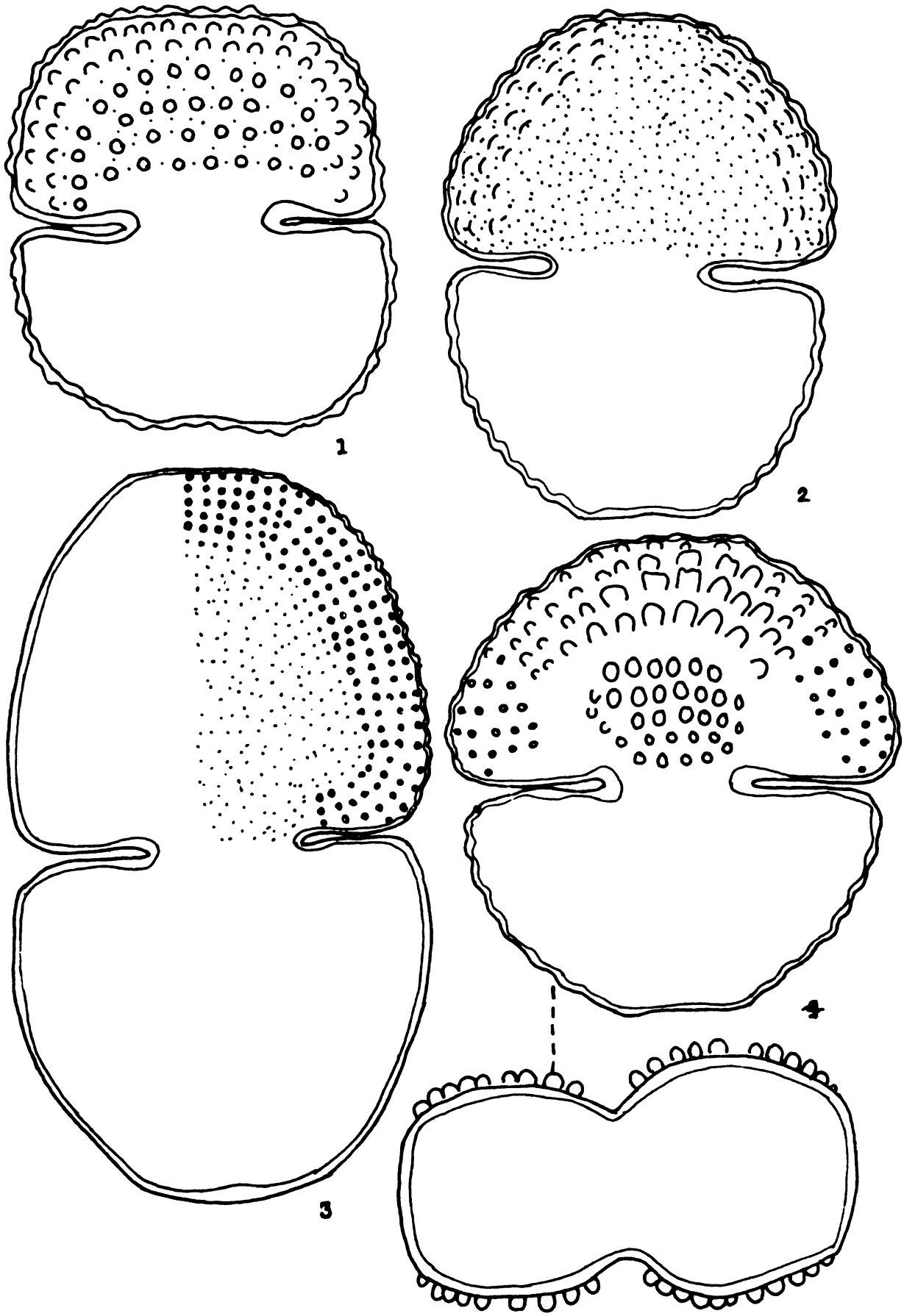
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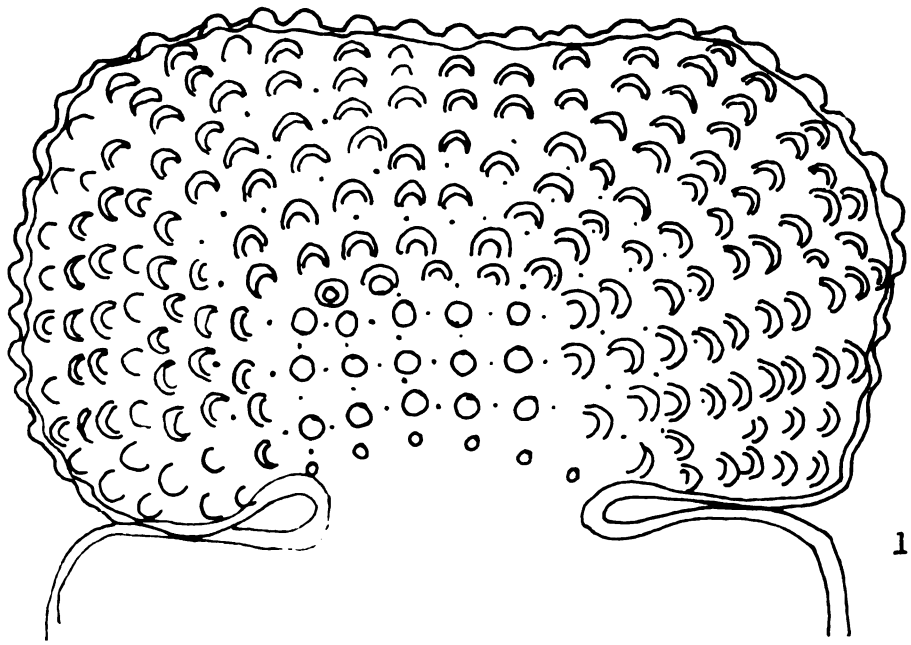
Plate 21

1. C. quadrum var. sublatum (Nordst.) West and West.
2. C. Botrytis var. tumidum fa. nudum fa. nov.



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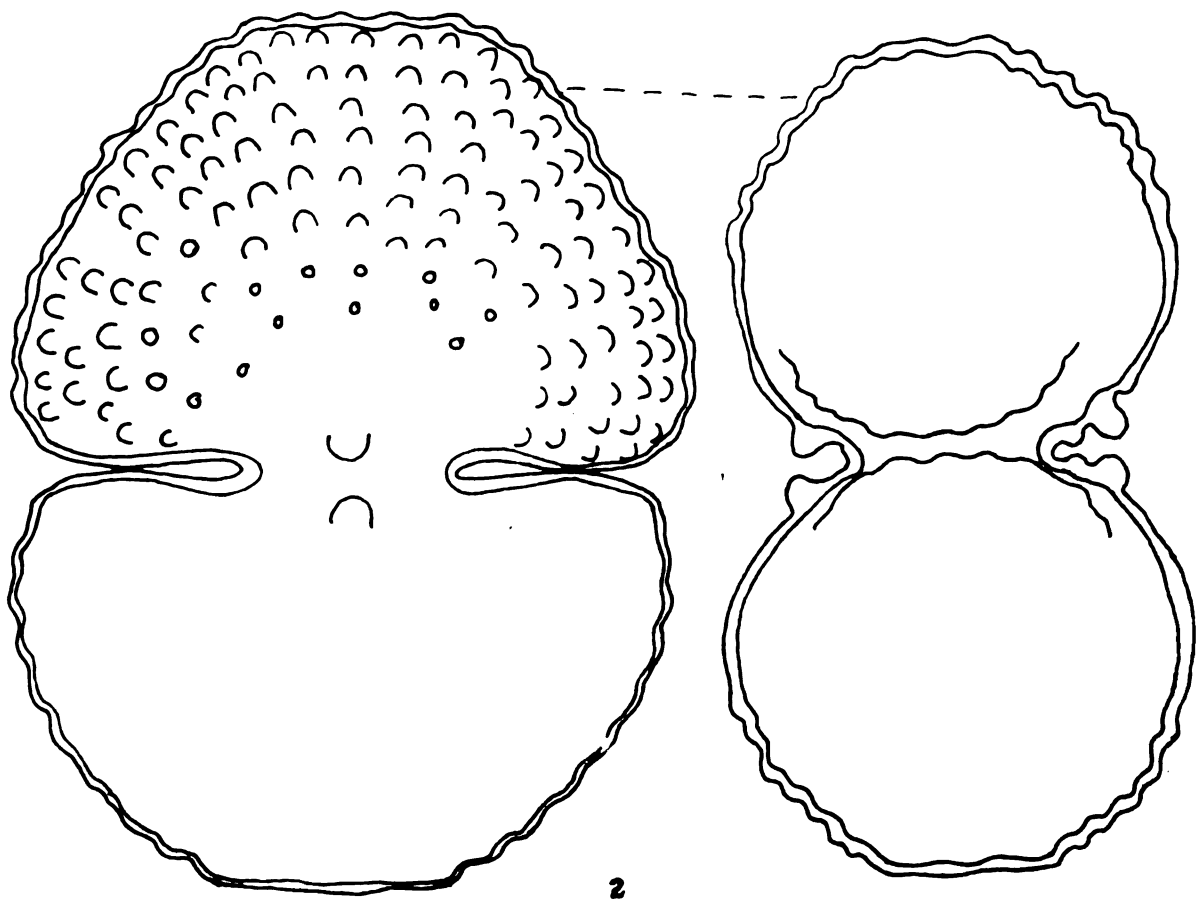

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Plate 22

1. Staurastrum brevispinum Breb.
2. S. brevispinum var. Boldtii Lagerheim.
3. S. brevispinum var. retusum (West and West) Borge.
4. S. orbiculare Ralfs.
5. S. orbiculare var. extensum Nordst.
6. S. orbiculare var. Ralfsii West and West.
7. S. subpygmaeum West.
8. S. clepsydra Nordst. fa.
9. S. pseudopachyrynchum Wolle.
10. S. Prescottii sp. nov.
11. S. Prescottii sp. nov.

Plate 23

1. Staurastrum grande var. parvum West.
2. S. punctulatum var. pygmaeum (Breb.) West and West.
3. S. cuspidatum var. maximum var. nov.
4. S. connatum var. americanum West and West.
5. S. dejectum var. inflatum West.
6. S. granulosum (Ehrenb.) Ralfs.

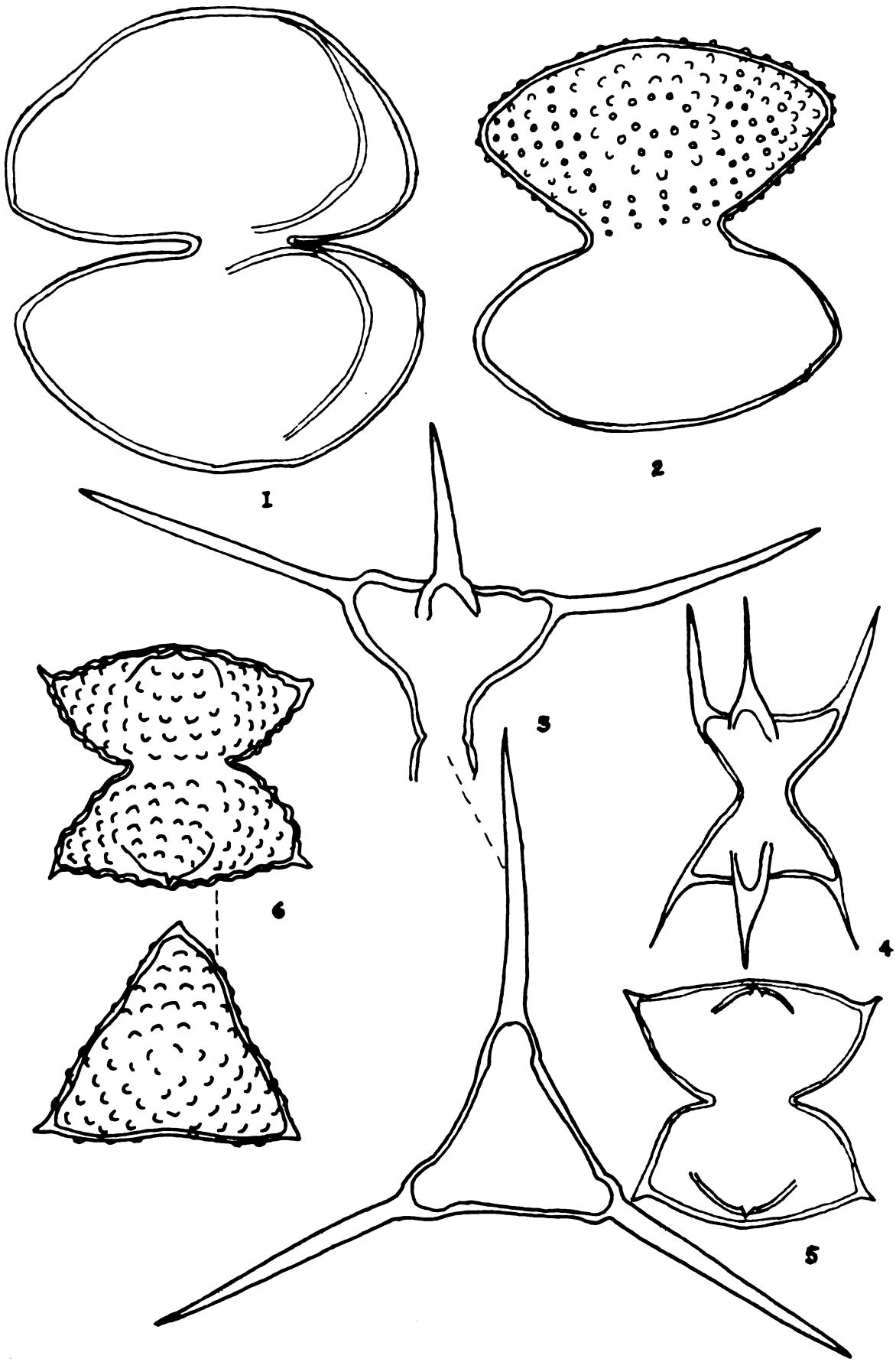
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Plate 24

1. Staurastrum quadrangulare var. armatum West.
2. S. trifidum var. inflexum West and West.
3. S. aviculoides Gronblad fa.
4. S. avicula var. subarcuatum (Wolle) West and West.
5. S. avicula var. coronulatum var. nov.
6. S. subcruciatum Cooke and Willis.

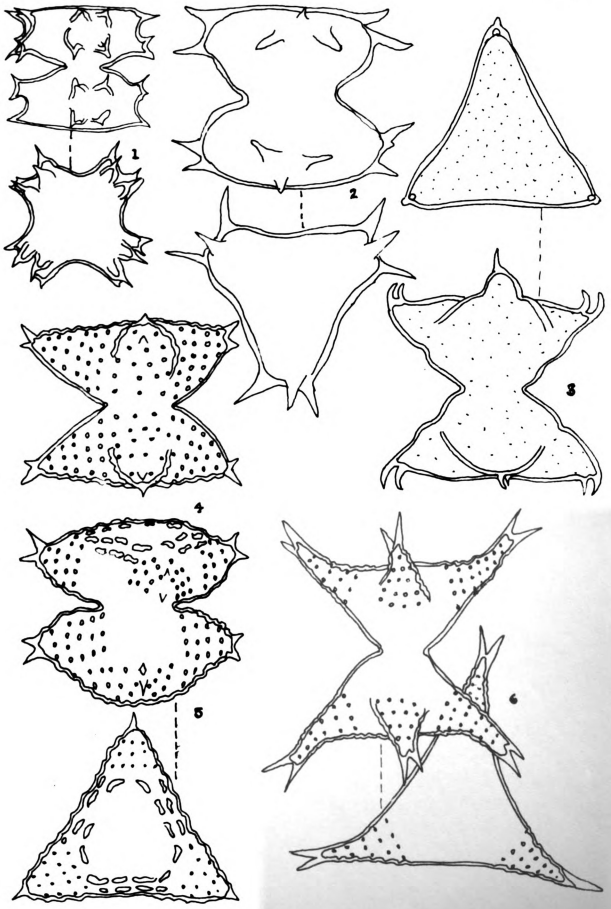
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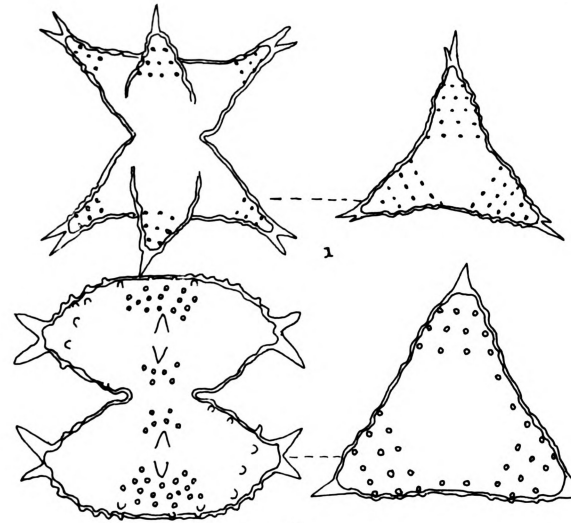
Plate 25

1. Staurastrum subcruciatum Cooke and Willis fa.
2. S. subdenticulatum Nordst. fa.
3. S. setigerum Cleve.



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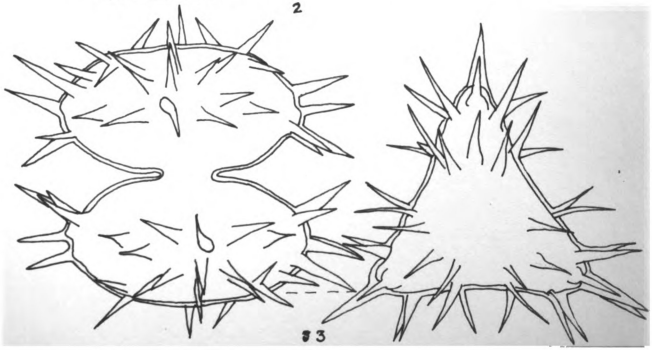

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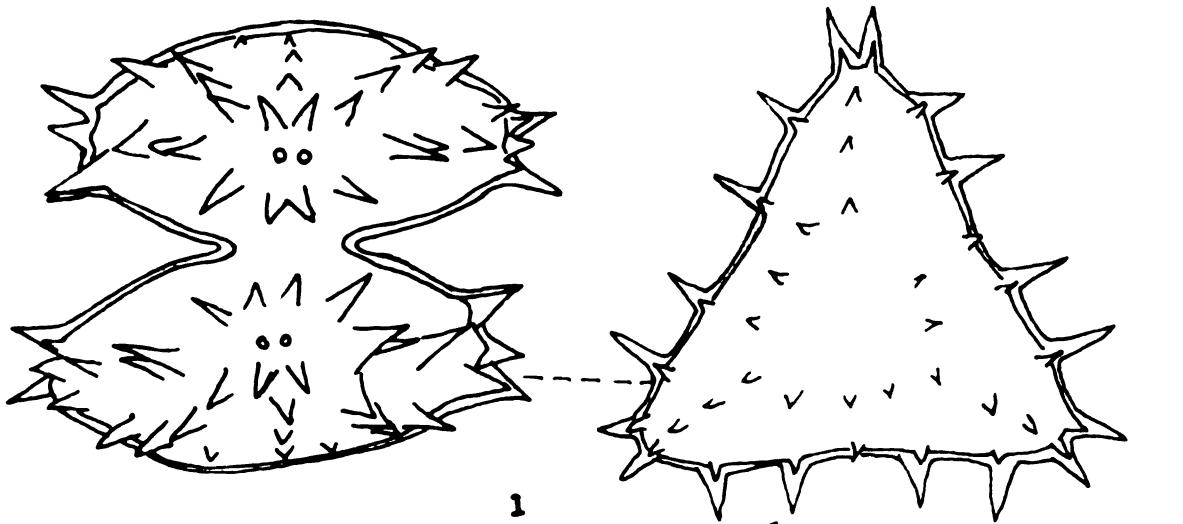
Plate 26

1. Staurastrum setigerum var. brevispinum G. M. Smith.
2. S. setigerum var. pectinatum West and West.
3. S. spiculiferum G. M. Smith.
4. S. muricatum Breb.
5. S. Bohlinianum Schmidle fa.



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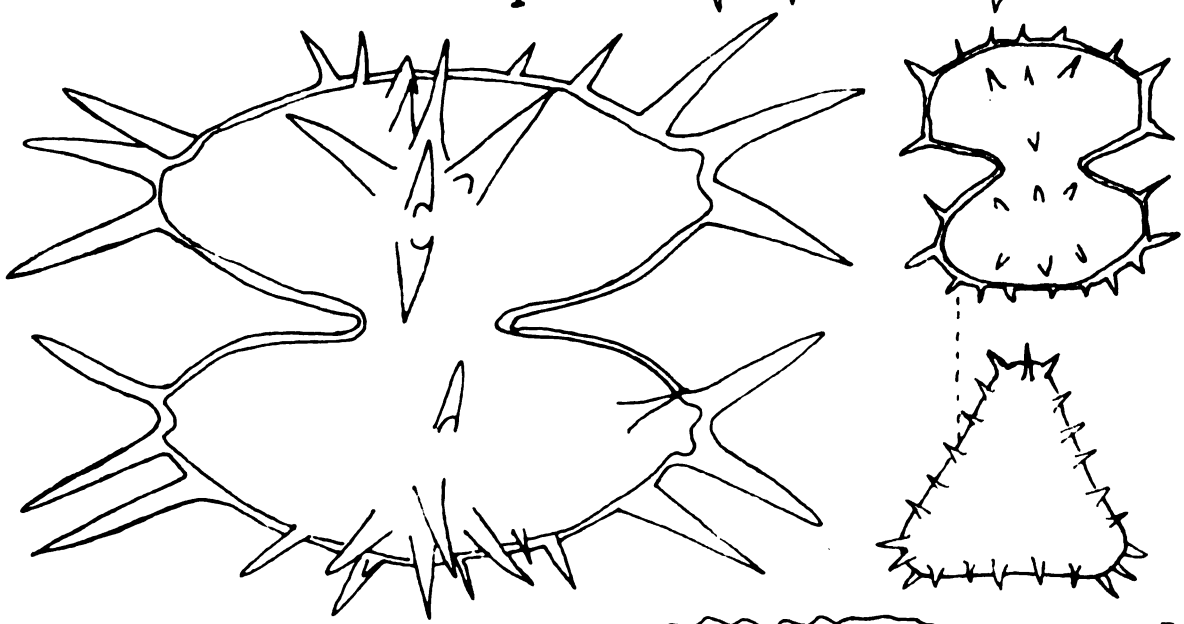

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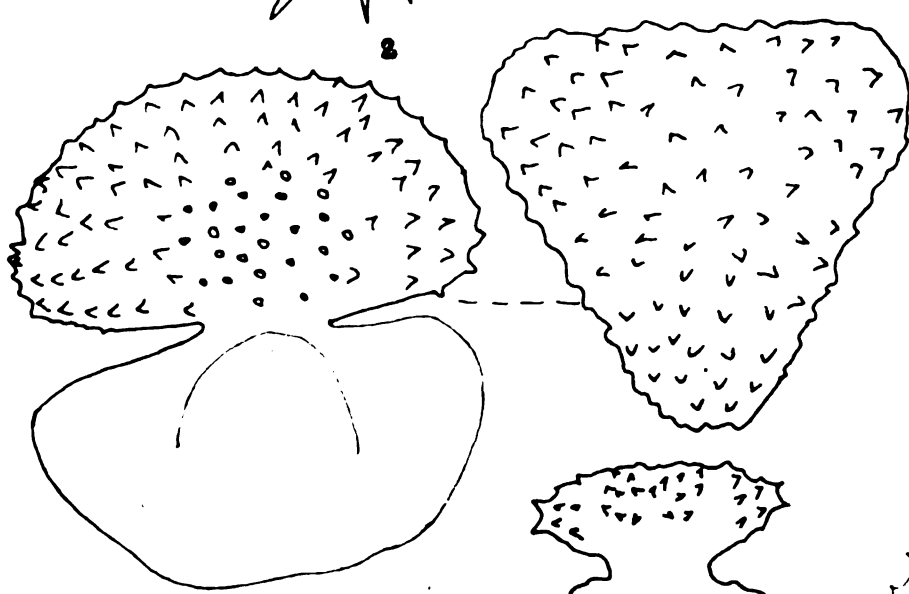

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Plate 27

1. Staurastrum pilosum (Naeg.) Archer.
2. S. spongiosum var. perbifidum fa. spinosa Irenee-Marie.
3. S. cornutum fa. reductum fa. nov.
4. S. brachiatum var. major var. nov.

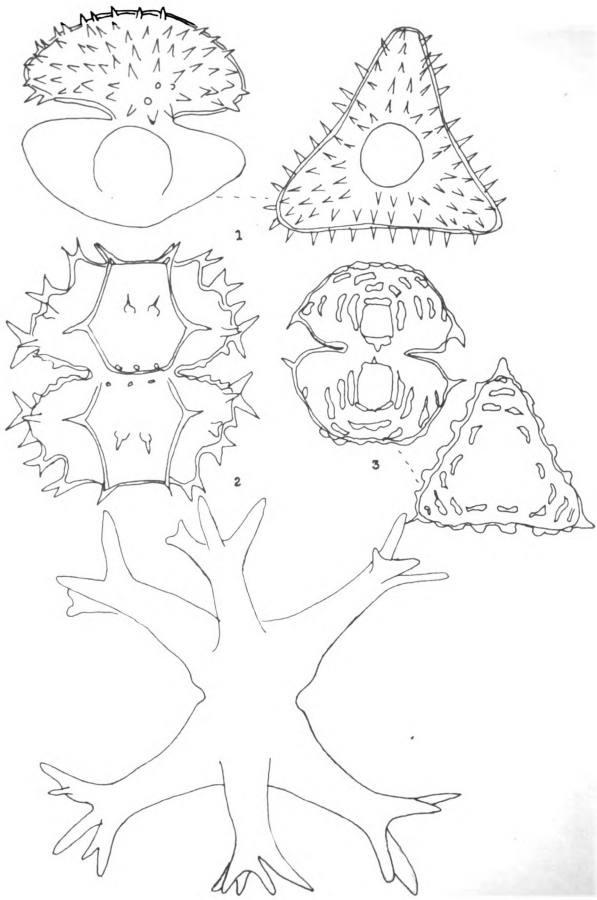
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Plate 28

1. *Staurastrum grallatorium* Nordst.
2. *S. grallatorium* var. *forcipigerum* Lagerh.
3. *S. natator* West.
4. *S. controversum* Breb.
5. *S. affine* West and West fa.
6. *S. subgracilimum* West and West.

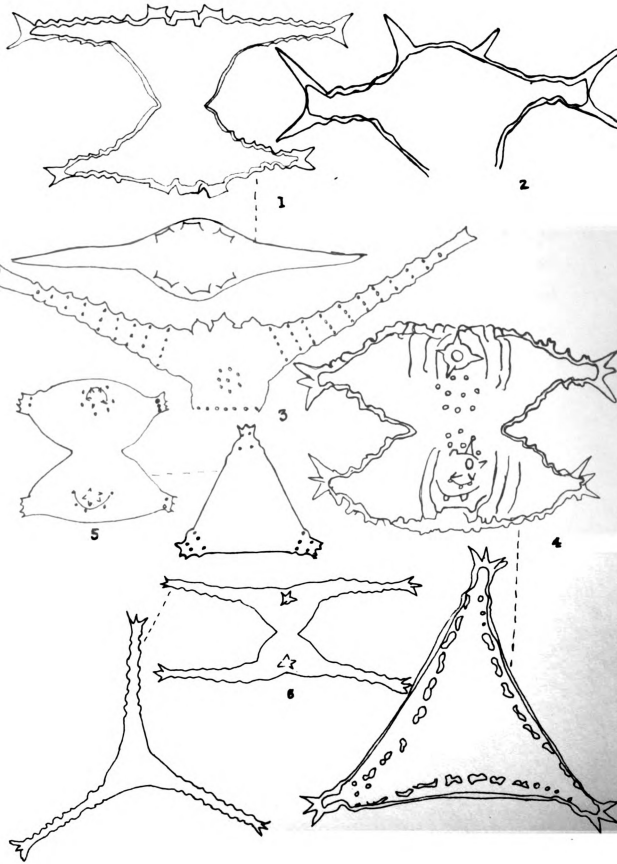
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Plate 29

1. *Staurastrum anchora* West and West.
2. *S. crenulatum* var. *britannicum* Messikommer.
3. *S. protectum* var. *planctonicum* G. M. Smith.
4. *S. Johnsonii* var. *depauperatum* G. M. Smith.
5. *S. Sebaldii* var. *ornatum* Nordst.
6. *S. proboscideum* var. *ornatum* var. nov.
7. *S. rugosum* Irenee-Marie.

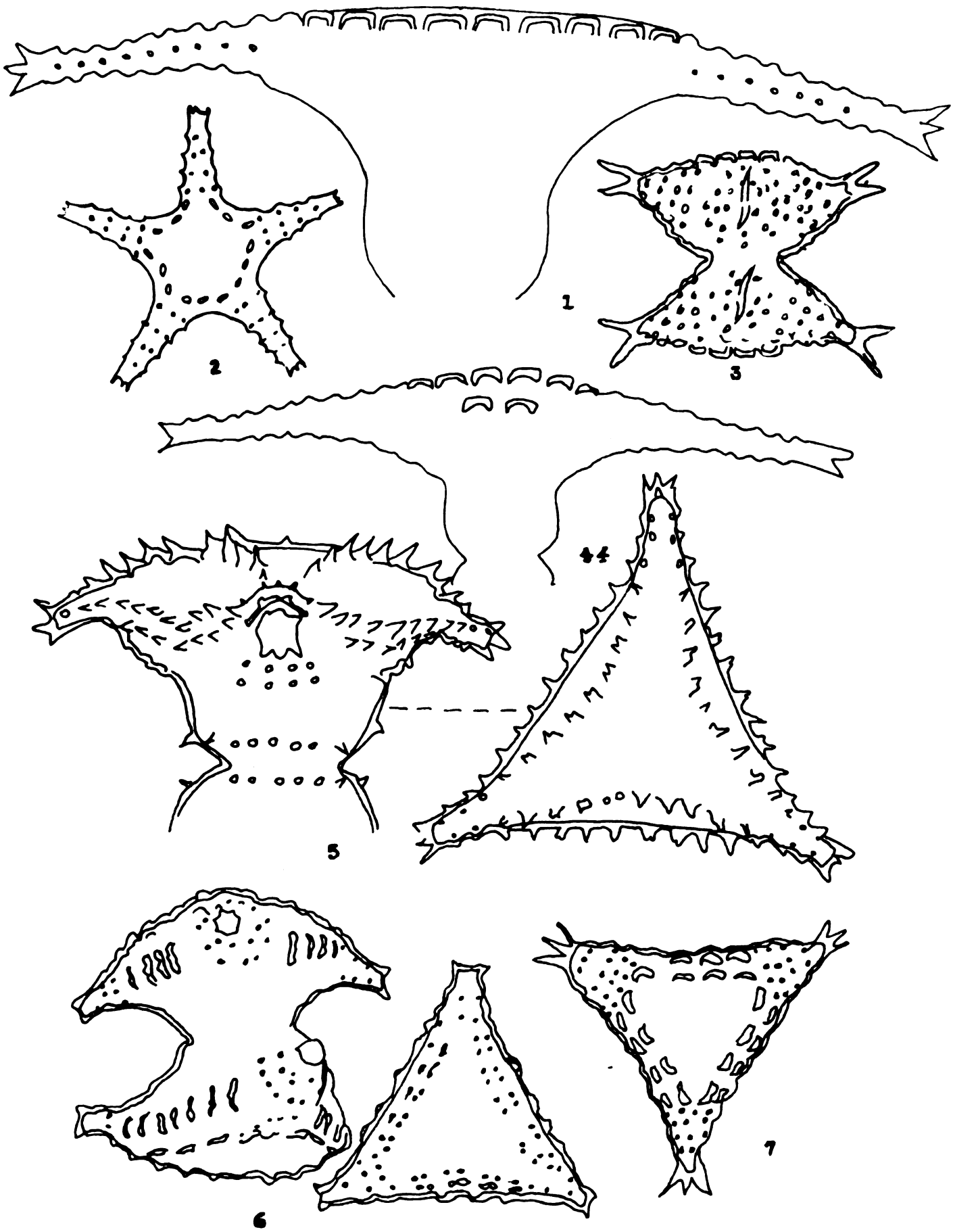
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Plate 30

1. *Staurastrum anatinum* var. *truncatum* West.
2. *S. quebecense* var. *ornatum* var. nov.
3. *S. boreale* West and West.
4. *S. gracile* var. *coronatum* Boldt.
5. *S. vestitum* var. *semivestitum* fa.

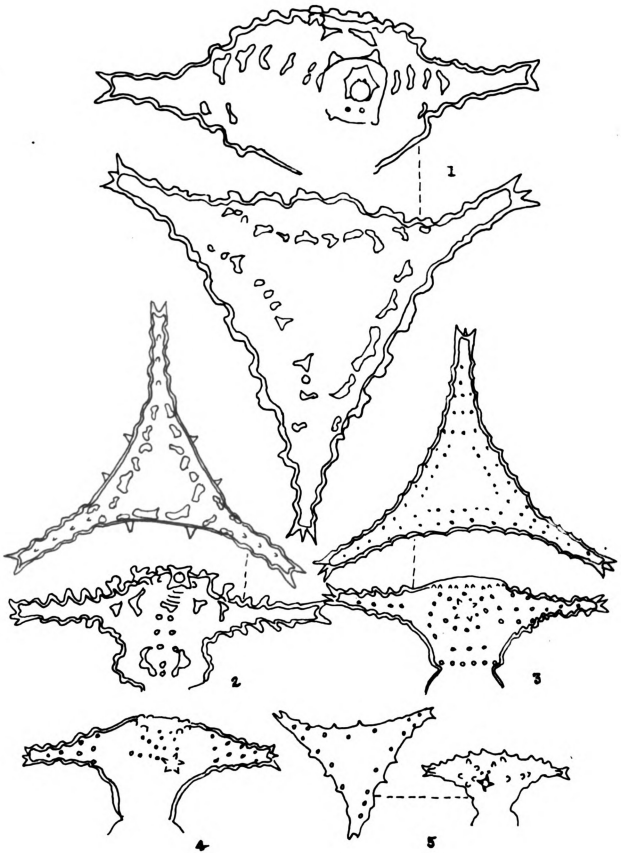
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Plate 31

1. *Staurastrum floriferum* West and West.
2. *S. gyrans* Johnson.
3. *S. distentum* var. *Michiganensis* var. nov.
4. *S. distentum* var. *Michiganensis* var. nov.
5. *S. furcatum* var. *pisciforme* Turner.

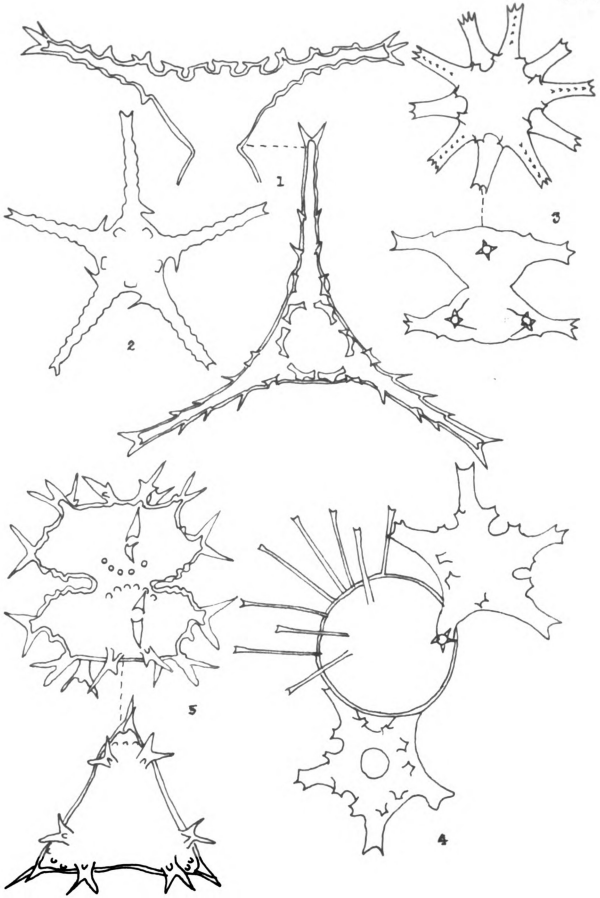
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Plate 32

1. *Staurastrum ankyroides* var. *pentacladum* G. M. Smith.

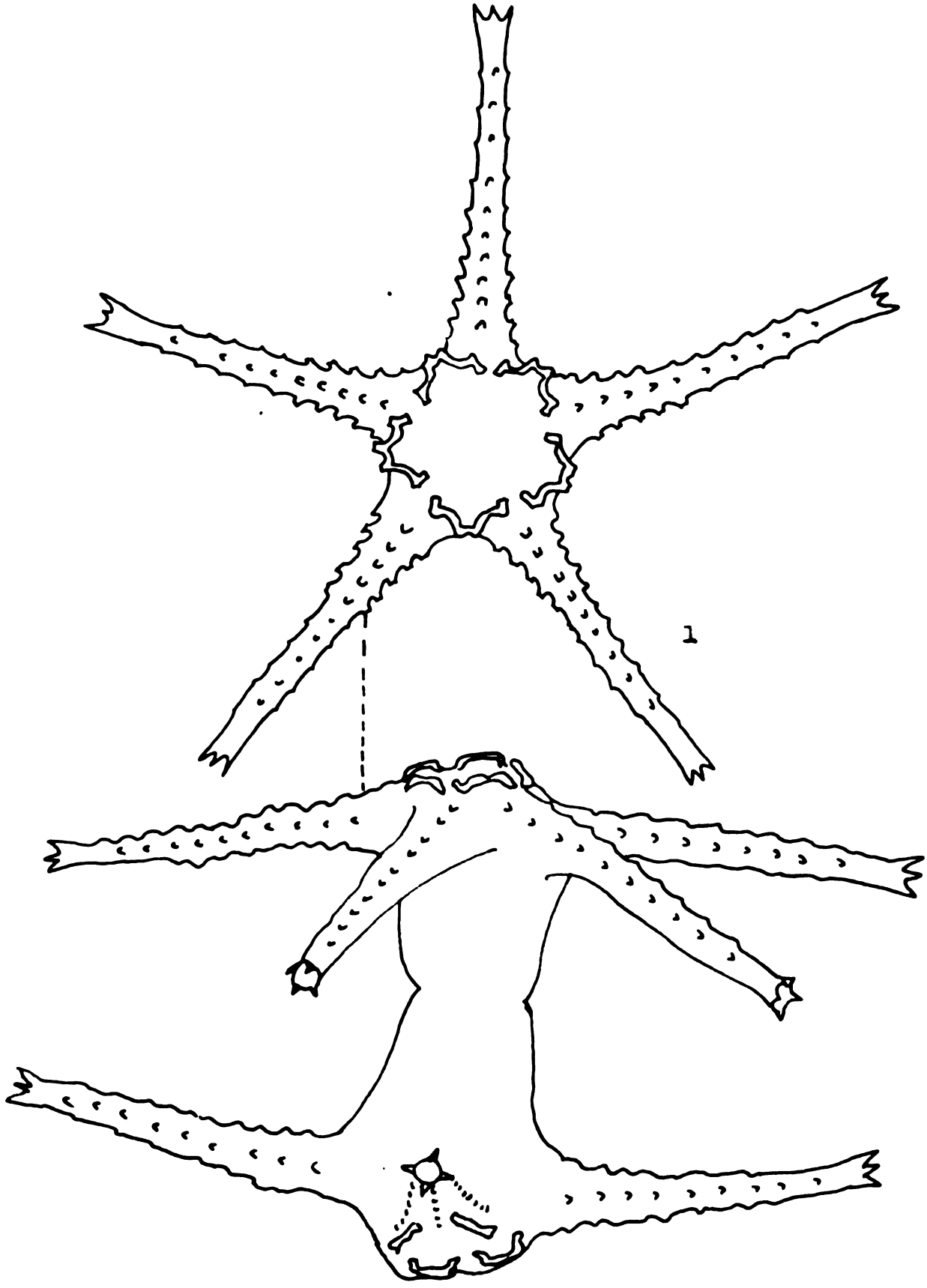
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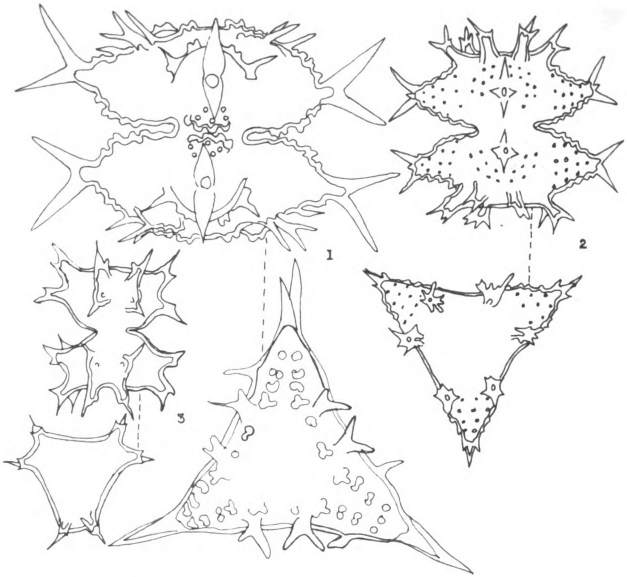
Plate 33

1. Staurastrum forficulatum var. cornutiforme var. nov.
2. S. arcuatum var. pseudopisciforme fa. Irenee-Marie nob.
3. S. gemelliparum Nordst.
4. S. tohopekaligense var. brevispinum G. M. Smith.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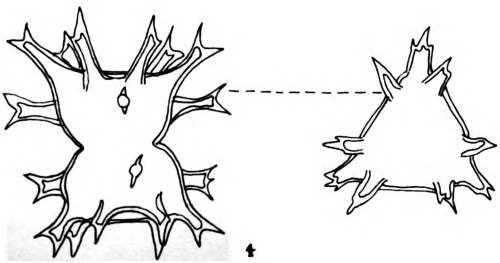
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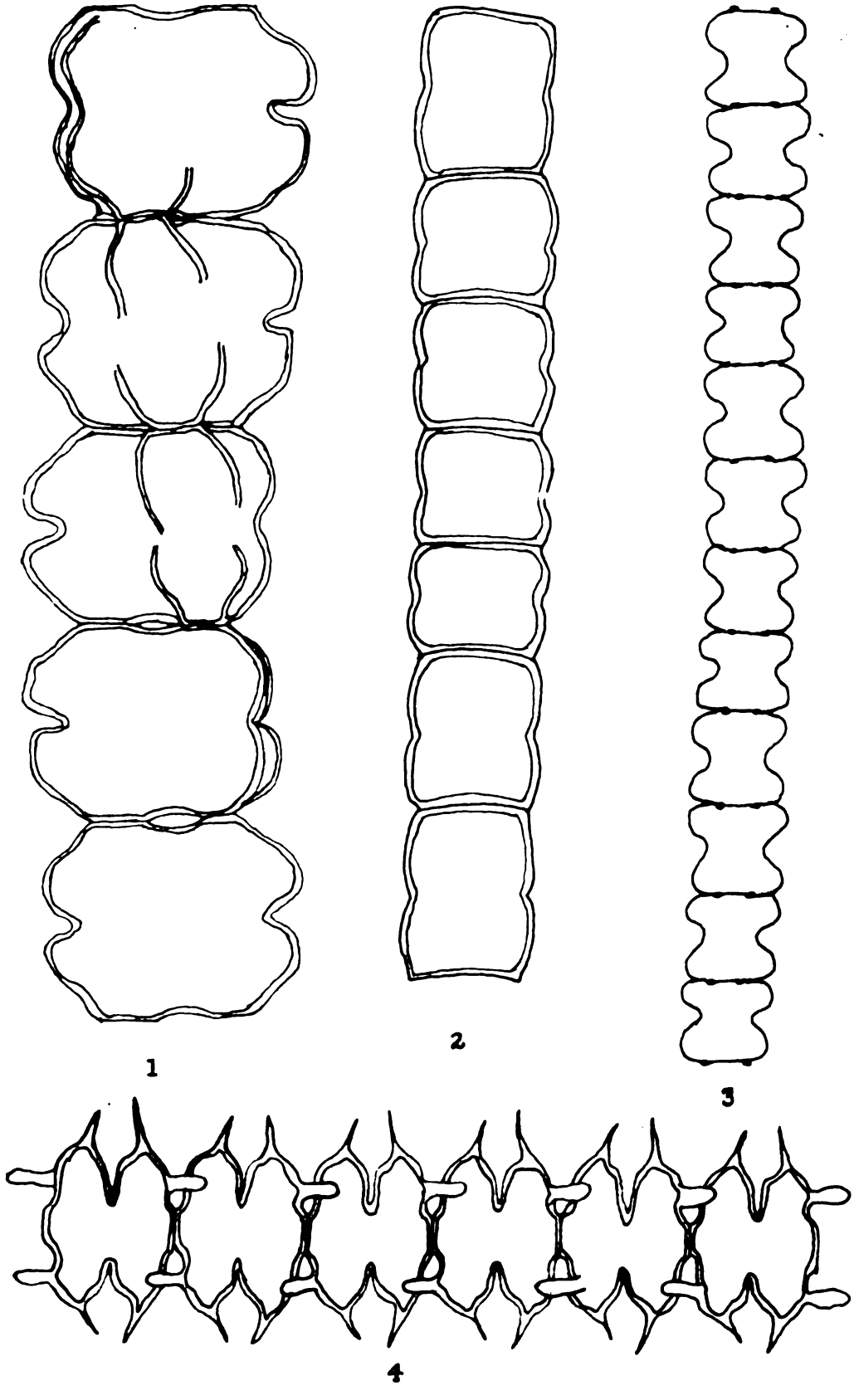
Plate 34

1. Staurastrum furcatum var. Taylorii var. nov.
2. S. furcatum fa. spinosa Gronblad.
3. S. bicoronatum Johnson.

Plate 35

1. Desmidium occidentale West and West.
2. Hyalotheca dissiliens var. tatrica Racib.
3. Sphaerozosma exiguum Turner.
4. Onychonema laeve var. latum West and West.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