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A taxonomic and ecological study of the desmids of Lily Lake

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A TAXONOMIC AND ECOLOGICAL STUDY OF THE DESMIDS OF LILY LAKE

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CHAPTER I

INTRODUCTION

The purpose of this study is to determine the species of desmids found in Lily Lake, a subalpine lake in the Uinta Mountains of Utah. This lake was selected as a study site as it is an acidic, cold, lentic bog pond characteristic for desmid growth. Descriptions and keys to the genera and species are included. Each species is categorized also to its relative frequency.

Desmids belong to the class Chlorophyceae (or Green Algae), the order Conjugatae and the family Desmidiaceae. Desmidiaceae are minute, unicellular or sometimes united into colonies of a more or less fragile nature. The cells are variable in form, usually constricted in the middle forming two symmetrical halves or semicells. The cell-wall in the majority of desmids exhibits characteristic surface markings.

Available information on the desmids of a subalpine lake in Utah is limited. Palmer (1968) reported fourteen genera and seventy-eight species in her studies of Lilly Lake. Coombs (1964) listed seventeen genera and ninety-six species of desmids from lakes, meadows, ponds, rivers and riverlets of the Western Uinta Mountains and adjacent areas. Seventeen of the species were reported only in the rivers or riverlets. Forty-four species from Mirror Lake were listed by Snow (1940). Flowers (1939) listed sixteen genera and 120 species in his studies of the "Algae of Utah". Snow and Stewart (1939) listed twenty-eight species in a preliminary report of the algae of Mirror Lake, Utah. Tanner (1931)

reported twenty-one genera and identified five species. Norrington (1925) reported finding desmids in the streams and lakes of the Uinta Mountains, but gives no listing of genera or species.

In the above reports, no information was given concerning the relative frequencies or the descriptions of the genera and species. The data were from individual samples and do not cover the growing season. The reports list only the species or genera present. Data were gathered for an entire growing season in the present study.

Lily Lake is located in the Wasatch National Forest T15, R9E, S31 of the Uinta Mountains. It is one-half mile west of Trial Lake at an elevation of approximately 10,000 feet (Christensen and Harrison, 1961). The only access to the lake is by walking a trail from Trial Lake. The lake is surrounded by a sedge meadow that grows in peat soil. The peat is floating on the water in the deepest end of the lake. This peat has been measured to a depth of twenty feet under the meadow (Christensen and Harrison, 1961).

The lake is small, about five hundred feet long and two hundred feet wide. Christensen and Harrison (1961) report that the lake's maximum depth is sixteen feet. The water was clear during the entire growing season. No silt was observed due to the melting of spring snows or incoming rain water.

In cooperation with the United States Forest Service, the lake and surrounding forest have been set aside as a study area for the Botany Department of Brigham Young University (Christensen and Harrison, 1961).

CHAPTER II

METHODS AND MATERIALS

Desmids were collected weekly from seven sampling stations located at different sites throughout the lake (Figure 1). Nineteen collecting trips were made from June 26th through the 7th of November 1964 (Table 1). Collections were made in 1965 and may be referred to individually, but are not included collectively in this report. Environmental data of the water were recorded each week. No data were taken during the winter months.

Surface samples were taken by means of a plankton net at stations one, two, and seven. The net was thrown from the shore into the lake and pulled back to the shore at stations one and two. A boat was used to pull the net along the surface of the water at station seven.

Periphyton samples were collected at stations one, three, four, five, and six. At station one the samples were obtained by scraping material from the stem and lower side of the leaf of the water lilies, from organic matter lying on the bottom of the lake, from the wood of branches and logs in the water, and from dead grass and sedge leaves which were attached to the shore below the water level. The water at this station was never over two feet deep during the collecting period. The samples obtained at station three consisted of material scraped from a sheet of glass, a naturally occurring submerged log, and from organic matter of a floating peat mat. The glass sheet was

Figure 1. Map of Lily Lake, Utah. Enlargement. (Christensen and Harrison, 1961)

TABLE 1

ENVIRONMENTAL DATA ON LILY LAKE

Date	pH	Water Temp. °C	Air Temp. °C	ppm Oxygen	Day Length Hrs.	Min.	Light Conditions	Time of Day	Comments
6-26-64	5.9	17°	17°	---	15	5	2	1:00	Run off heavy
7-4-64	---	20°	21°	---	15	0	5	3:30	
7-11-64	5.0	23°	25°	---	14	53	5	2:00	Run off decreasing
7-18-64	6.1	23°	25°	---	14	45	6	11:30	Water entering lake less 1cfs (estimate)
7-24-64	7.2	23°	25°	---	14	34	7	12:00	
8-1-64	---	20°	21°	5.5	14	18	5	12:00	
8-8-64	7.4	21°	23°	6.0	14	04	5	1:00	
8-15-64	---	18°	18°	6.0	13	46	6	10:15	
8-22-64	7.2	16°	17°	5.5	13	31	7	11:30	

TABLE 1 Continued

Date	pH	Water Temp. °C	Air Temp. °C	ppm Oxygen	Day Length Hrs.	Min.	Light Conditions	Time of Day	Comments
8-29-64	7.2	13°	13°	7.5	13	17	7	11:00	First trace of snow
9-4-64	---	14°	19°	7.0	12	59	7	11:15	
9-11-64	---	14°	16°	6.5	12	40	6	11:00	
9-18-64	---	12°	7°	7.9	12	23	2	1:30	Stormy day
9-29-64	---	11°	9°	7.6	12	2	4	10:00	
10-3-64	7.5	12°	8°	8.1	11	41	7	3:00	
10-9-64	---	12°	15°	6.7	11	15	4	12:00	
10-16-64	7.2	7°	15°	8.2	11	4	5	9:15	Ice around shore out 12-18 inches
10-28-64	---	7°	12°	8.3	10	57	4	3:15	Ice around shore out 12-18 inches
11-7-64	7.2	4°	9°	---	10	40	5	11:30	Ice covered lake 2 1/2 inches thick

suspended in about six feet of water and touched the bottom of the lake. The organic matter consisted of dead grass and sedge leaves, sphagnum stems and leaves, and organic matter that adhered to the log.

Stations four, five, and six were artificial glass habitats for growth. The sheets of glass were irregular, varying in shape from six to twelve inches wide. The glass was suspended at a depth of thirty inches at station four, sixty inches at station five, and ninety inches at station six. The periphyton samples were obtained by scraping material from this glass.

After the samples were removed from the lake, they were preserved in FAA solution.[1] They were then brought to the laboratory and centrifuged. The supernatant was poured off and the material was placed in a twenty percent KOH solution for at least two weeks. The samples were again centrifuged and the supernatant poured off. The samples were then washed in distilled water to remove the KOH. The water was removed by centrifuging and decanting, and the samples were preserved in a ten percent glycerin and ninety percent distilled water solution.[2] The samples were then mounted directly on a slide and examined for desmids present. During the examination of samples collected, some of the smaller desmids, less than fifteen microns, could have been overlooked due to their small size and the scanning methods used to observe the desmids present. Scanning was done with

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[1] FAA solution

50% Alcohol	90 c.c.
35-40% Formalin	5 c.c.
99% Acetic Acid	5 c.c.

[2] Interview with Kent McKnight, Chairman Botany Dept., Brigham Young University, 1964.

magnification of 100X and identification at 430X.

Collections of samples were made as early as 9:15 A.M. and as late as 3:30 P.M. during the growing season (Table 1).

Light conditions at the time of collecting were recorded by an arbitrary scale as follows: (1) stormy, (2) very overcast or cloudy, (3) overcast or cloudy, (4) bright though cloudy, (5) bright and clear with very high and thin overcast, (6) bright and clear, and (7) extremely bright and clear (Table 1).

The dissolved oxygen was measured in parts per million with a Yellow Spring Instrument Oxygen Meter, Model 51. The temperature of the water was determined with a centigrade thermometer at the time collections were made. The pH was measured at the same time with a Beckman pH Meter, Model G.

The length of the day in hours and minutes (Table 1) is the time between sunrise and sunset as given by the U. S. Weather Bureau at Salt Lake City, Utah.

Eight samples were taken during each collecting trip. Each species was listed as present or absent in the lake. A record of presence might refer to a single individual of a desmid species or a great many individuals. The term "percent frequency" used in this study refers to the number of times the species was collected in the lake during the nineteen collections made. For example, *Closterium Cynthia* occurred four times out of the nineteen collections. Thus, it has a percent frequency of 21%.

Identification was based on the structure of the cell-wall. The shape, size and surface markings were used to identify and describe the genera and species. Four volumes on the British

Desmidiaceae by W. West and G. S. West (1904-1912) and one volume on the British Desmidiaceae by Carter (1923) are the principle keys used to identify and describe the desmids. The Flore Desmidiale de la Region de Montreal by Irenee-Marie (1938) and British Desmidieae by Ralfs (1848) have keys and descriptions that were used to identify species not found in the British Desmidiaceae. Irenee-Marie contributions in Hydrobiologia (1952, 1956, 1957a, 1957b) were used as reference material to correctly establish identifications to some species.

CHAPTER III

RESULTS

Seventeen genera with 167 species of Desmidiaceae were obtained from Lily Lake (Table 2). There were ninety-four different species in this study that have not been reported in Utah waters. This does not include those that were keyed to genus only. Three genera, *Cosmarium*, *Closterium* and *Staurastrum* accounted for 101 of the 167 species and were the dominant genera.

The percent frequency of each species is reported in Table 2. On the basis of their percent frequency, each of the desmids was placed in one of five groups: (i) abundant, (ii) common, (iii) frequent, (iv) occasional, and (v) scarce.

Fourteen species were categorized as being abundant (i). *Euastrum Didelta*, *Triploceras gracile*, *Cosmarium margaritiferum*, and *Xanthidium armatum* var. *fissum* were the most abundant species occurring with a frequency of 100%. Five species had a frequency of 95%; four species showed a frequency of 90% and one had a frequency of 84% (Table 2).

The common group (ii) of algae showed twenty-two species with a range of 60% to 79%. Twenty-four species were in the 40% to 59% frequent group (iii). The occasional group (iv) was represented by forty-three species in the 20% to 39% range. The largest group, with sixty-four desmid species, is the scarce category (v) with a percent frequency of 5% to 19%.

TABLE 2

SPECIES FOUND IN RELATIONSHIP TO COLLECTION WEEKS AND ABUNDANCE

Species	Percent Frequency	1964 J. 26	July 4	11	18	24	August 1	8	15	22	29	September 4	11	18	29	October 3	9	16	28	N. 7
Abundant Species																				
Euastrum Didelta	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Triploceras gracile	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cosmarium margaritiferum	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Xanthidium armatum var. *fissum*	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Netrium Digitus	95	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Pleurotaenium Ehrenbergii	95	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Cosmarium pyramidatum	95	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Staurastrum ophiura	95		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Gymnozyga sp.	95	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Closterium calosporum	90		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x
Euastrum aboense	90	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
Pleurotaenium nodosum	90		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
Micrasterias muricata	90	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Staurastrum cerastes	84	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x
Common Species																				
Closterium angustatum	79	x	x	x	x	x	x	x	x	x		x	x	x	x	x				x
Euastrum obesum	79	x	x	x	x	x	x	x	x	x		x	x	x			x	x	x	
Cosmarium undulatum	79		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x		
Cosmarium Phaseolus var. *elevatum*	74	x	x	x	x	x	x					x	x	x	x	x	x	x	x	
Cosmarium contractum forma *Jacobsenii*	74	x	x	x	x	x	x					x	x	x	x	x	x	x	x	
Cosmarium orbiculatum	74		x	x	x	x	x	x	x	x	x	x	x	x	x	x				
Staurastrum setigerum	74		x		x	x	x	x	x	x	x	x	x	x	x	x				x
Staurastrum furcatum	74	x	x	x	x	x	x	x	x	x		x	x	x	x	x				
Closterium didymotocum	68	x	x	x	x	x	x	x	x	x	x			x	x	x				
Euastrum elegans	68	x	x	x	x	x				x		x	x	x	x	x	x	x		
Cosmarium tumidum	68	x	x	x	x	x	x	x	x	x	x	x	x			x				

TABLE 2 Continued

Species	Percent Frequency	1964 J. 26	July 4	11	18	24	August 1	8	15	22	29	September 4	11	18	29	October 3	9	16	28	N. 7
Cosmarium ornatum	68	x	x	x	x	x	x					x	x	x	x	x	x	x		
Cosmarium Boeckii	68			x	x				x	x	x	x	x	x	x	x	x	x		x
Xanthidium antilopaeum var. *laeve*	68		x	x	x	x	x	x	x	x	x	x	x			x				x
Xanthidium cristatum	68	x	x	x	x	x					x	x	x	x	x	x	x			
Arthrodesmus Bulnheimii var. *subincus*	68		x	x	x	x	x				x	x	x	x	x	x	x	x		
Staurastrum cornutum	68		x	x	x	x	x				x	x	x	x	x	x	x	x		
Desmidium cylindricum	68	x	x	x	x	x	x	x	x	x	x	x	x						x	
Closterium striolatum	63	x	x	x	x	x	x	x	x	x	x	x								x
Staurastrum anatinum	63		x	x	x	x	x	x	x	x	x	x				x				x
Staurastrum Arctiscon	63		x		x	x	x	x	x	x	x	x	x			x			x	
Staurastrum polymorphum	63	x	x	x	x	x	x					x				x	x	x	x	x
Frequent Species																				
Euastrum bidentatum	58	x		x	x							x	x	x	x	x	x	x		x
Closterium lineatum	53	x		x	x	x	x	x				x	x						x	x
Closterium Ralfsii var. *hybridum*	53	x		x	x	x	x	x	x	x				x						x
Euastrum humerosum	53	x	x	x	x	x	x					x				x			x	x
Euastrum denticulatum	53						x	x	x	x		x	x	x		x			x	
Triploceras verticillatum	53							x				x	x	x	x	x	x	x	x	x
Micrasterias depauperata var. *Wollei*	53	x	x	x	x	x	x	x	x	x		x								
Cosmarium venustum	53	x	x	x	x	x	x	x	x	x		x								
Xanthidium antilopaeum	53	x		x	x	x	x	x	x	x		x				x				
Staurastrum Brasiliense var. *Lundellii*	53		x	x	x	x	x	x	x	x	x	x								
Penium sp. (2)	47			x		x	x					x	x	x	x	x			x	
Closterium Archeranianum	47	x	x		x	x	x	x				x	x	x						
Euastrum crassum	47	x	x									x	x	x	x	x	x	x		
Cosmarium Hammeri var. *protuberance*	47	x	x	x	x	x	x	x	x	x										
Cosmarium furcatospermum	47	x	x	x	x	x	x	x	x			x								
Cosmarium quadrifarium forma *hexasticha*	47	x			x							x	x	x	x	x		x	x	

TABLE 2 Continued

Species	Percent Frequency	1964 J. 26	July 4	11	18	24	1	August 8	15	22	29	September 4	11	18	29	October 3	9	16	28	N. 7
Staurastrum gladiosum	47				x	x						x	x	x	x	x	x	x		
Desmidium Swartzii	47		x		x						x	x	x				x	x	x	x
Closterium laterale	42	x	x		x	x	x	x					x							x
Closterium Kutzingii	42	x	x	x	x	x	x					x								x
Euastrum binale forma *Gutwinskii*	42	x	x	x				x				x	x	x					x	
Micrasterias papillifera	42	x			x	x	x	x		x	x						x			
Cosmarium quadratulum	42		x	x	x	x	x					x	x	x						
Staurastrum orbiculare var. *Ralfsii*	42			x								x	x	x	x	x	x	x		
Occasional Species																				
Pleurotaenium Trabecula var. *rectum*	37	x	x	x							x	x				x				x
Arthrodesmus subulatus var. *Subaequalis*	37		x	x	x	x	x					x					x			
Netrium Nagelii	32				x							x	x	x	x	x				
Closterium intermedium	32				x	x					x			x			x			x
Micrasterias pinnatifida	32				x							x	x	x	x	x				
Micrasterias oscitans	32							x	x	x	x	x								x
Micrasterias conferta	32		x	x	x	x	x					x								
Cosmarium sp. (3)	32	x		x	x	x	x		x											
Cosmarium pseudopyramidatum	32		x	x	x	x	x					x								
Cosmarium subspeciosum var. *validius*	32			x								x	x	x					x	x
Cosmarium Eloisianum var. *depressum*	32		x									x	x	x			x		x	
Cosmarium viride	32		x											x	x	x	x	x		
Cosmarium obtusatum	32	x	x	x				x				x							x	
Cosmarium viride forma *glabra*	32	x	x	x	x	x	x													
Cosmarium nitidulum	32										x			x	x	x	x	x		
Desmidium Swartzii var. *ambyodon*	32		x	x				x	x		x	x								
Netrium oblongum	26		x	x	x	x	x													
Penium minutum	26				x		x					x	x	x						
Euastrum sp.	26	x		x										x	x	x				

TABLE 2 Continued

Species	Percent Frequency	1964 J. 26	July 4	11	18	24	August 1	8	15	22	29	September 4	11	18	29	October 3	9	16	28	N. 7
Euastrum insulare	26				x							x	x	x			x			
Cosmarium Cucumis	26			x	x	x	x					x								
Cosmarium angulosum	26	x	x		x							x								
Cosmarium Portianum	26	x	x					x						x			x			
Cosmarium subexcavatum var. *ordinatum*	26	x		x	x	x	x													
Cosmarium orthostichum var. *pumilum*	26		x		x							x					x			x
Xanthidium antilopaeum var. *hebridarum*	26		x	x				x			x	x								
Staurastrum punctulatum	26	x	x	x				x												x
Staurastrum gracile var. *coronulatum*	26											x	x	x			x			x
Staurastrum polymorphum var. *pusillum*	26	x	x	x			x					x								
Staurastrum anatinum var. *Lagerheimii*	26											x	x	x			x			x
Hyalotheca dissiliens	26				x							x	x			x			x	
Closterium Cynthia	21		x	x								x				x				
Closterium Pseudodiane	21	x										x	x			x				
Closterium sp. (3)	21				x							x	x	x						
Closterium sp. (4)	21			x		x						x				x				
Micrasterias Sol var. *ornata*	21				x	x					x	x								
Micrasterias radiata	21										x	x	x	x						
Cosmarium bioculatum	21			x	x							x					x			
Cosmarium subcrenatum	21	x	x	x								x								
Cosmarium norvegicum	21			x								x	x	x						
Cosmarium pseudamoenum	21		x		x	x						x								
Cosmarium quinarium forma *irregular*	21			x								x	x	x						
Arthrodesmus triangularis	21				x							x				x	x			
Scarce Species																				
Closterium sp. (1)	16	x											x						x	
Closterium lanceolatum	16			x								x							x	
Euastrum ansatum	16		x		x							x								

TABLE 2 Continued

Species	Percent Frequency	1964 J. 26	July 4	11	18	24	August 1	8	15	22	29	September 4	11	18	29	October 3	9	16	28	N. 7
Euastrum elegans var. *Novae Semliae*	16	x			x							x								
Pleurotaenium Ehrenbergii var. *undulatum*	16							x					x			x				
Micrasterias rotata	16							x					x	x						
Cosmarium amoenum	16		x	x	x															
Cosmarium elegantissimum forma *minor*	16			x	x	x														
Cosmarium denticulatum forma *Borgei*	16			x	x								x							
Cosmarium trachypleurum var. *minus*	16		x		x	x														
Cosmarium isthmochondrum	16	x			x							x								
Staurastrum alternans	16											x	x	x						
Staurastrum margaritaceum	16				x						x	x								
Sphaerozosma Wallichii var. *anglicum*	16			x	x															x
Desmidium quadratum	16	x									x					x				
Penium sp. (3)	11				x							x								
Closterium juncidium	11	x																		x
Closterium juncidium var. *elongatum*	11				x															x
Closterium Diane	11			x																x
Closterium sp. (2)	11				x															x
Closterium parvulum	11	x	x																	
Closterium sp. (5)	11											x	x							
Pleurotaenium maximum	11	x												x						
Micrasterias truncata	11															x				x
Micrasterias Sol	11				x							x								
Micrasterias papillifera forma *major*	11				x															x
Micrasterias apiculata var. *brachyptera*	11	x										x								
Micrasterias denticulata	11		x									x								
Micrasterias sp.	11				x							x								
Cosmarium sp. (1)	11	x			x															
Cosmarium melanosporum	11	x		x																
Cosmarium tinctum	11	x			x															

TABLE 2 Continued

Species	Percent Frequency	1964 J. 26	July 4	11	18	24	August 1	8	15	22	29	September 4	11	18	29	October 3	9	16	28	N. 7
Cosmarium sp. (2)	11		x		x															
Cosmarium moniliforme forma *punctata*	11	x									x									
Cosmarium sp. (4)	11			x								x								
Cosmarium refringens var. *minor*	11		x	x																
Cosmarium meneghinii	11	x						x												
Cosmarium difficile	11	x										x								
Cosmarium sp. (5)	11			x	x															
Cosmarium orthostichum	11											x								x
Cosmarium pseudoconnatum	11							x				x								
Cosmarium pseudamoenum var. *basilare*	11			x	x															
Arthrodesmus triangularis var. *inflatus*	11			x								x								
Arthrodesmus Ralfsii	11			x	x															
Staurastrum dilatatum	11		x																	x
Staurastrum cuspidatum	11	x										x								
Staurastrum cuspidatum var. *divergens*	11	x										x								
Staurastrum anatinum var. *truncatum*	11		x					x												
Staurastrum aculeatum	11			x																x
Onychonema filiforme	11				x						x									
Hyalotheca undulata	11							x	x											
Desmidium coarctatum	11				x							x								
Penium sp. (1)	5				x															
Penium sp. (4)	5											x								
Closterium macilentum	5		x																	
Closterium costatum	5			x																
Closterium pusillum	5			x																
Micrasterias Americana	5							x												
Cosmarium connatum	5				x															
Xanthidium antilopaeum var. *polymazum*	5											x								
Staurastrum sp.	5			x																

TABLE 2 Continued

Species	Percent Frequency	1964 J. 26	July 4	11	18	24	August 1	8	15	22	29	September 4	11	18	29	October 3	9	16	28	N. 7
Staurastrum spongiosum	5			x																
Staurastrum hexacerum	5											x								
Spondylosium planum	5		x																	

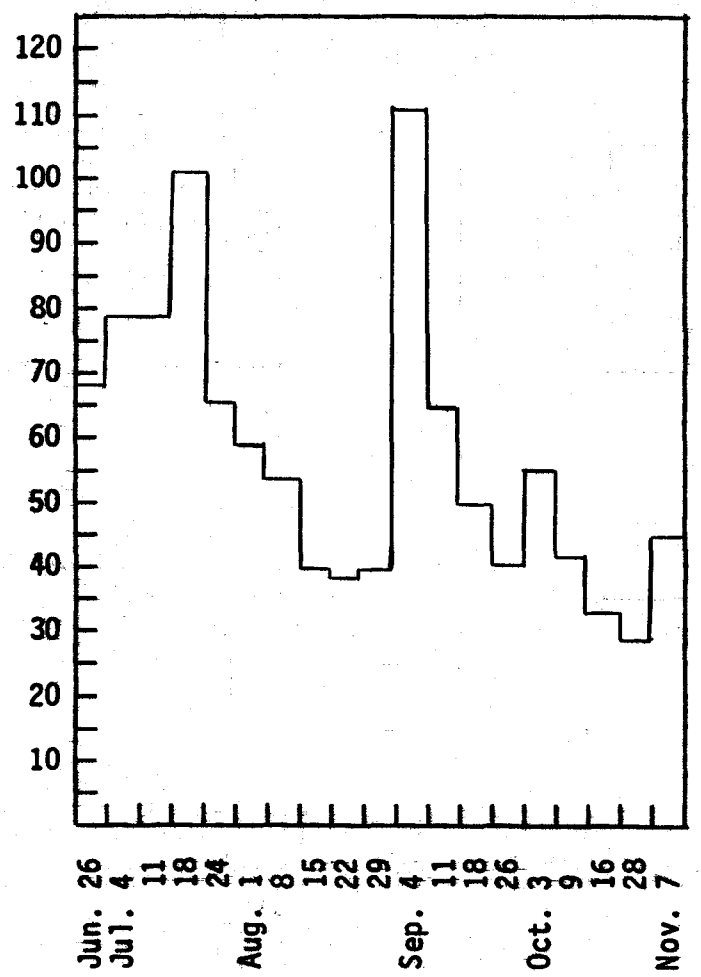
No counts were made to show the relative numerical abundance. The author did observe, however, that *Closterium lineatum*, *Closterium* sp. (5), and *Closterium Ralfsii* var. *hybridum* (Plate II, Figs. 4, 6, 8) appeared to be more abundant numerically than was generally observed for other species. These were prominent in samples collected from the artificial glass habitats.

The occurrence by species present varies considerably as shown in Table 3. Two peaks, or algal blooms, were reached during the weeks of July 18th and September 4th. The water temperature was at a peak of 23^{0} centigrade for the July 18th bloom, and the September 4th increase also appears to be caused by a rise in water temperature which followed a cold stormy period (Table 3).

This study showed that as the water temperature decreased and dissolved oxygen increased, the number of desmid species present decreased. Rooney (1967) reported that as the water temperature increased, the dissolved oxygen decreased, and as the temperature increased, the number of species of fungi present increased. The water temperature remained constant from July 11th through July 24th at 23^{0} (Table 1). During this time the desmid population reached a peak and began a decline. Gradual disappearance of species continued for several weeks only to increase rapidly again as warm weather stopped the water temperature decline and caused it to rise again slightly. Even though the water temperature showed an increase of only one degree on September 4th, it may have been warmer following the stormy weather of late August and before the recording of the temperature September 4th. Note that the water and air temperature generally showed only a one or two degree difference with the

TABLE 3

THE NUMBER OF SPECIES COLLECTED IN RELATIONSHIP TO THE COLLECTION WEEKS



exception of September 4th which showed a five degree span (Table 1). These data and Rooney's data (1967) show nearly the same trends for an entire growing season.

The key to genera is made on the basis of the structure of the cell-wall. The shape, size and surface markings are used to identify and describe the genera and species.

The basic morphological descriptions which were used to identify the species collected from Lily Lake are given below. All descriptions are from W. West and G. S. West (1904-1912) and Carter (1923) unless otherwise specified. The keys are from W. West and G. S. West (1904-1912) and Carter (1923) except where it was necessary to make changes for this limited number of species. Species found in this study, but not included in W. West and G. S. West (1904-1912) and Carter (1923) were placed where the author felt was the appropriate place. Nomenclature follows these studies.

Key to the Genera of Desmidiaceae

1. Cell-wall unsegmented, without pores. Point of division of cells not fixed, and unknown previous to the actual division. The young half of the cell is developed obliquely, and its walls are absolutely continuous with the walls of the older half. Cells solitary, relatively short and unconstricted. *Netrium*, p. 23.
2. Cell-wall segmented, with a differentiated outer layer. Cell division following a fixed type and the younger half cells interpolated between the old ones. The younger portions of the cell-wall are not continuous with the older portions but are joined obliquely to them.

2.

2. Point of division of cells variable or sometimes fixed (at the isthmus). 3.

3. Cells of moderate length, straight and more or less cylindrical. Points of division often variable, following no law. Cell-wall with or without pores. *Penium*, p. 24.

3. Cells elongate, generally curved, attenuating towards each end. Points of division regularly placed in the middle region of the cell. Cell-wall commonly with pores. *Closterium*, p. 26.

2. Point of division always fixed (at the isthmus). 4.

4. Cells solitary or colonial. The obliquely-fitting new and old parts of the cell-wall at the point of division (the isthmus) remain plane. 5.

5. After division the cells become free and solitary individuals. 6.

6. Cells elongated and cylindrical; constriction slight. 7.

7. Apices of cells truncate or rounded. *Pleurotaenium*, p. 36.

7. Apices of cells cleft, incision widely open or narrow. Cell-wall adorned with rings of furcate processes. *Triploceras*, p. 38.

6. Cells relatively short, commonly compressed or radiating; constriction usually deep. 8.

8. Cells compressed (at right angles to the plane of the front view); from the vertical view fusiform or elliptical. 9.

9. Cells almost always with an apical incision and a moderately lobed margin; with a central protuberance. *Euastrum*, p. 39.

9. Cells very compressed, with deeply lobed or incised margins. *Micrasterias*, p. 46.

9. Cells with a more or less entire margin, often furnished with warts or spines. 10.

10. Cells commonly with a central protuberance. 11.

11. Cell-wall either smooth, or granulate, or verrucose. Central protuberance present or absent. *Cosmarium*, p. 56.

11. Cell-wall with regularly arranged spines, generally in pairs. Central protuberance always present. *Xanthidium*, p. 85.

10. Cells without a central protuberance; angles spinate. *Arthrodesmus*, p. 88.

8. Cells from the vertical view commonly radiating; triangular, quadrangular, or up to eleven radiate; rarely fusiform. *Staurastrum*, p. 90.

5. After division the cells remain attached to form colonies. 12.

12. Cells attached by special apical processes. 13.

13. Apical processes very short. *Sphaerozosma*, p. 104.

13. Apical processes long and overlapping the apex of the adjoining cell.

Onychonema, p. 105.

12. Apices of cells plane and flat. 14.

14. Cells deeply constricted.

Spondylosium, p. 105.

14. Cells very slightly constricted.

Hyalotheca, p. 106.

4. Cells attached to form thread like colonies. The obliquely fitting new and old portions of the cell-wall at the point of division (the isthmus) develop a girdle like thickening, which projects back into each of the old semicells during division. 15.

15. Cells short; fusiform, triangular or quadrangular (rarely circular) in vertical view. *Desmidium*. p. 107.

15. Cells elongate, cylindrical. *Gymnozyga*, p. 109.

Key to the Species

I. *NETRIUM* Nag., 1849

Cells without any medium constriction, straight, cylindrical, subcylindrical or fusiform. Cell-wall smooth, without pores and unsegmented.

Key to the Species of *Netrium*

1. Cells generally long, 130-385 microns. *N. Digitus*.

1. Cells of medium length, 90-160 microns. 2.

2. Apices truncately rounded, length usually over four times

longer than width. *N. Nagelii.*

2. Apices rounded, length usually less than four times longer than width. *N. oblongum.*

Netrium Digitus (Ehrenb.) Itzigs. & Rothe. Rabenh. Alg., No. 508, 1856. (Plate I, Fig. 1)

Cells generally large, three to four times longer than wide, not constricted, gradually attenuated from the middle toward the apices which are rounded truncate. Length 130-385 microns; diameter 40-80 microns; breadth near apices 18-40 microns.

Netrium Nagelii (Breb.) nob. Pritch. Inf., p. 751, 1861. (Plate I, Fig. 2)

Cells of medium size, 115-160 microns long, about 4.5 times longer than wide, not constricted, oblong-lanceolate; apices broadly but truncately rounded.

Netrium oblongum (De Bary) Lutkem. Conjug., p. 42, 73, t. 7, Gf. 1, 2, 1858. (Plate I, Fig. 3)

Cells of medium size, 3-4 times longer than their diameter, not constricted, oblong-cylindrical, gradually narrowed toward the rounded apices. Length 95-135 microns; breadth 30-40 microns.

II. *PENIUM* Breb., 1844

Cells straight, cylindrical, subcylindrical, fusiform, unconstricted or with slight medium constriction; apices rounded to truncate. Cell-wall smooth, with pores or rarely with striations.

Key to the Species of *Penium*

1. Cells unconstricted, usually with no distinct demarcation between the old and the young semicells. *P.* sp. (1).
1. Cells either conspicuously constricted in the middle or very slightly constricted; always with a distinct demarcation between the newer and the older parts of the cell-wall. 2.
    2. Cells 1.5-4 times longer than broad. 3.
        3. Cells 2-3 times longer than broad, cylindrical; apices rounded to slightly truncate. *P.* sp. (2).
        3. Cells less than twice as long as broad, ellipsoid-subcylindrical, with broad rounded apices. *P.* sp. (3).
    2. Cells elongated, up to 30 times longer than broad. 4.
        4. Cells almost cylindrical, very slightly attenuated, with truncate apices. *P. minutum.*
        4. Cells attenuating with rounded apices. *P.* sp. (4).

Penium sp. (1) (Plate I, Fig. 4)

Cells large, about 10 times longer than wide, unconstricted, with subtruncate poles, attenuating toward each end, with about 10 striations across the medium part. Cell-wall may be finely punctate.

Penium sp. (2). (Plate I, Fig. 5)

Cells small, 2-3 times longer than their diameter, slight constriction, cylindrical with slight attenuation toward apices which are rounded or slightly truncate.

Penium sp. (3) (Plate I, Fig. 6)

Cells small, about 1.5-2 times longer than broad, slight constriction, ellipsoid-subcylindrical with rounded broad apices.

Penium minutum (Ralfs) Cleve. Brit. Desm., p. 158, t. 26, f. 5, 1848. (Plate I, Fig. 7)

Cells of medium size, 8-12 times longer than their diameter, almost cylindrical, with medium constriction, gradually attenuated toward the apices, which are truncate.

Penium sp. (8) (Plate I, Fig. 8)

Cells large, 5-6 times longer than broad, cylindrical, attenuating toward apices, which are rounded. Cell-wall smooth, with slight constriction.

III. *CLOSTERIUM* Nitzsch, 1817

Cells elongated, always more or less attenuated, generally curved and often strongly arcuate or lunate, unconstricted; poles obtuse, truncate, rostrate or attenuated to fine needle-like points. Cell-wall smooth or striated, often brown or yellow-brown in color.

Key to the Species of *Closterium*

1. Cells with a medium girdle or cylindrical piece of cell-wall which arises subsequent to cell division and is interpolated between the new and old semicells. 2.
   2. Cells strongly curved, lunate. Cell-wall striated. 3.
      3. Cells small, less than 160 microns long. *C. Cynthia.*
      3. Cells of medium size, 180-240 microns long. *C. Archerianum.*
   2. Cells slightly curved, ventral margin sometimes almost straight. 4.
      4. Cell-wall smooth. 5.
         5. Breadth of cell usually 24-50 microns, annular

thickening of a dark brown color at each apex.

C. didymotocum.

5. Breadth of cell usually less than 24 microns, no annular thickening. *C. macilentum.*

4. Cell-wall striated. 6.

6. Cells with costae visible across cell-wall. 7.

7. Cell-wall with 4-5 costae visible across cell.

C. angustatum.

7. Cell-wall with 6-8 costae visible across cell.

C. costatum.

7. Cell-wall with 8-10 costae visible across cell; cell very much elongated up to 850-950 microns.

C. sp. (1).

6. Cells with striae visible across cell-wall. 8.

8. Cell-wall with 14-21 striae visible across cell.

C. striolatum.

8. Cell-wall with 8-10 striae visible across cell.

C. intermedium.

8. Cell-wall with 5-7 striae visible across cell.

C. juncidum.

1. Cells without a median girdle, the adult condition being attained on the growth to matruity of the younger semicells. 9.

9. Cells strongly curved, lunate. 10.

10. Cells 150 microns or more in length. 11.

11. Cells with arc of less than 140^{0}. 12.

12. Cells with arc of 112^{0}-130^{0}. *C. Diane.*

12. Cells with arc of 78^{0}-88^{0}. *C. Pseudodiane.*

11. Cells with arc of more than 140°. 13.

13. Cells 150-170 microns long. *C.* sp. (2).

13. Cells over 200 microns long, no spine like projection on apices. *C.* sp. (3).

10. Cells less 150 microns in length. 14.

14. Cells 96-121 microns in length. *C. parvalum.*

14. Cells 77-108 microns in length. *C. calosporum.*

9. Cells slightly curved; ventral margin almost straight or slightly concave. 15.

15. Cells lanceolate, gradually attenuated to the poles which are usually subacute. 16.

16. Cells 5-10 times longer than diameter. *C. lanceolatum.*

16. Cells 12-14 times longer than diameter. *C.* sp. (4).

15. Cells lanceolate, slightly attenuated to the poles which are obtuse or truncate. *C. pusillum.*

9. Cells slightly curved; poles very much attenuated, acute, subacute, or rounded. 17.

17. Median portion of cells not (or rarely) ventricose; poles incurved. 18.

18. Cells with 10-20 striae visible across cell-wall. *C. lineatum.*

18. Cells with 35-40 striae visible across cell-wall. *C.* sp. (5).

17. Median portion of cells ventricose. 19.

19. Cells gradually attenuated to the poles. 20.

20. Cells with 23-34 striae visible across cell.

C. Ralfsii var. *hybridum.*

20. Cells with 45-60 striae visible across cell.

C. laterale.

19. Cells suddenly attenuated into elongate poles.

C. Kutzingii.

Closterium Cynthia De Not. Desm. Ital., p. 65, t. 7, f. 71, 1867. (Plate I, Fig. 9)

Cells small, about 6-10 times longer than their diameter, strongly curved, outer margin 120^{0}-140^{0} (rarely 170^{0}) of arc, inner margin not tumid, gradually narrowed to the apices, which are obtusely rounded. Cell-wall finely striate, about 14 striae visible across the cell. Distance between apices 73-160 microns; breadth 11-18 microns.

Closterium Archerianum Cleve. in Lund. Desm., Suec. p. 77, t, 5, f. 13, 1871. (Plate I, Fig. 10)

Cells of medium size, about eleven times longer than the diameter, strongly curved, outer margin about 123^{0}-145^{0} of arc, inner margin not tumid, gradually and regularly attenuated to the apices, which are narrow and obtusely rounded. Cell-wall striate, striae rather variable, from eight to eleven visible across the cell. Distance between apices 196-230 microns; breadth 18-30 microns.

Closterium didymotocum Corda in Alm. de Carlsbad, pp. 185, 190, 192, 209, t. 5, f. 64-65, 1835. (Plate I, Fig. 11)

Cells large, 9-12 times longer than their diameter, slightly curved, outer margin from 27^{0}-32^{0} of arc, inner margin very slightly

concave or almost straight, median portion of cell with subparallel sides, gradually and slightly attenuated toward the apices, which are broad and truncate with rounded angles (and sometimes very slightly recurved). Cell-wall reddish-brown or yellow-brown in color, smooth or very rarely with traces of a fine striation, with an annular thickening of a dark brown color at each apex. Distance between apices 295-672 microns; breadth 24-48 microns; breadth of apices 13-20 microns.

Closterium macilentum Breb. Liste Desm., p. 153, t. 2, f. 36, 1856. (Plate I, Fig. 12)

Cells of medium size, very elongate and narrow, 24-40 times longer than their diameter, slightly curved toward the extremities, median portion straight with parallel sides, inner margin not tumid, gradually attenuated toward the apices, which are obtusely rounded. Cell-wall smooth. Length 264-722 microns; breadth 11-20 microns.

Closterium angustatum Kutz. Phyc. germ., p. 132, 1845. (Plate I, Fig. 13)

Cells of medium size, 14-18 (sometimes only about ten) times longer than their diameter, moderately curved, outer margin from 45^{0}-51^{0} of arc, inner margin not tumid, gradually but slightly attenuated from the middle to each extremity; apices truncately rounded or sometimes rounded, often slightly swollen and subcapitate. Cell-wall with four costae visible across the cell. Distance between apices 290-403 microns; breadth 16-28 microns; breadth of apices 12-15 microns.

Closterium costatum Corda in Alm. de Carlsbad, p. 185, etc., t. 5, f. 61-63, 1834. (Plate I, Fig. 14)

Cells of medium size, 6-10 (commonly seven or eight) times longer than their diameter, moderately curved, outer margin from 90^{0}-98^{0} of arc, gradually attenuated toward the apices, which are rounded, truncately rounded, or rounded-conical. Cell-wall with 6-8 costae visible across the cell. Distance between apices 340-405 microns; breadth 48-66 microns. The figured specimen from Lily Lake has a narrower breadth.

Closterium sp. (1) (Plate I, Figs. 15, 16)

Cells elongate and slender, 25-35 times longer than their diameter, cylindrical in the median portion and with the margins parallel, gradually attenuated toward the apices, which are truncately rounded. Cell-wall with 8-10 costae.

Closterium striolatum Ehrenb. Entwick. Lebends. d. Infus., p. 68, 1832. (Plate I, Fig. 17)

Cells of medium size, 8-12 times longer than their diameter, moderately curved, outer margin from 39^{0}-69^{0} of arc, inner margin concave, never tumid, but sometimes straight in the middle, gradually attenuated to the apices, which are broad and truncate with rounded angles. Cell-wall with 14-21 striae visible across the cell. Distance between apices 235-478 microns; breadth 22-53 microns; breadth of apices 10-14 microns.

Closterium intermedium Ralfs, Brit. Desm., p. 171, t. 29, f. 3 and f. 2H, 1848. (Plate I, Fig. 18)

Cells of medium size, 12-15 times longer than their diameter, moderately curved, outer margin from 36^{0}-45^{0} of arc, inner margin slightly concave, not tumid but sometimes straight in the median portion, gradually attenuated toward the apices, which are truncate with rounded angles. Cell-wall striated, with 8-10 visible striae across the cell. Length 234-465 microns; breadth 16-31 microns; breadth of apices 10-12 microns.

Closterium juncidum Ralfs, Brit. Desm., p. 172, t. 29, f. 6, 1848. (Plate I, Fig. 19)

Cells elongate and slender, 24-40 times longer than their diameter, straight in the median portion and with the margins parallel, toward the apices slightly incurved and attenuated; apices obtusely rounded. Cell-wall with 5-7 visible striae across the cell. Length 110-330 microns; breadth 4-8 microns.

Closterium juncidium Ralfs var. *elongatum* Roy & Biss. Scott. Desm., p. 245, 1894. (Plate I, Fig. 20)

Cells longer than type, elongate and slender, up to forty times longer than their diameter, straight in the median portion and with the margins parallel, toward the apices slightly incurved and attenuated; apices obtusely rounded. Cell-wall with 5-7 visible striae across the cell. Length 355-400 microns; breadth 11.2 microns.

Closterium Diane Ehrenb. Infus., p. 92, t. 5, f. xvii, 1-6, 1838. (Plate I, Fig. 21)

Cells of medium size, usually 10-12 times longer than their diameter, strongly curved, outer margin about 112^{0}-130^{0} of arc, inner

margin scarcely or very slightly tumid, gradually and gracefully attenuated toward the apices, which are obtusely rounded; dorsal margin at each apex obliquely truncate and thickened. Cell-wall smooth. Distance between apices 270-380 microns; breadth 16-36 microns; breadth of apices about six microns.

Closterium Pseudodianae Roy Desm. Alford District, p. 201, 1890. (Plate I, Fig. 22)

Cells of medium size, 14-20 (commonly 16-18) times longer than their diameter, moderately curved, outer margin 78^{0}-88^{0} of arc, inner margin almost straight in the median part of the cell, gradually attenuated toward the apices, which are narrow and obtuse, with a slight thickening on the dorsal margin. Cell-wall smooth. Distance between apices 192-253 microns; breadth 12-14 microns; breadth of apices 2.5-3 microns. The figured specimen from Lily Lake has a shorter distance between apices.

Closterium sp. (2) (Plate I, Fig. 23)

Cells of moderate size, 8-10 times longer than their diameter, strongly curved, more so towards the extremities than in the median portion, outer margin 165^{0}-175^{0} of arc, inner margin not tumid, gradually attenuated to the apices, which are obtusely rounded. Cell-wall smooth.

Closterium sp. (3) (Plate I, Fig. 24)

Cells of medium size, about eight times longer than their diameter, strongly curved, outer margin about 170^{0} of arc, inner margin not tumid, strongly attenuated toward the apices, which are acute.

Cell-wall smooth.

Closterium parvulum Nag. Gatt. einz. Alg., p. 106, t. 6C, f. 2, 1849. (Plate I, Fig. 25)

Cells small, 9-15 times longer than their diameter, strongly curved, outer margin 120^{0}-140^{0} of arc, inner margin not tumid, gradually attenuated to the apices which are acutely rounded. Cell-wall smooth. Distance between apices 96-121 microns; breadth 11-14.5 microns; breadth of apices about 1.5 microns.

Closterium calosporum Wittr. Skandinav. Desm., p. 23, t. i, f. 11, 1869. (Plate I, Fig. 26)

Cells small, 8-10 times longer than their diameter, strongly curved, outer margin 125^{0}-135^{0} of arc, inner margin not tumid, gradually attenuated to the apices, which are subacute or acutely rounded. Cell-wall smooth. Distance between apices 77-108 microns; breadth 9-12 microns.

Closterium lanceolatum Kutz. Phycol. germ., p. 130, 1845. (Plate II, Fig. 1)

Cells large, 5-10 times longer than their diameter, sublanceolate, almost straight, outer margin slightly curved, about 30^{0}-36^{0} of arc, inner margin straight or slightly convex, gradually narrowed toward the apices, which are acutely rounded. Cell-wall smooth. Length 234-370 microns; breadth 32-72 microns. The figured specimen from Lily Lake is longer between the apices.

Closterium sp. (4) (Plate II, Fig. 2)

Cells large, 12-14 times longer than their diameter, slightly

curved, outer margin 45^{0}-55^{0} of arc, inner margin very slightly concave, margins gradually attenuated toward the apices, which are narrow, truncate with rounded angles. Cell-wall smooth.

Closterium pusillum Hantzsch. in Rabenh. Alg. Europ., no. 1008, 1861. (Plate II, Fig. 3)

Cells very small, subcylindrical, 4-7.5 times longer than their diameter, slightly curved, outer margin 40^{0}-50^{0} of arc, inner margin slightly concave, very gradually and gently attenuated to the apices, which are obtusely or truncately rounded. Cell-wall smooth. Length 30-50 microns; breadth 4-9 microns.

Closterium lineatum Ehrenb. 1834. (Plate II, Figs. 4, 5)

Cells large, long and narrow, 16-24 times longer than their diameter, moderately curved, median portion of the cell fairly straight and cylindrical, inner margin faintly and widely tumid, moderately curved and gradually attenuated toward the apices, which are broad and truncately rounded. Cell-wall striated, striae rather variable, from ten to twenty visible across the cell. Length 415-760 microns; breadth 17-35 microns; breadth of apices 7-10 microns. The figured specimen from Lily Lake has a wider breadth.

Closterium sp. (5) (Plate II, Figs. 6, 7)

Cells large, long and narrow, about 18-20 times longer than broad, moderately curved, median portion of cell fairly straight and cylindrical, slightly attenuating toward apices, which are broad and rounded. Cell-wall striated, with 35-40 striae visible across the cell.

Closterium Ralfsii Breb. var. *hybridum* Rabenh. Krypt. Fl. Sachs., p. 174, 1863. (Plate II, Figs. 8, 9)

Cells longer than in the type, 12-18 times longer than their diameter, somewhat variable in size, ventral inflation less prominent than type, with subtruncate apices, 23-34 striae visible across cell, attenuated towards extremities, outer margin about 35^{o} of arc. Length 306-700 microns; breadth 24-44 microns; breadth of apices 6-11.5 microns.

Closterium lacerale Nordst. in Wittr. & Nordst. Alg. Exsic., no. 383, 1880. (Plate II, Fig. 10)

Cells large, stout, 8-11 times longer than their diameter, slightly curved, outer margin 43^{o}-65^{o} of arc, inner margin broadly subtumid, gradually attenuated to the apices, which are truncate or subtruncate. Cell-wall finely striated, 45-60 striae visible across the cell. Length 284-535 microns; breadth 41-60 microns; breadth of apices 7-8 microns.

Closterium Kutzingii Breb. Liste Desm., p. 156, t. 2, f. 40, 1856. (Plate II, Fig. 11)

Cells of medium size, 20-28 times longer than their greatest diameter, almost straight, median part of cell fusiform-lanceolate, outer and inner margins almost equally convex, attenuated toward each extremity into long, colorless, setaceous processes; apices slightly incurved, rounded, and often slightly swollen. Cell-wall striated, 10-18 striae visible across the cell. Length 370-600 microns; breadth 16-23 microns; breadth of apices 3-4 microns.

IV. *PLEUROTAENIUM* Nag., 1849

Cells straight, elongated and cylindrical, slightly constricted in the middle, with a prominent and usually projecting suture; semicells commonly with an inflated base, which is never plicate, lateral margins straight, undulate, or nodulose; apices truncate or truncately rounded, frequently plicated round the periphery or furnished with a ring of tubercles. Cell-wall rarely smooth, commonly punctate or minutely scrobiculate, sometimes granulose or papillate.

Key to the Species of *Pleurotaenium*

1. Cells cylindrical or slightly attenuated. 2.
   2. Apices furnished with a ring of tubercles or conical teeth. *P. Ehrenbergii.*
   2. Apices without tubercles. 3.
      3. Cells less than 600 microns long; no undulation of lateral margin immediately above basal inflation of semicell. *P. Trabecula* var. *rectum.*
      3. Cells over 600 microns long; semicells usually with slight undulation above basal inflation. *P. maximum.*
1. Cells furnished with rings of nodules. *P. Nodosum.*

Pleurotaenium Ehrenbergii (Breb.) De Bary Conj., p. 75, 1858. (Plate II, Fig. 12)

Cells of medium size, rather narrow and subcylindrical, 15-20 times longer than their diameter; semicells somewhat variable in form, very slightly attenuated from base to apex, with a distinct though small basal inflation and two undulations immediately above

it; apices truncate, bordered by a ring of conical or rounded tubercles, 7-10 in number (4-5 visible across the apex). Cell-wall punctate. Length 240-480 microns; breadth at base of semicell 18-35 microns, at middle of semicell 16-26 microns, at apices 14.5-22 microns. The figured specimen from Lily Lake is about 100 microns longer.

Pleurotaenium Ehrenbergii (Breb.) De Bary var. *undulatum* Schaarschm. Magyar. Desm. p. 278, t. 1, f. 21, 1883. (Plate II, Fig. 13)

Cells larger than in the type, 15-20 times longer than their diameter; semicells with basal inflation prominent and lateral margins gently undulate from base to apex; apices truncate, ring of conical or rounded tubercles lacking. Cell-wall punctate. Length 600-700 microns; breadth in middle of semicells 28-30 microns, at apices 26-27 microns. The figured specimen from Lily Lake is much larger than this description; however, the general description fits this specimen.

Pleurotaenium Trabecula (Ehrenb.) Nag. var. *rectum* Delp. Desm. Subalp., p. 129, t. 20, f. 8-11, 1877. (Plate II, Fig. 14)

Cells rather smaller than in the type, straight, 12-18 times longer than their diameter; semicells with one basal inflation, almost cylindrical, very gradually attenuated toward the apices, lateral margins above the slight basal inflation straight. Cell-wall often smooth. Length 212-408 microns; breadth at base of semicell 22-23 microns; breadth at apices 14-20 microns.

Pleurotaenium maximum (Reinsch) Lund. Desm. Suec., p. 89, 1871.

(Plate II, Fig. 15)

Cells large, subcylindrical and elongated, 12-18 times longer than their diameter; semicells with a prominent basal inflation and often with a smaller undulation immediately above it, very slightly tumid and then gradually tapering to the apices, which are truncate with rounded angles. Cell-wall punctate. Length 568-852 microns; breadth at base of semicells 38-54 microns; breadth in middle of semicells 31-42 microns; breadth of apices 22-30 microns. The figured specimen from Lily Lake is slightly larger.

Pleurotaenium nodosum (Bail.) Lund. Desm. Suec., p. 90, 1871.

(Plate II, Fig. 16)

Cells large or moderately large, 6-8 times longer than their diameter; semicells with nodulose margins, caused by four rings of prominent nodules, one basal ring, and three other equidistant rings, 6-8 nodules in each ring, gradually tapering from base to apex; apices dilated, convexo-truncate, furnished with a peripheral ring of 6-8 conical teeth. Cell-wall smooth or punctate. Length 280-520 microns; maximum breadth 40-80 microns; breadth of apices 24-50 microns.

V. *TRIPLOCERAS* Bailey, 1851

Cells elongated, cylindrical, with whorls of tooth like projections, median constriction, slightly attenuated toward poles; apices truncate, usually with two or four furcate protuberances, (protuberance may have 1-3 spines).

Key to the Species of *Triploceras*

1. Cell whorls with single spine on each projection. *T. gracile.*

1. Cell whorls with two spines on each projection. *T. verticillatum.*

Triploceras gracile Bailey Micr. observ., p. 38, t. 1, f. 10, 1851. (Plate II, Fig. 17)

Cells large, 7-12 times longer than their diameter, median constriction; semicell attenuation towards apices, with 8-24 whorls of tooth-like projections, with 10-20 teeth in each whorl; apices truncate with furcate spine-like protuberances. Length 338-422 microns; breadth 30-42 microns. Description from Irenee-Marie.

Triploceras verticillatum Bailey Micr. observ., p. 37, t. 1, fig. 9, 1851. (Plate II, Fig. 18)

Cells large 8-12 times longer than their diameter, median constriction; semicell circular, slightly attenuated towards apices, with 12-30 whorls of teeth-like projections, each whorl with 10-24 bifid tooth-like projections; apices widely truncate, angles with small spine (usually furcate), with scattered teeth between margin and terminal whorl of projections. Length 401-472 microns; breadth 42-46 microns. Description from Irenee-Marie.

VI. *EUASTRUM* Ehrenb., 1832

Cells of variable size, longer than broad, deeply constricted in the middle, sinus generally linear; semicells commonly truncate-pyramidate, apex with a median incision of variable depth, sometimes scarcely evident or absent, lateral margins entire, sinuate, or variously lobed, at or near the center of the semicells with one or more somewhat hemispherical protuberances variously disposed.

Key to the Species of *Euastrum*

1. Polar lobe with a distinct median notch, often deep and linear. 2.
   2. Cells generally large (length 50-205 microns), polar lobe short, external angles of polar lobe rounded. Cell-wall usually punctate or scrobiculate. 3.
      3. Lateral margins lobed or sinuate. 4.
         4. Cells over 160 microns long, narrow incisions between lobes. *E. crassum.*
         4. Cells less than 160 microns long, wide incisions between lobes or sinuate. 5.
            5. Cells over 100 microns long, semicells with protuberances, lobed or sinuate margin. 6.
               6. Five lobes, incisions widely open, polar lobe nearly anvil-shaped. *E. humerosum.*
               6. Sinuate margin (almost five lobes). *E. Didelta.*
            5. Cells less than 100 microns, lateral margins sinuate, scrobiculations disposed more or less in a regular pattern across semicells. *E. aboense.*
      3. Lateral margins entire, cells small. 7.
         7. Cell with protuberances. *E. ansatum.*
         7. Cell-wall smooth. *E. obesum.*
   2. Cells generally small (length 10-79 microns); external angles of polar lobe usually furnished with a spine. Cell-wall smooth, granulate, or spinous. 8.
      8. Lateral margins lobed or sinuate. 9.
         9. Length 50-75 microns. *E. bidentatum.*
         9. Length 20-40 microns. *E.* sp.

8. Lateral margins usually without lobes. 10.

10. Semicells ovate-pyramidate, apex convex, with a deep and median narrow incision. *E. elegans*.

10. Semicells subpyramidate, apex truncate, generally with a slight median notch. 11.

11. Central protuberance usually trigranulate. *E. binale* forma *Gutwinskii*.

11. Central protuberance usually more than three granules, numerous granules or denticulations within basal angles and the apex. *E. denticulatum*.

1. Polar lobe entire, generally somewhat retuse in the middle; semicells distinctly three-lobed. *E. insulare*.

Euastrum crassum (Breb.) Kutz. Phycol. germ., p. 135, 1845. (Plate III, Fig. 1)

Cells large, about twice as long as broad, elliptical oblong, deeply constricted, sinus narrowly linear; semicells in front view unequally three-lobed, with narrow incisions between lobes closed or slightly open; polar lobes convex and broadly cuneate, with a deep and narrow median incision. Cell-wall punctate, angles of lobes strongly thickened. Length 163-205 microns; breadth 79-106 microns; breadth of isthmus 24-30 microns.

Euastrum humerosum Ralfs, Brit. Desm., p. 82, t. 13, f. 2, 1848. (Plate III, Fig. 2)

Cells of moderate size, less than twice as long as broad, deeply constricted, sinus narrowly linear and dilated at the apex; semicells five-lobed, incisions between the lobes widely open, upper

incisions deeper and less widely open than lower incisions; polar lobe dilated, almost anvil-shaped with rounded angles, apex convex, straight, or even slightly retuse, with a deep narrow incision; upper lateral lobes mamillate, directed upwards and outwards; lower lateral lobes subquadrate with retuse margins and rounded angles; semicells with three prominent protuberances across the base and two smaller ones across the middle. Cell-wall punctate. Length 110-123 microns; breadth 65-75 microns; breadth of isthmus 15.5-22 microns.

Euastrum Didelta (Turp.) Ralfs in Ann. Mag. Nat. Hist. xiv, p. 190, t. 7, f. 2a and b only, 1844. (Plate 3, Fig. 3)

Cells moderately large, more than twice as long as broad, deeply constricted, sinus narrowly linear with dilated extremity; semicells pyramidate with truncate apex and sinuate margins, sometimes almost five-lobed; basal angles broadly rounded, rounded-rectangular; lateral margins with two hollows, often unequal; apical part of cell standing out as a polar lobe, subtruncate at the apex with rounded angles, and a deep linear incision in the middle; semicells with three protuberances across base and two across middle. Cell-wall punctate. Length 130-195 microns; breadth 70-91 microns; breadth of isthmus 16-27 microns.

Euastrum aboense Elfv. Anteck. Finska Desm., p. 7, t. 1, f. 2, 1881. (Plate III, Fig. 4)

Cells small, about 1.5 times longer than their diameter, deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells pyramidate-rounded, lateral margins sinuate, with two shallow hollows and a broad rounded projection in between;

apex subtruncate with rounded angles and a narrow median incision; 7-13 conspicuous scrobiculations disposed more or less in a regular pattern across broad part of the semicell. Length 58-65 microns; breadth 37-42 microns; breadth of isthmus 11.5-13 microns.

Euastrum ansatum Ralfs, Brit. Desm., p. 85, t. 14, f. 2, 1848. (Plate III, Fig. 5)

Cells somewhat small, about twice as long as broad, deeply constricted, sinus narrowly linear with a dilated extremity; semicells pyramidate with a broad base; basal angles rounded, upper part of margins concave; apex rotundo-truncate, with a narrow and fairly deep median incision; semicells with a slight protuberance above isthmus and two or three rather large ones across the center of the semicell with the center one being harder to visualize. Length 70-91 microns; breadth 32-47 microns; breadth of isthmus 12-15 microns. The figured specimen from Lily Lake is shorter in length.

Euastrum obesum Josh. Burmese Desm., p. 638, t. 23, f. 19, 20, 1868. (Plate 3, Fig. 6)

Cells of medium size, about twice as long as broad, deeply constricted, sinus narrowly linear; semicells pyramidate, basal angles broadly-rounded, lower part of lateral margins convex, upper part slightly concave; apex widely subtruncate with rounded angles having a narrow median incision. Cell-wall smooth. Length 50-111 microns; breadth 30-59 microns; breadth of apex 17-28 microns; breadth of isthmus 9-21 microns.

Euastrum bidentatum Nag. Gatt. einzell. Alg., p. 122, t. 7D, F. 1a-f,

1849. (Plate III, Fig. 7)

Cells small, about 1.5 times longer than broad, deeply constricted, sinus narrowly linear with a dilated extremity; semicells subpyramidate, with bilobulate sides; lower lobe subrectangular, sometimes emarginate, and furnished with two or three sharp granules; upper lobe rounded, sometimes with one or two sharp granules; apex convex, with a deep median notch, which may be open or closed, with a short blunt spine at each apical angle; semicells with a granulated protuberance in the center above the isthmus, with a large granule below and on each side of the apical incision, and with a few variously-disposed granules within the lateral lobes, and the apex. Length 51-61 microns; breadth 32-39 microns; breadth of apex 25-29 microns; breadth of isthmus 6.3-11 microns.

Euastrum sp. (Plate III, Fig. 8)

Cells very small, 1.5 times longer than broad, very deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells truncato-pyramidate, three-lobed; polar lobe widely rectangular-oblong, apex truncate with a narrow median incision, apical angles furnished with a short spine; lateral angles with 3-4 marginal acute granules; semicells with two granules within apex, one on each side of the notch; smooth central protuberance.

Euastrum elegans (Breb.) Kutz. Phycol. germ., p. 135, 1845. (Plate III, Fig. 9)

Cells small, about 1.5 times longer than broad, median constriction deep, sinus narrowly linear; semicells ovate-pyramidate, basal angles subrectangular, retuse-emarginate, above with the sides concave;

superior angles apiculate; apex convex, with a deep and narrow median incision; semicells with a triverrucose protuberance in the center above the isthmus. Cell-wall generally smooth. Length 29-36.5 microns; breadth 19-22 microns; breadth of isthmus 5.8-7 microns.

Euastrum elegans (Breb.) Kutz. var. *Novae Semliae* Wille Ferskv. Alg. Nov. Semlj., p. 32, t. 12, f. 8, 1879. (Plate III, Fig. 10)

Cells small, nearly twice as long as broad, deeply constricted, sinus narrowly linear; semicells ovate-pyramidate, basal angles obliquely-truncate or acutely-rounded, and with an undulation between the basal angle and the upper apiculation; apex strongly convex (or broadly rounded) with a deep and narrow median incision; central protuberance above isthmus triverrucose or granulate; semicells sometimes with a few granules within the marginal undulations. Cell-wall generally smooth. Length 36.5-53 microns; breadth 22.5-34 microns; breadth of isthmus 3.8-9 microns.

Euastrum binale (Turp.) Ehrenb. forma *Gutwinskii* Schmidle Alg. Geb. Oberrheins, p. 552, 1894. (Plate III, Fig. 11)

Cells very small, about 1/3 times longer than broad, deeply constricted, sinus narrowly linear; semicells subpyramidate, basal angles triundulate or slightly tricrenate, upper part of lateral margins concave; apex broad and truncate, retuso-emarginate in the middle, upper angles forming a minute apiculus. Cell-wall smooth. Length 22-29 microns; breadth 14-20 microns; breadth of isthmus 4.8-5.5 microns.

Euastrum denticulatum (Kirchn.) Gay Note Conj. du midi de France, p. 335, 1884. (Plate III, Fig. 12)

Cells very small but variable in size, about 1 1/4 times as long as broad, very deeply constricted, sinus narrowly linear with a dilated extremity; semicells subquadrate or subpyramidate, almost trapezoid, basal angles rounded or subrectangular, furnished with a number of granules or denticulations, upper part of lateral margins concave, apical part of semicell protracted, broadly rectangular, upper angles furnished with an acute granule or short spine; apex truncate with a slight median notch; semicells with a granulated central protuberance, and a number of granules or denticulations within the basal angles and the apex. Length 13-26 microns; breadth 11.5-21 microns: breadth of isthmus 3.5-6.5 microns.

Euastrum insulare (Wittr.) Roy in Scott. Naturalist, April 1877. (Plate III, Fig. 13)

Cells minute, 1 1/2 times longer than broad, deeply constricted, sinus narrowly linear, with a dilated extremity; semicells three-lobed, interlobular incisions subrectangular; polar lobe widely rectangular, angles rounded, apex truncate and retuse-emarginate in the middle; lateral lobes short, basal angles subrectangular, sides slightly retuse. Vertical view elliptic, with a very slight protuberance at the middle on each side. Cell-wall smooth. Length 17.5-30 microns; breadth 11.5-22 microns; breadth of isthmus 3.3-6 microns.

VII. *MICRASTERIAS* Ag., 1827

Cells of variable size, often large, usually a little longer

than broad, sometimes subcircular in general outline, usually much compressed, very deeply constricted in the middle, sinus usually linear (open outwards in several species); semicells subsemicircular, usually five-lobes (in some species three-lobed); polar lobe generally widely cuneate, emarginate, or widely notched; lateral lobes usually bilobulate, lobules generally slightly bilobed; median part of base of semicells generally without protuberances.

Key to the Species of *Micrasterias*

1. Polar lobe entire; lateral lobes of semicells two, transversely placed, generally entire, and attenuated to their extremities. 2.
   2. Cells less than 100 microns long. *M. pinnatifida.*
   2. Cells over 700 microns long. 3.
      3. Polar lobe with acuminate poles. *M. oscitans.*
      3. Polar lobe with bifid poles. *M. depauperata* var. *Wollei.*
1. Polar lobe with a median incision of variable depth (rarely almost absent); lateral lobes of semicells four, radiately disposed, and widening outwards. 4.
   4. Lateral lobes generally much divided; interlobular incisions narrow. 5.
      5. Interlobular incisions not deep. 6.
         6. Polar lobe widely cuneate, apex convex and usually flattened or slightly retuse. *M. truncata.*
         6. Polar lobe subcuneate, dilated from a somewhat narrow base, with two minute papillae on the apical margin near angles. *M. conferta.*
      5. Interlobular incisions deeper. 7.

7. Cells circular in outline. *M. Sol.*

7. Cells subcircular, subelliptic, or broadly elliptic. 8.

8. Cells with acute granules or denticulations on each side of sinus and interlobular incisions. 9.

9. Polar lobe cuneate with concave sides. *M. papillifera.*

9. Polar lobe distinctly exserted, lower portion with subparallel sides, upper portion widely dilated. *M. apiculata* var. *brachyptera.*

8. Cells without acute granules or denticulations. 10.

10. Cells subcircular; lobules subdivided into four equal emarginate (or bidentate) parts by three incisions. *M. rotata.*

10. Cells broadly elliptic; lobules divided into four (sometimes only two) subequal, retuse or emarginate parts. *M. denticulata.*

4. Lateral lobes with fewer divisions; interlobular incisions widely open. 11.

11. Lobes producing long processes. 12.

12. Processes with a furcate apex. *M. radiata.*

12. Processes attenuating towards apex. *M. muricata.*

11. Angles of lobes producing short processes with emarginate-bidentate apices. *M.* sp.

1. Polar lobe with accessory processes; lateral lobes of semicell two, symmetrical or asymmetrical. *M. Americana.*

Micrasterias pinnatifida (Kutz) Ralfs, Brit. Desm., p. 77, t. 10, f. 3,

1848. (Plate III, Fig. 15)

Cells small, a little broader than long, deeply constricted, sinus open, triangular-acuminate with a narrowed apex; semicells three lobed, the interlobular incisions deep and broadly rounded; lateral lobes horizontally disposed, semifusiform, with attenuated and minutely bifid apices; polar lobe widely spreading, extremities narrower than those of the lateral lobes and minutely bifid, apex convex, straight, or sometimes very slightly retuse. Cell-wall very minutely punctate. Length 53-76 microns; breadth 57-80 microns; breadth of polar lobe 39-57 microns; breadth of isthmus 12-18 microns.

Micrasterias oscitans Ralfs in Jenner's Flora Turnbridge Wells, p. 198, 1845. (Plate III, Fig. 14)

Cells of medium size, about as long as broad, deeply constricted, inner half of sinus usually narrowly linear, outer half open and acutely conical; semicells three lobed; polar lobe wide, fusiform or subfusiform with acuminate (rarely bifid) poles and convex apex; insicions below the polar lobe deep and somewhat widely open; lateral lobes horizontal, ovate-triangular, with minutely bifid extremities. Cell-wall finely punctate. Length 125-146 microns; breadth 123-135 microns; breadth of polar lobe 91-95 microns; breadth below polar lobe 52-56 microns; breadth of isthmus 24-26 microns. The figured specimen from Lily Lake has a wider breadth and wider polar lobes.

Micrasterias depauperata Nordst. var. *Wollei*, Cushman. (Plate III, Fig. 16)

Cells of medium size, slightly longer than broad, deeply constricted, inner half of sinus usually narrowly linear, outer half

open and acutely conical; semicells three lobed; polar lobe wide, with bifid poles and a slightly convex apex; incisions below the polar lobe medium deep and widely open; lateral lobes larger and somewhat inflated with bifid angles near sinus and a separate spine-like projection above those at the angles. Cell-wall punctate. Identification from Irenee-Marie.

Micrasterias truncata (Corda) Breb. in Ralfs' Brit. Desm., p. 75, t. 8, f. 4, t. 10, f. 5, 1848. (Plate III, Fig. 17)

Cells small, generally a little longer than broad, elliptical with widely truncate poles, deeply constricted, sinus narrowly linear, often slightly open towards the outside; semicells scarcely five lobed, incisions below the polar lobe moderately deep and generally somewhat open, incisions between the two lateral lobes slightly open and not so deep; lateral lobes somewhat variable, typically bilobulate with each lobule emarginate; polar lobe very widely cuneate, apex convex and usually flattened or slightly retuse in the middle, lateral angles acuminate or emarginate. Cell-wall punctate. Length 87-138 microns; breadth 78-129 microns; breadth of polar lobe 65-97 microns; breadth of isthmus 18-27 microns.

Micrasterias conferta Lund. Desm. Suec., p. 14, t. 1, f. 5, 1871. (Plate III, Fig. 18)

Cells somewhat small, broadly elliptic, deeply constricted, sinus narrowly linear; semicells five lobed, with all the lobes and lobules closely approximated, the interlobular incisions being narrowly linear and not very deep; polar lobe subcuneate, dilated from a somewhat narrow base, lateral margins concave, apex convex

but slightly retuse in the middle, with two minute papillae on the apical margin near each of the slightly obtuse angles, often with a pair of small teeth on each side of the median hollow; lateral lobes about equal in breadth, each divided by a shallow incision into two lobules, lobules again divided, the four ultimate divisions being equal in size and retuse-emarginate. Cell-wall with punctuations. Length 84-89 microns; breadth 74-82 microns; breadth of polar lobe 40-44 microns; breadth of isthmus 16-19 microns.

Micrasterias Sol (Ehrenb.) Kutz. Spec. Alg., p. 171, 1849. (Plate IV, Fig. 1)

Cells approximately circular in outline, very deeply constricted, sinus slightly open with each margin faintly two or three undulate; semicells deeply five lobed, with the incisions between both the lobes and lobules deep and slightly open, sometimes open inwards but closed outwards; polar lobe with subparallel sides, slightly expanded at the apex, apical margin retuse-emarginate, each angle emarginate-dentate, with a small tooth attached within the apical margin near the angle on each side; lateral lobes unequal, superior lateral lobes slightly larger than inferior lateral lobes and generally (but not always) more subdivided; inferior lateral lobes divided into four equal lobules by three incisions, the median one being much deeper than the other two, each lobule furcate-dentate at the extremity (or sometimes further divided into two furcate-dentate portions of equal size); superior lateral lobes divided into eight equal lobules by seven incisions of which the median one is much the deepest, each lobule furcate-dentate at its extremity; margins of interlobular incisions generally slightly

undulate like the sinus. Length 162-191 microns; breadth 158-192 microns; breadth of polar lobe 36-38 microns; breadth of isthmus 17-18 microns. The figured specimen from Lily Lake is larger.

Micrasterias Sol (Ehrenb.) Kutz. var. *ornata* Nordst. in Pointsfor. Skand. Vaxt. iv, p. 25, 1880. (Plate IV, Fig. 2)

Cells approximately circular in outline, very deeply constricted, sinus slightly open with each margin faintly two or three undulate; semicells deeply five lobed, with the incisions between both the lobes and lobules deep and slightly open, sometimes open inward but closed outwards; polar lobe with subparallel sides, slightly expanded at the apex, apical margin retuse-emarginate, each angle emarginate-dentate, with a small tooth attached within the apical margin near the angle on each side; lateral lobes unequal, superior lateral lobes slightly larger than inferior lateral lobes and generally (but not always) more subdivided, inferior lateral lobes divided into four equal lobules by three incisions, the median one being much deeper than the other two, each lobule furcate-dentate at the extremity (or sometimes further divided into two furcate-dentate portions of equal size); superior lateral lobes divided into eight equal lobules by seven incisions of which the median one is much the deepest, each lobule furcate-dentate at its extremity; margins of interlobular incisions generally slightly undulate like the sinus, with a row of minute teeth or denticulations on each side of the sinus and of the incisions between the five lobes and the median incisions of the lobes. Length 112-188 microns; breadth 110-171 microns; breadth of isthmus 16-18 microns. The figured specimen from Lily Lake is larger.

Micrasterias papillifera Breb. in Ralfs' Brit. Desm., p. 72, t. 9, f. 1, 1848. (Plate III, Fig. 19)

Cells of moderate size, usually a little longer than broad, subelliptic or subcircular, deeply constricted, sinus very narrowly linear; semicells five lobed, with the lobes and lobules usually almost approximate, interlobular incisions linear; polar lobe cuneate with concave sides, apex concave with a slight median notch, each angle slightly produced and furcate-emarginate, with a pair of small teeth on each side of the median notch; lateral lobes cuneate, of almost equal breadth, each divided by a moderately deep incision into two lobules, lobules again divided, the four ultimate divisions of each lobe being emarginate (or rarely tridenticulate). Cell-wall generally minutely punctate, with a few acute granules or denticulations on each side of the sinus and the interlobular incisions. Length 118-145 microns; breadth 108-145 microns; breadth of polar lobe 35-44 microns; breadth of isthmus 15-22 microns.

Micrasterias papillifera Breb. forma *major* (Plate III, Fig. 20)

This is the same as the type only larger in size.

Micrasterias apiculata (Ehrenb.) Menegh. var. *brachyptera* (Lund.) nob. Desm. Suec., p. 12, t. 1, f. 4, 1871. (Plate IV, Fig. 3)

Cells large, longer than the type, very deeply constricted, sinus widely open outwards but linear towards its apex; semicells five lobed; polar lobe more projecting, relatively larger and wider, with a distinct constriction below the apex, apical margin widely retuse, angles with a pair of diverging spines and with a large curved spine on the apical margin close to each angle, and with a

pair of spines on each side of the apical notch; lateral lobes subequal, bilobulate, lobules furnished with two (sometimes three) marginal curved spines; sinus and incisions between the lobes widely open, especially the incisions between the polar lobe and the superior lateral lobes; generally with a row of spines bordering each side of the polar lobe and the sinus. Cell-wall punctate. Length 191-230 microns; breadth 131-180 microns; breadth of isthmus 34-37 microns; breadth of polar lobe 54-60 microns.

Micrasterias rotata (Grev.) Ralfs in Ann. Mag. Nat. Hist., p. 259, t. 6, f. 1, 1844. (Plate IV, Fig. 4)

Cells large, a little longer than broad, subcircular in outline, very deeply constricted, sinus narrowly linear; semicells five lobed, interlobular incisions narrowly linear; polar lobe gradually widening upwards, with concave sides, often slightly projecting, apex retuse-emarginate, angles slightly produced and bidentate; lateral lobes unequal and broadly cuneate, each divided into two lobules by a deep incision; superior lateral lobes larger than inferior lobes, each lobule subdivided into four equal emarginate (or bidentate) parts by three incisions, the median one being the deepest; lobules of inferior lateral lobes divided into two (sometimes four) bidentate parts. Length 208-366 microns; breadth 165-305 microns; breadth of isthmus 29-43 microns; breadth of polar lobe 48-80 microns.

Micrasterias denticulata Breb. Alg. Falaise, p. 54, t. 8, 1835. (Plate IV, Fig. 5)

Cells large, about 1/6 times longer than broad, broadly

elliptic in outline, deeply constricted, sinus narrowly linear; semicells five lobed, interlobular incisions narrowly linear; polar lobes narrowly cuneate, with dilated apex and concave sides, not projecting beyond the lateral lobes, apical margin retuse with a widely open notch in the center, angles obtuse or sometimes truncate emarginate; lateral lobes almost equal and broadly cuneate, superior lobes sometimes a little larger than inferior ones, divided into two lobules by a deep incision, each lobule further divided into four (sometimes only two) subequal, retuse or emarginate parts. Length 205-350 microns; breadth 177-277 microns; breadth of isthmus 23-40 microns; breadth of polar lobe 55-75 microns.

Micrasterias radiata Hass. Brit. Freshw. Hass., p. 386, t. 90, f. 2, 1845. (Plate IV, Fig. 6)

Cells of medium size, usually a little longer than broad, broadly elliptic in outline, deeply constricted, sinus narrowly linear, semicells five lobed, interlobular incisions narrowly linear; polar lobes narrowly cuneate, with dilated apex and concave sides, not projecting beyond the lateral lobes, apical margin retuse with a widely open notch in the center, angles obtuse or sometimes truncate emarginate; lateral lobes almost equal and broadly cuneate, superior lobes sometimes a little larger than inferior ones, divided into two lobules by a deep incision, each lobule further divided into four (sometimes only two) subequal, retuse or emarginate parts. Length 205-350 microns; breadth 177-277 microns; breadth of isthmus 23-40 microns; breadth of polar lobe 55-75 microns.

Micrasterias radiata Hass. Brit. Freshw. Hass., p. 386, t. 90, f. 2,

1845. (Plate IV, Fig. 6)

Cells of medium size, usually a little longer than broad, very deeply constricted, sinus widely open with an acute apex; semicells five lobed, incisions between the lobes wide and fairly deep; polar lobe with parallel sides in the lower half, dilated upwards, with each angle produced into a long, narrow, diverging process with a deeply furcate apex; lateral lobes commonly equal, but subject to variation, normally divided into two long, narrow, diverging lobules, with deeply-furcate apices; sometimes one or both lateral lobes are simple and undivided. Length 123-145 microns; breadth 113-186 microns; breadth of isthmus 17-30 microns; breadth of polar lobe 65-92 microns.

Micrasterias muricata (Bailey) Ralfs, Brit. Desm., p. 210, 1848. (Plate IV, Fig. 7)

Cells of medium size, 2-3 times longer than broad, rectangular, moderately deep constriction, sinus widely open; semicells five lobed, with very wide incisions; lateral lobes composed of cylindrical processes, processes slightly attenuating towards terminal end; polar lobe with similar shaped appendages extending laterally. Identification from Irenee-Marie.

Micrasterias sp. (Plate IV, Fig. 8)

Cells of moderate size, a little longer than broad, very deeply constricted, sinus open with acute or linear apex; semicells five lobed, interlobular incisions widely open, those on each side of the polar lobe much deeper than those between the superior and inferior lateral lobes; polar lobe subquadrate in its lower half, upper half

dilated, apex widely retuse, angles produced into short diverging processes with emarginate-bidentate apices; lateral lobes divided into two short, slightly diverging, elongate-quadrate lobules, emarginate-bidentate (sometimes tridentate or quadridentate with a median notch) at the apex. Cell with a few acute granules or denticulations above the isthmus and on each side of the sinus and incisions of the polar lobe.

Micrasterias Americana (Ehrenb.) Ralfs, Brit. Desm., p. xix, 1848.

(Plate IV, Fig. 9)

Cells of medium size, about 1/6 times longer than broad, deeply constricted, sinus somewhat open, toward the apex acute; semicells five lobed; polar lobe large, broad, and outstanding, cuneate from the base upwards, apical margin widely retuse, angles each produced into a thick divergent process with a truncate-denticulate apex, from near the base of each process a second accessory process arises, similar but smaller; incisions on each side of polar lobe widely open; lateral lobes rather small, incision between them open and not very deep, each lobe divided into two lobules by a wide and shallow notch, the two proximate lobules being smaller than the two distil lobules, each lobule with three or four teeth at the extremity. Cells with fine punctuations scattered all over, granules on a small protuberance in the middle above the isthmus. Length 125-160 microns; breadth 100-145 microns; breadth of polar lobe 63-75 microns; breadth of isthmus 17-22.5 microns.

VIII. *COSMARIUM* Corda, 1834

Cells very variable in size, usually a little longer than broad (sometimes 1 1/2 times or rarely about twice as long as broad), generally somewhat compressed, symmetrical in three planes at right angles to each other; constricted in the middle often deeply, but sometimes very slightly; semicells very variable in outline, elliptical, subcircular, semicircular, subquadrate, or truncate-pyramidate, apex rounded, truncate or subtruncate, without an apical incision, center of the semicell sometimes protuberant; vertical view elliptic, subelliptic, or oblong (rarely circular), often with a protuberance (sometimes more than one) at the middle on each side. Cell-wall smooth, punctate, scrobiculate, granulate, verrucose, or papillate, the various markings usually being arranged in a definite pattern.

The genus *Cosmarium* is the largest of the genera of desmids. For this reason the genera is divided into two divisions, a section with smooth cell-walls and a section with rough cell-walls. A dichotomous key is not strictly followed in the key.

Key to the Species of *Cosmarium*

Division I. Cell-wall smooth, punctulate or scrobiculate; outline never granulate, margins sometimes undulate or crenate.

1. Semicells semicircular, semi-elliptical, or subsemicircular in outline. 2.

2. Semicells semicircular or subsemicircular in outline; cells about as long as broad or a little longer than broad, rarely 1 1/3 times longer than broad. 3.

3. Margin of semicell entire. *C.* sp. (1).

3. Margin of semicell undulate. *C. undulatum.*

2. Semicells semi-elliptical in outline; cells 1 1/2-2 times longer than broad; margin of semicells entire. *C. Cucumis.*

1. Semicells transversly elliptical, oblong-elliptical, or reniform in outline. 4.

4. Semicells elliptic-reniform; sinus closed. 5.

5. Isthmus narrow; vertical view with a protuberance on each side. 6.

6. Cells as long as broad; semicells generally hexagonal-elliptic. *C. Phaseolus* var. *elevatum.*

6. Cells longer than broad; semicells subsemicircular-elliptic. *C. tumidum.*

5. Isthmus broader; vertical view elliptic. *C. melanosporum.*

4. Semicells elliptical or elliptic-oblong in outline; sinus open. 7.

7. Cell-wall smooth. 8.

8. Cells about as long as broad, deeply constricted. *C. bioculatum.*

8. Cells longer than broad, moderately constricted. *C. tinctum.*

7. Cell-wall finely punctate. *C. contractum* forma *Jacobsenii.*

4. Semicells narrowly elliptical or elliptic-oblong, depressed. *C.* sp. (2).

1. Semicells distinctly pyramidate or subpyramidate in outline, usually truncate. 9.

9. Margin of semicells entire, not crenate or undulate. 10.

10. Semicells pyramidate, lateral margins retuse or subretuse, very rarely straight. 11.

11. Cell-wall smooth. *C. Hammeri* var. *protuberans*.

11. Cell-wall punctate. *C.* sp. (3).

10. Semicells pyramidate, lateral margins convex, rarely straight. 12.

12. Cells never more than 1 1/4 times longer than broad. 13.

13. Semicells pyramidate-semicircular. 14.

14. Cells a little longer than broad or about the same size. *C.* sp. (4).

14. Cells about 1.5 times longer than broad. *C. refringens* var. *minor*.

13. Semicells pyramidate-trapeziform. *C. nitidulum*.

12. Cells 1 1/3-1 3/4 times longer than broad. 15.

15. Cell length 58-100 microns. *C. pyramidatum*.

15. Cell length 43-50 microns. *C. pseudopyramidatum*.

9. Margin of semicells undulate or crenate. 16.

16. Cell length 48-60 microns. *C. obtusatum*.

16. Cell length 20-25 microns. *C. venustum* forma *minor*.

1. Semicells circular or subcircular (rarely almost semicircular) in outline. 17.

17. Constriction fairly deep. 18.

18. Center of semicell with a circle of granules. *C.* sp. (5).

18. Cell-wall finely punctate. *C. moniliforme* forma *punctata*.

17. Constriction slight. 19.

19. Cell length 65-100 microns; semicells transversely subelliptic with a broad base, apex slightly flattened. *C. connatum*.

19. Cell length 47-58 microns; semicells semi-elliptic with a slightly narrowed base. *C. pseudocomatum.*

1. Semicells generally elliptic-hexagonal, subhexagonal, or polygonal in outline. 20.

20. Angles of semicells produced. 21.

21. Cells suboctangular, almost 1 1/2 times as long as broad. *C. Meneghinii.*

21. Cells a little longer than broad. *C. quadratulum.*

20. Angles of semicells not produced. 22.

22. Cell-wall smooth. *C. angulosum.*

22. Cell-wall very minutely and densely punctate. *C. difficile.*

1. Cells subcylindrical or fusiform-cylindrical, with a very slight constriction; lateral margins not parallel, generally convex. *C. viride.*

Division II. Cell-wall granulate, verrucose, or papillate.

1. Semicells semicircular, subsemicircular, or semi-elliptical in outline; cells approximately circular, subcircular, or elliptical in outline. *C. quadrifarium* forma *hexasticha.*

1. Semicells circular or subcircular in outline. 2.

2. Constriction slight. *C. subexcavatum* var. *ordinatum.*

2. Constriction fairly deep. *C. orbiculatum.*

1. Semicells reniform, elliptical, subelliptical, or oblong-elliptical in outline. 3.

3. Semicells distinctly reniform in outline. *C. ornatum.*

3. Semicells elliptical in outline, sinus linear. 4.

4. Cell-wall uniformly granulate, or nearly so. 5.

5. Granules rounded, disposed in about ten vertical series, with about 20-30 visible at the margin of each semicell. *C. Portianum.*

5. Granules relatively large, and somewhat distant, normally arranged in seven or eight vertical series, with three or four granules in each series, eleven to fourteen visible at the margin of the semicell. *C. orthostichum.*

4. Cell-wall not uniformly granulate; granules in the center of the semicells differentiated and sometimes isolated. 6.

6. Semicells subreniform-oblong, lateral margins each with 5-7 acute granules. *C. trachypleurum* var. *minus.*

6. Semicells semicircular-elliptic, sides convex and furnished with four or five acute granules. *C. isthmochondrum.*

1. Semicells pyramidate or subpyramidate in outline with the apex truncate. 7.

7. Cells as long as broad, or very slightly longer. 8.

8. Semicells somewhat widely truncate, without a central inflation. 9.

9. Cell length over forty microns long. 10.

10. Cells slightly longer than broad, usually under seventy-five microns long. *C. margaritiferum.*

10. Cells about 1 1/2 times longer than broad, usually over seventy-five microns long.

C. Eloisianum var. *depressum.*

9. Cell length under forty microns. *C. furcatospermum.*

8. Semicells with differentiated central granules and a slight indication of a central inflation. 11.

11. Cells subhexagonal. *C. quinarium* forma *irregularis.*

11. Cells elliptical. *C. norvegicum.*

8. Semicells with a distinct central inflation. 12.

12. Semicells subsemicircular, with a broad flattened tumor in the center above the isthmus furnished with 5-7 vertical series of granules (3-6 granules in each series). *C. subcrenatum.*

12. Semicells trapeziform-semicircular, with a slight but broad tumor above the isthmus furnished with about four granules. *C. Boeckii.*

7. Cells 1 1/4 times longer than broad, or more. 13.

13. Margin of semicells crenate; crenations usually finely granulate. *C. subspeciosum* var. *validius.*

13. Margin of semicells entire. *C. denticulatum* forma *Borgei.*

1. Semicells more or less rectangular or subrectangular (rarely subpyramidate) in outline. 14.

14. Semicells rounded-quadrate, moderately constricted. *C. amoenum.*

14. Semicells oblong, only slightly constricted. Cell is proportionately a little narrower than *C. amoenum.*

C. pseudamoenum.

1. Semicells subcylindrical; constriction of cells slight.

C. elegantissimum forma *minor.*

Cosmarium sp. (1) (Plate VI, Fig. 4)

Cell about 1 1/4 times longer than broad, deeply constricted, sinus narrowly linear; semicells semicircular, basal angle slightly rounded, with a mammilate tooth above isthmus. Side view circular. Vertical view elliptical. Cell-wall appears to be scrobiculate.

Cosmarium undulatum Corda in Alm. de Carlsbad, p. 243, t. 5, f. 26, 1839. (Plate V, Fig. 1)

Cells rather small, quadrate-elliptic, about 1 1/3 - 1 1/2 times as long as broad, deeply constricted, sinus narrow with a dilated extremity; semicells widening upwards near the base, then subsemicircular, margins with 10-12 equal undulations. Side view of semicell subcircular. Vertical view elliptic. Cell-wall smooth. Length 54-64 microns; breadth 39-52 microns; breadth of isthmus 12.5-17 microns.

Cosmarium Cucumis (Corda) Ralfs' Brit. Desm., p. 93, t. 15, f. 2, 1848. (Plate V, Fig. 2)

Cells large, 1 1/2 - 1 3/4 times as long as broad, deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells semi-elliptic or widely truncate-ovate from a broad base, both inferior and superior angles rounded, apex rounded. Side view of semicell obtusely ovate. Vertical view broadly elliptic or elliptic-oblong. Length 62-102 microns; breadth 34-56 microns; breadth of isthmus 20-38 microns. The figured specimen from Lily Lake has a slightly narrower isthmus and the cell-wall shows dense and minute scrobiculations similar to *Cosmarium Cucumis* var. *helveticum*.

Cosmarium Phaseolus Breb. var. *elevatum* Nordst. Norges Desm., p. 17, t. 1, f. 5, 1873. (Plate V, Fig. 3)

Cells small, as long as broad, deeply constricted, sinus narrow with a dilated extremity; semicells generally hexagonal-elliptic, apex truncate-convex. Side view of semicell subcircular, with a slight protuberance at the middle on each side. Vertical view narrowly elliptic. Cell-wall minutely punctate. Length 26.4-28.8 microns; breadth 25.2-30 microns; breadth of isthmus 7-10 microns. The figured specimen from Lily Lake is slightly smaller.

Cosmarium tumidum Lund. Desm. Suec., p. 45, t. 3, f. 16, 1871. (Plate V, Fig. 4)

Cells rather small, a little longer than broad, deeply constricted, sinus narrow, widening outwards; semicells subsemicircular-elliptic; apices broadly convex. Side view of semicell circular. Vertical view elliptic-rhomboid, widely tumid at the middle on each side. Cell-wall finely punctate, punctulations larger in the center of the semicells. Length 33-37 microns; breadth 27-32 microns; breadth of isthmus 8-9.5 microns. The figured specimen from Lily Lake is slightly smaller.

Cosmarium melanosporum Arch. in Ann. Mag. Nat. Hist., 5th ser. XII, p. 124, 1883. (Plate V, Fig. 5)

Cells small, as long as broad, or sometimes a little longer than broad, deeply constricted, sinus narrow, widening outwards; semicells transversely oblong, basal angles well rounded, upper angles more rounded; apex broadly convex. Side view of semicell circular. Vertical view elliptic. Length 15-19 microns; breadth 15-19 microns;

breadth of isthmus 5-6.7 microns.

Cosmarium bioculatum Breb. in Ralfs' Brit. Desm., p. 95, t. 15, f. 5, 1848. (Plate V, Fig. 6)

Cells minute, about as long as broad, deeply constricted, sinus narrow toward the apex and widening outwards; semicells transversely oblong-elliptic, both base and apex flattened, sides rounded. Side view of semicell subcircular. Vertical view oblong-elliptic. Cell-wall smooth. Length 15-21 microns; breadth 15-21 microns; breadth of isthmus 4.8-6.7 microns.

Cosmarium tinctum Ralfs, Brit. Desm., p. 85, t. 32, f. 7, 1848. (Plate V, Fig. 7)

Cells minute, a little longer than broad, moderately constricted, sinus narrow toward the apex but open outwards; semicells elliptic. Side view of semicell subcircular. Vertical view elliptic. Cell-wall smooth. Length 10-15 microns; breadth 7.5-11.6 microns; breadth of isthmus 4.5-8.4 microns.

Cosmarium contractum Kirchn forma *Jacobsenii* (Roy) nob. Biss. Desm. Windermere, p. 194, 1884. (Plate V, Fig. 8)

Cells rather small, about 1 1/2 times longer than broad, very deeply constricted, sinus open but rounded at the apex; semicells more equally elliptic or oblong-elliptic; ventral margin always more convex than the dorsal margin. Side view of semicell circular. Vertical view elliptic. Length 28-45 microns; breadth 18-27 microns; breadth of isthmus 4.5-7.5 microns.

Cosmarium sp. (2) (Plate V, Fig. 9)

Cells small, about as long as broad, medium constriction, sinus opening outwards; semicells depressed, transversely elliptic; apex convex, lateral margins rounded. Cell-wall smooth.

Cosmarium Hammeri Reinsch var. *protuberans* West and G. S. West, Some N. Amer. Desm., p. 246, t. 14, f. 35, 1896. (Plate V, Fig. 10)

Cells of moderate size, about 1 1/4 times longer than broad, subhexagonal, deeply constricted, sinus narrowly linear with a dilated apex, opening outwards; semicells truncate-pyramidate, basal angles well rounded, upper part of sides suddenly converging and slightly retuse, upper angles rounded; apex broadly truncate, straight or slightly retuse. Vertical view elliptic with a median tumor on each side. Cell-wall smooth. Length 24-35 microns; breadth 18.5-21.5 microns; breadth of isthmus 7-7.5 microns.

Cosmarium sp. (3) (Plate V, Fig. 12)

Cells of moderate size, about 1 1/4 times longer than broad, subhexagonal, deeply constricted, sinus narrowly linear with a dilated apex, opening outwards; semicells truncate-pyramidate, basal angles well rounded, upper part of sides suddenly converging and slightly retuse, upper angles rounded; apex broadly truncate, straight or slightly retuse. Vertical view elliptic with a median tumor on each side. Cell-wall punctate. This species is distinguished from *Cosmarium Hammeri* var. *protuberans* only by the fine punctate cell-wall and its slightly larger size.

Cosmarium sp. (4) (Plate V, Fig. 12)

Cells small, a little longer than broad, deeply constricted, sinus narrow with a dilated apex; semicells with pyramidate-semicircular, basal angles rounded, lateral margins convex (nearly straight): apex widely truncate and generally straight.

Cosmarium refringens W. R. Taylor var. *minor* var. nov. (Plate V, Fig. 13)

Cells smaller than type, about 1.5 times longer than broad, moderately constricted, sinus linear with a dilated apex; semicells pyramidate-semicircular, basal angles rounded, lateral margins convex; apex widely truncate and straight. Identification is from Irenee-Marie (1952).

Cosmarium nitidulum De Not. Desm. Ital., p. 42, t. 3, f. 26, 1867. (Plate V, Fig. 14)

Cells of moderate size, a little longer than broad, deeply constricted, sinus very narrowly linear with a slightly-dilated extremity; semicells truncate-subsemicircular, basal angles broadly rounded, sides convex and converging upwards, upper angles slightly rounded; apex small, truncate-convex, straight, or slightly retuse. Side view of semicell subcircular. Vertical view elliptic. Cell-wall very minutely punctate (punctulations often scarcely visible). Length 30-41 microns; breadth 23-33 microns; breadth of isthmus 8-10 microns.

Cosmarium pyramidatum Breb. in Ralfs' Brit. Desm., p. 94, t. 15, f. 4a-c. 1848. (Plate V, Fig. 15)

Cells large, about 1 1/2 times as long as broad, truncate-elliptic in outline, deeply constricted, sinus very narrow and dilated toward the apex; semicells truncate-pyramidate, basal angles well rounded, sides convex and in the upper part converging, upper angles obtuse; apex narrowly truncate. Side view of semicell elliptic oblong. Vertical view elliptic. Cell-wall minutely scrobiculate. Length 58-100 microns; breadth 45-62 microns; breadth of isthmus 17.5-20 microns.

Cosmarium pseudopyramidatum Lund. Desm. Suec., p. 41, t. 2, f. 18, 1871. (Plate V, Fig. 16)

Cells of moderate size, about 1 3/4 times as long as broad, deeply constricted, sinus narrowly linear; semicells truncate-pyramidate or truncate-semi-elliptical, basal angles rounded, sides convex and converging to apex which is narrowly truncate, upper angles obtuse. Side view of semicell broadly elliptic. Vertical view elliptic. Cell-wall distinctly punctate. Length 43-50 microns; breadth 25-33 microns; breadth of isthmus 7-10.5 microns.

Cosmarium obtusatum Schmidle, Ost-Africa Desmid., p. 38, 1898. (Plate V, Fig. 17)

Cells of medium size, about 1 1/6 times as long as broad, deeply constricted, sinus very narrow with dilated apex; semicells truncate-pyramidate, basal angles slightly rounded, sides convex with about eight undulations, also with two similar series within each margin having an appearance not unlike granules; apex truncate. Side view of semicell broadly elliptic. Vertical view oblong-elliptic. Cell-wall punctate. Length 48-60 microns; breadth 42-50

microns; breadth of isthmus 15-15.5 microns. The figured specimen from Lily Lake has a broader isthmus.

Cosmarium venustum (Breb.) Arch. forma *minor* Wille, Ferskv. Alg. Nov. Semlf., p. 43, 1879. (Plate V, Fig. 18)

Cells rather small, about 2/3 the size of the type, about 1 1/4 times longer than broad, very deeply constricted, sinus narrowly linear with a dilated apex; semicells truncate-pyramidate, sides (including the rounded upper and lower angles) triundulate; apex widely truncate and generally slightly retuse (more rarely straight). Side view of semicell elliptic. Vertical view elliptic. Cell-wall minutely punctate. Length 20-25 microns; breadth 16-18 microns; breadth of isthmus 6-7 microns.

Cosmarium sp. (5) (Plate V, Fig. 19)

Cells small, about 1.5 times longer than broad, deeply constricted, sinus widely open, semicells circular, slightly compressed; center of semicell with a circle of granules. Side view of semicell circular. Vertical view elliptical.

Cosmarium moniliforme (Turp.) Ralfs forma *punctata* Lagerh. Algol. Bidr. II, p. 197, 1887. (Plate V, Fig. 20)

Cells small, about twice as long as broad, deeply constricted, sinus widely open, but usually acute; semicells circular or subcircular. Side view of semicell circular or subcircular. Vertical view circular. Cell-wall finely punctate. Length 24-43 microns; breadth 14-25 microns; breadth of isthmus 3.5-6.7 microns. The figured specimen from Lily Lake is larger.

Cosmarium connatum Breb. in Ralfs' Brit. Desm., p. 108, t. 17, f. 10, 1848. (Plate V, Fig. 21)

Cells large, almost 1 1/3 times longer than broad, moderately constricted, sinus very widely open with an obtuse apex; semicells transversely sub-elliptic with a broad base; apex commonly very slightly flattened. Vertical view subcircular, slightly compressed. Cell-wall often somewhat thick, finely scrobiculate, and densely but minutely punctate between the scrobiculations. Length 65-100 microns; breadth 46-74 microns; breadth of isthmus 40-50 microns.

Cosmarium pseudoconnatum Nordst. Desm. Brasil., p. 214, t. 3, f. 17, 1870 (Plate V, Fig. 22)

Cells of moderate size, almost 1 1/2 times as long as broad, very slightly constricted by a broad and very shallow sinus; semicells semi-elliptic with a slightly narrowed base, in outline about 2/3 the circumference of a circle. Vertical view circular or subcircular. Cell-wall punctate, the punctulations near the isthmus being sometimes arranged in transverse series. Length 47.5-57.5 microns; breadth 33-44 microns; breadth of isthmus 31-40 microns. The figured specimen from Lily Lake fits this description except the cell-wall was not punctulated.

Cosmarium Meneghinii Breb. in Ralfs' Brit. Desm., p. 96, t. 15, f. 6, 1848. (Plate V, Fig. 23)

Cells small, suboctangular, almost 1 1/2 times as long as broad, deeply constricted, sinus narrow and linear; semicells transversely rectangular in the lower part and pyramidate-truncate in the upper part, lower parts of sides parallel and slightly retuse, upper

parts of sides strongtly convergent and retuse; apex widely retuse, all the angles somewhat rounded. Side view of semicell broadly elliptic or subcircular. Vertical view elliptic. Cell-wall smooth. Length 12.5-24 microns; breadth 9.5-17 microns; breadth of isthmus 3-6 microns.

Cosmarium quadratulum (Gay) De Toni, Syll. Alg., p. 934, 1889.

(Plate V, Fig. 24)

Cells very small, a little longer than broad, deeply constricted, sinus narrowly linear with a slightly dilated apex; semicells transversely subrectangular, sides and apex slightly retuse, basal and upper angles obliquely truncate. Side view of semicell elliptic-circular. Vertical view elliptic. Cell-wall smooth. Length 12.5-15 microns; breadth 11-12.7 microns; breadth of isthmus 2-3.4 microns. The figured specimen from Lily Lake is slightly smaller.

Cosmarium angulosum Breb. Liste Desm., p. 127, t. 1, f. 17, 1856.

(Plate V, Fig. 25)

Cells small, about 1 1/2 times longer than broad (sometimes very little longer than broad), deeply constricted, sinus narrow and linear; semicells subquadrate or subrectangular, inferior angles scarcely rounded, sides straight and parallel, superior angles obliquely truncate; apex truncate and straight. Side view of semicell subcircular. Cell-wall smooth. Length 14.5-28 microns; breadth 13.5-18 microns; breadth of isthmus 3.2-6 microns.

Cosmarium difficile Lutkem Desm. Attersees, p. 551, t. 8, f. 3, 1893.

(Plate VI, Fig. 1)

Cells small, about 1 1/2 times as long as broad, deeply constricted, sinus narrowly linear with a slightly dilated apex; semicells subrectangular with an elevated apex, basal angles rectangular and rounded, lower part of sides slightly retuse, upper part of sides retuse and converging towards the apex, which is convexly truncate with a minute median depression; semicell with three transverse rows of minute scrobiculations, one close to the base, one above the middle, and one just below the apex. Side view of semicell oblong-ovate. Vertical view elliptic-oblong. Cell-wall very minutely and densely punctate. Length 28-33 microns; breadth 20-22.5 microns; breadth of isthmus 4-6 microns. The figured specimen from Lily Lake is slightly smaller.

Cosmarium viride (Corda) Josh., New and Rare Desm., p. 34, t. 254, f. 3, 1885. (Plate VI, Fig. 2)

Cells somewhat small, about 1 3/4 times longer than broad, moderately constricted, sinus a very obtuse-angled depression; semicells obovate-circular, widest part about 1/3 from the apex; apex commonly very slightly depressed. Vertical view circular. Cell-wall punctate. Length 41-55 microns; breadth 20-33 microns; breadth of isthmus 14-22 microns. The figured specimen from Lily Lake is larger and no punctulations were observed on this species.

Cosmarium viride forma *glabra* nob. (Plate VI, Fig. 3)

Cells somewhat small, about 1 3/4 times longer than broad, moderately constricted, sinus a very obtuse-angled depression; semicells obovate-circular, widest part about 1/3 from the apex; apex commonly very slightly depressed. Vertical view circular.

Cell-wall smooth. Length 34-39 microns; breadth 18-22 microns; breadth of isthmus 14-16 microns.

Cosmarium quadrifarium Lund. forma *hexasticha* (Lund.) Nordst. Freshw. Alg. N. Zeal., p. 49, 1888. (Plate VI, Fig. 5)

Cells rather under medium size, about 1 1/4 times longer than broad, deeply constricted, sinus narrowly linear with a slightly dilated apex; semicells semicircular, basal angles subrectangular and only a little rounded, margin furnished with 15-17 truncate-emarginate warts, those at the basal angles commonly slightly reduced with six parallel series of emarginate verrucae in the marginal region, two series usually visible within the marginal warts; central granules variable, commonly similar to those of the type, but sometimes in four transverse series. Poles of side and vertical views with six granules. Cell-wall often minutely punctate. Length 40-53 microns; breadth 32-44 microns; breadth of isthmus 14-21 microns.

Cosmarium subexcavatum West and G. S. West var. *ordinatum* West and G. S. West, Notes Alg. II, p. 293, t. 412, f. 3, 1900. (Plate VI, Fig. 6)

Cells small, about 1 2/5 times as long as broad, a little longer than in the typical form, moderately constricted, sinus open and subrectangular; semicells broadly obovate; granules small, disposed in about six horizontal and eight vertical series, 15-16 showing at the margin. Vertical view circular or circular-elliptic. Length 29-37 microns; breadth 17-23 microns; breadth of isthmus 11.5-13.5 microns.

Cosmarium orbiculatum Ralfs in Ann. Mag. Nat. Hist. XIV, p. 392, t. 11, f. 2, 1844. (Plate VI, Fig. 7)

Cells small, twice as long as broad, deeply constricted, sinus widely open outwards from an acute apex; semicells circular. Cell-wall covered with subconical granules having no regular disposition, 14 or 15 showing at the margin. Vertical view circular. Length 35-38 microns; breadth 18-20 microns; breadth of isthmus 6.5-8 microns. The figured specimen from Lily Lake is larger.

Cosmarium ornatum Ralfs in Ann. Mag. Nat. Hist. XIV, p. 392, t. 11, f. 3, 1844. (Plate VI, Fig. 8)

Cells small, as long as broad, deeply constricted sinus narrowly linear with a slightly dilated apex; semicells reniform, with slightly produced, truncate apices, basal angles and lower parts of sides braodly rounded, upper parts of lateral margins immediately below the apex sometimes very slightly retuse; apex broadly truncate and straight; lateral margins with 7-9 prominent granules, slightly reduced in size just below the apex and often not reaching so far as the upper angles; apex with about seven marginal granules; with a number of conspicuous granules within the lateral margins, often in short oblique series, and with one or two series of granules (variable both in size and number) within the apex; with a granulated protuberance in the center of each semicell, granules conspicuous and variable both in size and disposition (sometimes arranged in short vertical series and sometimes more or less concentrically disposed). Side view of semicell depressed-subcircular, with a very slightly produced and truncate apex. Vertical view elliptic-oblong,

with broadly rounded poles, and with a broad, granulate tumor at the middle on each side; central region of apex smooth. Length 32-41 microns; breadth 33-41 microns; breadth of isthmus 10-11.5 microns.

Cosmarium Portianum Arch. Quart. Journ. Micr. Sci. viii, p. 235, t. 11, 1860. (Plate VI, Fig. 9)

Cells rather small, about 1 1/3 times as long as broad, deeply constricted, sinus gradually opening from a rounded extremity, isthmus slightly elongated; semicells elliptic and granulate; granules rounded, disposed in about ten vertical series, and sometimes in oblique series also (rarely more or less irregular), with about 20-23 visible at the margin of each semicell. Side view of semicell circular. Vertical view elliptic. Length 30-40 microns; breadth 22-30 microns; breadth of isthmus 8-12 microns.

Cosmarium orthostichum Lund. Desm. Suec., p. 24, t. 2, f. 9, 1871. (Plate VI, Fig. 10)

Cells rather small, a little longer than broad, deeply constricted, sinus narrow with a slightly dilated extremity; semicells subelliptic or subreniform-elliptic, dorsal margin somewhat more convex than ventral margin, median part of apex rarely straight. Side view of semicell circular. Vertical view elliptic. Cell-wall granulate; granules relatively large, and somewhat distant, normally arranged in seven or eight vertical series, with three or four granules in each series (median granules rarely duplicated), 11-14 visible at the margin of the semicell; in the vertical view the granules are sometimes approximately arranged in transverse series, and at other times there is a clear central space. Length 32-36

microns; breadth 28-33 microns; breadth of isthmus 9.5-11 microns.

Cosmarium orthostichum Lund. var. *pumilum* Lund. Desm. Suec., p. 25, t. 2, f. 10, 1871. (Plate VI, Fig. 11)

Cells smaller than the typical form, semicells oblong-elliptic, granules disposed in six vertical and three horizontal series. Length 21.5-25 microns; breadth twenty microns; breadth of isthmus 5-8 microns.

Cosmarium trachypleurum Lund. var. *minus* Racib., in Spraw. Kom. fizyj. Akad. Umiej. Krakow. XIX, p. 11, t. 1, f. 5, 1884. (Plate VI, Fig. 12)

Cells rather under medium size, 1 1/4 times as long as broad, somewhat smaller and more compressed than type, deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells subreniform-oblong, lateral margins each with 5-7 acute granules, with the acute marginal granules continued over the apex, with seven large rounded granules in the center, one central and six peripheral, and with minute punctulations between them. Side view of semicell circular. Vertical view elliptic. Cell-wall very delicately punctate between the granules. Length 31-34.5 microns; breadth 26.5-33 microns; breadth of isthmus 8.5-12 microns. The figured specimen from Lily Lake has nine large rounded granules in the center, one central and eight peripheral.

Cosmarium isthmochondrum Nordst. Norges Desm., p. 12, t. 1, f. 2, 1873. (Plate VI, Fig. 13)

Cells small, about 1 1/6 times as long as broad, deeply

constricted, sinus narrowly linear; semicells semicircular-elliptic, basal angles obtuse and furnished with a papilla, sides convex and furnished with four or five acute granules; apex subtruncate (very slightly convex) and smooth; semicells with a single series of four minute granules within each lateral margin and two larger granules within the median part of the apex, with a large granule immediately above the isthmus, and with one or two scrobiculations in the center of the semicell. Side view of semicell circular, with a granule on each side of the apex and one just above the isthmus on each side. Vertical view elliptic, sides granulate, with two larger granules at the middle on each side, poles somewhat pointed. Length 30-35 microns; breadth 27-30 microns; breadth of isthmus 7.5-11 microns.

Cosmarium margaritiferum Menegh. Synops. Desm., p. 219, 1840.

(Plate VI, Fig. 14)

Cells rather under medium size, slightly longer than broad, very deeply constricted, sinus narrowly linear with a dilated extremity; semicells broadly pyramidate-truncate, basal and upper angles rounded, sides slightly convex; apex wide and straight or very slightly convex. Cell-wall granulate, granules large, not quite uniform in size, those in the center of the semicells and near the basal angles and lateral margins generally somewhat larger than the others, with 7-9 granules visible on each lateral margin, those near the apex usually smaller than those at the base; apex smooth (destitute of marginal granules); granules with no definite disposition, but scattered at equal distances, sometimes in very indistinct oblique series, with some minute scrobiculations surrounding the granules in the center of the semicells.

Cell-wall between all the granules densely and very minutely punctate. Side view of semicell circular, granules of lateral margins very prominent, apex smooth. Vertical view elliptic with the granules at the middle on each side rather larger than the other marginal granules, in the center with a punctated area destitute of granules. Length 50-59 microns; breadth 42-56 microns; breadth of isthmus 13-16 microns.

Cosmarium Eloisianum Wolle var. *depressum* West and G. S. West (Plate VI, Fig. 15)

Cells about 1 1/2 times longer than broad, deeply constricted, sinus linear, opening towards exterior, enlarged at bottom; semicell elliptical, margin with 25-30 triangular teeth strongly accuminate; center protuberance strongly scrobiculate; apex slightly flattened with teeth continuing below margin; basal angles contain four or five scattered teeth beside marginal teeth; prominant granule on each side of isthmus. Description from Irenee-Marie.

Cosmarium furcatospermum West and G. S. West, New Brit. Freshw. Algae, p. 7, t. 1, f. 13, 1894. (Plate VI, Fig. 16)

Cells small, a little longer than broad, deeply constricted, sinus linear; semicells truncate-semicircular or oblong-subsemicircular, basal angles subrectangular or slightly rounded; lateral margins 4-5 crenate-granulate; apex widely truncate and 5-6 undulate, with two (rarely with one) series of small granules within the whole margin, and with the central region of the semicells smooth or most minutely punctate. Side view of semicell subcircular. Vertical view elliptic or oblong-elliptic. Length 18-22 microns; breadth

16.5-19 microns; breadth of isthmus 5.7-7 microns. The figured specimen from Lily Lake is slightly smaller.

Cosmarium quinarium Lund. forma *irregularis* Nordst. Norges Desm., p. 13, 1873. (Plate VI, Fig. 17)

Cells somewhat small, subhexagonal in general outline, about 1 1/4 times as long as broad, deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells broadly pyramidate-truncate, basal angles obtuse, apical angles rounded, sides convex; apex truncate; margin furnished with 14-15 acute granules which give it an acutely undulate character, with a series of ten acute or rounded granules just within the margin, and with 5-9 central granules disposed in an irregular manner. Side view of semicell circular, with three acute granules at each side. Vertical view elliptic and granulate except for a smooth area in the center, granules at the middle on each side larger and more prominent, marginal granules acute. Length 39-42 microns; breadth 33-34.5 microns; breadth of isthmus 9.5-11 microns. The breadth and breadth of isthmus of the figured specimen of Lily Lake is smaller.

Cosmarium norvegicum Strom. (Plate VI, Fig. 18)

Cells small, elliptical, lateral margin convex with four crenulations, of which three at the top are emarginate; apex straight with two or three undulations; deeply constricted, sinus narrowly linear with a slightly dilated extremity. Cell-wall with four or five rows of concentric granules along margin, diminishing in size toward the center; center of semicell with four rows of three or four granules larger than marginate granules. Description from

Irenee-Marie.

Cosmarium subcrenatum Hantzsch in Rabenh. Alg., no. 1213, 1861. (Plate VI, Fig. 19)

Cells small, a little longer than broad, deeply constricted, sinus narrowly linear; semicells subsemicircular with a truncate apex, basal angles more or less subrectangular, sides 4-6 (commonly five)-crenate, upper crenations slightly larger than lower crenations, apex four (more rarely five)-crenate, generally with minute binate granules immediately within each crenation (except the one or two basal ones), and within these with one or two series of minute granules disposed both radially and concentrically, with a broad flattened tumor in the center above the isthmus furnished with 5-7 vertical series of granules (3-6 granules in each series). Side view of semicell ovate from a broad base; apex truncate, upper parts of sides retuse. Vertical view elliptic, with a broad tumor on each side furnished with about five very distinct granules, poles rounded or truncate. Length 23-37 microns; breadth 18-30 microns; breadth of isthmus 8-14 microns.

Cosmarium Boeckii Wille, Norges Ferskv. Alg. p. 28, t. 1, f. 10, 1880. (Plate VI, Fig. 20)

Cells somewhat small, very slightly longer than broad, very deeply constricted, sinus narrowly linear; semicells trapeziform-semicircular, lateral margins convex, incised-crenate, crenations three, upper and lower emarginate, middle crenation entire and subacute; apex truncate, and 4-5 (generally five)-undulate-nodulose, with two series (rarely only one) of granules within the margin, with more

granules in the outer series than in the inner; center of semicell with a rather slight but broad tumor, usually furnished with four granules disposed in a cruciate manner, lower granule situated immediately above the isthmus and often stronger than the others. Side view of semicell obovate-circular, margin with 9-12 granules. Vertical view elliptic, poles five-granulate, with a slight and broad three-granulate tumor on each side. Length 29-38 microns; breadth 27-35.5 microns; breadth of isthmus 8-13 microns.

Cosmarium subspeciosum Nordst. var. *validius* Nordst., Botan. Notis., p. 160, 1887. (Plate VI, Fig. 21)

Cells rather large, 1 1/4 - 1 1/3 times as long as broad, deeply constricted, sinus narrowly linear; semicells pyramidate-subsemicircular, from the flat base at first slightly dilated, then very gradually attenuated to the subtruncate apex, basal angles scarcely rounded, apical angles slightly rounded; margin 16-18-crenate, four apical crenations and 7-9 on each convex side, those crenations near the basal angles smaller than the apical ones; crenations (except those at the basal angles) minutely bigranulate, within the margins minutely granulate, granules arranged in radial and concentric series, three outer concentric series geminate, two inner series single; in the center above the isthmus with a rounded granulate tumor, with 7-9 vertical series of granules. Side view of semicell ovate-rectangular, slightly tumid at the base on each side, apical angles slightly rounded. Vertical view elliptic, with a tumor at the middle on each side, poles rounded. Length 68-84 microns; breadth 47-53 microns; breadth of isthmus 17.5-22 microns. The

figured specimen from Lily Lake showed about 21-22 marginal crenations.

Cosmarium denticulatum Borge forma *Borgei*, Austral. Susswasserchlor., p. 19, t. 3, f. 31, 1896. (Plate VI, Fig. 22)

Cells ovale, deeply constricted, sinus linear, closed in middle, opening outwardly and enlarged at bottom; semicell margin convex with about thirty-five teeth on the periphery and four or five rows within the margin; apex void of marginate teeth, straight or slightly rounded, teeth within margin diminish in size toward center of cell; from two to four rows of granules transverse semicell on each side of isthmus extending slightly beyond breadth of isthmus, center granules larger in size than those at near basal angles. Cell-wall densely scrobiculate. Description from Irenee-Marie.

Cosmarium amoenum Breb. in Ralfs' Brit. Desm., p. 102, t. 17, f. 3, 1848. (Plate VI, Fig. 23)

Cells somewhat small, almost twice as long as broad, moderately constricted, sinus rather variable, often slightly open and acute-angled (more rarely sublinear); semicells rounded-quadrate with sides and apex very slightly convex, sometimes semi-elliptic. Cell-wall granulate, granules in more or less distinct vertical series (from 6-9 of these series visible across the face of a semicell), about 20-25 visible round the margin of a semicell, granules at the base of the semicell sometimes more or less regularly disposed in vertical pairs. Side view of semicell ovate-oblong or subelliptic-oblong. Vertical view broadly elliptic. Length 42.5-55 microns; breadth 23-30 microns; breadth of isthmus 11-17 microns.

Cosmarium pseudamoenum Wille, Sydamerik Algfl., p. 18, t. 1, f. 37, 1884. (Plate VI, Fig. 24)

Cells somewhat small, about twice as long as broad, almost cylindrical, only slightly constricted, sinus a small and open notch; semicells oblong with the sides straight or very slightly convex; apex broadly rounded or faintly truncate in the middle. Cell-wall uniformly granulate, granules small and rather variable in disposition, sometimes irregular, sometimes in more or less distinct longitudinal series, and not infrequently in decussating oblique series. Side view of semicell oblong with a rounded apex. Vertical view subcircular-elliptic. Length 44-59 microns; breadth 18-29 microns; breadth of isthmus 15-24 microns.

Cosmarium pseudamoenum Wille var. *basilare* Nordst. in Botan. Notis., p. 160, 1887. (Plate VI, Fig. 25)

Semicells with a transverse double series of granules across the base just above the isthmus, each pair of granules being part of a bigranulate wart. Length 40-53 microns; breadth 22.5-30 microns; breadth of isthmus 15-22 microns. The figured specimen from Lily Lake shows six or seven verrucae in horizontal series and about five verrucae in vertical series.

Cosmarium elegantissimum Lund. forma *minor* West, Alg. W. Ireland, p. 164, t. 24, f. 10, 1892. (Plate VI, Fig. 26)

Cells less than 2/3 the size of the typical form, about 2 1/2 times longer than broad, perfectly cylindrical with hemispherical ends, median constriction very slight, sinus a slight excavation; semicells oblong, with a rectangular base; apex strongly convex.

Cell-wall furnished with emarginate verrucae (about nineteen visible round the margin of a semicell), disposed in regular vertical and horizontal series, about eight or nine horizontal series and about nine vertical series seen in front view. Vertical view circular, with about twenty-two small nodulations round the margin. Length 49-54 microns; breadth 22-23 microns; breadth of isthmus 17-19.5 microns. The figured specimen from Lily Lake is smaller.

IX. *XANTHIDIUM* Ehrenb., 1837

Cells of very variable size, usually somewhat longer than broad, invariable compressed, symmetrical in three planes at right angles to each other; median constriction invariably deep; semicells of variable outline, elliptical, elliptic-hexagonal, trapeziform, or polygonal, generally with a flattened apex, center of the semicell (with rare exceptions) differentiated as a thickened, often scrobiculated, and generally protuberant area. Vertical view more or less elliptic, generally with a protuberance at the middle on each side. Cell-wall furnished with simple, or more rarely with furcate spines, sometimes disposed in a median plane, but usually arranged more or less symmetrically on each side of a median plane.

Key to the Species of *Xanthidium*

1. Cells large with tri- or quadrifurcate processes.

X. armatum var. *fissum.*

1. Cells of medium size or small, with long simple spines. 2.

2. Semicells with two pairs of spines on each side. *X. antilopaeum.*

2. Semicells with two pairs of spines and one single spine on each side. *X. cristatum.*

Xanthidium armatum (Breb.) Rabenh. var. *fissum* Nordst. Alg. aq. dulc. et Char. Sandvic., p. 17, t. 2, f. 6, 1878. (Plate VII, Fig. 1)

Cells large, from 1 1/3 - 1 1/2 times as long as broad, deeply constricted, sinus open and acute-angled, somewhat acuminate at the extremity; semicells somewhat octangular (the isthmus as one of the eight sides); lower margins slightly convex, inferior and superior margins usually very slightly concave but not infrequently straight; apex straight or slightly convex, with the two lateral angles and the apical angle on each side furnished with spines longer than in the type, two to three furcate at the apex, with a similar furcate spine within each lateral angle and a pair just within the apex (all of which are subject to variation); central wart of the semicells elongate and similar to the marginal spines, three to four furcate at the apex. Length (with spines) 135-160 microns; breadth (with spines) 104-122 microns; breadth of isthmus 30-34 microns.

Xanthidium antilopaeum (Breb.) Dutz. Spec. Alg., p. 177, 1849. (Plate VI, Fig. 2)

Cells of medium size, as long as broad (without the spines), deeply constricted, sinus somewhat variable in depth, very shortly linear (or none at all), with a slightly dilated extremity; semicells subelliptic-hexagonal, all the angles very slightly rounded; sides and apex usually straight, each of the four exposed angles furnished with a pair of simple, straight or slightly curved, fairly long

spines, central area of moderate size, generally round, thickened and variously scrobiculated. Cell-wall finely punctate. Length without spines 42-76 microns, with spines 54-114 microns; breadth without spines 42-72 microns, with spines 57-108 microns; breadth of isthmus 14.5-26 microns.

Xanthidium antilapaeum (Breb.) Kutz. var. *laeve* Schmidle, Beitr, Algenfl. Schwarzwald. u. Rheineb., p. 94, t. 4, f. 7, 1893. (Plate VII, Fig. 4)

Cells larger than the type, longer than broad (without the spines), deeply constricted, sinus somewhat variable in depth, shortly linear, with a slightly dilated extremity; semicells subelliptic-hexagonal, all the angles very slightly rounded; sides and apex usually straight, each of the four exposed angles furnished with a pair of simple, straight or slightly curved, fairly long spines, central area destitute of a thickened or scrobiculated protuberance. Length without spines 79-90 microns, with spines 96-121 microns; breadth without spines 62-79 microns, with spines 88-116 microns; breadth of isthmus 20-35 microns.

Xanthidium antilopaeum (Breb.) Kutz. var. *polymazum* Nordst. Norges Desm., p. 38, t. 1, f. 19, 1873. (Plate VII, Fig. 3)

Cells of medium size, a little longer than broad (without the spines), deeply constricted, sinus variable in depth, linear with a slightly dilated extremity; semicells subelliptic-hexagonal, all the angles very slightly rounded; sides and apex convex, each of the four angles furnished with a pair of simple, straight or slightly curved, fairly long spines; semicell with a semicircular series of

large rounded granules above the central protuberance. Cell-wall finely punctate. Length without spines 46-68 microns, with spines 62-85 microns; breadth without spines 45-62 microns, with spines 58-76.5 microns; breadth of isthmus 12-16 microns.

Xanthidium antilopaeum (Breb.) Kutz. var. *hebridarum* West & G. S. West. Further Contrib. Freshw. Plankton Scott. Lochs, p. 500, t. 7, f. 21, 1905. (Plate VII, Fig. 5)

Cells of medium size, a little longer than broad (without the spines), deeply constricted, sinus somewhat variable in depth, shortly linear, with a dilated extremity; semicells subelliptic-hexagonal, all the angles rounded; sides and apex convex; semicells with three spines on each lateral margin, all of which are disposed in a median vertical plane, one spine only inserted at the upper angles, the other two approximated near the lateral angles; central area consisting of a small obtusely mamillate protuberance around which is grouped in various ways a number of minute scrobiculations. Length without spines 46-50 microns, with spines 61-71 microns; breadth without spines 42-49 microns, with spines, 69-82 microns; breadth of isthmus 12-14 microns.

Xanthidium cristatum Breb. in Ralfs' Brit. Desm., p. 115, t. 19, f. 3, 1848. (Plate VII, Fig. 6)

Cells of medium size, a little longer than broad (without spines), deeply constricted, sinus rather variable, sometimes narrowly linear with a dilated extremity and sometimes slightly open; semicells trapeziform-subsemicircular, with a broad, subreniform, flat, or somewhat convex base, and with a basal, lateral and apical

angle on each side; apex truncate and generally straight, basal angles furnished with a single slightly convergent spine, lateral and apical angles each furnished with a pair of divergent spines, spines all simple and straight; central area differentiated into a thickened protuberance, generally with a slight vertical elongation with a punctate appearance. Length without spines 44-55 microns, with spines 60-77 microns; breadth without spines 34.5-48 microns, with spines 48-68 microns; breadth of isthmus 13-15.5 microns.

X. *ARTHRODESMUS* Ehrenb., 1838

Cells mostly small, sometimes minute, usually about as broad as long, invariable compressed, symmetrical in three planes at right angles to each other; median constriction generally fairly deep, sinus nearly always open; semicells very generally obversely triangular, sometimes subquadrate and sometimes elliptic or subelliptic; center of semicell quite plane and undifferentiated. Vertical view elliptic, with no median protuberances. Cell-wall furnished with simple spines disposed in a median plane, one inserted at each lateral angle.

Key to the Species of *Arthrodesmus*

1. Sinus open, semicells in form of an inverted triangle. 2.
   2. Apex of semicell elevated, retuse in the middle; angles furnished with long spines. *A. triangularis.*
   2. Apex of semicell straight or flat; angles furnished with short spines. *A. Ralfsii.*
1. Sinus closed (or nearly so) and linear, semicells subrectangular,

elliptic or narrowly elliptic. 3.

3. Lateral angles with a divergent spine, semicells subrectangular. *A. Bulnheimii* var. *subincus*.

3. Lateral angles with a horizontally placed spine, semicells elliptic. *A. subulatus* var. *subaequalis*.

Arthrodesmus triangularis Lagerh. Bidr. Amerik. Desm.-fl., p. 244, t. 27, f. 22, 1885. (Plate VII, Fig. 7)

Cells rather small, a little longer than broad (without the spines), deeply constricted, sinus a wide excavation, isthmus generally elongated and shortly cylindrical; semicells obversely triangular; apex slightly elevated and convex, slightly retuse in the median part; sides slightly rounded and furnished with a long horizontally placed spine. Length (without spines) 23-30 microns; breadth (without spines) 19-25 microns; length of spines 12.5-25 microns; breadth of isthmus 5-7 microns.

Arthrodesmus triangularis Lagerh. var. *inflatus* West & G. S. West, Some Desm. U. S., p. 320, 1898. (Plate VII, Fig. 8)

Cells rather small, a little longer than broad (without the spines), deeply constricted, sinus a wide excavation, isthmus generally elongated and very shortly cylindrical; semicells much inflated, angular-elliptic; apices elevated and generally slightly truncate or faintly retuse in the middle; spines very slightly divergent. Length 24-38 microns; breadth without spines 19-25 microns, with spines 57-72 microns; breadth of isthmus 5.8-7.5 microns.

Arthrodesmus Ralfsii W. West (Plate VII, Fig. 9)

Cells small, usually a little longer than wide (without the spines), deeply constricted, sinus a wide excavation, isthmus generally elongated and cylindrical; semicells trapezoidae; apex flat, sides furnished with short, slightly convergent placed spines. Description from Irenee-Marie.

Arthrodesmus Bulnheimii Racib. var. *subincus* W. West Alg. W. Ireland, p. 168, 1892. (Plate VII, Fig. 10)

Cells of medium size, smaller than the type, a little longer than broad (without the spines), deeply constricted, sinus narrowly linear with a slightly dilated apex; basal angles of the semicells rounded to such a degree that the semicells are almost obversely semicircular, each apical angle furnished with a long, stout, divergent spine. Cell-wall smooth. Length without spines 23-26 microns, with spines 51-54 microns; breadth without spines 25-28 microns, with spines 45-54 microns; breadth of isthmus 6.5-8 microns.

Arthrodesmus subulatus Kutz. var. *subaequalis* West and G. S. West, Alg. N. Ireland, p. 58, 1902. (Plate VII, Fig. 11)

Cells of medium size, about as long as broad (without the spines), deeply constricted, sinus widely open from a more or less subacuminate apex; semicells more narrowly elliptical with a less conspicuous difference in convexity between the ventral and dorsal margins, lateral angles somewhat rounded, each furnished with a long, stout, straight, and horizontally disposed spine; spines shorter than in the type. Length 31-38 microns; breadth without spines 31-42 microns, with spines 52-65 microns; long. spin. 10.5-11.5 microns; breadth of isthmus 8-12 microns.

XI. *STAURASTRUM* Meyen, 1829; em. Ralfs

Cells of very variable size, generally longer than broad (excluding spines or processes), usually with a radial symmetry; median constriction variable in depth; semicells most variable in outline, subcircular, elliptic, subtriangular, campanulate, trapeziform, etc., with the angles frequently produced into hollow processes of variable length; vertical view 3-5 (or even up to eleven) -angular or -radiate (rarely compressed). Cell-wall smooth, punctate, scrobiculate, or granulate, or clothed with spines of various kinds; sometimes furnished with flattened, emarginate, or spiny verrucae.

Key to the Species of *Staurastrum*

1. Angles of semicells not produced into processes. 2.
   2. Cells smooth or punctate, without spines, verrucae or granules. *S. orbiculare* var. *Ralfsii*.
   2. Cells with small granules, spines or verrucae. 3.
      3. Cells furnished with small granules, regularly or irregularly disposed, often covering the whole cell-wall or sometimes more or less restricted to the angles. 4.
         4. Granules few and restricted to the angles which are produced. *S.* sp.
         4. Granules more or less evenly distributed all over the cell. 5.
            5. Semicells oblong-elliptic, angles more or less produced and often subtruncate; apex flattened. 6.
               6. Sinus open and acute angled. *S. alternans*.
               6. Sinus open with ventral portion of semicell

inflated in median part, so that the greater portion of the semicell is raised up.

S. dilatatum.

5. Semicells angularly elliptic (often rhomboid-elliptic), with a strongly convex apex; angles rounded. *S. punctulatum.*

3. Cells furnished with spines. 7.

7. Cells furnished with spines at the angles only, each angle provided with single or binate spines, rarely with three or four. 8.

8. Cells having a single spine at each angle.

S. cuspidatum.

8. Cells with more than one spine at each angle. 9.

9. Cell-wall smooth or punctulate, never granulate.

S. Brasiliense var. *Lundellii.*

9. Cell-wall rough with tiny granules.

S. cornutum.

7. Cells with numerous spines, either clothing the whole surface of the cell-wall or more or less restricted to the vicinity of the angles. 10.

10. Spines of considerable length and of two very distinct kinds, a few at the angles being considerably stouter than the rest. *S. setigerum.*

10. Spines all more or less similar. *S. gladiosum.*

2. Cells with verrucae, which are emarginate or very much reduced and 2-3-spinate. *S. spongiosum.*

1. Angles of semicells produced into processes. 11.

11. Processes arising exclusively from the angles of the semicells, and therefore, all arising in the same horizontal plane. 12.

12. Cells without prominent accessary spines on the "body" of the cell. 13.

13. Cells in vertical view 2-5-radiate; if more than 4-radiate, processes relatively short. 14.

14. Faces of semicell smooth or provided with granules or small denticulations; conspicuous verrucae never present except on the apex of the semicell. 15.

15. Processes well developed, at least as long as the body of the cell is broad. *S. gracile* var. *coronulatum*.

15. Processes only feebly developed, not as long as the body of the cell is broad. 16.

16. Dorsal margin of the semicell less convex than the ventral. 17.

17. Cells usually broader than long. *S. polymorphum*.

17. Cells about the same length as width or a little longer. *S. margaritaceum*.

16. Dorsal and ventral margins almost equally convex. *S. hexacerum*.

14. Faces of semicell provided with large and

prominent verrucae. 18.

18. Processes convergent. *S. Cerastes.*

18. Processes horizontal or divergent.

S. anatinum.

13. Cells in vertical view usually 5-9 rayed, processes nearly twice as long as the "body" of the cell is broad, and radiating like the spokes of a wheel.

S. Ophiura.

12. Cells with prominent accessory spines, either simple or emarginate, but of considerable length, on the "body" of the cell. *S. aculeatum.*

11. Processes not arising exclusively from the angles of the semicells, and, therefore, with their points of origin in more than one horizontal plane. 19.

19. Processes quite smooth. *S. furcatum.*

19. Processes rough with granules or denticulations.

S. Arctiscon.

Staurastrum orbiculare Ralfs var. *Ralfsii* West and G.S. West in Ralfs' Brit. Desm., t. 21, f. 5 a-g (not 5 h and i) 1848. (Plate VIII, Fig. 1)

Cells of medium size, a little longer than broad, almost circular in general outline, very deeply constricted, sinus narrowly linear with a slightly dialated extremity; semicells subtriangular, basal angles and apex rounded, sides slightly convex. Vertical view triangular, sides slightly concave, angles broadly rounded. Cell-wall smooth. Length 31-41 microns; breadth 22-36 microns; breadth of

isthmus 7-11 microns.

Staurastrum sp. (Plate VIII, Figs. 2, 3)

Cells small, about as long as broad, deeply constricted, sinus open and subrectangular, with an acuminate extremity; semicells very widely cuneate, lateral margins slightly convex; apex strongly convex, lateral angles markedly mamillate, each mamilla with three rings of minute granules, few granules in each ring. Vertical view triangular; sides very faintly convex, angles slightly produced and submamillate, with three rings of minute granules.

Staurastrum alternans Breb. Ralfs' Brit. Desm. p. 132, t. 21, f. 7, 1848. (Plate VIII, Figs. 4, 5)

Cells small, a little longer than broad, twisted at the isthmus through 60^{o}, deeply constricted, sinus open and acute-angled; semicells rather narrowly oblong-elliptic, lateral angles rounded; apex slightly convex. Vertical view triangular, angles of one semicell alternating with those of the other, sides concave, angles rounded. Cell-wall granulate, granules arranged in concentric rings around the angles, but scattered and somewhat reduced in the middle of the apex. Length 22-33 microns; breadth 21-31 microns; breadth of isthmus 7.5-9.5 microns.

Staurastrum dilatatum Ehrenb. Infus., p. 143, t. 10, f. xii, 1838. (Plate VIII, Figs. 6, 7)

Cells small, about as long as broad or sometimes a little longer, deeply constricted, sinus widely open and minutely acuminate at the extremity; semicells elliptic-subfusiform, dorsal margin flattened,

ventral margin greatly inflated in the median part, so that the greater portion of the semicell is raised up on a smaller ventral piece, lateral angles rounded or rounded truncate. Vertical view three to five angular, angles of one semicell often alternating with those of the other, sides deeply concave, angles rounded. Cell-wall granulate, granules arranged in concentric rings around the angles, and in regular series between the angles, extreme apex smooth or with a few minute punctulations. Length 21-46 microns; breadth 22-46 microns; breadth of isthmus 7.5-13 microns.

Staurastrum punctulatum Breb. Ralfs' Brit. Desm., p. 133, t. 22, f. 1, 1848. (Plate VIII, Figs. 8, 9)

Cells small, a little longer than broad, deeply constricted, often twisted at the isthmus, sinus open and acute-angled (about 70^{o}); semicells subrhomboid-elliptic, dorsal and ventral margins about equally convex, angles somewhat acutely rounded. Vertical view triangular, angles acutely rounded, sides slightly retuse in the middle; angles of one semicell often partly or entirely alternating with those of the other. Cell-wall uniformly granulate with flattened granules, which are in regular series around the angles. Length 26-40.5 microns; breadth 23-36.5 microns; breadth of isthmus 8-16 microns.

Staurastrum cuspidatum Breb. in Menegh. Synops. Desm., p. 226, 1840 (Plate VIII, Fig. 10)

Cells small, about as long as broad, or a little longer, not including the spines, very deeply and broadly constricted, with a long cylindrical sinus about as long as a single semicell, sinus

broad and obtuse, widening outwards; semicell fusiform, ventral margin more convex than the dorsal, lateral angles terminating in a stout spine, either parallel or converging. Vertical view usually triangular, sides concave, angles inflated, each with a spine. Length, without spines, 20-31 microns; breadth, without spines, 18-28 microns; breadth of isthmus 5-7 microns; length of spines 5-12 microns.

Staurastrum cuspidatum Breb. var. *divergens* Nordst. Desm. Brasil, p. 225, t. 5, f. 49, 1870. (Plate VIII, Figs. 11, 12)

Cells smaller than the type, a little longer than broad, not including the spines, very deeply and broadly constricted, with a long cylindrical sinus about as long as a single semicell, sinus broad and obtuse, widening outwards; semicells fusiform, ventral margin more convex than the dorsal, lateral angles terminating in a stout spine, spines conspicuously divergent. Vertical view triangular, sides concave, angles inflated, each with a spine. Length, without spines, 23-25 microns; breadth, without spines, 21-23.3 microns; breadth of isthmus 6.6 microns; length of spines 5-10 microns.

Staurastrum Brasiliense Nordst. var. *Lundellii* West & G. S. West, Some N. Amer. Desm., p. 259, 1896. (Plate VIII, Figs. 13, 14)

Cells very large, about 1 1/5 times longer than broad, deeply constricted; sinus broad, deeply excavated at its apex; semicells cuneate, sides and apex nearly straight, upper angles somewhat obliquely truncate, and provided with three stout spines each, two of which lie in the same horizontal plane, the third being inserted

in a more dorsal position and at an angle to the others. Vertical view five-, rarely six-angled, sides deeply concave, angles broad and bifid, each lobe attenuated into a stout spine, and with a third spine at each angle lying between the other two, inserted on the apex. Length, without spines, 75-80 microns; with spines 120-130 microns; breadth, without spines, 63-80 microns, with spines, 120-140 microns; breadth of isthmus 28-34 microns; length of spines 25-30 microns.

Staurastrum cornutum Arch. in Ann. Mag. Nat. Hist. p. 232, 1881. (Plate VIII, Figs. 15, 16)

Cells small, longer than broad, not including the spines, wide constriction, sinus linear; semicells elliptic with one single or deeply cleft stout spine, ventral margin convex and undulating, dorsal margin with a single small forked spine near each angle spine and smaller emarginate spines in between, with a row of spines within the margin. End view triangular with a stout spine at each angle, and about four small emarginate spines on the margin of the straight sides, and one row of similar spines within the margin. Length and breadth, without side spines, 27 microns; isthmus 11 microns; length of spine 9 microns.

Staurastrum setigerum Cleve, Sverig. Desm., p. 490, t. 4, f. 4, 1864. (Plate VIII, Fig. 17)

Cells of medium size, a little longer than broad, deeply constricted, sinus acute and open; semicells elliptical, ventral margin more convex than the dorsal, angles obtusely rounded and provided with 2-5 (usually three) long stout spines arranged in a

vertical row. Surface of cell provided with a number of long but more delicate spines than those at the angles, arranged in distant obscure circles round the angles. Vertical view triangular, sides nearly straight, angles rather acutely rounded. Length, without spines, 50-56 microns; breadth, without spines, 42-45 microns; breadth of isthmus 14.5-17 microns.

Staurastrum gladiosum Turn. New Rare Desm. p. 6, t. 16, f. 21, 1885. (Plate VIII, Figs. 18, 19)

Cells rather under medium size, about as long as broad, sinus acute and not very widely open; semicells elliptic-reniform, dorsal and ventral margins almost equally convex. Cell-wall uniformly covered with stout spines, about 14-20 visible along the peripheral margin, arranged in obscure circles round the angles, and more or less scattered further away. Vertical view triangular, sides slightly concave, angles broadly rounded, about nine spines visible along each lateral margin, spines in the center of the apex sparsely scattered. Length without spines 37.5-41 microns, with spines 47.5-51 microns; breadth without spines 37.5-40 microns, with spines 48-50 microns; breadth of isthmus 11-12 microns.

Staurastrum spongiosum Breb. Ralfs' Brit. Desm., p. 141, t. 23, f. 4, 1848. (Plate VIII, Figs. 20, 21)

Cells rather under medium size, about as long as broad, or a little longer, roughly circular in outline, deeply constricted, sinus narrow, sometimes almost linear; semicells subsemicircular or sub-pyramidate-truncate in outline, basal angles obtuse and ending in a short verrucose process; about 8-10 emarginate processes visible

round the periphery, and six others forming a curved series across the face of the semicell. Vertical view triangular, sides usually slightly convex, angles ending in a short verrucose process, each lateral margin with six emarginate processes, and three similar pairs arranged across each angle, decreasing in size toward the angles; center of apex smooth. Length 45-53 microns; breadth 42-50 microns; breadth of isthmus 12 microns.

Staurastrum gracile Ralfs var. *coronulatum* Boldt, Sibir, Chlorophy., p. 116, t. 5, f. 28, 1885. (Plate IX, Figs. 1, 2)

Cells variable, usually of small or medium size, 1.5-2 times longer than broad, excluding the processes, constriction slight, usually an acute notch; semicells variable in form, usually more or less cup-shaped, lower angles broadly rounded, lateral margins nearly vertical or slightly diverging, rarely slightly concave, semicells usually broadening slightly toward the apex, which is very slightly convex; with two emarginate processes at the top of each face; upper angles produced to form shorter processes than the type, of variable length, each tipped with three or four minute spines, and provided with several concentric series of denticulations; processes usually horizontal, sometimes slightly converging. Vertical view triangular or quadrangular, with two emarginate verrucae within each lateral margin. Length 21-36 microns; breadth, including processes, 32.5-43 microns; breadth of isthmus 6-11 microns.

Staurastrum polymorphum Breb. in Ralfs' Brit. Desm. p. 135, t. 22, f. 9, 1848. (Plate IX, Figs. 3, 4)

Cells small, about 1 1/4 times broader than long, including the

processes, constriction moderately deep, sinus acute and almost rectangular, sometimes minutely acuminate at its apex; semicells variable in form, subelliptical, subfusiform or even subcuneate, ventral margin usually more strongly convex than the dorsal; semicells attenuated at the angles to form short stout processes, horizontal or very slightly incurved, tipped with three or four minute spines and provided with three or four series of minute denticulations; "body" of semicell also granulate, granules arranged in concentric series round the angles. Vertical view usually three- (-seven-) angular, the two semicells of the same individual often differing in the number of processes, lateral margins very slightly concave; center of apex smooth. Length 21-29 microns; breadth, including processes, 21-43 microns; breadth of isthmus 6-8 microns.

Staurastrum polymorphum Breb. var. *pusillum* West, Clare Isl. Alg., p. 23, 1912. (Plate IX, Figs. 5, 6)

Cells much smaller, processes thinner and slightly inflexed; "body" of semicell similar in form to the type. Length 18-18.5 microns.

Staurastrum margaritaceum (Ehrenb.) Menegh. Synops. Desm., p. 227, 1840. (Plate IX, Figs. 7, 8)

Cells small, about as long as broad, or often slightly longer, constriction not deep, sinus open; semicells variable in form, cup-shaped, subspherical or subfusiform, upper angles of the cell produced to form short obtuse processes, projecting horizontally, or sometimes slightly inflexed. Cell-wall rough with minute granules, arranged in concentric series round the angles, sometimes with a distinct

circle of granules round the base of the semicell. Vertical view 3-9 angled, more often four-, five- or six-angled, sides concave, center of apex smooth, angles produces to form short truncate processes. Length 24-30 microns; breadth, including processes, 16-48 microns; breadth of isthmus 6-10 microns.

Staurastrum hexacerum (Ehr.) Wittr. Gotl. Ol. sotv. Alg., p. 51, 1872. (Plate IX, Figs. 9, 10)

Cells small, about 1 1/5 times broader than long, deeply constricted, sinus open and acute; semicells fusiform or subtriangular, both dorsal and ventral margins convex, tapering toward the angles to form very short processes which end in about three minute teeth. Cell-wall rough with tiny granules, arranged in concentric series round the angles, granules in the center of the faces and on the apex of the semicell much reduced. Vertical view usually triangular, lateral margins concave, angles very slightly turgid. Length 23-28 microns; breadth, including processes, 27-34 microns; breadth of isthmus 7-8 microns. The figured specimen from Lily Lake is larger.

Staurastrum Cerastes Lund. Desm. Suec. p. 69, t. 4, f. 6, 1871. (Plate IX, Figs. 11, 12)

Cells of medium size, about as long as broad, or sometimes broader, constriction small, an acute notch; semicells almost cylindrical in the lower part, widening considerably upwards; apex strongly convex, lateral angles produced to form stout processes, attenuated toward their apices, and gracefully incurved so that the processes of the two semicells are nearly in contact; upper margin of process verrucose (in some aspects the apex of the semicell also

is verrucose), about nine verrucae visible along each process, becoming more crowded and simpler towards the apex of the process; lower margin smooth; with another series of verrucae stretching horizontally from tip to tip of adjacent processes across the face of the semicell, and a further series of granules round its base. Vertical view three- or four-angled, angles produced into short tapering processes, lateral margins concave and verrucose, and with another curved series of verrucae stretching from angle to angle just within each margin. Length 48-57 microns; breadth, including processes, 58-72 microns; breadth of isthmus 10-12 microns.

Staurastrum anatinum Cooke & Wills, Cooke in Grevillea, p. 92, t. 139, f. 6, 1880. (Plate IX, Figs. 13, 14)

Cells large, about 1 1/2 times broader than long, including the processes, deeply constricted, sinus acute, and opening widely; semicells subfusiform, ventral margin more convex than the dorsal, upper angles produced to form fairly long stout divergent processes, provided with several series of well-marked denticulations and tipped with two or three strong spines; apex of semicell slightly convex, and verrucose. Vertical view triangular or quadrangular, sides straight or very slightly concave, angles produced to form processes, lateral margins verrucose, with another series of about six emarginate verrucae just within each margin. Length, without processes, 33-46 microns, with processes, 50-65 microns; breadth, with processes, 80-113 microns; breadth of isthmus 10-15.5 microns.

Staurastrum anatinum Cooke & Wills, var. *Lagerheimii* (Schmidle) West & G. S. West, Plankton Engl. Lake Distr., p. 289,

1909. (Plate IX, Figs. 15, 16)

A variety with very short processes, which are less than half the normal length; arrangement of verrucae as in the type. Length 53-65 microns; breadth, with processes, 72-88 microns.

Staurastrum anatinum Cooke & Wills var. *truncatum* West, Alg. W. Ireland, p. 185, t. 24, f. 2, 1892. (Plate IX, Fig. 17)

Semicells more elliptical than in the type, ventral and dorsal margins almost equally convex, but with the apex distinctly flattened, processes inserted lower than in the type, and beginning abruptly, the "body" not tapering so gently into the processes. Length 50-65 microns; breadth, including processes, 75-100 microns; breadth of isthmus 15-20 microns.

Staurastrum Ophiura Lund. Desm. Suec., p. 69, t. 4, f. 7, 1871. (Plate IX, Figs. 18, 19)

Cells large, about twice as long as broad, not including the processes, constriction slight; semicells cuneate, broadening upwards; apex slightly convex, upper angles produced to form long slender processes, parallel, or very slightly converging with undulate and denticulate margins, upper margin rougher than the lower; semicell with a ring of papillae at its base, of which about seven are visible, and with a circle of large conical granules or flattened verrucae on its apex. Vertical view 4-9-radiate, processes very long and gradually tapering to their apices, which are provided with about three minute spines, and with numerous series of denticulations which become larger toward the base of the process; apex with a circle of large conical nodules or flattened verrucae, which usually

alternate with the processes. Length 65-91 microns; breadth, without processes, 34-46 microns, including processes, 128-169 microns; breadth of isthmus 19.5-26 microns.

Staurastrum aculeatum (Ehrenb.) Menegh. Synops. Desm., p. 226, 1840.

(Plate X, Figs. 1, 2)

Cells of medium size, about as long as broad, or up to 1 1/3 times broader than long, deeply constricted, sinus acute and open; semicells subelliptical or subfusiform, dorsal and ventral margins almost equally convex, though the ventral margin is not infrequently slightly more convex than the dorsal; lateral angles slightly or not at all produced, terminating in three or four strong spines and sometimes with one or two series of denticulations beneath; apex of semicell with a dorsal series of spines, the median ones being sometimes emarginate; semicells also with a lateral series of spines running horizontally from angle to angle across the face of the semicell. Vertical view triangular or quadrangular, sides nearly straight, angles scarcely produced, tipped with three or four strong spines; lateral margins with a row of spines, and with a dorsal series of spines just within each lateral margin. Length 33-50 microns; breadth, including spines, 48-60 microns; breadth of isthmus 12-16 microns.

Staurastrum furcatum (Ehr.) Breb. Liste Desm., p. 136, 1856.

(Plate X, Figs. 3, 4)

Cells small, about as long as broad (including the processes), or sometimes slightly longer or shorter than broad, deeply constricted, sinus acute and open; semicells subelliptical or subglobose, dorsal

and ventral margins almost equally convex, lateral angles produced to form short, stout, nearly horizontal processes, with bifid apices, the two teeth lying in the same vertical plane; apical margin of each face of the semicell with two short bifid processes, which are nearly erect. Cell-wall smooth, or very minutely punctate. Vertical view triangular, angles scarcely produced ending in a spine, sides straight or very slightly concave, with two short bifid processes projecting from each lateral margin. Length, including processes, 25-33 microns; breadth, including processes, 20-40 microns; breadth of isthmus 6-10 microns.

Staurastrum Arctiscon (Ehr.) Lund. Desm. Suec., p. 70, t. 4, f. 8, 1871. (Plate X, Fig. 5)

Cells large, about 1 1/2 times longer than broad, excluding the processes, constriction fairly deep; sinus nearly rectangular with subacute apex; semicells broadly elliptical or subspherical, provided with two whorls of processes; lower whorl consisting of nine processes, nearly horizontal, five of which are visible in the front view; upper whorl of six processes, ascending obliquely; processes nearly as long as the body of the semicell is broad, tipped with three spines, and with 2-7 series of denticulations; body of cell smooth. Vertical view nearly circular, with a marginal series of nine processes, and an apical series of six shorter processes. Length, without processes, 66-96 microns, with processes, 100-155 microns; breadth, without processes, 46-68 microns, with processes, 92-160 microns; breadth of isthmus 24-33 microns.

XII. *SPHAEROZOSMA* Corda, 1835

Cells usually very small, flattened and deeply constricted; sinus open or narrow and linear; semicells elliptical, oblong or subrectangular, cells united to form long filaments by means of special apical appendages, often twisted and enveloped in a mucous; apex of each semicell provided with one or two pairs of small rounded tubercles or short capitate processes, which are closely applied to the corresponding processes of the next cell.

Sphaerozosma Wallichii Jacobs var. *anglicum* West & G. S. West, Alg. S. England, p. 497, t. 6, f. 6, 1897. (Plate X, Fig. 6)

Cells smaller than the type, slightly broader than long, constriction fairly deep, sinus smaller than in the type and oval in shape; semicells narrowly oblong, angular, sides truncate with two or three granules on the lateral margins of the semicells, and others scattered sparsely and irregularly across the surface. Length 10-11.5 microns; breadth 10.5-11 microns; breadth of isthmus six microns.

XIII. *ONYCHONEMA* Wallich, 1860

Cells small, forming simple filamentous colonies, compressed, deeply constricted, sinus narrow; semicells elliptic or reniform, sometimes with strong lateral spines; each semicell with two capitate processes of considerable length projecting from its apex; processes disposed asymmetrically, and overlapping the adjacent cell.

Onychonema filiforme (Ehr.) Roy and Biss. Jap. Desm., p. 242, 1886.

(Plate X, Fig. 7)

Cells small, about as long as broad, deeply constricted, sinus narrow, almost linear; semicells elliptical or subreniform, ventral margin almost straight, dorsal margin broadly rounded; semicells with two long processes, nearly as long as the semicell itself; disposed asymmetrically, and overlapping the adjacent cell of the filament (only one of the processes of any semicell is seen in the front view, the second one being on the opposite side of the filament). Cells united, forming long twisting filaments. Length, not including processes, 9-12.5 microns; breadth 10-12.5 microns; breadth of isthmus 3.5-4 microns.

XIV. *SPONDYLOSIUM* Breb. 1844

Cells usually small, or of medium size, flattened and often deeply constricted with a narrow or open sinus; semicells variable in shape, often with broadly truncate or concave apices. Vertical view elliptical, triangular or trilobed. Cells united to form long filamentous colonies by the simple close apposition of their apices, sometimes twisted and often enveloped in mucilage. In one species the filaments are often observed attached to other aquatic plants by means of a short basal gelatinous cushion.

Spondylosium planum (Wolle) West & G. S. West, Periodic. Phytopl. Brit. Lakes, p. 430, t. 19, f. 5-8, 1912. (Plate X, Fig. 8)

Cells of medium size, about 1 1/6 times broader than long, subquadrangular, angles rounded, deeply constricted, sinus obtuse,

open; semicells transversely oblong, angles broadly rounded; apices flat. Cell-wall smooth; cells united into filaments, not twisted. Length 11.5-19.5 microns; breadth 12-25 microns; breadth of isthmus 5-11.5 microns.

XV. *HYALOTHECA* Ehrenb. 1840

Cells subcylindrical, shorter or longer than broad, very slightly constricted, semicells trapezoid, subquadrate or oblong, with straight or slightly convex lateral margins; cells united by their broadly truncate apices to form long filamentous colonies, which are sometimes twisted and almost invariably enveloped in a gelatinous sheath of some thickness.

Key to the Species of *Hyalotheca*

1. Cells broader than long. *H. dissiliens*.
1. Cells longer than broad. *H. undulata*.

Hyalotheca dissiliens (Sm.) Breb. in Ralfs' Brit. Desm., p. 51, t. 1, f. 1, 1848. (Plate X, Fig. 9)

Cells of medium size, about 1 1/4 times broader than long; constriction extremely small, consisting of a very slight concavity in the middle of the lateral margins; cells united by their apices to form long slimy filaments, constricted at the joints; apex of semicells broadly truncate, about as broad as the isthmus, lateral margins slightly convex; vertical view circular, sometimes with two opposite papillae, or three, equidistant. Length 10-33 microns; breadth 10-39 microns.

Hyalotheca undulata Nordst. in Whittr. and Nordst. Alg. exsic., no. 248, 1879. (Plate X, Fig. 10)

Cells very small, 1 1/2 times longer than broad, lateral margins with a broad shallow indentation, so that they are biundulate; semicells globose-obovate, with truncate apices; diameter of isthmus and apex of semicells about equal. Cells in end view circular. Length 10-17.5 microns; breadth 6-9 microns.

XVI. *DESMIDIUM* Ag. 1824

Cells united to form twisting filamentous colonies, sometimes embedded in a thick mucous sheath; cells often extremely depressed, usually much broader than long, with a distinct but moderately deep constriction. Vertical view either elliptical, usually with mamillate poles, or three- or four-angled.

Key to the Species of *Desmidium*

1. Semicells angular in vertical view. *D. Swartzii.*
1. Semicells circular or elliptical in vertical view, often with opposite mamillae. 2.
   2. Vertical view elliptical. 3.
      3. Apex broad or widely truncate, over 15 microns. *D. cylindricum.*
      3. Apex truncate of medium width, less than 15 microns. *D. coarctatum.*
   2. Vertical view subcircular. *D. quadratum.*

Desmidium Swartzii Agardh, Syst. Alg. p. 9, 1824. (Plate X, Fig. 11)

Filaments triangular, twisted; cells medium large, nearly

twice as broad as long, constriction moderately deep, sinus linear toward its apex, opening more widely; semicells narrowly oblong, lateral margins usually somewhat obliquely truncate, with the upper angle of the truncate margin consqicuously protruded toward the apex, the lower angle more rounded; apex of semicell broadly truncate, with a short connecting process at each angle of the cell. Vertical view triangular, angles acutely rounded, sides slightly concave. Length 12-20 microns; breadth 37-50 microns; breadth of isthmus 30-52.5 microns; breadth of apices 30-41 microns.

Desmidium Swartzii Ag. var. *amblyodon* (Itz.) Rabenh. Krypt. -fl. Sachs., p. 181, 1863. (Plate X, Figs. 12, 13)

Filaments triangular, twisted; cells medium large, about 1/2 - 2 times as broad as long, constriction moderately deep, sinus generally open; semicells narrowly oblong, lateral margins distinctly and broadly rounded; apex broadly truncate, with a short connecting process at each angle of the cell. Vertical view triangular, angles acutely rounded, sides concave. Cells with small papilli. Length 15-20 microns; breadth 32-50 microns; breadth of isthmus 25-45 microns.

Desmidium cylindricum Grev. Scott, Crypt. Fl, vol. v, t. 293, vol. vi, p. 38, 1827. (Plate X, Fig. 14)

Cells large, about 1 1/2 times broader than long, constriction slight, sinus linear; semicells short, pyramidate-truncate, basal angles acutely rounded, lateral margins gently biundulate; apex broad and truncate. Cells in vertical view elliptical with a rounded mamilla-like protuberance at each pole; cells united by their broad,

flat apices to form twisting filaments, with a thickened protruding rim between each pair of cells. Length about 24 microns; breadth 41-56 microns; breadth of isthmus 45-47 microns; breadth of apices 26-40 microns.

Desmidium coarctatum Nordst. Freshw. Alg. N. Zealand., p. 25, t. 2, f. 3, 1888. (Plate X, Fig. 15)

Filaments flattened, twisted, cells in front view elliptical, about 1 1/2 times broader than long, with a slight medium constriction, sinus linear, basal angles of semicells acutely rounded, lateral margins slightly undulate; apex of semicell about 1/3 its diameter. Vertical view narrowly elliptical with prominent rounded mamillae at the opposite poles. Length 25-34 microns; breadth 34-38 microns; breadth of isthmus 33 microns; breadth of apex 12-14 microns.

Desmidium quadratum Nordst. Norges Desm., p. 49, t. 1, f. 24, 1873. (Plate X, Fig. 16)

Filaments nearly cylindrical, twisted; cells about 1 1/4 times broader than long, slightly constricted, with a shallow linear sinus; semicells short, pyramidate-truncate, lateral margins biundulate, basal angles acutely rounded; apex rather broad and truncate. Side view of semicell quadrangular with scarcely any trace of a median constriction. Vertical view subcircular with two opposite mamillae. Cell-wall finely punctate. Length 19-20 microns; breadth 25 microns; breadth of apex 12.5 microns.

XVII. *GYMNOZYGA* Ehrenb. 1841

Cells cylindrical or barrel-shaped, united by their flat ends

to form slightly twisted filaments. There is a very slight median constriction, and often a swelling of variable size at the base of each semicell. Vertical view circular, often with two opposite mamillae.

Gymnozyga sp. (Plate X, Fig. 17)

Filaments twisting, formed of rather barrel-shaped cells; cells with a slight medium constriction; lateral margin of semicell having basal 1/2 convex and apical 1/2 being concave; apex broad and truncate. Vertical view circular.

CHAPTER IV

DISCUSSION

Keys and descriptions have not been made of the genera and species of desmids of a subalpine lake in Utah. Palmer (1968) reported fourteen genera and seventy-eight species in her studies of Lilly Lake. Photographs of twenty-seven of the species were included. Coombs (1964) listed ninety-six species in his studies. Seventeen of the species were found only in rivers or riverlets. No keys or descriptions are included in the above studies. Flowers (1939) includes a key to sixteen genera and has illustrations of 120 species in his work on the "Algae of Utah".

There are ninety-four different species in this study that are reported for the first time in Utah waters. The author feels that since there is a wide variety of species found by other authors that a complete key to the species and genera of desmids of Utah is necessary. Limitations of studies to one lake or even several lakes, ponds, rivers and riverlets tend to limit the number of desmids reported in Utah waters. This study, and the studies of Snow, Coombs, Palmer and Flowers list 265 different species. However, the author feels that several of the species listed are identical, but have been identified as different species. By comparing the species listed through keys, illustrations, and descriptions, a more accurate identification could be determined. It can be assumed that since these studies list this many species, additional studies will add additional

species to the list of desmids found in Utah.

Genera and Species

The distribution of genera throughout the five abundance groups indicates that no genus is found predominantly in any group. The distribution of genera in each group is as follows: (i) abundant, ten genera, (ii) common, seven genera, (iii) frequent, nine genera, (iv) occasional, twelve genera, and (v) scarce, fourteen genera. Of the fourteen genera, four are represented by one species only: *Sphaerozosma*, *Onychonema*, *Spondylosium*, and *Gymnozyga*. All but *Gymnozyga* are in the scarce category.

From observations by the author and interpretation of Tables 1 and 2, the following comments are made concerning the genera and species.

The distribution of species in each group is as follows: (i) abundant, fourteen species, (ii) common, twenty-two species, (iii) frequent, twenty-four species, (iv) occasional, forty-three species, and (v) scarce, sixty-four species. Few of the species of *Closterium*, *Micrasterias*, *Cosmarium*, and *Staurastrum* genera are in the abundant group while many of the species are in the scarce group. The genus *Euastrum* was represented by two species each in four groups and five species in the frequent category. *Xanthidium* had two species in the common group and one each in the other four groups. *Desmidium* had two species in the scarce group, and one each in the occasional, frequent and common groups. *Sphaerozosma*, *Onychonema* and *Spondylosium*, with one species each, were in the scarce category and *Gymnozyga* was represented in the abundant category with one species. *Penium*

and *Hyalotheca* were not found in the abundant or common groups, and *Netrium*, *Pleurotaenium*, *Triploceras*, and *Arthrodesmus* had variable distributions.

The physical factor that seemed to limit the number of species in the abundant and common groups was water temperature. As the temperature of the water increased, the number of species present increased, and as the temperature decreased, the number of species decreased. Rooney (1967) stated that as the temperature increased, the dissolved oxygen decreased, and the number of fungi species increased. Table 2 shows that the majority of species of desmids were found during the earlier part of the growing season (July) when the water temperature was at its maximum and that near the end of the growing season few species were reported present, expecially for the scarce group.

Prescott (1962) states that the acid bog lake, when it is shallow enough to permit optimum temperatures, is probably more productive than any other type in the number of algae species. This being true, the conditions from July 11th through July 24th, when the water temperature was 23^{0} and the pH showed an acid condition, were ideal for optimal algae growth. Tables 2 and 3 show that at this time the number of species was at a relative maximum. The even higher number of species on September 4th appears to be due to the increased water temperature at that time.

The rise in water temperature is directly related to the air temperature (Table 1). The winter snow and ice usually disappears by late June allowing the water temperature to increase. Rooney's data collected in 1965 and the data of 1964 are evidence that seasonal

variations affect water conditions. Rooney's water temperature of June 24th was 0.5° while this study showed a water temperature of 14° on June 26th. Water temperature for 1964 was 20° or over from July 5th through August 8th. Rooney did not observe water temperatures above 18° during the entire season. The air temperature for 1964 was 20° or over for the same dates as the water temperature was above 20°. Rooney observed an air temperature of 20° only on one date, July 8th. The 1964 summer environmental conditions were warmer and summer conditions arrived two weeks earlier than in 1965. This would provide a longer growing season and accounts for the higher water temperatures recorded in 1964.

Collections of *Penium* and *Arthrodesmus* genera were limited to the time of low water temperature and high oxygen content. No other genus showed this trend. However, the following species were less abundant during the period of high water temperature and low oxygen content: *Closterium Kutzingii, Euastrum humerosum, Euastrum elegans, Euastrum bidentatum, Cosmarium Phaseolus* var. *elevatum, Cosmarium contractum* forma *Jacobsenii, Cosmarium quadratulum, Cosmarium ornatum, Xanthidium cristatum, Staurastrum cornutum,* and *Staurastrum polymorphum.* One species, *Micrasterias oscitans,* was found predominantly during this period and *Euastrum denticulatum* and *Triploceras verticillatum* were present during and after this period.

It is interesting to note that as the water temperature increased, the pH and number of species increased also. As the water temperature decreased, the dissolved oxygen increased, the pH remained the same and the number of species decreased. The seasonal occurrence of species or genera is influenced by many environmental factors that

need consideration in studying a lake. These factors are carbon dioxide and oxygen content, water temperature, pH, the flushing effect of the melting snow, types and conditions of substrata, aquatic organisms feeding on desmids, and light conditions.

Substrata

The natural habitats were the most productive for the growing of desmids. The samples collected showed that the number of species found was greater on the natural habitats than on artificial glass habitats.

The samples collected at stations one, two, and three were examined more in detail to determine what species were found in Lily Lake. After a preliminary survey of the samples collected, it was obvious to the author that the periphyton and net samples contained the majority of desmid species being observed. It would be nearly impossible to say that the periphyton sample contained more species than the net sample because of the collecting methods. For example, as the net was pulled to the shore at station one, material from water lilies was scraped into the net. When the author walked along the shore at stations one and two, the "quaking bog" had the tendency to cause material to be forced into the water from the bottom of the lake and from the quaking bog. This material was also collected into the net.

The artificial glass habitats were excellent substrata for *Closterium lineatum*, *Closterium Ralfsii* var. *hybridum* and *Closterium* sp. (5). These three species were very abundant in the samples taken from the sheets of glass. The sample scraped from the glass suspended

thirty inches deep had a more dense growth attached than those at sixty or ninety inches. The deeper the glass was suspended, the fewer were the desmids found. Individuals of other species were rarely found attached to the glass. The use of the net in mid-lake showed few free floating desmids.

Limitations of the Study

Some limitations to this study were in: (1) The length of time the lake was studied; (2) Current keys used in identification of species; and (3) A numerical abundance was not determined for the species present.

CHAPTER V

SUMMARY

1. The family Desmidiaceae was represented by seventeen genera and 167 species in Lily Lake.

2. There were ninety-four different species in this study that have not been reported in Utah waters.

3. The most dominant genera were *Cosmarium* with fifty-one species and *Closterium* and *Staurastrum* each with twenty-five species.

4. The 167 species were placed in five groups based on their percent frequency: (i) abundant (80-100%) with fourteen species, (ii) common (60-79%) with twenty-two species, (iii) frequent (40-59%) with twenty-four species, (iv) occasional (20-39%) with forty-three species, and (v) scarce (5-19%) with sixty-four species. Four species, *Euastrum Didelta, Triplocerας gracile, Cosmarium margaritiferum* and *Xanthidium armatum* var. *fissum* had a percent frequency of 100%.

5. Two algae blooms were recorded during the study, one peak during July, and one during September.

6. As pH, air and water temperature increased, the number of species collected increased, and as water temperature decreased, oxygen increased and the number of species collected decreased.

7. Keys and descriptions to the genera and species are given.

APPENDIX A

ILLUSTRATIONS OF THE DESMIDS

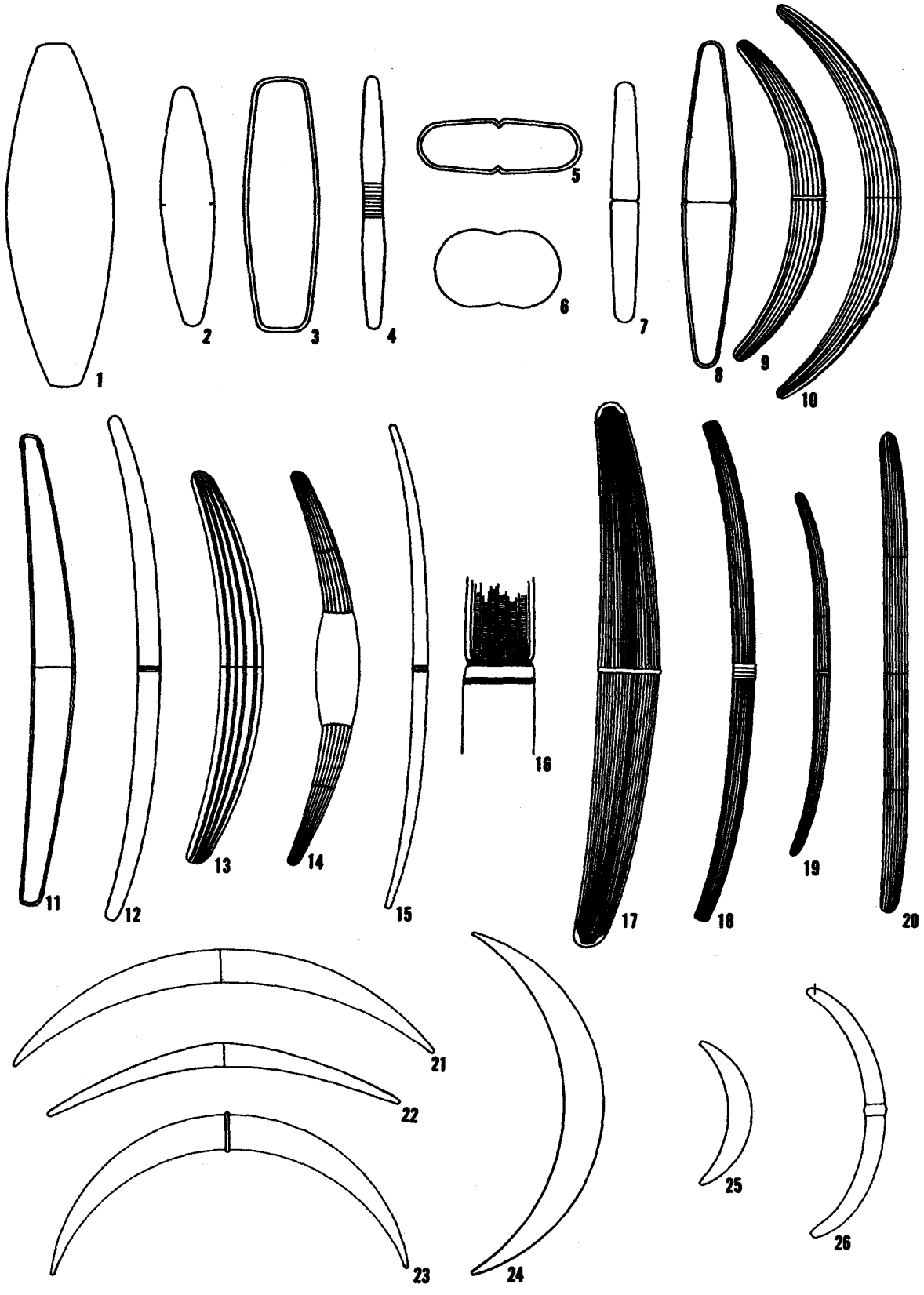
OF

LILY LAKE

EXPLANATION OF PLATE I

Figure:

1. *Netrium Digitus* (Ehrenb.) Itzigs. and Rothe. 255X.
2. *Netrium Nagelii* (Breb.) nob. 305X.
3. *Netrium oblongum* (de Bary) Lutkem. 445X.
4. *Penium* sp. (1). 110X.
5. *Penium* sp. (2). 735X.
6. *Penium* sp. (3). 465X.
7. *Penium minutum* (Ralfs) Cleve. 395X.
8. *Penium* sp. (4). 240X.
9. *Closterium Cynthia* De Not. 340X.
10. *Closterium Archerianum* Cleve. 280X.
11. *Closterium didymotocum* Corda. 175X.
12. *Closterium macilentum* Breb. 160X.
13. *Closterium angustatum* Kutz. 190X.
14. *Closterium costatum* Corda. 185X.
15. *Closterium* sp. (1). 90X.
16. Enlargement of isthmus region of fig. 15. 385X.
17. *Closterium striolatum* Ehrenb. 220X.
18. *Closterium intermedium* Ralfs. 205X.
19. *Closterium juncidum* Ralfs. 265X.
20. *Closterium juncidum* Ralfs var. *elongatum* Roy and Biss. 215.
21. *Closterium Dianae* Ehrenb. 220X.
22. *Closterium Pseudodianae* Roy. 375X.
23. *Closterium* sp. (2). 380X.
24. *Closterium* sp. (3). 230X.
25. *Closterium parvulum* Nag. 270X.
26. *Closterium calosporum* Wittr. 380X.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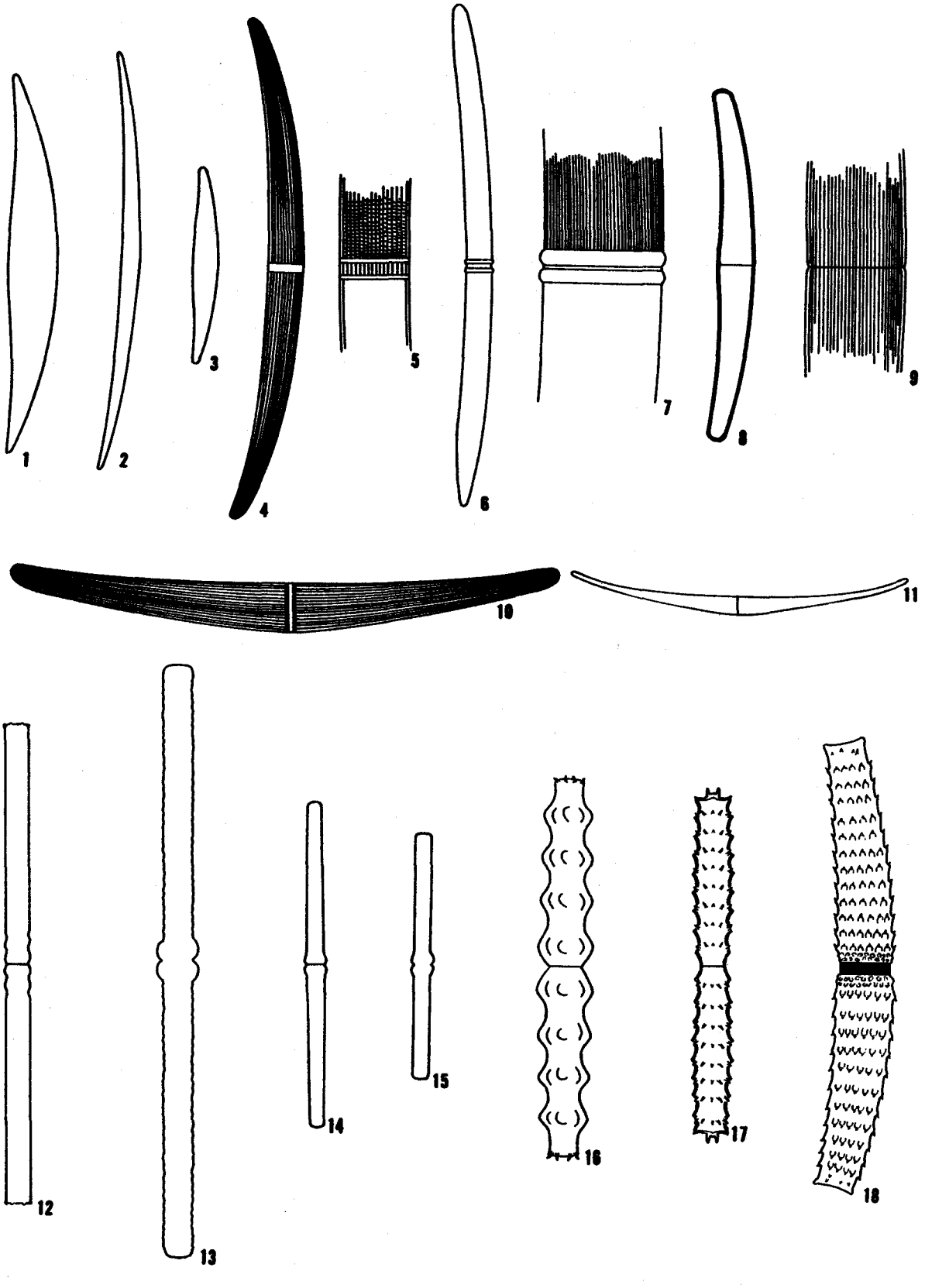
EXPLANATION OF PLATE II

Figure:

1. *Closterium lanceolatum* Kutz. 155X.
2. *Closterium* sp. (4). 145X.
3. *Closterium pusillum* Hantzsch. 665X.
4. *Closterium lineatum* Ehrenb. 125X.
5. Enlargement of isthmus region of fig. 4. 458X.
6. *Closterium* sp. (5). 90X.
7. Enlargement of isthmus region of fig. 6. 415X.
8. *Closterium Ralfsii* Breb. var. *hybridum* Rabenh. 120X.
9. Enlargement of isthmus region of fig. 8. 490X.
10. *Closterium laterale* Nordst. 170X.
11. *Closterium Kutzingii* Breb. 150X.
12. *Pleurotaenium Ehrenbergii* (Breb.) 140X.
13. *Pleurotaenium Ehrenbergii* (Breb.) De Bary var. *undulatum* Schaarschm. 115X.
14. *Pleurotaenium Trabecula* (Ehrenb.) Nag. var. *rectum* Delp. 200X.
15. *Pleurotaenium maximum* (Reinsch) Lund. 485X.
16. *Pleurotaenium nodosum* (Bail.) Lund. 200X.
17. *Triploceras gracile* Bail. 175X.
18. *Triploceras verticillatum* Bail. 170X.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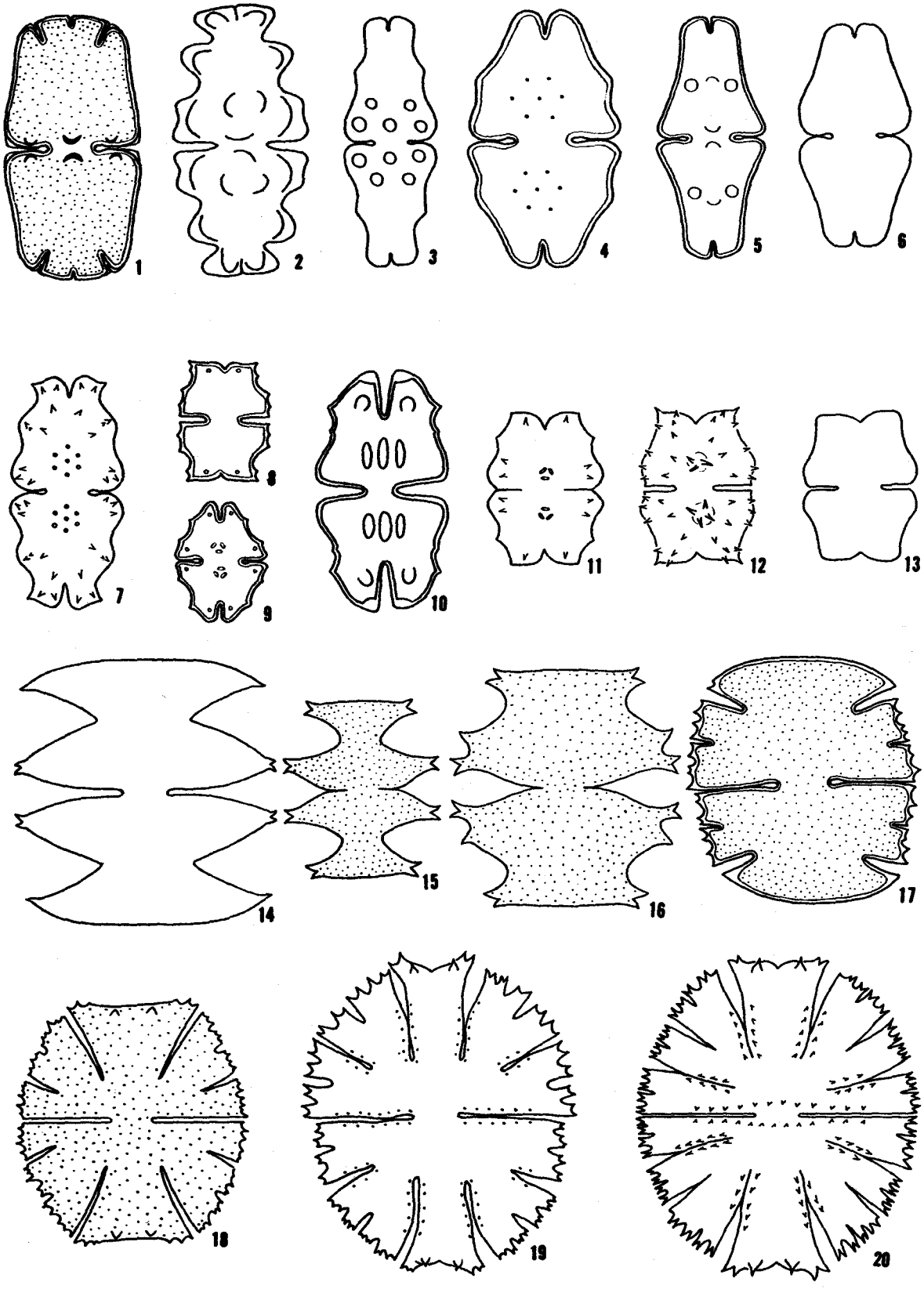
EXPLANATION OF PLATE III

Figure:

1. *Euastrum crassum* (Breb.) Kutz. 255X.
2. *Euastrum humerosum* Ralfs. 375X.
3. *Euastrum Didelta* (Turp.) Ralfs. 320X.
4. *Euastrum oboense* Elfv. 670X.
5. *Euastrum ansatum* Ralfs. 705X.
6. *Euastrum obesum* Josh. 680X.
7. *Euastrum bidentatum* Nag. 590X.
8. *Euastrum* sp. 645X.
9. *Euastrum elegans* (Breb.) Kutz. 690X.
10. *Euastrum elegans* (Breb.) Kutz. var. *Novae Semliae* Wille. 870X.
11. *Euastrum binale* (Turp.) Ehrenb. forma *Gutwinskii* Schmidle. 1060X.
12. *Euastrum denticulatum* (Kirchn.) Gay. 1240X.
13. *Euastrum insulare* (Wittr.) Roy. 1565X.
14. *Micrasterias oscitans* Ralfs. 305X.
15. *Micrasterias pinnatifida* (Kutz) Ralfs. 455X.
16. *Micrasterias depauperata* Nordst. var. *Wollei* Cushman. 280X.
17. *Micrasterias truncata* (Corda) Breb. 420X.
18. *Micrasterias conferta* Lund. 490X.
19. *Micrasterias papillifera* Breb. 400X.
20. *Micrasterias papillifera* Breb. forma *major*. 225X.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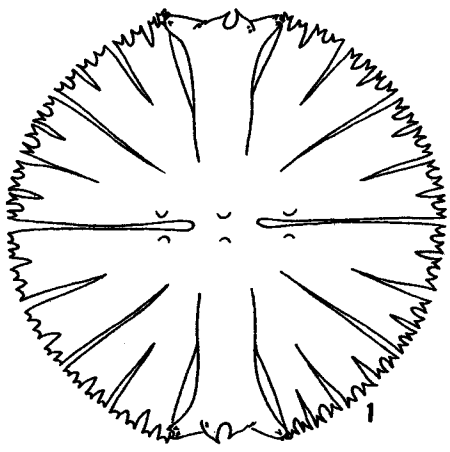
EXPLANATION OF PLATE IV

Figure:

1. *Micrasterias Sol* (Ehrenb.) Kutz. 205X.
2. *Micrasterias Sol* (Ehrenb.) Kutz. var. *ornata* Nordst. 230X.
3. *Micrasterias apliculata* (Ehrenb.) Menegh. var. *brachyptera* (Lund.) nob. 295X.
4. *Micrasterias rotata* (Grev.) Ralfs. 205X.
5. *Micrasterias denticulata* Breb. 230X.
6. *Micrasterias radiata* Hass. 315X.
7. *Micrasterias muricata* (Bailey) Ralfs. 265X.
8. *Micrasterias* sp. 250X.
9. *Micrasterias Americana* (Ehrenb.) Ralfs. 295X.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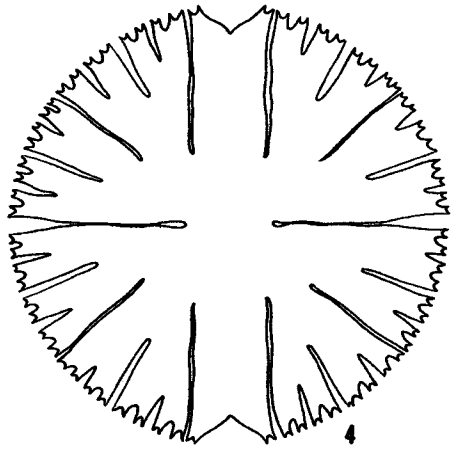
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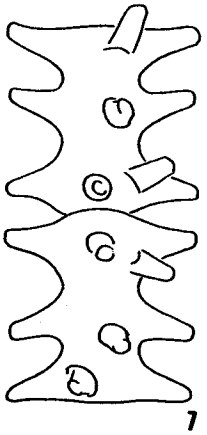
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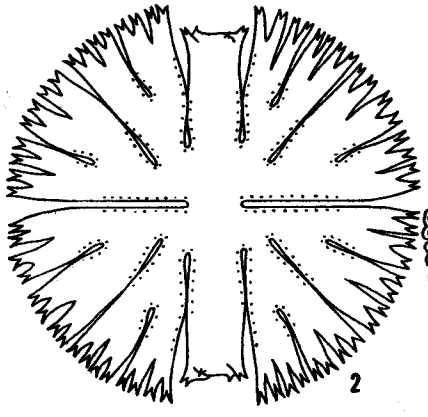
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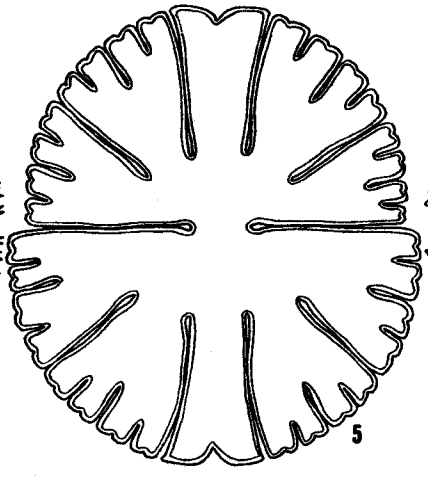
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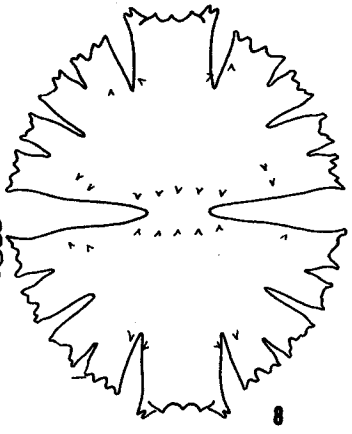
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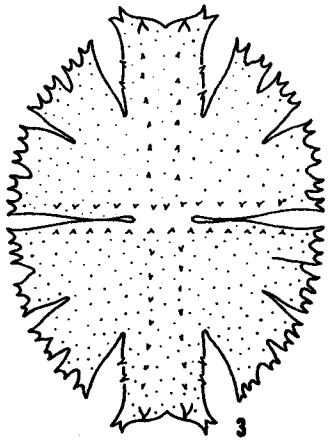
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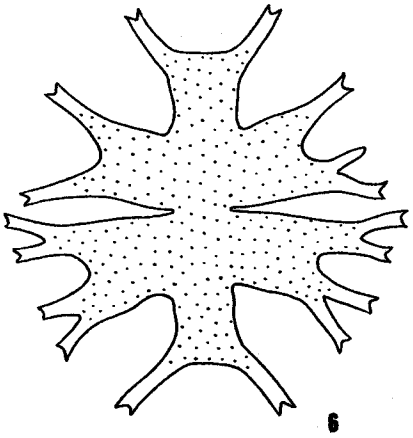
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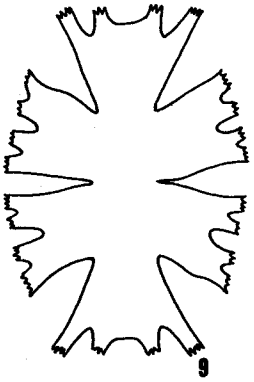
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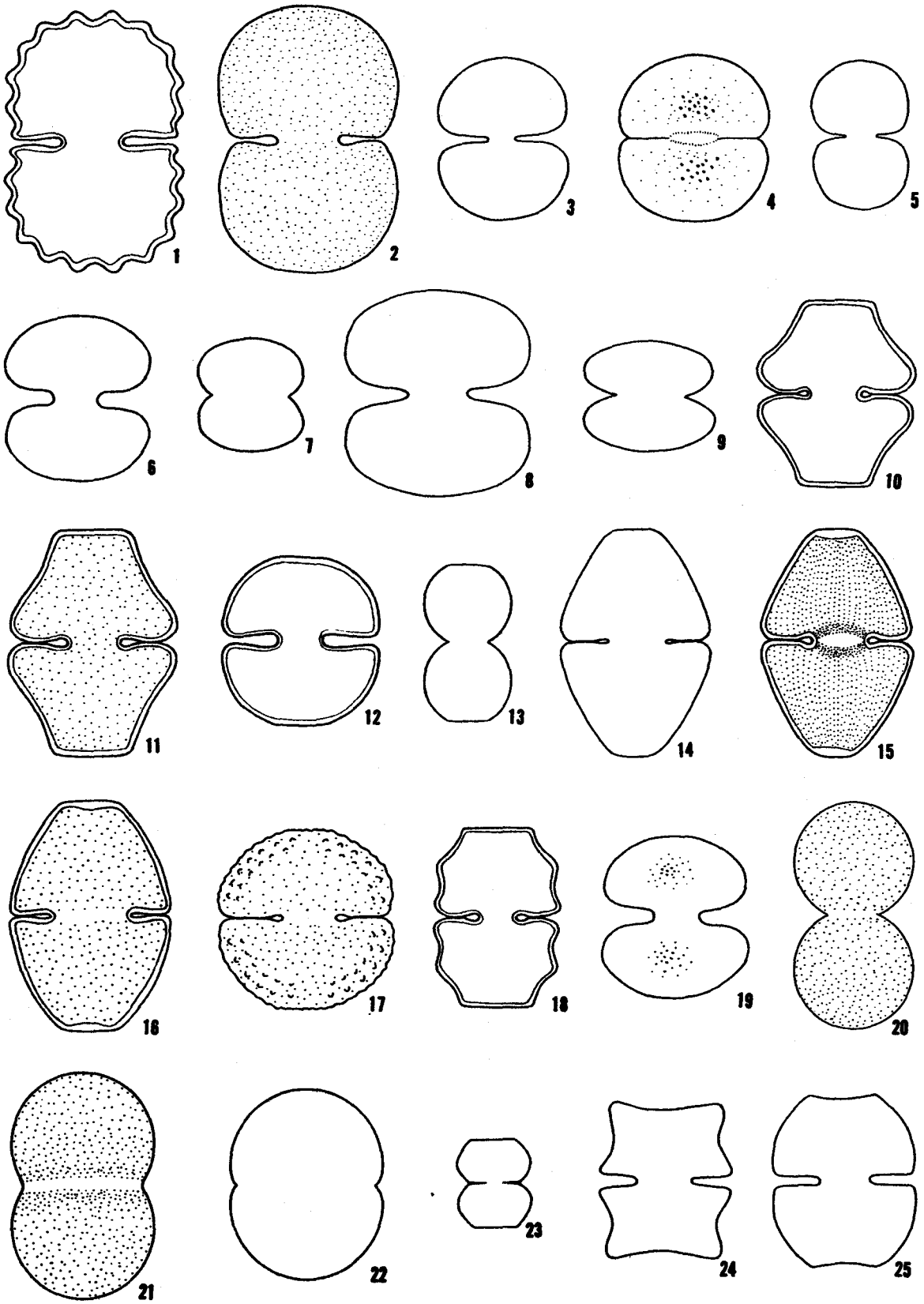
EXPLANATION OF PLATE V

Figure:

1. *Cosmarium undulatum* Corda. 705X.
2. *Cosmarium Cucumis* (Corda) Ralfs. 620X.
3. *Cosmarium Phaseolus* Breb. var. *elevatum* Nordst. 890X.
4. *Cosmarium tumidum* Lund. 950X.
5. *Cosmarium melanosporum* Arch. 125X.
6. *Cosmarium bioculatum* Breb. 1720X.
7. *Cosmarium tinctum* Ralfs. 1880X.
8. *Cosmarium contractum* Kirchn forma *Jacobsenii* (Roy) nob. 1230X.
9. *Cosmarium* sp. (2). 1850X.
10. *Cosmarium Hammeri* Reinsch var. *protuberans* West and G. S. West. 1210X.
11. *Cosmarium* sp. (3). 1190X.
12. *Cosmarium* sp. (4). 1770X.
13. *Cosmarium refringens* W. R. Taylor var. *minor* var. nov. 1530X.
14. *Cosmarium nitidulum* De Not. 1190X.
15. *Cosmarium pyramidatum* Breb. 530X.
16. *Cosmarium pseudopyramidatum* Lund. 935X.
17. *Cosmarium obtusatum* Schmidle. 615X.
18. *Cosmarium venustum* (Breb.) Arch. forma *minor* Wille. 1430X.
19. *Cosmarium* sp. (5). 1320X.
20. *Cosmarium moniliforme* (Turp.) Ralfs forma *Punctata* Lagerh. 775X.
21. *Cosmarium connatum* Breb. 585X.
22. *Cosmarium pseudoconnatum* Nordst. 680X.
23. *Cosmarium Meneghinii* Breb. 1250X.
24. *Cosmarium quadratulum* (Gay) De Toni. 2400X.
25. *Cosmarium angulosum* Breb. 1250X.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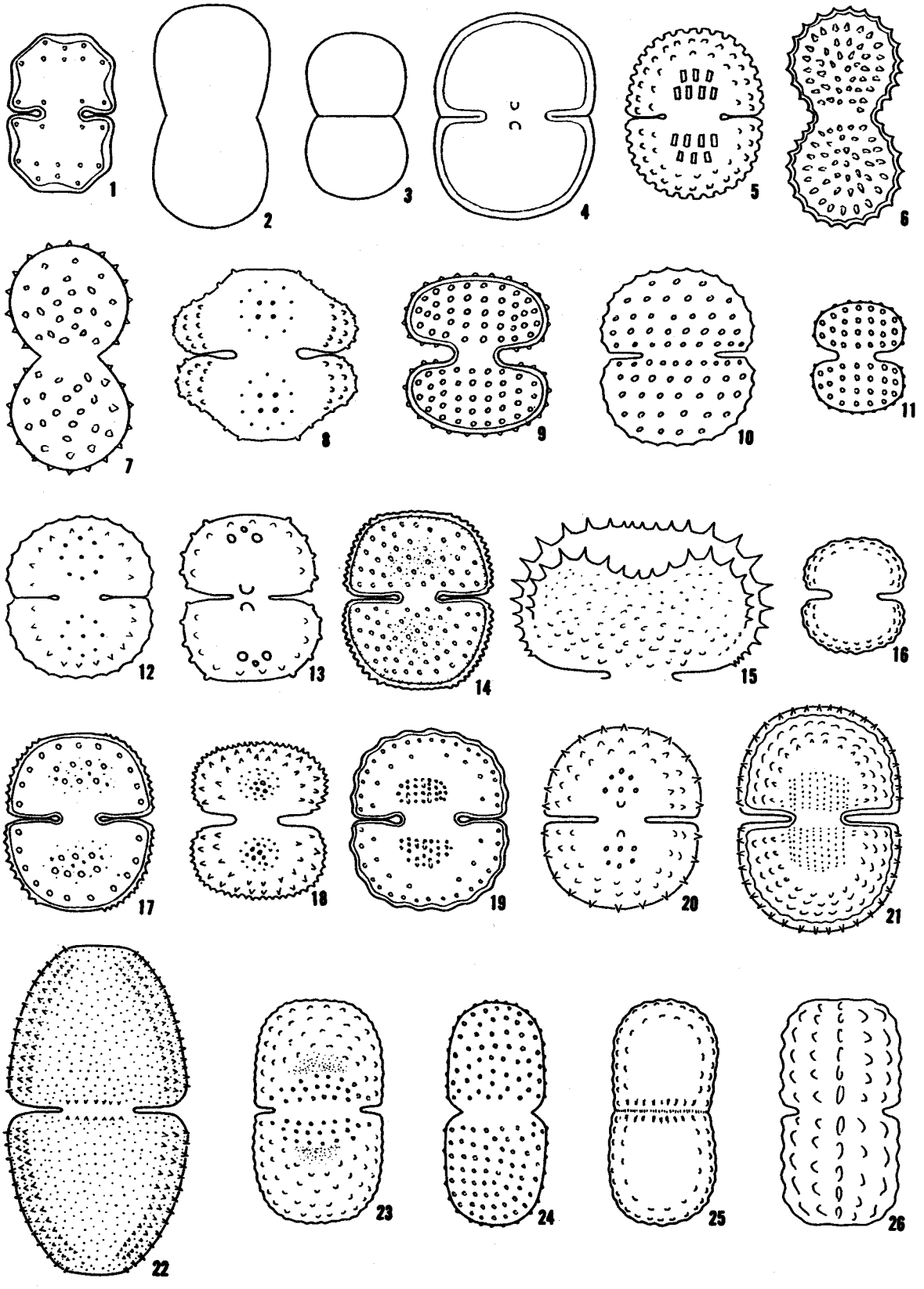
EXPLANATION OF PLATE VI

Figure:

1. *Cosmarium difficile* Lutkem. 1125X.
2. *Cosmarium viride* (Corda) Josh. 640X.
3. *Cosmarium viride* (Corda) Josh. forma *glabra* nob. 735X.
4. *Cosmarium* sp. (1). 777X.
5. *Cosmarium quadrifarium* Lund. forma *hexasticha* (Lund.) Nordst. 490X.
6. *Cosmarium subexcavatum* West and G. S. West var. *ordinatum* West and G. S. West. 915X.
7. *Cosmarium orbiculatum* Ralfs. 950X.
8. *Cosmarium ornatum* Ralfs. 855X.
9. *Cosmarium Portianum* Arch. 825X.
10. *Cosmarium orthostichum* Lund. 880X.
11. *Cosmarium orthostichum* Lund. var. *pumilum* Lund. 905X.
12. *Cosmarium trachypleurum* Lund. var. *minus* Racib. 1295X.
13. *Cosmarium isthmochondrum* Nordst. 875X.
14. *Cosmarium margaritiferum* Menegh. 455X.
15. *Cosmarium Eloisianum* Wolle var. *depressum* West and G. S. West. Semicell slightly tilted. 560X.
16. *Cosmarium furcatospermum* West and G. S. West. 1965X.
17. *Cosmarium quinarium* Lund. forma *irregularis* Nordst. 715X.
18. *Cosmarium norvegicum* Strom. 981X.
19. *Cosmarium subcrenatum* Hantzsch. 985X.
20. *Cosmarium Boeckii* Wille. 940X.
21. *Cosmarium subspeciosum* Nordst. var. *validius* Nordst. 420X.
22. *Cosmarium denticulatum* Borge forma *Borgei* nov. 110X.
23. *Cosmarium amoenum* Breb. 800X.
24. *Cosmarium pseudamoenum* Wille. 975X.
25. *Cosmarium pseudamoenum* Wille var. *basilare* Nordst. 755X.
26. *Cosmarium elegantissimum* Lund. forma *minor* West. 1000X.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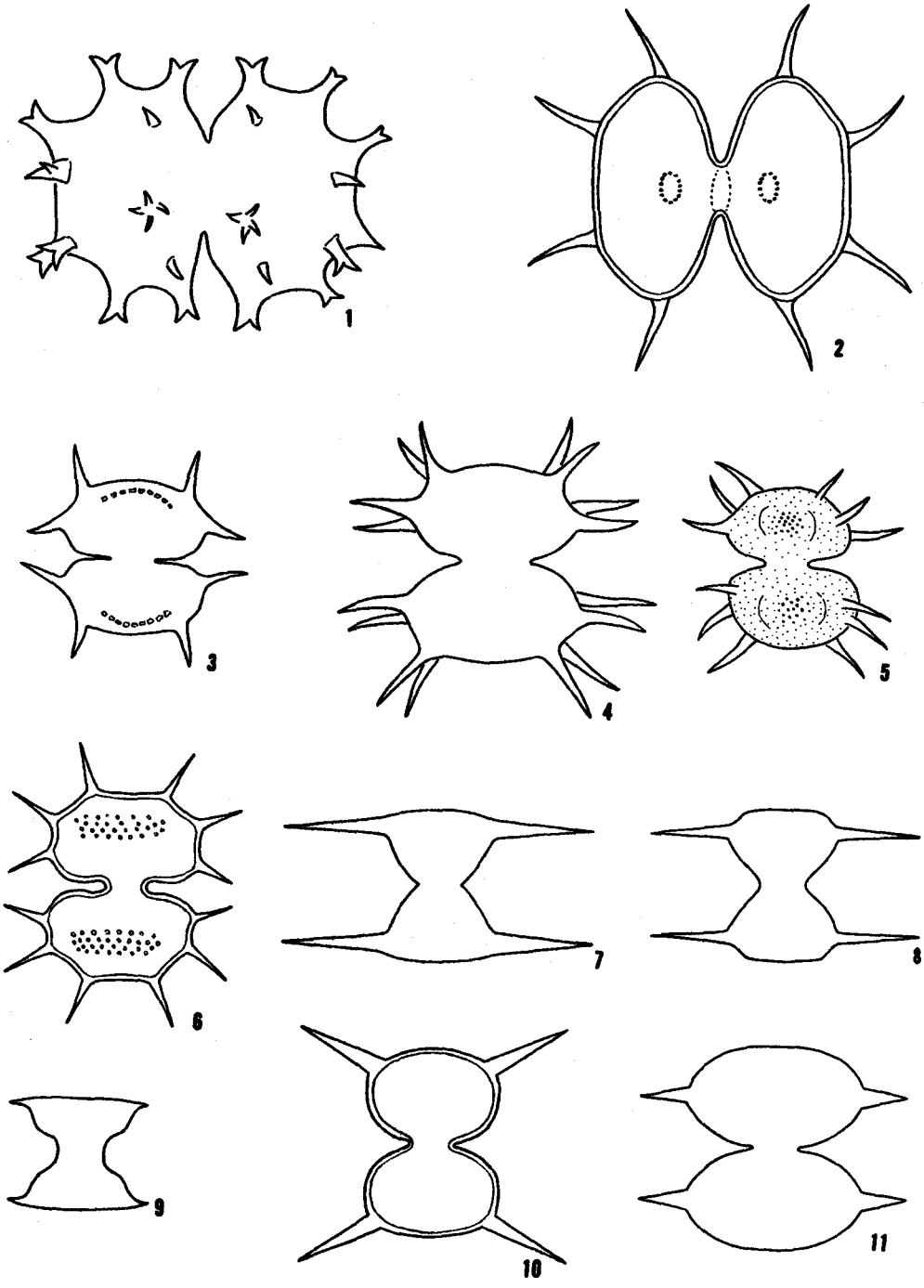
EXPLANATION OF PLATE VII

Figure:

1. *Xanthidium armatum* (Breb.) Rabenh var. *fissum* Nordst. 375X.
2. *Xanthidium antilopaeum* (Breb.) Kutz. 590X.
3. *Xanthidium antilopaeum* (Breb.) Kutz. var. *polymazum* Nordst. 400X.
4. *Xanthidium antilopaeum* (Breb.) Kutz. var. *laeve* Schmidle. 530X.
5. *Xanthidium antilopaeum* (Breb.) Kutz. var. *hebridarum* W. and G. S. West. 370X.
6. *Xanthidium cristatum* Breb. 460X.
7. *Arthrodesmus triangularis* Lagerh. 770X.
8. *Arthrodesmus triangularis* Lagerh. var. *inflatus* W. and G. S. West. 805X.
9. *Arthrodesmus Ralfsii* W. West. 940X.
10. *Arthrodesmus Bulnheimii* Racib. var. *subincus* W. and G. S. West. 795X.
11. *Arthrodesmus subulatus* Kutz var. *subaequalis* W. and G. S. West. 830X.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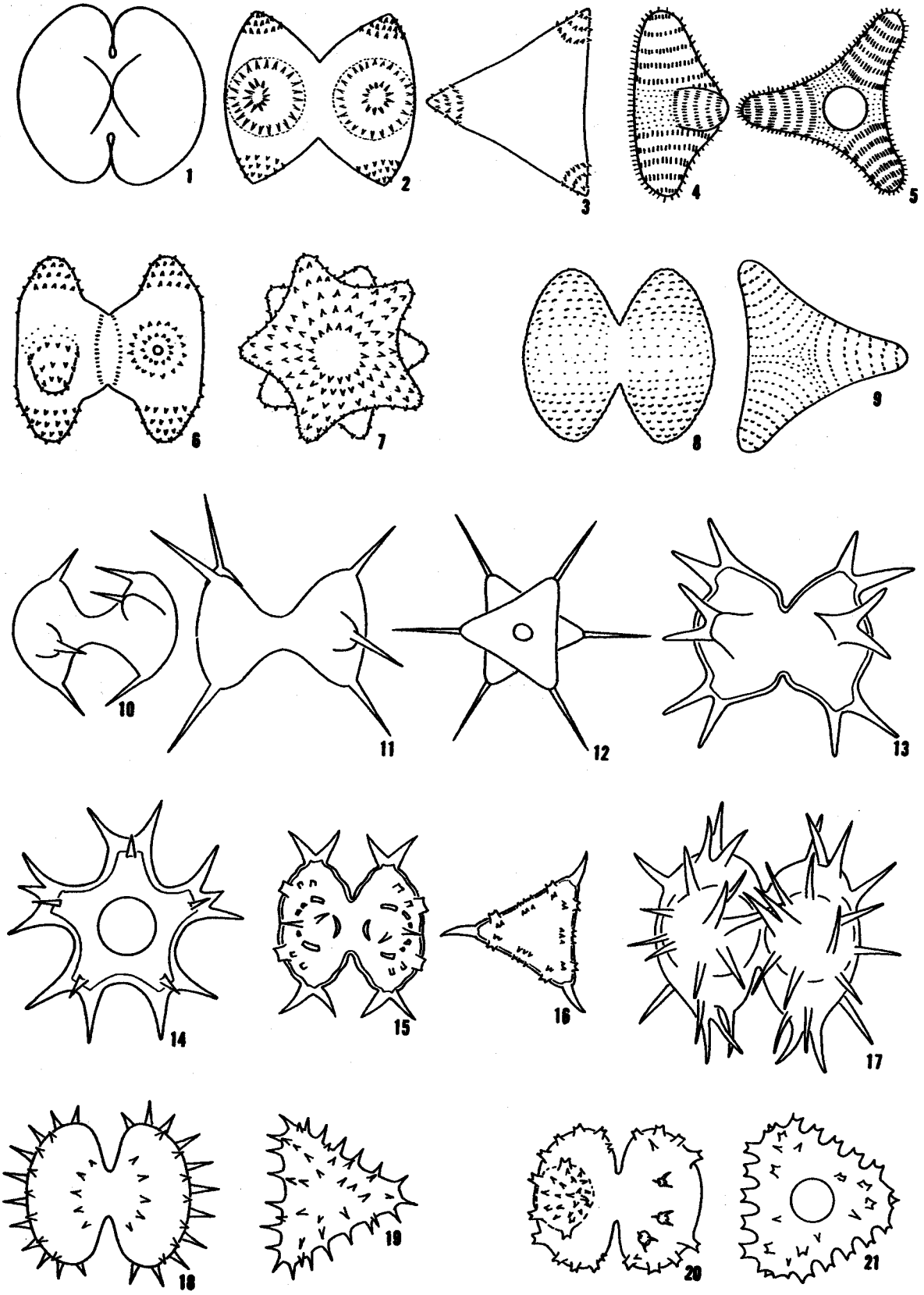
EXPLANATION OF PLATE VIII

Figure:

1. *Staurastrum orbiculare* Ralfs var. *Ralfsii* West and G. S. West. 780X.
2. *Staurastrum* sp. 1450X.
3. End view of fig. 2. 1450X.
4. *Staurastrum alternans* Breb. Semicell. 1140X.
5. *Staurastrum alternans* Breb. End view. 1140X.
6. *Staurastrum dilatatum* Ehrenb. 855X.
7. *Staurastrum dilatatum* Ehrenb. End view. 855X.
8. *Staurastrum punctulatum* Breb. 1000X.
9. *Staurastrum punctulatum* Breb. End view. 1000X.
10. *Staurastrum cuspidatum* Breb. 860X.
11. *Staurastrum cuspidatum* Breb. var. *divergens* Nordst. 690X.
12. *Staurastrum cuspidatum* Breb. var. *divergens* Nordst. End view. 690X.
13. *Staurastrum Brasiliense* Nordst. var. *Lundellii* West and G. S. West. 385X.
14. *Staurastrum Brasiliense* Nordst. var. *Lundellii* West and G. S. West. End view. 385X.
15. *Staurastrum cornutum* Arch. 645X.
16. *Staurastrum cornutum* Arch. End view. 645X.
17. *Staurastrum setigerum* Cleve. 390X.
18. *Staurastrum gladiosum* Turn. 620X.
19. *Staurastrum gladiosum* Turn. End view. 620X.
20. *Staurastrum spongiosum* Breb. 665X.
21. *Staurastrum spongiosum* Breb. End view. 665X.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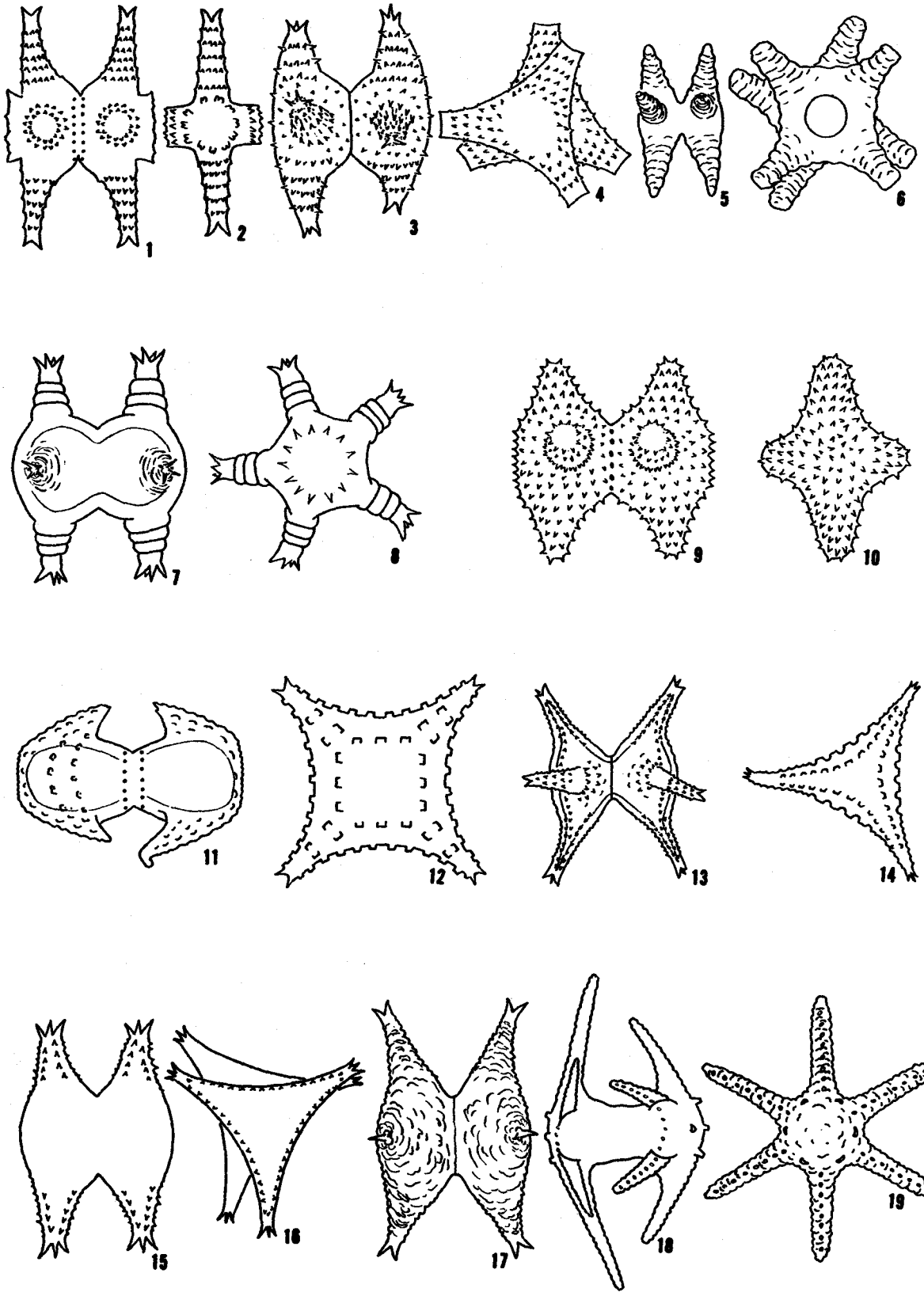
EXPLANATION OF PLATE IX

Figure:

1. *Staurastrum gracile* Ralfs var. *coronulatum* Boldt. 720X.
2. *Staurastrum gracile* Ralfs var. *coronulatum* Boldt. End view. 720X.
3. *Staurastrum polymorphum* Breb. 965X.
4. *Staurastrum polymorphum* Breb. End view. 965X.
5. *Staurastrum polymorphum* Breb. var. *pusillum* West. 875X.
6. *Staurastrum polymorphum* Breb. var. *pusillum* West. End view. 875X.
7. *Staurastrum margaritaceum* (Ehrenb.) Menegh. 1075X.
8. *Staurastrum margaritaceum* (Ehrenb.) Menegh. End view. 1075X.
9. *Staurastrum hexacerum* (Ehrenb.) Wittr. 895X.
10. *Staurastrum hexacerum* (Ehrenb.) Wittr. End view. 895X.
11. *Staurastrum Cerastes* Lund. 750X.
12. *Staurastrum Cerastes* Lund. End view. 750X.
13. *Staurastrum anatinum* Cooke and Wills. 390X.
14. *Staurastrum anatinum* Cooke and Wills. End view. 390X.
15. *Staurastrum anatinum* Cooke and Wills var. *Lagerheimii* (Schmidle) West and G. S. West. 750X.
16. *Staurastrum anatinum* Cooke and Wills var. *Lagerheimii* (Schmidle) West and G. S. West. End view. 750X.
17. *Staurastrum anatinum* Cooke and Wills var. *truncatum* West. 405X.
18. *Staurastrum Ophiura* Lund. 385X.
19. *Staurastrum Ophiura* Lund. End view. 385X.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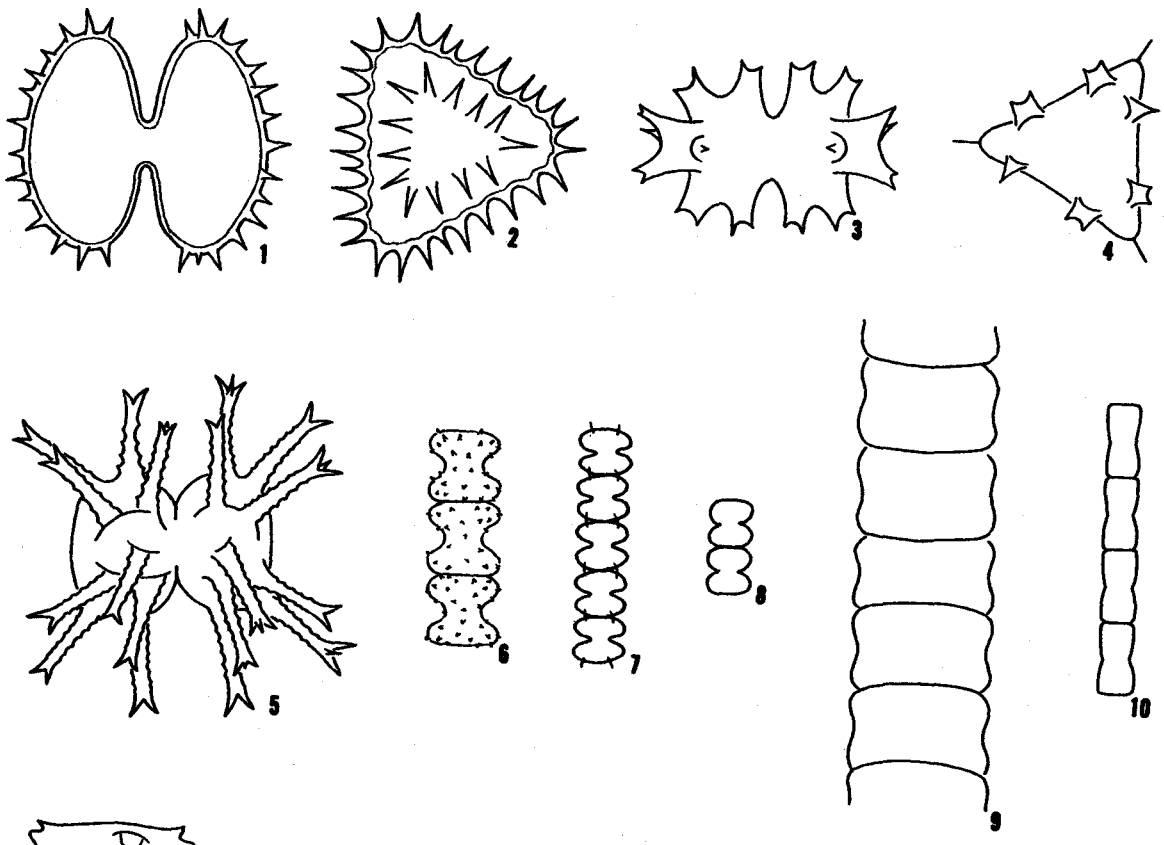
EXPLANATION OF PLATE X

Figure:

1. *Staurastrum aculeatum* (Ehrenb.) Menegh. 975X.
2. *Staurastrum aculeatum* (Ehrenb.) Menegh. End view. 975X.
3. *Staurastrum furcatum* Breb. 1170X.
4. *Staurastrum furcatum* Breb. End view. 1170X.
5. *Staurastrum Arctiscon* Lund. 375X.
6. *Sphaerozosma Wallichii* Jacobs var. *anglicum* West and G. S. West. 1000X.
7. *Onychonema filiforme* (Ehrenb.) Roy and Biss. 650X.
8. *Spondylosium planum* (Wolle) West and G. S. West. 650X.
9. *Hyalotheca dissiliens* (Sm.) Breb. 590X.
10. *Hyalotheca undulata* Nordst. 730X.
11. *Desmidium Swartzii* Agardh. 445X.
12. *Desmidium Swartzii* Agardh. var. *amblyodon* (Itz.) Rabenh. 930X.
13. *Desmidium Swartzii* Agardh. var. *amblyodon* (Itz.) Rabenh. End view. 930X.
14. *Desmidium cylindricum* Grev. 500X.
15. *Desmidium coarctatum* Nordst. 475X.
16. *Desmidium quadratum* Nordst. 490X.
17. *Gymnozyga* sp. 610X.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A TAXONOMIC AND ECOLOGICAL STUDY OF THE DESMIDS OF LILY LAKE

An Abstract

of a Thesis

Presented to the

Department of Botany

Brigham Young University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

James L. Pedersen

June 1969

ABSTRACT

During the summer of 1964 a taxonomic and ecological study was made of the desmids (microscopic green algae) found in Lily Lake.

The study site is a subalpine lake in the Wasatch National Forest of the Uinta Mountains, Utah. The lake is located about one-half mile west of Trial Lake at an elevation of approximately 10,000 feet. The lake is an acidic, cold, lentic bog pond characteristic of this region.

Desmids were collected at weekly intervals from seven sampling sites. The water temperature, pH, dissolved oxygen, light conditions and length of day from sunrise to sunset were recorded at the time of collection. Periphyton samples were obtained by scraping material from the stems and lower sides of leaves of water lilies, organic matter lying on the bottom of the lake, submerged logs and stems, dead sedge and grass leaves of the quaking peat, and organic matter of a floating peat mat. Surface samples were obtained by use of a plankton net. Small sheets of broken glass were suspended in the water as artificial habitats for desmid growth.

There were 167 species collected representing seventeen genera of the family Desmidiaceae. Illustrations were made of every species collected. Ninety-four different species were found that have not been reported in Utah waters. The species were divided into five groups based on their percent frequency: (i) abundant (80-100%), (ii) common (60-79%), (iii) frequent (40-59), (iv) occasional (20-39%), and (v) scarce (5-19%).

There were fourteen abundant species. Four of these were observed in each collection made: *Euastrum Didelta, Triploceras gracile, Cosmarium margaritiferum,* and *Xanthidium armatum* var. *fissum.* There were twenty-two common species, twenty-four frequent species, forty-three occasional species, and sixty-four scarce species. Five genera contained the majority of species found. *Cosmarium* was represented with fifty-one species; *Closterium* and *Staurastrum* each had twenty-five species; *Micrasterias* had sixteen species; and thirteen species were in the *Euastrum* genera. *Xanthidium, Penium, Pleurotaenium, Arthrodesmus, Desmidium, Netrium, Triploceras, Hyalotheca, Sphaerozosma, Onychonema, Spondylosium* and *Gymnozyga* were the remaining genera. There were thirty-seven species in this latter group.

The natural habitats provided the best environment for the growth of desmids. Periphyton samples from the shallow water contained the largest number of species. Artificial habitats of glass sheets were especially favorable for the growth of *Closterium lineatum, Closterium ralfsii* var. *hybridum* and *Closterium* sp. (5). Few species were found free-floating where the lake was over six feet deep.

As the pH, air, and water temperature increased during the growing season, the number of species collected increased, and as the water temperature decreased, oxygen increased, and the number of species collected decreased.