

BULLETIN OF THE UNIVERSITY OF WISCONSIN

SERIAL NO. 1270

GENERAL SERIES NO. 1048

Phytoplankton of the Inland Lakes of Wisconsin

Part II Desmidiaceae

BY
GILBERT MORGAN SMITH

*This Bulletin Constitutes Part II of Bulletin 57 of the Wisconsin
Geological and Natural History Survey*

MADISON
PUBLISHED BY THE UNIVERSITY
1924

FOREWORD

In 1920 the Wisconsin Geological and Natural History Survey issued the first part of a report on the plankton algae of the inland lakes of Wisconsin¹ by Dr. Gilbert M. Smith. This report included all of the plankton algae, except the desmids and diatoms.

The present volume comprises the second part of this report, and includes the Desmidiaceae. A third part, including the Bacillarieae, is in preparation and will complete the investigations of the algae of Wisconsin lakes. The material has been sent for study and report to Mr. Fr. Meister, of Zürich, Switzerland.

The present report is published as one of the scientific studies of the University of Wisconsin as well as a bulletin of the Survey. The arrangement is made in accordance with Sec. 36.26 of the Wisconsin Statutes. It is especially appropriate that this particular bulletin should be printed by the University since Dr. Smith is associate professor in the department of botany and the report has been prepared in connection with the work of the department. The report is listed as Bulletin 57, Part 2, in the publications of the Survey, and as No. 1270 in the University Bulletins.

E. A. BIRGE,
President, University of Wisconsin,
President, Commissioners, Wisconsin Geological
and Natural History Survey.

MADISON, MAY 12, 1924.

¹Phytoplankton of the Inland Lakes of Wisconsin. Part I. Wisconsin Geol. & Nat. Survey. Bull. No. 57; Sci. series, No. 12. Pp. 1-243; Pl. 1-51. Madison. 1920.

1. Introduction

The purpose of this study is to investigate the effects of the proposed system on the performance of the system. The system is designed to improve the efficiency of the system by reducing the time taken to process the data. The system is designed to be able to handle large amounts of data and to be able to process the data in a timely manner. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system.

The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system.

The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system.

The system is designed to be able to handle the data in a way that is consistent with the requirements of the system.

The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system. The system is designed to be able to handle the data in a way that is consistent with the requirements of the system.

PREFACE.

Part 1 of this bulletin, which covers the plankton algae of Wisconsin, exclusive of the Desmidiaceae and Bacillarieae, appeared in 1920. Since this account of the plankton desmids is a continuation of the same investigation and is based upon the same collections, it is unnecessary to repeat the data given on pages 13-19 of Part 1, which describes the location and morphometry of the various lakes from which plankton samples were collected.

The method of treatment of the various species is the same as that followed in the first section. In addition to the citation of the original description of the alga there has been a liberal citation of articles that contain characteristic figures. A list of all stations for each alga is given, following its description, and the same method has been used for designating its frequency at each station as was used in the first part.

Since all drawings have been made from preparations the vertical and front views are from different individuals. For this reason each drawing has been given a different number. All of the figures of the plates have been drawn from Wisconsin specimens and all dimensions, unless expressly stated, are those of cells as found in the plankton of Wisconsin lakes. Since only varieties of a number of species are represented in the local flora descriptions of the type are taken from other sources. Where illustrations have been drawn of these types they are given as text figures and with an indication of the source of the material.

The difficulties involved in the determination of the species of Desmidiaceae are well known to all students of the family. In the preparation of this section the Wisconsin specimens have been compared with species found in the plankton of various European lakes and the opportunity of studying foreign plankton Desmidiaceae has added greatly to the certainty of determination of members of the local flora.

In the course of this investigation, through the kindness of Professor Yapp of the University of Birmingham, I have had free access to the collections and drawings of the late Professor G. S. West. While studying the material at Birmingham Dr. Nellie Carter placed at my disposal her material for the completion of W. & G. S. West's British Desmidiaceae. Dr. A. B. Rendle furnished facilities for examining the herbarium of the British Museum of Natural History and for consulting the rich library of that institution. The privilege of studying the Huitfeld-Kaas collections from Norwegian lakes was

granted by Professor Wille of Christiania. Mr. Karl Strom supplemented these collections with his own from other Norwegian lakes and made determinations of certain puzzling forms. I am under especial obligations to Dr. O. Borge of Stockholm, Sweden, and to Charles Bullard of Cambridge, Massachusetts. Dr. Borge devoted a large portion of his time during my stay in Stockholm to checking over the determination of a majority of the Wisconsin Desmids and comparing them with his extensive iconography. Besides demonstrating a method of making mounts of individual Desmids, Mr. Bullard has allowed me to consult his preparations and his unpublished drawings of American Desmidiaceae and has placed at my disposal his wide experience with the group. Although the investigators named above have given assistance in determination of doubtful species, I assume full responsibility for all errors of determination.

*The University of Wisconsin,
Department of Botany,
March, 1922.*

Family *DESMIDIACEAE*.

Cells solitary or united in colonies. Naked or enclosed by a hyaline gelatinous envelope that is homogeneous or radially fibrillar. Colonies filamentous or growing in three dimensions. Shape of the cells exceedingly variable, generally with a pronounced constriction in the median portion dividing them into two similar semicells. Semicells always with a bilateral or a radial symmetry. Cells frequently with the walls having a characteristic ornamentation. Nucleus single and lying at the median constriction. Chloroplasts of each semicell generally solitary and axial, with one or more pyrenoids; more rarely with more than one axial or parietal chloroplast in each semicell or extending throughout the entire length of the cell.

Asexual reproduction by vegetative cell division, the divisions taking place at the isthmus and new semicells being formed at the point of division. Aplanospore formation known in a few instances.

Sexual reproduction isogamous, by aplanogametes.

KEY TO THE GENERA.

Cells not united in colonies.

Cell length at least twice the breadth.

Without a median constriction.

Chloroplast ribbon-like.

Ribbon axial and straight.....GONATOZYGON (p. 4)

Ribbon parietal and spiral.....SPIROTAENIA (p.p.) (p. 5)

Chloroplast not ribbon-like.

Cells straight.

Longitudinal ridges of chloroplast notched.....NETRIUM (p. 6)

Longitudinal ridges of chloroplast unnotched.

Ridges straight.....PENIUM (p.p.) (p. 7)

Ridges spirally twisted.....SPIROTAENIA (p.p.) (p. 5)

Cells curved and generally strongly attenuated at poles..CLOSTERIUM (p. 8)

With a median constriction.

Cell apices incised.....TETMEMORUS (p. 20)

Cell apices not incised.

Bases of semicells not swollen.....PENIUM (p.p.) (p. 7)

Bases of semicells swollen.

Semicell bases with vertical plications.....DOCIDIUM (p. 17)

Semicell bases without plications.

Wall with transverse rings of verrucae.....TRIPOCERAS (p. 18)

Wall without transverse rings of verrucae....PLEUROTAENIUM (p. 13)

Cell length not over twice the breadth.

Cells compressed.

Apex of semicells incised.

Lateral margins not deeply incised.....EUASTRUM (p. 21)

Lateral margins deeply incised.....MICRASTERIAS (p.p.) (p. 40)

- Apex of semicells not incised.
 Lateral margins deeply incised.....MICRASTERIAS (p.p.) (p. 40)
 Lateral margins not incised.
 With spines.
 Cell face with central protuberance.....XANTHIDIUM (p.p.) (p. 55)
 Cell face without a central protuberance.....ARTHRODESMUS (p. 125)
 Without spines.
 Angles continued in processes.....STAUSTRUM (p.p.) (p. 62)
 Angles not continued in processes.....COSMARIUM (p. 28)
 Cells radially symmetrical.
 Face with a central protuberance.....XANTHIDIUM (p.p.) (p. 55)
 Face without a central protuberance.....STAUSTRUM (p.p.) (p. 62)
- Cells united to form permanent colonies.*
- Colonies filamentous.
 Cell length several times the breadth.....PLEUROTAEINIUM (p.p.) (p. 13)
 Cell length never double the breadth.
 Cells united by special apical processes.
 Processes interlocking.....SPHAEROSOMA (p. 136)
 Processes overlapping adjacent cells.....ONYCHONEMA (p. 135)
 Cells not united by apical processes.
 Without a girdle-like thickening at point of division.
 Deeply constricted.....SPONDYLIUM (p. 139)
 Not deeply constricted.....HYALOTHECA (p. 141)
 With a girdle-like thickening at point of division.
 Length greater than breadth.....GYMNOZYGA (p. 146)
 Breadth greater than length.....DESMIDIUM (p. 143)
 Colonies not filamentous.....COSMOCLADIUM (p. 37)

GONATOZYGON De Bary 1856.

Cells cylindrical, length many times the breadth, without a trace of a median constriction; sides of cells parallel, except near apices where they may be either slightly dilated or convergent; apices truncate, with angles only slightly rounded, at times subcapitate. Cell wall smooth, finely granulate, or clothed with minute spicules or spines. Chloroplasts axial ribbon-like strands extending from pole to pole or from each pole to middle of cell; pyrenoids fairly numerous and at regular intervals along the chloroplast. Cell division at any point in the cell wall, the cells frequently remaining attached at apices and forming temporary colonies of variable length. Colonies readily separating into component cells on being disturbed and always separating prior to conjugation.

Zygospores spherical and with smooth walls.

KEY TO THE SPECIES.

- Cell wall granulate.....(1) *G. monotaenium*
 Cell wall with spines.
 Spines the same diameter at base and apex.....(2) *G. pilosum*
 Spines broader at bases.....(3) *G. aculeatum*

1. GONATOZYGON MONOTAENIUM De Bary. Pl. 52, Fig. 1.

in Rabenhorst, Die Algen Sachsens, Dec. 53; No. 536. 1856.

Gonatozygon Ralfsii De Bary, Unters. u. d. Fam. d. Conj. 76, pl. 4, figs. 23-25. 1858.

Cells usually quite long, cylindrical, length 25-30 times the breadth, apices somewhat dilated and truncate, angles slightly rounded. Cell wall minutely granulate except at extreme ends of cells. Chloroplasts axial and with about ten pyrenoids. (Tycho plankton.)

Zygospores spherical, with smooth walls (De Bary).

Length 370-408 μ ; breadth of median portion 8-11.5 μ , breadth apices 11-15 μ .

Diameter zygospores 25-28 μ (De Bary).

Crab (rrr).

2. GONATOZYGON PILOSUM Wolle. Pl. 52, Fig. 2.

Bull. Torr. Bot. Cl. 9: 27, pl. 13, fig. 16. 1882; W. & G. S. West, Monogr. Brit. Desm. 1: 34, pl. 1, figs. 19-20. 1904.

Length about eighteen times the breadth; cell apices very slightly dilated, truncate, with angles slightly rounded. Cell wall very densely covered with very short, hair-like spicules. Chloroplasts axial, with about six pyrenoids. (Tycho plankton.)

Zygospores unknown.

Length 142 μ ; breadth without spines 7.5 μ ; length spines 1-1.5 μ .

Rudolph (rrr).

3. GONATOZYGON ACULEATUM Hastings. Pl. 52, Fig. 3.

Am. Mo. Micr. Jour. 13: 29 (with text figure). 1892; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 230, pl. 12, figs. 1-2. 1896.

Cells fairly long, cylindrical, length 15-20 times the breadth (without spines); apices somewhat dilated and truncate, apical angles very slightly rounded. Cell wall densely clothed with small, sharp, erect spines; truncate ends without spines. Chloroplasts with 6-9 pyrenoids. (Tycho plankton.)

Zygospores unknown.

Length 211-212 μ ; breadth of median portion 12.5 μ ; breadth of apices 15-22 μ ; length of spines 4.5-9.5 μ .

Bear (rrr), Dummy (rrr).

SPIROTAENIA De Brébisson 1848.

Cells of variable size, length at least five times the breadth, neither constricted nor compressed; cells usually cylindrical and with parallel sides, more rarely with sides attenuated or fusiform; poles commonly broadly rounded, infrequently subacute. Cell wall smooth and without pores. Chloroplast a fairly broad, parietal, spirally twisted ribbon extending from pole to pole; or axial and with longitudinal blades that are spirally twisted; in either case with several pyrenoids. Cell wall with no fixed point at which division takes place.

Zygospores generally spherical; with smooth, areolate, or short-spined walls.

The investigations of Lütkemüller show that the segmentation or lack of segmentation of the wall, a feature that is associated with the presence or absence of pores, is a fundamental point in the classification of the family. Most genera belong to the first type; *Gonatozygon*, *Spirotaenia* and *Netrium* are the only genera with unsegmented walls found in the Wisconsin plankton.

SPIROTAENIA CONDENSATA De Brébisson. Pl. 52, Fig. 4.

in Ralfs, Brit. Desm. 179, pl. 34, figs. 1A-1C. 1848; Archer, Quart. Jour. Micr. Sci. N.S. 7: 186, pl. 8, figs. 5-11. 1867.

Cells relatively large, straight or slightly curved, length 5-12 times the breadth; cell shape cylindrical, not attenuated towards the apices, poles broadly rounded. Cell wall smooth. Chloroplast a broad spiral ribbon, extending from pole to pole and almost completely covering the interior of the cell wall; pyrenoids fairly numerous, at least one every turn. (Tychoplankton.)

Zygospores spherical; wall with a thin, inner, brownish layer and a thick, colorless, areolate, outer layer (Archer).

Length 150 μ ; breadth 25 μ .

Diameter zygospores 60 μ (Archer).

Devils (rrr).

NETRIUM Nägeli 1849 (emend. Lütkemüller 1902).

Cells generally large, length at least three times the breadth, neither constricted in the median portion nor compressed; cell shape cylindrical to naviculoid, with lateral margins gradually attenuated to truncate apices, or parallel and then sharply convergent in the apical region. Cell wall always smooth and without pores. Chloroplasts axial, usually one in each half-cell, with 6-12 longitudinal, radiating plates that have strongly notched edges; pyrenoids always axial, usually a single long rod, but at times with the rod fragmenting to form an axial row of spherical to irregularly shaped pyrenoids. Cell division at no definite point.

Zygospores spherical, with smooth, thick walls.

W. & G. S. West (Monogr. Brit. Desm. 1: 63) give the reasons for adopting Lütkemüller's separation of *Netrium* from *Penium* on the basis of the structure of the cell wall.

NETRIUM DIGITUS (Ehrenberg) Itzigsohn & Rothe. Pl. 52, Fig. 5.

in Rabenhorst, Die Algen Sachsens Dec. 50: No. 508. 1856; W. & G. S. West, Monogr. Brit. Desm. 1: 64, pl. 6, figs. 14-16. 1904; Carter, Ann. of Bot. 33: 227, pl. 14, figs. 13-15. 1919.

Cells usually large, length 3-5 times the breadth, neither constricted nor compressed; cell shape broadly naviculoid, with lateral margins convex and attenuated to truncate apices with rounded angles. Cell wall smooth. Chloroplasts axial, one in each half-cell, usually with eight radiating longitudinal plates that end at the cell

wall and have deep notches that form rectangular teeth; pyrenoids usually a single elongate rod in the axial portion of the chloroplast. (Tycho plankton.)

Zygospores spherical, with smooth thick walls (W. & G. S. West).

Length 177–230 μ ; breadth of median portion 48 μ ; breadth at apices 12.5–23 μ .

Diameter of zygospores 73.6 μ ; thickness of zygospore wall 3.2 μ (W. & G. S. West).

Clear Crooked (rrr), Devils (1) (rrr), Devils (2) (rrr), Speese (rrr), Squirrel (rrr).

Exceedingly variable in size and relative proportions of length and breadth. The striking axial chloroplast with notched longitudinal rays is the most prominent feature of the alga.

PENIUM De Brébisson 1844.

Cells of variable length, length usually several times the breadth, generally straight, with median portion somewhat constricted or without a median constriction; sinus, when present, only a slight depression. Cells not compressed, shape generally cylindrical, at times fusiform to subelliptic, frequently somewhat attenuated at poles, apices usually truncate and with rounded angles. Point of cell division definite. Cell wall colorless to brownish, smooth to punctate or granulate, at times with the granules arranged in definite longitudinal series. Chloroplasts axial, with longitudinal radiating plates that extend to the cell wall; pyrenoids generally in an axial row at center of chloroplasts.

Zygospores spherical to rectangular, walls usually smooth.

KEY TO THE SPECIES.

Cell wall with rows of granules.....(1) *P. margaritaceum*
Cell wall without granules(2) *P. minutum*

1. *PENIUM MARGARITACEUM* (Ehrenberg) De Brébisson. Pl. 52, Fig. 6. in Ralfs, Brit. Desm. 149, pl. 25, figs. 1A–1C; pl. 33, fig. 3. 1848.

Cells of medium size, length about ten times the breadth, slightly constricted in median portion; cell shape cylindrical, with lateral margins very slightly attenuated at poles and apices broadly rounded. Cell wall with transverse lines at points of division; ornamented with vertical rows of minute granules, older portions of wall brownish. Chloroplasts with a fairly massive axial portion from which about ten longitudinal ridges radiate to the cell walls; pyrenoids fairly numerous and forming an axial row in the central portion of chloroplast. (Tycho plankton.)

Zygospores spherical, with smooth walls (Ralfs).

Length 160 μ ; maximum breadth 17.5 μ ; breadth at apices 10 μ .

Diameter of zygospores 46 μ (Ralfs).

Lynx (rrr).

2. *PENIUM MINUTUM* (Ralfs) Cleve. Pl. 52, Fig. 7.

Öfvers. Kgl. Sv. Vet.-Ak. Förh. 20: 493. 1864.

Docidium minutum Ralfs, Brit. Desm. 158, pl. 26, figs. 5A-5B. 1848.

Cells of medium size, length about ten times the breadth, slightly constricted, sinus a small V-shaped depression, isthmus very broad; semicells cylindrical, with lateral margins very slightly attenuated towards the apices, bases of semicells not inflated, apices truncate, with angles somewhat rounded. Vertical view circular. Cell wall smooth or finely punctate. Chloroplast axial, with an axial row of about six pyrenoids. (Tycho plankton.)

Zygospores unknown.

Length $116\ \mu$; breadth semicell base $10\ \mu$, semicell apex $6.25\ \mu$; breadth isthmus $7.5\ \mu$.

Lindy (rrr).

The specimens observed were somewhat narrower than the typical *P. minutum* and approached the variety *gracile*. The lack of a basal swelling of the semicell, as well as a lack of apical or basal ornamentation, shows that the species cannot be referred to either *Docidium* or *Pleurotaenium*.

CLOSTERIUM Nitzsch 1817.

Cells greatly elongated and always, usually markedly, attenuated; in most cases curved, rarely straight; without a median constriction. Cell wall colorless or yellow to brown in color; smooth or with longitudinal striae that are usually ridges but may be series of granules; commonly with one or more transverse lines at middle of cell or at different points along the cell. Cells with a single chloroplast in each semicell that is either entire or with longitudinal ridges radiating from a comparatively slender central axis; generally with a single axial row of pyrenoids, more rarely with pyrenoids scattered throughout chloroplast. Cell apices hyaline in portion not occupied by chloroplasts and with a conspicuous vacuole that contains one or more granules that show a Brownian movement.

Zygospores spherical, ellipsoid, ovoid, or quadrangular; with a heavy, smooth or scrobiculate wall that is without processes.

KEY TO THE SPECIES.

Cells with a median girdle.....(1) *Cl. subtruncatum*

Cells without a median girdle.

Poles not sharply attenuated.

Curvature pronounced.....(2) *Cl. Venus*

Curvature not pronounced.

Inner margin tumid.....(3) *Cl. moniliferum*

Inner margin not tumid.....(4) *Cl. acerosum*

Poles sharply attenuated.

Wall longitudinally striated.

Poles truncate.....(8) *Cl. Ralfsii*

Poles not truncate.

Attenuated poles very narrow.....(9) *Cl. Kuetzingianum*

Attenuated poles fairly broad.....(10) *Cl. decorum*

Wall smooth.

Apices rounded.....(5) *Cl. gracile*

Apices acute.

Length at least 75 times the breadth.....(6) *Cl. aciculare*

Length less than 35 times the breadth.....(7) *Cl. acutum*

1. CLOSTERIUM SUBTRUNCATUM W. & G. S. West. Pl. 52, Fig. 8.

Jour. Linn. Soc. Bot. 33: 159, pl. 8, fig. 4. 1897; Borge, Ark. för Botanik 1: 78, pl. 1, fig. 14. 1903.

Cells of medium size, length 9–12 times the breadth, curvature moderate, arc of curvature of outer margin about 65°; inner margin concave; somewhat attenuated towards the poles which are broadly truncate and slightly tumid in polar region of outer margin. Cell wall slightly thicker at poles, colorless to brownish yellow; with a median girdle and with numerous longitudinal striae. Chloroplast with an axial row of about eight pyrenoids. (Tychoplankton.)

Zygospores unknown.

Distance between apices 225–300 μ ; breadth of median portion 20–26 μ ; about 12 striae in 10 μ .

Clam (rrr), Fish (rrr).

2. CLOSTERIUM VENUS Kützing. Pl. 52, Fig. 9.

Phycol. Germ. 130. 1845; Ralfs, Brit. Desm. 220, pl. 35, fig. 12. 1848; W. & G. S. West, Monogr. Brit. Desm. 1: 137, pl. 15, figs. 15–20. 1904.

Cells small, distance between apices 8–10 times the breadth; strongly curved, the outer margin making an arc of 150°–165°, inner margin with a curvature resembling that of the outer; gradually attenuated to subacute apices. Cell wall colorless, rarely colored; without a median girdle; smooth. Terminal vacuoles large. (Tychoplankton.)

Zygospores oblong, ends concave and sides tumid in median portion; angles rounded; spore wall smooth. Halves of zygospore at times cruciately twisted (W. & G. S. West).

Distance between apices 70 μ ; breadth 8 μ .

Length of zygospore 23–28.5 μ ; breadth of zygospore 18–22 μ (W. & G. S. West).

Monona (rrr).

3. CLOSTERIUM MONILIFERUM (Bory) Ehrenberg. Pl. 52, Fig. 10.

Die Infusionsthierehen 91, pl. 5, figs. 16–16'. 1838; Ralfs, Brit. Desm. 166, pl. 28, figs. 3A–3B. 1848; Lundell, Nova Acta Reg. Soc. Sci. Upsaliae, 3 Ser. 8: 80, pl. 5, fig. 14. 1871.

Cells fairly large, length 6–8 times the breadth, curvature of outer margin conspicuous, inner margin with central portion tumid and apical portions with approximately the same curvature as the outer margin; apices bluntly rounded. Cell wall colorless, without a median girdle; smooth. Chloroplasts with 6–8 longitudinal ridges and an axial row of 5–9 pyrenoids that vary greatly in size. Terminal vacuoles conspicuous. (Tychoplankton.)

Zygospores ovoid, smooth; enclosed in a laminated gelatinous envelope (Lundell).

Distance between apices 244–252 μ ; breadth 46–50 μ .

Monona (rr).

4. CLOSTERIUM ACEROSUM (Shrank) Ehrenberg. Pl. 53, Fig. 1.

Symbolae Physicae seu Icones et Descriptiones etc. pl. 2, fig. 9. 1828 (sec. Nordst. Index Desm.); Ralfs, Brit. Desm. 164, pl. 27, figs. 2A–2L. 1848.

Cells fairly large, length 10–13 times the breadth; median portion straight and apical region slightly curved; outer margin curved but inner margin straight; gradually attenuated to subacute or rounded apices. Cell wall colorless, rarely brownish in older specimens; without a median girdle; smooth, or in rare cases with delicate striae. Chloroplast with two longitudinal ridges in front view of cell and an axial row of 10–12 pyrenoids. Terminal vacuoles with numerous granules. (Tychoplankton.)

Zygospores spherical and smooth-walled (Ralfs).

Length 288–328 μ ; breadth 19–22.5 μ .

Diameter of zygospore 63 μ (Ralfs).

Camp (rr), Center (rrr).

5. CLOSTERIUM GRACILE De Brébisson.

in Chevalier, Des microscopes et de leur usage 272. 1839; Mém. de la Soc. imp. d. Sc. nat. de Cherbourg 4: 155, pl. 2, fig. 45. 1856; W. & G. S. West, Monogr. Brit. Desm. 1: 166, pl. 21, figs. 8–12. 1904.

Cells fairly small, acicular, very delicate, length about thirty times the breadth; median portion straight and with sides parallel, terminal portions gracefully attenuated to blunt apices. Cell wall colorless; without a median girdle; smooth. Chloroplast with 5–7 pyrenoids.

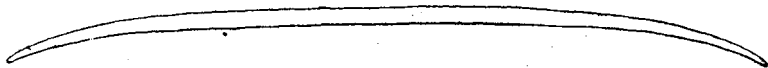


Fig. 1. *Closterium gracile* De Brébisson ($\times 610$). From a herbarium specimen in the British Museum of Natural History collected by De Brébisson.

Zygospores spherical to subquadrate; with a smooth wall.

Length 130–190 μ , breadth median portion 3.4–6 μ ; breadth apices 1.2–2.4 μ (W. & G. S. West).

Diameter of zygospore 20–27.5 μ (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. *ELONGATUM* W. & G. S. West. Pl. 53, Fig. 2.

Monogr. Brit. Desm. 1: 168, pl. 21, figs. 14-16. 1904.

Cells very much longer and with curvature confined to the apical regions. (Tychoplankton.)

Length 418-480 μ ; maximum breadth 8 μ ; breadth near apices 5-8 μ .

Little Bass (rrr), Pokegama (rr).

6. *CLOSTERIUM ACICULARE* T. West.

Trans. Micr. Soc. London N. S. 8: 153, pl. 7, fig. 16. 1860 (in Quart. Jour. Micr. Sci. 8: 1860).

Cells greatly elongated, length many times the breadth; median portion narrow and straight, terminal portions curved; very gradually attenuated to acutely rounded apices. Cell wall colorless; without a median girdle; smooth. Chloroplast with an axial row of 6-8 pyrenoids.

Zygospores unknown.

Length 500 μ ; greatest breadth 5 μ (T. West).

Not found in the plankton of Wisconsin lakes.

var. *SUBPRONUM* W. & G. S. West. Pl. 53, Fig. 3.

Monogr. Brit. Desm. 1: 175, pl. 23, figs. 4-5. 1904.

Cells longer and with attenuation of terminal portion more delicate. Chloroplast extending half way from cell center to cell apex. (Facultative plankton.)

Length 540-610 μ ; breadth 7.5 μ .

Browns (r), Green (r), Mendota (r).

7. *CLOSTERIUM ACUTUM* (Lyngbye) De Brébisson. Pl. 53, Fig. 4.

in Ralfs, Brit. Desm. 177, pl. 30, figs. 5A-5E; pl. 34, fig. 5. 1848.

Cells small, generally curved, rarely straight; very gradually attenuated to subacute or rounded apices. Cell wall colorless; without a median girdle. Chloroplasts without longitudinal ridges and with an axial row of 2-4 pyrenoids. (Tychoplankton.)

Zygospores oblong, with ends very deeply emarginate and sides slightly convex; angles rounded and forming projections that lie parallel to the long axis of the zygospore (Ralfs).

Length 177 μ ; breadth 3.75 μ .

Length of zygospore 43 μ ; breadth of zygospore 13 μ (Ralfs).

Green (rrr).

8. *CLOSTERIUM RALFSII* De Brébisson.

in Jenner, Flora of Tunbridge Wells X. 1845 (Ref. Nordst. Index Desm.); in Ralfs, Brit. Desm. 174, pl. 30, figs. 2A-2B. 1848.

Cells large, length 6-8 times the breadth, somewhat curved, arc of curvature of outer margin about 45°, inner margin tumid in median portion; more sharply attenuated at extremities and with apices

bluntly truncate. Cell wall yellow-brown, with apical portion a deeper shade; without a median girdle, with numerous fine striae extending to the cell apex. Chloroplast ridged (?), with an axial row of 5-6 pyrenoids.

Zygospores unknown.

Length $317\ \mu$; breadth $54\ \mu$ (Ralfs.)

Not found in the plankton of Wisconsin lakes.

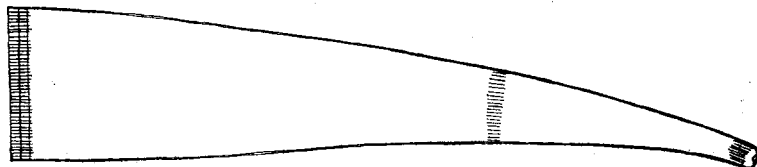


Fig. 2. *Closterium Ralfsii* De Brébisson ($\times 350$). From a herbarium specimen in the British Museum of Natural History collected by De Brébisson.

var. HYBRIDUM Rabenhorst. Pl. 53, Fig. 5.

Kryptogamenfl. Sachs. Abt. 1: 174. 1863; W. & G. S. West, Monogr. Brit. Desm. 1: 183, pl. 24, figs. 8-13. 1904.

Cells narrower than the foregoing and with inflation of the inner margin less prominent. (Tychoplankton.)

Zygospores double; subovoid, with smooth walls (W. & G. S. West).

Length $430\ \mu$; breadth in median portion $38\ \mu$, at apices $9\ \mu$; 10 striae in $17.5\ \mu$.

Diameter of zygospores $51.5-80\ \mu$ (W. & G. S. West).

Found (rrr), Jag (rrr).

9. *CLOSTERIUM KUETZINGII* De Brébisson. Pl. 53, Fig. 6.

Mem. d. l. Soc. imp. d. Sc. nat. de Cherbourg 4: 156, pl. 2, fig. 40. 1856; Raciborski, Sprawozd. Kom. fizyogr. Akad. um. w Krakowie 19: 8, pl. 1, fig. 2. 1884; W. & G. S. West, Monogr. Brit. Desm. 1: 186, pl. 25, figs. 6-11. 1904.

Cells long, of medium breadth; straight, median portion naviculoid and ends continued in processes with parallel sides and rounded apices; terminal portion of processes somewhat curved. Cell wall colorless to straw colored, without a median girdle but longitudinally striated; striae delicate, 15-20 visible across face of cell, extending to base of terminal processes. Chloroplast occupying striated portion of cell, without longitudinal ridges, with an axial row of 4-6 pyrenoids. Terminal vacuoles conspicuous. (Tychoplankton.)

Zygospores subrectangular, with angles truncate and sides between angles concave (Raciborski, W. & G. S. West).

Cells $367-398\ \mu$ long; $18-20\ \mu$ broad in median portion, $2.5\ \mu$ broad at apices; 10 striae in $10\ \mu$.

Greatest breadth of zygospore $48-51\ \mu$, shortest breadth $35-36\ \mu$ (W. & G. S. West).

Carson (rrr), Crab (rrr), Meronk (rrr).

10. CLOSTERIUM DECORUM De Brébisson. Pl. 53, Fig. 7.

Mem. d. l. Soc. imp. d. Sc. nat. de Cherbourg 4: 151, pl. 2, fig. 39. 1856; Kirchner, Kryptogamenfl. v. Schles. 2^e: 139. 1878; W. & G. S. West, Monogr. Brit. Desm. 1: 184, pl. 17, figs. 7-8; pl. 25, figs. 1-3. 1904.

Cells fairly large, length 12-15 times the breadth, median portion straight, terminal portion curved; median area narrowly fusiform and attenuated towards the apices, terminal portions with subparallel sides but fairly stout and with apices truncate. Cell wall yellowish-brown; without a median girdle but longitudinally striated, the striae extending to cell apices; 15-18 striae visible across the face of the median portion of the cell. Chloroplasts ridged and with an axial row of 7-10 pyrenoids. (Tychoplankton.)

Zygospores angular (Kirchner); subspherical and smooth-walled (W. & G. S. West).

Cells 450 μ long; 27.5 μ broad in median portion, 5 μ broad at apices; 10 striae in 14 μ .

Diamond (rrr).

PLEUROTAENIUM Nägeli 1849.

Cells usually quite large, length several times the breadth, median constriction well defined but not deep, cells always straight; semicells never compressed, commonly cylindrical and somewhat attenuated towards the poles, very rarely ovate; poles always truncate, usually with angles more or less rounded and, except in rare cases, with a ring of mamillate to conical tubercules; bases of semicells inflated, at times with lateral margins above the inflations undulate. Cell walls rarely smooth, usually finely to coarsely punctate, never with vertical plications on swollen bases of semicells; walls at times of uneven thickness, the thinner portions producing a somewhat definite pattern. Chloroplasts usually numerous and parietal, in the form of straight to undulate bands that extend the length of the semicell and contain numerous pyrenoids; rarely axial and with longitudinal plates and an axial row of pyrenoids. Parietal chloroplasts at times fragmenting into small rhomboidal masses each containing a single pyrenoid.

Zygospore formation rare. Zygospores spherical and with smooth walls.

KEY TO THE SPECIES.

Lateral walls the same thickness.

Poles without tubercules.....(1) *P. Trabecula*

Poles with tubercules.

Walls with whorls of tumors.....(5) *P. nodosum*

Walls without whorls of tumors.

Strongly attenuated at poles.....(4) *P. truncatum*

Not strongly attenuated at poles.

Sides undulate above basal inflation.....(3) *P. Ehrenbergii*

Sides not undulate above inflation.....(2) *S. subcoronulatum*

Lateral walls with thin areas.....(6) *P. Trochiscum*

1. PLEUROTAENIUM TRABECULA (Ehrenberg) Nägeli.

Gatt. einz. Algen 104, pl. 6, fig. A. 1849; W. & G. S. West, Monogr. Brit. Desm. 1: 209, pl. 30, figs. 11-13. 1904.

Cells fairly large, length 11-15 times the breadth, median constriction well defined; semicells cylindrical, very slightly attenuated towards the poles, with a well defined basal inflation and a single undulation above the basal inflation; apices truncate, with well rounded angles, smooth and without tubercules. Cell wall punctate.

Zygospores ellipsoidal, with smooth walls (W. & G. S. West).

Cells 390-664 μ long; 26-46 μ broad at base of semicells, 16-32 μ at apices.

Zygospores 70 μ long; 48 μ broad (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. RECTUM (Delponte) W. & G. S. West. Pl. 54, Fig. 1.

Monogr. Brit. Desm. 1: 212, pl. 30, figs. 9-10. 1904.

Cells smaller, length generally proportionally greater; semicells without undulations above the basal inflations. (Tychoplankton.)

Cells 284 μ long; 20 μ broad at base, 12.5 μ broad at apex; isthmus 15 μ broad.

Lindy (rrr).

2. PLEUROTAENIUM SUBCORONULATUM (Turner) W. & G. S. West.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 44, pl. 5, fig. 33. 1895.

Docidium subcoronulatum Turner, Kgl. Sv. Vet.-Ak. Handl. 25, No. 5: 29, pl. 3, fig. 1. 1893.

Cells fairly large, length about 12 times the breadth, united to form filaments, median constriction fairly well marked; semicells cylindrical, with bases inflated and lateral margins slightly undulate in the lower third of the semicell, lateral margins very slightly attenuated towards the apices; apices dilated, truncate, with rounded angles and a transverse ring of elliptic tubercules (about 10 visible in front view of cell). Cell wall smooth or finely punctate.

Zygospores unknown.

Cells 407-453 μ long; 29-37 μ broad at base of semicells, 25-29 μ broad at apices (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. DETUM W. & G. S. West. Pl. 54, Fig. 2-4.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 235, pl. 13, figs. 2-3. 1896; G. S. West, Jour. Linn. Soc. Bot. 38: 110. 1907.

Cells with a distinct ligature-like constriction just below the apex that gives the apex a distinctly dilated appearance. Cells united to form filaments. (Facultative plankton.)

Cells 385-567 μ long; 24-30 μ broad at base of semicells, 16-22 μ at apical constriction, 24-28 μ at apex (with tubercules); isthmus 23-24 μ broad.

Bass (1) (rrr), Bass (3) (rrr), Diamond (rrr), Howey (sss), Red Bass (rrr).

The ligature-like constriction lies about a tenth of the distance from the apex to the semi-cell base end and is the chief distinction between the variety and the type. This constriction is variable in depth and is much more prominent in some specimens than in others. The interlocking of the apical tubercles is a very constant feature and the cells are united in filaments that have a considerable degree of permanence, in fact if a break occurs in a filament it is more commonly at the isthmus than at the point of contact between adjacent cells. This union of cells to form filaments is of frequent occurrence in the tropics but is very rare in temperate regions. The alga was found in sufficient abundance to warrant the assumption that it can multiply under plankton conditions.

3. *PLEUROTAENIUM EHRENBERRGII* (De Brébisson) De Bary. Pl. 54, Figs. 5-8.

Unters. u. d. Fam. d. Conj. 75. 1858; W. & G. S. West, Monogr. Brit. Desm. 1: 205, pl. 29, figs. 9-11; pl. 30, fig. 1. 1904.

Cells fairly large, length 15-30 times the breadth at the base, slightly constricted, sinus a shallow depression; semicells cylindrical, with lateral margins slightly attenuated, the convergence being more pronounced in the apical region; basal inflation conspicuous and with a single undulation above it that looks like a second basal inflation; apex truncate and with angles slightly rounded, apex with a sub-apical ring of 8-9 (5 generally visible in front view) conical papillae with very blunt apices. Chloroplasts parietal, numerous, forming undulate longitudinal bands; with several pyrenoids. (Tychoplankton.)

Zygospores spherical to subspherical, with smooth walls (W. & G. S. West).

Cells 350-650 μ long; 25-35 μ broad at base of semicells, 15-24 μ at apices; isthmus 23-30 μ broad.

Dutchmans (rrr), Little Dector (rrr), Meta (rrr), Muskallonge (rrr), Oak (rrr), Sand (rrr), Speese (rrr).

The organism is subject to considerable variation in size, in relative proportions between length and breadth as well as in the apical attenuation. In typical specimens there is but a single undulation above the basal inflation but it is not at all uncommon to have more than one of these inflations. Specimens like those shown in Figures 7-8, with the undulations extending half way to the apex from the bases of the semicells, approach the variety *undulatum*.

var. *UNDULATUM* Schaarschmidt. Pl. 54, Fig. 9.

Magyar. Tudom. Akad. Math. s. Természettud. Közlemények 18: 278, pl. 1, fig. 21. 1882 (Ref. Nordst. Index Desm.); W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 6: 145, pl. 18, fig. 28. 1902.

Lateral margins gently undulate from basal inflation to the semi-cell apex. (Tychoplankton).

Cells $355\ \mu$ long; $24\ \mu$ broad at semicell base, $16.5\ \mu$ at apex; isthmus $22\ \mu$ broad.

Speese (rrr).

The dimensions of the variety as found in Wisconsin lakes agree very closely with those that W. & G. S. West give for their Ceylon specimens.

var. *ELONGATUM* W. West. Pl. 54, Fig. 10.

Jour. Linn. Soc. Bot. 29: 119. 1892; W. & G. S. West, Monogr. Brit. Desm. 1: 207, pl. 30, fig. 3. 1904.

Length about 25 times the breadth; cells somewhat narrower than the type. (Tychoplankton.)

Cells $560\ \mu$ long; $24\ \mu$ broad at base of semicells, $17\ \mu$ at apex; isthmus $20\ \mu$ broad.

Jenny (rrr).

4. *PLEUROTAEINIUM TRUNCATUM* (De Brébisson) Nägeli. Pl. 55, Figs. 1-2.

Gatt. einz. Algen 104. 1849; W. & G. S. West, Monogr. Brit. Desm. 1: 203, pl. 29, figs. 3-4. 1904.

Cells large, length about 8 times the greatest breadth, median constriction well defined; semicells cylindrical in lower half and then attenuated to a truncate apex that is about half the breadth of the base of the semicells, semicell bases with a single, distinct, basal inflation; lateral margins convex, apex slightly tumid and with rounded lateral angles; apical tubercles small flattened elevations, about seven visible in front view of cell. Chloroplasts numerous, about eight visible in front view of cells; parietal, slightly undulate, longitudinal bands with numerous pyrenoids. (Tychoplankton.)

Zygospores unknown.

Cells 535 – $577\ \mu$ long; 70 – $72.5\ \mu$ broad at base of semicells, 32.5 – $77\ \mu$ at apex; isthmus 60 – $64\ \mu$ broad.

Carroll (rrr), Dutchmans (rrr).

In one specimen the lateral margins possessed two undulations above the swollen bases of the semicells. Unfortunately no other cells were collected from this station so that it is impossible to state whether or not this undulation in the lower part of the semicell is a constant feature.

5. *PLEUROTAEINIUM NODOSUM* (Bailey) Lundell. Pl. 54, Fig. 11.

Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8: 90. 1871; W. & G. S. West, Monogr. Brit. Desm. 1: 214, pl. 31, figs. 3-6. 1904.

Cells large, length about 8 times the breadth, median constriction conspicuous; semicells cylindrical, with lateral margins convergent towards a truncate apex and with four tumors on each margin; with four transverse whorls of mamillate tumors, one whorl at semicell base and the other three equidistant between basal whorl and apex;

polar region dilated, with apex slightly tumid and angles rounded; pole ornamented with a subapical whorl of conspicuous, conical, upwardly curved teeth (5 generally visible in front view of cell) that do not extend beyond the apex. Cell wall smooth or punctate. Front view with about four longitudinal, parietal, slightly undulate chloroplasts that contain numerous pyrenoids. (Tychoplankton.)

Zygospores unknown.

Cells 337–410 μ long; 47.5–50 μ broad at inferior whorl, 37–42.5 μ at superior whorl, 25–27.5 μ at apex (without spines); breadth isthmus 30–32.5 μ .

Little Doctor (rrr), Tank (rrr).

Sharply differentiated from the other species by the whorls of mamillate protuberances.

6. PLEUROTAEINIUM TROCHISCUM W. & G. S. West.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 235, pl. 13, figs. 4–5. 1896; *ibid.* 6: 142, pl. 19, figs. 7–8. 1902.

Cells of medium size, length 10–16 times the breadth, constriction well marked; semicells cylindrical, with sides slightly attenuated towards the poles, basal inflation pronounced; poles truncate, flattened, with rectangular angles, and without polar tubercles. Cell wall with 12–15 transverse rings of irregular to quadrangular areas where the wall is not internally thickened; thin areas on basal inflation much smaller and more irregular, thin areas of polar region irregularly elongate.

Zygospores unknown.

Cells 265–468 μ long; 20–42 μ broad at base of semicells, 21–29 μ at apex. (W. & G. S. West.)

Not found in the plankton of Wisconsin lakes.

Var. *tuberculatum* var. nov. Pl. 55, Fig. 3.

Apices with a ring of conical to rounded tubercles (about 5 visible in front view of cell). About 5 parietal, longitudinal, ribbon-like chloroplasts with fairly smooth outline visible in front view; pyrenoids numerous. (Tychoplankton.)

Cells 384–420 μ long; 32–34 μ broad at base of semicells, 23–27.5 μ at apex; isthmus 24–26.5 μ broad.

Little Doctor (rrr), Sunday (rrr).

In the scanty material observed the apical tubercles so commonly found in the genus were well defined. Since such careful investigators as W. & G. S. West have not described them it is evident that the Wisconsin plants differ from the type and since this presence or absence of apical tubercles is such an important feature of the genus these cells are considered a distinct variety.

DOCIDIUM De Brébisson 1844 (emend. Lundell 1871).

Cells solitary, relatively small, straight, length several times the breadth, cylindrical; median constriction shallow, sinus always widely open, isthmus breadth practically the same as the breadth of the cell;

semicells with straight or undulate sides and with truncate apices that are without ornamentation, inflated bases of semicells always with short vertical plications that frequently have a granule at the base of each plication. Cell wall smooth, finely punctate, or with delicate vertical striae. Chloroplasts axial and with irregular longitudinal ridges; with 6-8 pyrenoids arranged in an axial series.

Zygospores unknown.

In his British Desmidiaceae Ralfs includes both *Pleurotaenium* and *Docidium* in the same genus. Lundell was the first to differentiate clearly between the two and this characterization of the two genera has been followed by W. & G. S. in their Monograph. *Docidium* differs from *Pleurotaenium* in the vertical plications at the bases of the semicells, the lack of ornamentation at the apices of the semicells, and in the axial chloroplasts.

DOCIDIUM UNDULATUM Bailey. Pl. 55, Fig. 4.

Smithsonian Cont. to Knowl. 2, Art. 8: 36, pl. 1, fig. 2, 1851 (sep.); W. & G. S. West, Monogr. Brit. Desm. 1: 194, pl. 27, figs. 7-10. 1904.

Length about 15 times the breadth, cells very slightly constricted, sinus widely open; semicells with sides strongly undulate (6-8 undulations between isthmus and apex) and apex narrowly obversely trapezoidal, angles of apex rounded and top flattened; basal plications ending in a small granule on the end towards the isthmus, about six visible in front view of semicell. Cell wall smooth. Chloroplast with an axial row of about eight pyrenoids. (Tycho plankton.)

Zygospores unknown.

Cells 205 μ long; 15 μ broad at basal inflation, 12.5 μ at apex.

Diamond (rrr).

TRIPLOCERAS Bailey 1851.

Cells large, length several times the breadth, median constriction well defined but shallow; semicells cylindrical, always straight, somewhat attenuated from bases to poles, never compressed, with lateral margins strongly undulate; undulations caused by transverse whorls of mamillate protuberances that terminate in a single spine or broadly emarginate verrucae; poles flattened and with two long, upturned, divergent, obliquely disposed processes with truncate ends that bear 2-3 short sharp spines (front view of polar processes giving the cell apices a deeply incised appearance); apex with a protuberance midway between bases of processes that bears one or two erect spines. Cell wall, except for verrucae, smooth. Chloroplasts axial, with longitudinal plates that extend from semicell base to apex; pyrenoids in an axial row.

Zygospores unknown.

A highly differentiated genus that shows but little in common with the other genera that have straight elongate cells. The apical processes and transverse rows of verrucae on the cell wall are not found in related genera.

KEY TO THE SPECIES.

- Protuberances with simple spines.....(1) *T. gracile*
 Protuberances with emarginate verrucae.....(2) *T. verticillatum*

1. TRIPLOCERAS GRACILE Bailey. Pl. 55, Figs. 5-6.

Smithsonian Cont. to Knowl. 2, Art. 8: 38, pl. 1, fig. 10. 1851 (sep.); G. S. West, Jour. Linn. Soc. Bot. 39: 54, text figs. 7A-7B. 1909.

Cells large, length 12-20 times the breadth; median constriction fairly well defined; semicells cylindrical, somewhat attenuated at poles, without line of lateral margins strongly undulate, undulate outline caused by transverse whorls of mamillate protuberances that terminate in acute, horizontally disposed, spinate verrucae in inferior portion of semicell and upwardly disposed spinate verrucae in superior portion; semicell apices flattened and with two fairly long, divergent, obliquely disposed, truncate processes terminating in two or three short spines; apex also with a single (rarely two) mamillate protuberance arising midway between the bases of the polar processes and terminating in an acute erect spine. Vertical view of pole elliptic, with poles terminating in spines and each lateral margin with a single, alternately disposed, truncate process. Cell wall without pores. Chloroplast axial, with 6-8 straight delicate longitudinal ridges extending from semicell base to apex; pyrenoids fairly numerous and forming an axial row. (Tychoplankton.)

Zygospores unknown.

Cells 368-550 μ long; 27.5-31.5 μ broad at basal whorl (with verrucae), 18-25 μ broad at apical whorl (with verrucae), and 10-12.5 μ broad just above apical whorl. Distance between ends of apical processes 30-36 μ .

Crooked (rrr), Devils (rrr), Jag (rrr), Little Doctor (rrr), Rudolph (rrr).

The great variability of this species is well known and there has always been a conflict of opinion as to the limits of variation in the type. G. S. West's discussion of the type and its varieties is so thoroughgoing that further remarks are superfluous.

2. TRIPLOCERAS VERTICILLATUM Bailey. Pl. 55, Figs. 7-9.

Smithsonian Cont. to Knowl. 2, Art. 8: 37, pl. 1, fig. 9. 1851 (sep.).

Docidium verticillatum Bailey, in Ralfs, Brit. Desm. 218, pl. 35, figs. 9A-9E. 1848; Wollé, Freshw. Algae of U. S. 27, pl. 61, fig. 18. 1887.

Cells large, stouter than the preceding species, length 8-12 times the breadth, median constriction well defined; semicells cylindrical, somewhat attenuated towards the poles, with outline of lateral margins strongly undulate, with 12-22 transverse whorls of mamillate protuberances that terminate in broad emarginate verrucae (triangular in front view), protuberances in superior portion of semicell at times terminating in simple spines; apices truncate, with two long, divergent, obliquely disposed processes that terminate in two long spines; semicell apices also with a mamillate protuberance bearing two erect spines that lies midway between the bases of the apical

processes. Cell wall smooth. Chloroplast axial, with longitudinal plates extending from semicell base to apex; pyrenoids forming a median row and fairly numerous. (Tychoplankton.)

Zygospores unknown.

Cells 480–504 μ long; 30–41 μ broad at basal whorl (with verrucae), 25–28 μ broad at apical whorl (with verrucae), 13–21 μ broad just above apical whorl. Distance between ends of apical processes 31–48 μ .

Des Moines (rrr), Little Doctor (rrr).

A much rarer species than *T. gracile* and differing in the nature of the transverse whorls of verrucae. Figure 9 is a transition form between the two in which the base of the semicell is typical *verticillatum* and the apex *gracile*.

TETMEMORUS Ralfs 1844.

Cells usually fairly large, length 2–8 times the breadth, median constriction slight to fairly deep but always well defined, sinus always open; semicells straight, cylindrical to subfusiform, with poles somewhat compressed and having a very conspicuous vertical incision, incision generally linear and with a slightly inflated apex. Cell wall smooth, punctate, or minutely scrobiculate. Chloroplasts axial and with 8–10 vertical radiating plates that are simple or bifurcate at the point where they reach the cell wall; pyrenoids fairly numerous, spherical to bacillar and arranged in a linear series along the central axis.

Zygospores spherical to rectangular, with smooth walls.

The elongate cells with apical incisions separate this genus from all others found in Wisconsin lakes.

TETMEMORUS BREBISONII (Meneghini) Ralfs. Pl. 55, Fig. 10.

Ann. & Mag. of Nat. Hist. 14: 257, pl. 8, figs. 1A–1D. 1844; Nordstedt, Lunds Univ. Arsskr. 9: 39. 1873.

Cells large, length 5–6 times the greatest breadth, fairly deeply constricted, sinus with a subacute apex and outer margin widely open; semicells cylindrical, somewhat attenuated towards the poles, basal angles very broadly rounded; apex rounded, with a very deep linear incision in the median portion. Lateral view of semicells compressed in the polar region and giving the whole cell a subfusiform appearance. Cell wall slightly thickened near the outer margins of the polar incisions; entire wall covered with numerous punctae arranged in vertical rows running from semicell base to apex. Chloroplasts axial, with about eight vertical radiating plates that terminate in broad parietal forks at the cell wall; pyrenoids axial and variable in shape. (Tychoplankton.)

Zygospores spherical, with smooth walls (Nordstedt).

Cells 226–264 μ long; 39–45 μ broad at base, 25–31 μ at apex, 21–27.5 μ at isthmus; apical incision 10 μ deep.

Zygospores 80 μ in diameter (Nordstedt).

Duck (rrr), Tank (rrr).

EUASTRUM Ehrenberg 1832 (emend. Ralfs 1844).

Cells of variable size, length generally about twice the breadth, deeply constricted, sinus generally linear and with apex inflated and outer portion open; semicells usually truncate-pyramidal, incised to form three or five lobes, polar lobe always with an apical incision which is usually deep but which may be reduced to a shallow depression; incisions forming lateral lobes frequently greatly reduced. Cell wall smooth, punctate or granulate, sometimes with spines on outer margin; with one or more protuberances at base of semicells and at times with other protuberances at center of cell face or at poles; in certain species with small rounded or elongate verrucae definitely arranged on the cell wall. Vertical view generally elliptic, with poles rounded and definite protuberances at sides. Lateral view of semicells narrowly truncate-pyramidal, with basal inflations fairly prominent. Chloroplasts of larger species axial and with two lobes to each cell face that end in massive parietal laminae; chloroplasts of smaller species axial and with simple lobes; in one case with two chloroplasts in each semicell; pyrenoids single to numerous.

Zygospores spherical to ellipsoidal; with smooth, mamillate or short-spined walls.

The compressed cells in which the length is not more than about twice the breadth show that this genus is related to *Cosmarium*, but the apical incision distinguishes it from *Cosmarium*. This apical incision may be reduced to a shallow depression so that the distinction between the two genera is very finely drawn. The apical incision is, however, associated with the presence of one or more protuberances at the base of the semicells. In the apical incision it shows an affinity with certain elongate genera, as *Tetmemorus* and *Ichthyocercus*, but in these genera the cells are not conspicuously compressed and the length is several times the breadth.

KEY TO THE SPECIES.

Polar lobe incised.

Semicell base with more than one protuberance.

Three-lobed semicells.....(1) *E. crassum*

Five-lobed semicells.

Polar lobe rectangular.....(2) *E. didelta*

Polar lobe not rectangular.

Protuberances of the same size.....(3) *E. oblongum*

Protuberances not of the same size.

Two small protuberances above isthmus.....(4) *E. affine*

One large protuberance above isthmus.....(5) *E. pinnatum*

Semicell base with one protuberance.

Polar incision ovate.....(6) *E. Glaviovii*

Polar incision not ovate.

Apex flattened.....(7) *E. pulchellum*

Apex elevated.

Lateral lobes with spines.....(9) *E. divaricatum*

Lateral lobes without spines.....(8) *E. elegans*

Polar lobe emarginate.

Lateral lobes cuneate.....(11) *E. verrucosum*

Lateral lobes subquadrate.....(10) *E. gemmatum*

1. *EUASTRUM CRASSUM* (De Brébisson) Kützing. Pl. 56, Fig. 1.
Phycol. Germ. 135. 1845; Ralfs, Brit. Desm. 81, pl. 11, figs. 3A-3E. 1848.

Cells very large, length about twice the breadth, deeply constricted, sinus narrowly linear, with apex slightly inflated and outer margin closed, isthmus narrow; semicells subrectangular, three-lobed, the polar lobe much smaller than the lateral lobes, polar lobe broadly cuneate, with apex tumid, angles broadly rounded; polar incision deep, sublinear, and somewhat expanded at the apex; incisions forming lobes open, with rounded apices and parallel sides; lateral lobes very broad, margins slightly concave, superior and inferior angles rounded. Cell wall finely punctate, conspicuously thickened at the angles of the lobes, with three prominent hemispherical protuberances across the base of the semicell, one above the isthmus and one near each basal angle. Vertical view broadly oval, with a tumid inflation at each pole and three less pronounced inflations on each side. Lateral view of semicells narrowly pyramidate, with apices truncate and angles somewhat rounded. Chloroplast an axial plate with four radiating arms, two to each cell face, that form parietal masses against the cell wall; pyrenoids fairly numerous and mostly in parietal portions of chloroplast. (Tycho plankton.)

Zygospores unknown.

Cells 230 μ long; 80 μ broad at base of semicells, 62.5 μ at apex, 45 μ at apical lobe; 30 μ at isthmus; apical incision 11.5 μ deep.

Meta (rrr), Speese (rrr).

2. *EUASTRUM DIDELTA* (Turpin) Ralfs. Pl. 56, Fig. 2.

Ann. & Mag. of Nat. Hist. 14: 190, pl. 7, figs. 2A-2B. 1844; W. & G. S. West, Monogr. Brit. Desm. 2: 15, pl. 35, figs. 3-7. 1905; Carter, Ann. of Bot. 33: 241, pl. 16, figs. 63-65. 1919.

Cells fairly large, length about twice the breadth, very deeply constricted, sinus linear, with apical portion inflated and outer portion widely open, isthmus narrow; semicells narrowly truncate-pyramidate, five-lobed, the lateral lobes at times reduced to strong undulations; polar lobe vertically oblong, with angles rounded, polar incision fairly deep and linear but with outer portion slightly expanded; lateral incisions very shallow and broadly rounded; lateral lobes very broadly rounded. Cell wall smooth or punctate, with five hemispherical protuberances on each semicell, a transverse row of three at the base of the semicell, one just above the isthmus and one midway between the isthmus and each basal angle; with a second transverse row of two protuberances just above and alternating with those of the basal row. Vertical view elliptic, poles bearing a single protuberance and sides each with five protuberances. Lateral view of semicells truncate-pyramidate and with angles rounded. Chloroplast axial and with two processes extending to each cell face; pyrenoids confined to processes. (Tycho plankton.)

Zygospores spherical, clothed with very short papillae that are frequently curved (W. & G. S. West).

Cells $97.5\ \mu$ long, $52.5\ \mu$ broad at base of semicells, $24\ \mu$ broad at apical lobe, $17.5\ \mu$ at isthmus; apical incision $6\ \mu$ deep.

Zygospores $73.6\text{--}86\ \mu$ in diameter without papillae; papillae $9\text{--}13\ \mu$ long (W. & G. S. West).

Big. St. Germain (rrr), Fish (rrr), Meta (rrr).

3. EUASTRUM OBLONGUM (Greville) Ralfs. Pl. 56, Fig. 3.

Ann. & Mag. of Nat. Hist. 14: 189, pl. 6, figs. 4A-4C. 1844; Brit. Desm. 80, pl. 12, figs. A-G. 1848.

Cells large, length about twice the breadth, deeply constricted, sinus linear, with apical portion somewhat inflated and outer margin widely open, isthmus narrow; semicells subrectangular, distinctly five-lobed, polar lobe broadly cuneate, with apex strongly tumid, angles broadly rounded and polar incision deep and narrowly V-shaped; interlobular incisions deep, open and with rounded apices; superior lateral lobes subquadrate, somewhat smaller than the inferior lateral lobes and at an angle with the long axis of the semicell, margins somewhat retuse; inferior lobes subquadrate, with rounded angles and concave margins. Cell wall punctate and with a large protuberance just above the isthmus and one just within the margins of both the inferior and superior lateral lobes. Vertical view broadly elliptic, with poles rounded and four protuberances on each side of the cell. Lateral view narrowly elongate-pyramidate, with bases parallel for a short distance and then converging to a truncate apex. Chloroplast an axial plate with four lobes, two extending to each cell face and forming parietal masses. (Tychoplankton.)

Zygospores spherical and densely covered with short mamillate-conical protuberances (Ralfs).

Cells $152\ \mu$ long; $70\ \mu$ broad at basal lobes of semicells, $64\ \mu$ broad at median lobes, $41\ \mu$ broad at apical lobe, $21\ \mu$ broad at isthmus; apical incision $10\ \mu$ deep.

Zygospores $148\ \mu$ in diameter; papillae $25\ \mu$ long (Ralfs).

Mercer (rrr).

4. EUASTRUM AFFINE Ralfs. Pl. 56, Fig. 4.

Ann. & Mag. of Nat. Hist. 14: 191, pl. 7, figs. 3A-3B. 1844; Brit. Desm. 82, pl. 13, figs. 3A-3E. 1848.

Cells fairly large, length nearly twice the breadth, very deeply constricted, sinus linear, with apex slightly inflated and outer margin somewhat open, isthmus narrow; semicells truncate-pyramidate, distinctly five-lobed, polar lobe subincudate, with apex tumid, angles broadly rounded, polar incision deep and with a slightly expanded apex; incisions forming lateral lobes fairly deep, broadly rounded; superior lateral lobes mamillate, about equidistant between semicell apex and isthmus; inferior lateral lobes subquadrate, with angles rounded and lateral margins strongly emarginate. Cell wall punctate, with a transverse row of rounded protuberances at base of semicell, two small protuberances just above the isthmus and a larger protuberance at each basal angle, with a second transverse row of two

protuberances just above the smaller ones of the inferior row. Vertical view elliptic, with poles rounded and four protuberances on each side. Lateral view oblong-pyramidate, with basal portion subquadrate and sides converging to a quadrate apex, angles somewhat rounded. Chloroplast with a central axial plate from which radiate four parietal plates, two to each cell face; pyrenoids 5-8, all in parietal plates. (Tychoplankton.)

Zygospores unknown.

Cells 104-110 μ long; 58-61 μ broad at basal lobes of semicells, 40-42.5 μ at median lobes, 28-31 μ at apical lobe, 17.5 μ at isthmus; apical incisions 5-7 μ deep.

Little Doctor (rrr), Lost (rrr).

Differing from *E. didelta* in the deeper incisions forming the lobes and in both number and arrangement of the protuberances on the cell wall.

5. EUASTRUM PINNATUM Ralfs. Pl. 56, Fig. 5.

Brit. Desm. 81, pl. 13, figs. 1A-1E. 1848; W. & G. S. West, Monogr. Brit. Desm. 2: 10, pl. 34, figs. 3-6. 1905.

Cells fairly large, length about twice the breadth, deeply constricted, sinus narrowly V-shaped to linear, with apex expanded, isthmus narrow; semicells truncate-pyramidate, distinctly five-lobed, polar lobe anvil-shaped, with apex concave, angles broadly rounded and polar incision deep and expanded towards the apex; incisions forming lobes deep but widely open and with rounded apices; superior lateral lobes elongate-mamillate, with superior margin at right angles to inferior margin and forming an angle of 45 degrees with the long axis of the semicell; inferior lateral lobes subquadrate, with margins strongly retuse and angles rounded. Cell wall punctate, with a large protuberance just above the isthmus and one within each lateral lobe as well as with two smaller protuberances at bases of lateral lobular incisions. Vertical view elliptic, with poles mamillate and each side with three protuberances. Lateral view of semicells narrowly truncate-pyramidate, with lateral margins concave just below the apex and angles rounded. (Tychoplankton.)

Zygospores unknown.

Cells 137.5 μ long; 67 μ broad at basal lobes of semicells, 57 μ broad at median lobes, 35 μ at apical lobes, 19 μ at isthmus; apical incision 6.5 μ deep.

Crooked (rrr), Found (rrr).

6. EUASTRUM GLAZIOVII Børgesen. Pl. 56, Fig. 6.

Vidensk. Medd. f. d. naturhist. Forening i Kiöbenhavn 1890: 36, pl. 3, fig. 23. 1890.

Cells somewhat under medium size, length about twice the breadth, very deeply constricted, sinus linear, with apex somewhat inflated and outer margin widely open, isthmus very narrow; semicells distinctly three-lobed, polar lobe almost anvil-shaped, with angles somewhat rounded and each bearing a stout horizontally disposed spine,

apex strongly elevated, polar incision very deep, obversely ovate and with outer margin almost closed, lateral margins of polar lobe with a small spine at the base; incisions between lobes widely open and with broadly rounded apices; lateral lobes subquadrate, with margins retuse in the median portion, angles rounded and each bearing a pair of short sharp divergent spines. Cell wall smooth, thickened at the polar angles and at the angles on either side of the apical incision, with a central protuberance above the isthmus and scattered granules on either side of the polar incision and at the base of the semicells. Vertical view elliptic, with poles strongly truncate and a protuberance in the middle of the sides. Lateral view of semicells ovate, with a small protuberance at the bases. (Tychoplankton.)

Zygospores unknown.

Cells $63\ \mu$ long; without spines $37\ \mu$ broad at base of semicells, $22\ \mu$ at apex; with spines $40\ \mu$ broad at base of semicell, $35\ \mu$ at apex; $8\ \mu$ broad at isthmus; apical incision $7.5\ \mu$ deep.

Little Doctor (rrr).

7. EUASTRUM PULCHELLUM De Brébisson. Pl. 56, Fig. 7.

Mem. d. l. Soc. imp. d. sc. nat. de Cherbourg 4: 124, pl. 1, fig. 5. 1856; W. & G. S. West, Monogr. Brit. Desm. 2: 46, pl. 38, figs. 14-15. 1905.

Cells small, length about one and a quarter times the breadth, deeply constricted, sinus linear, with outer portion slightly open, isthmus narrow; semicells truncate-pyramidate, the division into three lobes very poorly defined, polar lobe transversely oblong, with apex slightly concave and polar incision quite broad, angles acute and continued in short widely divergent spines; incisions forming lobes broad, very shallow depressions; lateral lobes broadly rounded and with profile bearing 3-4 short sharp spines. Cell wall with a triangle of three elongate verrucae just above the isthmus, a conspicuous rounded granule at either side of the apical incision, and a few scattered spines within the margins of the lateral lobes. Vertical view oblong-elliptic, with short spines in the polar region and a conspicuous truncate protuberance in the middle of each side. Lateral view of semicells narrowly pyramidate-ovate, with apex rounded and bearing a single erect spine, bases with a conspicuous truncate protuberance. (Tychoplankton.)

Zygospores unknown.

Cells $26\ \mu$ long; $23\ \mu$ broad at base of semicells, $16\ \mu$ at apex, $6.5\ \mu$ at isthmus; depth of apical incision $2.5\ \mu$.

George (rrr).

8. EUASTRUM ELEGANS (De Brébisson) Kützing. Pl. 56, Fig. 8.

Phycol. Germ. 135. 1845; W. & G. S. West, Monogr. Brit. Desm. 2: 48, pl. 38, figs. 16-21. 1905.

Cells small, length about one and a half times the breadth, deeply constricted, sinus linear and with apex expanded, isthmus narrow; semicells ovate, not incised to form lobes, apex uncinately and with upper margin very strongly inflated and angles apiculate; apical incision deep and narrowly V-shaped; basal angles very broadly

rounded. Cell wall smooth, with a triangle of three elongate verrucae just above the isthmus and two small granules on either side of the apical incision and at basal angles of the semicells. Vertical view narrowly elliptic, with a truncate protuberance on either side midway between the poles. Lateral view of semicells ovate and with a protuberance on either side of the base. Chloroplast a massive axial plate with two lobes extending towards each cell face; pyrenoid central and single. (Tychoplankton.)

Zygospores spherical, with fairly short straight spines that have blunt apices (W. & G. S. West).

Cells $36\ \mu$ long; $25\ \mu$ broad at base of semicells, $11.3\ \mu$ at apex, $5\ \mu$ at isthmus; apical incisions about $5\ \mu$ deep.

Zygospores (without spines) $20\text{--}29\ \mu$ in diameter; spines $7.5\text{--}9.5\ \mu$ long (W. & G. S. West).

George (rrr), Jones (rrr).

9. EUASTRUM DIVARICATUM Lundell. Pl. 56, Fig. 9.

Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8: 21, pl. 2, fig. 5. 1871.

Cells small, length about one and a quarter times the breadth, deeply constricted, sinus linear, with apical portion slightly inflated, isthmus narrow; semicells truncate-pyramidal, rather distinctly three-lobed, the polar lobe somewhat smaller than the lateral lobes; polar lobe transversely oblong, with apex tumid, angles obtuse and each furnished with a divergent spine, polar incision fairly deep and open; lateral lobes broadly triangular and with rounded angles, with two or three marginal spines of variable length. Cell wall smooth, with a triangle of short linear verrucae above the isthmus and a large rounded granule on either side of the polar incision, about four smaller granules within the margins of the lateral lobes. Vertical view elliptic, with a short spine at each pole and with sides crenulate, median portion of each side with a short truncate protuberance. Lateral view of semicells sublanceolate, with a protuberance on either side of the base. (Tychoplankton.)

Zygospores unknown.

Cells $43\ \mu$ long; $38\ \mu$ broad at base of semicells, $20\ \mu$ at apex, $7.5\ \mu$ at isthmus; apical incisions about $5\ \mu$ deep.

Muskallonge (rrr).

10. EUASTRUM GEMMATUM De Brébisson. Pl. 57, Figs. 1-2.

in Meneghini, Linnaea 14: 221. 1840; Ralfs, Brit. Desm. 87, pl. 14, figs. 4A-4E. 1848.

Cells fairly small, length about one and half times the breadth, deeply constricted, sinus linear, with apex inflated and outer margin widely open, isthmus narrow; semicells distinctly three-lobed, polar incision reduced to a broad emargination; lateral incisions deep, broadly open and with rounded apices; lateral lobes subquadrate, with angles broadly rounded and lateral margins deeply retuse. Cell wall finely granulate, with granulation prominent at angles of polar and lateral lobes and on the three protuberances at the bases of the

semicells, one above the isthmus and one on each lateral lobe. Vertical view elliptic, with poles rounded and three very prominent protuberances on each side. Lateral view of semicells subrectangular, with bases inflated, polar angles rounded, and apices concave. (Tycho-plankton.)

Zygospores unknown.

Cells 54–56 μ long; 41–43 μ broad at base of the semicells, 20 μ at polar lobe, 12.5 μ at isthmus.

Muskallonge (rrr), Tank (rrr).

11. EUASTRUM VERRUCOSUM Ehrenberg.

Abh. d. k. Akad. d. Wiss. zu Berlin 1833: 247. 1835; Ralfs, Brit. Desm. 79, pl. 11, figs. 2A–2D. 1848; Carter, Ann. of Bot. 33: 245, pl. 17, figs. 90–92. 1919.

Cells of medium size, length slightly greater than the breadth, very deeply constricted, sinus with inner half sublinear and apex slightly inflated, outer half gradually opening outwards, isthmus very narrow; semicells truncate-pyramidal, distinctly three-lobed, the polar lobe smaller than the lateral lobes, polar lobe broadly cuneate, with angles rounded and polar incision reduced to an emargination of the polar lobe; incisions forming the lobes deep, sublinear, with rounded apices and widely open outer extremities; lateral lobes broadly cuneate, divided into two lobules by a very deep emargination, superior lobule subrect, inferior lobule horizontally disposed, lobules broadly rounded. Cell wall distinctly granulate, with granules more pronounced at angles of lobes, bases of semicells with a very large protuberance just above the isthmus and flanked by a smaller protuberance in each of the lateral lobes, protuberances, especially the central one, furnished with somewhat elongate verrucae arranged in concentric circles. Vertical view compressed-hexagonal, with the angles rounded and a conspicuous protuberance in the center of the longer sides, cell outline granulate. Lateral view of semicells urn-shaped, with a deep emargination at the apex. Semicells with two axial chloroplasts, each chloroplast with 4–5 irregular ridges radiating to front and sides of cell wall; pyrenoids single and central in each chloroplast.

Zygospores unknown.

Cells 107 μ long; 108 μ broad (Ralfs).

Not found in the plankton of Wisconsin lakes.

var. REDUCTUM Nordstedt. Pl. 56, Fig. 10.

Lunds Univ. Arsskr. 16: 9, pl. 1, fig. 14. 1880 (sep.).

Cells smaller, sinus linear, with apex inflated and outer margin open; polar lobes subrectangular, incisions forming lobes more widely open; lateral lobes only slightly emarginate. (Tycho-plankton.)

Cells 58 μ long; 52 μ broad at base of semicells, 23 μ at apical lobe; 12 μ at isthmus.

Devils (rrr), Little Doctor (rrr).

The sinus, lateral incision, shape of the polar lobe and the degree of indentation of the lateral lobes differentiate this variety.

COSMARIUM Corda 1834.

Cells never forming permanent colonies; of variable size though in the majority of cases fairly small, length never more than twice the breadth, generally only slightly greater, in a few species with breadth greater than the length; median constriction usually conspicuous and frequently linear; cells compressed and with front view of semicells quite variable in outline (circular, semicircular, elliptic, ovate, trapezoidal, reniform or subquadrate), at times with the apex elevated but never with the apical elevation incised, central area of semicells at times protuberant. Vertical view generally elliptic, frequently with an elevation in the median portion of the sides. Lateral view of semicells most commonly circular. Cell wall smooth or variously ornamented with granules of varying size or minute verrucae, the ornamentation usually following a definite pattern; never ornamented with spines. Chloroplasts usually single, axial, and with four radiating plates and central pyrenoids; semicells at times with two chloroplasts that have several radiating plates and each chloroplast with a single pyrenoid; a few larger species with four parietal chloroplasts each containing several pyrenoids.

Zygospores generally spherical or ellipsoidal, rarely angular; zygospore wall smooth or papillate to spinate.

Certain of the species in this very large genus can scarcely be distinguished from *Euastrum*; other species resemble closely *Penium* while the rare triradiate varieties might be considered *Staurastrum*. *Euastrum* is separated from *Cosmarium* by the apical incision. *Cosmarium* differs from *Penium* in the compressed cells and from *Staurastrum* in the lack of spines.

Since the drawings in this work have been made from preparations in which in many cases but a single cell of the species was available the side and top views are lacking. These views are essential for the critical interpretation of the various species and certain records of the genus have been omitted since vertical and lateral views were not available. In Wisconsin lakes *Cosmarium* is a comparatively rare organism whereas in certain European lakes it may be present in quantity.

KEY TO THE SPECIES.

Cell wall smooth or punctate, outline never granulate.

Semicell outline truncate-pyramidal..... (5) *C. granatum*

Semicell outline not truncate-pyramidal.

Sinus linear.

Semicells semicircular..... (1) *C. circulare*

Semicells elliptic..... (2) *C. depressum*

Sinus open.

Semicells subcircular..... (4) *C. contractum*

Semicells broadly elliptic..... (3) *C. bioculatum*

Cell wall ornamented and outline granular.

Apices of semicells not elevated.

Cell apex flattened.

- Lateral margins crenulate.....(6) *C. cyclicum*
 Lateral margins granulate.
 Granules evenly distributed.....(8) *C. Botrytis*
 Granules restricted to margin and center.
 Central area not granulate.....(16) *C. ovale*
 Central area granulate.
 Many granules within margin.....(15) *C. punctulatum*
 Few granules with margin.....(14) *C. quinarium*
 Cell apex rounded.
 Semicells not reniform.
 Sinus open, isthmus elongate.....(10) *C. Portianum*
 Sinus linear.....(7) *C. amoenum*
 Semicells reniform.....(9) *C. reniforme*
 Apices of semicells elevated.
 Semicells distinctly three-lobed.....(13) *C. protractum*
 Semicells not three-lobed.
 Apex of sinus widely inflated.....(12) *C. commissurale*
 Apex of sinus not widely inflated.....(11) *C. ornatum*

1. COSMARIUM CIRCULARE Reinsch. Pl. 57, Fig. 3.

Acta Soc. Senckenberg 6: 5, pl. 3, figs. C-C'. 1867 (sep.)

Cells fairly large, cell outline circular, deeply constricted, sinus linear and with outer extremity somewhat inflated; semicells semicircular, with basal angles rounded. Vertical view narrowly elliptic. Lateral view of semicells narrowly subcircular. Cell wall minutely punctate. Chloroplasts axial and with two pyrenoids. (Tycho plankton.)

Zygospores unknown.

Cells 47.5 μ long; 39 μ broad; breadth of isthmus 15 μ .

Cranberry (rrr).

The cells observed were at the minimal dimensions usually given for this species.

2. COSMARIUM DEPRESSUM (Nägeli) Lundell. Pl. 57, Fig. 4.

Nova Acta Reg. Soc. Upsaliae 3 Ser., 8: 38. 1871.

Cosmarium Scenedesmus Delponte, Mem. R. Accad. d. Sci. di Torino 2 Ser., 28: 101, pl. 7, figs. 28-34. 1877 (sep.).

Cells slightly under medium size, breadth somewhat greater than the length, very deeply constricted, sinus linear and with outer extremity expanded, isthmus very narrow; semicells transversely elliptic and with dorsal margin more broadly rounded than the ventral, lateral margins broadly rounded. Vertical view elliptic. Lateral view of semicells circular. Cell wall smooth. Chloroplasts with a single pyrenoid. (Tycho plankton.)

Zygospores spherical, with a smooth wall (Delponte).

Cells 38-51 μ long; 43-52 μ broad; breadth of isthmus 7.5-9 μ .

Fish (rrr), Fowler (rrr), Mercer (rrr), Nicaboyne (rrr), Oconomowoc (rrr), Okauchee (rrr), Sand (rrr).

var. *ACHONDRUM* (Boldt) W. & G. S. West. Pl. 57, Figs. 5-6.

Trans. Roy. Soc. Edinburgh 41: 484. 1905; Monogr. Brit. Desm. 2: 177, pl. 62, figs. 6-9. 1905.

Semicell shape subhexagonal, apices truncate and dorsal margins with a distinct angularity instead of a smooth curve. (Tychoplankton.)

Cells 28 μ long; 27 μ broad; breadth of isthmus 7.5 μ ; thickness 11 μ .

Found (rr), Sand (rrr), Sishebogema (rr).

The alga as I have found it in Wisconsin lakes is somewhat smaller than the cells of this variety that W. & G. S. West describe from the Scottish plankton. The size and general shape of the Wisconsin specimens is that of *C. abbreviatum* var. *planctonicum* W. & G. S. West but the broader semicells show that it should be referred to *C. depressum*.

3. *COSMARIUM BIOCULATUM* De Brébisson. Pl. 57, Figs. 7-8.

in Ralfs, Brit. Desm. 95, pl. 15, figs. 5A-5F. 1848.

Cells very small, length and breadth about equal, deeply constricted, sinus linear but open, with outer margin expanded and apex rounded, isthmus narrow; semicells transversely elliptic, with median portion of dorsal and ventral margins flattened, lateral margins very broadly rounded. Vertical view oblong-elliptic. Lateral view of semicells circular. Cell wall smooth. Chloroplasts axial and with one pyrenoid. (Tychoplankton.)

Zygospores spherical, armed with short blunt conical projections whose length is about twice the breadth (Ralfs).

Cells 18 μ long; 16-17 μ thick; breadth of isthmus 5.5 μ ; thickness 7.5 μ .

Dummy (rrr).

4. *COSMARIUM CONTRACTUM* Kirchner. Pl. 57, Figs. 9-11.

Kryptogamenfl. von Schlesiens 2^e: 147. 1878; Wille, Desm. U. S. 63, pl. 16, fig. 1; pl. 50, fig. 24. 1884; W. & G. S. West, Monogr. Brit. Desm. 2: 170, pl. 61, figs. 23-25, 34. 1905.

Cells fairly small, length about one and a half times the breadth, very deeply constricted, sinus open but with apex acuminate; semicells elliptic-circular, with ventral margin more rounded than the dorsal. Vertical view very broadly elliptic. Lateral view of semicells circular. Cell wall smooth or very finely punctate. Chloroplasts axial and with a single pyrenoid. (Facultative plankton.)

Zygospores spherical to angular-spherical, smooth-walled (W. & G. S. West).

Cells 29-37 μ long; 22-24 μ broad; 5-6.5 μ broad at isthmus; 15 μ thick.

Diameter of zygospores 31.5-35 μ (W. & G. S. West).

Beaverdam (s), Carroll (r), Horseshoe (rr), Shell (s).

var. PAPILLATUM W. & G. S. West. Pl. 57, Figs. 12-13.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 252, pl. 15, fig. 21. 1896.

Cells much larger than the type and with sinus more open; lateral angles of semicells with a single long papilla, the papillae being depressed towards the sinus. (Facultative plankton.)

Cells 45-49 μ long; 33-37 μ broad; 10-14 μ broad at isthmus; 25 μ in thickness. Length of papillae 1.5-2 μ .

Devils (s).

The cells of this variety that I have found in the plankton of Devils Lake have the characteristic shape and inward pointing papillae that W. & G. S. West show in their figure but their size is somewhat smaller.

In the plankton of Big Bass, Horseshoe and Shell lakes there was an even smaller form with shorter papillae that were not depressed. This has been given the form name *minor* (Trans. Wis. Acad. Sci., Arts & Lett. 20: 345, pl. 10, figs. 2-5. 1922) but might well be considered a distinct variety. The front view of this form is indistinguishable from certain forms of *Staurastrum brevispinum* De Brébisson so that the alga could be considered a compressed form of this *Staurastrum* species. Since no triradiate forms of the alga were found it has been relegated to *Cosmarium* instead of *Staurastrum*.

The dimensions of the form *minor* are: length 31-38 μ ; breadth 27-30 μ ; breadth of isthmus 8.75-10 μ ; thickness 17-25 μ . (Pl. 57, Figs. 14-17.)

5. COSMARIUM GRANATUM De Brébisson. Pl. 57, Fig. 18.

in Ralfs, Brit. Desm. 96, pl. 32, figs. 6A-6B. 1848.

Cells fairly small, length about one and a third times the breadth, deeply constricted, sinus linear, with apex slightly inflated and outer margin open, isthmus narrow; semicells pyramidal and with apices truncate, bases of lateral margins subparallel for a short distance and then converging or broadly rounded, apical angles obtuse. Vertical view elliptic. Lateral view ovate. Cell wall smooth to minutely punctate. Chloroplasts axial and with a single pyrenoid. (Tychoplankton.)

Zygospores unknown.

Cells 41 μ long; greatest breadth of semicell 30 μ , breadth at apex 9 μ ; breadth of isthmus 7.5 μ .

Trout (rrr).

6. COSMARIUM CYCLICUM Lundell.

Nova Acta Reg. Soc. Upsaliae 3 Ser., 8: 35, pl. 3, fig. 6. 1871.

Cells of medium size, subcircular in outline, length and breadth about equal, deeply constricted, sinus narrowly linear, with apex slightly dilated and outer extremity somewhat open, isthmus narrow;

semicells semicircular and with lateral angles somewhat rounded, cell outline crenulate. Vertical view narrowly elliptic but outlines of sides smooth. Lateral view of semicells ovate. Cell wall with 3-5 rows of undulations within the crenae, the undulations forming concentric series; central portion of wall smooth. Chloroplasts axial and with two pyrenoids.

Zygospores unknown.

Cells 49-52 μ long; 52-55 μ broad; 17-19 μ broad at isthmus; thickness 26 μ (Lundell).

Not found in the plankton of Wisconsin lakes.

var. *NORDSTEDTIANUM* (Reinsch) W. & G. S. West. Pl. 57, Figs. 19-20.

Monogr. Brit. Desm. 2: 146, pl. 58, fig. 12. 1905.

Cosmarium Nordstedtianum Reinsch, Contrib. ad Alg. et Fung. 89, pl. 10, figs. 11A-11B. 1875.

Semicells with apices truncate and undulation of cell wall within the crenae reduced in number. (Tycho plankton.)

Cells 52 μ long, 47-51 μ broad; breadth of isthmus 17 μ .

Meta (rrr).

The ornamentation of the cells as I have found it is similar to that given by W. & G. S. West and not the scattered granules covering the entire wall that Reinsch figures.

7. *COSMARIUM AMOENUM* De Brébisson.

in Ralfs, Brit. Desm. 102, pl. 17, figs. 3A-3C. 1848.

Cells fairly small, length about twice the breadth, slightly constricted, sinus open to sublinear, isthmus broad; semicells vertically rectangular and with rounded apices. Vertical view broadly elliptic. Lateral view of semicells narrowly oblong-elliptic. Cell wall granulate in outline and with face of cell bearing scattered granules in the apical region and vertical rows of granules extending from apical region to the semicell base, frequently with vertical pairs of granules forming a transverse belt across the base of the semicell. Chloroplasts axial and with two pyrenoids.

Zygospores unknown.

Cells 49 μ long; 24 μ broad; 18 μ broad at isthmus (Ralfs).

Not found in the plankton of Wisconsin lakes.

var. *MEDIOLAEVE* Nordstedt. Pl. 57, Fig. 21.

Bot. Not. 1887: 160. 1887; Kgl. Sv. Vet.-Ak. Handl. 22, No. 8: 50, pl. 5, fig. 12. 1888.

Semicells with granules lacking in median area of front view and with double row of granules at base of semicells prominent. (Tycho plankton.)

Cells 39 μ long; 23 μ broad; 15 μ broad at isthmus.

Speese (rr).

These cells are somewhat smaller than other investigators find them but the characteristic ornamentation shows that it is *C. amoenum* var. *mediolaeve*.

8. *COSMARIUM BOTRYTIS* (Bory) Meneghini. Pl. 57, Fig. 22.

Linnaea 14: 220. 1840; Ralfs, Brit. Desm. 99, pl. 16, figs. 1A-1D. 1848; Carter, Ann. of Bot. 34: 277. 1920.

Cells of medium size, length about a quarter greater than the breadth, deeply constricted, sinus linear, with apex slightly inflated and outer margin open, isthmus narrow; semicells truncate-pyramidal, with basal angles broadly rounded and apical angles more acute; semicell apices distinctly flattened. Vertical view elliptic and with sides inflated in median portion. Lateral view of semicells broadly elliptic. Cell wall coarsely granulate, with granules distributed over the entire wall but not forming a definite pattern. Semicells containing two chloroplasts, each with a central pyrenoid, the axis of each chloroplast giving rise to 4-6 plates that radiate towards the periphery and have their peripheral edges flattened against the cell wall. (Tycho plankton.)

Zygospores spherical, with numerous short radiating processes that have conical bases and trispinate apices (Ralfs.)

Cells 60-108 μ long; 52-74 μ broad; breadth of isthmus 14-26 μ .

Zygospores 51 μ in diameter, with spines 9.7 μ long (Ralfs.).

Beaverdam (rrr), Crab (rrr), Grindstone (rrr), Horseshoe (rr), Muskallonge (rrr), Number One (rrr), Sand (rrr), Whitney (rrr).

9. *COSMARIUM RENIFORME* (Ralfs) Archer. Pl. 57, Fig. 23.

Jour. of Bot. 12: 92. 1874; W. & G. S. West, Monogr. Brit. Desm. 3: 157, pl. 79, figs. 1-2; pl. 82, fig. 15. 1908.

Cosmarium margaritifera var. *reniformis* Ralfs, Brit. Desm. 100, pl. 16, fig. 2A. 1848.

Cells of medium size, length and breadth about equal, deeply constricted, sinus narrow, with apex greatly inflated and pyriform, outer portion dilated, isthmus narrow and somewhat elongate; semicells reniform, with outline coarsely granulate. Vertical view elliptic. Lateral view of semicells circular. Cell wall with coarse granules covering the entire surface and arranged in a criss-cross series. Chloroplasts axial and with two pyrenoids. (Tycho plankton.)

Zygospores spherical and with smooth walls (W. & G. S. West).

Cells 54 μ long; 50 μ broad; 16.5 μ broad at isthmus.

Diameter of zygospores 54-60 μ (W. & G. S. West).

Eagle (rrr).

10. *COSMARIUM PORTIANUM* Archer. Pl. 57, Fig. 24.

Quart. Jour. Mier. Sci. 8: 235, pl. 11, figs. 8-9. 1860.

Cosmarium orbiculatum De Bary non Ralfs, Unters. u. d. Fam. d. Conj. 41, pl. 6, figs. 49-50. 1858.

Cells fairly small, length about one and a half times the breadth, fairly deeply constricted, sinus a semicircular depression with a rounded apex, isthmus elongate; semicells transversely elliptic and with poles quite blunt, semicell outline granulate. Vertical view broadly elliptic. Lateral view of semicells circular. Cell wall granulate, with conspicuous granules arranged in vertical series, at times decussate. Chloroplasts axial and with one pyrenoid. (Tychoplankton.)

Zygospores spherical, furnished with numerous short conical protuberances with rounded apices (De Bary).

Cells 40 μ long; 28 μ broad; 10 μ broad at isthmus.

Beaverdam (rrr).

11. COSMARIUM ORNATUM Ralfs. Pl. 57, Fig. 25.

Ann. & Mag. of Nat. Hist. 14: 392, pl. 11, figs. 3A-3C. 1844; W. & G. S. West, Monogr. Brit. Desm. 3: 151, pl. 78, figs. 1-10. 1908.

Cells small, length and breadth about equal, deeply constricted, sinus linear, with apex slightly inflated and outer margin open, isthmus fairly narrow; semicells reniform, with a broad truncate elevation in the apical region, lateral margins broadly rounded, outline of cells granulate. Vertical view elliptic, with poles broadly rounded and central portion of sides somewhat inflated. Lateral view of semicells subcircular and with a somewhat truncate apex. Cell wall with granules within the margin (at times with granules in vertical series) and with a transverse double row of granules below the truncate portion of apex; central area with a circular area of conspicuous granules, face of semicell surrounding central area without granules. Chloroplasts axial and with two pyrenoids. (Tychoplankton.)

Zygospores spherical, with numerous fairly long stout spines that have conical bases and emarginate apices (W. & G. S. West).

Cells 31 μ long; 33 μ broad; 12.5 μ broad at isthmus.

Zygospores 46-50 μ broad without spines, 70-95 μ with spines (W. & G. S. West).

Crooked (rrr), Muskallonge (rrr).

12. COSMARIUM COMMISSURALE De Brébisson.

In Meneghini, Linnaea 14: 220. 1840; Ralfs, Brit. Desm. 105, pl. 16, figs. 8A-8D. 1848.

Cells fairly small, breadth one and a half times the length, very deeply constricted, sinus with inner portion rhomboidal, median portion linear, and outer portion dilated, isthmus very narrow; semicells reniform, with lateral angles broadly rounded and apex truncate and slightly elevated in the median portion. Vertical view elliptic and with a conspicuous semicircular inflation in the median portion. Lateral view of semicells broadly elliptic and with apex flattened. Cell wall (in front view) with outline of truncate apex and lateral angles granulate; median portion of cell face with a ring of granules enclosing scattered granules or with a circular area in which all

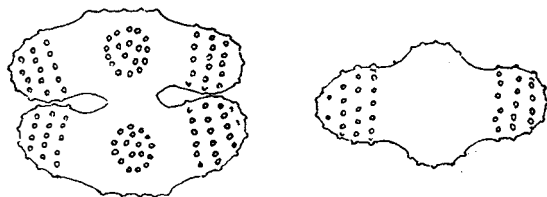


Fig. 3. *Cosmarium commissurale* De Brébisson ($\times 800$). From a herbarium specimen in the British Museum of Natural History collected by De Brébisson at Falaise, France.

granules are irregularly distributed. Vertical view of wall with transverse rows of granules at the poles and with central protuberance granulate. Chloroplast axial and with one pyrenoid.

Zygospores spherical, clothed with numerous long straight spines with emarginate apices and conical bases (Ralfs).

Cells $31\ \mu$ long; $39\ \mu$ broad; $8\ \mu$ broad at isthmus; $21\ \mu$ in thickness.

Not found in the plankton of Wisconsin lakes.

var. *CRASSUM* Nordstedt. Pl. 57, Fig. 26.

Vidensk. Medd. f. d. naturh. Foren. i Kiøbenhavn 1869: 213, pl. 3, fig. 19. 1870.

Breadth of cells one to one and a quarter times the length, inner portion of sinus linear and not rhomboidal; semicells elliptic in outline and with granulations more irregular. (Tychoplankton.)

Cells $32\ \mu$ long; $34\ \mu$ broad; $9\ \mu$ broad at isthmus.

Travis (rrr).

The relative proportions of the cells and the difference in sinus and semicell shape distinguish the variety although there is, in general, the same ornamentation as in the type.

13. *COSMARIUM PROTRACTUM* (Nägeli) De Bary. Pl. 57, Fig. 27.

Unters. u. d. Fam. d. Conj. 72. 1858; W. & G. S. West, Monogr. Brit. Desm. 3: 181, pl. 82, fig. 8; pl. 94, figs. 4-5. 1908.

Cells fairly small, length and breadth about equal, very deeply constricted, sinus linear, with apex slightly inflated and outer portion somewhat open, isthmus narrow; semicells reniform, with apices considerably elevated and giving the semicells a three-lobed appearance; lateral lobes broadly rounded; apical lobe truncate, with sides subparallel and apex flattened, angles of lobes somewhat rounded, cell outline granulate. Vertical view elliptic, with poles broadly rounded and sides with a conspicuous median protuberance. Lateral view of semicells ovate and with apices flattened. Cell wall with coarse granules near the margins of lobes, at times with these granules regularly arranged on the lateral lobes; central area with similar large granules arranged in concentric rings, wall between marginal granules and central area granulate but granules considerably smaller. Chloroplasts axial and with two pyrenoids. (Tychoplankton.)

Zygospores unknown.

Cells $40\ \mu$ long; maximal breadth $42.5\ \mu$; breadth at apex $17\ \mu$; breadth at isthmus $12\ \mu$.

Okauchee (rr).

14. COSMARIUM QUINARIUM Lundell. Pl. 57, Fig. 28.

Nova Acta Reg. Soc. Upsaliae 3 Ser., 8: 28, pl. 2, fig. 14. 1871; W. & G. S. West, Monogr. Brit. Desm. 3: 216, pl. 85, figs. 9-10. 1908.

Cells fairly small, length slightly greater than the breadth, deeply constricted, sinus linear, with apex slightly inflated and outer margin open, isthmus narrow; semicells truncate-pyramidal, with basal angles broadly rounded and apical angles not acute, lateral margins slightly convex and truncate apex flat; outline of semicells granulate. Vertical view elliptic. Lateral view of semicells circular. Cell wall with five conspicuous granules in two rows at center of semicell, the upper row with three and the lower with two granules, with a transverse subapical row of four similar granules; also with several smaller granules near the lateral margins and two or three small granules between the large ones at the center of the cell face. Chloroplast axial and with two pyrenoids. (Tychoplankton.)

Zygospores unknown.

Cells $42\ \mu$ long; $36\ \mu$ broad; $10\ \mu$ broad at isthmus.

Tank (rrr).

15. COSMARIUM PUNCTULATUM De Brébisson.

Mem. de la Soc. imp. d. Sc. nat. de Cherbourg 4: 129, pl. 1, fig. 16. 1856; W. & G. S. West, Monogr. Brit. Desm. 3: 206, pl. 84, figs. 13-14. 1908; *ibid.* 4: pl. 102, fig. 22. 1912.

Cells small, length slightly greater than the breadth, deeply constricted, sinus linear, with apex slightly inflated and outer extremity open, isthmus narrow; semicells broadly subtrapeziform, with basal and apical angles broadly rounded, lateral margins convex and apex straight to slightly convex; outline of semicells very finely granular. Vertical view elliptic. Lateral view of semicells circular. Cell wall minutely granulate near the margins and central area, if granulate, with granules approximately the same size as those of the margins. Chloroplasts axial, with one pyrenoid.

Zygospores spherical, with numerous long spines with conical bases and deeply emarginate to bifurcate apices, if bifurcate with the bifurcations emarginate (W. & G. S. West).

Cells $34-36.5\ \mu$ long; $31-34\ \mu$ broad; $8.5-11\ \mu$ broad at isthmus; $17-18.5\ \mu$ thick (W. & G. S. West).

Zygospores $42-45\ \mu$ in diameter without spines, $65-68\ \mu$ with spines (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. SUBPUNCTULATUM (Nordstedt) Børgesen. Pl. 57, Fig. 29.

Medd. om Grönland 18: 12. 1894; W. & G. S. West, Monogr. Brit. Desm. 3: 209, pl. 84, figs. 15-20; pl. 85, figs. 1-3. 1908.

Semicells with granules of central area conspicuously larger than those near the margin, arrangement of granules at center generally not following a definite pattern. (Tychoplankton.)

Cells 33 μ long; 30 μ broad; 10 μ broad at isthmus.

George (rrr).

W. & G. S. West recognize the forms Alpha and Beta of the variety, the distinction being based upon smooth or granulate semicell apices. The Wisconsin specimens belong to the variety Beta with granulate apices.

16. COSMARIUM OVALE Ralfs. Pl. 58, Fig. 1.

Ann. & Mag. of Nat. Hist. 14: 394 (p. p.), pl. 11, figs. 7D-7E. 1844; Brit. Desm. 98, pl. 15, figs. 9A-9B. 1848; Carter, Ann. of Bot. 34: 282, pl. 13, figs. 82-83. 1920.

Cells very large, length one and a half times to nearly twice the breadth, outline oval, deeply constricted, sinus linear, with apical portion somewhat inflated and outer margin widely open, isthmus narrow; semicells truncate-pyramidal, with basal angles broadly rounded and sides gradually converging to a truncate apex, apex flattened to convex, cell outline with large conical granules with rounded apices, cells frequently without granules at the poles. Vertical view elliptic, with outline smooth except at poles. Lateral view of semicells ovate, with granulation of cell outline confined to apical region. Cell wall with large granules similar to those of the cell outline within the lateral margins but with apical area smooth, entire surface of wall minutely punctate; vertical view with a broad band of coarse granules extending from pole to pole and lateral view of semicells with the band extending from isthmus to apex. Semicells with four parietal chloroplasts, two generally opposite each front face, each chloroplast with numerous vertical laminate projections extending to the cell wall; main body of chloroplast with 6-12 pyrenoids.

Zygospores unknown.

Cells 180 μ long; maximum breadth 90 μ , breadth at apex 11 μ ; breadth at isthmus 39 μ .

Devils (rrr).

COSMOCLADIUM De Brébisson 1856.

Cells united by bands of gelatinous material to form spherical to ellipsoidal, sessile or free-floating colonies. Colonies enclosed by hyaline, homogeneous gelatinous envelopes. Cells small, quite similar in shape to those of *Cosmarium*; length somewhat greater than the breadth, median constriction usually deep and sinus linear; semicells usually compressed and front view elliptic. Vertical view elliptic and lateral view of semicells subcircular. Cell wall smooth, without ornamentation aside from pores. Chloroplasts axial, with one pyrenoid.

Zygospores spherical, with irregular, broad, angular projections.

The cells of this genus have the same shape as those of *Cosmarium* but the organization into a definite colony differentiates *Cosmocladium* from *Cosmarium*. With one exception this is the only colonial genus of the family in which cell division takes place in three planes and so gives rise to a colony that is not a filament. The gelatinous envelope enclosing the colony can only be demonstrated by special methods but the gelatinous strands connecting the individual cells are readily discernible. These strands have been the subject of special investigations by Schröder and Lütkenmüller and they have shown that the two sister cells are connected by strands that arise near the isthmus of the mother cell at the time of division. These investigators have also demonstrated the presence of definitely arranged pores in the cell walls and Schröder has figured radially arranged denser strands in the colonial envelope, these denser strands apparently originating at the pores of the cell wall.

KEY TO THE SPECIES.

- Cells strongly compressed.....(1) *C. saxonicum*
Cells not compressed.....(2) *C. Hitchcockii*

1. COSMOCLADIUM SAXONICUM De Bary. Pl. 58, Fig. 2.

Flora 48: 329, pl. 4, figs. 1-3. 1865; Schröder, Ber. d. D. bot. Ges. 18: 15, pl. 1, figs. 1-9. 1900.

Cells fairly small, length somewhat greater than the breadth, median constriction relatively deep, sinus sublinear, with apex rounded and outer margin widely open, isthmus fairly narrow; semicells transversely elliptic to subhemispherical, with dorsal margin more rounded than the ventral margin, lateral angles broadly rounded. Vertical view oblong-elliptic, with sides subparallel and poles somewhat flattened. Lateral view of semicells subcircular. Cell wall smooth. Chloroplast axial, with a single central pyrenoid. Colonial envelope a hyaline gelatinous matrix in which there are fairly broad denser strands connecting the cells. (Facultative plankton.)

Zygospores unknown.

Cells 22-30 μ long; 21-26 μ broad; 7-7.5 μ broad at isthmus; 12-14 μ thick. Colonies up to 275 μ in diameter.

Beaverdam (rr), Devils (ccc), Squirrel (rr), North Turtle (sss).

The cells of the species as I have found them in Wisconsin have more rounded semicells than De Bary or Schröder figure. The connecting threads also appear to be the same diameter throughout and do not have the expansion midway between the two cells that these investigators have noted.

2. *Cosmocladium Hitchcockii* (Wolle) comb. nov. Pl. 58, Figs. 3-9.

Dictyosphaerium Hitchcockii Wolle, Bull. Torr. Bot. Cl. 12: 126. 1885; Freshw. Algae of U. S. 186, pl. 157, fig. 12. 1887.

Dictyocystis Hitchcockii (Wolle) Lagerheim, Nuova Notarista 5: 226. 1890; W. & G. S. West, Jour. Linn. Soc. Bot. 35: 531. 1903; Brunthaler in Pascher, Süßwasserfl. Deutschl., Österr. u. d. Schw. 5, Chlorophyceae 2: 185, fig. 279. 1916.

Cells small, length about one and three quarters times the breadth, very slightly constricted, sinus a broad very shallow depression, breadth of isthmus nearly equal to that of semicell; semicells broadly ovate and with semicircular apices. Vertical view circular. Lateral view similar to that of front view. Chloroplast axial, usually but one in a cell, with four vertical parietal lobes and a single central pyrenoid. Cells connected by a single delicate strand that usually arises near the isthmus. Inbedded in a homogeneous gelatinous envelope. Gelatinous envelope at times with denser acicular gelatinous rays radiating from the walls of the cells. (Facultative planktonic.)

Zygospores unknown.

Cells 30–35 μ long with spines, 15–19 μ without spines; 20–30 μ broad with spines, 10–12 μ without spines; isthmus 8–10 μ broad. Colonies up to 120 μ in diameter.

Bear (r), Beaverdam (r), Clare (r), Fish (r), Horseshoe (rrr), Kitten (rr), Lac Court Oreilles (ss), Pokegama (rrr), Reserve (s), Rice (rr), Round (rr), Whitefish (rrr), Wildcat (rr).

In the cell shape and the tendency towards an arrangement in series radiating from a common center this alga shows a great similarity to the *Dictyosphaerium Hitchcockii* of Wolle and I believe that the organism described above is the one which he referred to *Dictyosphaerium*.

On the basis of Wolle's description of the chloroplast, "each cell having the chlorophyll radiately gathered around a large central granule", Lagerheim created the genus *Dictyocystis* since this alga evidently does not belong to *Dictyosphaerium*. In my opinion the cell shape is sufficiently like certain other *Cosmocladium* species [particularly *C. constrictum* (Archer) Joshua] to justify its removal from *Dictyocystis* to *Cosmocladium*. The organization of the colony with strands connecting the cells is a distinct *Cosmocladium* feature, although in most *Cosmocladium* species these strands are broad and appear as a double line. The radiating strands found in certain colonies seems to be good evidence that there are scattered pores in the wall of this alga as in other *Cosmocladium* species, but, unfortunately, empty cells were not available for the accurate determination of this point.

The greatest objection to considering the alga a Desmid is the chloroplast. In all members of the subfamily Placodermatae, to which, *Cosmocladium* belongs, there is a chloroplast in each semicell. In *C. Hitchcockii* there is but a single chloroplast that extends from pole to pole. In its axial position and four radiation lobes, however, it is similar to the type of chloroplast found in a majority of the species in the closely related genus *Cosmarium*.

If the alga is to be excluded from *Cosmoecium* I feel that *Dicthyocystis* should be retained as a separate genus, that, on account of its axial chloroplast, is closely related to *Asterococcus* of the Palmellaceae.

MICRASTERIAS Agardh 1827.

Cells usually solitary, rarely in filaments, frequently of large size and with the length somewhat greater than the breadth, median constriction always well defined and usually linear to sublinear, isthmus never broad; bilaterally symmetrical and greatly compressed (in one variety radially symmetrical); semicells semicircular to hexagonal, with two incisions from periphery to about half way to center dividing the semicell into three lobes—the central or polar lobe and two lateral lobes; or with four incisions that divide the semicell into one polar and four lateral lobes; depth of incision variable and shape linear to cuneate; polar lobe generally with apex expanded and somewhat emarginate, at times with accessory asymmetrical processes; lateral lobes rarely entire, usually with one, two, three or four series of secondary lobelets, the ultimate lobelets generally with emarginate apices or spines. Cell wall usually smooth, at times with rows of spines near the incisions or marginal denticulations; entire body of cell rarely covered with spines. Chloroplast a flattened massive axial plate having the same general contour as the semicell, with numerous small ridges at right angles to the chloroplast body, lobe of chloroplast in polar lobe of cell frequently deeply incised; pyrenoids numerous, from thirty to a hundred, and fairly evenly distributed throughout the chloroplast. Vertical view usually narrowly fusiform-elliptic and lateral view of semicells narrowly pyramidal.

Zygospores spherical, with long stout radially disposed spines that terminate in simple to quadrifid apices.

The genus comprises a heterogeneous range of cell shapes but the incisions forming the lobes are a very constant feature in all species. The cells are usually compressed and disc-shaped but the discovery of a triradiate variety of *M. pinnatifida* by William West (Jour. of Bot. 27: 206, pl. 291, fig. 15. 1889) shows that even in this genus certain qualifying statements must be made about the shape of the cell. Another feature of *Micrasterias* species is the large cell size and, although certain other genera have a few species that approach them in size, large cells are the rule and not the exception in *Micrasterias*.

KEY TO THE SPECIES.

Cells not united in filaments.

Polar lobe without accessory processes.

Semicells with two lateral lobes.

Cells small (1) *M. pinnatifida*

Cells large.

Polar incision acute-angled..... (2) *M. laticeps*

Polar incision broadly rounded..... (3) *M. depauperata*

Semicells with four lateral lobes.

Incisions of lateral lobes shallow.

Polar incisions deep.....(5) *M. conferta*

Polar incisions shallow.....(4) *M. truncata*

Incisions of lateral lobes deep.

Cell outline oval.

Lobes with more than one series of incisions.

Sides of incisions not undulate.

Lobelets not deeply emarginate.....(6) *M. denticulata*

Lobelets deeply emarginate.

With a conical projection above the isthmus (9) *M. Thomasiana*

Without a conical projection above the isthmus (8) *M. apiculata*

Sides of incisions undulate.....(7) *M. radiosa*

Lobes with a single incision.....(11) *M. radiata*

Cell outline quadrangular.....(10) *M. Torreyi*

Polar lobe with accessory processes.

Polar angles continued in long processes.

Lateral processes in the same plane.....(13) *M. Nordstedtiana*

Lateral processes not in the same plane.....(14) *M. muricata*

Polar angles with short processes.....(12) *M. americana*

Cells united in filaments.....(15) *M. foliaceae*

1. MICRASTERIAS PINNATIFIDA (Kützing) Ralfs. Pl. 59, Figs. 1-2.

Brit. Desm. 77, pl. 10, figs. 3A-3B. 1848; Johnson, Bot. Gaz. 19: 58, pl. 6, figs. 5-6. 1894; W. & G. S. West, Monogr. Brit. Desm. 2: 80, pl. 41, figs. 7-13. 1905.

Cells small, breadth slightly greater than the length, deeply constricted, sinus with apical portion linear and outer portion somewhat open, isthmus narrow; semicells three-lobed, polar lobe with basal portion subrectangular and with apical portion laterally expanded and resembling the lateral lobes but smaller, ends of lateral expansions bifid, polar lobe flattened to slightly convex; incisions between polar lobes and lateral lobes very broad and with rounded apices; lateral lobes horizontally disposed, lateral margins somewhat convergent and apex bifid (rarely trifid). Cell wall smooth. Vertical view narrowly elliptic, with poles drawn out and acuminate. Lateral view of semicells ovate-pyramidal, with apices rounded. Chloroplast extending into lateral lobes and lateral extensions of polar lobe, with two prominent vertical ridges; pyrenoids usually three, one in each lobe. (Tycho plankton.)

Zygospores spherical, with stout tapering spines that have rounded apices (W. & G. S. West).

Cells 54-60 μ long; 61-66 μ broad at the basal lobes, 45-50 μ broad at apex of polar lobes; isthmus 10-12.5 μ broad.

Kawagagesaga (rrr), Jenny (rrr), Lindy (rrr).

Readily distinguished by the small size and the broad incisions between the lobes.

2. MICRASTERIAS LATICEPS Nordstedt. Pl. 59, Fig. 3.

Vidensk. Medd. f. d. naturhist. Foren. i Kiöbenhavn 1869: 220, pl. 2, fig. 14. 1870; Wille, Desm. U. S. 115, pl. 37, figs. 4-5. 1884; Borge, Ark. för Botanik 1: 116, pl. 5, figs. 11-15. 1903.

Cells large, quadrangular, breadth somewhat greater than the length, very deeply constricted, sinus with apical portion linear and outer portion acute-angled, isthmus narrow; semicells three-lobed, polar lobe transversely fusiform with apex rounded and lateral angles very acute and slightly bent towards the base of the semicell; lateral lobes entire, horizontally disposed, lanceolate and with deeply bifid apices. Cell wall minutely punctate. Vertical view fusiform, with poles acuminate. Chloroplast completely filling the semicell, portion in polar lobe entire, with two conspicuous vertical ridges extending from the nucleus to the apex of the cell, with other ridges following the outline of the cell; pyrenoids 12-15. (Tychoplankton.)

Zygospores unknown.

Cells $140\ \mu$ long; $196\ \mu$ broad at basal lobes, $185\ \mu$ broad at polar lobe; isthmus $26\ \mu$ broad.

Crooked (rrr), Muskallonge (rrr).

Borge has shown that this alga is subject to considerable variation in the height of the lateral lobes and the degree of curvature of the apex of the polar lobe. In view of this wide range of variation it seems unwise to recognize the forms *major* and *minor* of Nordstedt.

The alga should be compared with *M. pinnatifida* (Kützinger) Ralfs and *M. oscitans* Ralfs. It differs from the former in the much greater size and from the latter in the greater breadth of the polar lobe and the narrower lateral lobes.

3. MICRASTERIAS DEPAUPERATA Nordstedt.

Vidensk. Medd. f. d. naturhist. Foren i Kiöbenhavn 1869: 222 (with text fig.). 1870; Cushman, Bull. Torr. Bot. Cl. 31: 395, text fig. 1. 1904; Borge, Arkiv för Botanik 15, No. 13: 64, pl. 5, figs. 16-17. 1919.

Cells of medium size, length about a third greater than the breadth, fairly deeply constricted, sinus sublinear and with outer portion somewhat open, isthmus narrow; semicells three-lobed, incision forming lobes deep and very broadly rounded, polar lobe with a very broad basal portion and upper portion somewhat expanded, polar apex convex and slightly retuse in the median portion, angles of the polar lobe deeply emarginate; basal lobes horizontally disposed, subrectangular, with a shallow semicircular incision and the lobelets deeply emarginate or the incision lacking and basal lobes with one or two teeth. Cell wall punctate. Vertical view broadly fusiform. Lateral view of semicells ovate.

Zygospores unknown.

Cells $81-104\ \mu$ long; $64-72\ \mu$ broad at basal lobes, $44-63\ \mu$ at apex of polar lobes; isthmus $14-16\ \mu$ broad; thickness up to $36\ \mu$ (Borge).

Not found in the plankton of Wisconsin lakes.

var. KITCHELII (Wolle) W. & G. S. West. Pl. 59, Fig. 4.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 239. 1896; Cushman, Bull. Torr. Bot. Cl. 31: 396, text fig. 2. 1904.

Microsterias Kitchellii Wolle, Desm. U. S. 116, pl. 37, figs. 1-3. 1884; Saunders, Proc. Washington Acad. Sci. 3: 408, pl. 44, fig. 23. 1901.

Cells larger, sinus with extremities more open; polar lobe much shorter; lateral lobes extending beyond the polar lobes and with incisions deeper. (Tychoplankton.)

Cells 142 μ long; 150 μ broad at basal lobes, 94 μ broad at apex of polar lobe; isthmus 20 μ broad.

Tank (rrr).

4. *MICRASTERIAS TRUNCATA* (Corda) De Brébisson. Pl. 60, Figs. 1-2. in Ralfs, Brit. Desm. 75, pl. 8, fig. 4; pl. 10, figs. 5A-5D. 1848; G. S. West, Jour. Linn. Soc. Bot. 34: 383, pl. 9, figs. 9-16. 1899; W. & G. S. West, Monogr. Brit. Desm. 2: 82, pl. 42, figs. 1-8; pl. 45, figs. 5-6. 1905.

Cells relatively small, circular in outline and with poles flattened, deeply constricted, sinus linear and with outer portion slightly open, isthmus narrow; semicells five-lobed, polar incisions somewhat open, comparatively shallow and with apex blunt; lateral incisions about half the depth of the polar incisions and acute-angled to sublinear; polar lobe broadly cuneate, with lateral margins widely divergent, polar apex convex and without a median depression, polar angles usually emarginate-bifid, rarely acuminate; lateral lobes asymmetrical to symmetrical in shape, with a very shallow rounded incision and the lobelets generally strongly emarginate. Cell wall smooth to punctate. Vertical view elliptic, with poles acuminate. Lateral view of semicells ovate-pyramidal. Chloroplasts with two prominent vertical ridges and irregularly disposed accessory ridges; pyrenoids 5-10. (Facultative plankton.)

Zygospores unknown.

Cells 70-87 μ long; 60-98 μ broad at the base of semicell, 55-68 μ broad at apex of polar lobe; isthmus 15-19 μ broad.

Beaverdam (rr), Chetek (rrr), Fish (rrr), Horseshoe (rrr), Sand (rrr), Soft (sss), Speese (rrr), Tank (rrr).

5. *MICRASTERIAS CONFERTA* Lundell.

Nova Acta Reg. Sci. Upsaliae 3 Ser. 8: 14, pl. 1, fig. 5. 1871; W. & G. S. West, Monogr. Brit. Desm. 2: 88, pl. 43, figs. 4-8. 1905.

Cells fairly small, with an elliptic outline, median constriction very deep, sinus linear and with outer extremities overlapping to slightly dilated, isthmus narrow; semicells five-lobed, with incisions forming the polar lobes much deeper than those forming the lateral lobes, polar incisions linear and outwardly curved, lateral incisions linear and straight; polar lobes obversely campanulate with bases narrow and apices flaring, apical margin convex but with median portion emarginate, apical margins with two erect spines near the angles and apical emargination flanked on either side by a small mamillate projection terminating in a short spine; lateral lobules with two series of shallow incisions, the ultimate lobules having their ends emarginate to slightly bispinate. Cell wall smooth to finely punctate, without spines or other

ornamentation. Vertical view with sides parallel and ends rounded but terminating in an acute point. Lateral view of semicells oblong, with vertical sides slightly concave, apex rounded and minutely trispinate.

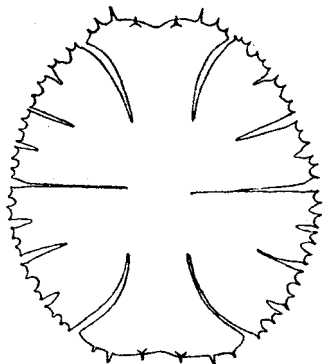


Fig. 4. *Microsterias conferta* Lundell ($\times 500$). From a plankton specimen collected at Figgenldin, Norway, by H. Huutfeldt-Kaas.

Zygospores unknown.

Cells $100\ \mu$ long; $87.5\ \mu$ broad at the basal lobes, $40\ \mu$ at apex of apical lobe; $17.5\ \mu$ broad at isthmus.

Not found in the plankton of Wisconsin lakes.

var. HAMATA Wolle. Pl. 59, Figs. 6-7.

Bull. Torr. Bot. Cl. 10: 19, pl. 27, fig. 1. 1883; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 241, pl. 14, figs. 8-9. 1896; Monogr. Brit. Desm. 2: 90, pl. 43, figs. 10-11. 1905.

Incision forming polar lobes more widely open, lateral margin of polar lobe with a semicircular excavation near the apex that causes the lateral margins to be subparallel. Chloroplast extending to margins of lobes, incision in polar lobe of chloroplast shallow, with two longitudinal ridges extending from polar apex to nucleus; pyrenoids 8-10. (Tychoplankton.)

Cells $75-92\ \mu$ long; $73-82\ \mu$ broad at base of semicells, $34-37\ \mu$ at apex of polar lobe; isthmus $12-13\ \mu$ broad.

Des Moines (rrr).

The variety and the type are distinguished by the degree of expansion in the upper part of the polar lobe. In size, general contour, and depth of incision the species resembles *M. papillifera* De Brébisson but the two differ in the shape of the polar lobe. The variety differs from the type in the curvature of the upper part of the lateral margins of the polar lobe, a curvature which causes the incision to be broader and which gives the polar lobe an exserted appearance. W. & G. S. West have shown the close relationship between the type and the variety and have figured specimens with one semicell typical and the other with the polar features of the variety.

6. MICRASTERIAS DENTICULATA De Brébisson. Pl. 59, Fig. 5.

Mem. de la Soc. Acad. Falaise 1835: 54, pl. 8. 1835; Ralfs, Brit. Desm. 70, pl. figs. 1A-1G. 1848; W. & G. S. West, Monogr. Brit. Desm. 2: 105, pl. 49, figs. 1-7; pl. 50, figs. 1-2. 1905; Carter, Ann. of Bot. 33: 299, pl. 19, figs. 2-8. 1919.

Cells large, broadly elliptic in outline, length somewhat greater than the breadth, very deeply constricted, sinus linear from apex to extremity, isthmus narrow; semicells five-lobed, incisions forming polar and lateral lobes deep and linear; polar lobe with lateral margins of basal portion subparallel and sides of upper portion somewhat divergent, apical margin rounded and not exerted, with a broad emargination in the median portion, angles of polar lobe blunt and rounded; lateral lobes equal in size, cuneate in shape and re-divided by two series of linear incisions, the depth of each succeeding incision being about half that of the preceding series, ultimate lobules with broad truncate ends that have rounded angles and a median emargination of variable depth. Cell wall punctate but without ornamentation. Vertical view narrowly elliptic, with poles forming sharp points and median portion of lateral margins with three small rounded elevations. Lateral view of semicells narrowly pyramidal, with the bases bearing an acutely pointed swelling and apex rectangular. Chloroplasts completely filling the cells, portion extending into the polar lobe with a conspicuous excavation, ridges of chloroplasts following the major incisions and not extending across the body of the semicell; pyrenoids numerous, 20-40 in each semicell. (Tycho-plankton.)

Zygospores spherical, with a thick lamellated wall bearing stout spines that are the same diameter throughout and have their apices bifid to trifid, at times with the incised portion recurved (Ralfs).

Cells 236-275 μ long; 195-235 μ broad at base of semicells, 54-68 μ at apex of polar lobes; 28 μ broad at isthmus.

Zygospores 80-116 μ in diameter without spines, 170-195 μ with spines (W. & G. S. West).

Beaverdam (rrr), Bass (rrr), Speese (rrr).

7. MICRASTERIAS RADIOSA Ralfs non (Lyngbye) Agardh.

Brit. Desm. 72, pl. 8, fig. 3. 1848.

Micrasterias Sol (Ehrenberg) Kützinger, Species Algarum 171. 1849; W. & G. S. West, Monogr. Brit. Desm. 2: 95, pl. 46, figs. 1-2. 1905.

Cells large, breadth equal to the length, circular in outline, very deeply constricted, sinus linear, with sides undulate and apex acute, isthmus very narrow; semicells five-lobed, incisions between lobes linear and deep; polar lobe arising near the isthmus, with lateral margins subparallel and apical portion somewhat expanded, apical margin deeply emarginate and with lateral margins deeply bifid, emargination flanked on either side by a subapical mamillate projection that bears a single conspicuous erect spine; lateral margins deeply incised, with inner portion of incisions more open and giving the lobelets an undulate appearance; superior lateral lobe usually somewhat larger than the inferior, superior of lateral lobes with three series of incisions the depth of each successive incision a third less

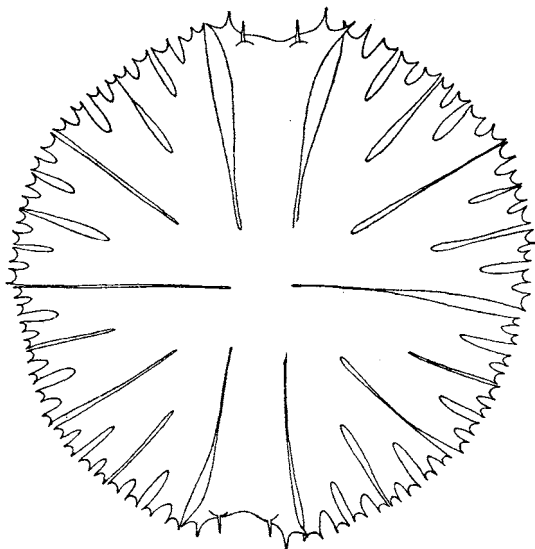


Fig. 5. *Micrasterias radiosa* Ralfs ($\times 400$). A plankton specimen from Grasmere, England, in the G. S. West collection.

than that of the preceding series, ultimate lobelets deeply emarginate and bifid, inferior lateral lobes sometimes with only two series of incisions. Cell wall smooth. Vertical view fusiform, with central portion slightly elevated and truncate. Lateral view of semicells linear-oblong, with apex tridenticulate. Chloroplast extending to ultimate lobelets, with apex of portion in polar lobe deeply incised, with two conspicuous vertical ridges extending from polar apex to the nucleus and secondary ridges bordering the major incisions; pyrenoids numerous, 50-65, in all parts of the chloroplast.

Zygospores unknown.

Cells $172\ \mu$ long; $174\ \mu$ broad at the base of the semicells, $50\ \mu$ at the apex of the polar lobe; isthmus $20\ \mu$ broad.

Not found in the plankton of Wisconsin lakes.

W. & G. S. West have discussed the nomenclature of this alga and shown that what Ralfs calls *M. radiosa* is not *M. radiosa* (Lyngbye) Agardh but *Micrasterias Sol* (Ehrenberg) Kützing (*Euastrum Sol* Ehrenberg). In spite of the fact that the name of *M. Sol* has priority, the ruling that Ralfs' British Desmidiaceae is to be taken as the starting point for the nomenclature of the Desmids requires the retention of the specific name *radiosa*.

It is distinguished from other deeply incised circular species by the deeper incisions, greater subdivision, and undulate margins of the lobes.

var. ORNATA Nordstedt. Pl. 60, Figs. 3-4.

Vidensk. Medd. f. d. naturhist. Foren. i Kiöbenhavn 1869: 223, pl. 2, fig. 11. 1870.

Microsterias Sol var. *ornata* Nordstedt. W. & G. S. West, Monogr. Brit. Desm. 2: 97, pl. 46, figs. 3-4. 1905.

Cells with the same proportions, degree of incision and undulate nature of incisions as in the type; portions of lobes adjacent to sinus, polar incisions, and sometimes lateral incisions with a single row of small spines. (Tychoplankton.)

Cells 240-248 μ long; 240-258 μ broad at base of semicells, 32-35 μ broad at apex of polar lobe; 25-27.5 μ broad at isthmus.

Beaverdam (rr), Found (rrr), Lindy (rrr), Nicaboyne (rrr), Sand (rrr).

The breadth of the incision is frequently much wider than that which Nordstedt gives in his original figure. The form name *elegantior* has been given to those cells with more open incisions and narrower lobelets by G. S. West (Mém. de la Soc. neuchâteloise d. sc. nat. 5: 1035, pl. 22, fig. 44. 1914) and Figure 4 shows a Wisconsin specimen which agrees well with his form.

8. MICRASTERIAS APICULATA (Ehrenberg) Meneghini. Pl. 61, Fig. 1.

Linnaea 14: 216. 1840; W. & G. S. West, Monogr. Brit. Desm. 2: 97, pl. 47, figs. 1-2. 1905; Carter, Ann. of Bot. 33: 300 (with text fig.). 1919.

Cells large, length somewhat greater than the breadth, deeply constricted, sinus with apex linear but outer portion somewhat open, isthmus narrow; semicells five-lobed, with incisions forming lobes extending about half way from the periphery to the cell center, polar incision open and acute-angled, lateral incisions narrow and with slightly divergent to convergent sides; polar lobe with lateral margins subparallel at base and then outwardly divergent at apex, polar apex deeply emarginate and polar angles with two fairly long divergently curved spines, polar apex with another conspicuous erect inwardly curved spine just within the lateral margin, apex frequently with a more delicate spine on each side of the median notch; lateral lobes usually equal in size and with two series of rather wide incisions, the ultimate lobelets terminating in 1-3 conspicuous outwardly curved spines. Cell wall covered with short spines that point towards the periphery of the cell and which are regularly arranged near the incisions but irregularly arranged in the median portion of the lobes; region just above the isthmus with 3-5 (usually four and quadrately arranged) more conspicuous spines. Vertical view rhomboid-elliptic, with acute poles. Lateral view of semicells narrowly truncate-pyramidal. Chloroplasts completely filling the semicells, with apex of portion in the polar lobe deeply incised, with two prominent ridges extending from the nucleus to the apex of the polar lobe and with secondary ridges near each incision of the lateral lobes; about 30 pyrenoids in each chloroplast. (Tychoplankton.)

Zygospores unknown.

Cells $260\ \mu$ long; $240\ \mu$ broad at base of semicells, $96\ \mu$ broad at apex of polar lobe; $32.5\ \mu$ broad at isthmus.

Hill (rrr).

var. FIMBRIATA (Ralfs) Nordstedt. Pl. 62, Fig. 1.

Vidensk. Medd. f. d. naturhist. Foren. i Kiöbenhavn 1888: 190. 1888. W. & G. S. West, Monogr. Brit. Desm. 2: 99, pl. 46, fig. 6; pl. 47, figs. 3-4. 1905.

Microsterias fimbriata Ralfs, Brit. Desm. 71, pl. 8, fig. 2. 1848; Wolle, Desm. U. S. 109, pl. 36, figs. 1-6. 1884; Freshw. Algae of U. S. 338. 1887.

Variety with polar lobes less sharply exserted on account of the narrower polar incisions; polar lobe with the curved spine within the lateral margin lacking but with the delicate spine on either side of the apical notch. Cell wall smooth. (Tychoplankton.)

Zygospores spherical, with scattered rather slender spines that have furcate apices and with the furcate ends recurved; at times with the notch very deep and extending below the middle of the spine (Wolle).

Cells $293\ \mu$ long; $252\ \mu$ broad at base of semicells, $67.5\ \mu$ broad at apex of the polar lobe; $40\ \mu$ broad at the isthmus.

Clear (rrr), Horseshoe (rrr).

Ralfs describes both *M. apiculata* and *M. fimbriata* in his British Desmidiaceae. The two are not considered distinct species since both have the same recurving of polar spines of different length and the same recurving of the spines at the ends of the lateral lobules. The chief difference in cell shape of the two is the exsertion of the polar lobe and the greater inflation of this lobe in *M. apiculata*. Since *M. apiculata* was described first it is taken as the type and *M. fimbriata* is placed as a variety. The variety *spinosa* of *M. fimbriata* does not seem worthy of varietal recognition so is considered a form which differs from *M. apiculata* var. *fimbriata* in the small spines near the lateral and polar incisions. All transitions from this form to the true variety can be found.

Forma *spinosa* (Bissett) W. & G. S. West (Monogr. Brit. Desm. 2: 100, pl. 47, fig. 5. 1905). Cells with rows of spines along the median construction, polar and lateral incisions. Pl. 61, Fig. 2. (Tychoplankton.)

Cells $257\ \mu$ long; $220\ \mu$ broad at base of the semicells, $70\ \mu$ broad at apex of the polar lobe, $39\ \mu$ broad at the isthmus.

Crooked (rrr).

9. MICRASTERIAS THOMASIANA Archer. Pl. 60, Fig. 5.

Quart. Jour. Micr. Sci. N. S. 2: 239, pl. 12, figs. 1-10. 1862; G. S. West, Jour. Linn. Soc. Bot. 34: 384, pl. 9, figs. 6-8. 1899; W. & G. S. West, Monogr. Brit. Desm. 2: 110, pl. 51, figs. 3-6. 1905.

Cells large, oval in outline, deeply constricted, sinus linear and with outer portion closed, isthmus narrow; semicells five-lobed, lobular

incisions narrow and extending slightly more than half the distance from the periphery to the cell center; polar lobe with lateral margins subparallel in basal portion and somewhat outwardly divergent in the apical portion, polar apex not projecting beyond the lateral lobes and with a fairly deep, acute or rounded emargination at the center; lateral angles emarginate to bifid, central emargination at times flanked on either side by an erect spine; lateral lobes of approximately the same size, with three series of incisions, the depth of each successive incision approximately half that of the preceding series, ultimate lobelets with outer face slightly emarginate; face of cell with a transverse row of three large projections just above the isthmus, the central conical projection being flanked on either side by an outwardly curved projection with a mamillate to a truncate apex and with two spines; primary lateral lobules with a conical tooth at the base, secondary lobules sometimes each with a similar but smaller tooth; polar lobe with a basal tooth and sometimes two sub-apical teeth; teeth always directed outwards and lying in a semicircle that follows the general contour of the semicell. Vertical view narrowly fusiform, with a central conical projection and on either side of this an emarginate projection that faces the poles. Lateral view of semicells narrowly pyramidal, with apex truncate and bases rounded. Chloroplast extending into the ultimate lobelets, portion in polar lobe deeply emarginate, with longitudinal ridges following the major incisions; pyrenoids 20-40. (Tychoplankton.)

Zygospores spherical, with stout furcate spines (W. & G. S. West).

Cells $225\ \mu$ long; $192\ \mu$ broad at the base of the semicells; $47.5\ \mu$ broad at the apex of the polar lobe; $42.5\ \mu$ broad at the isthmus.

Meta (rrr).

The species is readily distinguished from the other deeply incised ones by the basal projections of the semicells and the arc of teeth at the base of the lobelets. These characters are, however, subject to great variation and individuals may be found where the prominence of these features is greatly reduced and where the central basal protuberance and certain of the subperipheral teeth are lacking.

10. MICRASTERIAS TORREYI Bailey. Pl. 62, Fig. 2.

in Ralfs, Brit. Desm. 210, pl. 35, fig. 5. 1848; Wille, Desm. U. S. 108, pl. 30, figs. 1-8. 1884.

Cells very large, rectangular in outline, length and breadth about equal, very deeply constricted, sinus linear and with outer portion somewhat open, isthmus very narrow; semicells five-lobed, incisions deep, with apices sublinear and outer portion acute-angled; polar lobe arising near the isthmus, lateral margins of the polar lobe subparallel but widely divergent near the apex, apical margin with a conspicuous median emargination that gives it a concave appearance, median emargination flanked on either side by a simple mamillate swelling; polar angles fairly acute and simple, very rarely emarginate; lateral lobes of unequal size, the superior lateral lobe very deeply incised and one of the lobelets, usually the one adjacent to

the polar lobe, in turn deeply incised, at times with both lobelets incised; inferior lateral lobes usually with but a single deep incision; all ultimate lobelets obversely spatulate and with their apices acuminate, truncate, or deeply emarginate. (Tychoplankton.)

Zygospores unknown.

Cells $410\ \mu$ long; $450\ \mu$ broad in widest part, $74\ \mu$ broad at apex of polar lobe; $27\ \mu$ broad at the isthmus.

Lake of the Woods (rrr).

This Desmid stands out from all others in its large size and in the palmate nature of the semicells. Wolle's figures show that it is exceedingly variable in the amount of incision of the lateral lobes and in the nature of the ends of the lobelets.

11. MICRASTERIAS RADIATA Hassall. Pl. 63, Figs. 1-3.

Brit. Freshw. Algae 386, pl. 90, fig. 2. 1845; W. & G. S. West, Monogr. Brit. Desm. 2: 113, pl. 52, figs. 1-4, 6-9. 1905; Carter, Ann. of Bot. 33: 300, pl. 20, figs. 15-18. 1919.

Micrasterias furcata Ralfs non Agardh, Brit. Desm. 73, pl. 9, figs. 2A-2B. 1848; Wolle, Desm. U. S. 111, pl. 35, figs. 5-6. 1884; Johnson, Bot. Gaz. 19: 58, pl. 6, figs. 7-8. 1894.

Cells fairly large, length usually slightly greater than the breadth, very deeply constricted, sinus diamond-shaped, with apex acute and outer portion somewhat convergent, isthmus narrow; semicells five-lobed, polar lobe with basal portion oblong and upper portion somewhat dilated, angles of polar lobe continued in long slightly attenuated divergent processes with deeply furcate apices, apex of polar lobe somewhat concave; lateral lobes formed by a deep, rather bluntly pointed, lanceolate incision that extends half way from the periphery to the cell nucleus, lobes divided by an acute-angled incision with a rounded apex to form two lobules with subparallel sides and deeply furcate apices. Cell wall smooth. Vertical view narrowly fusiform, with poles acute. Lateral view of semicells narrowly cordate, with apex rounded. Chloroplast extending into the lobules, portion in polar lobe with apex entire, with two vertical ridges extending from the polar apex to the nucleus, ridges of lateral lobes somewhat irregular; pyrenoids 12-15, rather evenly distributed. (Facultative plankton.)

Zygospores unknown.

Cells $172-185\ \mu$ long; breadth $142-165\ \mu$, breadth at apex of polar lobe $85-115\ \mu$; breadth at isthmus $18-21\ \mu$.

Beaverdam (rrr), Diamond (rrr), Horseshoe (rr), Kawaguesaga (rrr), Kimball (rrr), Sunday (rr).

W. & G. S. West have given a full nomenclatorial discussion of the species and have shown conclusively why Ralfs' name is untenable.

The deep furcation of the lateral lobes and the wide polar and lateral incisions produce much narrower lobules than those of other species which have the same type of incision. The species is subject

to considerable variation in the size and delicacy of the apical and lateral lobes, the short stocky form shown in Figure 2 being much more common than the delicate one of Figure 1.

The incision of the lateral lobes is also subject to variation and all transition stages may be found from those in which only one lateral lobe is entire to those in which there is no incision of the lateral lobes of either semicell. W. & G. S. West follow Johnson in considering this the normal range for the type and think that no varietal distinction can be made on this reduction of the incision in the lateral lobes. The point at which varietal distinctions shall be drawn is a perennial question for the taxonomist and the treatment of the range of variation rests in a large degree upon the personal view-point. My observation of the alga in Canadian lakes, where in certain stations cells with reduced lobes are found to the exclusion of those with incised lobes, leads me to the conclusion that Wolle was justified in considering the forms with reduced lobes a distinct variety. This view is strengthened by the statement of W. & G. S. West that: "this variation is of far commoner occurrence in the United States than in the British Islands . . . in Britain we have only met this notable variation of the lateral lobes in the Scottish plankton."

A most unusual variation from the normal is shown in Figure 3 where there are three simple processes on the polar lobe of one of the semicells as well as a lack of bifurcation of the lateral lobules on one half of the semicell.

var. *SIMPLEX* (Wolle) G. M. Smith. Pl. 63, Fig. 4.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 344, pl. 9, figs. 1-5. 1922.

Micrasterias furcata var. *simplex* Wolle, Bull. Torr. Bot. Cl. 12: 128, pl. 51, figs. 6-7. 1885.

Micrasterias radiata Hassall. W. & G. S. West, Monogr. Brit. Desm. 2: 113, pl. 52, fig. 5. 1905.

Micrasterias furcata Ralfs non Agardh. Johnson, Bot. Gaz. 19: 58, pl. 6, figs. 9-14. 1894.

Lateral lobes of processes of one or both semicells simple and terminating in a deeply furcate-emarginate apex. (Tychoplankton.)

Cells $135\ \mu$ long; greatest breadth $130\ \mu$, breadth at apex of polar lobe $65\ \mu$; breadth at isthmus $17.5\ \mu$.

Hill (rrr).

In the majority of cases all of the lobes are not reduced and one or more has the deep incision of the type. When this is the case the incision occurs in the lateral lobes adjacent to the polar lobe rather than in the lobes adjacent to the sinus.

var. GRACILLIMUM G. M. Smith. Pl. 64, Fig. 1.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 344, pl. 9, figs. 6-11. 1922.

Cells slightly larger than the type; base of the polar lobe much narrower; lateral lobes not incised, with parallel sides and apices furcate; horizontally disposed bases of the semicells only slightly tapering. (Facultative plankton.)

Cells 160 μ long; greatest breadth 130 μ , polar lobe 65 μ broad at apex; isthmus 17.5 μ broad.

Lindy (rrr), Little Doctor (rrr).

Distinguished from the foregoing by the much narrower base of the polar lobe and by the nature of the lateral margins. The basal portion of the semicell is likewise much narrower than the basal portion of the semicell in the type, this narrowness giving the cell a more delicate appearance. In this variety no case has been observed where there is an incision of the lateral lobes.

12. MICRASTERIAS AMERICANA (Ehrenberg) Ralfs. Pl. 63, Fig. 5;
Pl. 64, Fig. 2.

Brit. Desm. p. XIX. 1848; Wolle, Desm. U. S. 112, pl. 32, fig. 2. 1884; W. & G. S. West, Monogr. Brit. Desm. 2: 117, pl. 53, figs. 4-5; pl. 54, figs. 1-3. 1905.

Microasterias morsa Ralfs, Brit. Desm. 74, pl. 10, figs. 1A-1E. 1848.

Cells fairly large, deeply constricted, sinus acute-angled and with apex acuminate, isthmus narrow; semicells five-lobed, incisions between polar and lateral lobes broad and with blunt apices; incisions between lateral lobes narrowly fusiform and with apices rounded; polar lobe with lateral margins parallel at base and then outwardly divergent to form a cuneate apex; apical margin of polar lobe broadly retuse and with lateral margins forming upwardly divergent processes with slightly convergent sides and truncate-emarginate apices; apex of polar lobe with a second similar but smaller process arising near the base of each of the lateral processes, secondary processes less outwardly divergent than the primary processes and asymmetrically disposed, one on each side of the polar lobe; lateral lobes with a shallow broad incision dividing them asymmetrically, the lobules adjacent to the polar incision or to the sinus being longer than those adjacent to the median lateral incision; all lobules with ends truncate-retuse and with 3-4 acute or rounded denticulations; portion of lobules adjacent to the secondary incisions, apical polar incisions and sometimes the portion of the cell bordering the polar incision with marginal denticulations; semicell body with two fairly conspicuous blunt teeth at the base of the polar incisions, sometimes with a central supraisthmal protuberance bearing scattered granules; polar and lateral lobes with a few scattered granules. Vertical view rhomboidal, with poles truncate and polar lobe showing the asymmetrical position of the processes. Lateral view of the semicells narrowly pyramidal, with bases rounded and apices continued in four short processes. Chloroplast extending into all five lobes and with the portion in the polar lobe fairly deeply incised, with two vertical ridges extending

into the polar lobe and one or two ridges into each lateral lobe; pyrenoids more numerous in body of the cell than in lobes, 10-20 in each chloroplast. (Tychoplankton.)

Zygospores unknown.

Cells 125-140 μ long; greatest breadth 104-140 μ , breadth at apex of polar lobe 54-72 μ ; breadth at isthmus 27-29 μ .

Found (rr), Horseshoe (rrr), Howey (rrr), Thousand Islands (rrr).

M. americana is subject to considerable variation in the length of the polar processes and the depth of incision of the lateral lobes. The granules of the cell body are always scattered, though they have a tendency to be more numerous and more regularly arranged on the portions bordering the incisions. The two prominent spines at the bases of the polar incisions have not been pointed out by previous investigators of the alga and my attention was first called to them by Mr. Charles Bullard. I find that they are quite constant in all American specimens that I have examined, as well as in European specimens in my herbarium.

M. mahabuleshwariensis Hobson is quite like *M. americana* in the asymmetrical processes of the polar lobes and the general cell shape but differs in the lack of a lateral incision that divides the semicells into five lobes.

13. MICRASTERIAS NORDSTEDTIANA Wolle. Pl. 64, Fig. 3.

Bull. Torr. Bot. Cl. 11: 15. 1884; Desm. U. S. 113, pl. 52, figs. 3-5. 1884; Johnson, Bull. Torr. Bot. Cl. 22: 292 pl. 239, fig. 14. 1895; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 239, pl. 14, fig. 4. 1896.

Cells large, length and breadth about equal, deeply constricted, sinus somewhat open and with an acute apex, isthmus narrow; semicells five-lobed, polar incision widely open and with a rounded apex that gives the polar lobe an exserted appearance; polar lobe elongate, with erect subparallel sides that bear on each side of the median portion a simple mamillate projection or a conical projection with truncate ends that have short blunt teeth; upper angles of polar lobe continued in very long, slightly divergent, tapering, cylindrical processes that terminate in three minute blunt spines, polar apex flattened and with a shallow emargination in the median portion, apex with a second, considerably shorter, asymmetrically disposed, pair of similar processes; lateral processes separated by a blunt broad incision, subhorizontally disposed, gradually tapering to blunt apices that have three short divergent spines. Cell wall smooth or finely punctate. Vertical view diamond-shaped, with poles continued in straight cylindrical processes. Lateral view of semicells oblong, bases with a round inflation and apices rectangular. (Tychoplankton.)

Zygospores unknown.

Cells 203 μ long; greatest breadth 180 μ , breadth at apex of the polar lobe 138 μ ; breadth at isthmus 28 μ .

Diamond (rrr).

Having a superficial resemblance to *M. muricata* (Bailey) Ralfs but differing in that the lateral lobes all lie in the same plane, and in the lateral projections of the polar lobes.

14. MICRASTERIAS MURICATA (Bailey) Ralfs. Pl. 64, Figs. 4-5.

Brit. Desm. 210. 1848; Wolle, Desm. U. S. 118, pl. 31, figs. 4-7. 1884; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 239, pl. 14, figs. 5-6. 1896.

Cells large, length about one and a half times the breadth, fairly deeply constricted, sinus acute-angled at apex and then greatly dilated, outer portion with widely open parallel sides, isthmus relatively broad; semicells five-lobed, polar and lateral incisions very broad and with rounded apices; polar lobe with basal portion broad and rectangular, with upper portion greatly dilated and with the angles continued in long slightly tapering cylindrical processes that are upwardly curved and terminate in three or four minute blunt conical spines; polar apex convex, central portion with a conspicuous narrow emargination and the lateral margins with a second pair of asymmetrically disposed processes that are similar to those at the polar angles; superior lateral lobes divided by an incision to form two long horizontally disposed processes that lie above each other in a front view of the semicell, processes arising from a conical base; inferior lobes submamillate, with the apex continued in a long cylindrical horizontally disposed process, each process of inferior lateral lobe with two similar but shorter processes, the three lying in the same transverse plane at right angles to the long axis of the semicell, all processes of lateral lobes with truncate ends bearing three or four short blunt teeth. Cell wall smooth or finely punctate. Vertical view oblong, sides somewhat tumid and angles continued in long, slightly divergent processes, middle of each end with another similar process. Chloroplast confined to the cell body but with fine laminate projections running into the processes, portion in the polar lobe entire, with two conspicuous longitudinal ridges extending from the polar apex to the nucleus and with curving ridges at the bases of the lateral lobes; pyrenoids 12-15, confined to the body of the cell. (Tycho-plankton.)

Zygospores unknown.

Cells 160-198 μ long; 110-130 μ broad at the inferior lateral lobes, 88-106 μ broad at the superior lateral lobes, 86-96 μ broad at the apex of the polar lobes; isthmus 22-23 μ broad.

Bass (rrr), Bettine (rrr), Carson (rrr), Jenny (rrr), Lindy (rrr), Little Doctor (rrr), Nicaboyne (rrr).

The species has much in common with *Euastrum* where it was first placed by Bailey but it lacks the incision of the polar lobe and the ornamentation of the cell body that characterizes *Euastrum*. There is little danger of confusing it with other *Micrasterias* species.

15. MICRASTERIAS FOLIACEA Bailey. Pl. 65, Figs. 1-2.

in Ralfs, Brit. Desm. 210, pl. 35, fig. 3. 1848; Wallich, Ann. & Mag. of Nat. Hist. 3 Ser., 5: 280, pl. 14, figs. 1-4. 1860; Wolle, Desm. U. S. 118, pl. 38, figs. 10-11. 1884; Johnson, Bot. Gaz. 19: 56, pl. 6, figs. 1-4. 1894.

Cells of medium size, united in filaments by the interlocking of the polar lobe, rectangular in outline, very deeply constricted, sinus sublinear, isthmus very narrow; semicells five-lobed; polar lobe exerted, basal fourth of the polar lobe narrow, with erect parallel sides, upper three quarters of the lobe greatly expanded, anvil-shaped, with a very broad deep subrectangular excavation in the median portion of the apex, lateral angles of the polar lobe acuminate, lateral margins of the base of the apical excavation with two erect asymmetrically disposed spines of unequal length; lateral lobes asymmetrical, the superior lobes divergent, the inferior lobes horizontally disposed; superior lobe incised, with the lobelet bordering the polar incision simple and acuminate, with the other lobelet having an incision about half the depth of the primary lobular incision; all ultimate lobelets, except those bordering the polar incisions with truncate-emarginate apices. Cell wall smooth. Vertical view narrowly fusiform, with apices acuminate and median portion somewhat constricted. Chloroplast completely filling the cell, with the portion in the polar lobe entire, without conspicuous ridges; pyrenoids 10-15. (Tychoplankton.)

Zygospores spherical, furnished with rather numerous, fairly long spines with truncate-emarginate apices (Wallich).

Cells 78-90 μ long; 82-85 μ broad, 45-58 μ broad at the apex of the polar lobe; 15-20 μ broad at the isthmus.

Zygospores 45 μ in diameter (Wallich).

Des Moines (rrr).

XANTHIDIUM Ehrenberg 1837.

Cells of variable, though generally of medium size; length frequently somewhat greater than the breadth, median constriction deep and sinus linear to acute-angled; semicells almost universally compressed, very rarely radially symmetrical, of variable shape, though usually polygonal and with apex flattened but not incised; lateral margins with angles that bear simple, rarely furcate, spines; spines asymmetrically disposed with reference to the vertical plane. Vertical view elliptic. Lateral view of semicells circular to polygonal. Cell wall smooth to punctate, with a thickened protuberant area in the middle of the cell face that frequently is scrobiculate. Chloroplasts at times axial and two in each semicell, at other times parietal and four in each semicell; pyrenoids usually single in each chloroplast.

Zygospores spherical, with scrobiculate walls or with walls bearing simple to furcate spines.

The angular semicells with spines at the angles and the differentiated central area of the cell are the most striking characters of the genus. Except for certain rare triradiate varieties the cells are always compressed. These varieties show a close affinity with *Staurostrum*, while the forms with reduced spines may resemble *Arthrodesmus*.

KEY TO THE SPECIES.

- Spines broad furcate processes.....(1) *X. armatum*
 Spines simple.
 Semicell with two spines on lateral margin.....(4) *X. subhastiferum*
 Semicell with more than two spines on lateral margins.
 Each margin with two pairs of spines.....(2) *X. antilopaeum*
 Each margin with two pairs and a single spine.....(3) *X. cristatum*

1. *XANTHIDIUM ARMATUM* (De Brébisson) Rabenhorst.

Deutschl. Kryptogamenfl. 2, Abt. 2: 55. 1847 (Ref. Nordst. Index Desm.);
 Ralfs, Brit. Desm. 112, pl. 18, figs. A-G. 1848.

Cells large, length one and a quarter to one and a half times the breadth, deeply constricted, sinus acute-angled, with apex acuminate and outer margin widely open, isthmus narrow; semicells sub-octagonal, with margins facing the isthmus slightly convex, lateral margins concave, and apex plane; lateral and superior angles bearing very stout, short, solid processes that terminate in 2-4 tuberculate furcations, lateral margins with a single similar process within each angle; apex also with two similar subapical processes a short distance

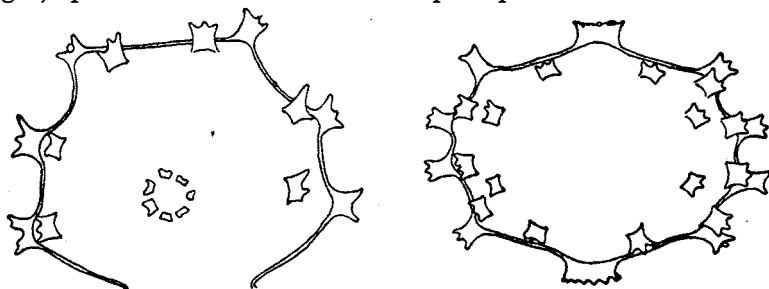


Fig. 6. *Xanthidium armatum* (De Brébisson) Rabenhorst ($\times 600$). From specimens collected at Loch Cormisa, Skye, Scotland, by W. & G. S. West.

inward from the angle; face of semicell with a single prominent solid tuberculate process with a ring of marginal teeth. Vertical view oblong-elliptic, with poles bearing four marginal and 3-4 intramarginal processes similar to those of the front view, middle of lateral margins with a solid, broad, truncate process with several tubercles at the distal end. Lateral view of semicells ovate-rectangular, with a broad solid tuberculate process at the base, and with four apical processes in addition to a median and basal transverse row of processes. Cell wall punctate. Semicells with four parietal chloroplasts each containing several pyrenoids.

Zygospores spherical, with thick walls containing numerous hemispherical depressions (Ralfs).

Cells $138\ \mu$ long with processes, $125\ \mu$ long without processes; greatest breadth with processes $91\ \mu$, without processes $80\ \mu$; apex $57\ \mu$ broad with processes, $47\ \mu$ without processes; isthmus $34\ \mu$ broad; thickness $70\ \mu$ with processes, $58\ \mu$ without processes.

Not found in the plankton of Wisconsin lakes.

var. *mediolaeve* var. nov. Pl. 65, Figs. 3-4.

Xanthidium armatum var. *cervicorne* G. M. Smith non W. & G. S. West. Trans. Wis. Acad. Sci., Arts & Lett. 20: 346. 1922.

Cells larger than the type, length (without spines) about a quarter greater than the breadth; concavity of lateral margins much more pronounced; processes at angle solid, much longer, with 3-5 deep furcations, the ultimate furcations being quite sharp; intramarginal processes of superior lateral angles lacking; center of cell smooth, without any sign of a process. (Tycho plankton.)

Cells 168-175 μ long with processes, 135-138 μ long without processes; greatest breadth 120-123 μ with processes, 92-98 μ without processes; isthmus 31-33 μ broad; processes 15-20 μ long.

Sunday (rrr).

In the elegant antler-like processes of the angles this variety resembles the variety *cervicorne* W. & G. S. West, to which Canadian specimens were referred. Study of European specimens of the varieties *cervicorne* and *fissum* Nordstedt shows that in these two varieties the central protuberance on the face of the semicell is readily observed. Since this central protuberance is not found on the cells that I have collected (both from Wisconsin and Ontario) the American alga is placed as a distinct variety. The intramarginal processes of the superior lateral angles were also lacking in all specimens collected but this feature is not of so great importance as the lack of a central protuberance since the varieties *fissum* and *cervicorne* may at times also lack the superior intramarginal processes.

2. *XANTHIDIUM ANTILOPAEUM* (De Brébisson) Kützinger. Pl. 65, Figs. 5-6.

Species Algarum 177. 1849; W. & G. S. West, *Monogr. Brit. Desm.* 4: 63, *pl.* 108, *figs.* 7-18. 1912.

Cells of medium size, length (without spines) about equal to the breadth, deeply constricted, sinus with inner portion linear and apex very slightly dilated, outer portion widely open, isthmus fairly narrow; semicells with ventral margin semielliptic and dorsal margin semihexagonal, lateral angles and angles of apex slightly rounded, basal angles very broadly rounded, apex flattened and bearing two, straight to slightly curved, suberect to widely divergent, fairly long, acutely pointed spines at each lateral margin; lateral angles each with a pair of similar, horizontally disposed spines. Vertical view elliptic, with broadly rounded poles that bear a pair of long divergent spines and a second pair of similar intrapolar spines, lateral margins with a slight median protuberance. Lateral view of semicells subspherical, with a pair of divergent spines at the apex and a second pair in the middle of the cell face. Cell wall finely punctate and with a median thickened area that is variously scrobiculate and frequently brownish in color. Chloroplasts generally four thin parietal plates in each

semicell; typically with one pyrenoid in each chloroplast. (Tycho-plankton.)

Zygospores spherical, bearing numerous long delicate spines with conical bases and bifurcate apices (W. & G. S. West.)

Cells 79–102 μ long with spines, 50–65 μ without spines; breadth of cells 80–96 μ with spines, 50–56 μ without spines; isthmus 14–19 μ broad; spines 15–22.5 μ long.

Zygospores 45–58 μ in diameter without spines, 80–98 μ with spines (W. & G. S. West).

Carroll (rrr), Des Moines (rrr), Jag (rrr), Rice (rrr).

var. *POLYMAZUM* Nordstedt. Pl. 65, Figs. 7–9.

Lunds Univ. Årsskr. 9: 38, pl. 1, fig. 20. 1873.

Cells with angles more rounded than the type, polar spines sub-erect (very rarely divergent.) Central area smooth but with an arc of emarginate to arcuate verrucae just below the semicell apex. Vertical view oblong-elliptic, with poles strongly emarginate. (Facultative plankton.)

Cells 70–88 μ long with spines, 52–58 μ long without spines; 73–86 μ broad with spines, 52–56 μ broad without spines; isthmus 15–17 μ broad; spines 10–15 μ long.

Beaverdam (ss), Carson (rrr), Cranberry (rrr), Crooked (rrr), Fish (rrr), Found (rr), George (rr), Hill (rr), Horseshoe (rr), Lake of the Woods (rrr), Lindy (rr), Lost (rrr), Lynx (rrr), Meta (rrr), Middle McKenzie (rrr), Nica-boyne (rr), Sand (rrr), Sanford (rrr), Speese (rrr).

The cells of this variety have more rounded angles than the type and as a result a much plumper appearance. The vertical view is also different since the poles are emarginate instead of broadly rounded. The chief feature of the variety, however, is the subapical arc of verrucae. The number and shape of these verrucae varies greatly and in certain specimens there is a double arc of verrucae.

The variety is widely distributed in Wisconsin lakes but never occurs in large quantities.

var. *MINNEAPOLIENSE* Wolle. Pl. 65, Figs. 10–11.

Bull. Torr. Bot. Cl. 11: 16. 1884; Desm. U. S. 94, pl. 52, fig. 16. 1884; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 252, text fig. 2. 1896.

Cell shape and arrangement of spines as in the variety *polymazum*; subapical verrucae generally arranged in an arc, rarely in an elliptical ring, with a small erect spine above or below the verrucae. (Tycho-plankton.)

Cells 78–82 μ long with spines, 50–58 μ long without spines; 79–83 μ broad with spines, 52–55 μ broad without spines; isthmus 16–17.5 μ broad; spines 12.5–15 μ long.

Bass (rr), Diamond (rrr), Horseshoe (rrr), Jenny (rr), Little Doctor (rrr), Meta (rrr), Rice (rr).

The only difference between this variety and the foregoing is the small erect spine associated with the verrucae below the apices of the semicells.

var. *DEPAUPERATUM* W. & G. S. West. Pl. 66, Fig. 1.

Trans. Bot. Soc. Edinburgh 23: 23, pl. 1, figs. 15-16. 1905.

Semicells with angles more rounded than in the type; spines on lateral margins much smaller and not regularly arranged in pairs, number of spines on a semicell frequently reduced. Central area with scrobiculations in an irregular ring. (Facultative plankton.)

Cells $68\ \mu$ long with spines, $65\ \mu$ long without spines; $84\ \mu$ broad with spines, $66\ \mu$ broad without spines; isthmus $27.5\ \mu$ broad; spines 7.5 - $10\ \mu$ long.

Otter (rr).

3. *XANTHIDIUM CRISTATUM* De Brébisson. Pl. 66, Figs. 2-3.

in Ralfs, Brit. Desm. 115, pl. 19, figs. 3A-3F. 1848; Reinsch, Cont. ad Alg. et Fung. 92, pl. 16, fig. 13. 1875.

Cells of medium size, length (without spines) somewhat greater than the breadth, deeply constricted, sinus sublinear to slightly open, with apex somewhat inflated, isthmus narrow; semicell elliptic-hexagonal, with sides facing the isthmus somewhat convex, lateral margins flattened, and apex plane; apical angles each with a pair of slightly divergent, medium sized, acutely pointed spines; superior lateral angles with a similar pair of somewhat divergent spines; inferior lateral angles with a single spine, basal spines of semicells convergent; face of semicell with a small, circular to elliptic, thickened area that is without ornamentation. Vertical view elliptic, with poles subtruncate and bearing three marginal and two intramarginal slightly divergent spines; lateral margins with a slight protuberance in the median portion. Lateral view of semicells subspherical, with a protuberance on each side and divergent apical and subapical spines. Cell wall finely punctate. Semicells with four parietal laminate chloroplasts, each containing a single pyrenoid. (Tychoplankton.)

Zygospores spherical, with long spines that have parallel sides and truncate apices (Reinsch).

Cells $65\ \mu$ long with spines, 45 - $48\ \mu$ long without spines; $48\ \mu$ broad with spines, $35\ \mu$ broad without spines; breadth of isthmus 10 - $12.5\ \mu$; length of spines 5 - $10\ \mu$.

Zygospores $50.4\ \mu$ in diameter; spines 16.8 - $19.6\ \mu$ long (Reinsch).

Chetek (rrr), Found (rrr), Island (rrr), Lac Court Oreilles (rrr).

The single convergent spines at the basal angles of the semicells differentiate this species from all others. The central protuberance is easily overlooked since it is without ornamentation.

var. UNCINATUM De Brébisson. Pl. 66, Fig. 4.

in Ralfs, Brit. Desm. 115, pl. 19, figs. 3D-3F. 1848.

Cells larger, semicells broadly subpyramidal, lateral margins concave between the angles, apex broadly truncate and plane; spines at polar and superior lateral angles suberect, generally slightly curved, spines of basal angle curved and subparallel; center of face of semicell with a broad granulate area, the granules generally in an irregular ring or ellipse. (Tychoplankton.)

Cells $75\ \mu$ long with spines, $60\ \mu$ without spines; $66\ \mu$ broad with spines, $48\ \mu$ broad without spines; isthmus $17.5\ \mu$ broad; spines 8-10 μ long.

Tank. (rrr).

The erect curved spines, granulate central area and semicell shape mark the points of difference between the variety and the type. The granulation of the central area is exceedingly variable in both size and number as well as in the arrangement of the granules.

4. XANTHIDIUM SUBHASTIFERUM W. West. Pl. 66, Figs. 5-12.

Jour. Linn. Soc. Bot. 29: 166, pl. 22, fig. 4. 1892; W. & G. S. West, *ibid.* 35: 540, pl. 16, figs. 4-5. 1903; W. & G. S. West, Trans. Roy. Irish Acad. 33: 102, pl. 11, figs. 13-15. 1906.

Cells of medium size, length and breadth (without spines) equal, very deeply constricted, sinus acute-angled, with apex acuminate and outer margin widely open, isthmus narrow; semicells transversely elliptic, curvature of ventral and dorsal margins about the same; lateral margins truncate-retuse, with two, long, fairly stout, somewhat divergent, straight or slightly curved spines that lie in the same vertical plane; semicell apices at times with a faint indication of a truncate elevation in the median portion. Vertical view elliptic, poles with two straight spines that lie in the same vertical plane, lateral margins with wall thickened in the median portion. Lateral view of semicells circular, with portion of wall above the isthmus thickened. Cell wall finely punctate, without ornamentation in the thickened portion of the cell face. Chloroplasts parietal, four in each semicell and each with a single pyrenoid. (Euplankton.)

Zygospores unknown.

Cells $41-73\ \mu$ long with spines, $35-52\ \mu$ long without spines; $60-101\ \mu$ broad with spines, $35-52\ \mu$ broad without spines; isthmus $9-14\ \mu$ broad; thickness $23-25\ \mu$; spines $10-28\ \mu$ long.

Adelaide (rrr), Bear (rr), Beaverdam (c), Birch (ss), Catherine (sss), Catfish (sss), Cranberry (sss), Devils (rrr), Diamond (ss), Duck (rr), Dummy (rr), Found (rrr), Half Moon (rrr), Horseshoe (s), Kawageusaga (rr), Lac du Flambeau (rrr), Mercer (ss), No Mans (ss), Rock (ss), Sanford (rrr), Shell (rr), Sishebogema (ss), Squirrel (rr), Tamarack (rr), North Turtle (rr).

There is considerable variation from the typical structure in this species. One type of variation includes cells with supplementary

spines on the apices of the semicells. These may range from a single extra apical spine on one of the two semicells (Figs. 10) to an extra spine at the lateral margin of both semicell apices. The highest development of this variation observed is shown in Figure 12 where there are two accessory spines arising at the same point. This suggests very strongly a transition to *X. hastiferum* Turner, but the great preponderance of typical *X. subhastiferum* in the collection shows that these specimens are not reduced forms of *X. hastiferum*.

The other type of variation is a reduction of the two spines at the lateral margin to a single spine. In most cases but one lateral margin of the semicell shows this reduction. In the rarer cases where the spines on both lateral margins of a semicell are reduced to a single spine the semicells have much the appearance of *Arthrodesmus convergens* Ehrenberg.

var. **TOWERI** (Cushman) G. M. Smith. Pl. 66, Figs. 13-18; Pl. 67, Figs. 1-3.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 346, pl. 10, figs. 9-13. 1922.

Semicells obversely subtriangular, sinus more open than in the type; ventral margin straight or curved, when curved much more tumid than the dorsal margin; spines much longer in proportion to the breadth of the semicell. (Euplankton.)

Cells 45-75 μ long with spines, 40-47 μ long without spines; 75-90 μ broad with spines, 39-45 μ broad without spines; isthmus 10-12 μ broad; thickness 24-26 μ ; spines 17.5-25 μ .

Carroll (s), Horseshoe (rrr), Shell (cc), Two Sisters (rrr).

This variety differs from the type in the greater proportionate length of the spines and in the difference between the dorsal and ventral margins of the semicells. There are the same variations in the presence of accessory apical spines or in the reduction of spines that are found in the type. The collections from Carroll lake were particularly interesting since they exhibited an almost complete series of transitions from the normal to a form that looks very much like *Arthrodesmus* or certain biradiate *Staurostrum* species.

var. **Johnsonii** (W. & G. S. West) comb. nov. Pl. 66, Figs. 4-7.

Xanthidium hastiferum var. *Johnsonii* W. & G. S. West, Jour. Linn. Soc. Bot. 33: 299. 1898.

Xanthidium antilopaeum var. *javanicum* Johnson non Nordstedt, Bull. Torr. Bot. Cl. 22: 295, pl. 239, fig. 10. 1895.

Semicells subsemicircular to subhexagonal, ventral margin with straight to tumid sides, apical margin strongly tumid, at times with median portion somewhat elevated; lateral margins with two, fairly stout, straight to strongly curved spines that lie in the same vertical

plane. Cell wall with a transverse to arcuate row of irregularly disposed subapical pores. (Facultative plankton.)

Cells 52–63 μ long with spines, 48–57 μ long without spines; 75–95 μ broad with spines, 48–53 μ broad without spines; isthmus 12.5–15 μ broad; spines 10–20 μ long.

Beaverdam (s), Lindy (rrr), Sand (rr), Silver (rrr).

The chief character of this variety, which Johnson erroneously referred to *X. antilopaeum* var. *javanicum* Nordstedt, is the rather irregular row of subapical pores. W. & G. S. West have considered this a variety of *X. hastiferum* Turner but as the accessory apical processes are of quite rare occurrence I feel that the variety belongs rather to *X. subhastiferum*. The peculiar cell shown in Figure 7 was found in the plankton of Beaverdam lake.

STAURASTRUM Meyen 1829.

Cells variable in size, with the length (without processes, spines or other appendages) generally somewhat greater than the breadth, median constriction usually deep though at times scarcely discernible, sinus generally acute-angled and isthmus narrow; semi-cells cylindrical, spherical, ellipsoidal, triangular, campanulate, cyathiform, hexagonal or variously shaped; with the cell wall smooth or punctate, without ornamentation or bearing granules, mucros, denticulations, simple to emarginate verrucae, spines, or combinations of these ornamentations; angles of a majority of the species continued in processes of variable length, though usually long, that in turn almost always have some sort of ornamentation and usually terminate in a truncate end with short divergent spines, at times with bifurcate ends that resemble spines; processes ordinarily arising in one whorl though sometimes in two transverse series of whorls. Vertical view at times with a bilateral symmetry though commonly with a radial symmetry; radially symmetrical species with triangular forms predominating though the 4–8 angled or radiate species not uncommon and with the number of angles as high as eleven in one whorl. Chloroplast generally with a simple axial mass containing one pyrenoid and with deeply incised lobes of variable size running to each angle of the cell, at times, especially in the larger species, with several pyrenoids in each lobe and with various irregularities; in very rare instances with parietal chloroplasts. Cells, particularly the plankton species, at times enclosed in a spherical gelatinous envelope.

Zygospores infrequently angular, usually spherical and with numerous conical elevations that are continued in long spines that have simple or furcate apices.

The genus comprises so many species of such variable shape that it is exceedingly difficult to describe it in anything but the most general terms. In spite of the groups of species which at first glance appear to have little in common with one another there are so many transition forms that it is impossible to break it up into a

number of subgenera. The simplest members of the genus resemble triangular *Cosmaria* that are without ornamentation, in fact it is impossible in certain cases to distinguish between varieties of *Cosmarium* species that are triangular in vertical view and *Staurastrum* species. These simple species lead up to those which have long spines at the angles and then to those which have spines or denticulations on both the angles and the cell body. The majority of the species have the cell angles continued in hollow processes, the triangular ones being the most numerous and probably the most typical for the genus. On one hand some of the triangular species have become compressed and form a group with a bilateral symmetry. On the other hand the radial symmetry of the species with more than three processes is very striking. The climax of development of processes is reached in those species in which there are two distinct whorls of processes on each semicell.

In addition to the close connection noted above between the simple *Staurastrum* species and *Cosmarium* there is also a close relationship between other *Staurastrum* species, particularly the biradial simple-spined species, and *Arthrodesmus*. The triradial varieties of one or two *Xanthidium* species also show a striking resemblance to *Staurastrum* species.

The genus is by far the most important one of the family in the plankton community. The total number of species and varieties found compares favorably with the total number of species of all the other genera of the Desmids, while the number of individuals observed is greatly in excess of all the other Desmids. It is in this genus that we find the largest number of forms which are true plankton organisms while many more that are known from the benthos seem to thrive even better under plankton conditions. In general the species with long processes, probably because of the greater buoyancy, seem best fitted for living in midlake, although some of the species without processes but with a conspicuous gelatinous envelope are also well equipped for the plankton.

KEY TO THE SPECIES.

(A) *Angles of cells not continued in hollow processes.*

(B) *Without spines at angles or on cell body.*

Cell wall smooth.

Isthmus not elongate.

Angles without mucros.

Ventral margin less rounded than the dorsal.

Cells small.....(3) *S. muticum*

Cells large.....(1) *S. grande*

Ventral margin more rounded than the dorsal.....(2) *S. subgrande*

Angles with mucros.....(4) *S. brevispinum*

Isthmus elongate.....(5) *S. pseudopachyrhynchum*

Cell wall with granules.

Lateral angles rounded.....(6) *S. alternans*

Lateral angles acute or truncate.

Vertical view with angles truncate.....(7) *S. denticulatum*

Vertical view with angles acute.

Angles with a single curved spine.....(9) *S. lunatum*

Angles with two divergent spines.....(8) *S. avicula*

(B) Cells with long spines at angles or on cell body.

Spines confined to angles.

Vertical view triangular.

Isthmus elongate.

Apex of semicells concave.

Vertical view with sides indented.....(10) *S. aristiferum*

Vertical view with sides not indented.....(11) *S. curvatum*

Apex of semicells convex.

Spines short and upwardly divergent.....(12) *S. dejectum*

Spines long and subparallel.....(13) *S. cuspidatum*

Isthmus not elongate.

Semicells transversely elliptic.....(15) *S. Dickiei*

Semicells obversely triangular.

Cells small and angles submamillate.....(16) *S. connatum*

Cells large and angles acute.....(14) *S. megacanthum*

Vertical view quadrangular.

Angles with a single spine.....(10) *S. aristiferum*

Angles with more than one curved spine.....(17) *S. quadrangulare*

Spines on angles and on body of semicells.

Spines all the same size.....(18) *S. breviaculeatum*

Spines of two sizes.

Median portion of cell apex without spines.

Semicells elliptic.....(20) *S. minnesotense*

Semicells hexagonal.....(21) *S. spiculiferum*

Median portion of cell apex with spines.....(19) *S. setigerum*

(A) Angles of cells continued in hollow processes.

(C) Processes in one whorl.

(D) Vertical view triangular.

Processes smooth(22) *S. brachiatum*

Processes variously ornamented.

Apex of semicells without verrucae.

Ends of processes with long divergent teeth.....(23) *S. pseudopelagicum*

Ends of processes with short teeth.

Semicell bases with a transverse ring of granules.....(24) *S. cingulum*

Semicell bases without transverse ring.....(25) *S. paradoxum*

Apex of semicells with verrucae.

Two verrucae on each side of cell.

Processes short(26) *S. protectum*

Processes long.

Ends with two long divergent spines.....(34) *S. lacustre*

Ends with short divergent teeth.

Processes subparallel(29) *S. floriferum*

Processes upwardly curved.....(30) *S. Bullardii*

More than two verrucae on each side of the cell.

With apical and subapical verrucae.

Two subapical verrucae on each cell side.....(31) *S. vestitum*

Four to seven subapical verrucae on each side.....(32) *S. anatinum*

With apical verrucae only.

Semicell base inflated and triangular.....(28) *S. longiradiatum*

Semicell base not triangular.....(27) *S. gracile*

(D) Vertical view not triangular.

(E) Semicells biradiate.

Semicells twisted at isthmus.

Cells very small.....(33) *S. tetracerum*

Cells of medium size.....(35) *S. contortum*

Semicells not twisted at isthmus.

Ends of processes all not in the same place..(40) *S. leptocladum* var. *sinatum*

Ends of processes all in same plane.

Apex without verrucae or spines.

Cell wall thicker in apical portion.....(37) *S. americanum*

Cell wall of uniform thickness.

Processes relatively short.....(33) *S. tetracerum* var. *validum*

Processes long.....(36) *S. chaetoceras*

Apex with verrucae or spines.

One spine or verruca on apex.....(40) *S. leptocladum*

More than one spine or verruca on apex.

Terminal spines of processes unequal.....(38) *S. grillatorium*
var. *forcipigerum*

Terminal spines of processes of same size.

Vertical view without a truncate projection.

Without ornamentation below apical verrucae.

3 apical verrucae.....(38) *S. grillatorium*

7-10 apical verrucae.....(39) *S. anchora*

With ornamentation below apical verrucae.....(41) *S. Johnsonii*

Vertical view with a truncate projection.

With a basal row of granules.

Processes straight.....(42) *S. natator*

Processes upwardly curved.....(40) *S. leptocladum* var. *insigne*

Without a basal row of granules.....(43) *S. urinator*

(E) Semicells with four or more processes.

Four processes on each semicell.

Outline of processes smooth.

Processes straight.

Cell body gradually fusing with processes.....(22) *S. brachiatum*

Cell body distinct at point of juncture.....(44) *S. subnudibrachiatum*

Processes with a knee-like bend.....(45) *S. inconspicuum*

Outline of processes not smooth.

Vertical view without emarginate verrucae.

Processes with concentric rings of granules.....(25) *S. paradoxum*

Processes without rings of granules..(47) *S. arachne* var. *curvatum* (p. p.)

Vertical view with emarginate verrucae.

Processes convergent.

Vertical view with four verrucae on cell body.....(49) *S. ankyroides*

Vertical view with several verrucae.....(46) *S. cerastes*

Processes subparallel to outwardly divergent.

Upper margin only of processes crenulate.....(48) *S. pentacerum*
var. *tetracerum*

Both margins crenulate.....(47) *S. arachne*

Five or more processes on each semicell.

Short processes with long terminal spines.....(55) *S. brasiliense* var. *Lundellii*

Long processes with short terminal teeth.

Processes upwardly divergent.

Cells of medium size.....(47) *S. arachne* var. *curvatum*

Cells large.....(52) *S. limneticum*

Processes subparallel to convergent.

Convergent processes.

Verrucae on cell body conspicuous....(49) *S. ankyroides* var. *pentacerum*

Verrucae on cell body inconspicuous.....(47) *S. arachne*

Subparallel processes.

Cell body without verrucae.....(53) *S. radians*

Cell body with verrucae.

Only upper margin of processes crenulate....(48) *S. pentacerum*

Both margins of processes crenulate.

Processes with transverse rings of granules.....(51) *S. rotula*

Processes with verrucae at base.....(50) *S. Ophiura*

C. Processes in two whorls.

Vertical view triangular.

Outline of processes smooth.

Processes short.....(54) *S. furcatum*

Processes long.....(56) *S. tohopekaligense*

Outline of processes not smooth.....(57) *S. furcigerum*

Vertical view circular.

Superior whorl with four bifurcate processes.....(58) *S. leptacanthum*

Superior whorl with six trifurcate processes.....(59) *S. Arctiscon*

1. STAUSTRUM GRANDE Bulnheim. Pl. 67, Figs. 8-9.

Hedwigia 1861: 51, pl. 9, fig. 14. 1861; W. & G. S. West, Monogr. Brit. Desm. 4: 140, pl. 119, figs. 11-13, pl. 120, fig. 1. 1912; Carter, Ann. of Bot. 34: 308, pl. 15, figs. 39-42. 1920.

Cells fairly large, length equal to or greater than the breadth, deeply constricted, sinus acute-angled, isthmus narrow; semicells transversely elliptic, with dorsal margin more rounded than the ventral, dorsal margin at times flattened at the apex, lateral angles rounded. Vertical view triangular, sides of cell body slightly concave, angles rounded to acutely pointed. Cell wall finely punctate. Chloroplast variable; with a small axial central mass and two large laminate blades to each angle of the cell; or without the central mass and a parietal arrangement; pyrenoids normally seven, one in the central mass and one in each blade, at times more numerous. (Tycho-plankton.)

Zygospores polygonal in profile, furnished with numerous stout, curved to straight spines that taper to an acute point (W. & G. S. West).

Cells 68 μ long; 60 μ broad at the base of the semicell, 28 μ broad at the apex; isthmus 14-15 μ broad.

Diameter of zygospores without spines 60 μ , with spines 100 μ (W. & G. S. West).

Bass (rrr), Devils (rrr).

The few specimens found in our lakes have more rounded angles than those from British lakes and they approach the variety *parvum* W. West in shape but not in size.

2. STAUSTRUM SUBGRANDE Borge.

Arkiv för Botanik 15, No. 13; 46, pl. 4, fig. 9. 1918.

Cells large, length 1.3–1.5 times the breadth, deeply constricted, sinus widely open and acute-angled; semicells transversely ovoid, with the ventral margin more rounded than the dorsal; lateral angles broadly rounded and without ornamentation. Vertical view triangular, with sides very slightly retuse and angles broadly rounded. Cell wall smooth.

Zygospores unknown.

Cells 76–83 μ long; 57–59 μ broad; isthmus 18.5–20 μ broad (Borge).

Not found in the plankton of Wisconsin lakes.

var. *minor* var. nov. Pl. 67, Figs. 10–12.

Cells about half the size of the type and somewhat broader in proportion to the length; dorsal margin of semicells much less rounded than the ventral. (Facultative plankton.)

Cells 36–40 μ long; 28–32 μ broad; isthmus 8–9 μ broad.

Devils (r).

3. STAUSTRUM MUTICUM De Brébisson. Pl. 67, Figs. 13–15.

in Meneghini, Linnaea 14: 228. 1840; Ralfs, Brit. Desm. 125, pl. 21, figs. 4A–4D; pl. 34, fig. 13. 1848; W. & G. S. West, Monogr. Brit. Desm. 4: 133, pl. 118, figs. 16–20. 1912.

Cells small, length and breadth about equal, deeply constricted, sinus open to sublinear, with an acute apex, isthmus narrow; semicells transversely elliptic, with the curvature of both margins the same or with the dorsal margin more rounded than the ventral; angles of semicells broadly rounded. Vertical view triangular, with sides markedly concave and angles broadly rounded. Cell wall smooth. (Tychoplankton.)

Zygospores spherical, armed with stout, comparatively short spines that are bifurcate at the distal end (De Brébisson).

Cells 27 μ long; 24–27.5 μ broad; isthmus 8.5 μ broad.

Diamond (rrr).

W. & G. S. West state that “both triangular and quadrangular vertical views are common” but I have observed only the triangular individuals. It may be distinguished from all other smooth-walled species without ornamentation by the size, the ratio between length and breadth, and by the shape of the semicells.

4. *STAURASTRUM BREVISPINUM* De Brébisson.

in Ralfs, Brit. Desm. 124, pl. 34, figs. 7A-7D. 1848; W. & G. S. West, Monogr. Brit. Desm. 4: 145, pl. 123, figs. 1-3. 1912.

Cells fairly small, length and breadth equal, deeply constricted, sinus open and with apex sublinear to acute, isthmus fairly narrow; semicells broadly elliptic, with ventral side more rounded than the dorsal, median portion of the strongly tumid ventral side truncate

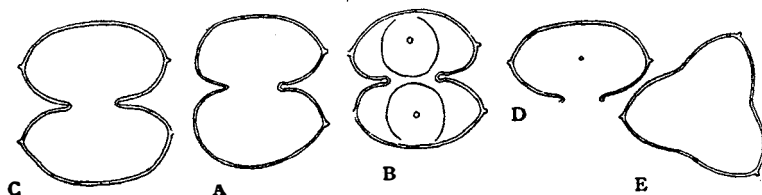


Fig. 7. *Staurastrum brevispinum* De Brébisson ($\times 600$). Plankton specimens from Irish lakes. Figs. A-B from Lough Corrib, Fig. C from Lough Leane, Figs. D-E from Lough Neagh. All from the G. S. West collection.

to very slightly retuse, lateral angles rounded and terminating in a small mucro. Vertical view triangular, sides of the cell body somewhat retuse and angles subacute to rounded; angles with a single rounded mucro. Cell wall smooth. Chloroplast axial, with a small central mass and two laminate arcuate arms running to each cell angle; pyrenoid single and central.

Zygospores unknown.

Cells 35-42 μ long; 35-42 μ broad; isthmus 10-13 μ broad.

Not found in the plankton of Wisconsin lakes.

The type of the species varies in the amount of curvature of the upper and lower halves of the semicells and the incurving of the sides of the cells when viewed from above. The mucro at the angles distinguishes the species from all others found in the state.

var. *BOLDTII* Lagerheim. Pl. 67, Figs. 16-17.

Nuova Notarisia 8: 163. 1893.

Staurastrum brevispinum forma Boldt, Öfvers. kgl. Sv. Vet.-Ak. Förh. 42, No. 2: 113, pl. 5, fig. 30. 1885.

Length of cells one and a quarter times the breadth, apical portion of sinus more linear than the type; apex of semicells more tumid. Vertical view triangular, with sides retuse. (Facultative plankton.)

Cells 40 μ long; 36-38 μ broad; isthmus 9 μ broad.

Shell (r).

Approaching the variety *alatum* W. & G. S. West, but with the curvature of the two sides of the semicells about the same.

var. *RETUSUM* Borge. Pl. 67, Figs. 18-19.

Bih. Kgl. Sv. Vet.-Ak. Handl. 19, Afd. 3, No. 5: 36, pl. 3, fig. 42. 1894.

Staurostrum brevispinum var. *Boldtii* forma *retusum* (Borge) W. & G. S. West, Monogr. Brit. Desm. 4: 148, pl. 123, fig. 6. 1912.

Cell shape as the foregoing but with the apices of semicells retuse in the median portion. (Facultative plankton.)

Cells 35-50 μ long; 38-40 μ broad; isthmus 11-12 μ broad.

Beaverdam (r), Fish (rrr), Sishebogema (rrr).

W. & G. S. West prefer placing the alga as a form of the variety *Boldtii* but I think it more logical to follow Borge in considering it a distinct variety.

var. *tumidum* var. nov. Pl. 67, Figs. 20-25.

Length of semicells about one and a half times the breadth, sinus widely open and acute-angled; semicells obsemicircular, with apices tumid and subtruncate in the median portion. Vertical view of cells triangular, with sides somewhat tumid (not retuse) and angles acute. (Euplankton?).

Cells 42-52 μ long; 32-41 μ broad; breadth of isthmus 11-13 μ .

Shell (ss).

When the cells are viewed from above the variety is sharply differentiated from the others of the species by the sharp angles and the outward swelling of the sides of the cells. It is the only variety in which the sides of the cells are not retuse. In the front view the proportions are different, no other variety having a length of one and a half times the breadth.

5. *STAURASTRUM PSEUDOPACHYRHYNCHUM* Wolle. Pl. 68, Figs. 1-3.

Desm. U. S. 125, pl. 51, figs. 32-35. 1884.

Cells small, length about equal to the breadth, deeply constricted, sinus open and with a broad rounded apex, isthmus elongate and fairly narrow; semicells rhomboidal-elliptic, with the dorsal margin convex and more tumid in the median region, lateral angles very broadly rounded. Vertical view triangular, with the sides strongly retuse and the angles broadly rounded. Cell wall smooth and of uniform thickness throughout. (Tycho plankton.)
Zygospores unknown.

Cells 32-34 μ long; 28-35 μ broad; isthmus 9-10.5 μ broad.

Dummy (rr).

The general shape of the cell is quite similar to *S. pachyrhynchum* Nordstedt but the cell wall does not have the thickening at the angles so characteristically present in *S. pachyrhynchum*. All of the specimens observed were triangular in vertical view.

6. *STAUSTRUM ALTERNANS* De Brébisson. Pl. 68, Fig. 4.

in Ralfs, Brit. Desm. 132, pl. 21, figs. 7A-7C. 1848; W. & G. S. West, Monogr. Brit. Desm. 4: 170, pl. 126, figs. 8-9. 1912.

Cells small, length about equal to the breadth, deeply constricted, sinus acute-angled and with apex subacute, isthmus narrow; semicells transversely elliptic, with the dorsal margin more flattened than the ventral, lateral angles broadly rounded; cell body with scattered granules that are arranged in concentric rings near the angles. Vertical view triangular, sides concave and angles rounded, the angles of one semicell alternating with those of the other. (Tycho plankton.)

Zygospores spherical, furnished with spines that are bifurcate at their apices (Ralfs).

Cells $35\ \mu$ long; $37\ \mu$ broad; isthmus $10\ \mu$ broad.

Speese (rrr).

7. *STAUSTRUM DENTICULATUM* (Nägeli) Archer. Pl. 68, Figs. 5-7.

in Pritchard, A History of Infusoria, 4th. Ed. 738. 1861; W. & G. S. West, Trans. Roy Irish Acad. 33: 103, pl. 11, fig. 11. 1906.

Phycastrum denticulatum Nägeli non Kützinger, Gatt. einz. Algen 128, pl. 8, fig. C3. 1849.

Cells small, breadth slightly greater than the length, fairly deeply constricted, sinus widely open and with apices fairly acute, isthmus narrow; semicells broadly triangular-ellipsoid, with ventral margin more strongly rounded than the dorsal, angles truncate and with two very short divergent spines, angles of semicells with two to four concentric rings of conical granules or short spines, the profile of the cell being distinctly scalloped between the spines; median portion of cell body smooth. Vertical view triangular, with sides strongly retuse and angles truncate and bearing two short divergent spines; central portion of cell body smooth, angles with two to four transverse rings of denticulations. Chloroplast with a small central mass and two laminate plates running to each angle of the cell; pyrenoid single and central. (Facultative plankton.)

Zygospores unknown.

Cells $26-29\ \mu$ long; $32-34\ \mu$ broad with spines, $28-32\ \mu$ broad without spines; isthmus $10\ \mu$ broad; spines $1.5-2\ \mu$ long.

Beaverdam (rr), Lac Court Oreilles (sss).

Differing from *S. avicula* De Brébisson in the fewer concentric rings of granules at the angles of the cells and the shape of the semicells. The angles in the vertical view are distinctly truncate and bear two spines (four in an end view), while in the vertical view of *S. avicula* the angles are sharp and bear a single spine (two in an end view).

Irish specimens examined in the G. S. West collection have one or two more rings of granules at the angles of the semicells than do the Wisconsin specimens, but this difference is of little importance.

8. *STAUSTRUM AVICULA* De Brébisson. Pl. 68, Figs. 8-10.

in Ralfs, Brit. Desm. 140, pl. 23, figs. 11A-11B. 1848.

Cells small, length about three quarters the breadth, deeply constricted, sinus widely open and apex with acute angles, isthmus fairly narrow; semicells obversely triangular, with the dorsal margin somewhat inflated; superior angles truncate and with two very short divergent denticulate spines; body of semicell with scattered granules in the central portion of the apex and the granules in concentric rings in the region of the angles. Vertical view triangular, with the sides slightly retuse and the angles acute, angles terminating in two short spines that lie in the same vertical plane (usually only one visible). Chloroplast axial, with a small central body and two arcuate lobes running to each angle of the cell; pyrenoid single and central. (Facultative plankton.)

Zygospores unknown.

Cells $31\ \mu$ long; $37\ \mu$ broad with spines, $31\ \mu$ broad without spines; isthmus $10\ \mu$ broad; spines 2-3 μ long.

Bear (rrr), Duck (sss), Horseshoe (rrr), Shell (rr).

9. *STAUSTRUM LUNATUM* Ralfs.

Brit. Desm. 124, pl. 34, figs. 12A-12B. 1848; W. West, Jour. Linn. Soc. Bot. 29: 173. 1892.

Cells small, breadth (without spines) slightly greater than the length, deeply constricted, sinus acute-angled, isthmus fairly broad; semicells obsemicircular, with apex convex; angles of semicells with a single stout upwardly curved spine. Vertical view triangular, with angles rounded and bearing a straight stout spine at each angle; sides of cell retuse. Cell wall punctate-granulate.

Zygospores unknown.

Cells $25\ \mu$ long without spines; $36\ \mu$ broad with spines, $30\ \mu$ broad without spines; isthmus $12.5\ \mu$ broad (W. West).

Not found in the plankton of Wisconsin lakes.

var. *PLANCTONICUM* W. & G. S. West. Pl. 68, Figs. 11-13.

Jour. Linn. Soc. Bot. 35: 546, pl. 16, figs. 11-12. 1903.

Cells somewhat larger and broader than the type; angles of semicells more arcuate in front view and with terminal spine much smaller; cell wall finely granulate, with granules in concentric rings near the angles but scattered in the central portion of the cell. Vertical view with lateral margins very slightly retuse. (Euplankton.)

Cells $35\ \mu$ long; breadth with spines $45-54\ \mu$, without spines $40-48\ \mu$; isthmus $10-12.5\ \mu$ broad; spines $2.5-4\ \mu$ long.

Chain (rr), Clear Crooked (rr), Cranberry (rrr), Found (rrr), Granite (r), Lac Court Oreilles (r).

The upwardly curved short spines at the angles of the semicells combined with the granulate cell wall distinguish this species. The variety has shorter spines and a more regular arrangement of the granules.

10. *STAURASTRUM ARISTIFERUM* Ralfs.

Brit. Desm. 123, pl. 21, figs. 2A-2B. 1848.

Cells of medium size, length (without spines) slightly greater than the breadth, deeply constricted, sinus widely open and with a rounded apex, isthmus elongate and narrow; semicells obversely triangular, with dorsal margins somewhat retuse and ventral margins indented midway between the isthmus and the apex; angles mamillate and

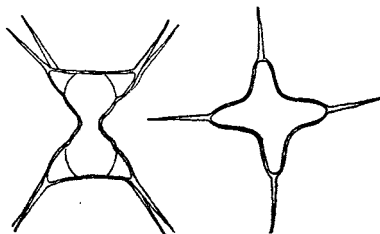


Fig. 8. *Staurastrum aristiferum* Ralfs ($\times 625$). From plankton specimens collected in Capel Curig lakes, Wales, by W. & G. S. West.

terminating in long delicately tapering spines with acute apices, spines outwardly divergent. Vertical view quadrangular (rarely triangular), with sides strongly retuse, angles rounded and bearing a single straight delicately tapering spine. Cell wall smooth.

Zygospores unknown.

Cells $58\ \mu$ long with spines, $27.5\ \mu$ long without spines; breadth $45\ \mu$ with spines, $25\ \mu$ without spines; isthmus $6\ \mu$ broad; spines 15 – $18\ \mu$ long.

Not found in the plankton of Wisconsin lakes.

var. *indentatum* var. nov. Pl. 68, Figs. 14-17.

Cells smaller than the type, isthmus narrower and not elongate; ventral margin of semicells slightly tumid and smooth in outline, angles mamillate. Vertical view triangular, sides slightly concave and with a sharp indentation midway between the angles. (Euplankton.)

Cells 35 – $44\ \mu$ long with spines, 20 – $22\ \mu$ long without spines; breadth 46 – $52\ \mu$ with spines, 22 – $25\ \mu$ without spines; isthmus 5 – $6.5\ \mu$ broad; spines 15 – $18\ \mu$ long.

Devils (r).

The typical *S. aristiferum* differs from other *Staurastrum* both in the indentation of the ventral margins of the semicells in the front view and in the indentation of the sides in the vertical view. This variety has the indentation in the vertical but not in the front view. It might well be placed with other species bearing a single spine at each angle of the semicells but the indentation of the cell shows that it belongs to *S. aristiferum*.

11. *STAUSTRUM CURVATUM* W. West. Pl. 69, Figs. 4-9.

Jour. Linn. Soc. Bot. 29: 172 pl. 22, fig. 13. 1892; W. & G. S. West, *ibid.* 35: 543, pl. 17, fig. 12. 1903.

Cells of medium size, length (with spines) somewhat less than the breadth, deeply constricted, sinus widely open and with apex very blunt and rounded (semicircular), isthmus narrow, elongate and subrectangular; semicells obversely subtriangular to sublunate, ventral margins slightly convex, dorsal margins concave; angles fairly sharp and continued in long stout straight spines that taper to a sharp point, spines strongly divergent. Vertical view triangular, sides of cells retuse and angles acute; angles each bearing a long stout gradually attenuated spine. Cell wall smooth. Chloroplast having a fairly massive triangular central mass with two parallel laminate blades running to each angle of the cell; pyrenoid single and central. (Euplankton.)

Zygospores unknown.

Cells 52-56 μ long with spines, 25-28 μ long without spines; breadth 64-80 μ with spines, 28-38 μ without spines; isthmus 7.5-8.5 μ broad; spines 21-25 μ long.

Dummy (ss).

Resembling *S. megacanthum* Lundell but differing in the smaller size of the body of the cell, the more divergent spines, and the rounded apex of the sinus.

var. *elongatum* var. nov. Pl. 69, Figs. 10-15.

Cells with isthmus elongate and cylindrical; incurving of semicell apices more pronounced. Vertical view with sides of the cell more retuse. (Euplankton.)

Cells 40-50 μ long with spines, 25-29 μ long without spines; breadth with spines 56-70 μ , without spines 25-33 μ ; isthmus 6-7 μ broad; spines 17.5-25 μ long.

Blue Gill (rrr), Carroll (sss), Lindy (sss).

This variety has an elongation of the isthmus that is comparable to the elongation of the isthmus of *S. cuspidatum* De Brébisson. It is readily distinguished from *S. cuspidatum* by the side of the cells and by the arrangement of the spines. The sides of the cells in a vertical view of the variety are more incurved than those of the type and as a result the body of the cell has a more delicate appearance.

12. *STAUSTRUM DEJECTUM* De Brébisson. Pl. 68, Figs. 18-24.

in Meneghini, *Linnaea* 14: 227. 1840; Ralfs, *Brit. Desm.* 121, pl. 20, figs. 5A-5M. 1848.

Cells fairly small, length (without spines) about equal to the breadth, deeply constricted, sinus acute-angled and with the apex

broadly rounded, isthmus narrowly elongate and subrectangular; semicells obversely subsemicircular, with dorsal margin slightly tumid, angles acute to rectangular and furnished with a single short acute spine, spines strongly outwardly divergent (suberect). Vertical view triangular, sides of cell retuse in median portion, angles acute, furnished with a single short straight acute spine. Cell wall smooth. Chloroplast with a small central mass and two conspicuous laminate blades leading to each angle of the cell; pyrenoid single and central. (Facultative plankton.)

Zygospores spherical, furnished with numerous stout straight spines with broad bases and rounded apices (Ralfs).

Cells 25–32 μ long with spines, 25–28 μ long without spines; breadth 29–41 μ with spines, 24–32 μ without spines; isthmus 5.5–6.5 μ broad; spines 2.5–5 μ long.

Zygospores 36 μ in diameter, spines 12–20 μ long (Ralfs).

Carson (r), Lac du Flambeau (rrr), Big McKenzie (rrr), Middle McKenzie (rrr), Mud (rr), Travis (sss).

The distinctive features of this species are the elongate isthmus and the upwardly slanting, comparatively small spines. In the elongate isthmus it resembles *S. cuspidatum* De Brébisson but the length of the spines and broader semicells readily distinguish the two. The cell shape is somewhat variable and at times the peculiar isthmus does not stand out as prominently as in Ralfs' figures.

var. INFLATUM W. West. Pl. 68, Figs. 25–26.

Jour. Linn. Soc. Bot. 29: 170, pl. 22, fig. 11. 1892; W. & G. S. West, Trans. Roy. Irish Acad. 32: 44, pl. 2, fig. 23. 1902.

Cells somewhat larger, sinus with a fairly acute apex and isthmus not elongate; apex of semicells more tumid. Vertical view with very short spines at angles and with sides more retuse. (Tychoplankton.)

Cells 31–34 μ long; breadth with spines 36–41 μ , without spines 31–35 μ ; isthmus 6–7 μ broad; spines 2–4 μ long.

Fish (rrr).

Differing from the type in the lack of elongation at the isthmus and the rounded dorsal margins of the semicells. The short outwardly divergent spines and ventral sides of the semicells are like those of *S. dejectum* so that the variety is well placed although it does not have the characteristic isthmus.

13. STAUSTRUM CUSPIDATUM De Brébisson. Pl. 68, Figs. 27–34.

in Meneghini, Linnaea 14: 226. 1840; Ralfs, Brit. Desm. 122, pl. 21, figs. 1A–1E; pl. 33, fig. 10. 1848.

Cells small, breadth (with spines) about twice the length, deeply constricted, sinus widely open and with apex broadly rectangular, isthmus narrow, rectangular, greatly elongated; semicells obversely

triangular, with ventral margins slightly convex and dorsal margins convex to slightly concave; lateral angles acute and furnished with a single, medium-sized, acutely pointed, straight spine; spines usually subparallel, though at times somewhat convergent or divergent. Vertical view triangular (very rarely quadrangular), with sides of cells retuse in the median portion; angles acute, furnished with a simple straight spine. Cell wall smooth. Chloroplast triangular in outline, fairly massive, with two parallel laminate lobes running to each angle of the semicell; pyrenoid single and central. (Facultative plankton.)

Zygospores spherical, with several mamillate projections, each terminating in a short stout spine (Ralfs).

Cells 23–28 μ long; breadth with spines 42–53 μ , without spines 19–26 μ ; breadth isthmus 5 μ ; length of spines 15–20 μ .

Diameter of zygospores 30 μ (Ralfs).

Beaverdam (rrr), Big Bass (rr), Bird (rrr), Chain (sss), Clare (rrr), Crawling Stone (rr), Devils (rr), Duck (rr), Dutchmans (rrr), Grindstone (rrr), Half Moon (rrr), Horseshoe (r), Jag (rrr), Lac Court Oreilles (rrr), Lac du Flambeau (rrr), Little Bass (rrr), Little Doctor (rrr), Lost (rr), Big McKenzie (rr), Mercer (rrr), Mud (rr), Muskallonge (rr), Nicaboyne (rrr), Owen (ss), Sishebogema (rr), Tank (sss), Travis (rrr), Whitefish (sss), Wolf (rrr).

The species can be distinguished at once from other triradiate species with a single spine at each angle of the semicells by the smaller size and the elongate isthmus.

var. CANADENSE G. M. Smith. Pl. 69, Figs. 1–3.

Trans. Wis. Acad. Sci. Arts & Letts. 20: 349, pl. 10, figs. 23–24. 1922.

Cells with a distinct indentation at the point of union of the two semicells; spines usually divergent. (Euplankton.)

Cells 37–39 μ long with spines, 26–32 μ long without spines; breadth 53–58 μ with spines, 21–23 μ without spines; isthmus 5 μ broad; spines 18–22 μ long.

Clear Crooked (rr).

14. STAURASTRUM MEGACANTHUM Lundell. Pl. 69, Figs. 16–21.

Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser. 8: 61, pl. 4, fig. 1. 1871.

Cells of medium size, about as long as broad (without spines), deeply constricted, sinus acute-angled to subrectangular, with an acute apex; semicells obversely triangular, with apex generally tumid, rarely straight; lateral margins of cells straight to slightly convex, angles with a single stout straight elongate spine; spines usually subparallel, rarely subdivergent. Cell wall smooth to finely punctate. Vertical view triangular, with sides somewhat retuse in the central portion, angles acute and with a single stout straight spine. (Facultative plankton.)

Zygospores unknown.

Cells 36–46 long with spines, 36–40 μ long without spines; breadth with spines 58–72 μ , without spines 41–49 μ ; breadth of isthmus 10–11.5 μ ; spines 12.5–17 μ long.

Adelaide (r), Bass (rr), Little Bass (rrr), Bear (rrr), Crooked (sss), Devils (rrr), Diamond (r), Duck (rrr), Dummy (sss), Grindstone (rrr), Jenny (rr), Jones (rrr), Lac Court Oreilles (ss), Lindy (rr), Lynx (rr), Nicaboyne (rrr), Reserve (sss), Sanford (rrr), Tank (rrr), Turtle (rr), Whitefish (cc).

The species should be compared with *S. dejectum* De Brébisson, *S. Dickiei* Ralfs, and *S. curvatum* W. West. It differs from all of them in the stouter spines at the angles, in size and in shape of the cells. Lundell states that there are both triangular and quadrangular members of the species but I have observed the triangular specimens only in the plankton of Wisconsin lakes.

var. SCOTICUM W. & G. S. West. Pl. 69, Figs. 22-24; Pl. 70, Figs. 1-2.

Jour. Linn. Soc. Bot. 35: 544, pl. 16, fig. 8. 1903.

S. megacanthum forma Borge, Bot. Not. 1897: 213, pl. 3, fig. 7. 1897.

Sinus subrectangular to obtuse-angled, isthmus proportionally narrower; apices of semicells generally concave, rarely straight; spines at angles longer and always divergent. Vertical view with sides of cells more retuse. (Euplankton.)

Cells 47-54 μ long with spines, 36-38 μ long without spines, breadth 67-82 μ with spines, 40-46 μ without spines; isthmus 8-10 μ broad; spines 20-25 μ long.

Bass (sss), Diamond (r), Horseshoe (rr), Jones (r), Little Doctor (rrr), Meta (rr), Shell (c).

The variety is more graceful than the type and differs in having concave apices of the semicells and longer spines.

15. STAUSTRUM DICKIEI Ralfs.

Brit. Desm. 123, pl. 21, figs. 3A-3B. 1848; W. West, Jour. Linn. Soc. Bot. 29: 171. 1892; G. S. West, Brit. Freshw. Algae 141, figs. 52A-52C. 1904.

Cells fairly small, breadth (with spines) about one and a quarter times the length, deeply constricted, sinus sublinear, opening outwards and with an acute apex, isthmus narrow; semicells transversely elliptic, the dorsal margin somewhat more tumid than the ventral margin, angles furnished with a single short stout acute spine, spines strongly convergent. Vertical view triangular, with sides of cells somewhat retuse and angles rounded and furnished with a short stout straight spine. Cell wall smooth.

Zygospores spherical, clothed with fairly numerous straight spines with acutely pointed apices (G. S. West).

Cells 35 μ long; breadth with spines 42 μ , without spines 29 μ ; isthmus 6 μ broad (W. West).

Not found in the plankton of Wisconsin lakes.

var. MAXIMUM W. & G. S. West. Pl. 70, Figs. 3-5.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 72, pl. 8, fig. 19. 1895; *ibid.* 255, pl. 18, fig. 13. 1896.

Cells about twice the size of the type, sinus acute-angled and with an acute apex; semicells more narrowly elliptic and with the curvature of dorsal and ventral margins the same; spines at angles stout, fairly long, and strongly convergent. (Tychoplankton.)

Cells 44–47.5 μ long; breadth with spines 62–72 μ , without spines 45–53 μ ; breadth of isthmus 12 μ ; spines 12–14 μ long.

Beaverdam (rrr), Fish (rr).

The dimensions of the alga as I have found it are those given by W. & G. S. West for the plant as originally discovered in Madagascar and not as they found it in North America. Like their North American specimens, however, the spines are strongly convergent and not recurved. The specimens from Beaverdam Lake (Fig. 5) were slightly smaller than those from Fish Lake (Figs. 3–4) but the stoutness of the spines and the open sinus show that they belong to the variety and not to the type.

16. STAUSTRUM CONNATUM (Lundell) Roy & Bisset.

Jour. of Bot. 24: 237. 1886.

Staustrum dejectum var. *connatum* Lundell, Nova Acta Reg. Soc. Upsaliae 3 Ser., 8: 60, pl. 3, fig. 28. 1871.

Cells small, length (without spines) about equal to the breadth, deeply constricted, sinus widely open and acute-angled; semicells obsemicircular, ventral margins rounded and apex slightly retuse; superior angles submamillate and bearing a single straight fairly short delicate spine, spines strongly divergent. Vertical view triangular, sides of cells slightly retuse and angles rounded, angles with a single short spine. Cell wall smooth.

Zygospores unknown.

Cells 22.4 μ long without spines; 21 μ broad without spines; isthmus 6.6 μ broad; spines 8–13 μ long (Lundell).

Not found in the plankton of Wisconsin lakes.

var. RECTANGULUM Roy & Bisset. Pl. 70, Figs. 6–7.

Jour. of Bot. 24: 237, pl. 268, fig. 12. 1886.

Sinus subrectangular and with a subacute apex; ventral margins of semicells only slightly rounded and angles less mamillate. (Facultative plankton.)

Cells 28 μ long with spines, 17.5 μ long without spines; breadth 31–32.5 μ with spines, 17 μ without spines; breadth of isthmus 4.5 μ ; spines 6–7.5 μ long.

Pine Tree (r).

The isthmus of the specimens that I have collected is less rectangular than Roy and Bisset show in their figure. The alga shows considerable resemblance to *S. cuspidatum* var. *divergens* Nordstedt but the isthmus is far too short for *S. cuspidatum*.

17. *STAUSTRUM QUADRANGULARE* De Brébisson forma. Pl. 70,
Figs. 8-9.

in Ralfs, Brit. Desm. 128, pl. 22, figs. 7A-7C; pl. 34, figs. 11A-11B. 1848;
W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 257, pl. 16, figs. 16-17.
1896; Borge, Arkiv för Botanik 1: 108, pl. 4, fig. 17. 1903.

Cells small, length about equal to the breadth, median constriction fairly deep, sinus subrectangular and with a blunt apex; semicells rectangular, with apex and lateral margins straight, lateral margin with a short curved spine at the superior and inferior angles, spines outwardly divergent; apex with a short perpendicular spine just within each lateral margin. Vertical view quadrangular, with strongly retuse sides and flattened emarginate corners each bearing two curved spines, basal portion of the semicell extending beyond the truncate angle, rounded, and with a single straight spine. (Tycho-plankton.)

Zygospores unknown.

Cells $27.5\ \mu$ long with spines, $22\ \mu$ long without spines; breadth with spines $25\ \mu$, without spines $20\ \mu$; breadth isthmus $10\ \mu$.

Lindy (rrr).

But two cells of this alga have been seen and although they undoubtedly belong to the species they do not agree precisely with any published figures.

18. *Staurostrum breviaculeatum* sp. nov. Pl. 70, Figs. 10-18.

Cells small, length and breadth about equal, deeply constricted, sinus acute-angled and with apex subacuminate, isthmus narrow; semicells transversely elliptic, dorsal margin sometimes flattened in the median portion; lateral angles broadly rounded and bearing four short quadrately arranged divergent spines; cell body with two transverse rows of 4-7 spines, the lower row half way between the isthmus and the cell apex, the upper midway between the lower row and the apex; cell apex with median portion bare and with margins towards the angles with 3-4 outwardly pointing spines. Vertical view triangular, sides of cells emarginate and angles broadly rounded and bearing four quadrately arranged short divergent spines; center of cell body with a triangular ring of spines, the sides of the triangle lying parallel to the margins of the cell and each side composed of three outwardly facing spines, angles of the central triangle connected to the corresponding angle of the cell by a short row of spines; lateral margins of cells with 6-8 erect spines and a second arcuate intramarginal row of spines that are of similar size and arrangement; outline of cell slightly emarginate between adjacent spines. Chloroplast with a small central mass and two laminate blades running to each angle of the cell; pyrenoid single and central. (Euplankton.)

Zygospores unknown.

Cells $38-46\ \mu$ long with spines, $36-42\ \mu$ long without spines; breadth with spines $37-55\ \mu$, without spines $34-44\ \mu$; isthmus $9-13\ \mu$ broad; spines $2-5\ \mu$ long.

Bass (rrr), Devils (rrr), Speese (rrr), Sunday (rrr), Tank (rrr), Travis (r).

This species is related to the *Staurastrum teliferum-setigerum* group of species but differs in having the spines at the angles shorter and the same size as those of the cell body. The regular arrangement of the spines on the cell body in the vertical view is also more pronounced in this species.

The spines in the few specimens from Tank lake were much smaller than those from the other lakes but they were arranged in the same regular pattern (Figs. 16-18).

19. *STAURASTRUM SETIGERUM* Cleve. Pl. 70, Figs. 19-25.

Öfvers. Kgl. Sv. Vet.-Ak. Förh. 20: 490, pl. 4, fig. 4. 1864; Lundell, Nova Acta Reg. Soc. Sci. Upsaliae 3 ser., 8: 64, pl. 4, fig. 3. 1871; Roy & Bisset, Ann. Scottish Nat. Hist. 1893: 243, pl. 3, fig. 9. 1893.

Cells of medium size, length (without spines) equal to the breadth, deeply constricted, sinus open but with an acute apex, isthmus narrow; semicells subelliptic, with the central portion of the rounded apex flattened, lateral margins truncate and with two stout divergent spines; dorsal margin with a stout spine near the angles and four more delicate spines on the apex; face of semicells with a transverse row of long delicate spines. Vertical view triangular, with the sides retuse and the angles acute; angles with three stout spines in the same vertical plane, two at the angle and one a short distance back from the angle; sides with four more delicate spines of the same length on each lateral margin, margin retuse between spines; body of semicells with another curved row of similar spines within the margin and one or two spines continuing the line formed by the stout spines on the angles. Chloroplasts axial, with a small central mass and lobes very deeply incised to form two arcuate plates that run to each angle; pyrenoid single. (Facultative plankton.)

Zygospores unknown.

Cells 52-57 μ long with spines, 42-48 μ long without spines; breadth with spines 60-67 μ , without spines 42-55 μ ; breadth of isthmus 11.5-12.5 μ ; length of stout spines 8-13 μ , of delicate spines 5-11 μ .

Beaverdam (sss), Fish (s), Nicaboyne (rrr).

The vertical view of this species shows more of the distinctive features than does the front view. The three stout spines forming a vertical row at the angle and the four delicate spines on each margin are quite constant features. The arrangement of the spines within the margin is subject to considerable variation and the description of their arrangement given above is found only in symmetrically developed specimens; the number of interior spines is also subject to variation. An atypical specimen is shown in Figure 24 where there are accessory stout spines at the angles and a large number of spines at the center of the cell.

var. OCCIDENTALE W. & G. S. West. Pl. 71, Figs. 1-4.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 260, pl. 16, fig. 27. 1896.

Cells somewhat smaller; semicells narrowly elliptic and with apices more flattened; stout spines at angles as in the type; delicate spines on the face of the semicells reduced to one near each angle. Vertical view with more rounded angles and margins with but two delicate spines on each side of the cell; central portion of the cell with fewer and more scattered spines. (Facultative plankton.)

Cells 41-45 μ long with spines, 32-33 μ long without spines; breadth with spines 57-63 μ , without spines 41-42 μ ; breadth of isthmus 11.5-12.5 μ ; stout spines 10-12.5 μ long, slender spines 4-9 μ long.

Lac Court Oreilles (ss), Reserve (rrr).

The semicells of this variety are more compressed in the front view than are those of the type. In a vertical view, aside from the more rounded angles, the occurrence of only two delicate marginal spines on each side is the most striking feature. In this respect the cells show a great resemblance to *S. subteliferum* Roy & Bisset, but the semicells of the two are quite different in front view.

var. PECTINATUM W. & G. S. West. Pl. 71, Figs. 5-8.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 260, pl. 16, fig. 28. 1896.

Cells with approximately the same shape and size as the type but with longer spines. Vertical view having delicate marginal spines confined to the angles and spines at the center of the cell more numerous. (Facultative plankton.)

Cells 56-60 μ long with spines, 45-49 μ long without spines; breadth with spines 58-66 μ , without spines 44-49 μ , breadth of isthmus 12.5-17 μ ; length of stouter spines 6.5-12.5 μ , length slender spines 5-9 μ .

Dummy (rrr), Owen (rrr), Horseshoe (rrr), Big St. Germain (rrr), Sand (ss).

W. & G. S. West give only a front view of this variety so that determination of the variety is somewhat doubtful.

var. BREVISPINUM G. M. Smith. Pl. 71, Figs. 9-13.

Trans. Wis. Acad. Sci. Arts & Lett. 20: 350, pl. 11, figs. 6-8. 1922.

Cells smaller, length and breadth about equal, sinus acute-angled and with an acute apex; semicells narrowly elliptic and with lateral margins flattened; lateral margins with four stout spines that are quadrately arranged and with one or two stout spines on the dorsal margin just back of the lateral spines; body of semicell with two transverse rows of smaller spines. Vertical view triangular, with angles rounded and sides very slightly concave; margin of cell bearing 5-6 more delicate and shorter spines and with portion between each pair of spines concave, body of cell with a second arcuate row

of spines within each margin, center with a ring of spines and a row of spines leading to each angle or with the rows only and the ring missing. (Euplankton.)

Cells 39–41 μ long; breadth with spines 42–53 μ , without spines 35–40 μ ; isthmus 12–14 μ broad; stout spines 5–7.5 μ long, slender spines 3–7 μ long.

Carroll (r).

This might be considered a distinct species but the arrangement of the spines and the two sizes of spines is that of *S. setigerum*. The variety also differs in the quadrispinate endings of the angles of the semicells.

20. STAUSTRUM MINNESOTENSE Wolle. Pl. 71, Figs. 14–15.

Bull. Torr. Bot. Cl. 12: 6, pl. 47, figs. 7–8. 1885; Freshw. Algae of U. S. 43, pl. 57, figs. 7–8. 1887; W. & G. S. West, Trans. Linn. Soc. Bot. 2nd. Ser. 5: 260, pl. 18, fig. 15. 1896.

Cells large, length and breadth about equal, deeply constricted, sinus widely open and with a more or less rounded apex, isthmus relatively narrow; semicells broadly elliptic, generally with the dorsal margin more tumid than the ventral, lateral angles each furnished with two long stout divergent spines that lie in the same vertical plane; face of the semicell with a second series of more delicate long spines, one just inside of each angle and two just below the apex. Vertical view triangular, with median portion of sides of the cells slightly retuse to slightly tumid and the portion near the angles straight; angles sub-rectangular to obtuse, terminating in two long stout spines that lie in the same vertical plane; each side of the cell with a single long delicate spine perpendicular to the cell wall that lies on the margin a short distance from the angle and with another similar intramarginal spine within each spine at the margin. Cell wall coarsely punctate. (Tychoplankton.)

Zygospores unknown.

Cells 145 μ long with spines, 125 μ long without spines; breadth of cells with spines 172 μ , without spines 112 μ ; isthmus 42.5 μ broad; stout spines 25–32 μ long, slender spines 25–28 μ long.

Muskallonge (rr).

This handsome Desmid cannot be confused with any other species. It is the only one with spines of two sizes which has punctate walls and anywhere near this size. The arrangement of the spines, particularly in the vertical view, is also unique. W. & G. S. West have called attention to certain inaccuracies in the drawings of Wolle and my observations on Wisconsin specimens confirm their statement that the angles in a vertical view of the cell are not nearly so sharp as Wolle shows them. There is some variation in the size and length of the spines but the two terminal spines at the angles are always stouter than the other four. Certain of the slender spines may also be lacking

so that the symmetrical arrangement of three pairs of spines at each angle is not found in every case.

21. *Staurastrum spiculiferum* sp. nov. Pl. 71, Figs. 16-20.

Cells fairly small, length (without spines) slightly greater than the breadth, deeply constricted, sinus acute-angled and with an acute apex, isthmus narrow; semicells hexagonal-rectangular, with the dorsal margin subconvex to subconcave; lateral angles broadly truncate and with the truncate faces somewhat convergent towards the isthmus; semicells ornamented with delicate spines of two different lengths, superior and inferior angles of lateral margin with a single long spine, the two spines diverging, cell apex with a shorter spine within each lateral margin and face of semicells with a similar spine near each lateral margin. Vertical view triangular, median portion of the sides with a slight truncate elevation; angles subrectangular and bearing two long straight spines that lie in the same vertical plane, cell margins with a single short vertical spine near each angle and two similar short spines within each angle. Cell wall finely punctate. (Euplankton.)

Zygospores unknown.

Cells 29-45 μ long with spines, 23-25 μ long without spines; breadth with spines 30-40 μ , without spines 20-24 μ ; breadth at isthmus 6.5-8.5 μ ; length of spines at angles 5-12.5 μ , length interior spines 3.5-5 μ .

Pine Tree (r). Long (rr).

In the shape of the cell the species has a certain resemblance to *S. quadrangulare* De Brébisson but the spines are much too fine for the alga to be considered a variety of *S. quadrangulare*. In the spines of two sizes, as well as in the arrangement of the spines it resembles *S. minnesotense* Wolle, but the shape of the cells and the sizes of the two algae are quite different.

The spines of the alga in the specimens from Long lake were shorter than those from Pine Tree lake and there were at times three long spines at the angles of the cells, two inferior and one superior spine.

22. *STAUSTRUM BRACHIATUM* Ralfs. Pl. 72, Figs. 1-4.

Brit. Desm. 131, pl. 23, figs. 9A-9G. 1848; Eichler, Pamietnik Fizyograficzny 12: 164, pl. 10, fig. 37. 1893; W. & G. S. West, Jour. Roy. Micr. Soc. 1896: 159, pl. 4, figs. 53-56. 1896; G. S. West, Jour. Linn. Soc. Bot. 34: 391, pl. 11, figs. 5-15. 1899.

Cells small, length (with processes) about equal to the breadth, deeply constricted, sinus widely open, with apex rounded to acute, isthmus relatively broad; semicells obversely triangular, with the ventral margins straight to slightly convex and the dorsal margins somewhat concave; angles continued in short hollow processes, the line of demarcation between cell body and processes very indistinct, processes terminating in three (rarely two) blunt teeth with rounded ends.

Vertical view triangular (rarely quadrangular), with sides retuse and the angles continued in broad processes, processes of one semicell usually alternating with those of the other. Cell wall smooth and without ornamentation. Chloroplast axial, with two lobes running to the end of each process; pyrenoid single and central. Cells frequently imbedded in a copious spherical gelatinous envelope with a radially fibrillar structure. (Facultative plankton.)

Zygospores pentahedral to octohedral, with sides straight; angles rectangular and continued in blunt spines (Ralfs, Eichler) or angles rounded and spines scarcely visible (W. & G. S. West).

Cells 28–35 μ long with processes, 15–17.5 μ long without processes; breadth with processes 27.5–34 μ ; breadth at isthmus 8–9 μ .

Carroll (rrr), Dummy (s), Little Bass (rrr).

G. S. West has discussed the variation of this species and states that the processes may be long and somewhat tapering or short and blunt. The apices may be either bi- or trifurcate and with the furcations ranging from a rather long incision (usually in the individuals with bifurcate processes) to small rounded knobs that show but little furcation.

23. *STAUSTRUM PSEUDOPELAGICUM* W. & G. S. West. Pl. 72,
Figs. 5–7.

Jour. Linn. Soc. Bot. 35: 547, pl. 18, *figs.* 1–3. 1903; Trans. Roy. Soc. Edinburgh 41: 504. 1905.

Cells fairly small, length (without processes) about twice the breadth, deeply constricted, sinus widely open to acute-angled and with an acuminate apex, isthmus narrow; semicells obversely semicircular to subtriangular, with apices flattened to convex; angles of semicells prolonged into long divergent processes that have their apices terminating in two or three long outwardly curved and divergent spines; subapical portion of processes with concentric rings of granules, basal portion with scattered granules; apex of semicells smooth or irregularly granulate. Vertical view triangular, with sides concave to convex and with the angles continued in long processes that terminate in three to two spines, when bispinate with the spines in the same vertical plane; body of the cell smooth to granulate; processes ornamented as in the front view. (Euplankton.)

Zygospores unknown.

Cells 40–55 μ long with processes, 24–30 μ long without processes; breadth with processes 54–71 μ , without processes 18–31 μ ; breadth at isthmus 6.5–8.5 μ ; length of terminal spines 5–8 μ .

Devils (rrr), Shell (sss).

The figures which W. & G. S. West give of the alga have a stouter cell body than is shown in my drawing. The more delicate form that I have figured is almost identical with a form of *S. pseudopelagicum* in the plankton from Loch Morar, Scotland, in the G. S. West collec-

tion. Since no form name was given to this I have not named the Wisconsin form. The original description states that the processes are terminated by two large divergent spines but in the local collections trispinate specimens are more abundant than bispinate. This point is of no taxonomic significance since both may occur on different processes of the same semicell. Although W. & G. S. West make no mention of the fact, the same variation occurs sparingly in the specimens from Loch Morar.

The distinguishing features of the species are the shape of the semicells, the nature of the sinus, the granulation of the cell wall, and the terminal spines of the processes. It should be compared with *S. pelagicum* W. & G. S. West, with *S. lacustre* G. M. Smith, and with certain forms of *S. paradoxum* Meyen (especially those figured by W. & G. S. West, Jour. Linn. Soc. Bot. **35**: 548, pl. 18, fig. 5. 1903).

var. tumidum var. nov. Pl. 72, Figs. 8-11.

Sinus always acute-angled; divergence of the processes not so marked and the transition from the body of the cell to the processes more gradual, ends of processes generally with three straight divergent fairly long spines, rarely with two or four spines; concentric granulation of processes much more pronounced than in the type; curvature of the apex of the semicells much greater and with one or two short spines near the point of origin of each process. Vertical view triangular, body of the cell granular to smooth. (Euplankton.)

Cells 40-55 μ long with processes, 24-31 μ long without processes; breadth with processes 54-80 μ , without processes 19-25 μ ; breadth at isthmus 6.5-8 μ ; length of terminal spines 5-7 μ .

Devils (rrr), Grindstone (sss), Lac Court Oreilles (ss), Lac du Flambeau (rrr), Whitefish (ss).

The variety differs from the type in the greater curvature of the cell apex, different shape of the sinus, and greater regularity of granulation. The terminal spines are conspicuous, as in the type, but are straight, not curved, and more variable in number.

24. STAUSTRUM CINGULUM (W. & G. S. West) G. M. Smith. Pl. 72, Figs. 12-14.

Trans. Wis. Acad. Sci. Arts & Lett. **20**: 353. 1922.

Staurastrum paradoxum var. *cingulum* W. & G. S. West, Jour. Linn. Soc. Bot. **35**: 548, pl. 18, figs. 6-7. 1903.

Cells of medium size, length (without processes) about one and three quarters that of the breadth, slightly constricted, sinus a small subrectangular depression, isthmus broad; semicells subcylindrical, without a basal inflation and with a ring of 12-15 minute spines (7-9

visible in a front view) just above the isthmus; apex of semicells flattened or slightly tumid, with processes arising just below the apex, processes slightly attenuated and upwardly curved, terminating in three minute divergent spines; apical portion of semicells and processes covered with minute spines that are generally scattered but at times arranged in concentric rings near the point of juncture of cell body and process. Vertical view triangular, with the angles continued in long straight processes whose ornamentation appears the same as in a front view; central portion of body of the cell without spines. (Euplankton.)

Zygospores unknown.

Cells 60–100 μ long with processes, 35–45 μ long without processes; breadth with processes 65–105 μ , without processes 18–30 μ ; breadth at isthmus 9–11.5 μ .

Balsam (rrr), Bear (r), Beaverdam (ss), Bloom (rr), Crawling Stone (rrr), Deer (rrr), Dummy (ss), Found (r), Granite (ss), Half Moon (r), Little Bear (rrr), Lost (r), Mercer (rrr), Meta (rr), Mud (rr), Pokegama (rr), Sand (sss), Sishebogema (ss), Two Sisters (rr), Wapagossett (rr), Whitefish (r).

Since this differs from *S. paradoxum* Meyen in the cylindrical body of the semicells, the nature of the sinus, and the slender upwardly curved processes as well as in the basal ring of spines it seems better to consider this a distinct species and not a variety of *S. paradoxum*. It should also be compared with *S. longiradiatum* W. & G. S. West.

25. STAUSTRUM PARADOXUM Meyen. Pl. 72, Figs. 15–22; Pl. 73, Figs. 1–2.

Nova Acta Phys. Med. Ac. Caes.-Leop. Nat. Cur. 14²: 777, pl. 43, figs. 37–38. 1829; Ralfs, Brit. Desm. 138, pl. 23, figs. 8A–8F. 1848; Roy & Bisset, Ann. Scottish Nat. Hist. 1893: 241. 1893; W. & G. S. West, Jour. Linn. Soc. Bot. 35: 548, pl. 18, figs. 4–5. 1903; Trans. Bot. Soc. Edinburgh 23: 27, pl. 2, figs. 33–35. 1905.

Cells of medium size, length somewhat greater than the breadth (without processes), median constriction fairly deep, sinus widely open and with an acute apex, isthmus fairly narrow; semicells obversely triangular to subcampanulate, with the dorsal margin flattened to slightly convex; angles continued in long somewhat attenuated processes that terminate in truncate ends that are tri- or quadrispinate; processes always divergent but the degree of divergence exceedingly variable; body of semicell with scattered granules and processes with concentric rings of granules. Vertical view triangular, with the angles continued in processes whose length is at least equal to the diameter of the cell body; central area of body of the cell with scattered granules or with the granules confined to the marginal region; processes with concentric rings of granules. Chloroplast axial, with a bilobed process running to each angle of the semicell; pyrenoid single and central. (Facultative plankton.)

Zygospores spherical, with a few long spines that terminate in bifurcate or trifurcate apices (Roy and Bisset.)

Cells 37–65 μ long with processes, 25–35 μ long without processes; breadth with processes 57–88 μ ; without processes 18–25 μ ; breadth at isthmus 7.5–11 μ .

Big Bass (sss), Beaverdam (rrr), Bettine (rrr), Carroll (sss), Clare (rr), Clear Crooked (rr), Crab (ss), Cranberry (r), Crawling Stone (ss), Devils (rrr), George (rrr), Granite (rrr), Horseshoe (rrr), Jenny (rrr), Lac du Flambeau (rrr), Little Rice (sss), Long (rrr), Lost (rrr), Middle McKenzie (rrr), Pine (rrr), Rice (rr), Red Bass (rrr), Sand (rrr), Shell (sss), South Crab (rrr), Tenderfoot (rrr), Tied Canoe (rrr), Travis (ss).

Although the genus *Staurastrum* was based upon this species and many observers have recorded it, the specific limits are poorly defined, even at the present day. After examining plankton material from many European and American lakes I have reached the conclusion that the essential characters are the relatively long and divergent processes and an absence of a row of verrucae just within and parallel to the margin of the cell body in a vertical view of the cell.

Staurastrum gracile Ralfs is an alga that is exceedingly difficult to separate from *S. paradoxum* but *S. gracile* usually has shorter sub-parallel processes and always a row of emarginate verrucae just within the lateral margins in a vertical view of the cell. *S. paradoxum* is subject to considerable variation in size and degree of divergence of the processes. Under plankton conditions the granulation becomes more pronounced, the granules at times becoming very short spines, while the terminal spines of the processes are also much larger. The present practice among phycologists is not to attempt a naming of the various forms of the species as it is found in the plankton.

var. LONGIPES Nordstedt. Pl. 73, Figs. 3–6.

Lunds Univ. Arsskr. 9: 35, pl. 1, fig. 17. 1873; W. & G. S. West, Trans. Roy. Soc. Edinburgh 41: 504, pl. 7, fig. 13. 1905.

Semicells cyathiform, with apices flattened; angles continued in very long graceful upwardly turned processes with finely crenulate margins and terminating in four divergent spines; cell body smooth and without ornamentation. Vertical view triangular, with the sides of the body of the cell concave and the processes with the same appearance as in the front view. (Euplankton.)

Cells 67–108 μ long with processes, 22–28 μ long without processes; breadth with processes 67–114 μ , without processes 18–22 μ ; breadth at isthmus 7.5–9 μ .

Little Bass (rr), Bear Trap (rr), Camp (rr), Center (sss), Chetek (rr), Devils (sss), Dummy (ss), Fowler (rr), Granite (ss), Hill (rrr), Hooker (rr), Lac la Belle (rrr), Mud (r), Nancy (s), Red Bass (rrr), Round (rr), Big St. Germain (rrr), Shell (rrr), Sishebogema (rrr), Speese (rrr), Two Sisters (rr), Trout (rr), Vermilion (r), Whitefish (ss).

The great length of the processes in proportion to the length of the cell body is the most striking feature of this variety. There is con-

siderable variation in the dimensions of the cells and I have found all gradations from the typical variety to the form *permagna* of W. & G. S. West (*l. c.* 504, *pl.* 7, *fig.* 14).

var. *PARVUM* W. West. Pl. 73, Figs. 7-15.

Jour. Linn. Soc. Bot. 29: 182, *pl.* 23, *fig.* 12. 1892.

Cells much smaller; processes more delicate as in the variety *longipes* but much shorter. (Facultative plankton.)

Cells 20-50 μ long with processes, 14-27 μ long without processes; breadth with processes 38-60 μ ; without processes 12-20 μ ; breadth at isthmus 5-6 μ .

Adelaide (ss), Big Bass (ss), Bloom (rrr), Bone (ss), Big Butternut (rrr), Little Butternut (ss), Duck (ss), Dunham (rrr), East (rr), Granite (r), Hooker (rrr), Long (rrr), Loveless (rr).

26. *STAUSTRUM PROTECTUM* W. & G. S. West.

Ann. Roy. Bot. Garden Calcutta 6: 217, *pl.* 16, *fig.* 12. 1907.

Cells fairly small, length about half the breadth (with processes), deeply constricted, sinus widely open and with apex acute, isthmus narrow; semicells broadly obversely triangular, with lower margins straight and apex slightly convex, angles continued in divergent processes of medium length; processes irregularly and finely granulate, terminating in two long divergent spines; apex of semicells with four bidenticulate verrucae; median part of body of the semicells with two similar subapical verrucae. Vertical view triangular, with sides slightly convex to slightly concave, angles with stout processes terminating in two spines that usually do not lie in the same vertical plane; median portion of each lateral margin with two bidenticulate verrucae and central portion of body of the cell with a ring of similar verrucae, two verrucae lying opposite each angle of the cell.

Zygospores unknown.

Cells 46 μ long with processes, 25 μ long without processes; breadth with processes 66 μ ; breadth at isthmus 8.5 μ (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. *PLANCTONICUM* G. M. Smith. Pl. 74, Figs. 1-4.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 355, *pl.* 12, *figs.* 8-12. 1922.

Cells with stouter processes, granulation of processes concentric and granules larger; verrucae on sides of semicells lacking, apical verrucae tridenticulate and forming a much smaller ring. Vertical view with sides of cell strongly retuse. (Euplankton.)

Cells 36-39 μ long with processes, 25-28 μ long without processes; breadth with processes 46-52 μ , without processes 30-34 μ ; breadth at isthmus 6-7 μ ; terminal spines 5-6.5 μ long.

Carroll (rr), Rudolph (rrr).

This organism shows such a strong resemblance to *S. protectum* in shape of the semicells, divergent spines on the processes, and apical verrucae that I feel it should be considered a variety. It differs primarily in the rings of granules on the processes and a lack of subapical verrucae.

27. *STAURASTRUM GRACILE* Ralfs. Pl. 73, Figs. 16-18.

Ann. & Mag. of Nat. Hist. 15: 155, pl. 11, figs. 3A-3B. 1845; Brit. Desm. 136, pl. 22, figs. 12A-12D. 1848; W. & G. S. West, Jour. Roy. Micr. Soc. 1897: 495, pl. 6, fig. 27. 1897; W. & G. S. West, Jour. Linn. Soc. Bot. 35: 529. 1903.

Cells of medium size, length generally greater than the breadth (without processes), deeply constricted, sinus widely open and with an acute apex, isthmus fairly narrow; semicells broadly triangular to cyathiform; dorsal margin slightly concave to somewhat convex, with a row of small emarginate verrucae, apex of semicell body sometimes with a short vertical row of granules below each apical verruca; angles continued in hollow processes of variable length, processes slightly attenuated, with transverse rings of granules and terminating in three or four small spines, processes parallel to widely divergent. Vertical view triangular, with sides of body of the cell slightly concave and angles continued in straight processes; cell body with an intramar-

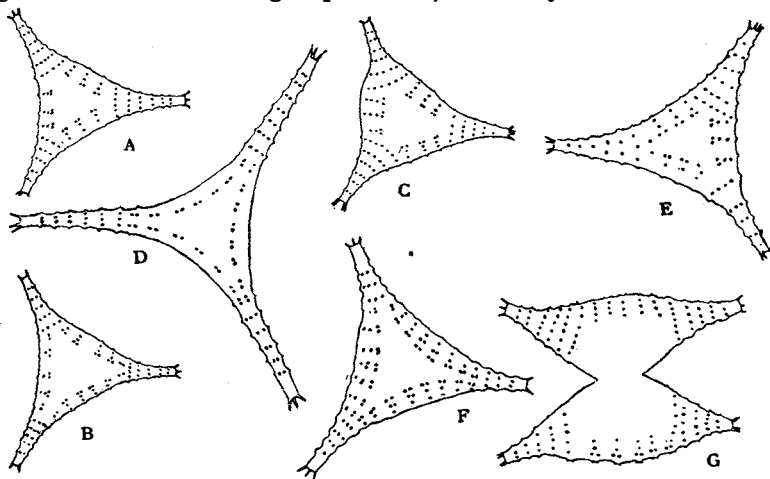


Fig. 9. *Staurastrum gracile* Ralfs (x 600). Figs. A-C from type material in the Jenner Herbarium of the British Museum of Natural History; Fig. D a plankton specimen collected in Loch Doon, Scotland, by W. & G. S. West; Figs. E-G plankton specimens from Norwegian lakes, Fig. E from Orrvandet, Figs. F, G from Lemonsjøen.

ginal row of pairs of granules (the verrucae of the front view) and at times short rows of granules at right angles to the sides of the cell, center of the cell without ornamentation; processes with transverse rings of granules and trispinate or quadrispinate. Chloroplast with a fairly small axial mass and two laminate blades running to each

angle of the cell and sometimes continuing a short distance into the processes; pyrenoid single and central. (Facultative plankton.)

Zygospores spherical, with numerous straight long spines that have inflated bases and apices with widely spreading bifurcations (W. & G. S. West).

Cells 95–107 μ long with processes, 46–49 μ long without processes; breadth with processes 93–118 μ , without processes 35–39 μ breadth at isthmus 10 μ .

Diameter of zygospores without spines 32 μ , with spines 60 μ (W. & G. S. West).

Des Moines (rr), Horseshoe (rr), Kawaguesaga (c).

Staurastrum gracile and *S. paradoxum* Meyen are closely related species and ones which are inextricably confused in phycological literature. The description and figure of the older species (*S. paradoxum*) might apply to many of the numerous triangular species with processes at the angles. Ralfs, the discoverer of *S. gracile* distinguished between the two on the basis of smaller size and divergent processes of *S. paradoxum* in his British Desmidiaceae; a work which has been taken as the starting point for the nomenclature of the family. Ralfs' description says nothing about the ornamentation of the body of the cell of *S. gracile* but the fortunate discovery of type material in the Jenner herbarium at the British Museum shows that the vertical view always has an intramarginal row of granules that lie in pairs and have a vertical row of granules running to the cell margin from each pair of granules. In this type material the processes are very short (Text Figs. 9A–9C). No specimens exactly like this were found in the plankton catches of the G. S. West collections, although specimens from Norwegian lakes in the Huitfeldt-Kaas collection were quite like them (Text Figs. 9F–9G). After examining the series found in the British plankton, as contained in the G. S. West collection, I feel that shape of the semicells and length or divergence of the processes cannot be used in distinguishing between *S. gracile* and *S. paradoxum* and that on these bases the two species should be united. The intramarginal row of granules in pairs (the apical verrucae of the front view) is a feature which separates the two and all specimens with these verrucae should be referred to *S. gracile*.

The species is undoubtedly of much more limited distribution than has been supposed and many references to it are unquestionably dealing with *S. paradoxum*. The Wisconsin specimens have long divergent processes and look, in vertical view, like the specimens found in Loch Doon, Scotland, by W. & G. S. West which they called a "very large form" (Text Fig. 9D).

28. *STAUSTRUM LONGIRADIATUM* W. & G. S. West. Pl. 74, Figs. 5-11.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 267, pl. 17, fig. 23. 1896; G. S. West, Jour. Linn. Soc. Bot. 39: 28. 1909.

Staustrium gracile var. *bulbosum* G. M. Smith non W. West, Trans. Wis. Acad. Sci., Arts & Lett. 19: 649. 1918.

Cells of medium size, breadth (with processes) 1.5-2 times the length, slightly constricted, sinus widely open, isthmus relatively broad; semicells campanulate and with cyathiform bases, apex flattened and ornamented with emarginate verrucae; angles of semicells continued in long divergent, parallel or slightly convergent processes with gradually attenuated margins, upper margin of processes deeply crenulate, crenulations on lower surface of processes shallow, ends truncate and with four short divergent spines. Vertical view triangular; body of the cell with straight to slightly concave sides, with an intramarginal row of two or three bidenticulate verrucae on each side of the cell; angles continued in long straight processes with undulate to subcrenulate margins and a single row of simple verrucae down the center. Vertical view of basal portion of the semicell triangular with the apices flattened and bearing one or two conical verrucae. Chloroplasts with a small axial mass and two laminate lobes running part way into each process; pyrenoid single and central. (Euplankton.)

Zygospores unknown.

Cells 46-96 μ long with processes, 41-49 μ long without processes; breadth with processes 73-108 μ , without processes 20-28 μ ; breadth at isthmus 8.5-10 μ .

Amicoy (sss), Bear (ss), Beartrap (rrr), Beaverdam (rr), Birch (aaa), Bird (rrr), Blake (r), Big Butternut (ss), Little Butternut (rr), Butternut (aa), Chetac (cc), Chetek (cc), Chetek (ss), Deer (ss), Des Moines (rrr), Duck (s), Dummy (ss), Hooker (rrr), Horse (cc), Horseshoe (ss), Found (r), Granite (r), Grassy (rrr), Lac Court Oreilles (rrr), Lake of the Woods (rr), Little Bass (rr), Long (aa), Lost (rr), Loveless (rr), Big McKenzie (r), Middle McKenzie (rrr), Nicaboyne (rr), Pokegama (ss), Poplar (rrr), Prairie (rr), Reserve (r), Rice (rrr), Round (r), St. Croix (rr), Big. St. Germain (r), Sand (r), Shell (rr), Silver (rr), Squirrel (rrr), Trout (rrr), Vermilion (sss).

This alga has considerable resemblance to *S. gracile* Ralfs in the shape of the semicells and especially to the variety *cyathiforme* in the swollen bases of the semicells. In *S. longiradiatum*, however, this swollen base is triangular in vertical view while in *S. gracile* var. *cyathiforme* W. & G. S. West it is circular.

The determination of this species is based upon a comparison of the Wisconsin material with specimens from the plankton of Yan Yean (Australia) in the G. S. West collection. In the figures of the alga published by W. & G. S. West the ratio between length of the semicell and breadth of the swollen basal portion is approximately 1:1 but in both the Australian and Wisconsin material this ratio is roughly 2:1. There is also a greater variation in the divergence of the processes than is given in the original description.

The dimensions of the alga as I have found it agree well with the variety *major* W. & G. S. West, which was described at the same time as the type, but since the dimensions of Australian specimens which G. S. West referred to the type are those of the variety *major* I feel that the variety should not be recognized.

29. *STAURASTRUM FLORIFERUM* W. & G. S. West. Pl. 74, Figs. 12-18.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 267, pl. 18, fig. 1. 1896.

Cells of medium size, breadth (with processes) two to three times the length, fairly deeply constricted, sinus widely open and with an acute apex, isthmus fairly narrow; semicells obversely trapeziform, with the ventral margins slightly convex and the dorsal margin flattened, cell apex with a row of emarginate verrucae; angles continued in long horizontal processes with subparallel sides, superior margin of processes with short acute spines, inferior margin of processes generally with shorter similar spines, ends of processes with three fairly stout short divergent spines, processes parallel to divergent. Vertical view triangular, cell body with straight sides and an intramarginal hexagonal ring of emarginate verrucae (two within each lateral margin); angles continued in long hollow slightly tapering processes with faintly undulate lateral margins, basal portion of processes with a double row of spines, apical portion with a single row, ends of processes with three stout divergent spines. Chloroplast with a small central mass and two long parallel plates running to each angle and continuing for a short distance into the processes; pyrenoid single and central. (Facultative plankton.)

Zygospores unknown.

Cells 23-44 μ long with processes, 22-26 μ long without processes; breadth with processes 52-86 μ , without processes 19-26 μ ; breadth at isthmus 6.5-8 μ .

Lake of the Woods (rrr), Paddock (rrr), Pokegama (r).

This alga has not been reported since it was described twenty-five years ago. I have found it at three stations, though never in any great quantity. There is more variation in both the amount of divergence of the processes and the dimensions of the cells than W. & G. S. West describe.

The length of the processes in the individuals from Pokegama lake was somewhat greater than that found in the other examples (Figs. 16-18) and the front view of these individuals suggests *S. anatinum* var. *longibrachiatum* but the ornamentation of the top view is quite distinctive and the two need never be confused.

30. *Staurastrum Bullardii* sp. nov. Pl. 74, Figs. 19-23; Pl. 75, Figs. 1-3.

Cells fairly large, breadth (with processes) equal to or slightly greater than the length, deeply constricted, sinus widely open and

with a sublinear apex, isthmus narrow; semicells obsemicircular, with apices truncate; angles continued in very long slightly attenuated quadrispinate processes, superior and inferior margins of processes crenulate, median portion at times with a row of granules; processes at first outwardly divergent and then upwardly curved; cell apex with two emarginate verrucae in the median portion, cell body without other ornamentation. Vertical view triangular, with the sides of the body of the cell straight and the angles continued in long straight processes with faintly undulate margins; body of the cell with two intramarginal emarginate verrucae in the middle of each side. Chloroplast with a small central mass and two short arcuate lobes extending to each angle; pyrenoid single and central. (Euplankton.)

Zygospores unknown.

Cells 70–88 μ long with processes, 23–30 μ long without processes; breadth with processes 81–100 μ , without processes 20–24 μ ; breadth at isthmus 8–10 μ .

Balsam (ss), Big Bass (r), Big McKenzie (rr), Birch Island (rrr), Blake (ss), Carroll (c), Clear Crooked (rr), Cochrane (rr), Crooked (rrr), Deer (ss), Des Moines (s), Dutchmans (rrr), Found (rrr), Grindstone (ss), Half Moon (s), High (rrr), Lac Court Oreilles (sss), Lac du Flambeau (rrr), Long (s), Lost (r), Loveless (rr), Mercer (ss), Middle McKenzie (ss), Mud (rr), Owen (cc), Reserve (sss), Round (s), Rudolph (rrr), Sand (rr), Squirrel (rr), Whitefish (ss), Wolf (rrr).

The species is dedicated to Mr. Charles Bullard in grateful appreciation of many courtesies extended during the preparation of the section of this work dealing with the Desmidiaceae. There is a certain suggestion of *S. paradoxum* var. *longipes* Nordstedt in the length and delicate nature of the processes, but in the shape of the cell body, apical verrucae, and curvature of the processes it is quite unlike it.

31. STAUSTRUM VESTITUM Ralfs. Pl. 75, Figs. 4–5.

Brit. Desm. 143, pl. 23, figs. 1A–1E. 1848; Delponte, Mem. d. R. Acad. d. Sc. di Torino 2 Ser., 28: 158, pl. 12, figs. 46–49. 1877 (sep.); Wolle, Desm. U. S. 138, pl. 45, figs. 28–30. 1884.

Cells of medium size, length about half the breadth (with processes), deeply constricted, sinus widely open and with apex acuminate, isthmus narrow; semicells broadly obtriangular, with lateral margins and apex straight, angles gradually attenuated into quite stout processes; processes parallel, with four to five concentric rings of conical spines that give the upper and lower margins a coarsely crenulate appearance, ends of processes with three short divergent spines; apex of semicells with four emarginate verrucae, center of face of semicell with two verrucae lying below the central verrucae of the apical series. Vertical view triangular, with the sides straight and the angles with a process that has the same appearance as in the front view; median portion of each side of the cell with two elongate bifid to emarginate verrucae projecting at right angles to the cell wall, marginal verrucae sometime flanked by similar but smaller verrucae; interior of cell with an

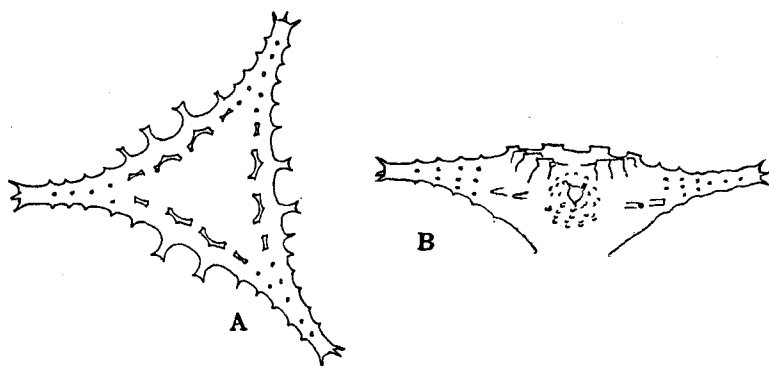


Fig. 10. *Staurastrum vestitum* Ralfs ($\times 600$). Specimens collected at Tarbert, Lewis, Scotland, by W. & G. S. West.

intramarginal row of four verrucae on each side, the two central verrucae arcuate and tridenticulate, the two terminal verrucae of each row broad and emarginate. (Tychoplankton.)

Zygospores spherical, clothed with elongate processes with inflated bases and bifurcate apices (Wolle).

Cells $40\ \mu$ long; breadth with processes $58\ \mu$, without processes $25\ \mu$; breadth at isthmus $10\ \mu$.

Found (rrr), Lost (rrr).

The few examples seen in Wisconsin lakes have a much more abrupt transition from the body of the semicells to the processes (as seen in vertical view) than is ordinarily the case. Since our specimens are not quite typical a figure is given of an English plankton specimen.

The determination of this species is an easy matter when the cells are viewed from above, the long verrucae projecting at right angles from the cell immediately separating it from the other species.

var. SUBANATINUM W. & G. S. West. Pl. 75, Figs. 6-10.

Trans. Roy. Irish Acad. 32: 54, pl. 1, fig. 28. 1902.

Cells with smaller bodies but longer and less robust processes; length of processes greater than the diameter of the cells; ornamentation as in the type but with the verrucae smaller and the terminal spines of the processes larger; processes slightly divergent. Chloroplast axial, with the central mass small and with a broad deeply furcate lobe running to each angle of the cell; pyrenoid single and central. (Euplankton.)

Cells $30-42\ \mu$ long with processes, $22-30\ \mu$ long without processes; breadth with processes $70-81\ \mu$, without processes $23-32\ \mu$; breadth at isthmus $10.5-11.5\ \mu$.

Diamond (sss), Jag (rr), Red Bass (rrr).

This variety is very happily named since it bears a striking resemblance to some of the pelagic varieties of *S. anatinum* Cooke & Wills.

The presence of the characteristic verrucae on the side of the semicells shows, however, that the variety belongs with *S. vestitum*. In the Wisconsin plankton these lateral verrucae are not so long as those figured by W. & G. S. West, but in all other particulars the two are identical.

32. STAUSTRUM ANATINUM Cooke & Wills.

Grevillea 9: 92, pl. 139, fig. 6. 1881; W. & G. S. West, Trans. Roy. Irish Acad. 32: 54, pl. 1, figs. 24-25. 1902; Carter, Ann. of Bot. 34: 307, pl. 14, figs. 19-20. 1920.

Cells fairly large, breadth (with processes) one and a half times to twice the length, deeply constricted, sinus acute and with apex acuminate, isthmus narrow; semicells broadly cyathiform, with the dorsal margin slightly convex and the ventral margin rounded, angles continued in fairly long hollow somewhat attenuated processes that usually terminate in three stout divergent spines, superior and inferior margins of processes coarsely serrate and body of processes with a median row of granules, processes subparallel to divergent; body of semicells with an apical row of 5-7 emarginate verrucae and another lower transverse subapical row of verrucae, lower part of body of semicells smooth. Vertical view triangular, with sides of cell body slightly concave to somewhat convex; angles continued in long straight processes with serrate margins and a single median row of granules, ends trispinate; sides of body of cells with emarginate verrucae and central area with similar verrucae (that appear as pairs of granules) just within the lateral margins and connecting with the axial rows of granules of the processes. Chloroplast with a very small central mass and a large broadly lanceolate lobe with a deep incision running to each angle of the cell; pyrenoids usually three, one in each lobe.

Zygospores unknown.

Cells 65 μ long with processes, 46 μ long without processes; breadth with processes 101-113 μ ; breadth at isthmus 15.5 μ (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. LONGIBRACHIATUM W. & G. S. West. Pl. 75, Figs. 11-16.

Trans. Roy. Soc. Edinburgh 41: 504, pl. 7, figs. 8-9. 1905.

Semicells obversely trapeziform; with the apex flattened or slightly concave; body of semicells without the subapical verrucae; processes long, gradually attenuated and with concentric rings of granules at the bases, ends tri- or quadrispinate, processes only slightly divergent. (Euplankton.)

Cells 43-68 μ long with processes, 30-35 μ long without processes; breadth with processes 80-92 μ , without processes 29-37 μ ; breadth at isthmus 10.5-12 μ .

Adelaide (rr), Crooked (ss), Meta (ss), Nancy (c), Sanford (rrr), Speese (s).

The primary distinction of the variety is the great length of the processes, the length being greater than the breadth of the body of the semicells. It also differs from the type in that the processes are less divergent and have concentric rings of granules at the base. The breadth with processes of the Wisconsin specimens is not as great as that of specimens from Scotland.

var. *CURTUM* G. M. Smith. Pl. 75, Figs. 17-20.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 354, pl. 12, figs. 6-7. 1922.

Cells smaller, semicells broadly cyathiform and with apex flattened, processes short and only subdivergent, cell body without the subapical row of verrucae. (Euplankton.)

Cells 35-48 μ long with processes, 25-28 μ long without processes; breadth with processes 55-74 μ , without processes 24-33 μ ; breadth at isthmus 9-11 μ .

Bass (rrr), Beaverdam (rrr), Cranberry (rr), Crawling Stone (rr), Found (rrr), Hill (r), Horseshoe (rrr), Lac Court Oreilles (rrr), Lindy (ss), Long (rrr), Jones (rrr), Nicaboyne (rrr), Sand (rrr).

The variety is distinguished from another small variety (*pelagicum* W. & G. S. West), found in British lakes, by the different proportions between length and breadth of the semicells, smaller degree of divergence of the processes, cell size, and the lack of the subapical verrucae. The cell shape and ornamentation is quite similar to the variety *longibrachiatum* but the processes are very much shorter.

var. *denticulatum* var. nov. Pl. 75, Figs. 21-25.

Shape of the semicells as in the variety *curtum*; processes with very long denticulations on the upper and the lower margins; cell apex with small straight linear verrucae and small linear subapical verrucae. (Euplankton.)

Cells 36-50 μ long with processes, 26-34 μ long without processes; breadth with processes 60-86 μ ; without processes 26-34 μ ; breadth at isthmus 10.5-12 μ .

Carroll (sss), Jag (rr), Mud (sss), Sishebogema (rrr), Tied Canoe (rrr).

The variety is distinguished by the great development of the teeth that ornament the processes and the reduction in size of the apical and subapical verrucae of the body of the cell. These smaller verrucae have the same position as those of the type but are not nearly so conspicuous, especially in a vertical view. In one case they were not regularly arranged but were scattered coarse granules (Fig. 21).

The spiny nature of the processes is quite similar to that of an alga from the plankton of Canadian lakes that I have considered a variety (*verrucosum*) of *S. aspinosum* Wolle. The relative length of the processes and the breadth of the cell body as well as the ornamentation of the cell body are quite distinct in the two algae.

33. *STAURASTRUM TETRACERUM* (Kützing) Ralfs.

Ann. & Mag. of Nat. Hist. 15: 150, pl. 10, figs. 1A-1C. 1845; Brit. Desm. 137, pl. 23, figs. 7A-7F. 1848; Lundell, Nova Acta Reg. Soc. Sci. Upsaliae, 3 Ser. 8: 68. 1871.

Cells very small, length (with processes) about equal to the breadth, deeply constricted, sinus obtuse-angled and with apices subacute, isthmus narrow; semicells obversely triangular, with apices very slightly retuse; angles continued in delicate slightly tapering processes with sharply crenulate margins; ends of processes without teeth (?). Vertical view compressed and body of semicells not much broader than the processes. Semicells almost invariably twisted at the isthmus.

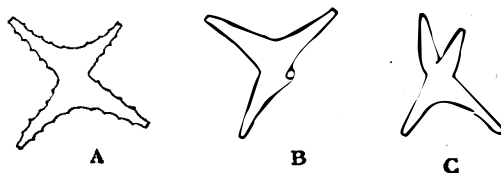


Fig. 11. *Staurastrum tetracerum* Ralfs (x 800). Specimens collected at Moidart, Scotland, by W. & G. S. West.

Zygospores spherical, with about sixteen processes that are dilated at the base and furcate at the apex (Lundell).

Cells 20-23 μ long with processes, 10 μ long without processes; breadth with processes 22.5 μ ; breadth at isthmus 5 μ .

Zygospores 30 μ in diameter with processes, 16 μ without processes (Lundell).

Not found in the plankton of Wisconsin lakes.

var. *VALIDUM* W. & G. S. West. Pl. 76, Figs. 9-10.

Jour. Roy. Micr. Soc. 1897: 495, pl. 6, fig. 25. 1897.

Cells somewhat larger, deeply constricted and with sinus rectangular; semicells obversely triangular and with point of origin sharply defined; length of processes somewhat greater than the breadth of the semicells; processes with margins subparallel and finely crenulate, terminating in four minute spines; body of semicell smooth but with a finely crenulate outline; semicells not twisted at the isthmus. (Facultative plankton.)

Cells 36-43 μ long with processes, 16-20 μ long without processes; breadth with processes 46-52 μ ; without processes 14-17 μ ; breadth at isthmus 6-7 μ ; thickness 7.5 μ .

Duck (r).

The variety as observed in our plankton has the processes more finely crenulate than W. & G. S. West show and does not have the smooth outline of the body of the semicell. It might possibly be a small variety of *S. chaetoceras* (Schröder) G. M. Smith but has been excluded since no granules were observed within the margins of the body or the processes of the cells.

var. EVOLUTUM W. & G. S. West. Pl. 76, Figs. 11-14.

Trans. Bot. Soc. Edinburgh 23: 25, pl. 2, fig. 31. 1905.

Cells larger and with much longer and more delicate processes. Vertical view triangular, with the sides slightly retuse and the angles continued in straight processes with finely crenulate margins. Processes of one semicell alternating with those of the other. (Facultative plankton.)

Cells 40-51 μ long with processes, 23-25 μ long without processes; breadth with processes 51-63 μ , without processes 16-18 μ ; breadth at isthmus 4.5-6 μ .

Middle McKenzie (ss).

var. TRIGONUM Lundell. Pl. 76, Figs. 15-16.

Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8: 69, 1871; W. West, Jour. Linn. Soc. Bot. 29: 187. 1892.

Cells small, fairly deeply constricted; processes stout in proportion to the size of the cells, divergent and with three or four deep crenulations on both the upper and the lower margins, median portion of processes with small spines. Vertical view triangular, with sides slightly retuse and angles with stout straight processes, lateral margins of processes deeply crenulate and ends quadrispinate. (Tycho-plankton.)

Cells 32 μ long with processes, 22 μ long without processes; breadth with processes 42 μ ; without processes 15 μ ; breadth at isthmus 7 μ .

Little Bass (rr), Crab (rrr), Horseshoe (rrr), Jones (rrr), Red Bass (rrr), Whitefish (rr).

Lundell mentions triangular forms of *S. tetracerum* and William West gives their dimensions. I have found a minute triradiate alga which I believe to be the one described by Lundell.

34. STAUSTRUM LACUSTRE G. M. Smith. Pl. 76, Figs. 1-8.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 355, pl. 12, figs. 13-15. 1922.

Cells of medium size, length (with processes) about equal to the breadth, fairly deeply constricted, sinus widely open and with apex acute, isthmus fairly narrow; semicells obversely triangular, with ventral margins straight or slightly tumid, dorsal margin flat, usually with the median portion truncate and elevated; angles continued in long slightly tapering processes that terminate in two very long divergent spines, proximal portion of processes with upper and lower surfaces coarsely crenulate and at times a median row of conical granules, distal portion always smooth, processes always strongly divergent; cell body without ornamentation except for two apical emarginate verrucae. Vertical view triangular, sides straight or slightly retuse; angles continued in long processes with subparallel sides and terminating in two long spines that lie in the same ver-

tical plane, processes generally smooth in outline, sometimes with 2-3 transverse rings of coarse conical granules in the basal portion; median portion of base of processes with an axial or a double row of granules; body of semicells with two emarginate verrucae just within each lateral margin. Vertical view of chloroplast with a small central mass and two long arcuate lobes running to the base of each process; pyrenoid single and central. (Euplankton.)

Zygospores unknown.

Cells 70-86 μ long with processes, 25-34 μ long without processes; breadth with processes 77-105 μ , without processes 17-20 μ ; breadth at isthmus 8-9 μ ; length of terminal spines 9-11 μ .

Bear (rrr), Devils (rrr), Dummy (r).

A very distinctive species in which the long straight divergent processes terminating in two divergent spines are quite unlike those of other plankton species of the genus. The ornamentation of the body of the cell and the base of the processes is somewhat variable. In some cases the bases of the processes have three or four rings of conical granules, in others the granules are found only on the upper and lower sides, while in still others the granules are lacking. The emarginate verrucae at the apex of the cell are at times absent. This lack of an ornamentation of the body of the cell is not always correlated with a lack of ornamentation of the processes since specimens with the best development of ornamentation of processes may have a lack of body ornamentation or vice versa.

35. *Staurastrum contortum* sp. nov. Pl. 76, Figs. 17-20.

Cells of medium size, breadth (with processes) generally about twice the length, deeply constricted, sinus obtuse-angled and widely open, isthmus narrow; semicells broadly obtriangular, with ventral and dorsal margins straight; body of semicells small and not sharply differentiated from the long attenuated processes; processes divergent, with margins sharply crenulate and ends tridenticulate. Semicells almost invariably twisted, usually at right angles to each other. Vertical view narrowly elliptic, with the poles prolonged into straight processes with undulate sides and trispinate ends; processes of the two semicells generally cruciform. Chloroplast, laminate, with one pyrenoid.

Zygospores unknown.

Cells 36-67 μ long with processes, 12 μ long without processes; breadth with processes 44-119 μ , without processes 10.5-12 μ ; breadth at isthmus 6 μ ; thickness 6 μ .

Big Bass (rrr), Bone (ss), Found (rrr), Grindstone (rr).

Twisting of the semicells is well known in some of the other small biradiate species of the genus but semicells lying at right angles to each other are quite unusual in the other species. This species shows

a great resemblance to the twisted forms of *S. excavatum* W. & G. S. West that G. S. West found in the Australian plankton. (Jour. Linn. Soc. Bot. 39: 71, pl. 6, figs. 19-20. 1909) but cannot be placed in *S. excavatum* since it lacks the characteristic apical excavation. The body of the cell of *S. contortum* is much smaller and less sharply defined than those of other biradiate species.

36. **Staurostrum Chaetoceras** (Schröder) comb. nov. Pl. 76, Figs. 21-24; Pl. 77, Fig. 1.

Staurostrum polymorphum Meyen (?) var. *chaetoceras* Schröder in Zacharias, Forschungsbr. a. d. Biol. Stat. su Plön 6²: 131, text figs. A-C. 1898.

Cells fairly large, length (with processes) about equal to the breadth, deeply constricted, sinus obtuse-angled and with a blunt apex, isthmus narrow; semicells obversely triangular, with the ventral margins sublinear and the apex flattened; angles continued in long divergent straight processes, the angle of divergence being a continuation of the angle of the sinus, processes slightly attenuated, delicate, with transverse concentric rings of minute granules and terminating in four minute teeth; body of semicells with outline finely crenulate and with a few scattered subapical granules, at times with a transverse row of granules just above the isthmus. Vertical view narrowly elliptic (very rarely triangular) with the poles continued in straight processes whose ornamentation is as in the front view. (Euplankton.)

Zygospores unknown.

Cells 46-89 μ long with processes, 19-22 μ long without processes; breadth with processes 65-89 μ , without processes 16-22 μ ; breadth at isthmus 5.5-6.5 μ ; thickness 10 μ .

Bear (rrr), Big Butternut (rrr), Blake (ss), Bone (r), Camp (r), Center (r), Chain (rrr), East (rr), Found (rr), Half Moon (r), Little Bass (s), Little Butternut (rr), Lost (r), Big McKenzie (rrr), Middle McKenzie (rr), Pokegama (ss), Whitefish (rrr), Wolf (rrr).

In describing the alga Schröder placed it as a variety of *S. paradoxum* Meyen (by mistake written *S. polymorphum* Meyen) but I feel that if it is to be given varietal rank it should be a variety of *S. tetracerum* (Kützinger) Ralfs. In spite of occasional triradiate semicells it should be grouped with the biradiate species and separated from the other species of this type by the lack of verrucae at the apex of the semicells. Most of the biradiate species also lack the concentric rings of granules on the processes that are found in *S. Chaetoceras*. These rings are easily overlooked, especially when the cell contents are present. In certain stations forms with exceptionally long processes were observed (Fig. 1).

37. *STAUSTRUM AMERICANUM* (W. & G. S. West) G. M. Smith.
Pl. 77, Fig. 2.

Trans. Wis. Acad. Sci., Arts & Lett. 10: 351. 1922.

Staurastrum grallatorium var. *americanum* W. & G. S. West, Trans. Linn. Soc.
2nd. Ser. Bot. 5: 265, pl. 17, fig. 15. 1896.

Cells of medium size, length (with processes) about two-thirds the breadth, deeply constricted, sinus widely open and with an acute apex, isthmus very narrow; semicells obsemicircular, with the apex somewhat convex, dorsal margin without ornamentation but with the wall thicker on the dorsal margin than elsewhere; angles continued in long processes that have subparallel sides, upper and lower margins of processes crenulate, processes subparallel to divergent and with ends minutely trispinate. Vertical view elliptic, with poles continued in hollow processes with undulate sides, body of cell without ornamentation. (Tychoplankton.)

Zygospores unknown.

Cells $61\ \mu$ long with processes, $29\ \mu$ long without processes; breadth with processes $90\ \mu$, without processes $26\ \mu$; breadth at isthmus $6.5\ \mu$.

Clare (rrr).

Although but two specimens were seen both agreed well with W. & G. S. West's description. The lack of ornamentation on the apex of the semicells and the thickened wall at this point are quite unlike other biradiate species. The shape of the semicells, lack of apical ornamentation and terminal ornamentation of the processes is so unlike that of *S. grallatorium* Nordstedt that the alga should be considered a distinct species and not a variety of *S. grallatorium*.

38. *STAUSTRUM GRALLATORIUM* Nordstedt. Pl. 77, Figs. 3-5.

Vidensk. Medd. f. d. naturhist. Foren. i Kiöbenhavn 1869: 228, pl. 4, fig. 52. 1870.

Cells somewhat under medium size, breadth (with processes) about twice the length, slightly constricted, sinus very widely open and with a rounded indentation of the relatively broad isthmus; semicells narrowly campanulate, apex truncate and with a median portion bearing three emarginate verrucae and somewhat elevated above the rest of the apex; body of semicells, except for the verrucae, without ornamentation; angles continued in long slightly attenuated hollow processes with sharply crenulate upper and lower margins, ends of processes deeply bifurcate, the bifurcations (not spines) being a continuation of the processes and hollow, processes subparallel. Vertical view elliptic, body of semicells relatively small and with the lateral margins greatly rounded, poles continued in long processes with straight or slightly undulate margins, processes terminating in two arms that lie in the same vertical plane. (Tychoplankton.)

Zygospores unknown.

Cells 42–48 μ long with processes, 32–34 μ long without processes; breadth with processes 69–86 μ , without processes 20 μ ; breadth at isthmus 8.5–9 μ ; thickness 14 μ .

Tank (rrr).

Superficially the species resembles *S. Johnsonii* W. & G. S. West but differs in the parallel processes, lack of subapical and isthmial ornamentation, termination of the processes, and shape of the semi-cells. Nordstedt's figure shows five elevated verrucae in the front view but in all of the specimens that I have seen there are only three. The shape of the semicells, especially the small body of the cell in a vertical view, and the branching of the ends of the processes show that the organism which I have found is *S. grallatorium*. The processes do not end in spines as do the other biradiate species of the genus, instead the process ending is bifurcate and distinctly hollowed.

var. *FORCIPIGERUM* Lagerheim. Pl. 77, Figs. 6–7.

Öfvers. kgl. Sv. Vet.-Ak. Förh. 42, No. 7: 249, pl. 27, fig. 27. 1886.

Staurostrum saltans var. *forcipigerum* Lagerheim, *ibid.* 44, No. 8: 539. 1887.

Semicells trapeziform, with apex truncate and bearing two elongate subapical verrucae, apex with two fairly long divergent spines asymmetrically disposed on the sides of the elongated median portion; processes with margins more coarsely crenulate and with fewer crenulations, furcation of ends of processes unequal, the fork on the side towards the isthmus always the longer. (Tychoplankton.)

Cells 45 μ long with processes, 38 μ long without processes; breadth with processes 65–72 μ ; without processes 21–25 μ ; breadth at isthmus 7.5–8.5 μ .

Hillman (rrr).

After describing the alga as a variety of *S. grallatorium* Lagerheim transferred it to *S. saltans* Joshua, an alga which was not correctly figured until some years later (W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 6: 188, pl. 22, figs. 13–14. 1902). Mr. Charles Bullard has shown me a preparation in which one semicell is typical *S. grallatorium* and the other the variety *forcipigerum*. From this it is evident that if the variety is to be recognized it belongs to *S. grallatorium*.

39. *STAURASTRUM ANCHORA* W. & G. S. West. Pl. 77, Figs. 8–9.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 266, pl. 17, figs. 21–22. 1896.

Cells large, breadth (with processes) twice the length, slightly constricted, sinus sublinear, isthmus relatively broad; semicells campanulate, with bases slightly inflated, apices flattened and smooth; angles of semicells prolonged in long somewhat tapering processes

that end in three divergent spines of medium size, upper and lower margins of processes deeply crenulate, processes parallel to somewhat convergent; median area of apex of cell body with a transverse subapical row of 8-10 emarginate verrucae. Vertical view elliptic, with a row of 8-10 emarginate verrucae just within each lateral margin; poles of cells continued in long tapering processes that have the same appearance as in the front view. (Tycho plankton.)

Zygospores unknown.

Cells $68\ \mu$ long; breadth with processes $143-162\ \mu$, without processes $45-58\ \mu$; breadth at isthmus $13.5\ \mu$; thickness $24\ \mu$.

Des Moines (rrr), Fish (rrr), Owen (rrr).

The largest of the biradiate members of the genus and one with a distinctive shape of the semicells and subapical ornamentation.

40. STAUSTRUM LEPTOCLADUM Nordstedt. Pl. 78, Figs. 1-7.

Vidensk. Medd. f. d. naturhist. Foren. i Kiöbenhavn 1869: 228, pl. 4, fig. 57. 1870; W. & G. S. West, Jour. Linn. Soc. Bot. 33: 317. 1898.

Staustrium leptocladum var. *cornutum* Wille, Bih. Sv. Vet.-Ak. Handl. 8, No. 18: 19, pl. 1, fig. 39. 1884; Johnson, Bull. Torr. Bot. Cl. 21: 289, pl. 211, fig. 3. 1894; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 79, pl. 9, figs. 12-13. 1895.

Cells fairly large, breadth (without processes) about half the length, slightly constricted, sinus a small semicircular depression, isthmus relatively broad; semicells subcampanulate, with bases inflated and apex strongly tumid; angles continued in long slightly attenuated processes that are at first outwardly divergent and then curve gracefully away from the isthmus, upper and lower margins of processes finely crenulate and ends bispinate; basal inflation of body of the semicells usually with a single transverse row of conical or vertically elongate granules, rarely smooth, median portion of semicell body with a tumid protuberance and dorsal margin with a single vertical subapical spine. Vertical view narrowly elliptic, with poles continued in straight slightly tapering processes with undulate margins, ends with two small spines that lie in the same vertical plane; median part of lateral margin slightly truncate. (Facultative plankton.)

Zygospores unknown.

Cells $71-95\ \mu$ long with processes, $35-41\ \mu$ long without processes; breadth with processes $67-105\ \mu$, without processes $18-21\ \mu$; breadth at isthmus $6-7\ \mu$; thickness $10-12\ \mu$.

Bear (sss), Bone (r), Carrol (s), Chain (sss), Clare (ss), Cranberry (rrr), Deer (s), Devils (r), Diamond (s), Grindstone (rrr), Half Moon (rrr), Horseshoe (c), Jag (rr), Little Butternut (rrr), Loveless (rr), Nancy (rrr), Sand (rrr), Sishebogema (rr), Trapper (sss), Whitney (rr).

The species and its varieties are distinguished by the curvature of the processes, at first divergent and then upwardly curved. Nordstedt in his description does not mention the subapical spine, a fea-

ture upon which Wille based his variety *cornutum*. My experience with the alga in Ontario, New York and Wisconsin has been so similar to that of W. & G. S. West that I agree fully with them when they say: "there can be no doubt that *S. leptocladum* always possesses the two spines at the apex of the semicells, this was made the character for a variety (*cornutum*) by Wille but we think it highly probable that these spines had been broken off in the specimens originally described by Nordstedt. All of the examples we have ever seen, from many diverse parts of the world, possessed these spines, and it is worthy of note that other observers only record the variety *cornutum*, a fact which confirms our suspicions as to the invariable presence of the apical spines in uninjured specimens."

In some of the specimens that I have seen the transverse row of granules on the basal swelling of the semicell was lacking, though it usually is a conspicuous feature.

var. DENTICULATUM G. M. Smith. Pl. 77, Figs. 10-14.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 351, pl. 11, fig. 14. 1922.

Variety with the subapical spines replaced by a broad emarginate elevation. Vertical view with the median portion of the lateral margins with a truncate elevation. (Facultative plankton.)

Cells 79-95 μ long with processes, 38-43 μ long without processes; breadth with processes 71-98 μ , without processes 18-21 μ ; breadth at isthmus 6-7 μ ; thickness 10-12 μ .

Balsam (s), Little Bass (rrr), Big McKenzie (c), Middle McKenzie (s), Oak (rrr), Pokegama (c).

var. INSIGNE W. & G. S. West. Pl. 77, Fig. 15; Pl. 78, Figs. 8-11.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 266, pl. 17, fig. 17. 1896.

Cells with the same general outline as the type, though with the upward curvature of the processes more pronounced; ventral margin of the body of the semicells with crenulations or emarginate verrucae extending from the base of the processes to the vicinity of the basal swelling; dorsal margin with 4-6 emarginate verrucae that lie just within the apex of the semicells and form a transverse row; center of semicells with a circular protuberance. Vertical view rhomboidal, with the median protuberance of the lateral margins truncate and with the poles continued in long straight processes with undulate margins. (Facultative plankton.)

Cells 55-100 μ long with processes, 36-42 μ long without processes; breadth with processes 86-110 μ , without processes 20-26 μ ; breadth at isthmus 6-8 μ ; thickness 15-18 μ .

Blake (s), George (r), Lake of the Woods (rrr), Nicaboyne (rrr), Big St. Germain (rrr).

A variety which is unlike the others of the species in the subapical ornamentation but which should be kept a variety of *S. leptocladum* because of the characteristic curvature of the processes.

var. SINUATUM Woll. Pl. 78, Figs. 12-14.

Bull. Torr. Bot. Cl. 10: 20, pl. 27, fig. 24. 1883.

Cells with the body much narrower and with the bases of the semicells not inflated; without ornamentation except for an apical notch; processes arising at the same point and with the same curvature as those of the type but not lying in the same plane. (Euplankton.)

Cells 65-88 μ long with processes, 25-29 μ long without processes; breadth with processes 80-93 μ , without processes 12-15 μ ; breadth at isthmus 7-8 μ ; thickness 10 μ .

Bass (sss), Grassy (rrr), Lindy (c), Little Doctor (ss), Lynx (rrr), Speese (rrr).

This variety is unique in the peculiar twisting of the processes and in the nature of the upper portion of the semicells, features which are seen to the best advantage in lateral views of the cells. The identification of the Wisconsin material with Wollé's variety *sinuatum* is open to question since he based his variety on the divergence of the processes and the emargination of the semicell apices. Wollé does not mention the variety in his general work on the Desmids of the United States so, perhaps, decided that it was not worthy of recognition. The front view of our alga is so like that which Wollé gives that it seems better to revive his old name than to try to consider it new.

The specimens from Blue Gill Lake were not twisted, the four ends of the processes lying in the same plane. The crenulation of the processes is also more marked and the ends are quadrispinate. This form has been given the name **planum**. Its length with processes is 88 μ , without processes 28 μ ; breadth with processes 110 μ , without processes 15 μ , breadth at isthmus 9 μ . (Pl. 78, Fig. 15).

41. STAUSTRUM JOHNSONII W. & G. S. West. Pl. 79, Figs. 1-6.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 266, pl. 17, fig. 16. 1896.

Staurastrum leptocladum Johnson non Nordstedt, Bull. Torr. Bot. Cl. 21: 288, pl. 211, fig. 2. 1894.

Cells of medium size, breadth (with processes) about one and a half times the length, slightly constricted, sinus a small semicircular depression, isthmus relatively broad; semicells subcampanulate, with inflated bases and slightly tumid apices, angles continued in long gradually tapering processes that terminate in three divergent spines, superior margin of processes crenulate, inferior margin also crenulate but with the crenulations less pronounced than those of the superior margin, median area of processes with a row of minute denticulations, processes somewhat divergent; body of semicells with two transverse rows of granules on the basal inflation, the row farthest from the isthmus frequently poorly developed and irregular, dorsal portion of body of semicells with a transverse subapical row of 5-7

emarginate verrucae and below this a transverse row of rings or masses of small granules the row forming a continuation of the median row of granules of the processes. Vertical view elliptic, with poles continued in straight slightly tapering processes terminating in three divergent spines, lateral margins of processes crenulate and with a single median row of granules; sides of body of cells with an intramarginal row of emarginate verrucae and a marginal row of verrucae. (Facultative plankton.)

Zygospores unknown.

Cells 59–85 μ long with processes, 35–41 μ long without processes; breadth with processes 79–110 μ , without processes 19–24 μ ; breadth at isthmus 9–12 μ ; thickness 12–13 μ .

Bass (ss), Bear (rrr), Carroll (sss), Carson (rr), Crooked (sss), Des Moines (rrr), Devils (r), Diamond (s), Hill (rrr), Horseshoe (sss), Howey (rr), Lindy (ss), Meronk (rr), Pine (rr), Shell (sss), Silver (rrr), South Crab (rrr), Sunday (rr).

The alga sometimes occurs in quantity in certain of the lakes. It is distinguished from others of the same general type by the size, divergence of the processes, and ornamentation. I have found that the divergence of the processes is generally greater than W. & G. S. West or Johnson figure but that this greater degree of divergence is not caused by a curvature of the processes. The subapical ornamentation of the body of the semicells is characteristic but subject to considerable fluctuation. In some specimens the granules below the emarginate verrucae are arranged in distinct rings, in others there are two opposed arcs of granules, in still other examples these arcs of granules are fused to form small arcuate verrucae.

In some of the lakes the cells were consistently smaller than the type and I have considered this a separate form. This form, **parvum** (Pl. 79, Fig. 6), has the same general shape and ornamentation as the type and differs only in the smaller size. Its length with processes is 42–68 μ , length without processes 25–31 μ ; breadth with processes 62–68 μ , without processes 18–21 μ ; breadth at isthmus 9 μ . Its distribution is as follows:

Found (rrr), Horseshoe (cc), Lynx (r), Pine Tree (ss), Travis (ss).

var. depauperatum var. nov. Pl. 79, Figs. 7–11.

Staurostrum leptocladum var. *divergens* G. M. Smith non Wolle; Trans. Wis. Acad. Sci., Arts & Lett. 19: 649. 1918.

Semicells campanulate and with basal swelling less pronounced; processes with the same kind of divergence as the type or with a slight curvature; apex of semicells with the subapical row of verrucae and second subapical row greatly reduced; bases of semicells without transverse rows of granules. (Euplankton?)

Cells 55–86 μ long with processes, 47–52 μ long without processes; breadth with processes 98–125 μ , without processes 22–30 μ ; breadth at isthmus 9–10.5 μ .

Bass (rrr), Beaverdam (rrr), Crab (rr), Cranberry (rrr), Crawling Stone (sss), Duck (rrr), George (r), Grindstone (rr), Lac Court Oreilles (r), Long (rr), Reserve (r), Whitefish (sss).

The general outline of the semicells in this variety is that of *S. Johnsonii* except for the basal swelling. The ornamentation of the base is lacking and the apical verrucation is much simpler. In some of the specimens there is a median row of granules on the processes, a feature found in *S. Johnsonii*, but not in the closely related *S. leptocladum* Nordstedt.

42. *STAURASTRUM NATATOR* W. West. Pl. 79, Fig. 12.

Jour. Linn. Soc. Bot. 29: 183, pl. 23, fig. 14. 1892.

Cells of medium size, length (without processes) about twice the breadth, slightly constricted, sinus a small semicircular depression, isthmus fairly broad; semicells subrectangular to subtrapeziform, with the lateral margins slightly convex and the apex straight; central portion of the apex with three tridenticulate verrucae in which the central spine is more prominent than the other two; angles of cells continued in long slightly curved processes that are ornamented with concentric rings of granules, ends of processes with three small

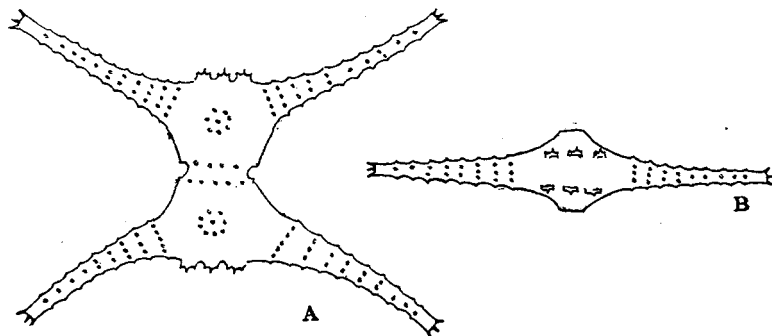


Fig. 12. *Staurastrum natator* W. West ($\times 800$). From type material collected by William West in the small lakes between Clifden and Roundstone, Galway, Ireland.

subdivergent spines, processes divergent; central area of body of semicells with a protuberance bearing a ring of 6–8 granules that enclose one or two similar granules, basal portion of semicells with a transverse row of minute granules, 6–8 of which are visible in a front view of the cell. Vertical view compressed and subelliptic, with the transition from the body of the cell to the processes gradual, central portion of the lateral margins with a truncate projection and margins

also with an intramarginal row of tridenticulate verrucae; processes with concentric rings of granules. (Tychoplanktont.)

Zygospores unknown.

Cells $60\ \mu$ long with processes, $34\ \mu$ long without processes; breadth with processes $88\ \mu$, without processes $20\ \mu$; breadth at isthmus $11.5\ \mu$.

Little Doctor (rrr).

The species has not been observed since it was described by William West. In reexamining type material in the G. S. West collection I have noted a ring of granules at the base of the semicells, a feature which was overlooked in the original description. A figure of an Irish specimen is also given for comparison with the Wisconsin material.

var. CRASSUM W. & G. S. West. Pl. 79, Figs. 13-15.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 265, pl. 17, fig. 14. 1896.

Semicells with a much larger ring of granules on the central protuberance; apical verrucae with denticulations of the same size. Vertical view with truncate projection much larger than that of the type. (Facultative planktont.)

Cells $42-50\ \mu$ long with processes, $30-33\ \mu$ long without processes; breadth with processes $58-70\ \mu$, without processes $18-21\ \mu$; breadth at isthmus $7.5-8.5\ \mu$; thickness $20\ \mu$.

Horseshoe (r).

S. natator can be separated from other biradiate species by the central protuberance, a feature which is much more pronounced in the variety *crassum*. When due allowance is made for the defects of draftmanship frequently found in the drawings of Wolle there is a possibility that *S. natator* var. *crassum* is identical with his *S. minneapolisense* (Bull. Torr. Bot. Cl. 12: 5, pl. 47, figs. 11-13. 1885). The front view of *S. minneapolisense* is, as W. & G. S. West have pointed out, quite different from that of *S. natator* var. *crassum*.

43. *Staurostrum urinator* sp. nov Pl. 79, Figs. 16-18.

Cells fairly large, breadth (with processes) about one and a quarter times the length, slightly constricted, sinus a small acute-angled indentation with a blunt apex, isthmus relatively broad; semicells campanulate with the lateral margins of the bases semicircular and generally bearing an erect spine in the median portion; apices flattened and with three somewhat emarginate verrucae; angles continued in long slightly attenuated processes that terminate in three short divergent spines, superior and inferior margins of processes with conspicuous teeth that point away from the body of the semicell, median area of processes smooth, processes outwardly divergent. Vertical view narrowly elliptic, lateral margin

with three emarginate verrucae and a truncate projection in the median portion, poles continued in straight processes with smooth margins and a median row of spines. (Facultative plankton.)

Zygospores unknown.

Cells 68–79 μ long with processes, 26–32 μ long without processes; breadth with processes 81–89 μ , without processes 19–21 μ ; breadth at isthmus 9–10.5 μ ; thickness 15 μ .

Little Doctor (r).

The species resembles *S. natator* W. West in the truncate projection on the face of the middle of the semicell but differs in the angle of divergence of the processes as well as the shape and ornamentation of the semicells. It is given the name *urinator* because of the resemblance of a side view to a diver.

44. STAUSTRUM SUBNUDIBRACHIATUM W. & G. S. West.

Trans. Roy. Soc. Edinburgh 41: 502, pl. 7, figs. 18–19. 1905.

Cells small, breadth (with processes) about one and a half times the length, slightly constricted, sinus widely open and with a blunt apex, isthmus fairly broad; semicells subspherical, with the upper portion continued in smooth gradually attenuated processes that terminate in two blunt teeth, ends of processes at times obtuse and entire, processes slightly divergent. Vertical view four or five radiate, with the processes of one semicell alternating with those of the other semicell, processes slightly attenuated and with the length about equal to the diameter of the cell; body of the cells gradually fusing with the processes, margin of cell retuse between the bases of the processes. Cell wall without ornamentation. Cells generally enclosed in a wide gelatinous envelope.

Zygospores unknown.

Cells 40–44 μ long with processes, 31–37 μ long without processes; breadth with processes 53–60 μ , without processes 20–22 μ ; breadth at isthmus 15–15.5 μ (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. *incisum* var. nov. Pl. 80, Figs. 1–4.

Cells smaller than the type, length (without processes) about one and a half times the breadth, median constriction very slight; semicells subspherical-quadrangular, with the processes arising abruptly from the body of the semicell; processes of one semicell opposite those of the other semicell, processes with parallel sides and deeply bifurcate apices, the bifurcations tending to lie in the vertical plane of the cell, furcations with rounded ends. Vertical view always tetragonal, with the body of the cell circular and the transition from process to body abrupt. Chloroplast axial, massive, with two long plate-like extensions running into each process, frequently with a plate entering each branch of the end of the process; pyrenoids single and central. Cells imbedded in a copious spherical gelatinous envelope. (Euplankton.)

Cells 38–41 μ long with processes, 20–21 μ long without processes; breadth with processes 43–52 μ , without processes 17–19 μ ; breadth at isthmus 10–13.5 μ .

Carson (rrr), Devils (rrr), Whitney (r).

This variety has considerable resemblance to *S. subnudibrachiatum* in the smooth processes and their general relation to the body of the cell. The variety differs, however, in the much sharper transition from body to processes, more rounded semicells, smaller median constriction, parallel sides of processes, and stronger forking of the ends of the processes. The general relation of process to body of semicell is more like that of *S. digitatum* G. S. West (Jour. Linn. Soc. Bot. 39: 66, pl. 5, figs. 11–12. 1909) but the processes are totally different. The forking of the processes is quite like that of *S. brachiatum* Ralfs but the bodies of the semicells are different. The extent to which the chloroplast extends into the processes is quite unique, since it can be traced to a point beyond the forking of the processes.

45. STAUSTRUM INCONSPICUUM Nordstedt.

Lunds Univ. Arsskr. 9: 26, pl. 1, fig. 11. 1873.

Cells small, length (with processes) about equal to the breadth, median constriction slight, sinus semicircular, isthmus elongate and broad; semicells subquadrate, with the lateral margins somewhat inflated, apex truncate and with median portion inflated, angles with short hollow processes that are at first parallel to the apex of the semicell and then bend upwards sharply with a knee-like joint at the point of bending, ends of processes truncate; body of cell and processes smooth. Vertical view quadrangular, with the sides emarginate and the angles continued in straight processes that are inflated and truncate at the ends.

Zygospores unknown.

Cells 17–26 μ long with processes, 14–15.5 μ long without processes; breadth with processes 17–26 μ ; breadth at isthmus 7–9 μ (Nordstedt.)

Not found in the plankton of Wisconsin lakes.

var. *planctonicum* var. nov. Pl. 80, Figs. 5–7.

Cells with the isthmus narrower and greatly elongate; processes longer and upward bending more pronounced; ends of processes with four minute spines. (Euplankton.)

Cells 26–30 μ long with processes, 17–19 μ long without processes; breadth with processes 22–30 μ , without processes 12.5 μ ; breadth at isthmus 5–6 μ .

Jag (r).

This variety approaches the variety *gracilior* Maskell but has much slenderer processes and cell body.

46. *STAUSTRUM CERASTES* Lundell. Pl. 80, Figs. 8-10.

Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8: 69, pl. 4, fig. 6. 1871; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 268, pl. 18, fig. 4. 1896.

Cells of medium size, breadth and length about equal, slightly constricted, sinus a slight wedge-shaped constriction, isthmus relatively broad; semicells trapeziform-rectangular, tapering only slightly towards the isthmus, dorsal margin rounded, angles continued in stout tapering hollow processes with truncate ends that terminate in three or four minute teeth, processes strongly convergent; base of semicells with conical papillae or mucros just above the isthmus; one usually lying midway between each adjacent pair of processes, rarely with the mucros directly below the processes; median portion of semicell with two transverse rows of bifid emarginate verrucae that are continued in the processes as a single row of conical verrucae; apex of semicells with emarginate verrucae that continue for a ways along the dorsal margin of the processes and then give place to simple conical verrucae; ventral margin of processes with simple verrucae. Vertical view quadrangular (in Wisconsin specimens) with the sides retuse and the angles continued in stout straight processes that gradually taper to a truncate end; central area of the cell body with a rectangle of twelve emarginate verrucae (three on each side) whose sides parallel those of the cell, angles of this design with two parallel rows of emarginate verrucae leading to the bases of the processes and then giving way to a double or to a single row of conical verrucae than continues to the end of the processes; lateral margins of cells with emarginate verrucae; lateral margins of processes with short outwardly divergent spines. (Tychoplankton.)

Zygospores unknown.

Cells 50 μ long; breadth with processes 45-52 μ , without processes 25 μ ; breadth at isthmus 11 μ .

Found (rrr), Rudolph (rrr), Speese (rrr).

The alga as found in Wisconsin is always quadrangular although triangular specimens are well known in Europe. There were also but four supraisthmal mucros in all individuals examined. These resemble, in this respect, the type figured by Lundell and not the type with a transverse row of mucros above the isthmus that W. & G. S. West show. Welsh plankton material examined in the G. S. West collection also had the transverse row of conical papillae at the base of the semicells. It is possible that a separation of forms can be made on this feature of basal ornamentation but for the present the two are considered identical.

47. *STAUSTRUM ARACHNE* Ralfs.

Ann. & Mag. of Nat. Hist. 15: 157, pl. 11, figs. 6A-6B. 1845; Brit. Desm. 136, pl. 23, figs. 6A-6B. 1848.

Cells fairly small, length about half the breadth (with processes), deeply constricted, sinus widely open from a subacuminate apex,

isthmus narrow; semicells broadly campanulate, with apices slightly tumid and with pairs of minute denticulations between the processes, body of semicells smooth; angles continued in long slightly tapering processes that terminate in three minute denticulations, dorsal margin of processes finely crenulate, ventral margin smooth or slightly crenulate, processes strongly convergent. Vertical view five-radiate (rarely six-radiate), the processes of one semicell alternating slightly with those of the other semicell; body of cell pentagonal (or hexagonal) with the sides somewhat emarginate, ornamented with a

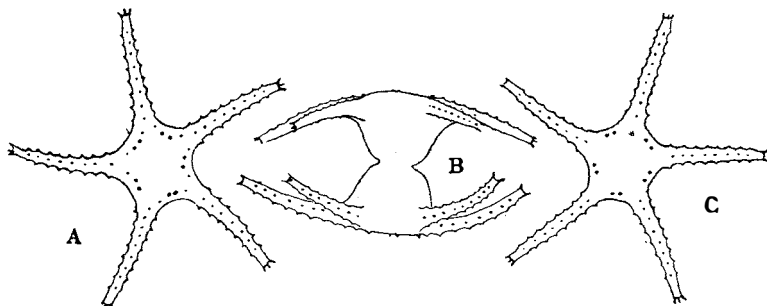


Fig. 13. *Staurastrum arachne* Ralfs ($\times 625$). From plankton material collected in the Capel Curig lakes, Wales, by W. & G. S. West.

pair of intramarginal denticulations between each pair of processes, sometimes with two more delicate denticulations, one on each side towards the base of the processes; central area without ornamentation; processes tapering slightly, straight or curved in the same direction, lateral margins finely crenulate and with a single median row of minute denticulations. Chloroplast axial, fairly massive, with two laminate lobes running into each process; pyrenoid single and central.

Zygospores unknown.

Cells $32\ \mu$ long; breadth with processes $60\text{--}65\ \mu$, without processes $15\text{--}18\ \mu$; breadth at isthmus $7.5\ \mu$.

Not found in the plankton of Wisconsin lakes.

Resembling *S. pentacerum* (Wolle) G. M. Smith in the five-radiate character of the semicells but much smaller and with a totally different shape of the semicells in front view. In this species the convergence of the processes is a constant feature (in the type) whereas in *S. pentacerum* the processes are parallel. The ornamentation of the cell body, as seen in the vertical view, is subject to some variation; the two denticulations lying midway between the processes are always present but the accessory denticulations flanking them are frequently lacking. The processes may be straight or all may be curved in the same direction as in *S. cyrtocentrum* De Brébisson.

var. CURVATUM W. & G. S. West. Pl. 80, Figs. 11-14.

Jour. Linn. Soc. Bot. 35: 549, pl. 18, fig. 9. 1903.

Cells somewhat larger than the type, less deeply constricted; semi-cells obversely subtriangular and with apices bearing small truncate verrucae; processes outwardly divergent. Vertical view four- or five-radiate, with central area of cell smooth or with a truncate verruca midway between each pair of adjacent processes. Chloroplast axial, with a small central body and a lobe arising midway between bases of processes, lobes with laminate ends, a single lobe running into the base of adjacent processes; pyrenoid single and central. (Euplankton.)

Cells 36-40 μ long with processes, 18-25 μ long without processes; breadth with processes 62-74 μ , without processes 18-20 μ breadth at isthmus 8.5 μ .

Carson (rr), Crab (sss), Dummy (rr), Dutchmans (rrr), Jag (rr), Lac Court Oreilles (rr), Shell (rrr).

The chief feature of the variety is the outward curving of the processes in the front view of a cell. There is also a difference in the ornamentation of the top of the cell and the cell shape. In the Wisconsin plankton the four-radiate specimens predominate.

48. STAUSTRUM PENTACERUM (Wolle) G. M. Smith. Pl. 80, Figs. 15-18.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 356, pl. 12, figs. 19-22. 1922.

Staurastrum Ophiura var. *pentacerum* Wolle, Bull. Torr. Bot. Cl. 9: 28, pl. 13, fig. 5. 1992; Desm. U. S. 134, pl. 43, fig. 13; pl. 44, fig. 3. 1884.

Cells of medium size, length about one and a half times the breadth (without processes), slightly constricted, sinus a small semicircular indentation, isthmus broad; semicells trapeziform-quadrate, with the apex slightly tumid and broader than the base, body of the semicell without ornamentation and apex with a row of subapical verrucae, processes arising just below the apex, subparallel, somewhat attenuated and terminating in three short divergent spines, dorsal margin finely crenulate, ventral margin smooth. Vertical view five-radiate (rarely six-radiate), with the processes of one semicell alternating with those of the other semicell; body of cell pentagonal or hexagonal, with sides retuse, and with a single broad emarginate verruca between each pair of processes, at times with two smaller verrucae one on each side of this larger verruca, central area without ornamentation; processes slightly tapering and with lateral margins crenulate or with two rows of spines. Chloroplast axial, massive, with reniform lobes arising between the bases of adjacent processes and with a single plate-like process running a short distance into each adjacent process. (Facultative plankton.)

Zygospores unknown.

Cells 36-41 μ long; breadth with processes 85-105 μ , without processes 18-20 μ ; breadth at isthmus 10 μ .

Adelaide (rrr), Bass (sss), Little Bass (r), Bear (rrr), Blue Gill (ss), Little Butternut (rr), Canteen (rrr), Carson (rrr), Cochrane (rrr), Crooked (ss), Devils (ss), Diamond (ss), Dummy (s), Dunham (rrr), George (rr), Half Moon (rrr), Jag (sss), Jenny (rr), Lake of the Woods (rrr), Lindy (r), Little Doctor (rrr), Long (rrr), Lynx (rr), Meta (ss), Nicaboyne (rr), Oak (r), Pine (rr), Rudolph (r), Sand (rrr), Sanford (rrr), Silver (rrr), Sishebogema (rrr), Speese (rr), Streitor (rrr), Sunday (rr), Tank (ss), Trapper (rrr), Whitney (rrr).

As I have stated elsewhere (*l. c.*) this alga seems sufficiently distinct from *S. Ophiura* Lundell to warrant recognition as a species. It differs from *S. Ophiura* in the relative proportions of the cells, smaller size, smaller number of processes, and different ornamentation, both in the apical verrucae and lack of spines on the bases of the semicells. The processes do not have the prolonged lateral verrucae of *S. Ophiura* and lack both the median row of spines and ornamentation of the ventral side.

var. TETRACERUM (Wolle) G. M. Smith. Pl. 80, Figs. 19-21.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 357, pl. 13, figs. 3-5. 1922.

Staurostrum Ophiura var. *tetracerum* Wolle, Bull. Torr. Bot. Cl. 9: 28, pl. 13, fig. 4. 1882; Desm. U. S. 134, pl. 44, figs. 1-2. 1884; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 268, pl. 18, fig. 16. 1896.

Cells with the same relative proportions and shape as the type; processes subparallel. Vertical view tetragonal and processes of one semicell alternating with those of the other semicell; processes with spines more prominent, sometimes with spines in the portion near the base bifid and with a median row of spines. (Facultative plankton.)

Cells 32-35 μ long; breadth with processes 85-120 μ , without processes 18-20 μ ; breadth at isthmus 10 μ .

Bass (rrr), Bird (sss), Lindy (cc), Nicaboyne (rr), Sand (rrr), Speese (rr).

A superficial examination of *S. ankyroides* Wolle might lead to the conclusion that it is an extremely well developed specimen of this variety. *S. ankyroides* differs in the nature of the lateral ornamentation of the processes, convergence of the processes and structure of the verrucae on the apices of the semicells.

49. STAUROSTRUM ANKYROIDES Wolle.

Bull. Torr. Bot. Cl. 11: 14, pl. 44, fig. 4. 1884; Desm. U. S. 137, pl. 51, fig. 4. 1884; G. M. Smith, Trans. Wis. Acad. Sci., Arts & Lett. 20: 358, pl. 13, figs. 13-15. 1922.

Cells large, length about three times the breadth (without processes), slightly constricted, sinus a small semicircular depression, isthmus broad; semicells cylindrical, with bases swollen and apex tumid, upper portion of semicell prolonged into four processes, the processes of one semicell alternating with those of the other semicell,

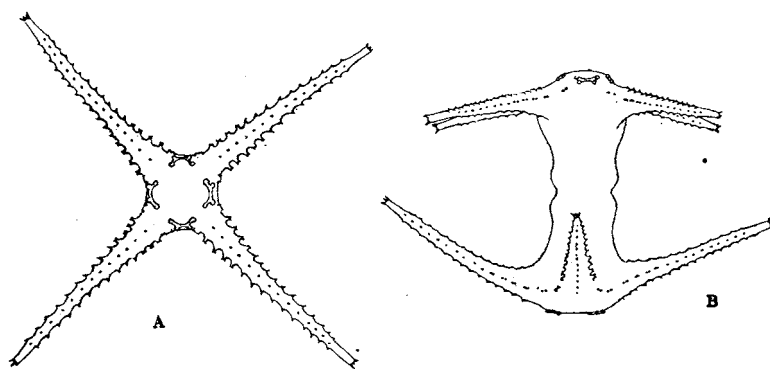


Fig. 14. *Staurastrum ankyroides* Wolle ($\times 500$). From a plankton collection made in Burned Rock lake, Ontario, Canada.

processes strongly convergent, with the upper margin more sharply crenulate than the lower margin, median area of processes with a row of bifid verrucae at the base and simple spines at the apex, ends of processes with three minute spines; apex of semicells bearing sub-apical emarginate verrucae. Vertical view quadrangular, angles with long gracefully attenuated processes that terminate in three spines, bases of processes with elongate bifid lateral verrucae and apices with simple lateral spines, median axis of processes with a single row of spines; body of cell with a conspicuous arcuate quadrigranulate verruca midway between every pair of processes.

Zygospores unknown.

Cells 60–68 μ long; breadth with processes 92–132 μ , without processes 20–24 μ ; breadth at isthmus 11–13.5 μ .

Not found in the plankton of Wisconsin lakes.

var. pentacladum var. nov. Pl. 81, Figs. 1–2.

Semicells with five processes; processes of one semicell alternating with those of the other semicell; apical verrucae on body of cell more nearly semicircular and closer together. (Euplankton?)

Cells 120–150 μ broad with processes, 25–28 μ broad without processes; breadth at isthmus 14 μ .

Crooked (rrr), Little Doctor (rrr).

The essential difference between the variety and the type is the five-radiate character of the cell. I have collected the alga in considerable quantity both in New York and Ontario (Canada) and find it constantly four-radiate. On the other hand the few individuals found in the two stations in Wisconsin were always five-radiate.

The alga should be compared with *S. pentacerum* (Wolle) G. M. Smith from which it differs in the more elegant body of the cell, much stouter lateral verrucae on the processes, ornamentation of under side of the processes, arcuate verrucae on the apex of the semicells, and in

the size of the cells. Although the processes resemble those of tetragonal and pentagonal forms of *S. Ophiura* Lundell it differs in the more delicate body of the cell, inflation of the base of the semi-cells, lack of a basal ring of conical spines, and most of all in the totally different ornamentation of the cell apices.

50. STAUSTRUM OPHIURA Lundell. Pl. 81, Figs. 3-4.

Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8: 69, pl. 4, fig. 7. 1871.

Cells very large, length two and half to three and a half times the breadth (without processes), slightly constricted, sinus small and semicircular, isthmus broad; semicells cyathiform, with strongly convex apices, base of semicells with a ring of stout conical verrucae with rounded apices and with four or five of these verrucae visible in a front view; superior portion of semicells prolonged into gracefully attenuated subparallel to convergent processes, upper surfaces of processes more sharply crenulate than the lower, ends of processes trispinate, median area of processes with bifid verrucae on the portion near the body of the cell and simple spines on the apical portion; rounded portion of semicell above the processes with a bifid verruca midway between apex and the insertion of the processes. Vertical view seven-rayed (rarely six- or eight-rayed), with rays gradually attenuated and trispinate, with lateral margins at base of processes bearing elongate emarginate to bifid verrucae and apical portion with simple spines, processes with a median row of simple spines; body of semicell with two broad emarginate verrucae at the margin between the insertion of each pair of processes; central portion of body with a ring of elongate bifid verrucae, the number of verrucae corresponding to the number of processes, verrucae alternating with, not opposite, the processes. (Tychoplankton.)

Zygospores unknown.

Cells 75-82 μ long; breadth with processes 115-160 μ , without processes 32-35 μ ; breadth at isthmus 23-25 μ .

Bass (rrr), Horseshoe (rrr), Lake of the Woods (rrr), Muskallonge (rrr).

This conspicuous and unique alga varies somewhat in the number, length, and convergence of the processes. In the Wisconsin plankton seven-rayed cells are the rule whereas in the English plankton eight- and nine-rayed specimens predominate. There is likewise variation in the ornamentation of the cell and the verrucae forming the central ring at the apex may be near the margin or the center. Lundell states that these verrucae are quadrifid but I have only noted bifid apical verrucae. Likewise the two emarginate verrucae between each pair of rays may be within the margin of the cell or projecting beyond it. The lateral verrucae of the processes are generally bifid, though cases have been found in which they are reduced to simple spines.

51. SAURASTRUM ROTULA Nordstedt. Pl. 81, Figs. 5-8.

Vidensk. Medd. f. d. naturh. Foren. i Kiöbenhavn 1869: 227, pl. 4, fig. 38. 1870; Wolle, Desm. U. S. 135, pl. 44, figs. 13-14. 1884; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 268, pl. 18, fig. 11. 1896.

Cells fairly large, length about twice the breadth (without processes), deeply constricted, sinus widely open and with a subacuminate apex, isthmus narrow; semicells subhexagonal, with portion below the processes straight-sided and that above truncate; body of semicells with a transverse row of subapical bidenticulate verrucae; processes arising midway between the apex and isthmus of semicells, subparallel, slightly attenuated and terminating in three short divergent spines, body of processes with three or four rings of sharp denticulations. Vertical view nine-rayed (very rarely eight-rayed), with the processes straight and slightly attenuated, ends of processes trispinate; body of cells with a single bidenticulate verruca at the base of each process, the verrucae forming an intramarginal ring. Cell wall smooth or finely punctate. (Tychoplankton.)

Zygospores unknown.

Cells 40-45 μ long; breadth with processes 92-102 μ , without processes 22-30 μ ; breadth at isthmus 10.5-12 μ .

Little Butternut (rrr), Des Moines (rrr), George (rrr), Round (rrr).

W. & G. S. West's criticism of Wolle's drawing which shows rectangular instead of conical apical papillae is, at least as far as Wisconsin specimens are concerned, without justification; the apical verrucae are distinctly bifid and not conical as their drawing shows. The species should be compared with *S. limneticum* var. *cornutum* G. M. Smith which appears closely related but is not, for reasons stated below, placed as a variety of *S. rotula*.

52. STAUSTRUM LIMNETICUM Schmidle.

Engl. Bot. Jahrb. 26: 52, pl. 4, fig. 5. 1899; G. S. West, Jour. Linn. Soc. Bot. 38: 129. 1907.

Cells large, length (without processes) about twice the breadth, deeply constricted, sinus widely open and with an acute apex, isthmus fairly narrow; semicells elliptic-obsemicircular, with the ventral margin more rounded than the dorsal (almost semicircular); processes arising at a point about a third of the distance from the apex to the isthmus, fairly delicate and very gracefully upwardly curved; lower margin of processes always crenulate and upper surface smooth or very shallowly crenulate, ends with three or four short divergent spines; body of semicells without ornamentation. Vertical view pentagonal or hexagonal, with sides slightly retuse and angles continued in long slightly tapering processes, lateral margins smooth, ends of processes trispinate to quadrispinate, processes of one semicell opposite those of the other semicell; central portion of cell body without ornamentation.

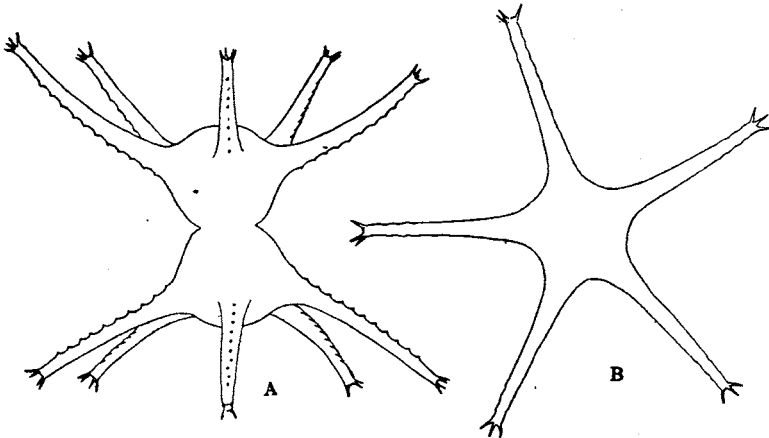


Fig. 15. *Staurastrum limneticum* Schmidle ($\times 600$). From plankton material collected in Lake Victoria Nyanza, Africa.

Cells 46–51 μ long; breadth with processes 100–130 μ , without processes 28–36 μ ; breadth at isthmus 14 μ (G. S. West).

Zygospores of the type unknown.

Not found in the plankton of Wisconsin lakes.

var. *cornutum* var. nov. Pl. 82, Figs. 1–2.

Staurastrum limneticum var. *burmense* G. M. Smith non W. & G. S. West, Trans. Wis. Acad. Sci., Arts & Lett. 20: 359, pl. 13, figs. 6–11. 1922.

Cells shorter and narrower than the type; length about two and a half times the breadth (without processes), sinus widely open and with apex rounded, isthmus narrow; semicells with sides of bases sublinear and processes upwardly divergent at apices but with bases subparallel, ornamented with three or four rings of conical teeth and ends of processes with three fairly long divergent spines, top of semicell with subapical elongate bidenticulate verrucae. Vertical view with length of processes one and a half times the diameter of the cell, five- to seven-rayed, with the processes straight and ornamented as in the front view; body of the cell with a bidenticulate verruca lying near the base of each process, verrucae forming a ring within the margin of the body of the cell; processes of one semicell alternating with those of the other semicell. (Euplankton.)

Zygospores spherical, with long slender spines that have their apices bifurcate and the bifurcations recurved.

Cells 48–52 μ long; breadth with processes 78–88 μ , without processes 20 μ ; breadth at isthmus 9 μ .

Diameter of zygospores with spines 85–92 μ , without spines 42–44 μ ; length of spines 20–24 μ .

Diamond (sss).

This is a clearly defined variety in which there are strong arguments for referring it to *S. rotula* Nordstedt or to *S. limneticum*.

The ring of bifurcate apical verrucae and ornamentation of the processes is more like that of *S. rotula*. The curved apices of the cells, smaller number of processes, and most of all the graceful upward curvature of the processes shows a greater resemblance to *S. limneticum*. The argument for referring this alga to *S. limneticum* is much stronger when the variety *burmense* W. & G. S. West (Ann. Roy. Bot. Garden Calcutta 6: 222, pl. 16, fig. 13. 1907) is taken into consideration. I have found that five- and six-radiate individuals are widely distributed in Ontario (Canada) and that these show a striking resemblance to the variety *burmense*, both in shape of the semicells and the curvature of the processes. A comparison of Canadian specimens with type material of the variety *burmense* from the G. S. West collection shows that the two are identical except for the apical verrucae.

The alga has been found in but one lake in Wisconsin and the cells are almost invariably with seven processes. The apical verrucae are also slightly stouter than those of cells found in the Ontario plankton but it does not seem advisable to separate the two on this account.

53. *STAURASTRUM RADIANS* W. & G. S. West. Pl. 82, Figs. 6-7.

Jour. Linn. Soc. Bot. 33: 318, pl. 18, fig. 18. 1898.

Cells fairly large, length (with processes) about half the breadth, fairly deeply constricted, sinus obtuse-angled and with the apex subacute, isthmus broad; semicells trapeziform in outline, with the apex slightly convex and the angles continued in straight short processes with coarsely crenulate margins, ends of processes with three or four stout divergent spines, processes parallel; body of semicell without ornamentation. Vertical view circular, with eight radiating processes, processes straight, coarsely crenulate in outline, bases of lateral margins with an elongate emarginate outgrowth on each side; apex of processes with three or four small stout divergent spines; body of cell without ornamentation. (Tycho plankton.)

Zygospores unknown.

Cells 40 μ long; breadth with processes 70 μ , without processes 30 μ ; breadth at isthmus 17.5 μ .

Des Moines (rrr), Big McKenzie (rrr).

A distinctive alga which is easily recognized in a vertical view.

54. *STAURASTRUM FURCATUM* (Ehrenberg) De Brébisson. Pl. 83, Figs. 1-3.

Mem. de la soc. imp. d. Sc. nat. de Cherbourg 4: 136. 1856; Rabenhorst, Flora Eur. Algarum 3: 218. 1868; Wolle, Desm. U. S. 150, pl. 40, figs. 40-41; pl. 48, figs. 15-16; pl. 52, fig. 34. 1884; W. West, Jour. Roy. Micr. Soc. 1890: 292, pl. 5, fig. 11. 1890.

Xanthidium furcatum Ehrenberg, Abh. Ak. d. Wiss. zu Berlin 1833: 318. 1834; Ralfs, Brit. Desm. 213. 1848.

Cells small, length (with processes) slightly greater than the breadth, deeply constricted, sinus acute-angled and with the apex acuminate, isthmus fairly narrow; semicells transversely elliptic-hexagonal, with ventral margin tumid and dorsal margin truncate; cell body with two whorls of processes, the three lower processes arising midway between the isthmus and the apex of the semicell; the six processes of the upper whorl subapical in insertion; processes of the lower whorl at right angles to the long axis of the cell, with subparallel lateral margins and ends deeply bifurcate; processes of the superior whorl similar to those of the lower whorl but lying at an angle of 45 degrees with the long axis of the cell; cell wall smooth. Vertical view triangular, sides of cell body straight and angles continued in very short processes; sides of cell each with two short intramarginal processes, one near each angle of the cell. (Tychoplankton.)

Zygospores spherical, with numerous elongate spines that are bifurcate at their apices (Rabenhorst).

Cells 27–30 μ long with processes, 18–20 μ long without processes; breadth with processes 22–27 μ , without processes 14 μ ; breadth at isthmus 7–8 μ .

Lindy (rrr).

The species resembles *Staurostrum tohopekaligense* Wolle in the double whorl of three inferior and six superior processes. The two are distinguished, however, by the smaller size, relatively shorter processes, different cell shape, and merging of the lower whorl of processes with the cell body in the vertical view of *S. furcatum*. *S. senarium* (Ehrenberg) Ralfs is a closely related species of the same cell size but with accessory processes in the lower whorl.

The use of Ralfs' British Desmidiaceae as the starting point for nomenclature involves certain difficulties in determining the correct name of the species. Ralfs described the species under the name *S. spinosum* and then in the appendix recognizes the *Xanthidium furcatum* of Ehrenberg. He suggests that this *Xanthidium* may belong to *Staurostrum*. Since Ralfs recognizes both names the older one is taken.

55. STAURASTRUM BRASILIENSE Nordstedt.

Vidensk. Medd. f. d. naturhist. Foren. i Kiöbenhavn 1869: 227, pl. 4, fig. 39. 1870. (non Lundell, Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8: 73, pl. 5, fig. 2. 1871.).

Cells large, breadth (with spines) one and a third times the length, deeply constricted, sinus widely open and with apex acute; isthmus broad, about half the diameter of the cell; semicells broadly cuneate, with the ventral margins slightly convex and the apex somewhat concave; angles truncate and with three very long stout divergent spines, the two inferior ones lying in the same horizontal plane, the superior one inserted at an angle. Vertical view four- (very rarely

five-) radiate, the angles bearing three (very rarely four) outwardly divergent stout spines; sides of cells deeply emarginate.

Zygospores unknown.

Cells 56–77 μ long with spines 43–51 μ long without spines; breadth with spines 65–99 μ , without spines 25–37 μ (Nordstedt).

Not found in the plankton of Wisconsin lakes.

var. LUNDELLII W. & G. S. West. Pl. 82, Figs. 3–5.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 259. 1896.

Staurastrum brasiliense Lundell (non Nordstedt), Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8: 73, pl. 5, fig. 2. 1871.

Cells (without spines) about twice the size of the type; apex of semi-cells straight or only slightly retuse. Vertical view five-sided (rarely six-sided); emargination of sides subsemicircular. Cell wall smooth or finely punctate. Chloroplast with a central mass and massive rays towards each angle, rays each with several smaller laminate rays; pyrenoids numerous, in both the central portion and the rays. (Facultative plankton.)

Cells 145 μ long with spines, 74 μ long without spines; breadth with spines 148 μ , without spines 92 μ ; breadth at isthmus 38 μ ; spines 27–37 μ long.

Bass (rrr), Diamond (r).

56. STAURASTRUM TOHOPEKALIGENSE Wolle.

Bull. Torr. Bot. Cl. 12: 128, pl. 51, figs. 4–5. 1885; Freshw. Algae of U. S. 45, pl. 59, figs. 4–5. 1887; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 6: 180, pl. 21, fig. 26. 1902.

Cells of medium size, breadth (without processes) somewhat less than the length, fairly deeply constricted, sinus widely open and with apex acute, isthmus narrow; semicells with bases obsemicircular and apices flattened; with three lateral processes arising about half way from apex to the isthmus, lateral processes parallel; upper part of semicells with six subapical processes arising just back of the lateral margins, subapical processes markedly divergent; all processes hollow, with subparallel sides and length about equal to the diameter

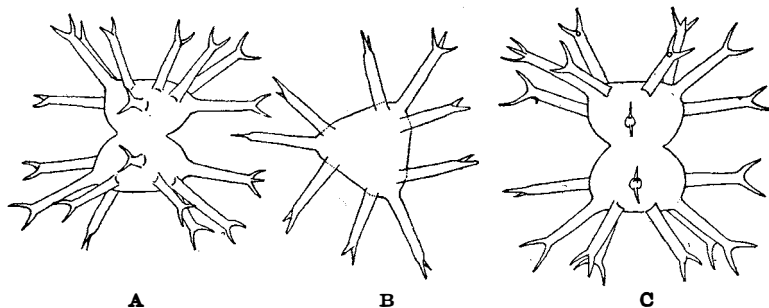


Fig. 16. *Staurastrum tohopekaligense* Wolle ($\times 500$). Plankton specimens from lakes in Ontario, Canada. Figs. A, C from Silver Lake, Fig. B from Gull Lake.

of the cell, ends of processes with two (seldom three) long divergent hollow spines. Cell wall smooth. Vertical view triangular, with sides straight but frequently bending in the vicinity of the angles to form a sharply pointed angle; angles prolonged into processes, each lateral margin of cell with two perpendicular processes arising one near each angle but inside the margin of the cell.

Zygospores unknown.

Cells 70–83 μ long with processes 32–39 μ long without processes; breadth with processes 67–75 μ , without processes 28–32 μ ; breadth at isthmus 15 μ ; length of terminal spines 4.5–6.5 μ .

Not found in the plankton of Wisconsin lakes.

This is a well defined species but one which is subject to considerable variation and one where, owing to the incomplete original description and poor figures, there is some doubt as to the type. The varieties *trifurcatum* and *quadrangulare* were described by W. & G. S. West in 1895 (Trans. Linn. Soc. 2nd. Ser. Bot. 5: 80, pl. 9, figs. 8–9) and the variety has been observed by them again in Ceylon in 1902 (*l. c.*) and in the Scottish plankton in 1905 (Trans. Roy. Soc. Edinburgh 41: 503, pl. 7, fig. 7). Two years later in discussing the plankton of the Central African lakes G. S. West (Jour. Linn. Soc. Bot. 38: 130, 1907) mentions quadrangular and triangular forms that "were typical as regards proportions and length of processes."

After a careful comparison of specimens from Burma and from the plankton of Victoria Nyanza (Africa), Scotland, New York, Ontario and Wisconsin I have reached the conclusion that text figure 16 is that of the type. It is characterized by processes which are about as long as the diameter of the cell, a flat cell apex, triangular body and long divergent spines at the ends of the processes. The figure of an American specimen from Wolle given by W. & G. S. West in 1902 (*l. c.*), which shows two supplementary processes on each face of the cell, has not been observed. This shows that the number of processes is no sure criterion in determining varieties in this species. In my opinion the ends of the processes in the West drawing are too rounded. The number of spines at the ends of the processes is generally two but I have found that occasionally the processes on either the superior or the inferior whorls may be trispinate.

The varieties *trifurcatum* and *quadrangulare* which have been found in Madagascar, Burma, and the African plankton should be considered synonyms of *S. tohopekaligense* var. *nonanum* (Turner) Schmidle.

var. *brevispinum* nom. nov. Pl. 82, Figs. 8–11.

Staurostrum tohopekaligense var. *trifurcatum* W. & G. S. West, Trans. Roy. Soc. Edinburgh 41: 503, pl. 7, fig. 7. 1905 (non Trans. Linn. Soc. 2nd. Ser. Bot. 5: 80, pl. 9, fig. 8. 1895).

Cells somewhat smaller and with diameter of the cell greater than the length of the processes. Processes trifurcate or bifurcate but with much shorter spines. Chloroplast massive, with a broad lobe arising opposite each side and sending a single ray into the two lateral processes; processes at angles with a single ray arising from the base of the chloroplast. (Facultative plankton.)

Cells $48\ \mu$ long with processes, $26\ \mu$ long without processes; breadth with processes $50\ \mu$, without processes $24\ \mu$; breadth at isthmus $11\ \mu$.

Carroll (rrr), Horseshoe (rrr), Lake of the Woods (rrr).

This alga as found in Wisconsin is identical with specimens from the Scotch plankton. It is distinguished from the type by the shorter processes and much shorter terminal spines of the processes. I have found specimens in which all processes are bispinate and others in which all are trispinate as well as intermediates between these two extremes.

57. *STAUSTRUM FURCIGERUM* De Brébisson. Pl. 83, Figs. 4-7.

in Meneghini, *Linnaea* 14: 226. 1840; G. S. West, *Brit. Freshw. Algae* 172, fig. 65G. 1904.

Didymocladon furcigerus Ralfs, *Brit. Desm.* 144 pl. 33, figs. 12A-12D. 1848.

Cells of medium size, length (with processes) slightly greater than the breadth, deeply constricted, sinus acute-angled and with the apex acuminate, isthmus narrow; semicells broadly hexagonal, with sides bordering the sinus slightly convex and the apex flattened or faintly concave; angles with two whorls of hollow processes, those of the inferior whorl stouter and attenuated to a blunt end furnished with three short divergent spines, body of processes with four to six concentric rings of small conical granules; processes of superior whorl more delicate, not so strongly attenuated and ending in three small divergent spines, ornamented with concentric rings of granules; processes of inferior whorl parallel, processes of superior whorl sub-erect to strongly divergent. Body of cell without ornamentation. Vertical view triangular; sides somewhat concave and angles continued in gently tapering processes with truncate trispinate ends, processes with concentric rings of granules; body of cell with three smaller radially arranged processes, one at each angle of the cell; central portion of cell body without ornamentation. (Facultative plankton.)

Zygospores spherical, furnished with numerous long spines that have conical bases and bifurcate apices (G. S. West).

Cells $60-66\ \mu$ long with processes, $31-38\ \mu$ long without processes; breadth with processes $52-60\ \mu$, without processes $28\ \mu$; breadth at isthmus $12.5-13.5\ \mu$.

Beaverdam (rrr), Des Moines (rrr), Duck (c), Granite (rr), Half Moon (rrr), Hill (rrr), Lac Court Oreilles (rrr), Silver (rrr).

var. *ARMIGERUM* forma *gracillimum* n. forma. Pl. 83, Figs. 8-11.

Staurostrum furcigerum var. *armigerum* (De Brébisson) Nordstedt Vidensk. Medd. f. d. naturh. Foren. i Kiöbenhavn 1888: 207. 1888.

Staurostrum armigerum De Brébisson, Mem. de la soc. imp. d. Sc. nat. de Cherbourg 4: 136, pl. 1, fig. 22. 1856.

Superior whorls containing six (not three) processes arising in pairs at the base of the processes of the inferior whorl and lying (in the vertical view) at right angles to the sides of the cell. Processes long and delicate and with their apices bifurcate. (Facultative plankton.)

Cells 63-68 μ long with processes, 30-32 μ long without processes; breadth with processes 67-73 μ , without processes 27-30 μ ; breadth at isthmus 12-15 μ .

Shell (r).

Three very similar species have been described in which there are three processes in the lower whorl and six in the upper. Nordstedt (*l. c.*) has shown that two of these become the varieties *eustephanum* (Ehrenberg) Nordstedt and *armigerum* (De Brébisson) Nordstedt of *S. furcigerum*; while the third *S. pseudofurcigerum* Reinsch cannot be recognized but belongs in part to the variety *armigerum* and in part to the variety *eustephanum*. The variety *armigerum* is characterized by long delicate processes with undulate margins and bifid ends while the processes of the variety *eustephanum* are short and have the ornamentation of the type.

58. *STAURASTRUM LEPTACANTHUM* Nordstedt. Pl. 83, Figs. 12-14.

Vidensk. Medd. f. d. naturhist. Foren. i Kiöbenhavn 1869; 229, pl. 4, fig. 46. 1870.

Cells fairly large, length (with processes) about the same as the breadth, fairly deeply constricted, sinus widely open and with the apex subacute, isthmus narrow; semicells subcircular to subhexagonal in outline, with the ventral margins slightly tumid, dorsal margins and apex tumid; cell body punctate and with processes arising in two whorls; lower whorl arising midway between the isthmus and the apex of the semicells, containing six processes (four visible in front view); processes subparallel, long and very slightly attenuated, terminating in a bifurcation that is continued in short spines, processes without ornamentation; superior whorl of processes subapical in insertion, processes four in number and similar to those of the lower whorl but lying at an angle of 45 degrees with the vertical axis of the semicell. Vertical view hexagonal, with sides slightly concave and angles continued in straight processes that terminate in a bifurcation, the two arms of the bifurcation lying in the same vertical plane, processes without ornamentation; central portion of cell body with four similar processes. Chloroplast with a comparatively small central mass and a single ray running into each process of both

whorls and continuing nearly to the point of bifurcation. (Facultative plankton.)

Zygospores unknown.

Cells 100–110 μ long with processes, 41–45 μ long without processes; breadth with processes 100–114 μ , without processes 25–28 μ ; breadth at isthmus 13 μ ; length of terminal spines 11–14 μ .

Bass (rrr), Crooked (rrr), Diamond (ss), Dummy (rr), Horseshoe (rr), Lake of the Woods (ss), Mud Hen (rrr), Shell (r), Tank (rrr).

The species shows a certain resemblance to *S. tohopekaligense* Wille in the two whorls of deeply bifurcate processes but the two differ in size of the cells, shape of the cells and number of processes. In Wisconsin specimens the lower whorl always has six and the upper whorl four processes but forms with six lower and six upper, nine lower and six upper, as well as eight lower and four upper have been described.

59. *STAUSTRUM ARCTICON* (Ehrenberg) Lundell. Pl. 84, Figs. 1–2.

Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8: 70, pl. 4, fig. 8. 1871.

Cells large, length slightly greater than the breadth (with processes), fairly deeply constricted, sinus open and acute-angled, isthmus broad; semicells subspherical, with bases obsemicircular and apices strongly tumid to semicircular; body of semicells without ornamentation, median portion of semicell body with a whorl of nine (five visible in front view) long stout very slightly tapering hollow processes, processes parallel to slightly divergent; apex of semicell with a whorl of six similar processes that are subapical in insertion and lie at an angle of 45 degrees with the lower series; both series of processes with three or four transverse rings of conspicuous conical granules, ends of processes with three stout hollow divergent spines. Vertical view circular, with nine straight marginal processes and an inner whorl of six intramarginal processes, structure of processes as in front view. Cell wall smooth or finely punctate. Chloroplast a central axial mass with a single arm running a short distance into each process; pyrenoid single and central. (Facultative plankton.)

Zygospores unknown.

Cells 120 μ long with processes, 70 μ long without processes; breadth with processes 114–120 μ , without processes 44–53 μ ; breadth at isthmus 29 μ .

Bass (rrr), Beaverdam (r), Clear Crooked (rrr), Des Moines (rrr), Diamond (ss), Found (rrr), Horseshoe (rrr), Lake of the Woods (ss), Silver (rrr), South Crab (rrr), Tank (rrr).

A very distinctive species where the number of processes in the two whorls is quite constant. Aside from differences in the length of the processes, which is generally shorter in American than in European individuals, the variation is confined to the number of rings of granules on the processes and the angle of the sinus.

var. GLABRUM W. & G. S. West. Pl. 83, Fig. 15; Pl. 84, Figs. 3-5.
Trans. Linn. Soc. 2nd. Ser. Bot. 5: 269, pl. 18, fig. 14. 1896.

Processes frequently shorter and stouter, without the transverse rings of granules, outline straight or somewhat undulate. Cell wall smooth or punctate. (Facultative plankton.)

Cells 105-120 μ long with processes, 62-65 μ long without processes; breadth with processes 106-115 μ , without processes 47-50 μ ; breadth at isthmus 25-26 μ .

Black Oak (rrr), Des Moines (rrr), Devils (rrr), Fish (rr), Long (rrr), Middle McKenzie (rrr), Mud Hen (rrr), Muskallonge (r), Poplar (sss), Reserve (rrr), Rooney (rr), Sand (rr), Soft (cc).

Intermediate stages between this variety and the type are sometimes found but generally the two are quite distinct.

ARTHRODESMUS Ehrenberg 1838.

Cells solitary, generally small, with the length usually equal to the breadth, usually compressed and bilaterally symmetrical in front view, rarely triangular in vertical view and with a radial symmetry, median constriction pronounced and with sinus widely open to linear; semicells in front view generally triangular, rarely elliptic, subtrapeziform or subrectangular, with simple straight or curved spines at the angles, spines lying in the same plane. Vertical view usually elliptic and with spines at the poles, rarely triangular. Lateral view of semicells subcircular. Cell wall of uniform thickness and without ornamentation on body of semicells. Cells sometimes embedded in a wide gelatinous sheath with blunt radial strands of denser mucilage. Chloroplasts axial, with one pyrenoid.

Zygospores spherical; with walls smooth or bearing simple spines.

This genus was originally founded on the compressed nature of the cells in combination with simple spines at the angles and lack of ornamentation on the body wall. We know now, however, that there are bilaterally symmetrical *Staurastrum* species with spines at the angles of the semicells and smooth walls. W. & G. S. West have also described radially symmetrical varieties of certain *Arthrodesmus* species so that there is no sharp distinction between *Arthrodesmus* and *Staurastrum*. The systematic treatment of the group is facilitated by considering it a separate genus and not a subgenus or section of *Staurastrum*. On the other hand, species like *A. octocornis* Ehrenberg and *A. tenuissimus* Archer approach some of the smaller *Xanthidium* species. The central portion of the cell face in *Xanthidium* is generally thickened or protruding, while in *Arthrodesmus* it is not differentiated.

KEY TO THE SPECIES.

Semicells with two spines.

Shape of semicells approximately elliptic.

Apex of semicells a smooth curve.

Spines short and convergent.....(1) *A. convergens*

Spines long, parallel to divergent.....(3) *A. subulatus*

Apex truncate in median portion.....(4) *A. michiganensis*

Shape of semicells not elliptic.

Diameter of semicells greater than length of spines.

Isthmus elongate(6) *A. constrictus*

Isthmus not elongate.

Spines convergent(7) *A. Ralfsii*

Spines divergent.....(5) *A. phimus*

Diameter of semicells less than length of spines.

Apex of semicells retuse.....(8) *A. quiriferus*

Apex of semicells not retuse.

Semicells subrectangular.....(2) *A. Bulnheimii*

Semicells subtriangular.

Apex flat.....(9) *A. incus*

Apex convex(10) *A. triangularis*

Semicells with four spines.....(11) *A. octocornis*

1. ARTHRODESMUS CONVERGENS Ehrenberg. Pl. 84, Fig. 6.

Die Infusionsthierehen 152, pl. 10, figs. 18A-18B. 1838; Ralfs, Brit. Desm. 118, pl. 20, figs. 3A-3D. 1848; G. S. West, Jour. Linn. Soc. Bot. 34: 397, text fig. 4. 1899; W. & G. S. West, Monogr. Brit. Desm. 4: 106, pl. 116, figs. 4-13. 1912.

Cells of medium size, breadth (without spines) slightly greater than the length, very deeply constricted, sinus narrowly linear and with outer portion widely open, isthmus narrow; semicells transversely elliptic, with the apex more rounded than the base of the semicell, lateral margins broadly rounded and furnished with a single stout tapering spine, spines strongly convergent and with the extremities of opposite pairs frequently apposed. Vertical view narrowly elliptic, with a short spine at each pole. Chloroplast axial, with a single conspicuous pyrenoid.

Zygospores spherical, with a smooth wall (W. & G. S. West).

Cells 30-45 μ long; breadth with spines 45-75 μ , without spines 32-48 μ ; isthmus 10-11 μ broad; spines 12-16 μ long.

Diameter of zygospores 39-48 μ (W. & G. S. West).

Diamond (rrr), Muskallonge (rrr).

Variation is much more pronounced in this species than in any other of the genus. This is particularly true of the spines and it is not at all unusual to find those of one semicell reduced or even entirely lacking. No particular significance can be attached to this suppression of spines since when new semicells are formed they are generally quite typical.

The species is the largest of the genus and is characterized by the elliptic semicells and the short converging spines. It has a certain

resemblance to *A. subulatus* Kützing but the latter has long parallel to divergent spines and a different shape of the semicells.

2. *ARTHRODESMUS BULNHEIMII* Raciborski. Pl. 84, Figs. 7-8.

Pamiętnik Wydz. Akad. Umiej. w Krakowie 17: 95, pl. 16, fig. 17. 1889; W. & G. S. West, Monogr. Brit. Desm. 4: 105, pl. 116, figs. 1-2. 1912.

Cells of medium size, length (without spines) slightly greater than the breadth, deeply constricted, sinus linear, isthmus narrow; semicells transversely subrectangular, with lateral margins subparallel and apex very slightly tumid, basal angles more rounded than the apical angles, apical angles with long fairly stout gradually attenuated spines, spines strongly divergent to suberect. Vertical view elliptic, with a single straight fairly stout spine at each pole. Cell wall smooth. Cells enclosed in a spherical gelatinous envelope with a radially fibrillar structure. (Tycho plankton.)

Zygospores unknown.

Cells 47-60 μ long with spines, 20-22 μ long without spines; breadth with spines 42-50 μ , without spines 20-23 μ ; breadth at isthmus 5-8 μ ; spines 18-25 μ long.

Lindy (rrr).

The transversely subrectangular semicells combined with the conspicuous long spines, and especially the suberect position of these spines, differentiate the alga from the others of the genus.

3. *ARTHRODESMUS SUBULATUS* Kützing. Pl. 84, Figs. 9-10.

Species algarum 176. 1849; W. & G. S. West, Monogr. Brit. Desm. 4: 109, pl. 116, fig. 14; pl. 117, fig. 1. 1912.

Cells of medium size, length (without spines) slightly greater than the breadth, median constriction deep, sinus widely open and with the apex acute, isthmus narrow; semicells obsemicircular, with bases convex and apices markedly tumid; lateral angles rounded and each bearing a single long gradually attenuated spine, spines parallel to slightly divergent. Vertical view elliptic, with a single spine at each pole. Chloroplast axial, with a single pyrenoid. (Facultative plankton.)

Zygospores spherical, with smooth walls (W. & G. S. West).

Cells 27-34 μ long; breadth with spines 53-80 μ , without spines 18-28 μ ; breadth at isthmus 6-7 μ ; spines 20-25 μ long.

Zygospores 30-36 μ in diameter (W. & G. S. West).

Diamond (rrr), Dummy (rrr), George (rr), Lindy (rrr), Tank (rrr), Travis (r), Whitney (rrr).

The distinguishing features of *A. subulatus* are the elevated apices and the semicircular bases of the semicells. It shows a certain resemblance to *A. convergens* Ehrenberg but the two are quite distinct.

var. *Nordstedtii* var. nov. Pl. 85, Figs. 1-3.

Apices of semicells slightly tumid, not strongly convex; spines always somewhat divergent. Vertical view narrowly elliptic. (Tycho plankton.)

Cells 35–38 μ long with spines, 27.5–30 μ long without spines; breadth with spines 68–85 μ , without spines 22–27 μ ; breadth at isthmus 6–8 μ ; thickness 12 μ ; spines 22–26 μ long.

Horseshoe (rrr), Meta (rr).

This variety differs from the type in the great reduction in the curvature of the portion of the semicell lying above the spines. In this respect the shape of the semicells shows a close affinity with the *A. subulatus* forma *major* figured by Nordstedt (Vidensk. Medd. f. d. naturh. Foren. i Kiöbenhavn 1869: 232, pl. 4, fig. 59. 1870) but the Wisconsin cells being much smaller have been considered distinct from the form *major*.

4. ARTHRODESMUS MICHIGANENSIS Johnson. Pl. 85, Fig. 4.

Bull. Torr. Bot. Cl. 22: 296, pl. 232B, fig. 12. 1895.

Cells somewhat under medium size, length about one and a half times the breadth (without spines), median constriction deep, sinus open, with apex broadly rounded, isthmus narrow and elongate; semicells broadly reniform-pyramidate, with the basal halves obelliptic and the apices truncate-pyramidate, flanks of truncate portion retuse; lateral angles of semicells broadly rounded and each with a long somewhat attenuated curved spine, spines inwardly convergent or outwardly divergent. Vertical view elliptic, with a single straight spine at each pole. (Tychoplanktont.)

Zygospores unknown.

Cells 37 μ long; breadth with spines 65 μ , without spines 27 μ ; breadth at isthmus 5.5 μ ; spines 21–23 μ long.

Soft (rrr).

This rare alga has not been reported since it was discovered. The specimens that I have seen are proportionally narrower than Johnson figures them and the spines may be convergent.

5. ARTHRODESMUS PHIMUS Turner. Pl. 85, Fig. 5.

Kgl. Sv. Vet.-Ak. Handl. 25, No. 5: 136, pl. 12, fig. 9. 1893; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 6: 192, pl. 22, fig. 21. 1902; Monogr. Brit. Desm. 4: 104, pl. 115, figs. 15–16. 1912.

Cells small, breadth (without spines) somewhat greater than the length, median constriction deep, sinus acute-angled and with the apex acuminate, isthmus fairly narrow; bases of semicells obsemicircular, apices strongly retuse, lateral angles blunt and each terminating in a single short pointed spine, spines divergent. Vertical view narrowly elliptic, with a short spine at each pole. Chloroplasts axial and with a single pyrenoid. (Tychoplanktont.)

Zygospores unknown.

Cells 36 μ long with spines, 25 μ long without spines; breadth with spines 42 μ , without spines 35 μ ; breadth at isthmus 7.5 μ ; spines 10 μ long.

Clear Crooked (rrr), Owen (rrr), Sand (rrr).

The few individuals that have been seen agree well with W. & G. S. West's drawings of the alga as it is found in India. More reliance should be put in their figures than on that of Turner which is merely a copy of a sketch by Wallich. The organism belongs in the group of short-spined species and is distinguished by the marked concavity of the apex of the semicell.

6. *ARTHRODESMUS CONSTRICTUS* G. M. Smith. Pl. 85, Figs. 6-8.

Trans. Wis. Acad. Sci., Arts & Lett. 20: 348, pl. 10, figs. 17-18. 1922.

Cells fairly small, breadth (without spines) somewhat greater than the length, deeply constricted, sinus a broad excavation with a sub-rectangular apex and sides opening outwards, isthmus narrow and greatly elongate; semicells broadly obversely triangular to transversely elliptic, apex somewhat tumid, lateral angles of semicells acute and each with a single fairly long gradually attenuated spine, spines divergent. Vertical view narrowly elliptic and with a single straight spine at each pole. (Euplankton.)

Zygospores unknown.

Cells 27-35 μ long with spines, 20-25 μ long without spines; breadth with spines 52-58 μ , without spines 25-28 μ ; breadth at isthmus 4-5 μ ; spines 15-18 μ long.

Bass (rrr), Blue Gill (rr), Carson (rrr), Horseshoe (rrr), Jenny (rrr), Lynx (rr), Pine Tree (rrr), Pokegama (rrr).

Showing a close relationship to both *A. incus* (De Brébisson) Hassall and *A. triangularis* Lagerheim, but differing in the much greater breadth of the semicell in proportion to the length. An elongate isthmus similar to that found in this species is known in certain varieties of *A. incus* but the narrowness of the isthmus is much more pronounced in *A. constrictus*.

7. *ARTHRODESMUS RALFSII* W. West. Pl. 85, Figs. 9-12.

Jour. Linn. Soc. Bot. 29: 168. 1892.

Arthrodesmus incus var. *Beta* Ralfs, Brit. Desm. 118, pl. 20, figs. 4E-4L. 1848.

Arthrodesmus incus var. *Ralfsii* (W. West) W. & G. S. West, Monogr. Brit. Desm. 4: 95, pl. 114, figs. 2-4. 1912.

Arthrodesmus incus var. *Ralfsii* forma *latiuscula* W. & G. S. West, Monogr. Brit. Desm. 4: 96, pl. 114, fig. 5. 1912; G. M. Smith, Trans. Wis. Acad. Sci., Arts & Lett. 19: 647. 1918.

Cells small, length about equal to the breadth (without spines), median constriction fairly deep, sinus widely open and with apex semicircular, isthmus broad but not elongated; semicells obversely trapeziform, with bases straight to slightly convex, apex straight or in rare cases slightly concave; lateral angles of semicells acute and bearing short stout gradually attenuated spines; spines convergent. Vertical view elliptic, with a single spine at each pole. (Facultative plankton.)

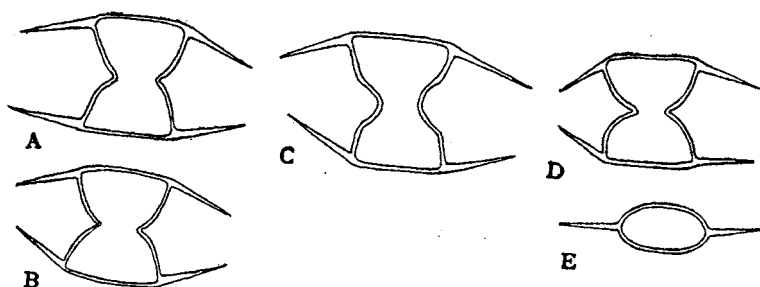


Fig. 17. *Arthrodesmus Ralfsii* W. West ($\times 700$). From material in the Jenner Herbarium of the British Museum of Natural History.

Zygospores spherical, with simple long spines (Ralfs).

Cells $16-18\ \mu$ long; breadth with spines $28-31\ \mu$, without spines about $16\ \mu$; breadth at isthmus $7.5-8.5\ \mu$; thickness $8-10\ \mu$; length of spines $7.5-8.5\ \mu$.

Dummy (rrr), George (rr), Horseshoe (rr), Pardee (rr).

This alga was first considered a distinct species by William West but later re-referred to *Arthrodesmus incus* where Ralfs originally described it as an unnamed variety.

I have examined type material collected by Ralfs and preserved in the Jenner herbarium of the British Museum and feel that the alga is sufficiently distinct to warrant the specific recognition that William West first gave it. The most striking character is the convergence of the spines. *Arthrodesmus Ralfsii* also differs from *A. incus* (De Brébisson) Hassall in the ratio between length and breadth as well as in the shape of the semicells.

The specimens from the Jenner herbarium are about one and a half times the sizes of the Wisconsin specimens and are somewhat broader than what W. & G. S. West consider typical *A. Ralfsii* since they also include the form *latiuscula* of W. & G. S. West.

var. **Brebissonii** (Raciborski) comb. nov. Pl. 85, Figs. 13-17.

Arthrodesmus incus var. *Brebissonii* Raciborski, Pamiętnik Wyd. Akad. Umiej. w Krakowie 17: 96, pl. 6, fig. 15. 1889; de Toni, Nuova Notarisia 5: 68. 1890.

Sinus widely open and with an acute, not rounded, apex; isthmus narrow; semicells obversely triangular, with the bases straight or slightly tumid; spines much stouter and longer than the type and more markedly convergent. (Facultative plankton.)

Cells $21-27\ \mu$ long; breadth with spines $47-60\ \mu$, without spines $21-25\ \mu$; breadth at isthmus $6.5-7\ \mu$; thickness $13\ \mu$; spines $16-18\ \mu$ long.

Chain (rrr), Mud (sss).

Differing from the foregoing in the triangular semicells, narrower isthmus, as well as in the greater length and degree of convergence of the spines.

8. *ARTHRODESMUS QUIRIFERUS* W. & G. S. West. Pl. 85, Fig. 18.

Jour. Linn. Soc. Bot. 35: 542, pl. 17, figs. 9-10. 1903; Monogr. Brit. Desm. 4: 101, pl. 115, figs. 6-7. 1912.

Cells fairly large, length (without spines) slightly greater than the breadth, median constriction deep, sinus widely open and with a rounded apex, isthmus narrow and slightly elongate; semicells obversely subtriangular, with the basal margins slightly convex and apex markedly retuse; angles of semicells somewhat rounded and each furnished with a single extremely long gradually attenuated spine, spines markedly divergent. Vertical view elliptic, with a long spine at each pole. Chloroplasts single, axial, with one pyrenoid. (Euplankton.)

Zygospores unknown.

Cells 50 μ long with spines, 35 μ long without spines; breadth with spines 91 μ , without spines 30 μ ; breadth at isthmus 7 μ ; length of spines 28 μ .

Clear Crooked (rrr), Speese (rr), Squirrel (rr).

The individuals that I have seen in Wisconsin lakes are not exactly typical, but after a comparison of them with type material from Loch Luichart (Scotland) in the G. S. West collection I feel convinced that they are a form of this species midway between the type and the form *compacta* W. & G. S. West. Unlike the British specimens the Wisconsin plants do not show a twisting at the isthmus.

The species should be compared with *Arthrodesmus incus* (De Brébisson) Hassall from which it differs in the longer spines and concave apices of the semicells.

9. *ARTHRODESMUS INCUS* (De Brébisson) Hassall. Pl. 85, Figs. 19-22.

Brit. Freshw. Algae 357, pl. 85, fig. 10. 1845; W. & G. S. West, Monogr. Brit. Desm. 4: 90, pl. 113, figs. 13-15. 1912.

Cells small, length (without spines) about equal to the breadth, median constriction deep, sinus widely open and with an acute apex, isthmus narrow but not elongate; semicells obversely triangular, with straight or slightly convex sides, apex straight or somewhat concave, angles of semicells acute and each with a single long gradually attenuated spine, spines subparallel to strongly divergent. Vertical view elliptic, with a long spine at each pole. Chloroplasts axial, with a single pyrenoid. (Facultative plankton.)

Zygospores structure not definitely known, probably spherical and with simple spines (W. & G. S. West).

Cells 27-50 μ long with spines, 22-27 μ long without spines; breadth with spines 65-80 μ , without spines 21-26 μ ; breadth at isthmus 6-7.5 μ ; spines 25-30 μ long.

Red Bass (rrr), Chain (rr), Devils (r), Speese (r).

Ralfs grouped several species under *A. incus* so that the typical *A. incus* of the early investigators is largely a matter of conjecture. I have followed W. & G. S. West in considering the above described alga the typical *A. incus* although it should be noted that their conception of the species is based upon phylogenetic rather than upon taxonomic grounds.

A. incus belongs to the group of species with long spines and straight-sided cells that includes *A. triangularis* Lagerheim and *A. quiriferus* W. & G. S. West. It is distinguished from *A. triangularis* by the shorter isthmus, straight apex of the semicell, and divergent spines.

var. *EXTENSUS* Andersson. Pl. 85, Figs. 23-26.

Bih. Kgl. Sv. Vet.-Ak. Handl. 16, Afd. 3, No. 5: 13, pl. 1, fig. 7. 1890. Eichler & Raciborski, Rozprawy Akad. Umiej. w Krakowie 2 Ser. 6: 119, pl. 3, fig. 23. 1893.

Arthrodesmus incus var. *vulgaris* Eichler & Raciborski, Rozprawy Akad. Umiej. w Krakowie 2 Ser. 6: 119, pl. 3, figs. 22, 24. 1893.

Sinus widely open and semicircular to semielliptic, isthmus elongate; semicells trapeziform, with basal angles rounded and superior angles sharper and with fairly short spines, spines parallel to divergent. (Facultative planktont.)

Cells 20-25 μ long; breadth with spines 45-62 μ , breadth without spines 15-17.5 μ ; breadth at isthmus 5-6 μ ; length of spines 15-22.5 μ .

Bear (rrr), Devils (r), George (rrr), Horseshoe (rrr), Jones (rrr), Lindy (ss), Lynx (rrr), Oak (rrr), Rudolph (rrr), Tank (r), Wolf (rrr).

This variety is characterized by the elongate isthmus and the angle at the base of the semicell, features which make the shape of the semicells trapeziform instead of triangular. In Wisconsin specimens the spines at the angles are usually subparallel instead of divergent.

var. *praelongus* var. nov. Pl. 85, Figs. 27-29.

Cells larger, sinus trapeziform; semicells obversely triangular, spines at the angles very long. (Euplanktont?)

Cells 21-22.5 μ long; breadth with spines 61-65 μ , without spines 17.5-20 μ ; breadth at isthmus 5 μ ; thickness 9 μ ; length of spines 22-28 μ .

Crab (rrr), Whitney (rrr).

Very similar to the foregoing in the elongate isthmus but with a sinus that has rounded and not angular sides. The spines are also longer than those of other varieties of the species. The variety might be considered a biradiate variety of *Staurostrum cuspidatum* De Brébisson.

10. *ARTHRODESMUS TRIANGULARIS* Lagerheim. Pl. 86, Fig. 1.

Öfvers. Kgl. Sv. Vet.-Ak. Förh. 42, No. 7: 244, pl. 27, fig. 22. 1885; W. & G. S. West, Ann. Roy. Bot. Garden Calcutta 6: 211, pl. 15, fig. 7. 1907; Monogr. Brit. Desm. 4: 97, pl. 114, figs. 11-13, 17. 1912.

Cells small, length equal to or slightly greater than the breadth (without spines), median constriction deep, sinus widely open and with a blunt flattened apex, isthmus narrow and elongate; semicells obversely triangular, with slightly convex sides and a distinctly convex apex which is slightly retuse in the central portion; angles of semicells somewhat pointed and each with a fairly long gradually attenuated spine, spines parallel to somewhat but not markedly divergent. Vertical view elliptic, with a single long spine at each pole. Chloroplast axial and with a single pyrenoid. (Tychoplankton.)

Zygospores unknown in the type.

Cells 15-23 μ long; breadth with spines 52-65 μ , without spines 14-22 μ ; breadth at isthmus 5 μ ; length of spines 18-22.5 μ .

Dummy (rr), Tied Canoe (rrr).

The type of this species is much scarcer than the varieties *rotundatus* and *subtriangularis*. The species is characterized by the convex apices of the semicells and the length of the spines.

var. *rotundatus* (Raciborski) comb. nov. Pl. 86, Figs. 2-4.

Arthrodesmus incus var. *rotundata* Raciborski, Pamietnik Wydz. Akad. Umiej. w Krakowie 17: 96, pl. 6, fig. 16. 1889; de Toni, Nuova Notarisia 5: 69. 1890; Eichler & Raciborski, Rozprawy Akad. Umiej. w Krakowie 2 Ser. 6: 120, pl. 3, figs. 16-17. 1893.

Arthrodesmus triangularis var. *inflatus* W. & G. S. West, Jour. Linn. Soc. Bot. 33: 320. 1898; Monogr. Brit. Desm. 4: 99 pl. 114, figs. 14-15. 1912.

Arthrodesmus triangularis forma W. West, Jour. Linn. Soc. Bot. 29: 168, pl. 24, fig. 19. 1892.

Cells slightly larger than the type; apices of semicells more convex and indentation at center of apex very much reduced or lacking. Elongation of isthmus not so conspicuous. (Facultative plankton.)

Zygospores spherical, sparsely clothed with long attenuated spines.

Cells 28-30 μ long; breadth with spines 70-76 μ , breadth without spines 21 μ ; breadth at isthmus 6-7 μ ; length of spines 20-25 μ .

Diameter of zygospores 24-30 μ ; with spines, 13-15 μ without spines.

Carroll (rr), Horseshoe (rr), Shell (rr), Streiter (rrr).

W. & G. S. West seem to have overlooked *Arthrodesmus incus* var. *rotundatus* when they described their variety *inflatus* of *A. triangularis*. The two are identical and Raciborski's name for the variety takes precedence.

A few zygospores of this species were noted in one of the collections and this is the first record of zygospore structure in the species.

var. SUBTRIANGULARIS (Borge) W. & G. S. West. Pl. 86, Figs. 5-7.

Trans. & Proc. Bot. Soc. Edinburgh 23: 24, pl. 2, fig. 36. 1905.

Arthrodesmus incus var. *subtriangularis* Borge, Bot. Not. 1897: 212, pl. 3, fig. 4. 1897.

Cells somewhat larger and with stouter spines; basal portion of semicells indented just above the isthmus or with an irregular angular swelling, apex of semicells more elevated than the type and with a pronounced indentation in the central portion, spines generally somewhat divergent. (Euplankton.)

Cells 35-43 μ long with spines, 30-32 μ long without spines; breadth with spines 75-78 μ , without spines 22-23 μ ; breadth at isthmus 7-8.5 μ ; length of spines 25 μ .

Blue Gill (sss), Crab (rrr), South Crab (sss), Crooked (rrr), Little Doctor (ss).

The variety differs in the irregularity of the outline of the basal portion of the semicells. This irregularity is usually produced by an indentation (Fig. 5) but individuals have been observed where there is angular swelling instead of an indentation (Figs. 6-7) and which, as far as the bases of the semicells are concerned, resemble varieties of *Arthrodesmus Ralfsii* W. West.

11. ARTHRODESMUS OCTOCORNIS Ehrenberg. Pl. 86, Figs. 8-12.

Die Infusionsthierehen 152. 1838; Wille, Desm. U. S. 97, pl. 24, figs. 21-23. 1884; W. & G. S. West, Monogr. Brit. Desm. 4: 111, pl. 117, figs. 6-10. 1912.

Xanthidium (?) *octocorne* (Ehrenberg) Ralfs, Brit. Desm. 116, pl. 20, figs. 2A-2E. 1848.

Cells small, length (without spines) about one and a quarter times the breadth, median constriction fairly deep, sinus semicircular, isthmus relatively broad; semicells trapeziform, with concave bases and lateral margins markedly incurved, the four rounded angles of semicells bearing a single long gradually attenuated spine, spines on lower angles parallel, those on upper angles divergent. Vertical view elliptic, with two spines inserted one above the other at each pole. Cell wall of uniform thickness and without ornamentation. Chloroplasts axial, with one pyrenoid. (Facultative plankton.)

Zygospores spherical to subspherical, with a few simple somewhat attenuated spines (W. & G. S. West).

Cells 35-44 μ long with spines, 14-20 μ long without spines; breadth with spines 25-38 μ , without spines 10-16 μ ; breadth at isthmus 5-6 μ ; thickness 6.5 μ ; length of horizontal spines 8-19 μ , length of oblique spines 11-17 μ .

Zygospores 28 μ in diameter with spines, 15 μ without spines (W. & G. S. West).

Blue Gill (rrr), Speese (rrr), Travis (c).

At first glance this species appears to be a minute *Xanthidium* but phycologists have excluded it from *Xanthidium* because there is no thickening of the cell wall on the face of the semicells. It is a

species that cannot be confused with any other of the genus *Arthrodesmus* being the only one with trapeziform semicells that bears long spines at the angles.

The alga occurred in sufficiently quantity in Travis Lake to warrant the assumption that in this case it was multiplying rapidly under plankton conditions.

ONYCHONEMA Wallich 1860.

Cells generally small, breadth usually somewhat greater than the length. United to form permanent filaments by two apical processes that lie on opposite sides of the apex and overlap adjacent cells of the filament. Cells compressed, deeply constricted and generally with a closed sinus; semicells elliptic, with a smooth or serrate outline, lateral angles smooth or furnished with a single long convergent spine. Cell wall smooth or with transverse rows or granules or pores, at times finely punctate. Vertical view fusiform-elliptic, with the apical processes of the front view alternately arranged and the poles rounded or bearing a single straight spine. Lateral view of semicells usually circular. Chloroplasts axial and with one pyrenoid. Colonies generally enclosed in a fairly broad gelatinous sheath.

Zygospores spherical and ornamented with short spines.

The genus is closely related to *Sphaerososma* Corda but differs in the nature of the apical processes. In *Onychonema* these processes hold the cells together in a filament by overlapping adjacent cells while in *Sphaerososma* the processes merely touch corresponding processes of adjacent cells.

KEY TO THE SPECIES.

- Lateral angles without spines.....(1) *O. filiforme*
 Lateral angles with spines.....(2) *O. laeve*

1. ONYCHONEMA FILIFORME (Ehrenberg) Roy & Bisset. Pl. 86, Figs. 13-14.

Jour. of Bot. 24: 242. 1886; Lütkenmüller, Beitr. z. Biol. d. Pflanzen 8: 365, pl. 18, fig. 28. 1902.

Cells small, breadth slightly greater than the length, deeply constricted, sinus sublinear, with the apex acute and the outer margin widely open, isthmus narrow; semicells broadly elliptic, dorsal margin more rounded than the ventral, lateral angles broadly rounded and without spines, apical processes quite long, divergent, and with a very slight swelling at the ends; adjacent cells of the filament not in contact except by the processes. Lateral view of semicells subcircular. Cell outline smooth and wall with two transverse rows of pores. Chloroplasts axial and with one pyrenoid. (Tycho plankton.)

Zygospores unknown.

Cells 12–18 μ long with apical processes, 8.5–12.5 μ long without processes; breadth 8.5–10 μ ; breadth at isthmus 4 μ ; length of apical processes 2.5–3.5 μ .

Dutchmans (rrr), Lindy (rr), Tank (rrr).

2. ONYCHONEMA LAEVE Nordstedt.

Vidensk. Medd. f. d. naturhist. Foren. i Kiöbenhavn 1869: 206, pl. 3, fig. 34. 1870; W. & G. S. West, Ann. Roy. Bot. Garden Calcutta 6: 224, pl. 12, figs. 8–10. 1907.

Cells somewhat under medium size, breadth (without spines) one and a half to two times the length, very deeply constricted, sinus linear, with apex slightly inflated and outer margin widely open, isthmus narrow; semicells transversely elliptic, with the ventral margin more rounded than the dorsal and furnished with two erect spine-like apical processes that terminate in small knobs; lateral angles rounded and each furnished with a single fairly long incurved spine. Cell outline smooth and the wall without granulation. Vertical view narrowly fusiform-elliptic, with poles bearing a single straight spine. Filaments at times enclosed in a gelatinous sheath.

Zygospores (of the variety *micracanthum*) spherical, furnished with numerous small sharp spines (W. & G. S. West).

Cells 16–17 μ long; breadth with spines 31–36.5 μ , without spines 21–25 μ ; breadth at isthmus 6 μ (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. LATUM W. & G. S. West. Pl. 86, Fig. 15.

Trans. Linn. Soc. 2nd. Ser. Bot. 5: 232, pl. 12, fig. 18. 1896.

Cells broader than the type, sinus open and with an acute or slightly inflated apex, apical margin of semicells with a truncate elevation in the median portion, adjacent cells of the filament with their truncate apical portions in contact; apical processes slightly divergent. (Facultative plankton.)

Cells 21–29 μ long with apical processes, 16–20 μ without processes; breadth with spines 27–36 μ , without spines 21–26 μ ; breadth at isthmus 5–6 μ ; length of apical processes 3–4 μ ; length lateral spines 5–6 μ .

Beaverdam (rrr), Devils (sss), Diamond (rrr), Horseshoe (rrr), Little Doctor (rrr), Soft (rrr), Sunday (rrr).

Although the variety differs from the type in the length of the lateral spines and nature of the isthmus the most striking feature is the truncate apical elevation. All specimens found in Wisconsin lakes can be referred to this variety.

SPHAEROZOSMA Corda 1834.

Cells usually small and with the breadth generally somewhat greater than the length. United to form permanent filaments by short apical processes that lie on opposite sides of the apices of the

semicells and interlock with corresponding processes from adjacent cells; processes frequently simple granules, never overlapping the adjacent cells. Cells compressed, generally moderately constricted and with an open sinus; semicells elliptic to oblong, lateral margins smooth or granulate, never with spines. Vertical view usually elliptic and lateral view of semicells subspherical. Cell wall smooth, punctate, or with granules arranged in a definite pattern. Chloroplasts axial and with one pyrenoid.

Zygospores generally spherical and with smooth or spinate walls.

The genus stands between *Spondylosium* and *Onychonema*. The short interlocking apical processes or granules are the most prominent diagnostic character. It is difficult to differentiate between many *Spondylosium* and *Sphaerosoma* species since these granules may be greatly reduced and easily overlooked.

KEY TO THE SPECIES.

- Apical processes somewhat elongate.....(1) *S. Aubertianum*
 Apical processes simple granules.
 Lateral margins of cells granulate.....(3) *S. excavatum*
 Lateral margins of cells smooth.....(2) *S. exiguum*

1. SPHAEROSOMA AUBERTIANUM W. West.

Jour. of Bot. 27: 206, pl. 291, fig. 17. 1889; Jour. Linn. Soc. Bot. 29: 115, pl. 19, fig. 1. 1892; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 230, pl. 12, figs. 7-8. 1896.

Cells of moderate size, breadth somewhat greater than the length, fairly deeply constricted, sinus with the apex acute and the outer margin widely open, isthmus fairly narrow; semicells elliptic to oblong-elliptic, with lateral margins conspicuously flattened, ventral and dorsal margins with the same degree of curvature; apical processes reduced to two small elongate granules that lie some distance from each other; lateral margins of semicells with two small granules on each side. Lateral view of semicells subspherical, the pairs of granules on side of semicell forming a linear series.

Zygospores spherical to subspherical, with numerous long spines that have broadly conical bases and simple acute apices (W. & G. S. West).

Cells 16.5-19 μ long; 18-23 μ broad; isthmus 5-8 μ broad (W. West).

Diameter of zygospores with spines 37.5-42 μ , without spines 19-24 μ (W. & G. S. West).

Not found in the plankton of Wisconsin lakes.

var. *ARCHERII* (Gutwinski) W. & G. S. West. Pl. 86, Fig. 16.
 Trans. Linn. Soc. 2nd. Ser. Bot. 5: 230. 1896.

Sphaerosoma Archeri Gutwinski, Bot. Cent. 43: 66. 1890; Sprawozd. kom. fizyogr. Akad. Umiej. w Krakowie 27: 29, pl. 1, fig. 4. 1891.

Cells larger; semicells transversely elliptic and with the lateral margins more rounded. Face of semicells with two transverse rows

of granules. Apical processes close together and more elongate than the type. (Facultative plankton.)

Zygospores spherical, with longer spines than the type (Gutwinski).

Cells 22–27 μ long with apical processes, 17.5–20 μ long without processes; breadth 30–35 μ ; breadth at isthmus 10–12 μ ; length of apical processes 2–3 μ .

Beaverdam (rr), Devils (rr), Horseshoe (rrr), Razorback (rrr), Shell (rrr), Fish (rrr).

2. SPHAEROSOMA EXIGUUM Turner. Pl. 86, Fig. 21.

Kgl. Sv. Vet.-Ak. Handl. 25, No. 5: 141, pl. 18, fig. 16. 1893.

Cells small, length and breadth about equal, sinus fairly deep, broad and with a rounded apex, isthmus relatively narrow; semicells transversely elliptic, with the ventral margin more rounded than the dorsal, lateral margins very broadly rounded and without granules; apical processes simple granules that lie some distance from each other. Chloroplasts axial and with one pyrenoid. (Tycho plankton.)

Zygospores unknown.

Cells 14 μ long, 12.5 μ broad; isthmus 6.5 μ broad.

Carson (rr), Jenny (rrr).

Except for the pair of granules between adjacent cells this looks very much like a small specimen of *Spondylium planum* (Wolle) W. & G. S. West.

3. SPHAEROSOMA EXCAVATA Ralfs. Pl. 86, Figs. 17–18.

Ann. & Mag. of Nat. Hist. 16: 15, pl. 3, figs. 8A–8C. 1845; Brit. Desm. 67, pl. 6, figs. 2A–2G. 1848.

Cells small, length slightly greater than the breadth, fairly deeply constricted, sinus a broad semicircular depression, isthmus elongate and fairly narrow; semicells oblong-elliptic, with the ventral margins more rounded than the dorsal, apex flattened, with the apical processes reduced to simple granules that lie some distance apart; lateral margins flattened, with 2–3 small granules, at times with one or two granules within the margins. Vertical view oblong-elliptic, with rounded poles. Lateral view of semicells subcircular, with the sides compressed. Chloroplast axial and with one pyrenoid. (Facultative plankton.)

Zygospores spherical, with smooth walls (Ralfs).

Cells 14 μ long, 11–12.5 μ broad; breadth at isthmus 6.5 μ ; thickness 5 μ .

Diamond (rrr), Horseshoe (r), Lac Court Oreilles (rrr), Little Doctor (rrr), Two Sisters (rr).

var. *Westii* var. nov. Pl. 86, Figs. 19-20.

Sphaerosoma excavata var. W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 231, pl. 12, fig. 9. 1896.

Cells with the isthmus less elongate; lateral margins of semicells with a single granule. (Facultative plankton.)

Cells 10.5 μ long; 7.5 μ broad. 5 μ broad at isthmus; 5 μ thick.

Carroll (r).

W. & G. S. West found but a single filament of this variety and so hesitated to describe it as new. I have found it in sufficient quantity in Carroll Lake to determine that the single granule is a constant character and hence constitutes a varietal difference.

SPONDYLOSIMUM De Brébisson 1844.

Cells usually of moderate size, ratio between length and breadth variable; united to form permanent filaments. Cells moderately to deeply constricted, sinus linear to somewhat open, with an acute to rounded apex; semicells usually compressed, rarely radially symmetrical, elliptic to oblong or triangular, apices flattened, at times with a truncate elevation or with a slight concavity, never with apical processes. Cell wall smooth or punctate, very rarely with granules arranged in a definite pattern. Chloroplasts axial and usually with but a single pyrenoid. Filaments with or without a gelatinous envelope.

Zygospores usually spherical and with smooth walls.

The older phycologists did not differentiate between *Spondylosium* and *Sphaerosoma* and as a result all of the earlier described species have been referred to both genera. The current conception differentiates *Spondylosium* from *Sphaerosoma* and from *Onychonema* on the absence of apical processes; all filamentous compressed species without apical processes and with a well-defined median constriction being referred to *Spondylosium*, *S. moniliforme* Lundell occupies a rather anomalous position since the cells of this species are triangular in vertical view and not compressed. In the classification of the filamentous species the presence or absence of a gridle-like thickening at the point of cell division also plays an important rôle. *Spondylosium* is one of the genera where there is no such thickening.

KEY TO THE SPECIES.

Vertical view compressed.

Cell apices not elevated.....(1) *S. planum*

Cell apices elevated in median portion.....(2) *S. pulchrum*

Vertical view triangular.....(3) *S. moniliforme*

1. SPONDYLIUM PLANUM (Wolle) W. & G. S. West. Pl. 86, Fig. 22;
Pl. 87, Figs. 1-2.

Jour. Linn. Soc. Bot. 40: 430, pl. 19, figs. 5-8. 1912.

Cells under medium size, compressed, breadth slightly greater than the length, moderately constricted, sinus widely open, with the apex broadly rounded and the outer margin open, isthmus fairly narrow; semicells oblong elliptic, with the ventral margin more rounded than the dorsal, lateral margins very broadly rounded, with apices of semicells flattened. Vertical view oblong-elliptic. Lateral view of semicells subcircular. Cell wall smooth. Chloroplasts axial and with a single pyrenoid. Filaments neither twisted nor enveloped in a gelatinous sheath; region of contact between adjacent cells very broad. (Facultative plankton.)

Zygospores unknown.

Cells 12-18 μ long; 12-22 μ broad; 7-12 μ broad at isthmus; 8-10 μ thick.

Beaverdam (rr), Blue Gill (sss), Carroll (rrr), Catfish (rr), Clear Crooked (rrr), Cranberry (ss), Crawling Stone (ss), Deer (rrr), Devils (r), Duck (rrr), Dunham (rrr), Found (s), Horseshoe (rr), Lac Court Oreilles (r), Lake of the Woods (rrr), Mercer (rrr), Middle McKenzie (rrr), Reserve (r), Rock (rrr), Shell (s), Whitefish (rr).

The species is subject to considerable variation in the size of the cells but the shape of the cells is a quite constant feature. It is a species that has become widely distributed as a plankton organism.

2. SPONDYLIUM PULCHRUM (Bailey) Archer. Pl. 87, Figs. 3-4.

in Pritchard, A History of Infusoria 4th. Ed., 724. 1861; Borge, Ark. för Botanik 15, No. 13: 72. 1918.

Sphaerzosma pulchrum Bailey in Ralfs, Brit. Desm. 209, pl. 35, figs. 2A-2B. 1848.

Sphaerzosma pulchrum var. *inflatum* Wolle, Desm. U. S. 29, pl. 49, fig. 8. 1884.

Cells large, compressed, breadth about twice the length, very deeply constricted, sinus sublinear, with the apex acute and the outer margin very slightly open; semicells transversely elliptic, curvature of the dorsal and the ventral margins the same, lateral margins very broadly rounded, semicell apices with a conspicuous truncate elevation in the central region, adjacent cells of filament in mutual contact only at truncate apical elevations. Lateral view of semicells sub-spherical, with apex truncate and flattened. Cell wall finely punctate. Chloroplasts axial, with 6-10 pyrenoids. (Facultative plankton.)

Zygospores (of the variety *brasiliense*) spherical, with smooth walls (Borge).

Cells 45-54 μ long with apical elevation, 38-45 μ long without elevation; breadth 76-83 μ ; breadth at isthmus 18-22 μ .

Bass (rrr), Little Doctor (rr), Nell (s), Speese (rrr).

The species has been bandied back and forth between *Sphaerosoma* and *Spondylosium*, largely because of the interpretation of the apical elevation of the semicells. Since these are elevations of the semicell apex and not apical processes the alga is a *Spondylosium* species.

There has been even more dispute as to the identity of the organism ever since its description. This confusion has been increased by certain European investigators referring another *Spondylosium* species to it; whereas in reality *S. pulchrum* is not found in Europe. Borge has reviewed with great care all of the accounts of the species and has come to the conclusion that most records of *S. pulchrum* should be referred to the variety *brasiliense* of Nordstedt (Wittrock & Nordstedt, Alg. Exs. No. 369. 1880), a variety that has long been overlooked; and that the variety *inflatum* Wolle is in reality the type. The variety *brasiliense* is distinguished by the reduced apical elevation, more linear sinus, and especially by the compressed median portion of the lateral margins in the vertical view.

In certain cases the Wisconsin specimens do not have the polar elevations in contact but the polar elevations are connected by very short broad gelatinous bands. In one filament also the cells were spirally twisted and not in a flat ribbon.

3. SPONDYLIUM MONILIFORME Lundell. Pl. 87, Figs. 5-7.

Nova Acta Reg. Soc. Sci. Upsaliae 3 Ser., 8:92, pl. 5, fig. 16. 1871.

Cells of medium size, radially symmetrical, length about twice to one and a half times the breadth, very deeply constricted, sinus widely open and with the apex rounded, isthmus narrow and somewhat elongate; semicells subtriangular, with the ventral margins rounded and the lateral margins convex; lateral angles broadly rounded and the polar angle rounded or slightly flattened where the cells are in mutual contact. Vertical view triangular, with the angles broadly rounded and the sides strongly concave. Cell wall smooth. Chloroplasts axial, with a small central mass and two broad plates running to each angle of the cell; pyrenoid single and central. Filaments not twisted, imbedded in a copious hyaline gelatinous envelope; area where cells are in apical contact narrow. (Facultative plankton.)

Zygospores unknown.

Cells 30-32.5 μ long; 20-24 μ broad; isthmus 10 μ broad.

Beaverdam (rr).

Differing from other species in the radial symmetry of the vertical view of the cells.

HYALOTHECA Ehrenberg 1841.

Cells united to form long filaments. Filaments not twisted but generally enclosed by a copious gelatinous envelope that at times is

radially fibrillar. Cells usually somewhat longer than broad, cylindrical to discoidal, median constriction very slight; ends of cells plane and without projections, polar angles usually rounded. Vertical view circular. Cell wall without ornamentation aside from transverse ridges or in rare cases transverse rows of granules just beneath the apices of the semicells. Chloroplasts axial and with several vertical lobes that extend to the cell walls; pyrenoids single and central. Cells without a girdle-like thickening at the point of division.

Zygospores spherical and smooth-walled.

This is distinguished from the other filamentous genera by the cylindrical cells and lack of apical processes. Examination of mature cells might lead to the conclusion that there is no real distinction between *Hyalotheca* and *Desmidium* but the manner of cell division in the two genera is quite different.

KEY TO THE SPECIES.

Cells without a transverse subapical ridge.....(1) *H. dissiliens*
Cells with a transverse subapical ridge.....(2) *H. mucosa*

1. HYALOTHECA DISSILIENS (Smith) De Brébisson. Pl. 87, Figs. 8-9.

in Ralfs, Brit. Desm. 51, pl. 1, figs. 1A-1L. 1848.

Cells fairly small, breadth one and a quarter to two times the length, very faintly constricted, sinus a slight annular depression midway between the poles, breadth of isthmus essentially that of the semicells; cells cylindrical-discoidal, with flattened apices and slightly rounded angles. Vertical view circular. Cell wall smooth, without ornamentation aside from an annular ridge just above the isthmus. Chloroplasts axial, with about six longitudinal rays that extend to the cell walls; pyrenoids single and central; cells with but a single chloroplast until nearly mature. Gelatinous colonial envelope broad. (Facultative plankton.)

Zygospores spherical, with smooth walls (Ralfs).

Cells 10-20 μ long; 20-27 μ broad.

Bird (rr), Carroll (rrr), Crab (rrr), Crooked (rrr), Devils (rrr), Howey (r), Lynx (rr).

2. HYALOTHECA MUCOSA (Dillwyn) Ehrenberg. Pl. 87, Fig. 10.

Ber. Verh. Preuss. Akad. d. Wiss. Berlin 1840: 212. 1841; Ralfs, Brit. Desm. 53, pl. 1, figs. 2A-2D. 1848; Lagerheim, Öfvers. Kgl. Sv. Vet.-Ak. Förh. 1883, No. 2: 54. 1883.

Cells fairly small, length slightly greater than the breadth, not constricted; shape of cells cylindrical, with the ends flattened and the angles rounded. Vertical view circular. Lateral walls with a double transverse subapical ridge at either end. Chloroplast axial, with broad vertical rays; pyrenoid single and central. Gelatinous sheath

of filament broad, at times with a radial structure. (Facultative plankton.)

Zygospores spherical, with smooth dark yellow walls (Lagerheim).

Cells 14-20 μ long; 17 μ broad.

Diameter of zygospores 30 μ .

Beaverdam (r), Duck (rrr), Fish (rrr), Horseshoe (rrr), Kimball (rrr), Lindy (rrr), Little Doctor (rrr), Meta (rrr), Mud Hen (rrr), Muskallonge (rr), Rooney (rr), Sand (rr).

The most conspicuous difference between this and the foregoing species is the transverse double ridge near the apex of the semicell. In most specimens this ridge appears to be a homogeneous band but in some cases it is a transverse double ring of angular granules.

DESMIDIUM C. A. Agardh 1824.

Cells united to form long filaments. Filaments usually spirally twisted and enclosed in a broad tough gelatinous envelope. Median constriction generally shallow and poorly defined. Cells not marked compressed, usually with a radial symmetry; breadth mostly about twice the length; semicells trapezoidal in front view and with the apices plane or depressed in the median portion and forming an elliptic open space between adjacent cells. Lateral view identical with the front view or subrectangular to octagonal. Vertical view triangular, quadrangular or broadly elliptic. Cell wall not ornamented. Chloroplasts axial, with one or more pyrenoids.

Zygospores formed between the conjugating cells or within the wall of one of the two conjugating cells; spherical to ellipsoidal; with smooth walls.

Although the genus does not contain many species the shape of the cells is somewhat variable and at first glance the species do not appear to belong together. At one time or another attempts have been made to break up *Desmidium* into smaller genera but the current practice is to place in the same genus all filamentous species without apical processes that have smooth walls and develop a girdle-like thickening at the time of division that pushes back into the old semicells.

KEY TO THE SPECIES.

Cell apices plane.

Vertical view angular.....(1) *D. Swartzii*
Vertical view elliptic.....(4) *D. Grevillii*

Cell apices with broad depressions.

Median constriction well marked.....(2) *D. Aptogonum*
Median constriction poorly defined.....(3) *D. Baileyi*

DESMIDIUM SWARTZII C. A. Agardh. Pl. 88, Figs. 1-2,

Systema Algarum 9. 1824; Ralfs, Brit. Desm. 61, pl. 4, figs. A-F. 1848.

Cells united in permanent filaments; filaments spirally twisted (one complete turn every 12-20 cells), enclosed by a broad firm gelatinous envelope that frequently is radially fibrillar. Cells slightly under medium size, breadth about twice the length, moderately constricted, sinus with inner portion having sides subparallel and apex rounded, outer portion widely open, isthmus very broad; semicells broadly trapezoidal, with lateral margins bearing in the median portion an acute upturned corner, semicells apices plane, without a depression that forms open spaces between adjacent cells. Cells separated by a flattened gelatinous cushion that is thickest at the outer margin. Vertical view triangular, with sides concave but slightly tumid in the median portion, angles broadly rounded (subcircular). Cell wall smooth. Chloroplast with a fairly massive central axial mass and with broadly ovate projections running to the angles of the cells, projections incised about half the distance from the apex to the central mass; pyrenoids in each lobe and at times in the central mass. (Tychoplankton.)

Zygospores subspherical to ellipsoidal, with broadly rounded poles, smooth-walled (Ralfs).

Cells 13-17.5 μ long; 35-42 μ broad; 27-36 μ broad at isthmus.

Beaverdam (rrr), Diamond (rrr), Devils (rrr), Fish (rrr), Found (rr), George (rrr), Horseshoe (rrr), Howey (rrr), Jag (rrr), Lac Court Oreilles (rrr), Little Doctor (rrr), Meta (rrr), Sand (rrr), Thousand Island (rrr).

This, the first member of the family to be described, is sharply differentiated from other species of the genus except *D. Aptogonum* De Brébisson. It is readily distinguished from *D. Aptogonum* by the lack of open spaces between contiguous cells.

2. DESMIDIUM APTOGONUM De Brébisson. Pl. 88, Figs. 3-4.

Mem. soc. acad. d. sc. de Falaise 1835: 268, pl. 2. 1835; W. & G. S. West, Trans. Linn. Soc. 2nd. Ser. Bot. 5: 233, pl. 12, fig. 24. 1896.

Aptogonum Desmidium (Ehrenberg) Ralfs, Brit. Desm. 64, pl. 32, figs. 1A-1H. 1848.

Cells united in permanent filaments that are spirally twisted (one complete turn in every 15-20 cells); filaments enclosed at times by a firm gelatinous envelope. Cells somewhat under medium size, breadth about twice the length, moderately constricted, sinus with sides subparallel and apex rounded, outer portion widely open, isthmus very broad; semicells trapeziform, with lateral margins bearing at the base an acutely upturned angle; semicell apices with a deep broad semielliptic to subrectangular depression that forms an elliptic to subrectangular open space between adjacent cells. Vertical view triangular, with sides slightly concave and angles broadly rounded. Cell wall smooth. (Tychoplankton.)

Zygospores spherical to broadly elliptic, with smooth walls (Ralfs).

Cells 18-20 μ long; breadth 31-43 μ ; breadth at isthmus 23-35 μ .

Zygospores 22-27 μ long, 20-25 μ broad (W. & G. S. West).

Devils (rrr).

Ralfs thought that the large foramen between the cells of the filaments in this species and *D. Baileyi* (Ralfs) Nordstedt justified placing them in a separate genus (*Aptogonum*) but *Aptogonum* is not recognized by phycologists of the present generation.

3. *DESMIDIUM BAILEYI* (Ralfs) Nordstedt. Pl. 88, Figs. 5-7.

Lunds Univ. Årsskr. 16: 4. 1880 (sep.); Kgl. Sv. Vet.-Ak. Handl. 22, No. 8: 25, pl. 2, figs. 4-5. 1888.

Aptogonum Baileyi Ralfs, Brit. Desm. 208, pl. 35, figs. 1A-1C. 1848.

Cells united to form filaments that are straight (not spirally twisted) and devoid of a gelatinous sheath. Cells fairly small, with the length and breadth about equal, median constriction reduced to a faint undulation; cell outline rectangular, with the lateral margins parallel and apices with a broad deep semielliptic depression that gives the appearance of short erect truncate projections at either lateral margin of the semicells apices. Adjacent cells of filaments almost completely separated by elliptical to subrectangular openings. Vertical view triangular, with slightly convex sides and rounded angles. Cell wall smooth. (Facultative plankton.)

Zygospores spherical and with smooth walls (Ralfs).

Cells 20-26 μ long; 21-27.5 μ broad.

Beaverdam (rrr), Crooked (rrr), Diamond (rrr), Found (r), Little Doctor (rrr), Muskallonge (rrr), Speese (rrr).

Sharply differentiated from the other species by the rectangular cells in which there is only the faintest indication of a median constriction. The filaments of this species, like those of *D. aptogonum* De Brébisson, have elliptic open spaces separating adjacent cells.

4. *DESMIDIUM GREVILLII* (Kützing) De Bary. Pl. 88, Fig. 8.

Unters. u. d. Fam. d. Conj. 42, pl. 4, figs. 30-31. 1858.

Desmidium cylindricum Greville, Scott. Crypt. Fl. 5: pl. 293. 1827.

Didymoprium Grevillii Kützing, Phycol. gen. 166. 1843; Ralfs, Brit. Desm. 57, pl. 2, figs. A-K. 1848.

Cells united to form filaments that are spirally twisted (about one complete turn in every ten cells); filaments enclosed in a broad firm gelatinous envelope; envelope frequently with radial fibrillae. Cells of medium size, breadth about twice the length, slightly constricted, sinus a small semicircular depression, isthmus very broad; semicells trapezoidal, basal angles very broadly rounded, apical angles obtuse; lateral margins frequently with a sharp projection midway between base and apex, the projections on opposite sides being connected by a faint line; apex flat, without open spaces between adjacent cells. Lateral view of cells octagonal, breadth about one and a half times the length, without a constriction in the median portion. Vertical

view broadly elliptic, with a distinct nodule at each pole. Cell wall smooth, except for faint vertical striae just above the isthmus.

Zygospores subspherical, with smooth walls (De Bary).

Cells 20–24 μ long; 45–48 μ broad; breadth at isthmus 40–42 μ .

Found (rr), No Mans (rrr).

The species is widely known under the name *D. cylindricum*. In founding the genus *Didymoprium* Kützing, for some unknown reason, gave the alga a new specific name, a name which Ralfs adopted in his British Desmidiaceae. The specific name *cylindricum* antedates the name *Grevillii* but the use of Ralfs as the starting point for nomenclature of the Desmidiaceae necessitates the use of the latter name.

In the conjugation of this species zygospore formation takes place within one of the old cells and not between the conjugating cells. This feature, however, has not been considered a justification for separating it from other species of the genus.

GYMNOZYGA Ehrenberg 1841.

Cells united to form long filaments. Filaments rarely twisted, frequently enclosed by a gelatinous sheath. Cells barrel-shaped, not compressed, length about twice the breadth, median constriction slight, at times a small groove running around the cell; apices flattened and without protuberances. Cell wall smooth or with vertical striae near the poles and at the isthmus. Chloroplasts axial and with radiating vertical laminae; pyrenoids single and central.

Zygospores spherical to broadly ellipsoidal, with smooth walls.

In the division of the *Gymnozyga* cell there is the same girdle-like thickening that pushes back into the old semicell at the time of division that is found in *Desmidium*.

GYMNOZYGA MONILIFORMIS Ehrenberg. Pl. 87, Fig. 11.

Berichte Verh. Preuss. Akad. d. Wiss. Berlin 1840: 212. 1841.

Cells barrel-shaped, united in permanent filaments, length about twice the breadth, sinus a small semielliptic depression, isthmus very broad; semicells with sides converging to a truncate apex, lateral margins distinctly concave and with apical angles only slightly rounded. Cell wall with vertical striae in the polar regions and at times with other vertical striae at the bases of the semicells. Vertical view circular. Chloroplasts axial, with 6–8 delicate laminate vertical processes to the cell wall; pyrenoids single and central. (Facultative plankton.)

Zygospores spherical to ellipsoidal and with broadly rounded poles, zygospore wall smooth (Ralfs).

Cells 26-35 μ long; breadth at base of semicells 15-22 μ , at apex of semicells 10-15 μ ; breadth at isthmus 13-19 μ .

Bettine (rrr), Blue Gill (rr), Carson (rr), Crooked (r), Howey (rr), Jag (rrr), Jones (rrr), Little Doctor (sss), Lynx (rrr), Red Bass (rr), Big St. Germain (r), Whitney (r).

PLATE 52.

All figures $\times 500$.

		Page
Fig. 1.	<i>Gonatozygon monotaenium</i> De Bary.....	5
Fig. 2.	<i>Gonatozygon pilosum</i> Wolle.....	5
Fig. 3.	<i>Gonatozygon aculeatum</i> Hast.....	5
Fig. 4.	<i>Spirotaenia condensata</i> De Bréb.....	6
Fig. 5.	<i>Netrium digitus</i> (Ehr.) Itz. & Roth.....	6
Fig. 6.	<i>Penium margaritaceum</i> (Ehr.) De Bréb.....	7
Fig. 7.	<i>Penium minutum</i> (Ralfs) Cleve.....	8
Fig. 8.	<i>Closterium subtruncatum</i> W. & G. S. West.....	9
Fig. 9.	<i>Closterium Venus</i> Ktz.....	9
Fig. 10.	<i>Closterium moniliferum</i> (Bory) Ehr.....	9

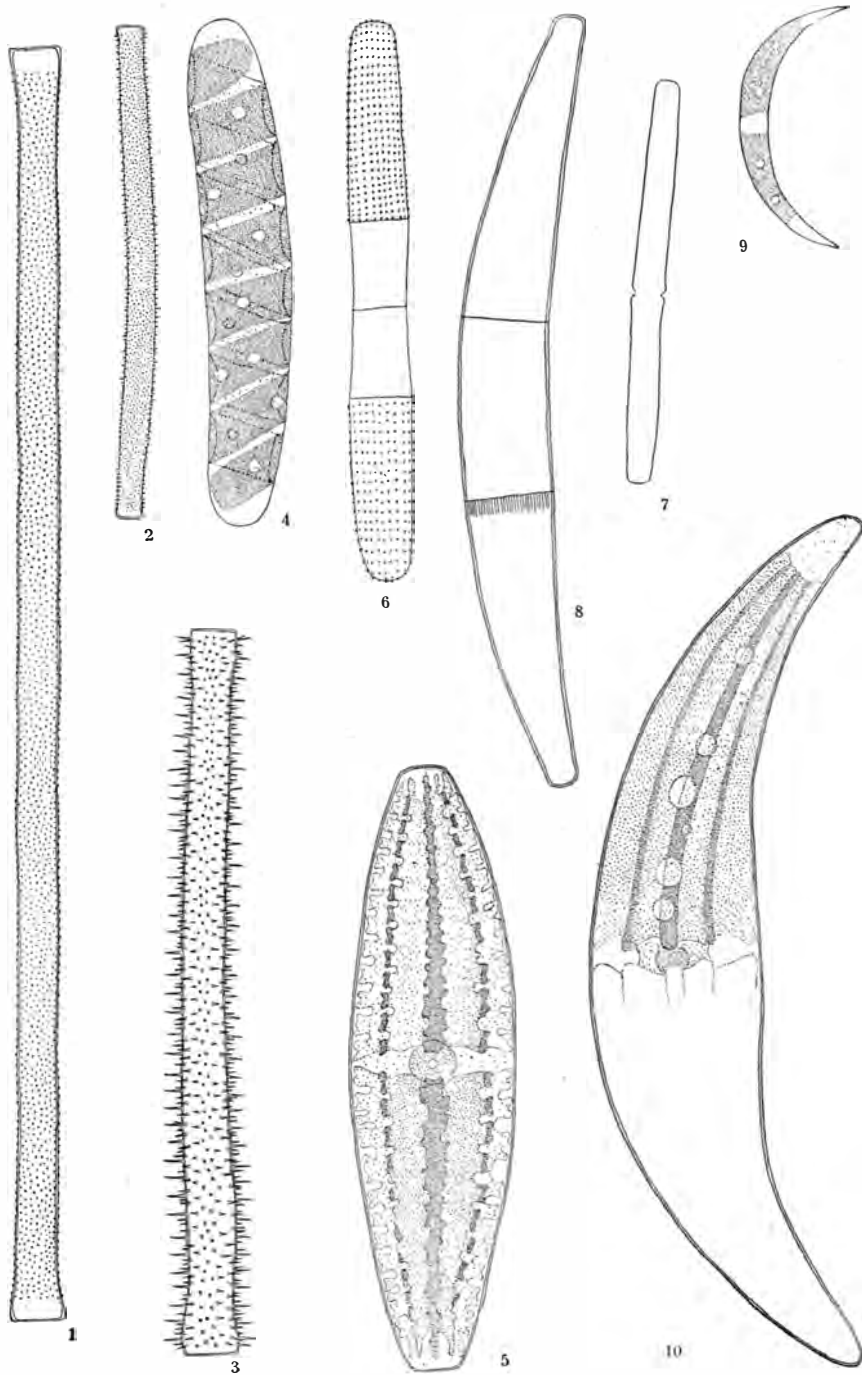


PLATE 53.

All figures x 400.

	Page
Fig. 1. <i>Closterium acerosum</i> (Schränk) Ehr.....	10
Fig. 2. <i>Closterium gracile</i> var. <i>elongatum</i> W. & G. S. West.....	11
Fig. 3. <i>Closterium aciculare</i> var. <i>subprorum</i> W. & G. S. West.....	11
Fig. 4. <i>Closterium acutum</i> (Lyngb.) De Bréb.....	11
Fig. 5. <i>Closterium Ralfsii</i> var. <i>hybridum</i> Rab.....	12
Fig. 6. <i>Closterium Kuetzingii</i> De Bréb.....	12
Fig. 7. <i>Closterium decorum</i> De Bréb.....	13

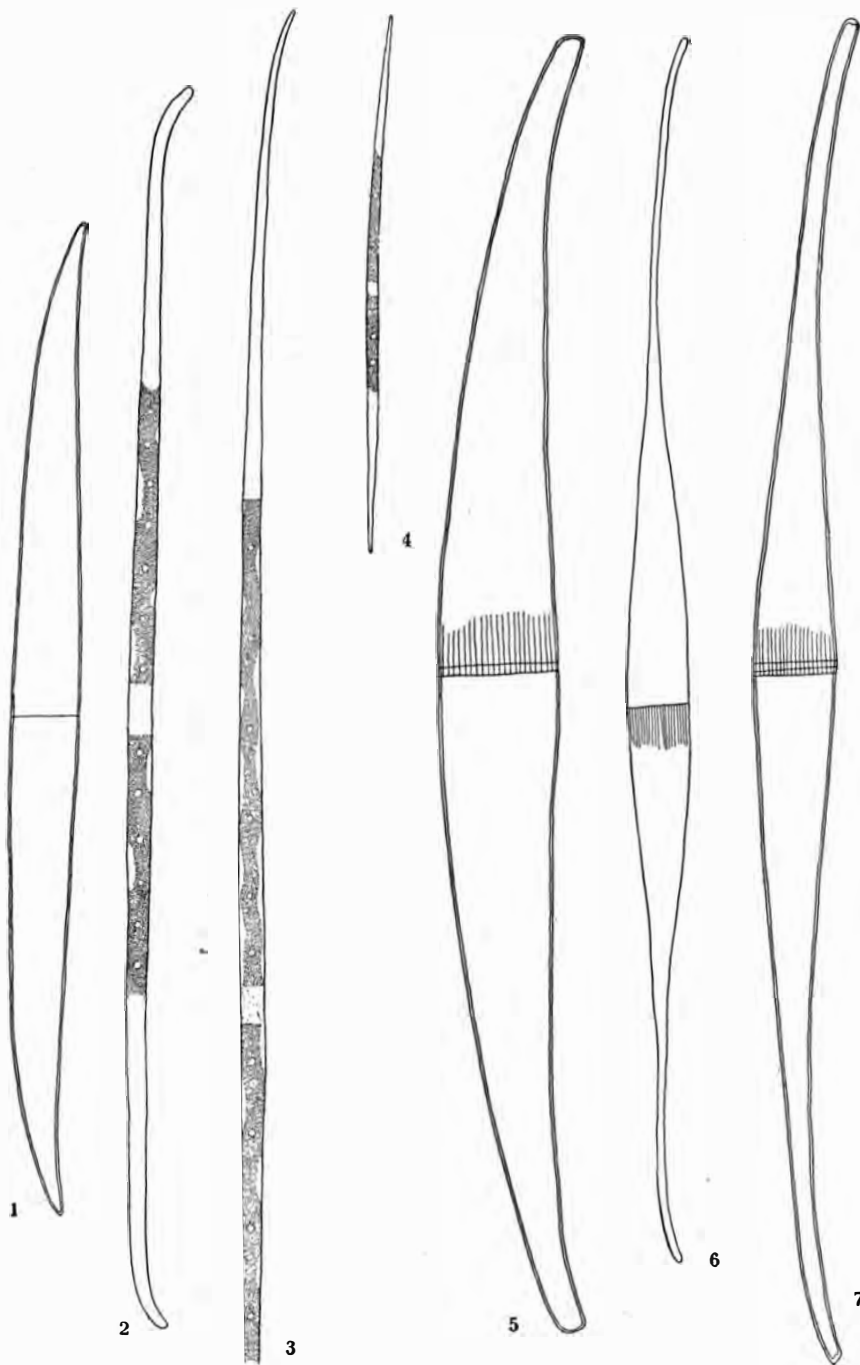


PLATE 54.

All figures x 400.

	Page
Fig. 1. <i>Pleurotaenium trabecula</i> var. <i>rectum</i> (Delp.) W. & G. S. West..	14
Figs. 2-4. <i>Pleurotaenium subcoronulatum</i> var. <i>detum</i> W. & G. S. West.....	14
Figs. 5-6. <i>Pleurotaenium Ehrenbergii</i> (De Bréb.) D. By.....	15
Figs. 7-8. <i>Pleurotaenium Ehrenbergii formae</i>	15
Fig. 9. <i>Pleurotaenium Ehrenbergii</i> var. <i>undulatum</i> Schaarsch.....	15
Fig. 10. <i>Pleurotaenium Ehrenbergii</i> var. <i>elongatum</i> W. West.....	16
Fig. 11. <i>Pleurotaenium nodosum</i> (Bail.) Lund.....	16

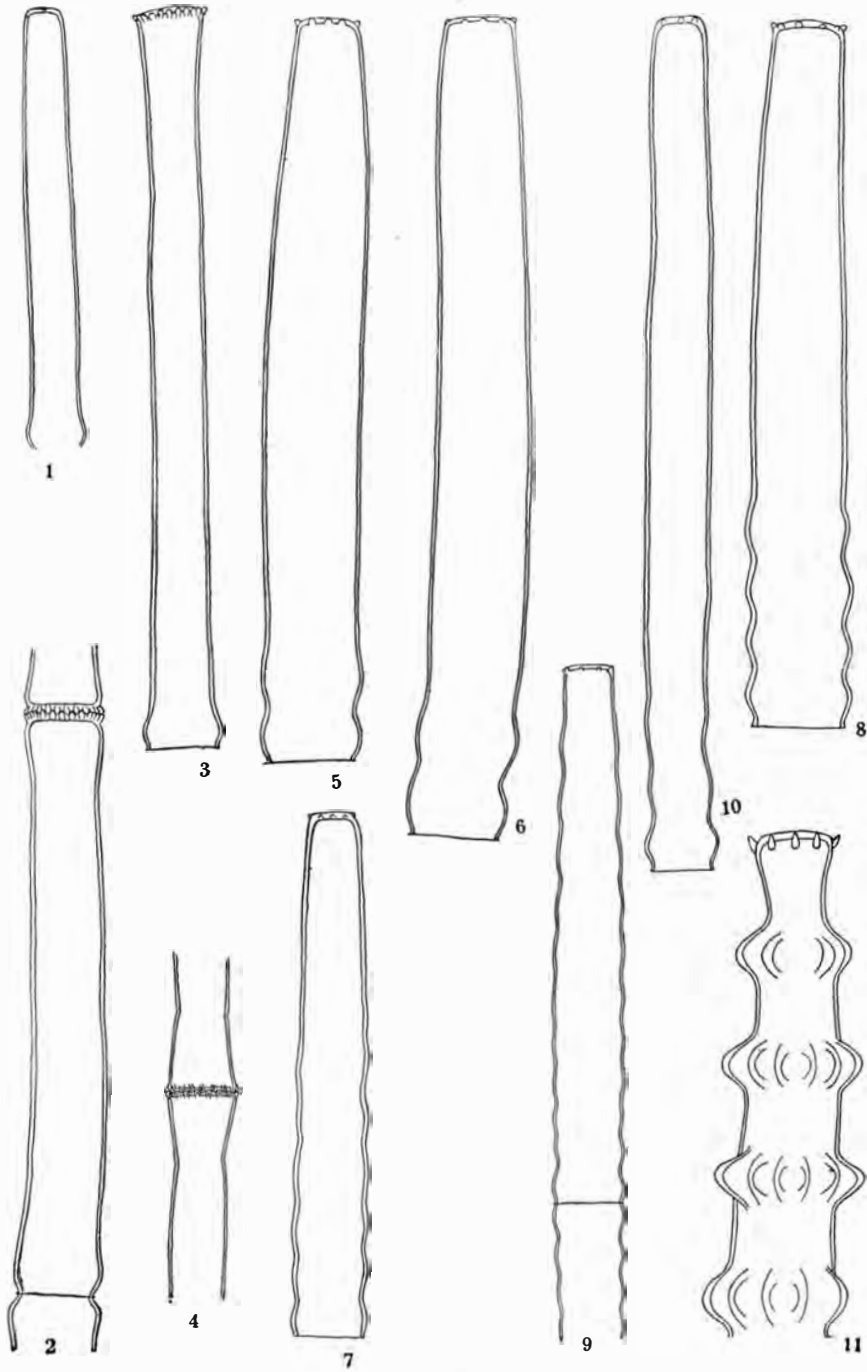


PLATE 55.

All figures x 400.

	Page
Figs. 1-2. <i>Pleurotaenium truncatum</i> (De Bréb.) Näg.....	16
Fig. 3. <i>Pleurotaenium trochiscum</i> var. <i>tuberculatum</i> var. nov.....	17
Fig. 4. <i>Docidium undulatum</i> Bail.....	18
Figs. 5-6. <i>Triploceras gracile</i> Bail.....	19
Figs. 7-9. <i>Triploceras verticillatum</i> Bail.....	19
Fig. 10. <i>Tetmemorus Brebissonii</i> (Menegh.) Ralfs.....	20

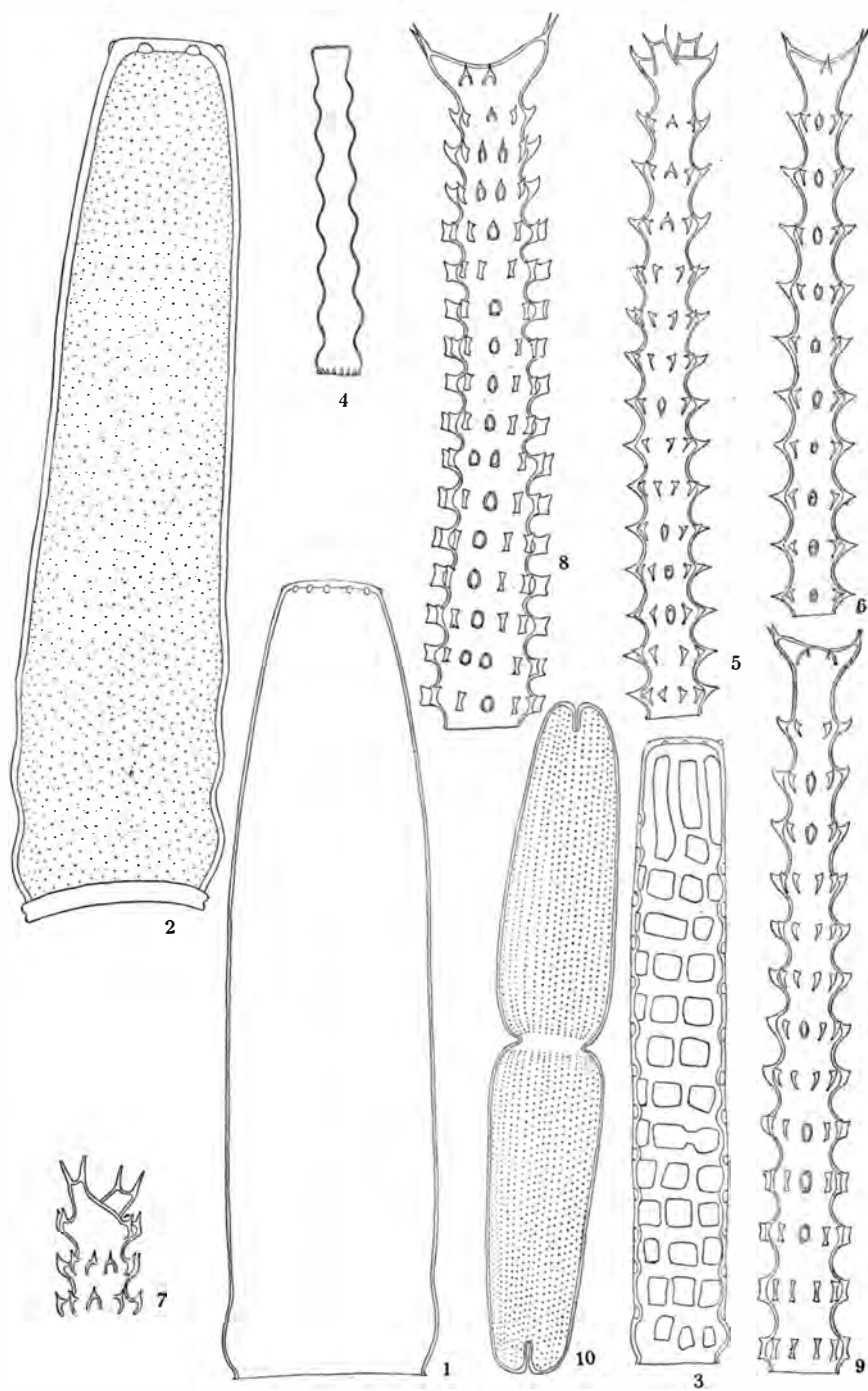


PLATE 56.

All figures x 600.

		Page
Fig. 1.	<i>Euastrum crassum</i> (De Bréb.) Ktz.....	22
Fig. 2.	<i>Euastrum didelta</i> (Turp.) Ralfs.....	22
Fig. 3.	<i>Euastrum oblongum</i> (Grev.) Ralfs.....	23
Fig. 4.	<i>Euastrum affine</i> Ralfs.....	23
Fig. 5.	<i>Euastrum pinnatum</i> Ralfs.....	24
Fig. 6.	<i>Euastrum Glaziovii</i> Børgesen.....	24
Fig. 7.	<i>Euastrum pulchellum</i> De Bréb.....	25
Fig. 8.	<i>Euastrum elegans</i> (De Bréb.) Ktz.....	25
Fig. 9.	<i>Euastrum divaricatum</i> Lund.....	26
Fig. 10.	<i>Euastrum verrucosum</i> var. <i>reductum</i> Nordst.....	27

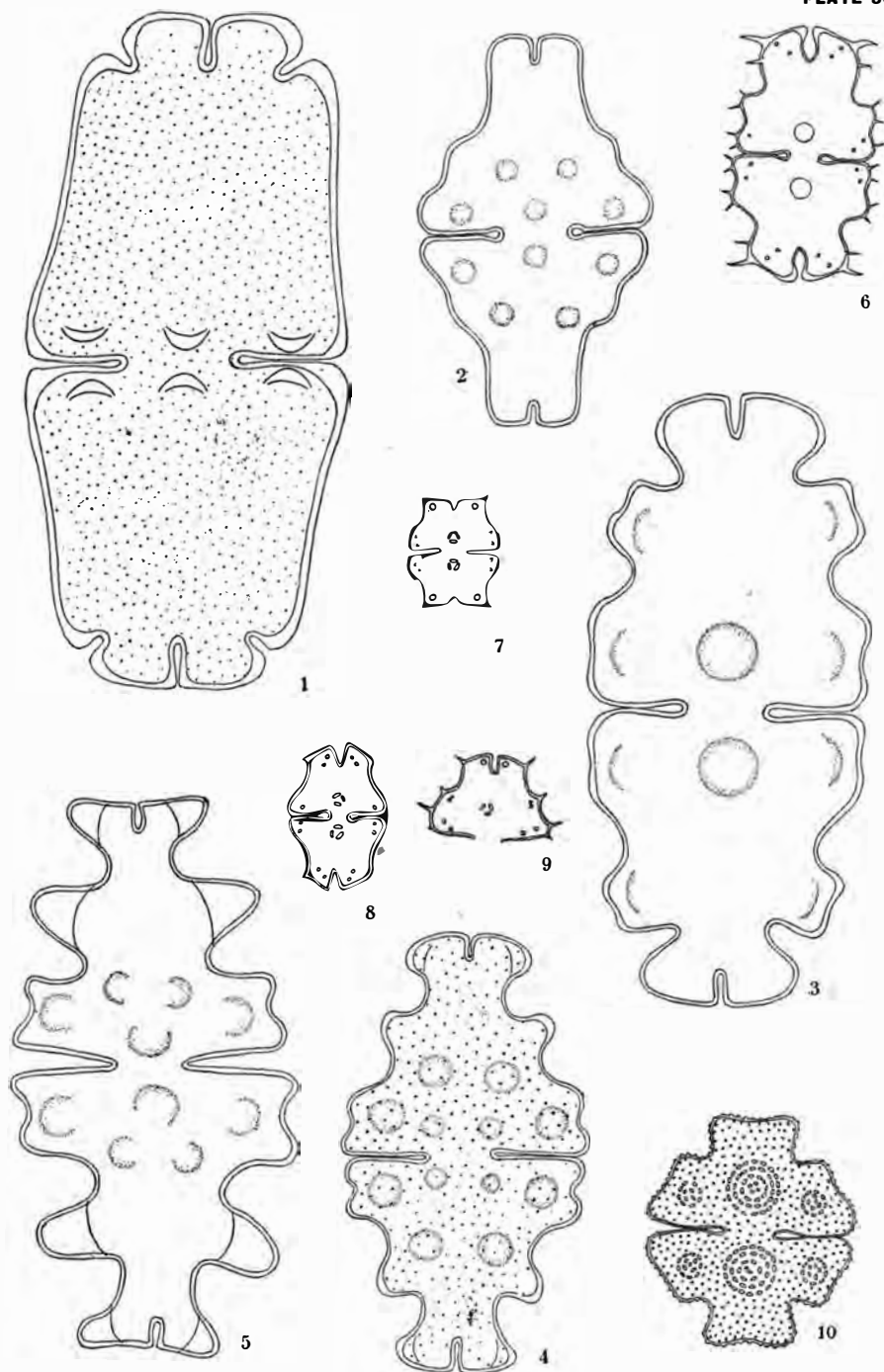


PLATE 57.

All figures $\times 600$.

	Page
Figs. 1-2. <i>Euastrum gemmatum</i> De Bréb.....	26
Fig. 3. <i>Cosmarium circulare</i> Reinsch.....	29
Fig. 4. <i>Cosmarium depressum</i> (Näg.) Lund.....	29
Figs. 5-6. <i>Cosmarium depressum</i> var. <i>achondrum</i> (Boldt) W. & G. S. West	30
Figs. 7-8. <i>Cosmarium bioculatum</i> De Bréb.....	30
Figs. 9-11. <i>Cosmarium contractum</i> Kirchn.....	30
Figs. 12-13. <i>Cosmarium contractum</i> var. <i>papillatum</i> W. & G. S. West.....	31
Figs. 14-17. <i>Cosmarium contractum</i> var. <i>papillatum</i> forma <i>minor</i>	31
Fig. 18. <i>Cosmarium granatum</i> De Bréb.....	31
Figs. 19-20. <i>Cosmarium cyclicum</i> var. <i>Nordstedtianum</i> (Reinsch) W. & G. S. West.....	32
Fig. 21. <i>Cosmarium amoenum</i> var. <i>mediolaeve</i> Nordst.....	32
Fig. 22. <i>Cosmarium Botrytis</i> (Bory.) Menegh.....	33
Fig. 23. <i>Cosmarium reniforme</i> (Ralfs) Arch.....	33
Fig. 24. <i>Cosmarium Portianum</i> Arch.....	33
Fig. 25. <i>Cosmarium ornatum</i> Ralfs.....	34
Fig. 26. <i>Cosmarium commissurale</i> var. <i>crassum</i> Nordst.....	35
Fig. 27. <i>Cosmarium protractum</i> (Näg.) De Bary.....	35
Fig. 28. <i>Cosmarium quinarium</i> Lund.....	36
Fig. 29. <i>Cosmarium punctulatum</i> var. <i>subpunctulatum</i> (Nords.) Børg...	37

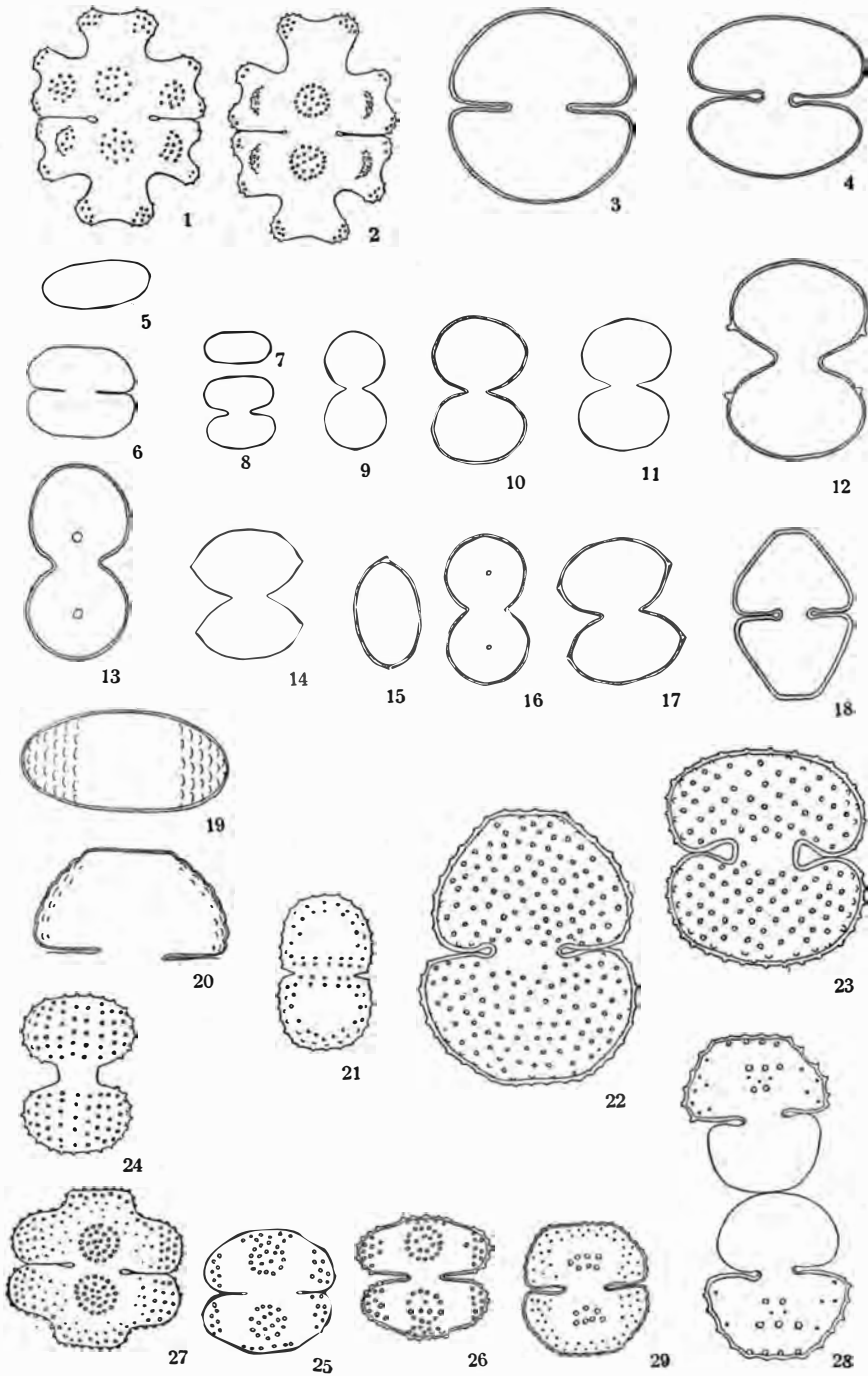


PLATE 58.

	Page
Fig. 1. <i>Cosmarium ovale</i> Ralfs (x 400).....	37
Fig. 2. <i>Cosmocladium sazonicum</i> De Bary (x 400).....	38
Figs. 3-9. <i>Cosmocladium Hitchcockii</i> (Wolle) comb. nov. (Fig. 3, x 400; 4, x 500; 5-a, x 1000).....	38

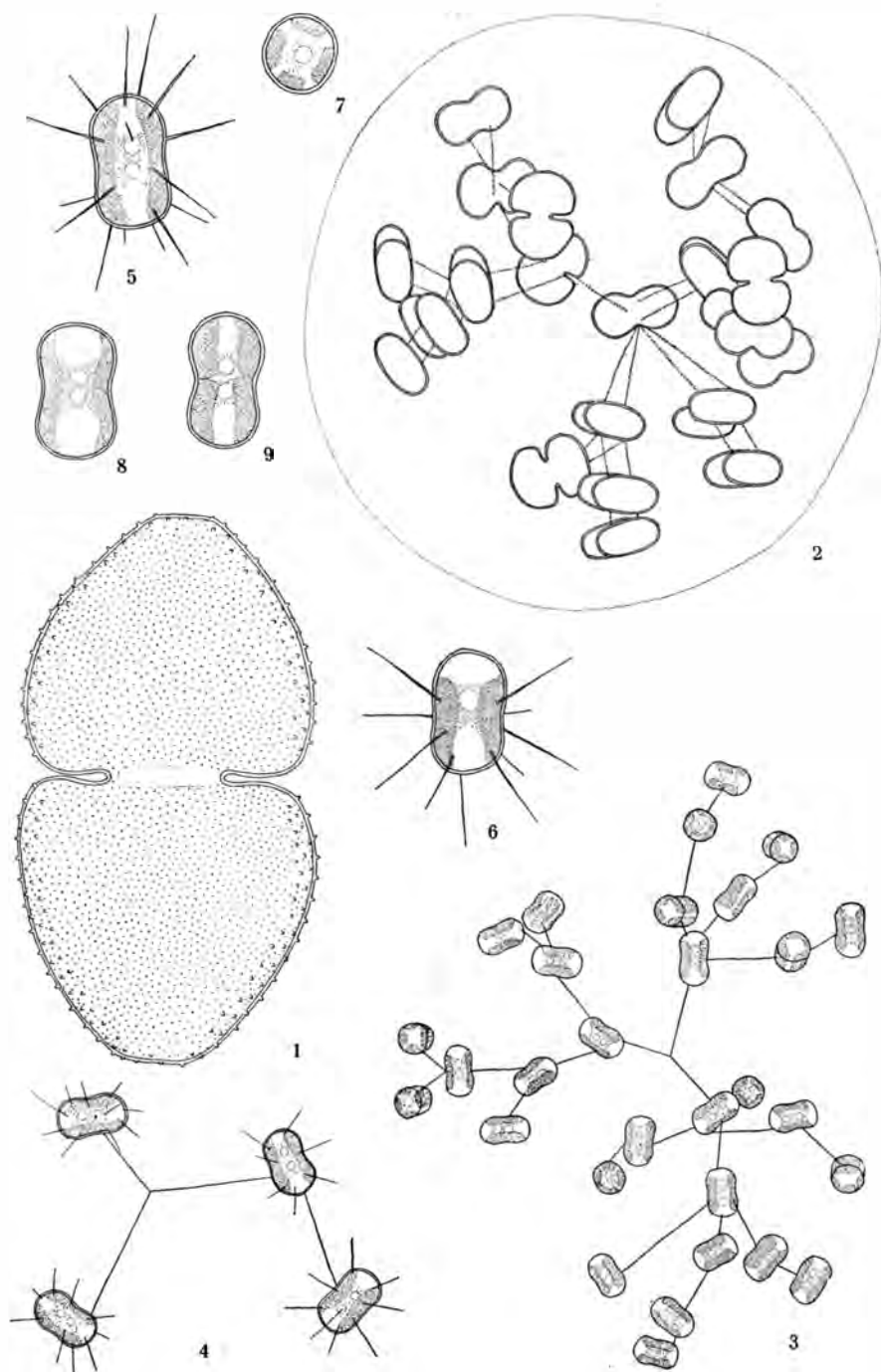


PLATE 59.

All figures $\times 400$.

	Page
Figs. 1-2. <i>Microsterias pinnatifida</i> (Ktz.) Ralfs.....	41
Fig. 3. <i>Microsterias laticeps</i> Nordst.....	41
Fig. 4. <i>Microsterias depauperata</i> var. <i>Kitchelii</i> (Wolle) W. & G. S. West	42
Fig. 5. <i>Microsterias denticulata</i> De Bréb.....	45
Figs. 6-7. <i>Microsterias conferta</i> var. <i>hamata</i> Wolle.....	44

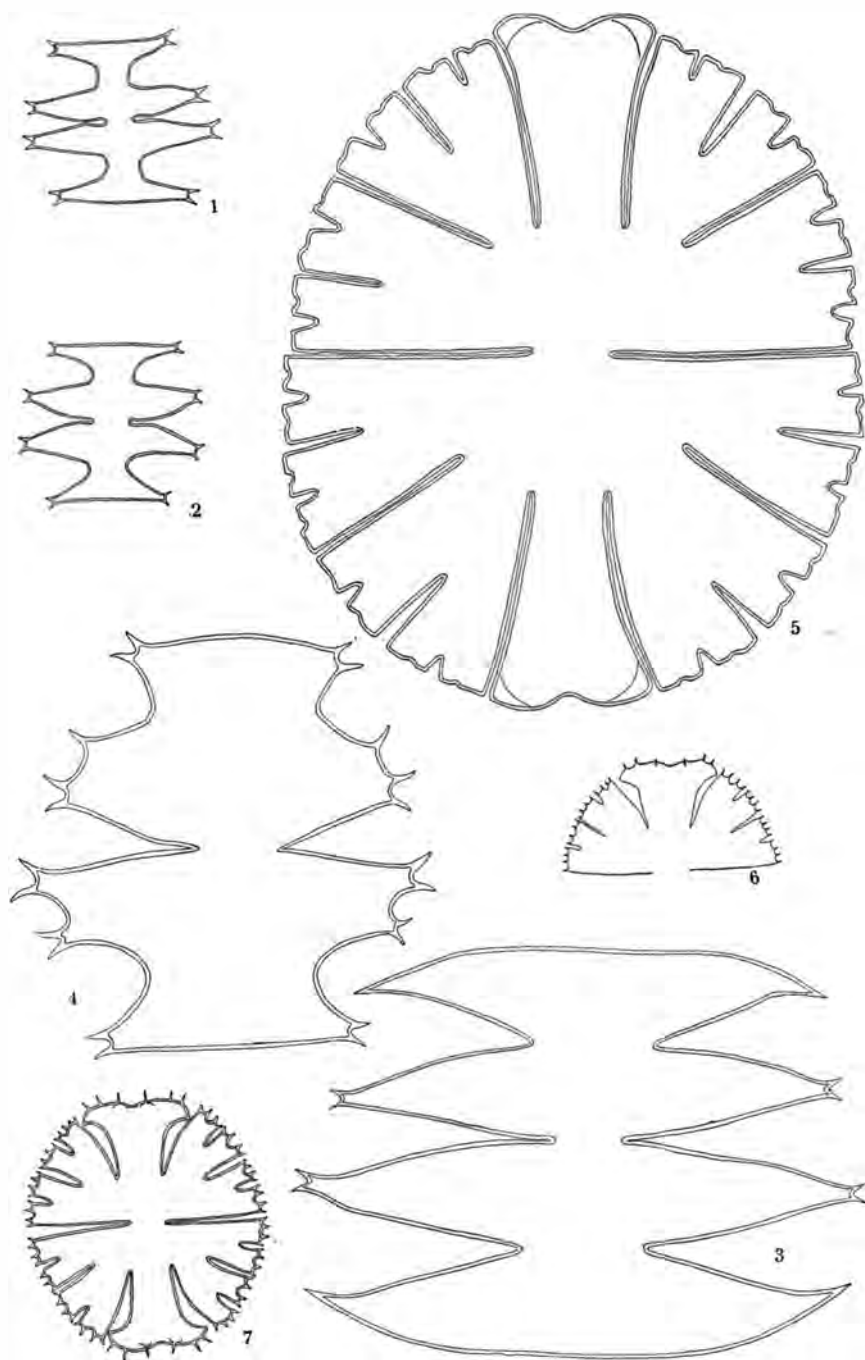


PLATE 60.

Figs. 1-3, 5 x 400; Fig. 4 x 200.

	Page
Figs. 1 2. <i>Micrasterias truncata</i> (Corda) De Bréb.....	43
Fig. 3. <i>Micrasterias radiosa</i> var. <i>ornata</i> Nordst.....	47
Fig. 4. <i>Micrasterias radiosa</i> var. <i>ornata</i> forma <i>elegantior</i> G. S. West...	47
Fig. 5. <i>Micrasterias Thomasiana</i> Arch.....	48

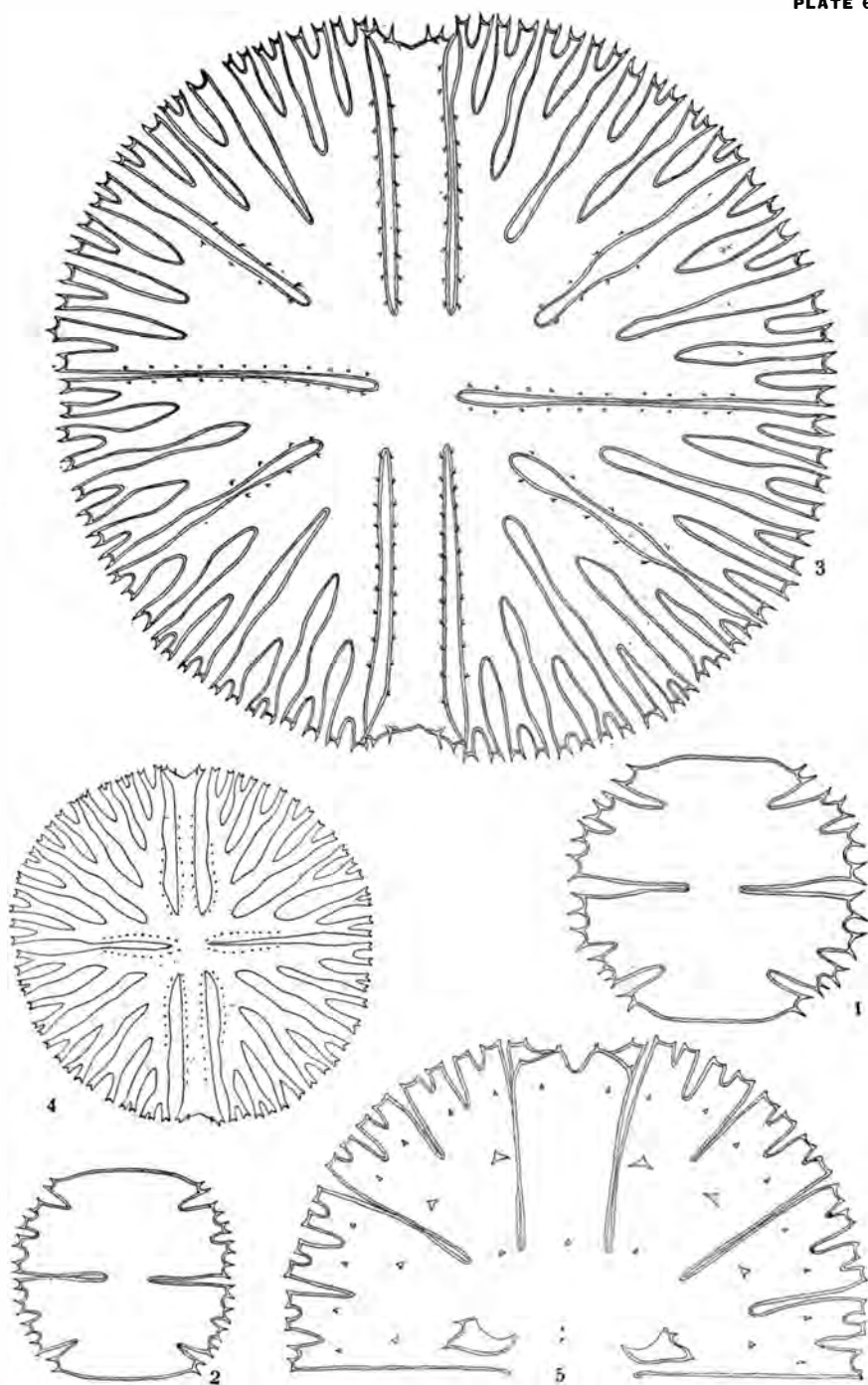


PLATE 61.

All figures x 400.

	Page
Fig. 1. <i>Micrasterias apiculata</i> (Ehr.) Menegh.....	47
Fig. 2. <i>Micrasterias apiculata</i> var. <i>fimbriata</i> forma <i>spinosa</i>	48

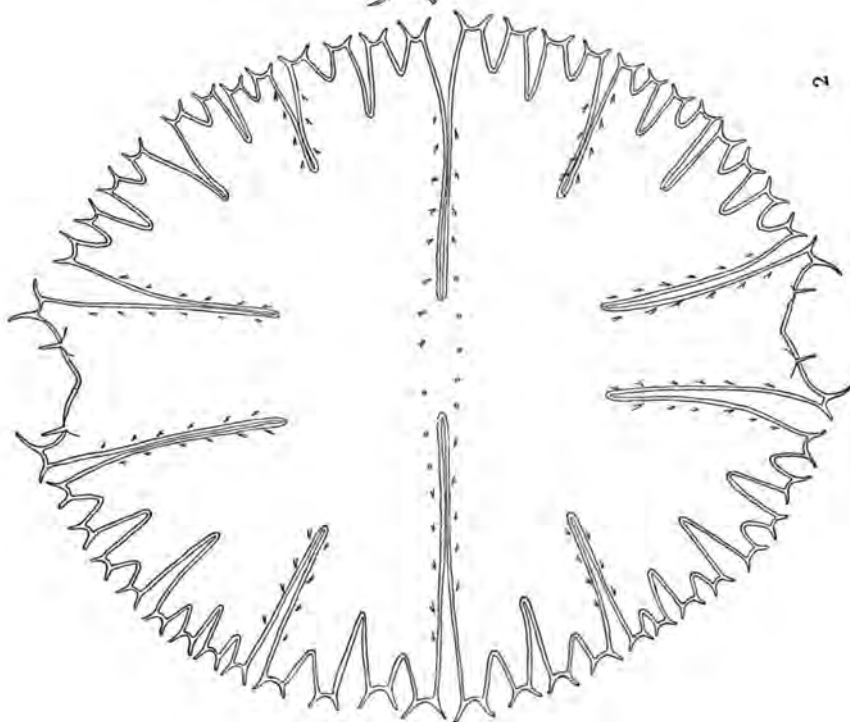
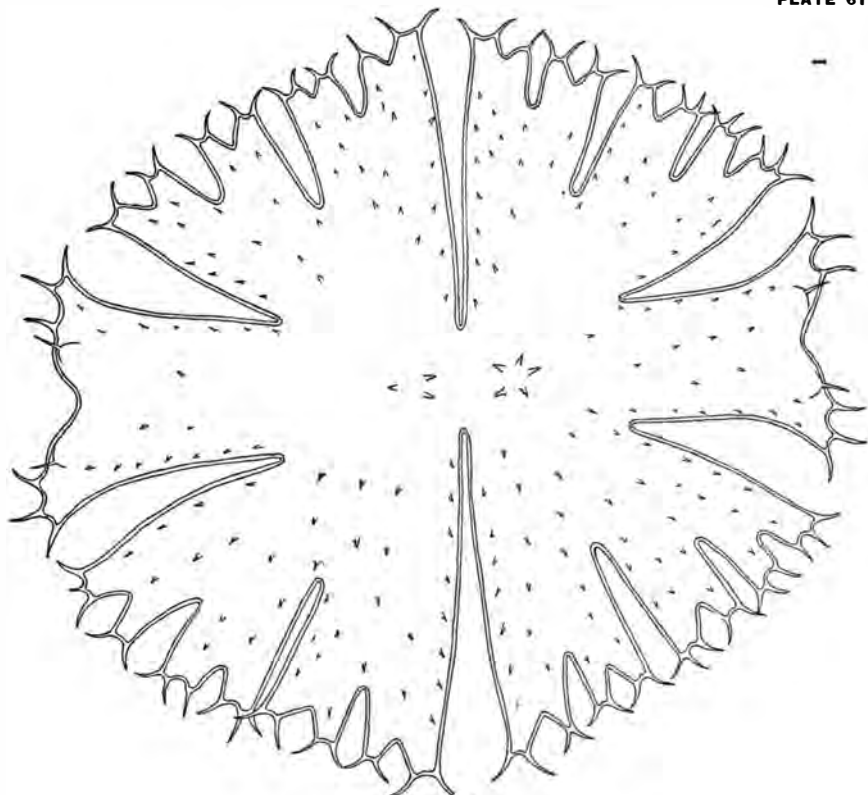


PLATE 62.

	Page
Fig. 1. <i>Microsterias apiculata</i> var. <i>fimbriata</i> (Ralfs) Nordst. (x 400) ..	48
Fig. 2. <i>Microsterias Torreyi</i> Bail. (x 200)	49

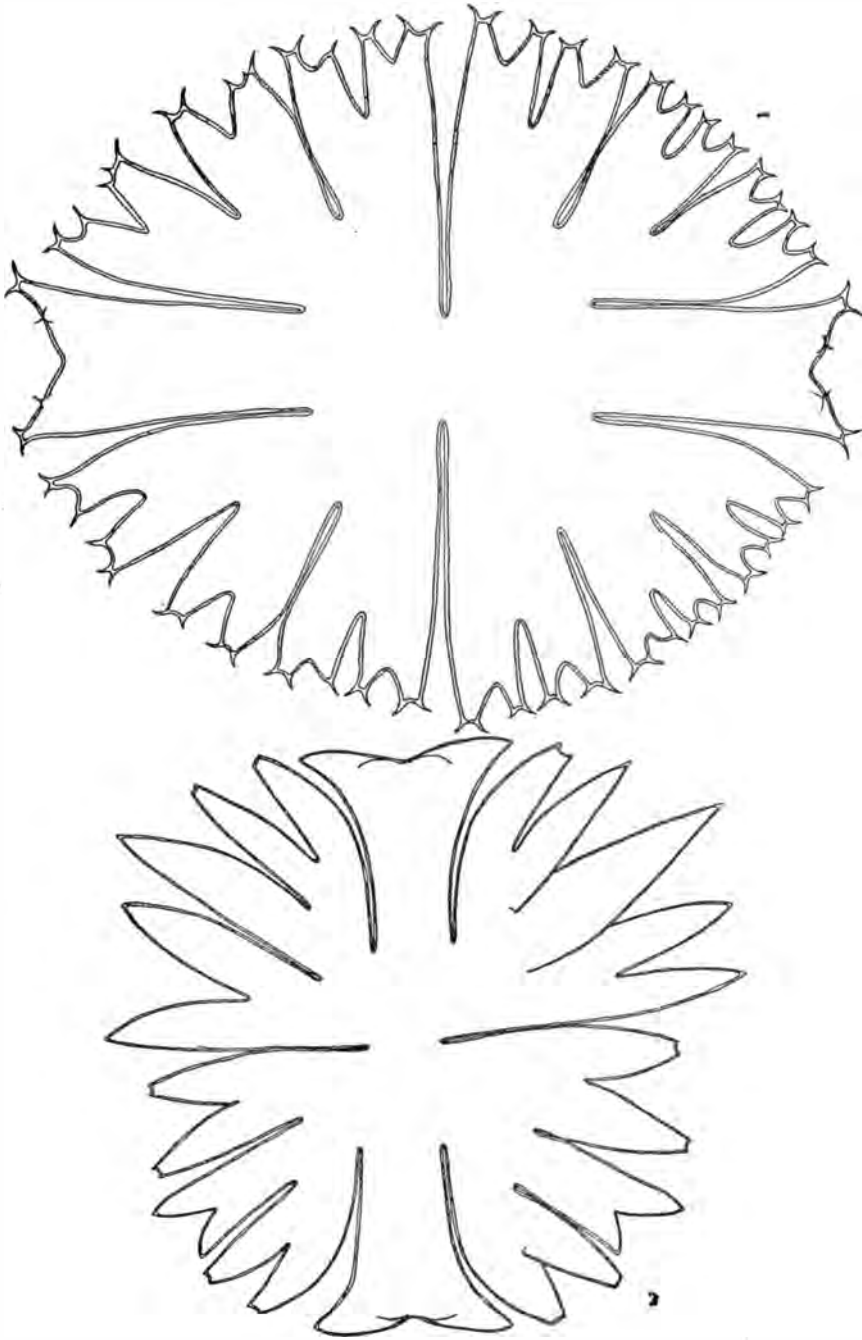


PLATE 63.

All figures x 400.

	Page
Figs. 1-3. <i>Microsterias radiata</i> Hass.....	50
Fig. 4. <i>Microsterias radiata</i> var. <i>simplex</i> (Wolle) G. M. Smith.....	51
Fig. 5. <i>Microsterias americana</i> (Ehr.) Ralfs.....	52

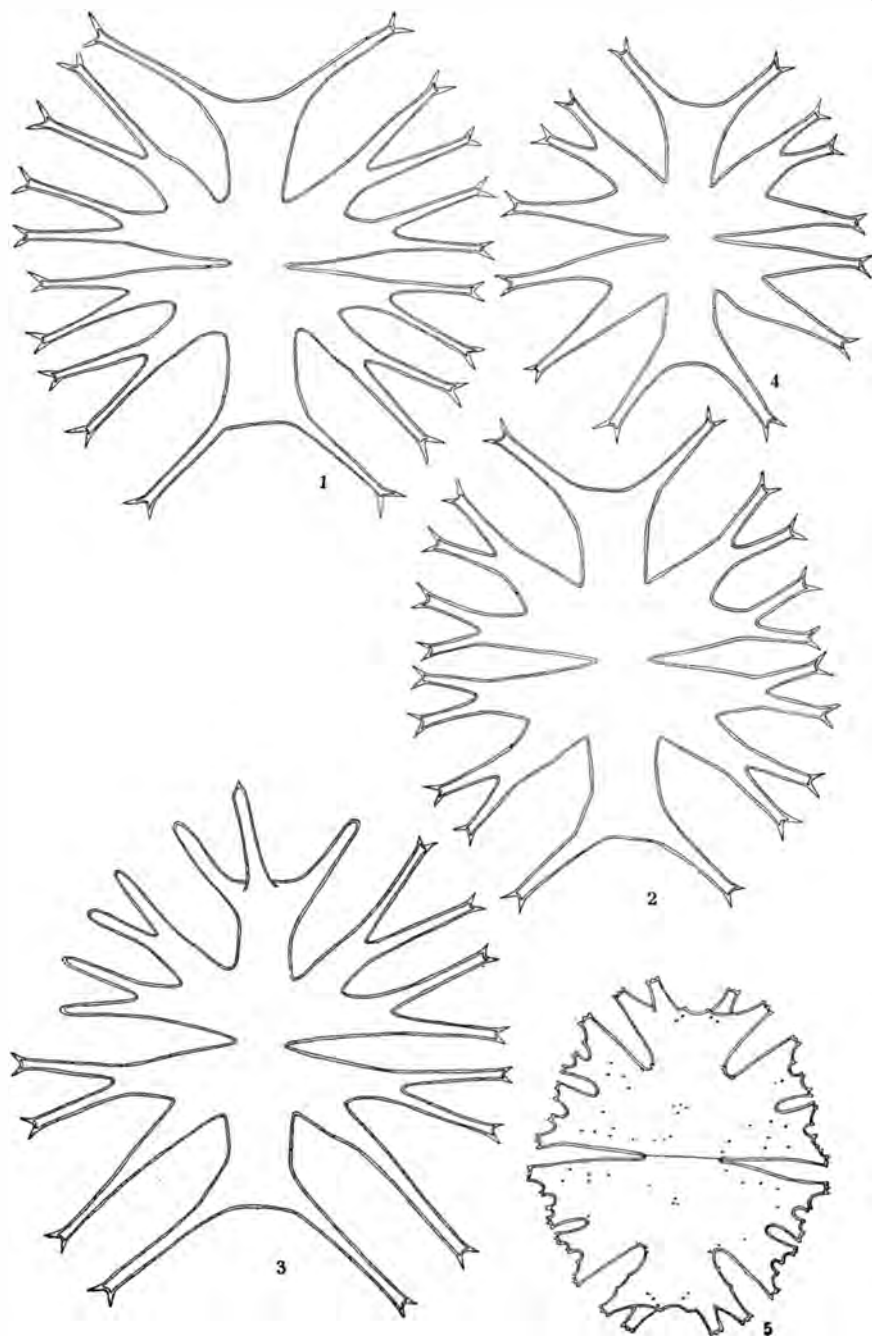


PLATE 64.

All figures $\times 400$.

	Page
Fig. 1. <i>Microsterias radiata</i> var. <i>gracillimum</i> G. M. Smith.....	52
Fig. 2. <i>Microsterias americana</i> (Ehr.) Ralfs.....	52
Fig. 3. <i>Microsterias Nordstedtiana</i> Wolle.....	53
Figs. 4-5. <i>Microsterias muricata</i> (Bail.) Ralfs.....	54

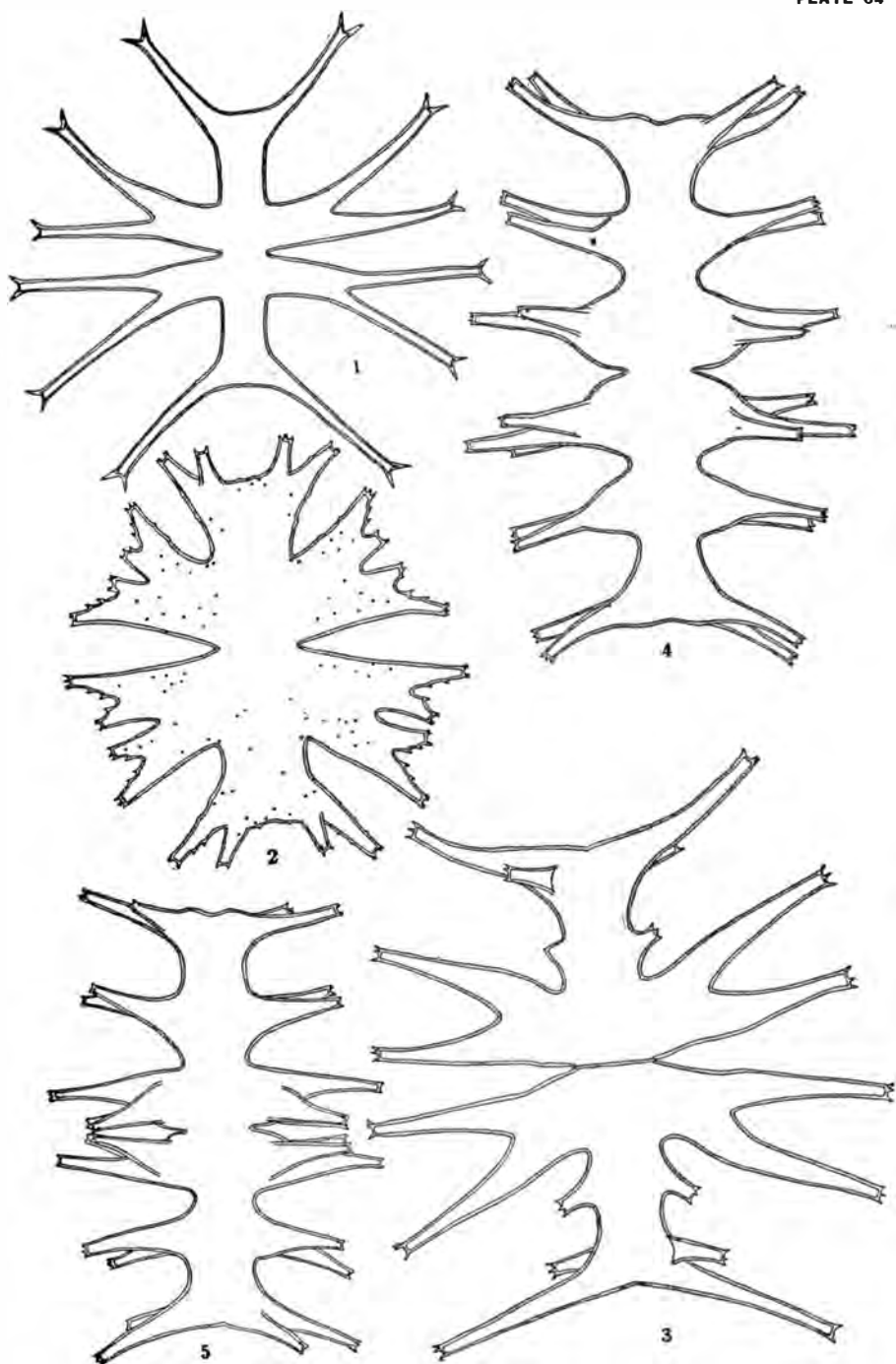


PLATE 65.

Fig. 1, x 250; Figs. 2-11, x 500.

	Page
Figs. 1-2. <i>Micrasterias foliacea</i> Bail.....	54
Figs. 3-4. <i>Xanthidium armatum</i> var. <i>mediolaeve</i> var. nov.....	57
Figs. 5-6. <i>Xanthidium antilopaeum</i> (De Bréb.) Ktz.....	57
Figs. 7-9. <i>Xanthidium antilopaeum</i> var. <i>polymazum</i> Nordst.....	58
Figs. 10-11. <i>Xanthidium antilopaeum</i> var. <i>minneapolisense</i> Wolle.....	58

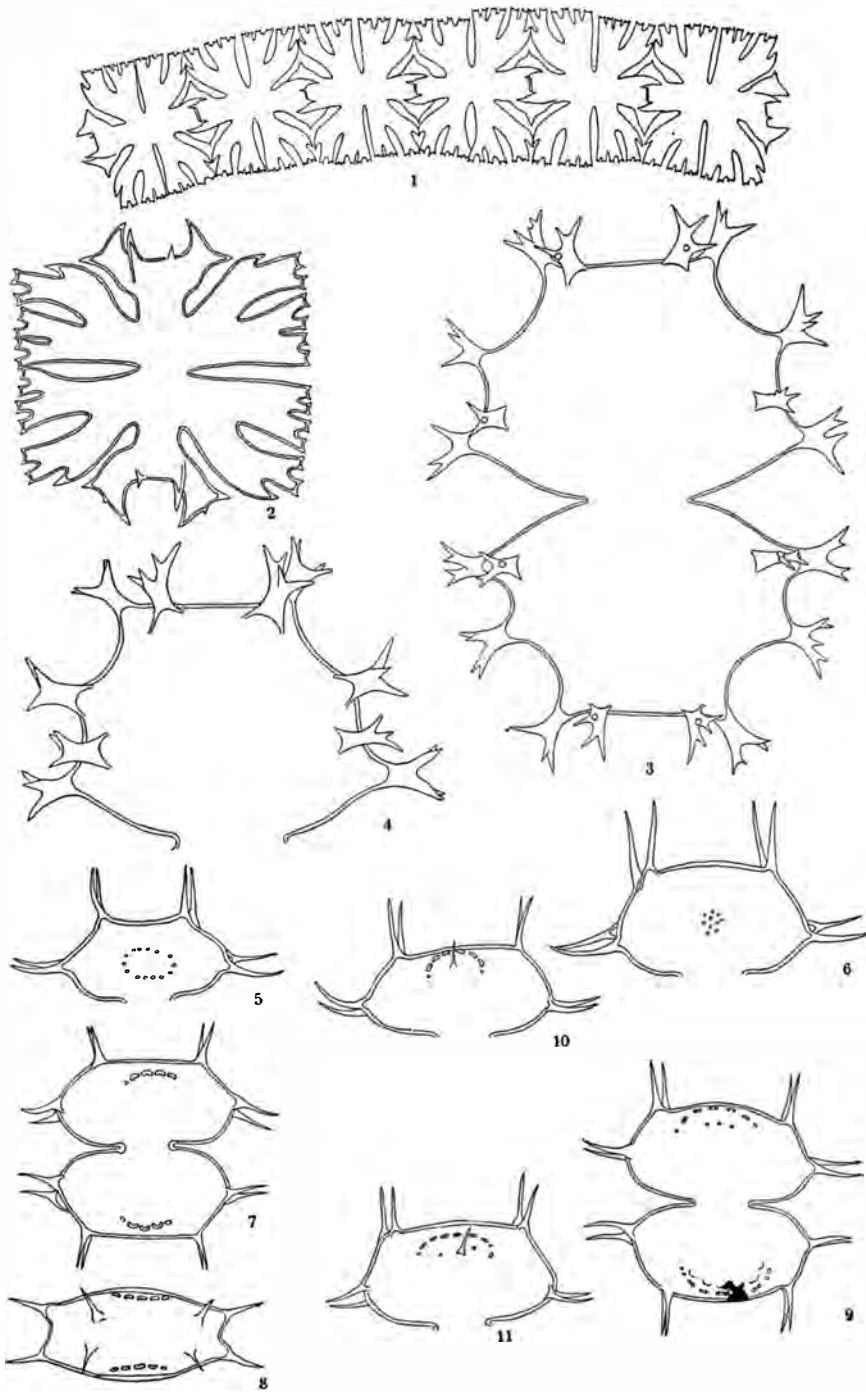


PLATE 66.

All figures $\times 500$.

	Page
Fig. 1. <i>Xanthidium antilopaeum</i> var. <i>depauperatum</i> W. & G. S. West	59
Figs. 2-3. <i>Xanthidium cristatum</i> De Bréb.....	59
Fig. 4. <i>Xanthidium cristatum</i> var. <i>uncinatum</i> De Bréb.....	60
Figs. 5-12. <i>Xanthidium subhastiferum</i> W. West.....	60
Figs. 13-18. <i>Xanthidium subhastiferum</i> var. <i>Toweri</i> (Cushm.) G. M. Smith..	61

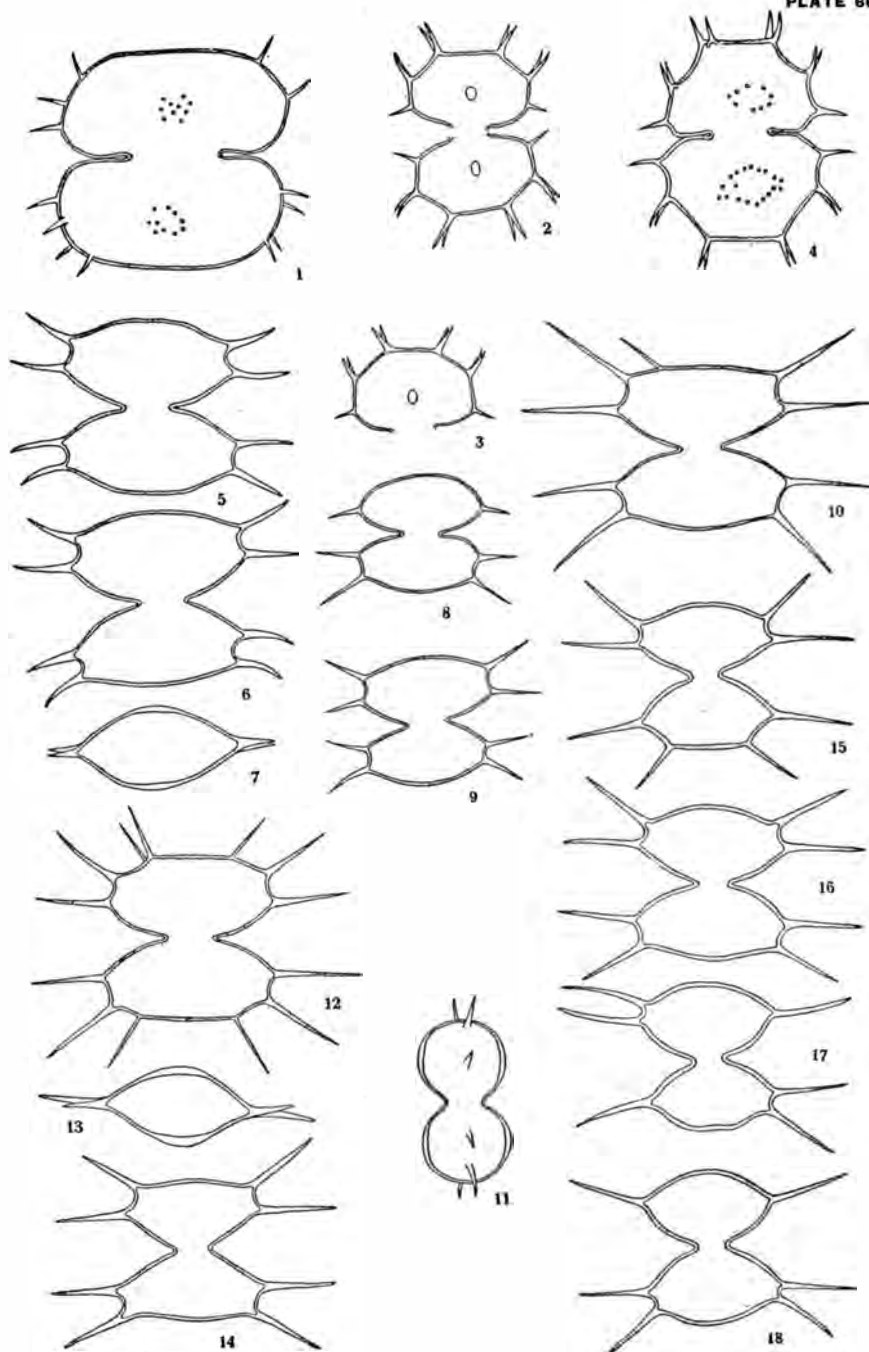


PLATE 67.

All figures x 500.

	Page
Figs. 1-3. <i>Xanthidium subhastiferum</i> var. <i>Toweri</i> (Cushm.) G. M. Smith.	61
Figs. 4-6. <i>Xanthidium subhastiferum</i> var. <i>Johnsonii</i> (W. & G. S. West) G. M. Smith.....	61
Fig. 7. <i>Xanthidium subhastiferum</i> var. <i>Johnsonii</i> forma.....	62
Figs. 8-9. <i>Staurastrum grande</i> Bulnh.....	66
Figs. 10-12. <i>Staurastrum subgrande</i> var. <i>minor</i> var. nov.....	67
Figs. 13-15. <i>Staurastrum muticum</i> De Bréb.....	67
Figs. 16-17. <i>Staurastrum brevispinum</i> var. <i>Boldtii</i> Lag.....	68
Figs. 18-19. <i>Staurastrum brevispinum</i> var. <i>retusum</i> Borge.....	69
Figs. 20-25. <i>Staurastrum brevispinum</i> var. <i>tumidum</i> var. nov.....	69

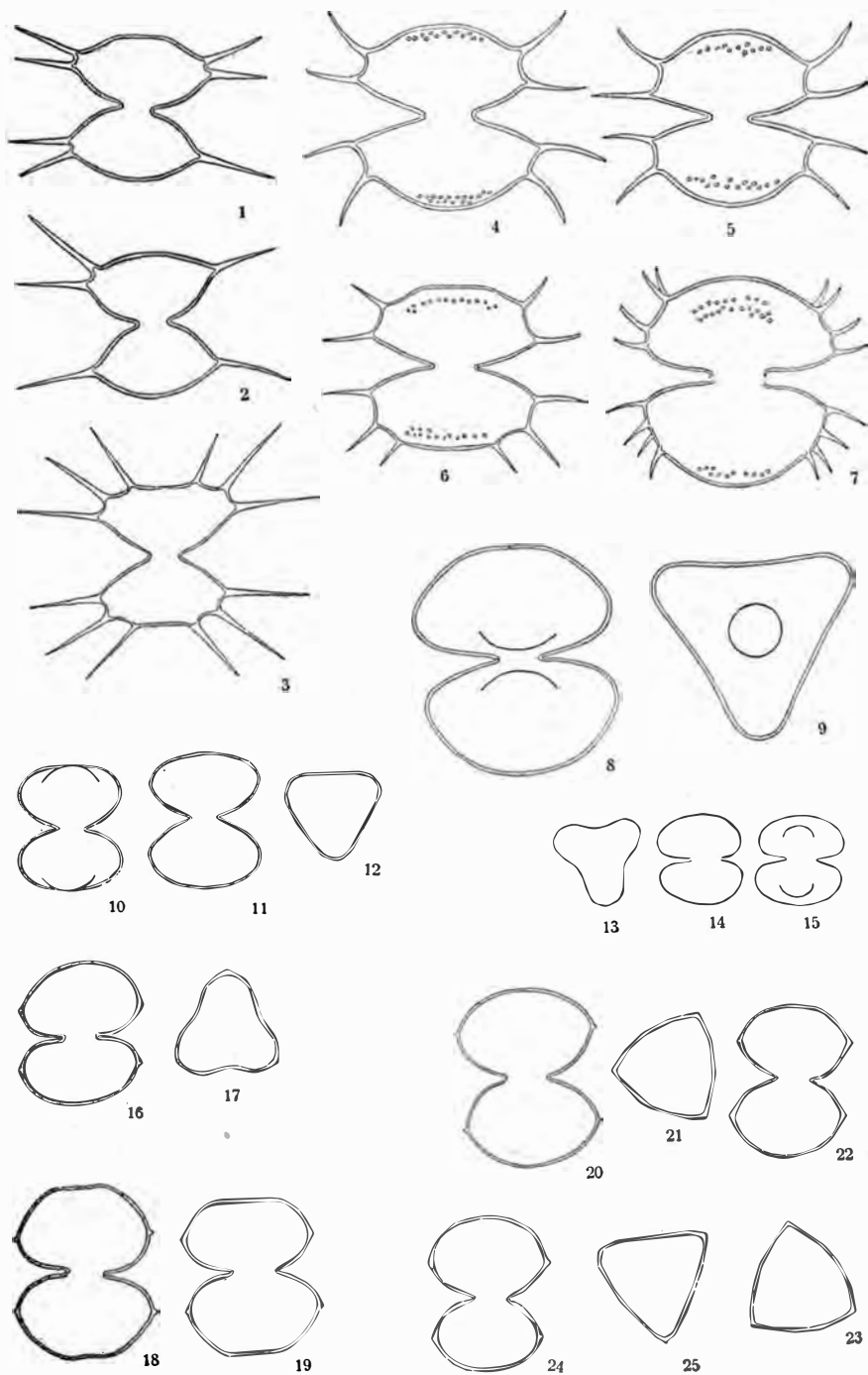


PLATE 68.

All figures x 600.

	Page
Figs. 1-3. <i>Staurastrum pseudopachyrhynchum</i> Wolle.....	69
Fig. 4. <i>Staurastrum alternans</i> De Bréb.....	70
Figs. 5-7. <i>Staurastrum denticulatum</i> (Näg.) Arch.....	70
Figs. 8-10. <i>Staurastrum avicula</i> De Bréb.....	71
Figs. 11-13. <i>Staurastrum lunatum</i> var. <i>planctonicum</i> W. & G. S. West.....	71
Figs. 14-17. <i>Staurastrum aristiferum</i> var. <i>indentatum</i> var. nov.....	72
Figs. 18-24. <i>Staurastrum dejectum</i> De Bréb.....	73
Figs. 25-26. <i>Staurastrum dejectum</i> var. <i>inflatum</i> W. West.....	74
Figs. 27-34. <i>Staurastrum cuspidatum</i> De Bréb.....	74

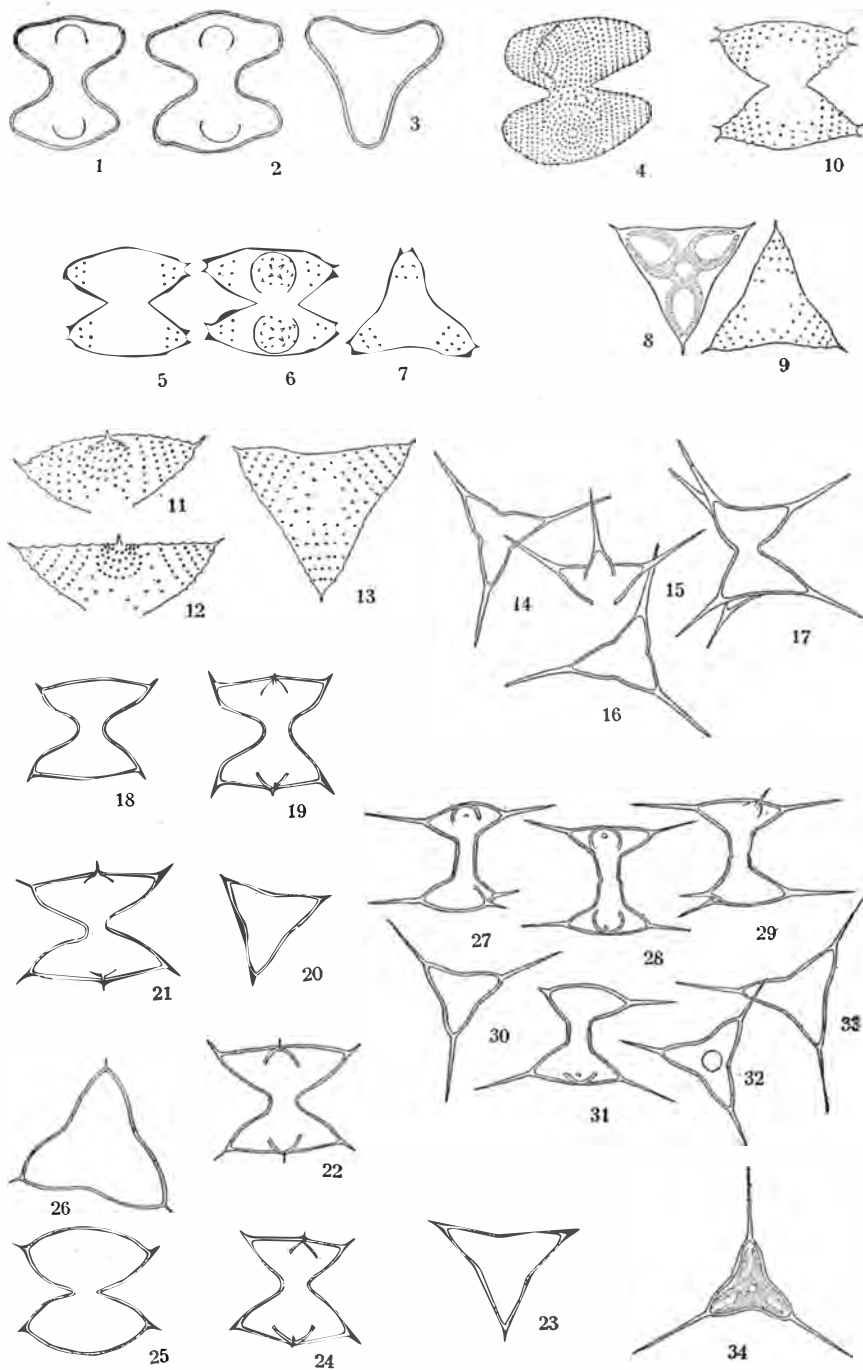


PLATE 69.

All figures x 500.

	Page
Figs. 1-3. <i>Staurastrum cuspidatum</i> var. <i>canadense</i> G. M. Smith.....	75
Figs. 4-9. <i>Staurastrum curvatum</i> W. West.....	73
Figs. 10-15. <i>Staurastrum curvatum</i> var. <i>elongatum</i> var. nov.....	73
Figs. 16-21. <i>Staurastrum megacanthum</i> Lund.....	75
Figs. 22-24. <i>Staurastrum megacanthum</i> var. <i>scoticum</i> W. & G. S. West.....	76

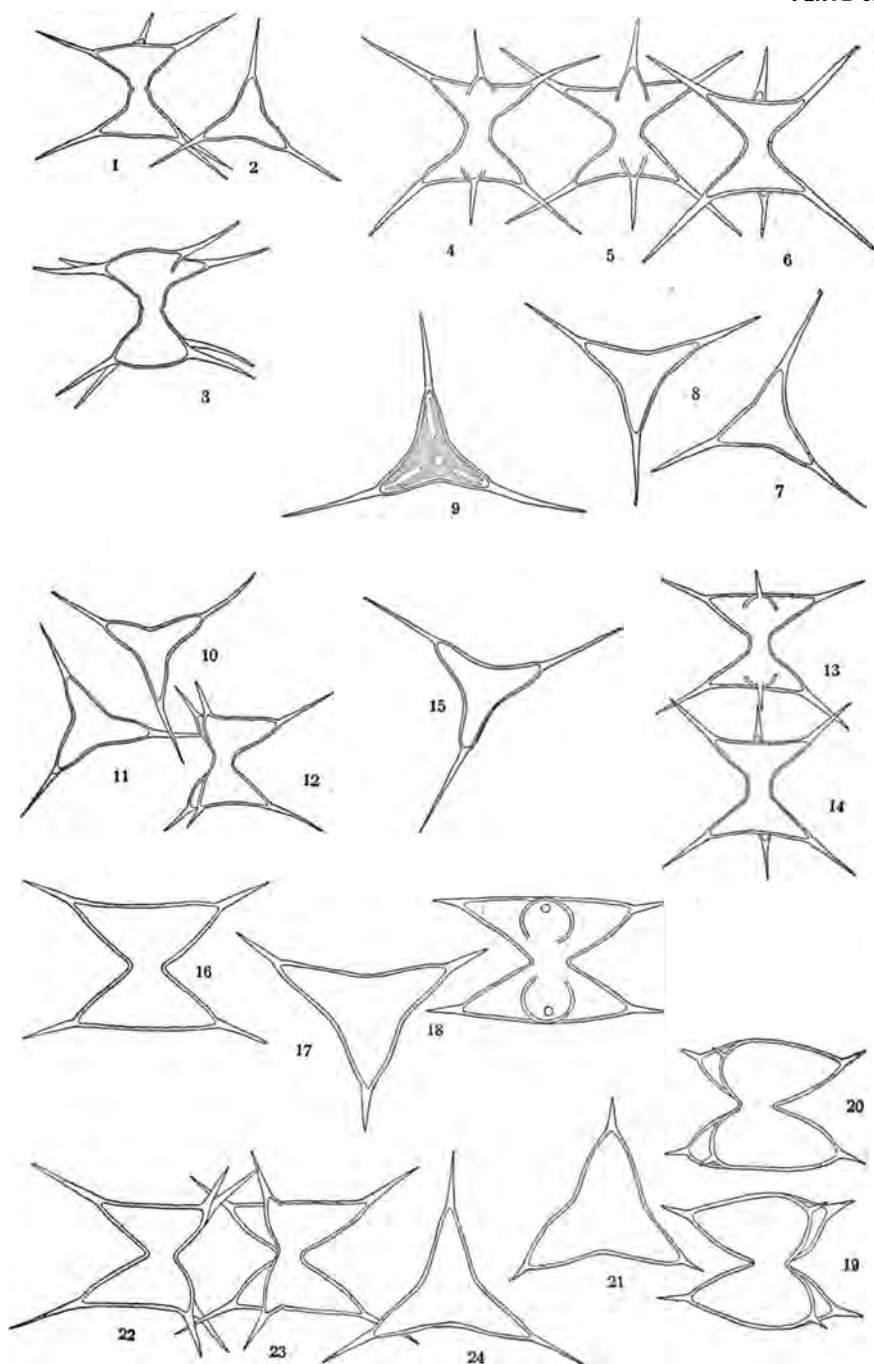


PLATE 70.

All figures x 500.

	Page
Figs. 1-2. <i>Staurastrum megacanthum</i> var. <i>scoticum</i> W. & G. S. West.....	76
Figs. 3-5. <i>Staurastrum Dickiei</i> var. <i>maximum</i> W. & G. S. West.....	76
Figs. 6-7. <i>Staurastrum connatum</i> var. <i>rectangulum</i> Roy & Biss.....	77
Figs. 8-9. <i>Staurastrum quadrangulare</i> De Bréb. forma.....	78
Figs. 10-15. <i>Staurastrum breviaculeatum</i> sp. nov.....	78
Figs. 16-18. <i>Staurastrum breviaculeatum</i> forma.....	79
Figs. 19-25. <i>Staurastrum setigerum</i> Cleve.....	79

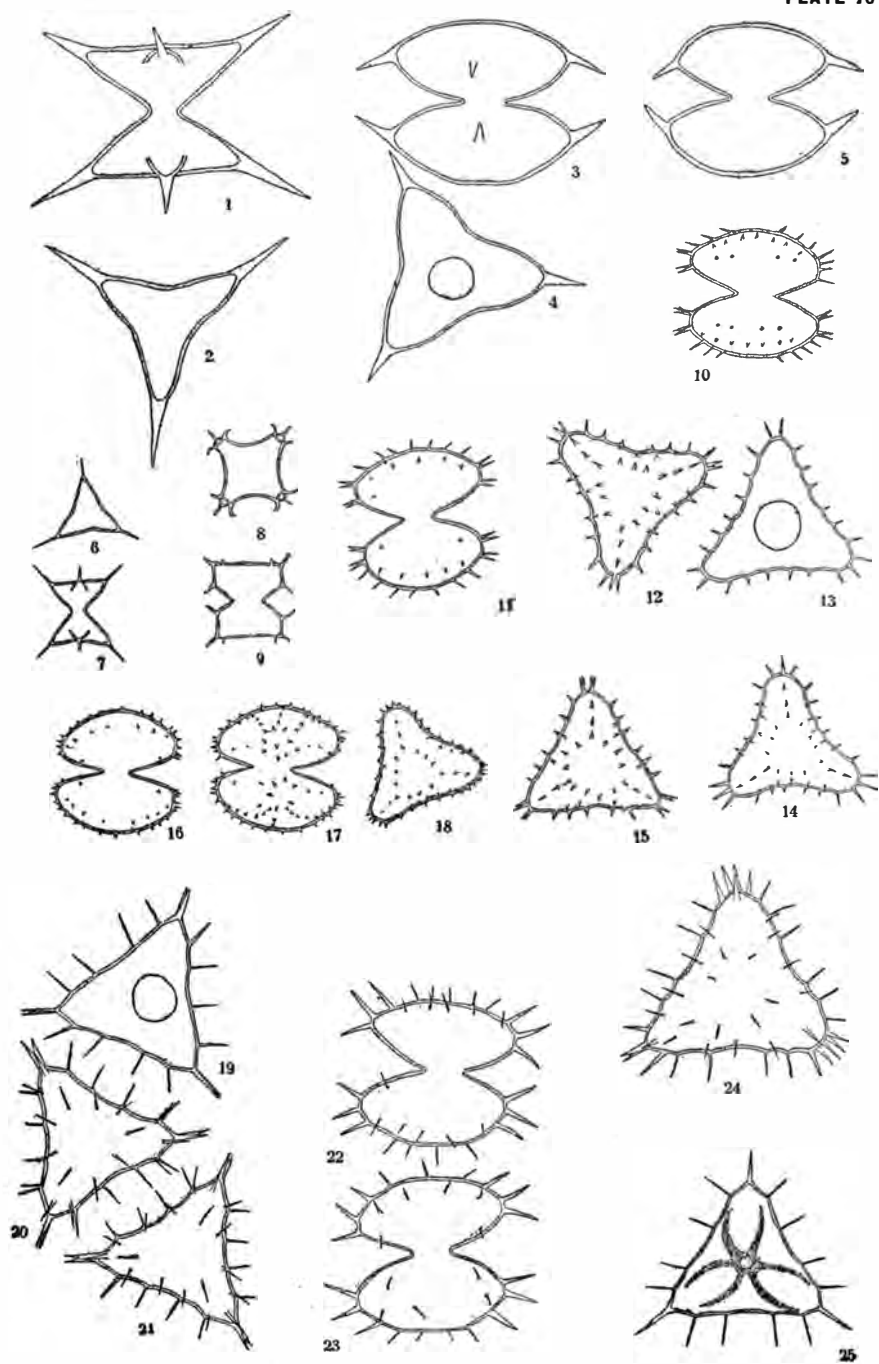


PLATE 71.

All figures x 500.

	Page
Figs. 1-4. <i>Staurastrum setigerum</i> var. <i>occidentale</i> W. & G. S. West.....	80
Figs. 5-8. <i>Staurastrum setigerum</i> var. <i>pectinatum</i> W. & G. S. West.....	80
Figs. 9-13. <i>Staurastrum setigerum</i> var. <i>brevispinum</i> G. M. Smith.....	80
Figs. 14-15. <i>Staurastrum minnesotense</i> Wolle.....	81
Figs. 16-20. <i>Staurastrum spiculiferum</i> sp. nov.....	82

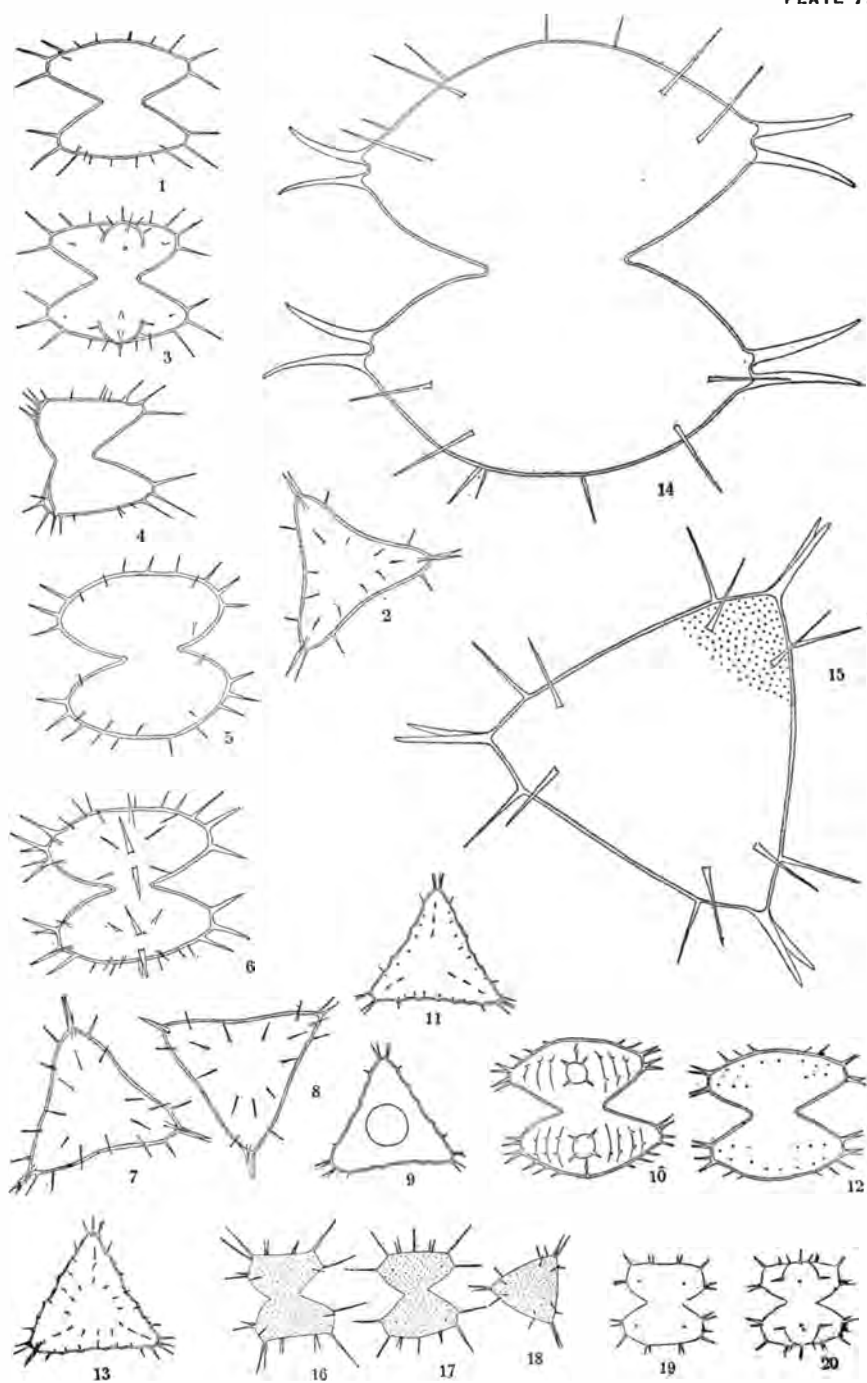


PLATE 72.

All figures $\times 500$.

	Page
Figs. 1-4. <i>Staurastrum brachiatum</i> Ralfs.....	82
Figs. 5-7. <i>Staurastrum pseudopelagicum</i> W. & G. S. West.....	83
Figs. 8-11. <i>Staurastrum pseudopelagicum</i> var. <i>tumidum</i> var. nov.....	84
Figs. 12-14. <i>Staurastrum cingulum</i> (W. & G. S. West) G. M. Smith.....	84
Figs. 15-22. <i>Staurastrum paradoxum</i> Meyen.....	85

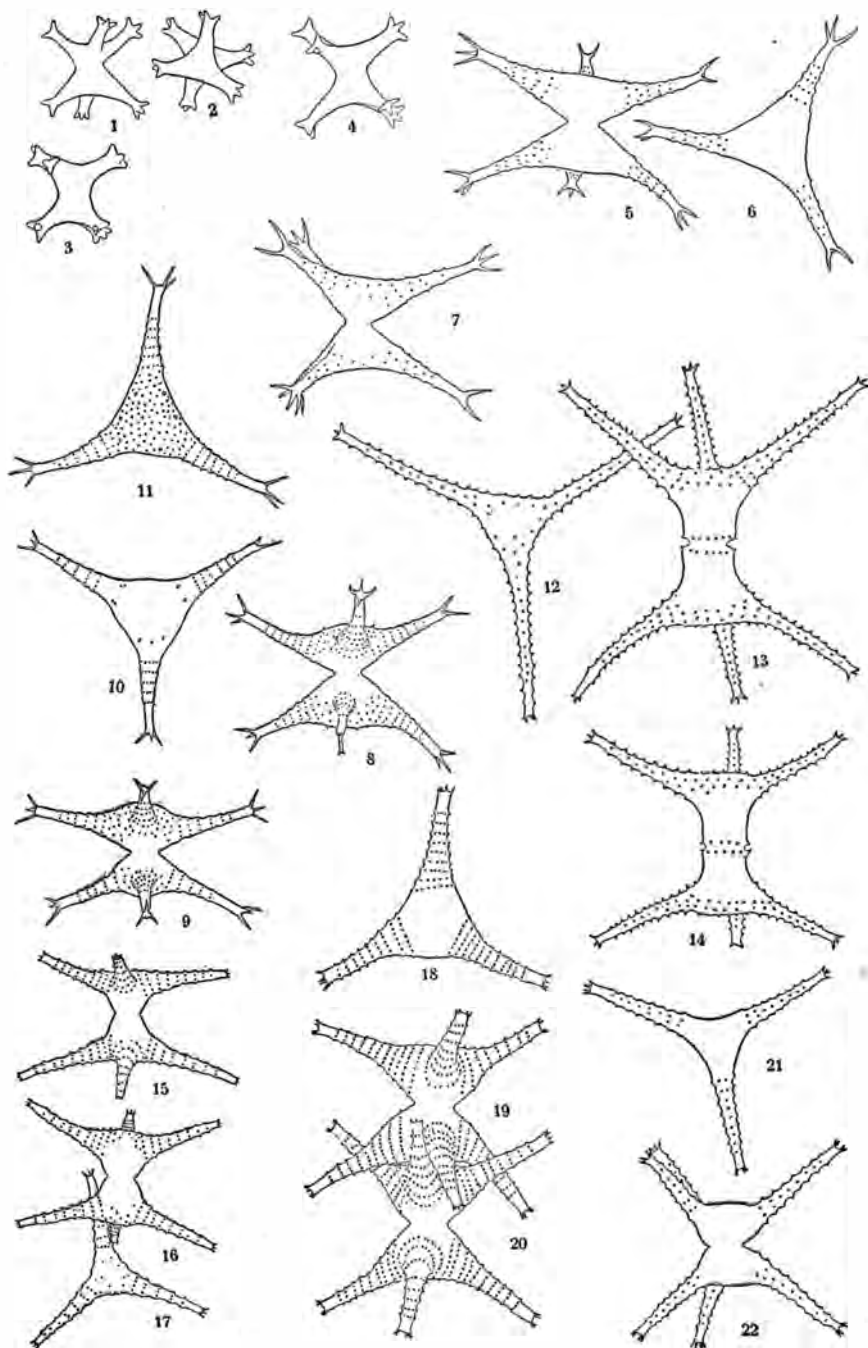


PLATE 73.

All figures x 500.

	Page
Figs. 1-2. <i>Staurastrum paradoxum</i> Meyen.....	85
Figs. 3-6. <i>Staurastrum paradoxum</i> var. <i>longipes</i> Nordst.....	86
Figs. 7-15. <i>Staurastrum paradoxum</i> var. <i>parvum</i> W. West.....	87
Figs. 16-18. <i>Staurastrum gracile</i> Ralfs.....	88

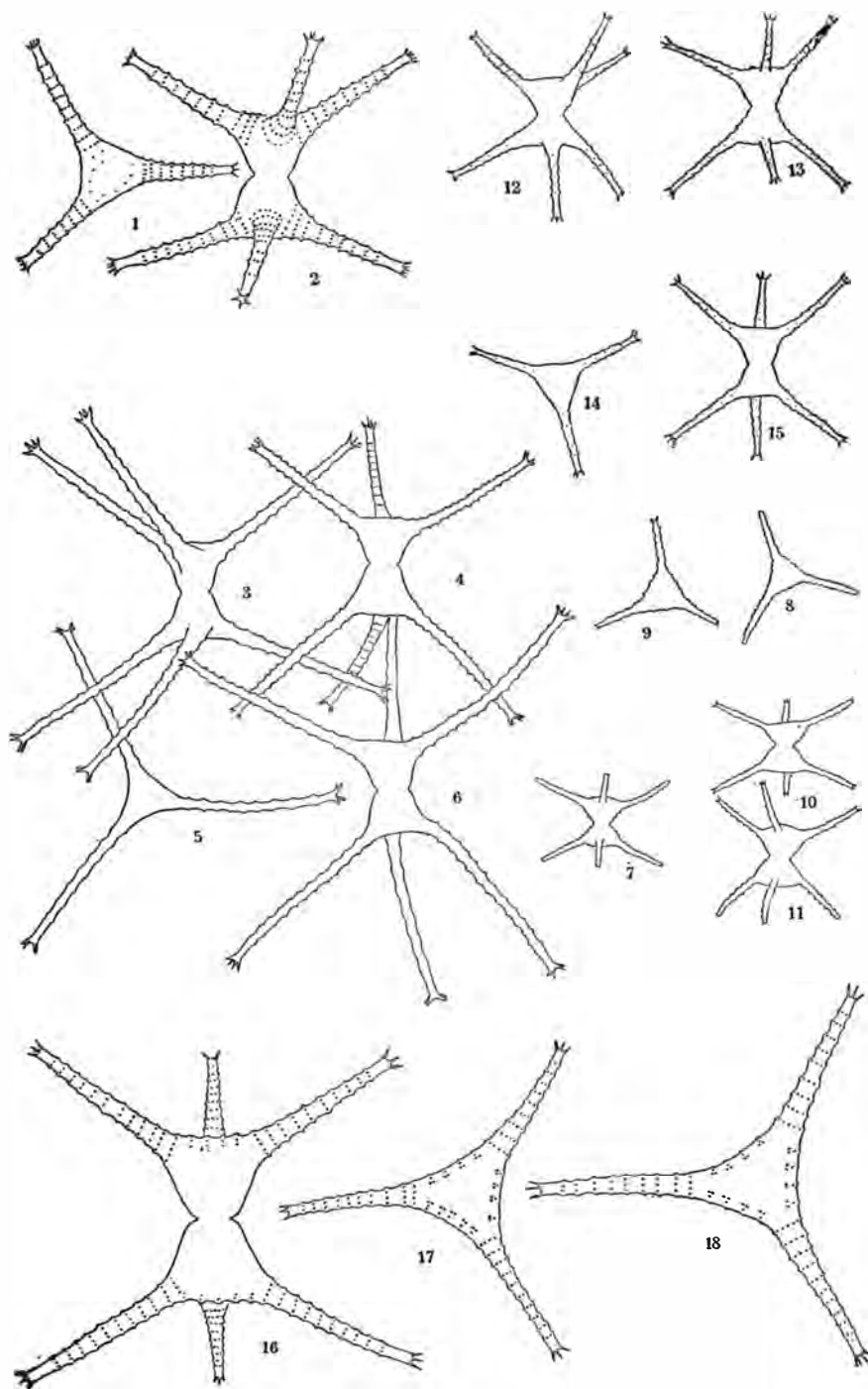


PLATE 74.

All figures x 500.

	Page
Figs. 1-4. <i>Staurastrum protectum</i> var. <i>planctonicum</i> G. M. Smith.....	87
Figs. 5-11. <i>Staurastrum longiradiatum</i> W. & G. S. West.....	90
Figs. 12-18. <i>Staurastrum floriferum</i> W. & G. S. West.....	91
Figs. 19-23. <i>Staurastrum Bullardii</i> sp. nov.....	91

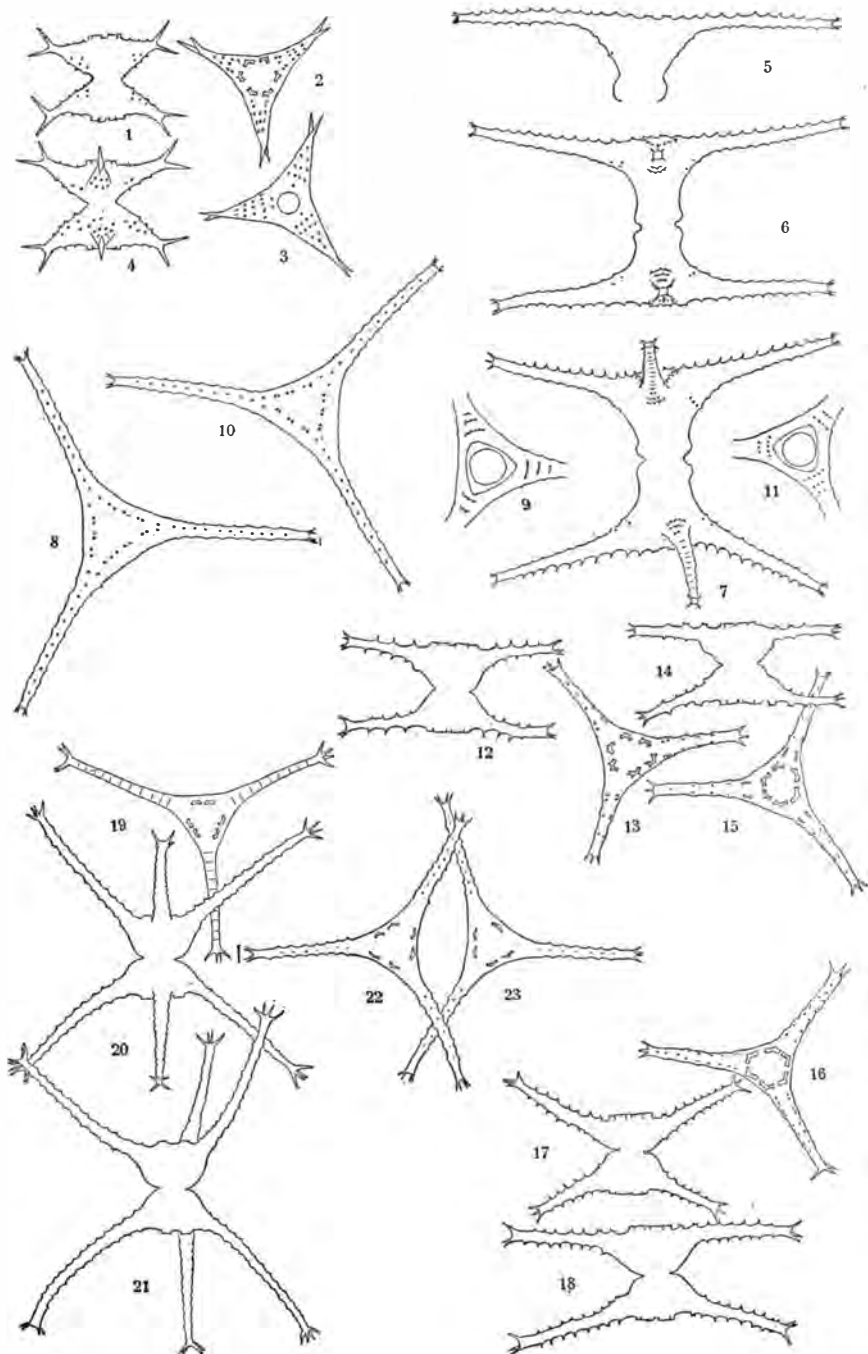


PLATE 75.

All figures x 500.

	Page
Figs. 1-3. <i>Staurastrum Bullardii</i> sp. nov.....	91
Figs. 4-5. <i>Staurastrum vestitum</i> Ralfs <i>formae</i>	92
Figs. 6-10. <i>Staurastrum vestitum</i> var. <i>subanatinum</i> W. & G. S. West.....	93
Figs. 11-16. <i>Staurastrum anatinum</i> var. <i>longibrachiatum</i> W. & G. S. West..	94
Figs. 17-20. <i>Staurastrum anatinum</i> var. <i>curtum</i> G. M. Smith.....	95
Figs. 21-25. <i>Staurastrum anatinum</i> var. <i>denticulatum</i> var. nov.....	95

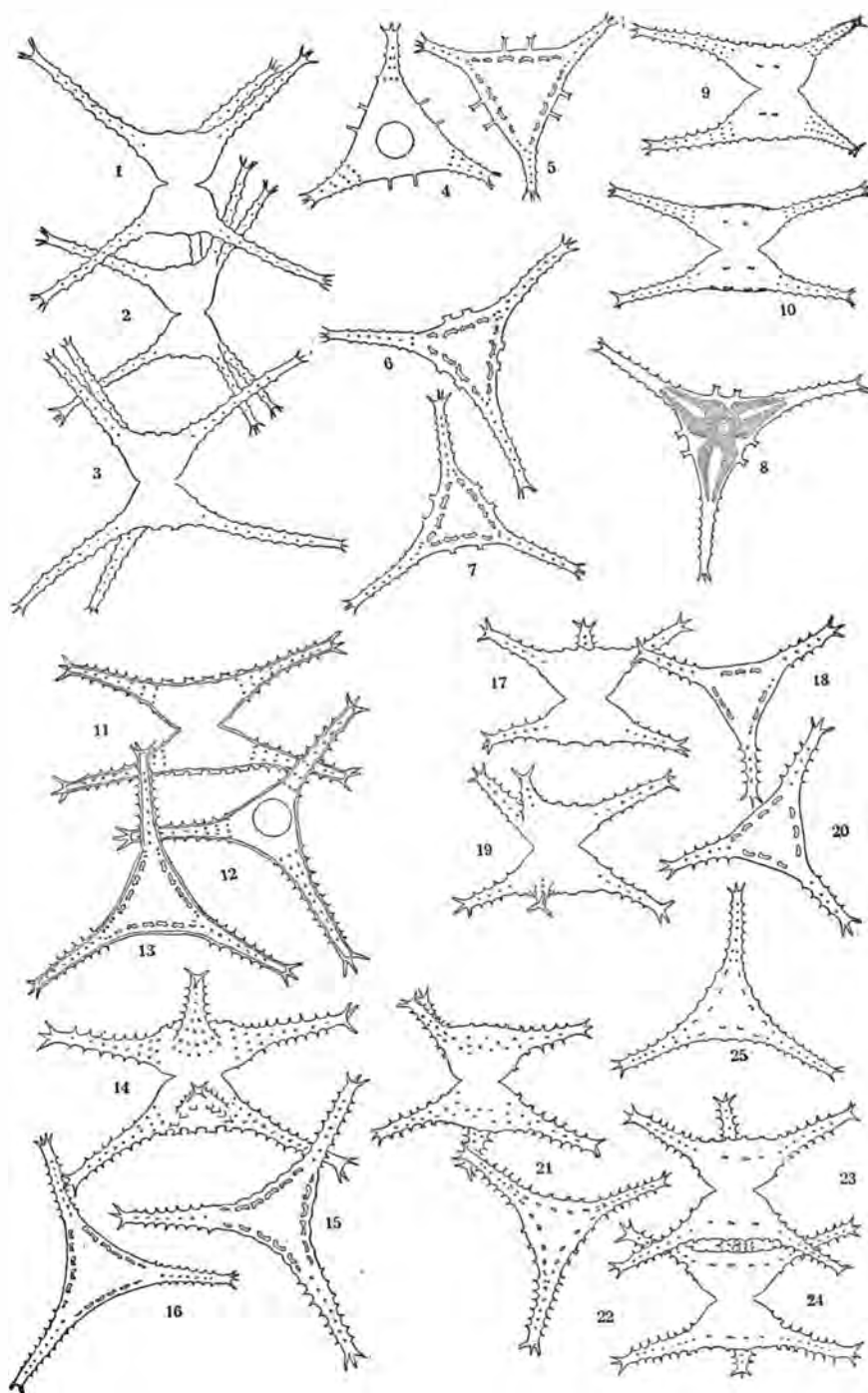


PLATE 76.

All figures x 500.

	Page
Figs. 1-8. <i>Staurastrum lacustre</i> G. M. Smith.....	97
Figs. 9-10. <i>Staurastrum tetracerum</i> var. <i>validum</i> W. & G. S. West.....	96
Figs. 11-14. <i>Staurastrum tetracerum</i> var. <i>evolutum</i> W. & G. S. West.....	97
Figs. 15-16. <i>Staurastrum tetracerum</i> var. <i>trigonum</i> Lund.....	97
Figs. 17-20. <i>Staurastrum contortum</i> sp. nov.....	98
Figs. 21-24. <i>Staurastrum Chaetoceras</i> (Schröd.) comb. nov.....	99

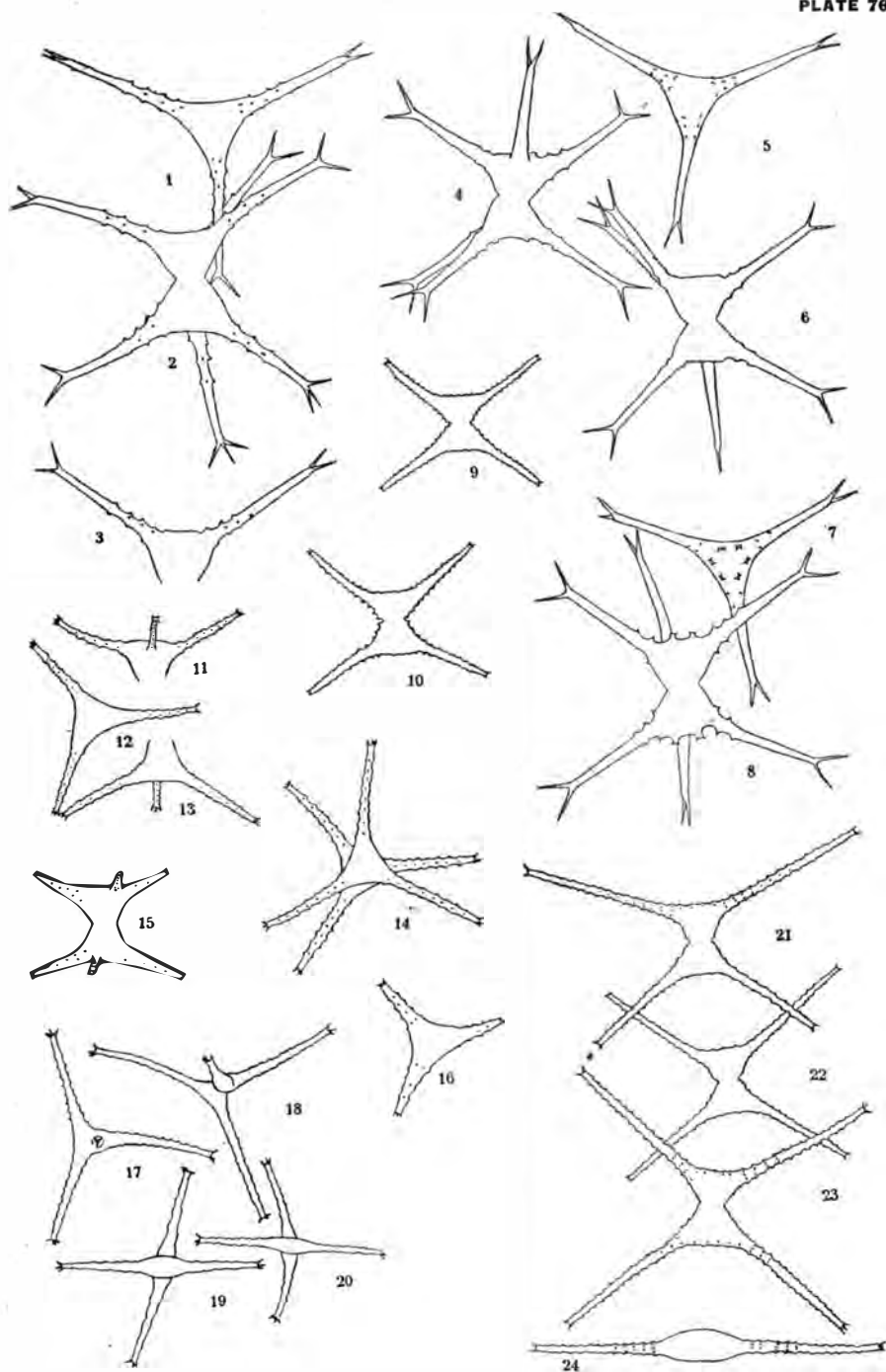


PLATE 77.

All figures x 500.

	Page
Fig. 1. <i>Staurastrum Chaetoceras</i> (Schröd.) comb. nov.....	99
Fig. 2. <i>Staurastrum americanum</i> (W. & G. S. West) G. M. Smith.....	100
Figs. 3-5. <i>Staurastrum grillatorium</i> Nordst.....	100
Figs. 6-7. <i>Staurastrum grillatorium</i> var. <i>forcipigerum</i> Lag.....	101
Figs. 8-9. <i>Staurastrum anchora</i> W. & G. S. West.....	101
Figs. 10-14. <i>Staurastrum leptocladum</i> var. <i>denticulatum</i> G. M. Smith.....	103
Fig. 15. <i>Staurastrum leptocladum</i> var. <i>insigne</i> W. & G. S. West.....	103

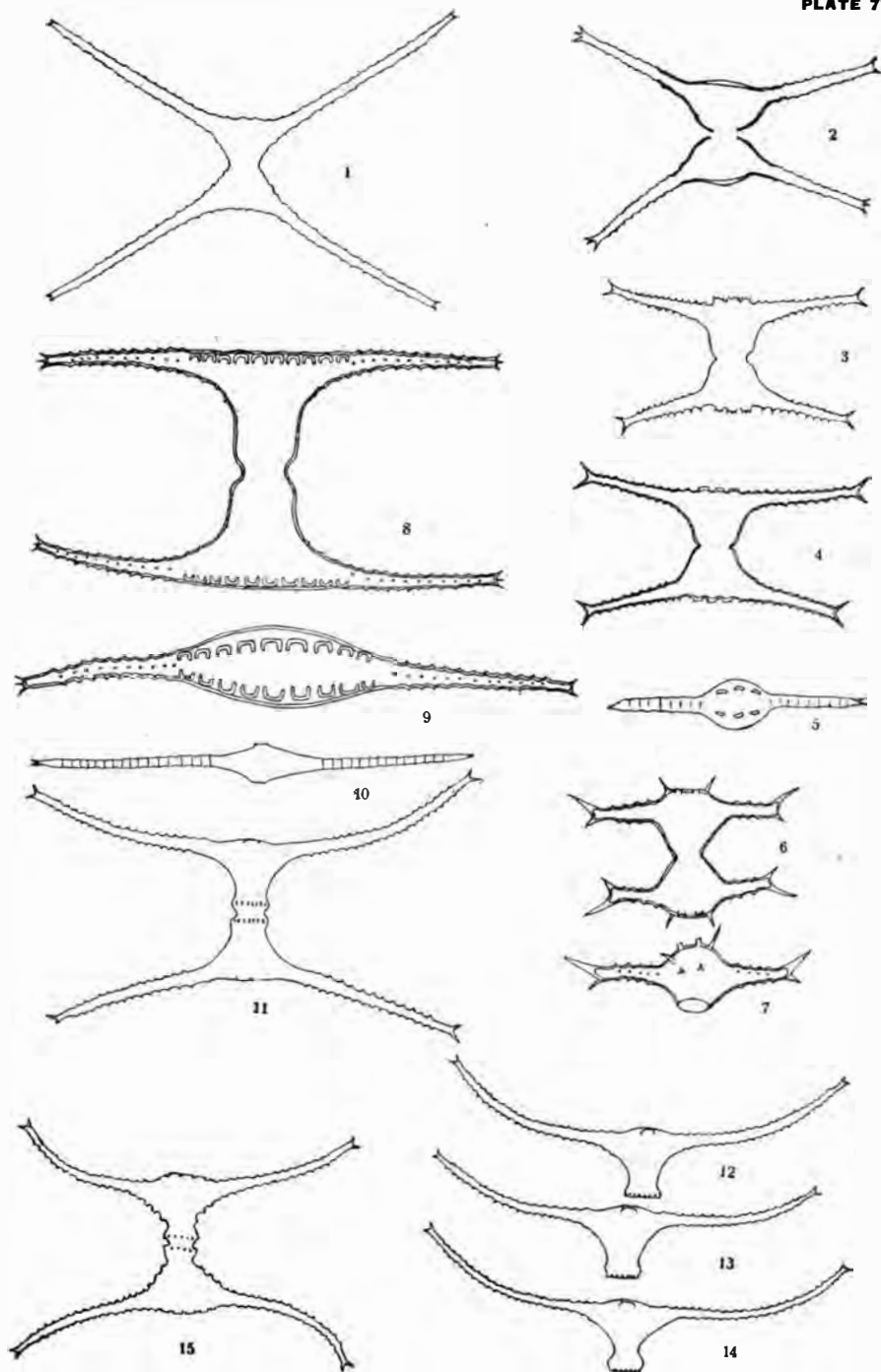


PLATE 78.

All figures x 500.

	Page
Figs. 1-7. <i>Staurastrum leptocladum</i> Nordst.....	102
Figs. 8-11. <i>Staurastrum leptocladum</i> var. <i>insigne</i> W. & G. S. West.....	103
Figs. 12-14. <i>Staurastrum leptocladum</i> var. <i>sinuatum</i> Wolle.....	104
Fig. 15. <i>Staurastrum leptocladum</i> var. <i>sinuatum</i> forma <i>planum</i>	104

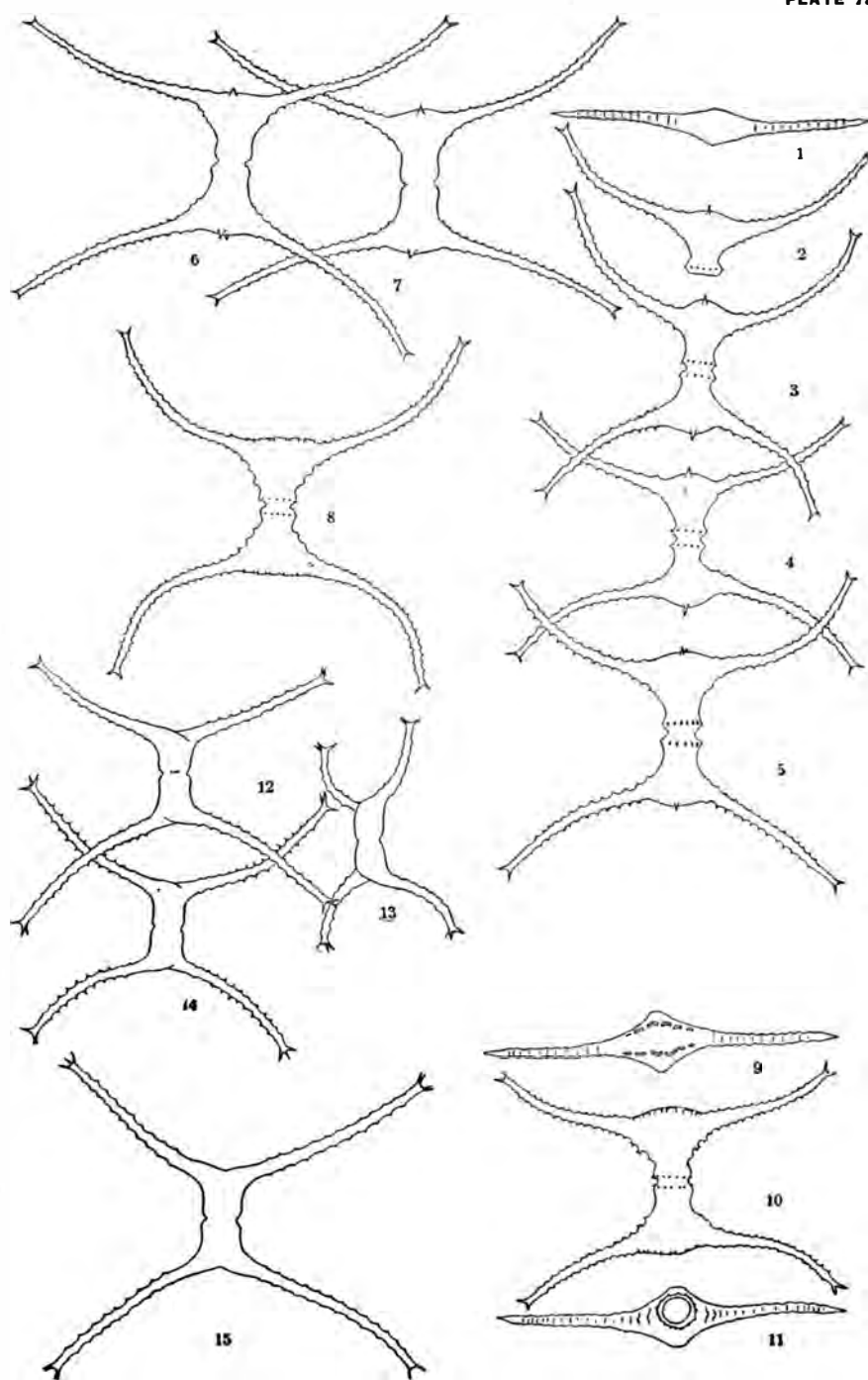


PLATE 79.

All figures x 500.

	Page
Figs. 1-5. <i>Staurastrum Johnsonii</i> W. & G. S. West.....	104
Fig. 6. <i>Staurastrum Johnsonii</i> forma <i>parvum</i>	105
Figs. 7-11. <i>Staurastrum Johnsonii</i> var. <i>depauperatum</i> var. nov.....	105
Fig. 12. <i>Staurastrum natator</i> W. West.....	106
Figs. 13-15. <i>Staurastrum natator</i> var. <i>crassum</i> W. & G. S. West.....	107
Figs. 16-18. <i>Staurastrum urinator</i> sp. nov.....	107

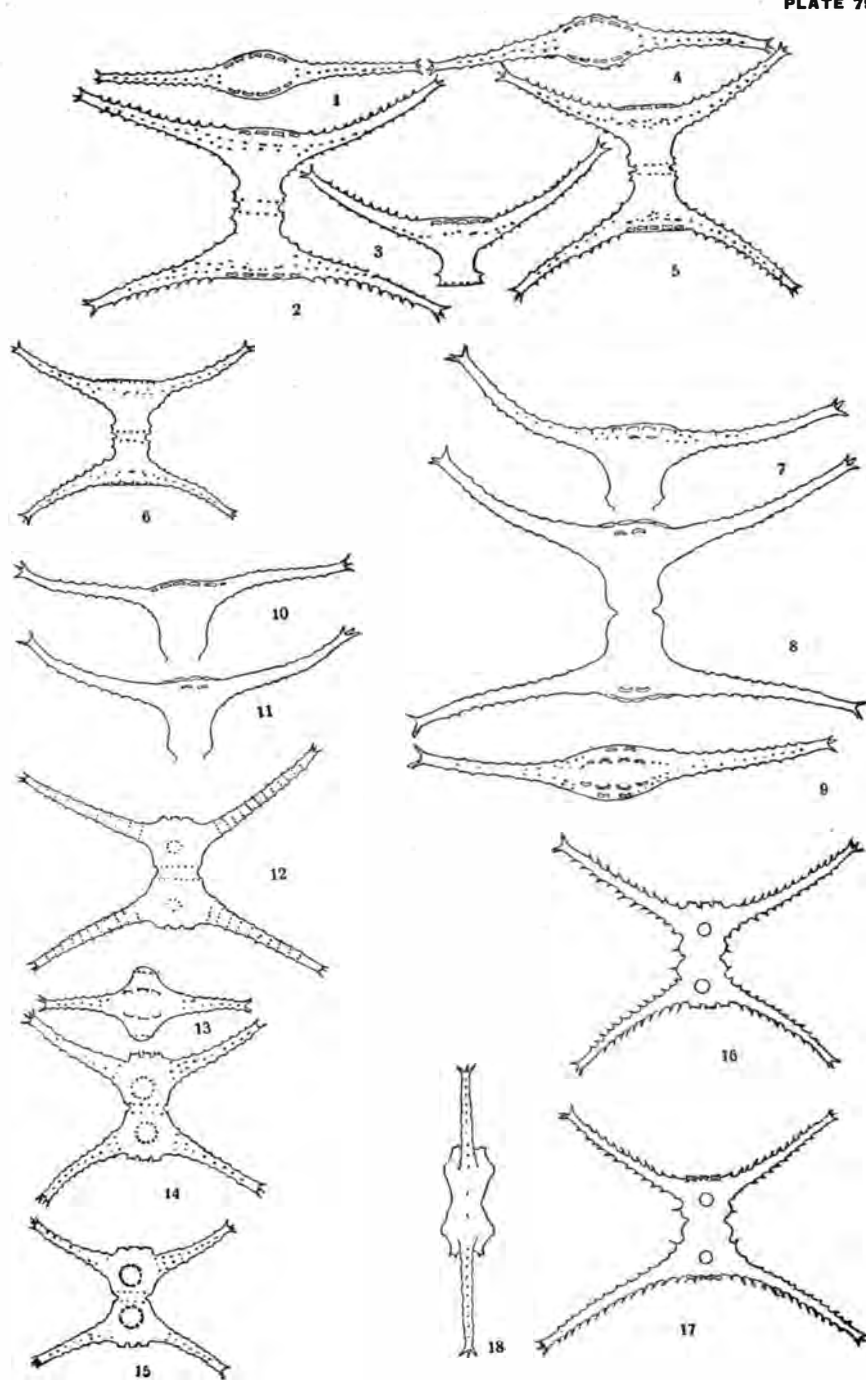


PLATE 80.

All figures x 500.

	Page
Figs. 1-4. <i>Staurastrum subnudibrachiatum</i> var. <i>incisum</i> var. nov.....	108
Figs. 5-7. <i>Staurastrum inconspicuum</i> var. <i>planctonicum</i> var. nov.....	109
Figs. 8-10. <i>Staurastrum cerastes</i> Lund.....	110
Figs. 11-14. <i>Staurastrum arachne</i> var. <i>curvatum</i> W. & G. S. West.....	112
Figs. 15-18. <i>Staurastrum pentacerum</i> (Wolle) G. M. Smith.....	112
Figs. 19-21. <i>Staurastrum pentacerum</i> var. <i>tetracerum</i> (Wolle) G. M. Smith.	113

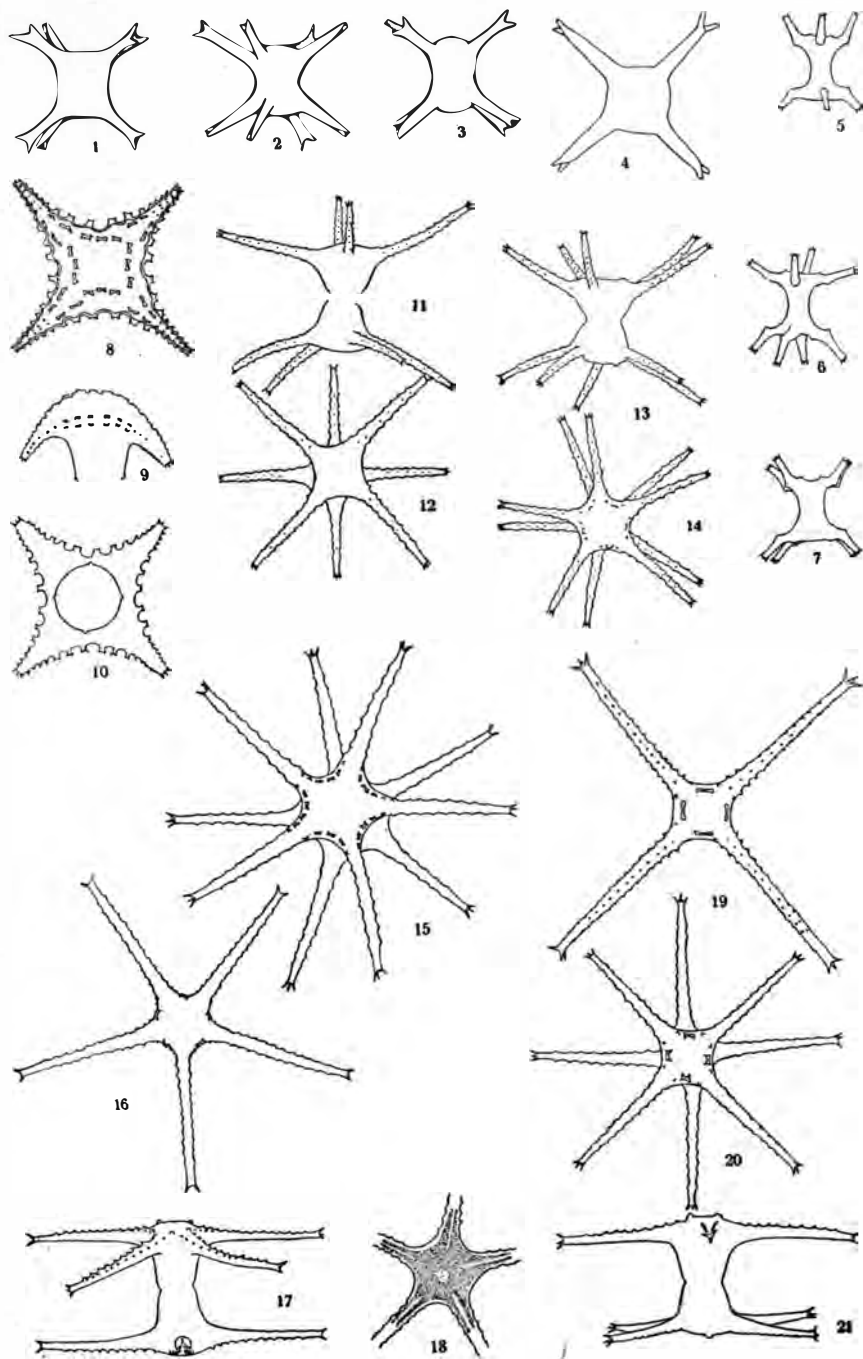


PLATE 81.

All figures x 500.

	Page
Figs. 1-2. <i>Staurastrum ankyroides</i> var. <i>pentacladum</i> var. nov.....	114
Figs. 3-4. <i>Staurastrum Ophiura</i> Lund.....	115
Figs. 5-8. <i>Staurastrum rotula</i> Nordst.....	116

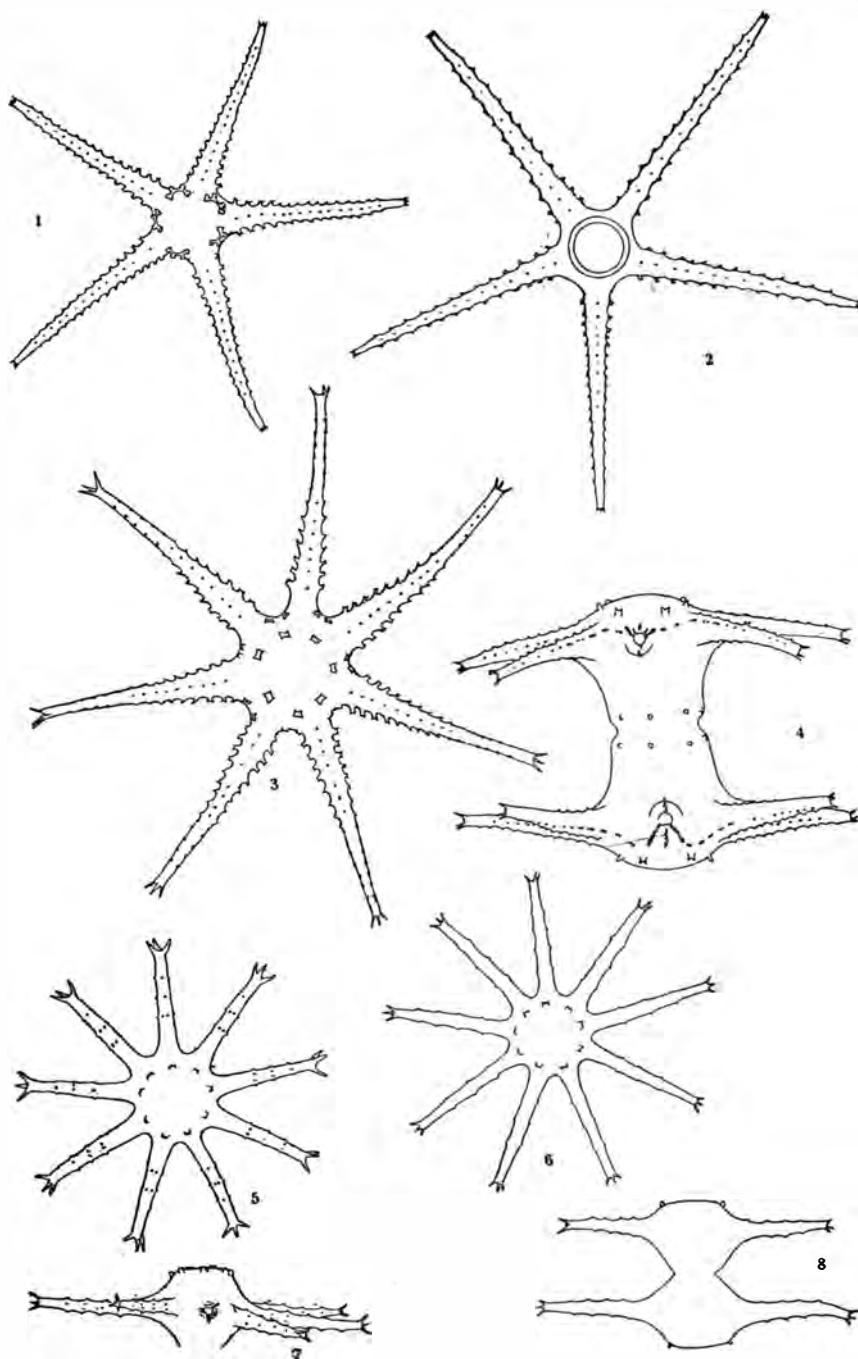


PLATE 82.

All figures x 500.

	Page
Figs. 1-2. <i>Staurastrum limneticum</i> var. <i>cornutum</i> var. nov.....	117
Figs. 3-5. <i>Staurastrum brasiliense</i> var. <i>Lundellii</i> W. & G. S. West.....	120
Figs. 6-7. <i>Staurastrum radians</i> W. & G. S. West.....	118
Figs. 8-11. <i>Staurastrum tohopekaligense</i> var. <i>brevispinum</i> var. nov.....	121

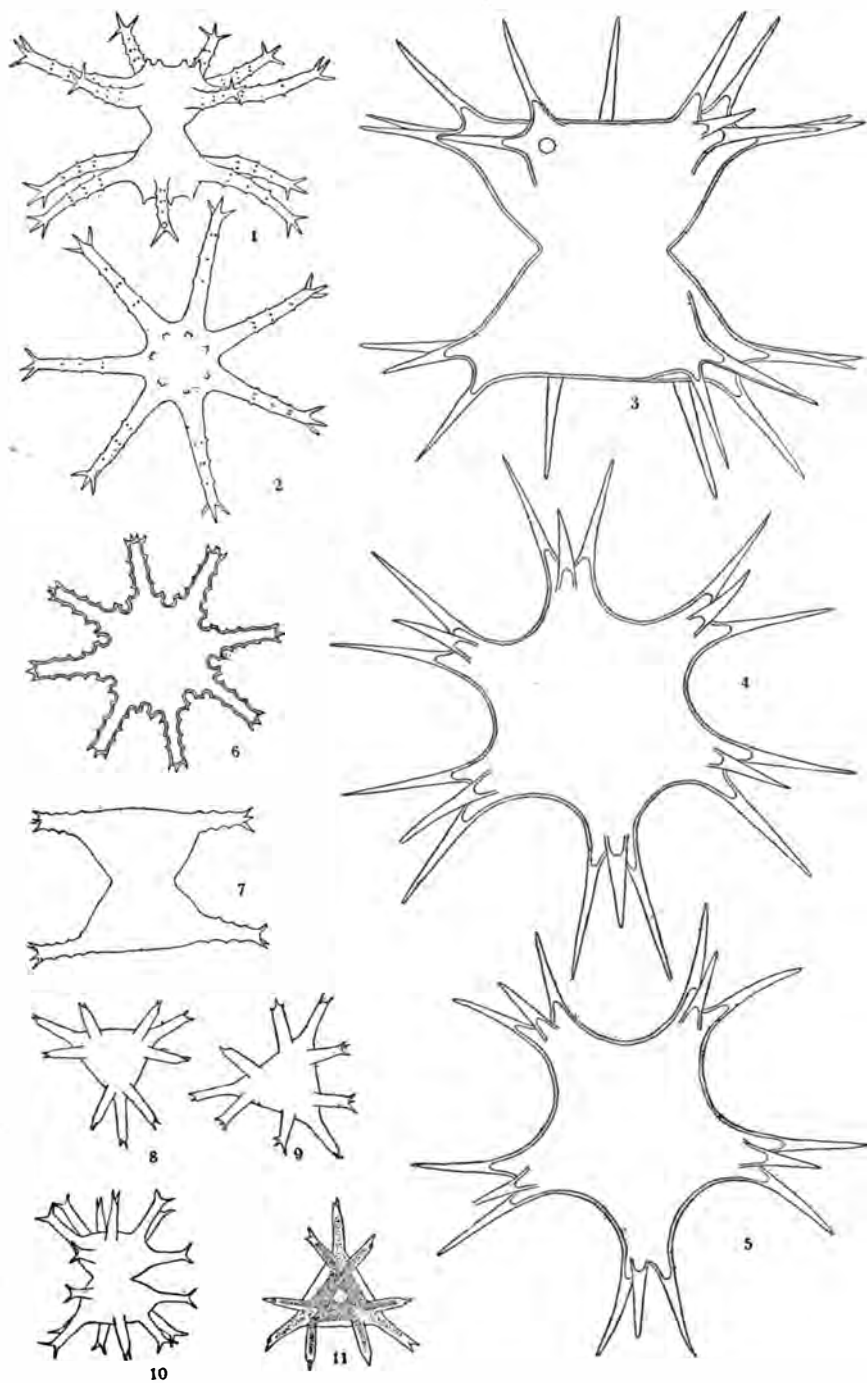


PLATE 83.

All figures $\times 500$.

	Page
Figs. 1-3. <i>Staurastrum furcatum</i> (Ehr.) De Bréb.....	118
Figs. 4-7. <i>Staurastrum furcigerum</i> De Bréb.....	122
Figs. 8-11. <i>Staurastrum furcigerum</i> var. <i>armigerum</i> forma <i>gracillimum</i>	123
Figs. 12-14. <i>Staurastrum leptacanthum</i> Nordst.....	123
Fig. 15. <i>Staurastrum Arctiscon</i> var. <i>glabrum</i> W. & G. S. West.....	125

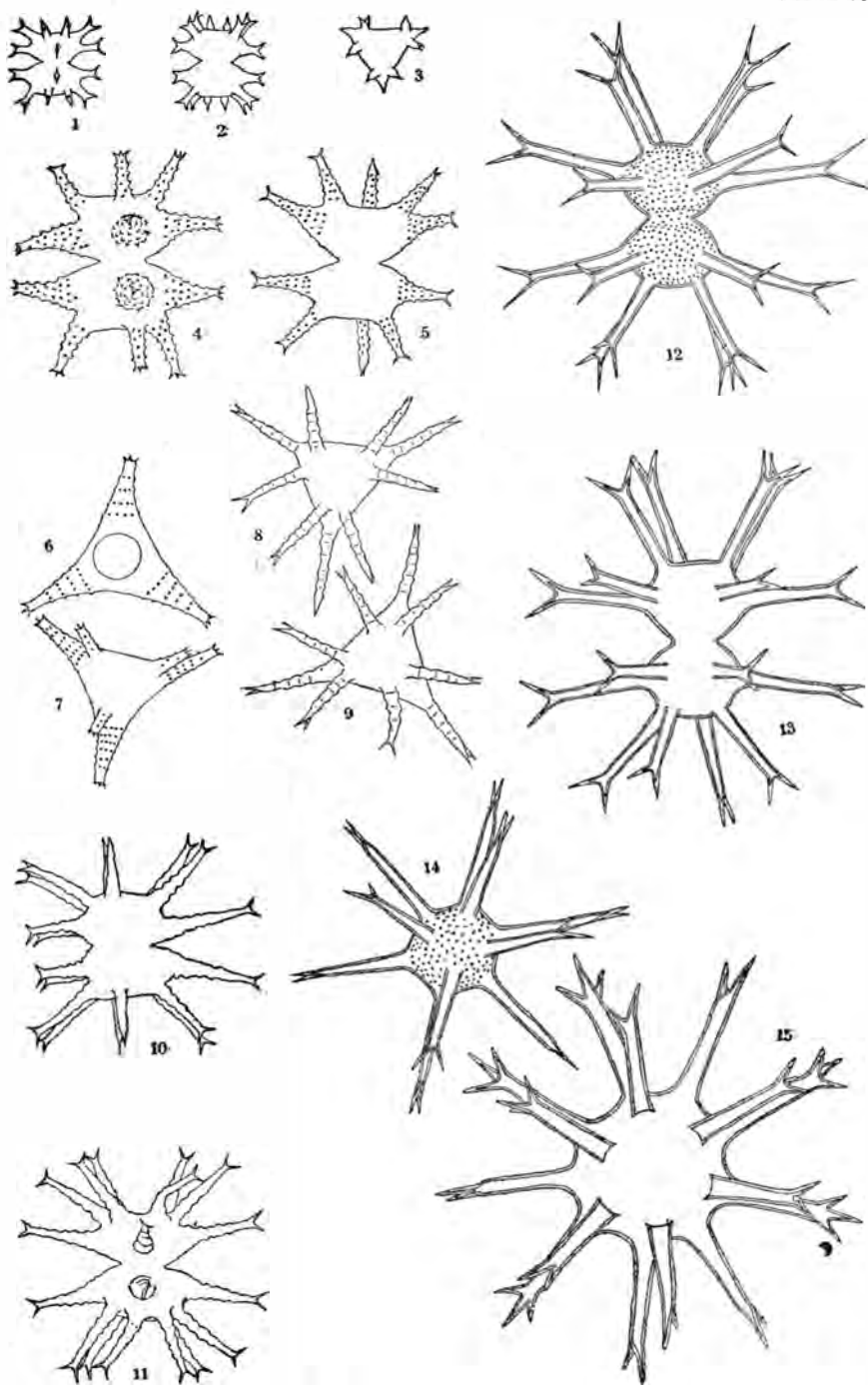


PLATE 84.

All figures $\times 500$.

	Page
Figs. 1-2. <i>Staurastrum Arctiscon</i> (Ehr.) Lund.....	124
Figs. 3-5. <i>Staurastrum Arctiscon</i> var. <i>glabrum</i> W. & G. S. West.....	125
Fig. 6. <i>Arthrodesmus convergens</i> Ehr.....	126
Figs. 7-8. <i>Arthrodesmus Bulnheimii</i> Racib.....	127
Figs. 9-10. <i>Arthrodesmus subulatus</i> Ktz.....	127

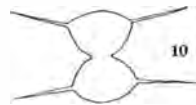
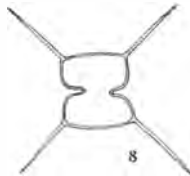
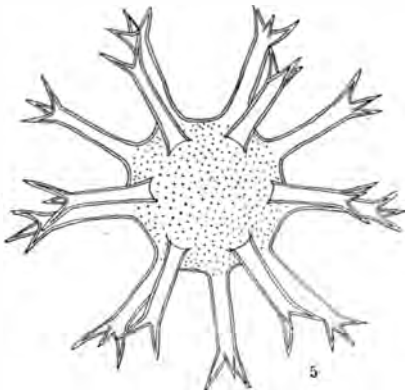
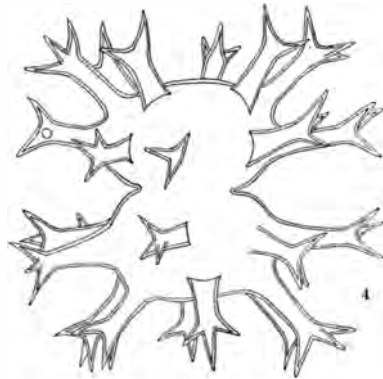
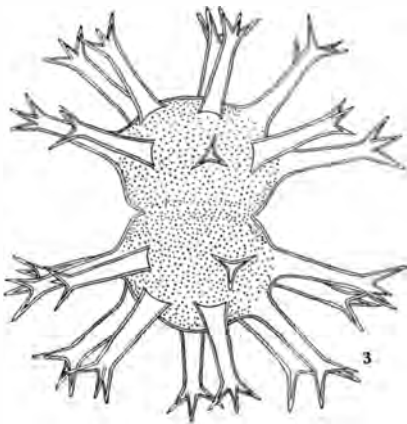
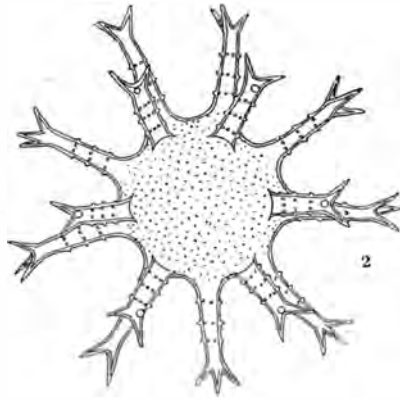
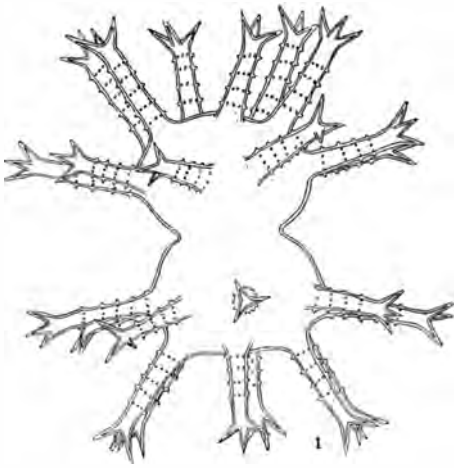


PLATE 85.

All figures $\times 600$.

	Page
Figs. 1-3. <i>Arthrodesmus subulatus</i> var. <i>Nordstedtii</i> var. nov.....	127
Fig. 4. <i>Arthrodesmus michiganensis</i> Johns.....	128
Fig. 5. <i>Arthrodesmus phimus</i> Turn.....	128
Figs. 6-8. <i>Arthrodesmus constrictus</i> G. M. Smith.....	129
Figs. 9-12. <i>Arthrodesmus Ralfsii</i> W. West.....	129
Figs. 13-17. <i>Arthrodesmus Ralfsii</i> var. <i>Brebissonii</i> (Racib.) comb. nov.....	130
Fig. 18. <i>Arthrodesmus quiriferus</i> W. & G. S. West.....	131
Figs. 19-22. <i>Arthrodesmus incus</i> (De Bréb.) Hass.....	131
Figs. 23-26. <i>Arthrodesmus incus</i> var. <i>extensus</i> Anders.....	132
Figs. 27-29. <i>Arthrodesmus incus</i> var. <i>praelongus</i> var. nov.....	132

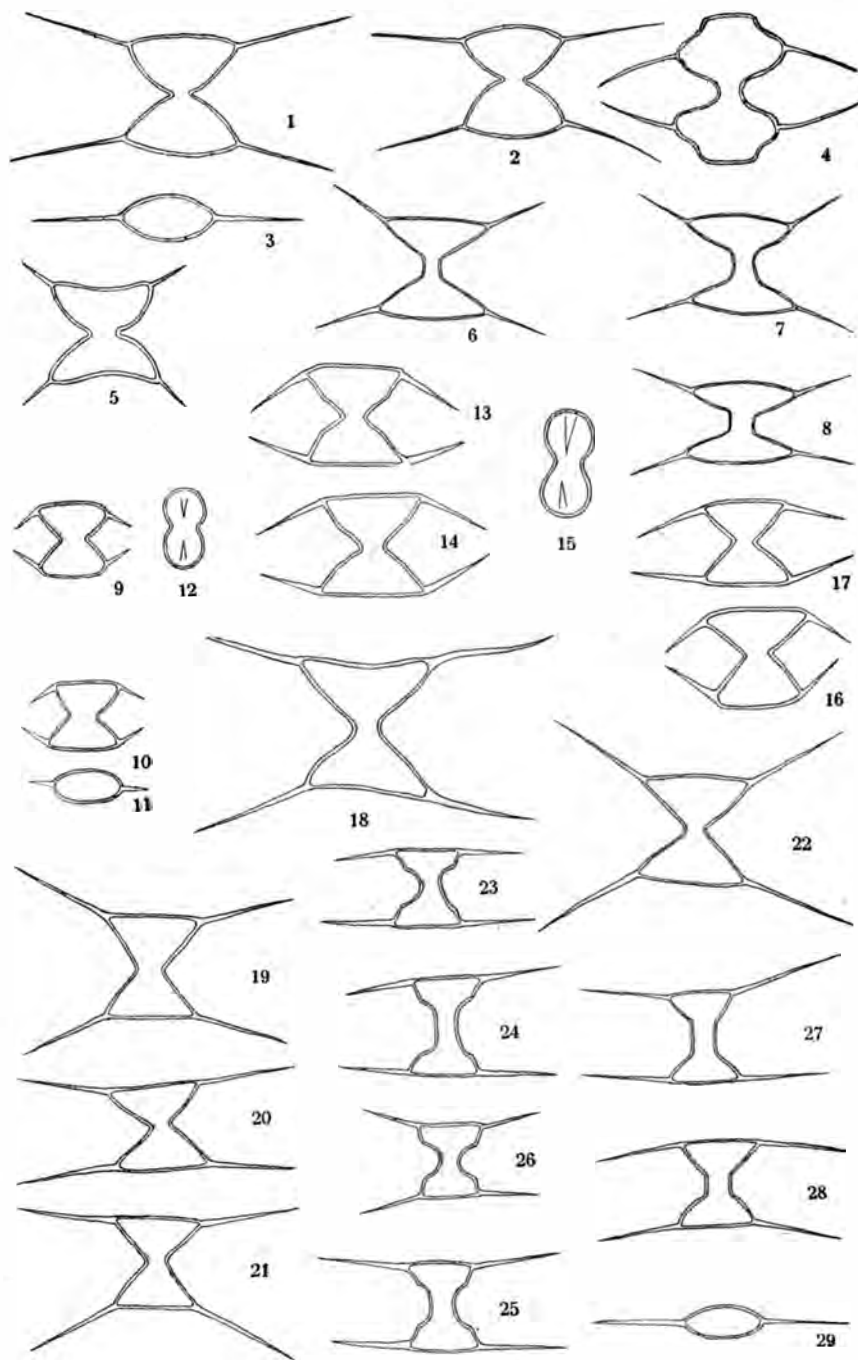


PLATE 86.

All figures $\times 600$.

	Page
Fig. 1. <i>Arthrodesmus triangularis</i> Lag.....	133
Figs. 2-4. <i>Arthrodesmus triangularis</i> var. <i>rotundatus</i> (Racib.) comb. nov.	133
Figs. 5-7. <i>Arthrodesmus triangularis</i> var. <i>subtriangularis</i> (Borge) W. & G. S. West.....	134
Figs. 8-12. <i>Arthrodesmus octocornis</i> Ehr.....	134
Figs. 13-14. <i>Onychonema filiforme</i> (Ehr.) Roy & Biss.....	135
Fig. 15. <i>Onychonema laeve</i> var. <i>latum</i> W. & G. S. West.....	136
Fig. 16. <i>Sphaerososma Aubertianum</i> var. <i>Archerii</i> (Gutw.) W. & G. S. West	137
Figs. 17-18. <i>Sphaerososma excavata</i> Ralfs.....	138
Figs. 19-20. <i>Sphaerososma excavatum</i> var. <i>Westii</i> var. nov.....	139
Fig. 21. <i>Sphaerososma exiguum</i> Turn.....	138
Fig. 22. <i>Spondylosium planum</i> (Wolle) W. & G. S. West.....	140

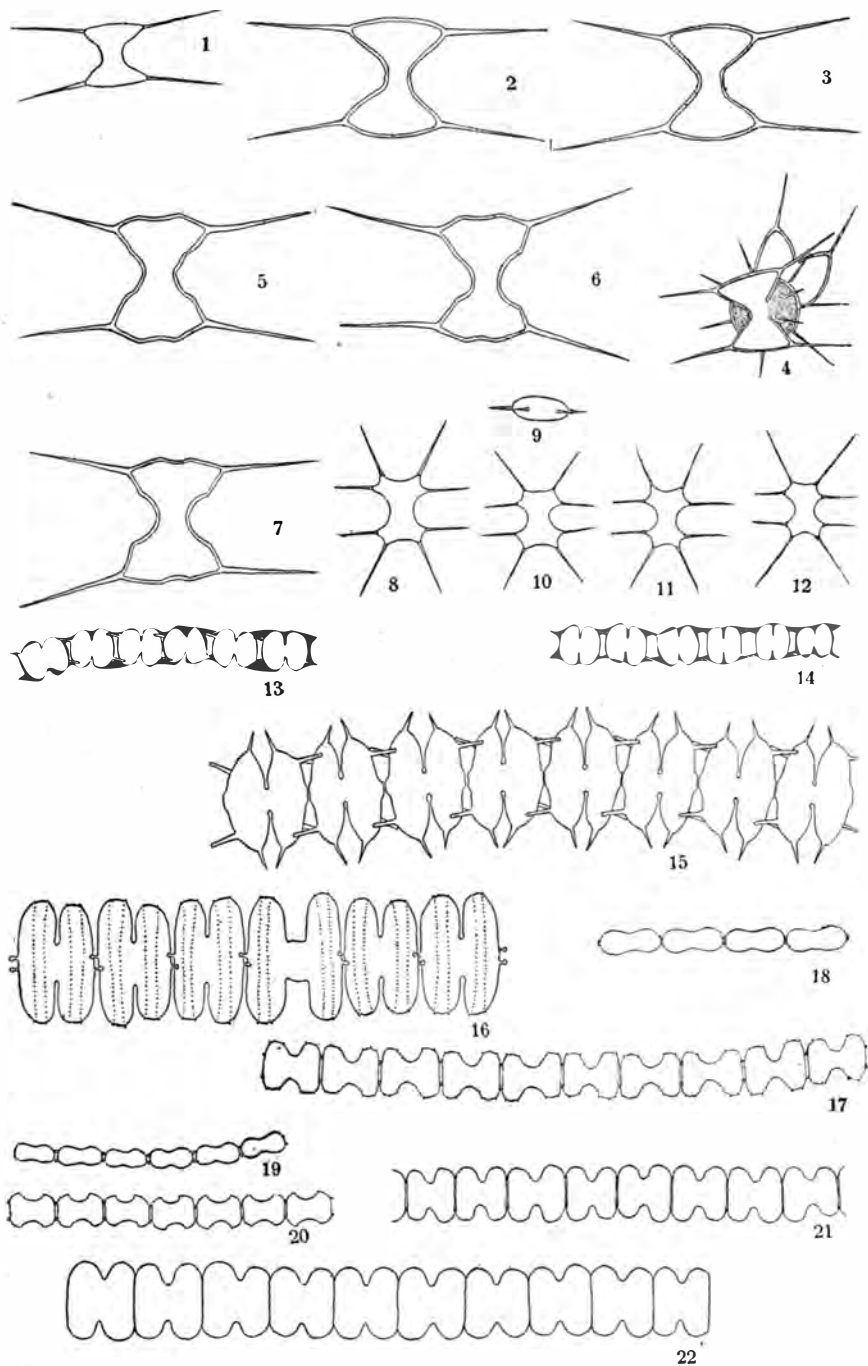


PLATE 87.

Figs. 1-2, 4-11, x 600; Fig. 3, x 300.

	Page
Figs. 1-2. <i>Spondylosium planum</i> (Wolle) W. & G. S. West.....	140
Figs. 3-4. <i>Spondylosium pulchrum</i> (Bail.) Arch.....	140
Figs. 5-7. <i>Spondylosium moniliforme</i> Lund.....	141
Figs. 8-9. <i>Hyalotheca dissiliens</i> (Smith) De Bréb.....	142
Fig. 10. <i>Hyalotheca mucosa</i> (Dillw.) Ehr.....	142
Fig. 11. <i>Gymnozyga moniliformis</i> Ehr.....	146

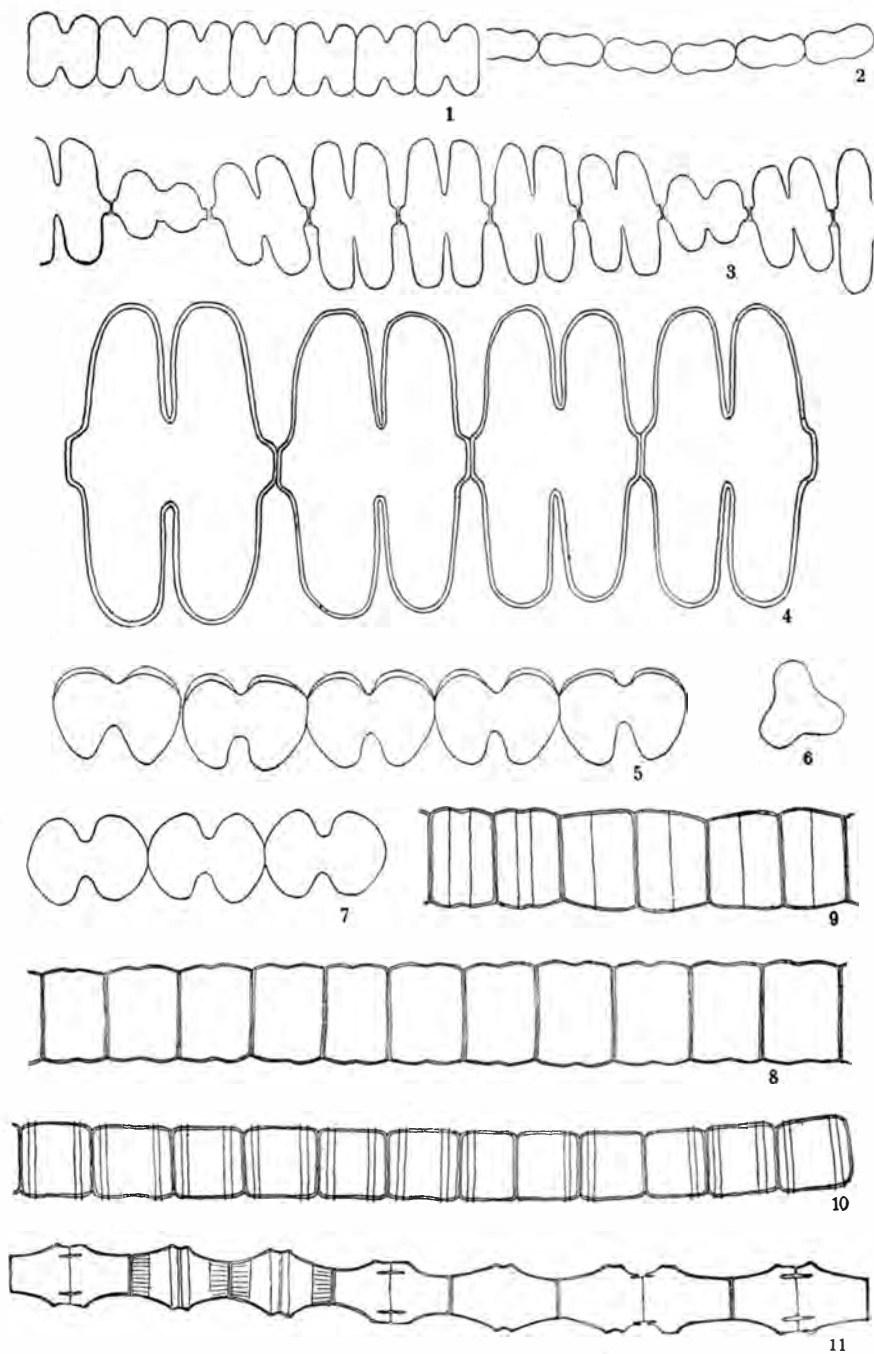
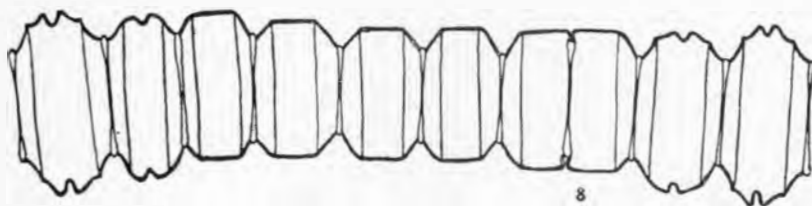
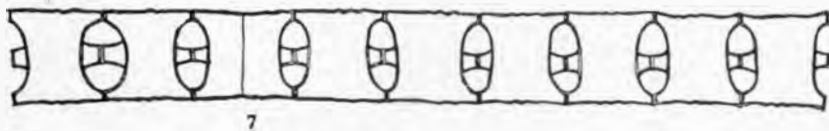
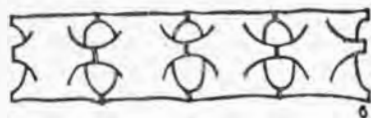
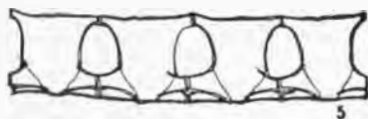
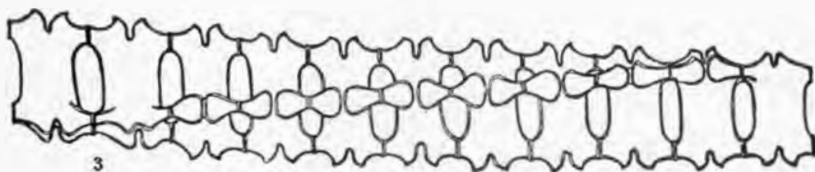
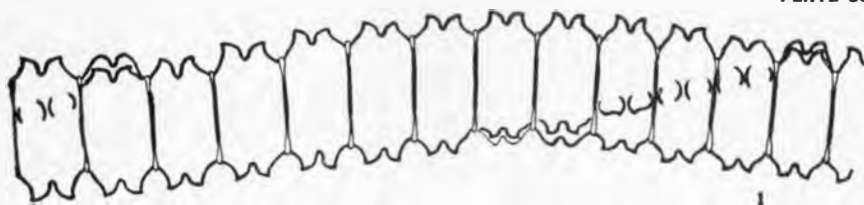


PLATE 88.

All figures $\times 600$.

	Page
Figs. 1-2. <i>Desmidium Swartzii</i> Ag.....	144
Figs. 3-4. <i>Desmidium Aptogonium</i> De Bréb.....	144
Figs. 5-7. <i>Desmidium Baileyi</i> (Ralfs) Nordst.....	145
Fig. 8. <i>Desmidium Grevillii</i> (Ktz.) De Bary.....	145



INDEX

APTOGONUM		GRACILE De Bréb. text fig. 1....	10
<i>Baileyi</i> Ralfs.....	145	v. ELONGATUM W. & G. S. West	
<i>Desmadium</i> (Ehr.) Ralfs.....	144	pl. 53, f. 2.....	11
ARTHRODESMUS Ehr.....	125-135	KUETZINGII De Bréb. pl. 53, f. 6	12
BULNHEIMII Racib. pl. 84, f. 7-8	127	MONILIFERUM (Bory) Ehr.	
CONSTRICUTUS G. M. Smith		pl. 52, f. 10.....	9
pl. 85, f. 6-8.....	129	RALFSII De Bréb. text fig. 2.....	11
CONVERGENS Ehr. pl. 84, f. 6...	126	v. HYBRIDUM Rab. pl. 53, f. 5	12
INCUS (De Bréb.) Hass.		SUBTRUNCATUM W. & G. S. West	
pl. 85, f. 23-26.....	132	pl. 52, f. 8.....	9
v. <i>Beta</i> Ralfs.....	129	VENUS Ktz. pl. 52, f. 9.....	9
v. <i>Breissonii</i> Racib.....	130	COSMARIUM Corda.....	28-37
v. EXTENSUS Anderss.		ABBREVIATUM v. PLANCTONI-	
pl. 85, f. 23-26.....	132	CUM W. & G. S. West.....	30
v. PRÆLONGUS G. M. Smith		AMOENUM De Bréb.....	32
pl. 85, f. 27-29.....	132	v. MEDIOLAEVE Nordst.	
v. <i>Ralfsii</i> (W. West) W. & G. S.		pl. 57, f. 21.....	32
West.....	129	BIOCULATUM De Bréb.	
f. <i>latiuscula</i> W. & G. S. West.....	129	pl. 57, f. 7-8.....	30
v. <i>rotundatus</i> Racib.....	133	BOTRYTIS (Bory) Menegh.	
v. <i>subtriangularis</i> Borge.....	134	pl. 57, f. 22.....	33
v. <i>vulgaris</i> Eich. & Racib.....	132	CIRCULARE Reinsch pl. 57, f. 3..	29
MICHIGANENSIS Johnson		COMMISSURALE De Bréb.	
pl. 85, f. 4.....	128	text fig. 3.....	34
OCTOCORNIS Ehr. pl. 86, f. 8-12.	134	v. CRASSUM Nordst. pl. 57, f. 26	35
PHIMUS Turn. pl. 85, f. 5.....	128	CONTRACTUM Kirchn.	
QUIRIFERUS W. & G. S. West		pl. 57, f. 9-11.....	30
pl. 85, f. 18.....	131	v. PAPILLATUM W. & G. S.	
f. COMPACTA W. & G. S. West.....	131	West pl. 57, f. 12-13.....	31
RALFSII W. West text fig. 17;		f. MINOR G. M. Smith	
pl. 85, f. 9-12.....	129	pl. 57, f. 14-17.....	31
v. BREISSONII (Racib.) G. M.		CYCLICUM Lund.....	31
Smith pl. 85, f. 13-17.....	130	v. NORDSTEDTIANUM (Reinsch)	
SUBULATUS Ktz. pl. 84, f. 9-10.	127	W. & G. S. West pl. 57, f. 19-20	32
f. <i>major</i> Nordst.....	128	DEPRESSUM (Näg.) Lund.	
v. NORDSTEDTII G. M. Smith		pl. 57, f. 4.....	29
pl. 85, f. 1-3.....	127	v. ACHONDRUM (Boldt) W. &	
TENUISSIMUS Arch.....	125	G. S. West pl. 57, f. 5-6.....	30
TRIANGULARIS Lag. pl. 86, f. 1.	133	GRANATUM De Bréb. pl. 57, f. 18	31
<i>forma</i> W. West.....	133	<i>margaritifera</i> v. <i>reniformis</i> Ralfs	33
v. <i>inflatus</i> W. & G. S. West.....	133	<i>Nordstedtianum</i> Reinsch.....	32
v. ROTUNDATUS (Racib.) G. M.		<i>orbiculatum</i> De Bary.....	33
Smith pl. 86, f. 2-4.....	133	ORNATUM Ralfs. pl. 57, f. 25....	34
v. SUBTRIANGULARIS (Borge)		OVALE Ralfs. pl. 58, f. 1.....	37
W. & G. S. West pl. 86, f. 5-7	134	PORTIANUM Arch. pl. 57, f. 24..	33
CLOSTERIUM Nitzsch.....	8-13	PROTRACTUM (Näg.) De Bary	
ACEROSUM (Schränk) Ehr.		pl. 57, f. 27.....	35
pl. 53, f. 1.....	10	PUNCTULATUM De Bréb.....	36
ACICULARE T. West.....	11	v. SUBPUNCTULATUM	
v. SUBPRONUM W. & G. S. West		(Nordst.) Börges. pl. 57, f. 29	37
pl. 53, f. 3.....	11	QUINARIUM Lund. pl. 57, f. 23.	36
ACUTUM (Lyng.) De Bréb.		RENIFORME (Ralfs) Arch.	
pl. 53, f. 4.....	11	pl. 57, f. 23.....	33
DECORUM De Bréb. pl. 53, f. 7.	13	<i>Scenedesmus</i> Delp.....	29

- COSMOCLADIUM** De Bréb.....37-40
CONSTRICUTUM (Arch.) Josh.... 39
HITCHCOCKII (Wolle)
 G. M. Smith pl. 58, f. 3-9..... 38
SAXONICUM De Bary pl. 58, f. 2 38
DESMIDIACEAE 3
DESMIDIUM C. A. Ag.....143-146
APTOGONUM De Bréb.
 pl. 88, f. 3-4.....144
BAILEYI (Ralfs) Nordst. pl. 88
 f. 5-7.....145
cylindricum Greville.....145
GREVILLEI (Ktz.) De Bary
 pl. 88, f. 8.....145
SWARTZII C. A. Ag. pl. 88, f. 1-2 144
Dictyocystis Hitchcockii (Wolle) Lag. 39
Dictyosphaerium Hitchcockii Wolle.. 38
Didymocladon furcigerus (De Bréb)
 Ralfs122
Didymoprium Grevillii Ktz.....145
DOCIDIUM De Bréb.....17-18
minutum Ralfs..... 8
subcoronulatum Turn..... 14
UNDULATUM Bail. pl. 55, f. 4... 18
verticillatum Bail..... 19
EUASTRUM Ehr.....21-27
AFFINE Ralfs pl. 56, f. 4..... 23
CRASSUM (De Bréb.) Ktz.
 pl. 56, f. 1..... 22
DIDELTA (Turp.) Ralfs.
 pl. 56, f. 8..... 25
DIVARICATUM Lund. pl. 56, f. 9 26
ELEGANS (De Bréb.) Ktz.
 pl. 56, f. 8..... 25
GEMMATUM De Bréb.
 pl. 57, f. 1-2..... 26
GLAZIOVII Berg. pl. 56, f. 6 24
OBLONGUM (Grev.) Ralfs
 pl. 56, f. 3..... 23
PINNATUM Ralfs pl. 56, f. 5.... 24
PULCHELLUM De Bréb.
 pl. 56, f. 7..... 25
Sol Ehr..... 46
VERRUCOSUM Ehr..... 27
 v. **REDUCTUM** Nordst.
 pl. 56, f. 10..... 27
GONATOZYGON De Bary.....4-5
ACULEATUM Hast. pl. 52, f. 3... 5
MONOTAENIUM De Bary
 pl. 52, f. 1..... 5
PILOSUM Wolle pl. 52, f. 2..... 5
Ralfsii De Bary..... 5
GYMNOZYGA Ehr.....146-147
MONILIFORMIS Ehr. pl. 87, f. 11 146
HYALOTHECA Ehr.....141-143
DISSILIENS (Smith) De Bréb.
 pl. 87, f. 8-9.....142
MUCOSA (Dillw.) Ehr.
 pl. 87, f. 10.....142
MICRASTERIAS C. A. Ag.....40-55
AMERICANA (Ehr.) Ralfs.
 pl. 63, f. 5; pl. 64, f. 2..... 52
APICULATA (Ehr.) Menegh.
 pl. 61, f. 1..... 47
 v. **FIMBRIATA** (Ralfs) Nordst.
 pl. 62, f. 1..... 48
 f. **SPINOSA** (Biss.) W. & G.
 S. West pl. 61, f. 2..... 48
CONFERTA Lund. text fig. 4..... 43
 v. **HAMATA** Wolle pl. 59, f. 6-7 44
DENTICULATA De Bréb.
 pl. 59, f. 5..... 45
DEPAUPERATA Nordst..... 42
 v. **KITCHELII** (Wolle) W. & G.
 S. West pl. 59, f. 4..... 42
fimbriata Ralfs..... 48
FOLIACEA Bailey pl. 65, f. 1-2.. 54
furcata Ralfs..... 50
 v. **simplex** Wolle..... 51
Kitchellii Wolle 43
LATICEPS Nordst. pl. 59, f. 3... 41
MAHABULESHWARENSIS Hobs. 53
morsa Ralfs..... 52
MURICATA (Bail.) Ralfs.
 pl. 64, f. 4-5..... 54
NORDSTEDTIANA Wolle
 pl. 64, f. 3..... 53
OSCITANS Ralfs..... 42
PAPILLIFERA De Bréb..... 44
PINNATIFIDA (Ktz.) Ralfs.
 pl. 59, f. 1-2..... 41
RADIATA Hass. pl. 63, f. 1-3... 50
 v. **GRACILLIMUM** G. M. Smith
 pl. 64, f. 1..... 52
 v. **SIMPLEX** (Wolle) G. M.
 Smith pl. 63, f. 4..... 51
Radiosa (Lyng.) Ag..... 46
RADIOSEA Ralfs text fig. 5..... 45
 v. **ORNATA** Nordst. pl. 60, f. 3. 47
 f. **ELEGANTIOR** G. S. West
 pl. 60, f. 4..... 47
sol (Ehr.) Ktz..... 45
 v. *ornata* Nordst..... 47
THOMASIANA Arch. pl. 60, f. 5.. 48
TORREYI Bail. pl. 62, f. 2..... 49
TRUNCATA (Corda) De Bréb.
 pl. 60, f. 1-2..... 43
NETRIUM Näg.....6-7
DIGITUS (Ehr.) Itz. & Rothe
 pl. 52, f. 5..... 6
ONYCHONEMA Wall.....135-136
FILIFORME (Ehr.) Roy & Biss.
 pl. 86, f. 13-14.....135
LAEVE Nordst.....136
 v. **LATUM** W. & G. S. West
 pl. 86, f. 15.....136
 v. **MICRACANTHUM** Norst....136
PENIUM De Bréb.....7-8
MARGARITACEUM (Ehr.)
 De Bréb. pl. 52, f. 6..... 7
MINUTUM (Ralfs) Cleve
 pl. 52, f. 7..... 8
 v. **GRACILE** Wille..... 8
Phycstrum denticulatum Näg..... 70
PLEUROTAEINIUM Näg.....13-17
EHRENBERGII (De Bréb.)
 De Bary pl. 54, f. 5-8..... 15

v. ELONGATUM W. West	
pl. 54, f. 10.....	16
v. UNDULATUM Schaarschm.	
pl. 54, f. 9.....	15
NODOSUM (Bail.) Lund.	
pl. 54, f. 11.....	16
SUBCORONULATUM (Turn.)	
W. & G. S. West.....	14
v. DETUM W. & G. S. West	
pl. 54, f. 2-4.....	14
TRABECULA (Ehr.) Näg.....	14
v. RECTUM (Delp.) W. & G. S.	
West pl. 54, f. 1.....	14
TROCHISCUM W. & G. S. West..	17
v. TUBERCULATUM G. M. Smith	
pl. 55, f. 3.....	17
TRUNCATUM (De Bréb.) Näg.	
pl. 55, f. 1-2.....	16
SPHAEROZOSMA Corda.....	136-139
Archeri Gutw.....	137
AUBERTIANUM W. West.....	137
v. ARCHERII (Gutw.) W. &	
G. S. West pl. 86, f. 16.....	137
EXIGUUM Turn. pl. 86, f. 21.....	138
EXCAVATA Ralfs pl. 86, f. 17-18..	138
var. W. & G. S. West.....	139
v. WESTII G. M. Smith	
pl. 86, f. 19-20.....	139
pulchrum Bail.....	140
v. inflatum Wolle.....	140
SPIROTAENIA De Bréb.....	5-6
CONDENSATA De Bréb.	
pl. 52, f. 4.....	6
SPONDYLIOSIUM De Bréb.....	139-141
MONILIFORME Lund.	
pl. 87, f. 5-7.....	141
PLANUM (Wolle) W. & G. S. West	
pl. 86, f. 22; pl. 87, f. 1-2.....	140
PULCHRUM (Bail.) Arch.	
pl. 87, f. 3-4.....	140
v. BRASILIENSE Nordst.....	141
STAUROSTRUM Meyen.....	62-125
ALTERNANS De Bréb. pl. 68, f. 4	70
AMERICANUM (W. & G. S. West)	
G. M. Smith pl. 77, f. 2.....	100
ANATINUM Cooke & Wills.....	94
v. CURTUM G. M. Smith	
pl. 75, f. 21-25.....	95
v. DENTICULATUM G. M. Smith	
pl. 75, f. 21-25.....	95
v. LONGIBRACHIATUM W. &	
G. S. West pl. 75, f. 11-16.....	94
v. PELAGICUM W. & G. S. West	95
ANCHORA W. & G. S. West	
pl. 77, f. 8-9.....	101
ANKYROIDES Wolle text fig. 14..	113
v. PENTACLADUM G. M. Smith	
pl. 81, f. 1-2.....	114
ARACHNE Ralfs text fig. 13.....	111
v. CURVATUM W. & G. S. West	
pl. 80, f. 11-14.....	112

ARCTISCON (Ehr.) Lund.	
pl. 84, f. 1-2.....	124
v. GLABRUM W. & G. S. West	
pl. 83, f. 15; pl. 84, f. 3-5.....	125
ARISTIFERUM Ralfs text fig. 8..	72
v. INDENTATUM G. M. Smith	
pl. 68, f. 14-17.....	72
armigerum De Bréb.....	123
ASPINOSUM v. VERRUCOSUM	
G. M. Smith.....	95
AVICULA De Bréb. pl. 68, f. 8-10	71
BRACHIATUM Ralfs pl. 72, f. 1-4	82
BRASILIENSE Nordst.....	119
v. LUNDELLI W. & G. S. West	
pl. 82, f. 3-5.....	120
BREVIACULEATUM G. M. Smith	
pl. 70, f. 10-18.....	78
BREVISPINUM De Bréb.	
text fig. 7.....	68
Forma Boldt.....	68
v. ALATUM W. & G. S. West..	68
v. BOLDTII Lag. pl. 67, f. 16-17	68
f. retusum (Borge) W. & G. S.	
West	69
v. RETUSUM Borge	
pl. 67, f. 18-19.....	69
v. TUMIDUM G. M. Smith	
pl. 67, f. 20-25.....	69
brasiliense Lund.....	120
BULLARDII G. M. Smith	
pl. 74, f. 19-23; pl. 75, f. 1-3...	91
CERASTES Lund. pl. 80, f. 8-10..	110
CHAETOCERAS (Schröder) G. M.	
Smith pl. 76, f. 21-24, pl. 77, f. 1	99
CINGULUM (W. & G. S. West) G.	
M. Smith pl. 72, f. 12-14.....	84
CONNATUM (Lund.) Roy & Biss.	77
v. RECTANGULUM Roy & Biss.	
pl. 70, f. 6-7.....	77
CONTORTUM G. M. Smith	
pl. 76, f. 17-20.....	98
CURVATUM W. West pl. 69, f. 4-9	73
v. ELONGATUM pl. 69, f. 10-15	73
CUSPIDATUM De Bréb.	
pl. 68, f. 27-34.....	74
v. CANADENSE G. M. Smith	
pl. 69, f. 1-3.....	75
v. DIVERGENS Nordst.....	77
CYRTOCERUM De Bréb.....	111
DEJECTUM De Bréb.	
pl. 68, f. 18-24.....	73
v. connatum Lund.....	77
v. INFLATUM W. West	
pl. 68, f. 25-26.....	74
DENTICULATUM (Näg.) Arch.	
pl. 68, f. 5-7.....	70
DICKIEI Ralfs.....	76
v. MAXIMUM W. & G. S. West	
pl. 70, f. 3-5.....	76
DIGITATUM G. S. West.....	109
eustephanum Ehr.....	123

- EXCAVATUM W. & G. S. West.. 99
 FLORIFERUM W. & G. S. West
 pl. 74, f. 12-18..... 91
 FURCATUM (Ehr.) De Bréb. pl.
 83, f. 1-3.....118
 FURCIGERUM De Bréb.
 pl. 83, f. 4-7.....122
 v. ARMIGERUM (De Bréb.)
 Nordst.123
 f. GRACILLIMUM G. M.
 Smith pl. 83, f. 8-11.....123
 v. EUSTEPHANUM (Ehr.)
 Nordst.123
 GRACILE Ralfs text fig. 9; pl. 73,
 f. 16-18..... 88
 v. *bulbosum* G. M. Smith..... 90
 CYATHIFORME W. & G. S.
 West 90
 GRALLATORIUM Nordst.
 pl. 77, f. 3-5.....100
 v. *americanum* W. & G. S. West.100
 v. FORCIPIGERUM Lag.
 pl. 77, f. 6-7.....100
 GRANDE Bulnh. pl. 67, f. 8-9.... 66
 v. PARVUM W. West..... 67
 INCONSPICUUM Nordst.....109
 v. GRACILIOR Mask.....109
 v. PLANCTONICUM G. M. Smith
 pl. 80, f. 5-7.....109
 JOHNSONII W. & G. S. West
 pl. 79 f. 1-5.....104
 f. PARVUM G. M. Smith
 pl. 79, f. 6.....105
 v. DEPAUPERATUM G. M. Smith
 pl. 79, f. 7-11.....105
 LACUSTRE G. M. Smith
 pl. 76, f. 1-8..... 97
 LEPTACANTHUM Nordst.
 pl. 83, f. 12-14.....123
leptocladum Johnson.....104
 LEPTOCLADUM Nordst.
 pl. 78, f. 1-7.....102
 v. *cornutum* Wille.....102
 v. DENTICULATUM
 G. M. Smith pl. 77, f. 10-14..103
 v. *divergens* G. M. Smith.....105
 v. INSIGNE W. & G. S. West
 pl. 77, f. 15; pl. 78, f. 8-11..103
 v. SINUATUM Wolle
 pl. 78, f. 12-14.....104
 f. PLANUM G. M. Smith
 pl. 78, f. 15.....104
 LIMNETICUM Schmidle
 text fig. 15.....116
 v. *burmense* G. M. Smith.....117
 v. BURMENSE W. & G. S. West.118
 v. CORNUTUM G. M. Smith
 pl. 82, f. 1-2.....117
 LONGIRADIATUM W. & G. S.
 West pl. 74, f. 5-11..... 90
 v. *major* W. & G. S. West..... 91
 LUNATUM Ralfs..... 71
 v. PLANCTONICUM W. & G. S.
 West pl. 68, f. 11-13..... 71
 MEGACANTHUM Lund.
 pl. 69, f. 16-21..... 75
forma Borge..... 76
 v. SCOTICUM W. & G. S. West
 pl. 69, f. 22-24; pl. 70, f. 1-2. 76
 MINNEAPOLIENSE Wolle.....107
 MINNESOTENSE Wolle
 pl. 71, f. 14-15..... 81
 MUTICUM De Bréb.
 pl. 67, f. 13-15..... 67
 NATATOR W. West text fig. 12;
 pl. 79, f. 12.....106
 v. CRASSUM W. & G. S. West
 pl. 79, f. 13-15.....107
 OPHURA Lund. pl. 81, f. 3-4.....115
 v. *pentacerum* Wolle.....112
 v. *tetracerum* Wolle.....113
 PACHYRHYNCHUM Nordst..... 69
 PARADOXUM Meyen
 pl. 72, f. 15-22; pl. 73, f. 1-2. 85
 v. *Chaetoceras* Schröd..... 99
 v. *cingulum* W. & G. S. West.... 84
 v. LONGIPES Nordst.
 pl. 73, f. 3-6..... 86
 f. *permagna* W. & G. S. West.. 87
 v. PARVUM W. West
 pl. 73, f. 7-15..... 87
 PELAGICUM W. & G. S. West... 84
 PENTACERUM (Wolle)
 G. M. Smith pl. 80, f. 15-18...112
 v. TETRACERUM (Wolle)
 G. M. Smith pl. 80, f. 19-21..113
polymorphum v. *Chaetoceras* Schröd. 99
 PROTECTUM W. & G. S. West... 87
 v. PLANCTONICUM G. M. Smith
 pl. 74, f. 1-4..... 87
pseudofurcigerum Reinsch.....123
 PSEUDOPACHYRHYNCHUM
 Wolle pl. 68, f. 1-3..... 69
 PSEUDOPELAGICUM W. & G. S.
 West pl. 72, f. 5-7..... 83
 v. TUMIDUM G. M. Smith
 pl. 72, f. 8-11..... 84
 QUADRANGULARE De Bréb.
 pl. 70, f. 8-9..... 78
 RADIANS W. & G. S. West
 pl. 82, f. 6-7.....118
 ROTULA Nordst. pl. 81, f. 5-8...116
saltans v. *forcipigerum* Lag.....101
 SENARIUM (Ehr.) Ralfs.....119
 SETIGERUM Cleve pl. 70, f. 19-25 79
 v. BREVISPINUM G. M. Smith
 pl. 71, f. 9-13..... 80
 v. OCCIDENTALE W. & G. S.
 West pl. 71, f. 1-4..... 80
 v. PECTINATUM W. & G. S.
 West pl. 71, f. 5-8..... 80
 SPICULIFERUM G. M. Smith
 pl. 71, f. 16-20..... 82
spinousum De Bréb.....119
 SUBGRANDE Borge..... 67
 v. MINOR G. M. Smith
 pl. 67, f. 10-12..... 67

- SUBNUDIBRACHIATUM** W. & G.
 S. West.....108
 v. **INCISUM** G. M. Smith
 pl. 80, f. 1-4.....108
TETRACERUM (Ktz.) Ralfs
 text fig. 11..... 96
 v. **EVOLUTUM** W. & G. S. West
 pl. 76, f. 11-14..... 97
 v. **TRIGONUM** Lund.
 pl. 76, f. 15-16..... 97
 v. **VALIDUM** W. & G. S. West
 pl. 76, f. 9-10..... 96
TOHOPEKALIGENSE Wolle
 text fig. 16.....120
 v. **BREVISPINUM** G. M. Smith
 pl. 82, f. 8-11.....121
 v. **NONANUM** (Turn.) Schmidle 121
 v. *quadrangulare* W. & G. S. West 121
 v. *trifurcatum* W. & G. S. West..121
URINATOR G. M. Smith
 pl. 79, f. 16-18.....107
VESTITUM Ralfs. text fig. 10;
 pl. 75, f. 4-5..... 92
 v. **SUBANATINUM** W. & G. S.
 West pl. 75, f. 6-10..... 93
TETMEMORUS Ralfs..... 20
BREISSONII (Menegh.) Ralfs
 pl. 55, f. 10..... 20
TRIPLOCEBAS Bail.....18-20
GRACILE Bail. pl. 55, f. 5-8.... 19
VERTICILLATUM Bail.
 pl. 55, f. 7-9..... 19
XANTHIDIUM Ehr.....55-62
- ANTILOPAEUM** (De Bréb.) Ktz.
 pl. 65, f. 5-6..... 57
 v. **DEPAUPERATUM** W. & G. S.
 West pl. 66, f. 1..... 59
 v. *javanicum* Johnson..... 61
 v. **MINNEAPOLIENSE** Wolle
 pl. 65, f. 10-11..... 58
 v. **POLYMAZUM** Nordst.
 pl. 65, f. 7-9..... 58
ARMATUM (De Bréb.) Rab.
 text fig. 6..... 56
 v. **CERVICORNE** W. & G. S.
 West 57
 v. *cervicorne* G. M. Smith 57
 v. **FISSUM** Nordst..... 57
 v. **MEDIOLAEVE** G. M. Smith
 pl. 65, f. 3-4..... 57
CRISTATUM De Bréb.
 pl. 66, f. 2-3..... 59
 v. **UNCINATUM** De Bréb.
 pl. 66, f. 4..... 60
furcatum Ehr.....118
HASTIFERUM Turn..... 61
 v. *Johnsonii* W. & G. S. West.... 61
octocorne (Ehr.) Ralfs.....134
SUBHASTIFERUM W. West
 pl. 66, f. 5-12..... 60
 v. **JOHNSONII** (W. & G. S.
 West) G. M. Smith pl. 66, f.
 4-7 61
 v. **TOWERI** (Cushm.) G. M. Smith
 pl. 66, f. 13-18; pl. 67, f. 1-3. 61