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UNIVERSITY OF IOWA STUDIES IN NATURAL HISTORY

Henry Frederick Wickham, Editor

VOLUME XII NUMBER 6

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CONTENTS

THE MOTILE ALGÆ OF IOWA

G. W. PRESCOTT

The motile algæ constitute a heterogeneous assemblage of micro-organisms, green or brown, rarely colorless. There are included here those plant-like forms which, in the normal vegetative condition, move about by means of definite locomotory organs, either flagella or cilia.

This report is based upon a three-year taxonomic study of Iowa algæ under the direction of Doctor R. B. Wylie, Professor of Botany, University of Iowa. It is offered with the thought that a unified treatment of these organisms may be of interest to the biologists of the region.

Many of the species included in this paper have not been reported heretofore from Iowa, and several are reported from North America apparently for the first time. Two varieties in the genus *Trachelomonas* are described as new to science. G. M. Smith (17) lists nine species from the Okoboji Region in Dickinson County, Iowa; Buchanan (2), Edmondson (7), Bessey (1), Wilson (19), and Fink (8) in their papers record a number of forms, many of which are also included in the report by G. M. Smith (17). The notes of these workers have been incorporated with my own so that the present paper represents a summary of our knowledge of these forms in Iowa from a taxonomic viewpoint. It is hoped that this report will stimulate interest in the motile algæ of the region, especially in the Volvocales and Dinoflagellatæ.

The taxonomic scheme employed here is adapted largely from the treatises of Smith (15), West and Fritsch (18), and Pascher and Lemmermann (12), the latter for the Flagellatæ especially. Colorless forms, closely related to the chlorophyll bearing flagellates are included here.

In taking up the several species, a citation to an authoritative description and figure has been given after each specific name. In the case of the forms which I have personally studied a brief description is included. For some of the species which I have not seen it has been thought best to give a synopsis of taxonomic characters adapted from authoritative descriptions. Where measurements are recorded the figures given in parentheses before or after the range of dimensions indicate a variation from the size usually reported for the species. Figures in parentheses within the range of dimensions indicate a size which appears to be the most common for this region. Following the descriptive remarks, collection and distribution data will be found. The names of the collectors are given in parentheses after the name of the county from which the species has been reported. The papers of the workers which give collection data for Iowa algæ are listed in the accompanying bibliography. Abbreviations of the collectors' names are as follows:

Bessey	(Bes)	Fink	(F)
Buchanan	(Buch)	Prescott	(P)
Edmondson	(E)	Smith	(S)
Wilson	(W)		

Class CHRYSOPHYCEÆ

Order I. HYMENOMONADALES

Family **Euhymenomonadaceæ**

SYNURA Ehrenberg, 1838

Cells broadly pyriform, radiately arranged in globose or oblong-ovoid, swimming colonies, with the narrower part of the cell directed toward the center of the colony; gelatinous envelope wanting; the outer and broader part of the cell firm and furnished with short, spine-like projections, or reticulations (sometimes both); two cilia of equal length, arising from the anterior end; chromatophores two, parietal, often very dense; eye-spot lacking.

1. *Synura uvella* Ehrenberg

Pascher, in Pascher and Lemmermann Flagellatæ, 2, 1913, p. 50, fig. 78a, c, d.

Anterior end of cells furnished with spines which may be extremely short and blunt or longer and pointed; diameter of cells 8-17μ; length 20-(30)35μ; diameter of colonies 100-200(250)μ. Plate I, fig. 1.

Plankton from sloughs and ponds, Johnson County, June. (P): Plankton from West Okoboji Lake, Dickinson County, July. (P).

This form often appears in great numbers in stagnant water during warm weather.

2. *Synura Adamsii* Smith

Roosevelt Wild Life Bull. 2, No. 2, 1924, p. 136. Pl. 5, figs. 4, 5.

Cells rather loosely arranged in spherical or subspherical colonies, elongate-pyriform or club-shaped, the inner end subacute, the apex rounded, bearing a few short, blunt, and scattered spines; chloroplasts 2, laminate; width of cells 6.5μ-10μ; length 42-47μ. Plate I, fig. 2.

Plankton in sloughs and ponds, Johnson County, April. (P). Previously reported from New York.

The colonies of this species readily break down when handled and in microscopical mounts the organisms frequently appear without any colonial organization.

Order 2. OCHROMONADALES

Family **Dinobryaceæ**

Dinobryon Ehrenberg, 1835

Cells solitary or in colonial aggregates, free-floating or attached, in the latter case the colonies may be sessile or furnished with a stipe; each cell inclosed within a more or less conical, campanulate or cylindrical, transparent receptacle; in colonial forms 1-4 receptacles with sharply pointed bases arising from the mouth of one receptacle, thus forming a diverging arbuscular aggregate; protoplast fusiform to ovoid, attached at the base of the receptacle by a stalk, with 2 cilia of unequal length at the anterior end; 1-2 chromatophores, laminate, parietal and golden-brown in color; cell content with several contractile vacuoles and a pigment-spot.

1. *Dinobryon calyciforme* Bachmann

Smith, 1920, p. 73, Pl. 13, figs. 5, 6. Pascher, 1913, p. 67, fig. 103.

Cells solitary, adhering to the colonial gelatin of such Myxophyceæ as *Microcystis*; both receptacle and protoplast elongate, the receptacle conical with a pointed base into which the protoplast closely shapes itself; 2 laminate, parietal chromatophores; cilia shorter than the length of the cell; receptacle 5-6μ(7μ) wide at the mouth; 30-(35μ)-40μ in length; cells about 25μ long. Plate I, fig. 3.

Appearing rarely in plankton collections from the shallow water of a marsh in which many colonial Myxophyceæ occur during late spring and fall. Johnson County. (P).

2. *Dinobryon divergens* Imhof

Smith, 1920, p. 75, Pl. 14, fig. 2; Pascher, 1913, p. 79, figs. 125-128.

Cells arranged in branching free-floating colonies; upper part of the receptacle cylindrical or with mouth expanded, bending at an angle of 45-90 degrees from the lower part of the receptacle which is conical, margins of the receptacle often undulate; width of receptacles at mouth 7-8μ; length 35-50μ. Plate I, fig. 4.

Plankton from West Okoboji Lake, Dickinson County, July. (P). Small artificial pond, Johnson County, June. (P).

3. *Dinobryon sertularia* Ehrenberg

Smith, 1920, p. 74, Pl. 13, fig. 13; Pl. 14, fig. 1; Pascher, 1913, p. 72, figs. 112, 114.

Colonies of cells free-floating and densely branched; receptacles rather broad with abruptly pointed bases, cylindrical in the anterior region, campanulate at the mouth; width of receptacles 10-14μ; length 30-(35)44μ. Plate I, fig. 6.

Plankton, Lake West Okoboji, Dickinson County, July. (P). Shallow marsh water, June. Clear Lake, Cerro Gordo County, July. (P).

4. *Dinobryon sociale* Ehrenberg

Smith, 1920, p. 74, Pl. 13, fig. 12; Pascher, 1913, p. 73, figs. 116, 117.

Colonies of cells free-floating, loosely branched but rather narrow and elongate in general outline; receptacles conical with slightly expanded mouths, bases sharply pointed; width of receptacles 7-8μ; length 30-(40)70μ. Plate I, fig. 5.

Plankton, Lake West Okoboji, Dickinson County, July. (P). Shallow marsh water, June. Clear Lake, Cerro Gordo County, July. (P).

5. *Dinobryon stipitatum* Stein

Smith, 1920, p. 74, Pl. 13, fig. 11; Pascher, 1913, p. 73, figs. 118-122.

Colonies of cells free-floating, rather narrow and elongate in outline; the cells closely arranged; receptacles, their bases extended to form stipes with subparallel sides; width of receptacles 6-8μ; length 56-96μ. Plate I, fig. 7.

Plankton from West Okoboji Lake, Dickinson County, July. (P). Clear Lake, Cerro Gordo County, July. (P).

Class CHLOROPHYCEÆ

Order 1. VOLVOCALES

Family **Volvocaceæ**

EUDORINA Ehrenberg, 1832

1. *Eudorina elegans* Ehrenberg

Smith, 1920, p. 96, Pl. 19, fig. 1; 1926, p. 166, Pl. 4, fig. 3; Buchanan, 1907, p. 79.

Colonies spherical, consisting of 16-32-64 cells rather loosely arranged at the periphery of a hyaline and gelatinous colonial envelope; cells spherical, sometimes with a beak-like anterior projection where 2 cilia of equal length arise: cilia diverging from one another only after emerging from the gelatinous envelope; one cup-like chloroplast which nearly fills the cell; pyrenoids several; cell content with one or two contractiles vacuoles and an eye-spot, all in the anterior region; diameter of cells 12-24μ; diameter of colonies 50-(100)-200μ. Plate II, fig. 2.

Plankton in open watering troughs, stagnant pools and ponds in warm weather. Johnson County. (P). Dickinson County. (S). Fayette County. (F).

GONIUM Mueller, 1773

Cells arranged in one layer to form a quadrangular, disc-shaped colony inclosed in a wide, hyaline, gelatinous envelope; cells globose or angular from mutual contact; 4-16 in a colony, biciliate, with the cilia all directed the same way; one chromatophore, containing a large pyrenoid; pigment spot present.

1. *Gonium pectorale* Mueller

Smith, 1920, p. 94, Pl. 16, figs. 14-15; Pascher, 1927, p. 418, figs. 376-379.

Colony composed of 16 cells, forming a somewhat rectangular flat plate, in which an outer series of 12 incloses an inner group of 4, quadrately disposed; cells 5-15μ in diameter; colonies 25-90μ wide. Plate I, fig. 9.

Plankton in small pools and ponds, often appearing with other members of the Volvocaceæ in such numbers as to give a vivid green color to small bodies of water.

Johnson County, July. (P). Story County. (Bes) (Buch).

2. *Gonium sociale* (Dujardin) Warming

Collins, 1909, p. 132; Pascher, 1927, p. 420, figs. 381, 382.

Colonies of four cells, cruciately placed within a narrow gelatinous sheath, so that a quadrangular open space is formed at the center of the group; cells oval, 9-20μ long; 5-14μ wide; colonies 20-48μ wide. Plate I, fig. 8.

Plankton in a two months old aquarium, Botany Laboratory, University of Iowa, April. (P).

PANDORINA Bory, 1824

1. *Pandorina morum* Bory

Smith, 1920, p. 95, Pl. 16, figs. 16-17; Pascher, 1927, p. 427, figs. 387-389.

Cells rather closely arranged to form a hollow, spherical or subspherical, free-swimming colony 4-8-16-32 individuals, surrounded by a wide gelatinous envelope; cells pyriform, angular from mutual contact, with the narrow end of the cell directed inwardly; cilia 2, parallel from the anterior end of the cell to the margin of the envelope, then widely diverging; 1 cup-shaped chromatophore containing a basal pyrenoid; pigment spot lateral in the anterior end; 2 contractile vacuoles just beneath the point of cilia attachment; cells 8-16μ in diameter; 16-celled colony 20-45μ wide.

Reproduction, by the repeated division of each cell in the colony, occurs frequently from May to August. All of the cells undergo division at about the same time. In this condition the individual cells, or daughter colonies, are widely separated in a gelatinous envelope of considerably greater diameter than that of a colony in the vegetative state.

Plankton in sloughs, pools, watering troughs, etc. Often appearing in dense numbers with other members of the Volvocaceæ. Plate II, fig. 3.

Johnson County, July. (P). Dickinson County. (S). Story County. (Bes) (Buch).

PLATYDORINA Kofoid, 1899

1. *Platydorina caudatum* Kofoid

Pascher, 1927, p. 433, fig. 393; Smith, 1926, p. 166, Pl. 4, figs. 4, 5.

Cells arranged in one layer to form a flattened, horseshoe-shaped colony, the cells pointing alternately at right angles from this plane; the colony twisted one-eighth of a turn from right to left, surrounded by a wide gelatinous envelope, the posterior part of which is extended into 3-5 cauda; cells spherical or oblate sphæroidal, 16-32 in a colony, the outer row made up of 10-12 cells, surrounding a central group of 6-20; width of cells 15-18μ; length 15-20μ. Plate II, fig. 9.

Plankton in lakes, Dickinson County, July. (P) (S).

PLEODORINA Shaw, 1894

Cells arranged to form globose, free-swimming colonies; the cells disposed in one layer at the periphery of the gelatinous common envelope, and of two kinds, smaller vegetative cells in the anterior region and larger reproductive cells in the posterior part; one large chromatophore in each cell, containing one to several pyrenoids; pigment spot in the anterior end.

1. *Pleodorina californica* Shaw

Pascher, 1927, p. 449, figs. 407-412; Smith, 1920, p. 97, Pl. 17, figs. 1-3; 1926, p. 166, Pl. 4, fig. 1.

Cells spherical, arranged 64-128 in spherical or subspherical colonies; about one-half of the cells being reproductive and one-half vegetative; diameter of vegetative cells 6-14μ; reproductive cells 6-34μ in diameter; colonies up to 300μ in diameter or even more, 400μ in some cases. Plate II, fig. 4.

Ponds, Muscatine County, July. (P). West Okoboji Lake, Dickinson County. (S).

2. *Pleodorina illinoisensis* Kofoid

Collins, 1909, p. 133, fig. 18. *Eudorina illinoisensis* Pascher, 1927, p. 443, fig. 404, 405.

Colony ellipsoid, soft, composed of 32 cells of which 4 vegetative cells in the anterior end are much smaller than the others, or reproductive cells; vegetative cells 9.5-12μ diameter; reproductive cells 12-25μ long. Plate II, fig. 1.

Watering trough. Johnson County, June. (P).

VOLVOX Linnæus, 1758

Globose, free-swimming colonies, containing from two hundred to thousands of biciliate, pyriform, spherical, ovoid, or disciform cells, crowded in a single layer near the periphery of the colonial envelope, in some species connected to one another by protoplasmic strands; one cup-shaped chromatophore with a single pyrenoid; one minute pigment spot; two contractile vacuoles.

1. *Volvox aureus* Ehrenberg

Collins, 1909, p. 135; Smith, 1920, p. 98, Pl. 18, fig. 2.

Colonies spherical, composed of 200-4000 cells, connected to one another by protoplasmic strands; autocolonies 4-14, arising from asexual reproductive cells; colonies diœcious; oogonia 3-9; antheridia arising from about half of the cells, each antheridium producing 16-32 antherozoids; zygote surrounded by a smooth wall; diameter of vegetative cells 5-9μ; diameter of colonies 200-(400μ)-680μ. Plate III, fig. 1.

Ponds. Johnson County, July. (P). Plankton in Dickinson County lakes, July. (P) (S).

2. *Volvox mononæ* G. M. Smith

Smith, 1920, p. 99, Pl. 18, fig. 1.

Colonies spherical, composed of 400-2500 globose cells, without protoplasmic connections, equipped with cilia which are 2-3 times the diameter of the cell in length; chromatophore bell-shaped, containing 1 pyrenoid; colonies diœcious, oogonia and antheridia found only in the daughter colonies, of which there are 3-10 within the old mother colony; vegetative cells 5-8μ in diameter; colonies 50-300μ-(350μ) in diameter. Plate III, fig. 2.

Ponds. Muscatine County, July. (P).

3. *Volvox globator* Linnæus

Smith, 1920, p. 98, Pl. 18, figs. 3-5.

Colonies spherical, composed of 3000 to 20,000 cells, with protoplasmic connections, monœcious and usually protanderous; parthenogonidia usually 8; 20-40 oogonia, formed in one colony; oospores brown, with a heavy membrane which has stellate projections; inner membrane gelatinous and quite thick; antheridia globose, as many as 5 in a colony; vegetative cells 2-3μ in diameter; oogonia about 50μ in diameter; antheridia 35-40μ in diameter; antherozoids 5-6μ long; parthenogonidia 50μ in diameter; colonies 600-800μ in diameter. Plate III, fig. 3.

Ponds and sloughs. Johnson County, May-July. (P) (Hob). Story County. (Bes) (Buch). Fayette County. (Fink). Wright County. (Buch). Dickinson County. (P) (Sm).

Family **Chlamydomonadaceæ**

CHLAMYDOMONAS Ehrenberg, 1838

Cells solitary, ovoid to subcylindrical, free-swimming in the vegetative condition; one cup-shaped chromatophore with a basal pyrenoid; cilia two to four, arising from the same point at the anterior end which may have a small but conspicuous beak-like projection; pigment spot and two contractile vacuoles in the anterior end; cells frequently entering a resting condition, becoming inclosed with a copious gelatinous envelope, and then by repeated cell division forming a palmella state involving an indefinite number of cells.

1. *Chlamydomonas anglica* Pascher

Pascher, 1927, p. 295, fig. 260.

Cells quite small, elliptical or broadly fusiform, frequently more strongly narrowed at the anterior than at the posterior end, both ends obtuse; membrane very fine, close, without an anterior papilla; cilia rather widely separated in their points of attachment at the anterior end, about as long as the cell; chromatophore usually a band-like ring, either completely covering the cell wall or not, the margins often irregularly lobed or incised; pigment spot and pyrenoids lacking; nucleus in the anterior end; contractile vacuole (?); cells 7.5-11μ long, 2-7μ wide. Plate IV, figs. 4, 5.

Plankton in slough, Johnson County, July. (P).

2. *Chlamydomonas dinobryoni* G. M. Smith

Smith, 1920, p. 91, Pl. 16, figs. 5-7.

Plankton, West Okoboji Lake, Dickinson County. (S).

3. *Chlamydomonas Ehrenbergii* Gorosch

Pascher, 1927, p. 204, figs. 142-144.

Cells oval or irregularly ovate, with the anterior end pointed, one side frequently inflated and somewhat tortuous or more convex than the other side; membrane delicate but very distinct, with a conical anterior papilla; cilia 1.5-2 times the length of the cell; chromatophore cup-shaped, massive in the posterior part; 1, sometimes 2, rarely more pyrenoids in the base of the chromatophore; pigment spot medially placed or to one side in the anterior end; cells 14-26μ long; gametes 8-11μ long; zygospores 12-16μ in diameter. Plate IV, figs. 1, 2.

Rare in slough, Johnson County, July. (P).

4. *Chlamydomonas globosa* Snow

Collins, 1909, p. 129; Smith, 1926, p. 166, Pl. 3, figs. 5, 6.

Cells spherical to slightly ovoid, without an anterior beak; chloroplast cup-shaped, dense in the posterior part, with a basal pyrenoid; pigment spot anterior and nearly median, often inconspicuous; 2 cilia, one and one-fifth times the length of the cell; cell 8-10μ in diameter. Plate IV, fig. 3.

Shallow marsh water, Johnson County, June. (P). Dickinson County. (S).

5. *Chlamydomonas Snowii* Printz

Smith, 1920, p. 91, Pl. 16, figs. 9-10.

Cells ovoid to ellipsoid, with an anterior beak; chloroplast massive in the posterior portion; 1 pyrenoid nearly centrally placed; length of cilia one and one-fifth times that of the cell; pigment spot variously located in the anterior region, often not visible; cells 6.5-8μ-(10μ) in diameter; 10-15μ-(17μ) long. Plate IV, fig. 6.

Plankton in shallow water of marsh, Johnson County, May. (P).

Family **Phacotaceæ**

Phacotus Perty, 1852

Cells flattened, round or oval in front view, bi-convex in lateral view; protoplast ovoid, surrounded by a thick, dark-colored envelope which consists of two valves, one over-lapping the other along the lateral margin; 2 cilia emerging through canals in the anterior end of the envelope; asexual reproduction by the formation of 2-8 daughter cells within the envelope of the mother cell, the daughter cells escaping by the separation of the valves of the mother cell integument after the new cells have developed their individual bivalve envelopes.

1. *Phacotus lenticularis* (Ehrenberg) Stein

Pascher, 1927, p. 358, fig. 325; Smith, 1926, p. 166, Pl. 5, figs. 1-3.

Cells ovoid, about 25μ long. Plate II, figs. 5, 6.

Plankton in slough, Dickinson County. (S).

Pteromonas Seligo, 1886

Cells flattened and variously shaped as soon in front view, oval, rounding with strongly flattened apex, or quadrate with the angles sharply pointed and extending forward anteriorly and backward posteriorly; protoplast spherical or ovoid, inclosed in a wide silicified envelope, consisting of two valves which the winged and form a suture along the lateral line of junction; one cup-shaped chromatophore containing one to six pyrenoids; asexual reproduction by the formation of two to four daughter cells within the mother cell envelope; sexual reproduction by isogametes which fuse in pairs to form a spherical, brown zygospore.

1. *Pteromonas aculeata* Lemmermann

Pascher, 1927, p. 368, fig. 339.

Cells in front view quadrate, a little longer than broad, the four angles extended into sharply pointed processes, the anterior processes directed forward and diverging slightly, the posterior angles extended backward and diverging; anterior and posterior margins, between the processes, nearly straight; in side view S-spindle-shaped, the two ends extended into fine points and curved in opposite directions, right and left; the lateral margins with three widely separated angulations, the margin concave between the projections, giving an undulated appearance to the border; protoplast quadrately rounded in front view, not filling the sheath laterally, containing 2 contractile vacuoles at the base of the two long cilia; several pyrenoids and an elongated pigment spot laterally placed in the anterior end; cells 19-33µ long; about 18µ wide. Plate V, figs, 11, 12.

Plankton, Iowa River, Johnson County, July. (P).

2. *Pteromonas angulosa* Lemmermann

Pascher, 1927, p. 365, figs. 332-336.

Protoplast broadly ovate (sometimes narrowly ovate) in front view, with very broad wings which are rounding except at the apex which is truncate and straight or nearly so, giving an almost circular outline to the cell; in side view elongate-fusiform to ovate; (in some forms the lateral margins of the protoplast, as seen in side view, have 2 widely and symmetrically disposed angulations, the side of the protoplast emarginate between the 2 angulations and then suddenly tapering to the retuse anterior and posterior ends); chromatophore cup-shaped, with a dense basal portion containing a single large pyrenoid; 2 contractile vacuoles at the base of the long cilia, and a narrow pigment spot in the anterior end. Plate V, figs. 2-5.

Plankton in shallow marsh water, Johnson County, June. (P).

Family **Polyblepharidaceæ**

PYRAMIDOMONAS Schmarda, 1850

Cells subpyramidate or cordate, broadened and lobed at the anterior end; cilia four, arising from one point at the anterior end; one cup-shaped, four-lobed chloroplast containing a single large pyrenoid in the posterior portion; one pigment spot and two contractile vacuoles usually present in the anterior region; vegetative reproduction by longitudinal splitting of the cell.

1. *Pyramidomonas inconstans* Hodgetts

New Phytologist 19. 1920.

Cells small, subpyramidate, cordate, or subcylindrical; anterior end truncate and slightly 4-lobed; subquadrate in vertical view; 1 chromatophore with a single basal pyrenoid; pigment spot in the anterior end of the cell, elongate; 2 (3) contractile vacuoles; length of cell (8.8μ)-10-15μ; 7.5-10μ wide; cilia 13-18μ long. Plate II, figs. 7, 8.

Plankton, Iowa River, Johnson County, July. (P).

Class EUGLENINEÆ

Family **Euglenaceæ**

EUGLENA Ehrenberg, 1838

Cells elongate, fusiform, often spirally twisted; swimming by means of a long or a short anterior flagellum; cell membrane or periplast soft and plastic, or somewhat rigid, often furnished with longitudinally and spirally arranged series of granules, warts, or fine striations; chloroplasts varied in form, disc-shaped and numerous in some species, or band-shaped and arranged to form two or more stellate masses, (sometimes parietal, longitudinal bands), many small paramylon grains of various shapes or sometimes only two in the form of rather large rings or rods, one anterior and the other posterior; pigment spot usually plainly visible, laterally located in the anterior end; one to several contractile vacuoles; vegetative reproduction by longitudinal splitting.

1. *Euglena acus* Ehrenberg

Lemmermann, 1913, p. 129, fig. 209.

Cells elongate-fusiform, truncate at the anterior end, extending posteriorly into a long sharp caudus; membrane with longitudinal striations; flagellum about one-third the length of the cell; chromatophores numerous, disc-shaped; pyrenoids absent; paramylon body rod-shaped; cells 140-180μ long. Plate IV, fig. 7.

Plankton with other species of *Euglena*, occurring commonly among filamentous algæ in small pools and ponds. Johnson County, May-July. (P). Fayette County. (W).

2. *Euglena acutissima* Lemmermann

Lemmermann, 1913, p. 129, fig. 210.

Cells linear, extended posteriorly into a long, sharp caudus; membrane smooth; chromatophores many, disc-shaped, forming spiral lines through the length of the cell; pigment spot conspicuous, sub-anterior and lateral; cells 123-125μ (130μ) long; 8-9μ wide. Plate IV, fig. 12.

Plankton in Iowa River, Johnson County, July. (P).

Occurring frequently in small bodies of water with other species of *Euglena* during warm weather.

3. *Euglena deses* Ehrenberg

Lemmermann, 1913, p. 131, fig. 212.

Cells elongate-cylindric, or somewhat band-shaped, posterior part usually curved and ending in a short, blunt point; membrane with fine spiral striations; flagellum short; chromatophores numerous, disc-shaped; pyrenoids not covered; paramylon body rod-shaped; cells 85-155μ long; 15-22μ wide. Plate IV, fig. 10.

In mud and shallow water at edge of Iowa River, Johnson County, June. (P).

Frequent among algæ. (E).

4. *Euglena elongata* Schewiakoff

Lemmermann, 1913, p. 125, fig. 181.

Cells elongate-fusiform, obtuse at the anterior end, tapering evenly but rather briefly to a blunt point posteriorly; membrane smooth; flagellum nearly as long as the cell; chromatophore a longitudinal, flat band; no pyrenoids; length of cell 64μ-(65-70μ); width (4μ)-5-6μ. Plate IV, fig. 16.

In shallow water and mud at edge of marsh. Johnson County, June. (P).

5. *Euglena pisciformis* Klebs

Lemmermann, 1913, p. 125, fig. 182.

Cells rather small, fusiform, tapering rapidly into a bluntly pointed posterior end; anterior end broadly obtuse; membrane spirally striated longitudinally; length of flagellum equal to that of the cell; 2 band-like chromatophores laterally arranged; 2 pyrenoids; paramylon body small, rod-shaped; cell 25-26μ long; 7-8μ broad. Plate IV, fig. 11.

Plankton in Iowa River, Johnson County, July. (P).

6. *Euglena proxima* Dangeard

Lemmermann, 1913, p. 129, fig. 193.

Cells fusiform, with a short, colored caudus; membrane spirally striated; flagellum very long, up to 1½ times the length of the cell; chromatophores numerous, disc-shaped; pyrenoids lacking; paramylon bodies ring-like or short cylindric; cells 60-70μ long; about 20μ wide. Plate IV, fig. 9.

With other species of *Euglena* forming a vivid green scum on the surface of the Iowa River, Johnson County, July. (P).

7. *Euglena sanguinea* Ehrenberg

Lemmermann, 1913, p. 128, fig. 185.

Cells broadly fusiform to nearly cylindrical, posterior part suddenly attenuated to form a short caudus; membrane with longitudinal series of fine granules, spirally arranged and diminishing in size toward the posterior end, sometimes discerned with difficulty; flagellum about as long as the cell; cells usually more or less blood-red in color, or with a reddish tinge; chromatophores numerous, star-shaped or disciform; pyrenoids present; paramylon grains round or ovate; cells 55-121μ long; 28-33μ broad. Plate IV, fig. 15.

Occurring rarely among filamentous algæ in the poolings of a slowly flowing stream. Johnson County, July. (P).

8. *Euglena spirogyra* Ehrenberg

Lemmermann, 1913, p. 131, fig. 208.

Cells elongate-cylindric, the posterior part gradually attenuated to a rather long, sharply pointed and colorless caudus; membrane yellowish to yellow-brown, ornamented with spirally arranged longitudinal series of large granules; flagellum short; chromatophores numerous; disc-shaped; pyrenoids lacking; paramylon bodies 2, ring-like, one in front of and one behind the nucleus; cells about 80μ long; 8-10μ wide, or more. Plate IV, fig. 8.

Our specimens appear to be consistently a little stouter than described for the type (70-75μ long; 10-15μ wide) and perhaps should be assigned as a variety of *Euglena spirogyra*.

With other species of *Euglena*, forming a scum on the surface of a small pool, Johnson County, September. (P). Fayette County. (W).

9. *Euglena spiroides* Lemmermann

Lemmermann, 1913, p. 130, fig. 194.

Cells elongate and band-like, spirally twisted, briefly tapering posteriorly into a short caudus; membrane with longitudinal rows of granules; flagellum short; chromatophores numerous, disc-shaped; pyrenoids absent; paramylon bodies round, small; cells 60-170μ long; about 16μ wide. Plate V, fig. 17.

This species is very graceful in its swimming habits, gliding forward with a slow, spirally rotating motion.

In the shallow water of a swamp, Johnson County, October. (P).

10. *Euglena viridis* Ehrenberg

Lemmermann, 1913, p. 127, fig. 189.

Cells fusiform, gradually tapering posteriorly to a rounded point; membrane with spiral striations; flagellum equal to the cell in length; pigment spot usually visible in the anterior end; chromatophore star-shaped, in front of the nucleus; pyrenoid present; paramylon body round or rod-like; cells 52-57μ long; 14-18μ wide. Plate IV, fig. 14.

Plankton from Iowa River, Johnson County, July. (P). Fresh and stagnant water. (E). Fayette County. (W).

LEPOCINCLIS Perty, 1852

Cells ovoid, elliptic or elongate-elliptic, free-swimming; periplast rigid, frequently spirally striated; one flagellum; chromatophores numerous, disc-like and parietal; paramylon bodies usually two, ring-shaped and laterally placed in the cell; contractile vacuoles present; pigment spot usually visible near the anterior end; no pyrenoids; either holophytic or saprophytic.

1. *Lepocinclis fusiformis* (Carter) Lemmermann

Lemmermann, 1913, p. 135, fig. 219.

Cells rather short and broadly fusiform, slightly constricted below the anterior end, membrane thick, transparent with many spiral striations; flagellum about equal to the cell in length; cell 25-36μ long; 14-23μ wide. Plate V, fig. 7.

Shallow water of marsh, Johnson County, June. (P).

2. *Lepocinclis ovum* (Ehrenberg) Lemmermann

Lemmermann, 1913, p. 134, fig. 216.

Cells oval, with the posterior part suddenly tapering to a short, sharp, straight caudus; membrane thick, with many spiral striations; flagellum length twice that of the cell; cell 30-38μ long; 15-18μ wide; caudus 6-7μ long. Plate V, fig. 8.

Plankton in small pools of stagnant water. Johnson County, July. (P).

var. *globula* (Perty) Lemmermann. Lemmermann, 1913, p. 134.

Cells nearly spherical, 20-27μ long; 16-21μ wide; flagellum twice as long as the cell.

Plankton in stagnant water, Johnson County, July. (P).

PHACUS Dujardin, 1841

Cells free-swimming, periplast firm, with longitudinal, sometimes spiral striations; body of cell flattened, one side convex and the other more or less concave, posterior part usually extended into a short or a long caudus; one flagellum, arising from the anterior end of the cell; chloroplasts many, small, or few and large; no pyrenoids; pigment spot conspicuous in some species.

1. *Phacus acuminata* Stokes

Lemmermann, 1913, p. 138, fig. 233.

Cells broadly ovate or subglobose, very broad in the basal part which becomes suddenly attenuated to form a short, sharply pointed caudus; membrane with longitudinal striations; dorsal fold extending nearly to the posterior end; flagellum about as long as the cell; two small paramylon bodies; about 25μ wide. Plate V, fig. 9.

Plankton in small pool of stagnant water, Johnson County, July. (P).

2. *Phacus brevicauda* (Klebs) Lemmermann

Lemmermann, 1913, p. 139, fig. 232.

Cell ovate to subglobose, the posterior part extended into a short caudus which may be sharp or merely an obtuse projection when the caudus is very strongly abbreviated; membrane longitudinally striated; dorsal fold extending nearly to the posterior end; flagellum about as long as the cell; one ring-shaped paramylon body; cell 31-35μ long; 23-25μ wide. Plate V, fig. 1.

Plankton in shallow water of marsh, Johnson County, May. (P).

3. *Phacus longicauda* (Ehrenberg) Dujardin

Lemmermann, 1913, p. 138, fig. 235.

Cells oval, tapering posteriorly, at first suddenly and then gradually into a long pointed caudus; membrane spirally striated with longitudinal series of fine granules; flagellum much shorter than the length of the cell; one large, disc-shaped paramylon body; cell 85-115μ long; 46-70μ wide in the broadest place. Plate V, fig. 13.

Plankton in the shallow water of a marsh, and in small stagnant pools. Johnson County. (P).

var. *torta* Lemmermann. Drezepolski, 1925, p. 232, fig. 124.

Cells somewhat longer and narrower than in the type, strongly twisted into 2-3 spiral turns; cells 75-120μ long, 40-50μ wide. Plate V, figs. 15, 16.

Plankton in shallow, often stagnant water. Johnson County, July. (P).

4. *Phacus pleuronectes* (O. F. M.) Dujardin

Lemmermann, 1913, p. 138, fig. 236.

Cells ovate, broad anteriorly, tapering abruptly into a relatively short caudus which projects at an angle from the median axis of the cell; tortuous just above the base of the caudus; dorsal groove extending down to the middle of the cell; membrane longitudinally striated; flagellum as long as the cell or longer; paramylon bodies 1-2, ring-shaped; cells 30-33μ wide; 49μ long. Plate V, fig. 14.

Plankton in shallow water of marsh. Johnson County, July. (P). Common (E).

5. *Phacus pyrum* (Ehrenberg) Stein

Lemmermann, 1913, p. 139, fig. 245.

Cells pyriform, extended posteriorly into a rather long, finely pointed caudus; membrane spirally striated, the striations forming ridges which, as they pass around the cell, cause the margin of the periplast to appear undulated; flagellum equal to the length of the cell; two large or several small paramylon bodies; cells 30-35μ long; 13-20μ wide. Plate V, fig. 6.

In plankton collected from the film on the surface of a small pool. Johnson County. (P). Found associated with *Euglena viridis*. (E).

TRACHELOMONAS Ehrenberg

Cells motile; highly metabolic, inclosed within a firm envelope or lorica which may be smooth, punctate, warty or spiny; one flagellum, emerging from the anterior end of the lorica through a circular opening which may be at the end of a collar or neck; chromatophores two and plate-like or numerous and disc-shaped; paramylon bodies usually present; pyrenoids present or not; pigment spot frequently visible.

1. *Trachelomonas abrupta* Swirenko

Deflandre, 1926, p. 695, figs. 344, 345, 346-352, 354-361, 364, 365.

Lorica ellipsoid-cylindric, sides parallel or somewhat rounding; poles broadly rounded; flagellum pore without a collar; membrane densely and finely scrobiculate; pigment spot present; chromatophores 10; no pyrenoids; length of lorica 27-30μ; width 18-19μ. Plate VI, fig. 23.

Plankton from shallow water of marsh. Johnson County, June. (P).

var. *Bonnieri* Drezepolski, 1925, p. 210, fig. 68.

Cells cylindric-ovate or even narrower; lorica surface granular, setaceous or merely punctate; flagellum opening surrounded by a low collar which may sometimes be lacking; flagellum as long as the lorica; length 24-40μ; width 15-30μ. Plate VI, fig. 1.

Plankton in the pools of a small stream, Johnson County, March. (P).

2. *Trachelomonas affinis* var. *levis* Lemmermann

Lemmermann, 1913, p. 153, fig. 296.

Lorica broadly fusiform, extending posteriorly into a sharp point and anteriorly into a rather long neck; flagellum opening usually oblique; surface of lorica smooth; length 60-68.5μ; width 26-27μ. Plate VI, fig. 2.

Plankton from Iowa River. Johnson County, July. (P).

3. *Trachelomonas allia* Drez.

Deflandre, 1926, p. 652, fig. 233, 238.

Lorica cylindric-ellipsoid, the poles broadly and equally rounded; sides parallel for one-third of their length; surface evenly and densely covered with short spines; flagellum opening without a collar; membrane brownish-yellow; length 30-35μ; width 19-22.5μ. Plate VI, fig. 24.

Plankton in stagnant pools and swamps. Johnson County, June-August. (P).

4. *Trachelomonas armata* (Ehrenberg) Stein

Lemmermann, 1913, 150, fig. 275.

Lorica broadly oval, not punctate but with a circlet of long spines at the posterior end; flagellum opening with a thickened rim bearing a ring of tooth-like spines; flagellum twice as long as the lorica; lorica 29-64μ long. Plate VI, fig. 3.

Plankton from shallow marsh water. Johnson County, June. (P).

var. *Steinii* Lemmermann. Deflandre, 1926, p. 690, figs. 314, 316, 322, 324, 326, 327.

Lorica as in the type, often larger, with an irregular number of spines forming a circlet around the flagellum opening, the spines variable in size; posterior pole with larger spines than with the type or with a larger number of small spines; spines at anterior end frequently truncated or obtusely pointed; flagellum opening with or without a short collar, which, if present, may have a denticulate or a crenulate margin; length of lorica without spines 37-40μ; width 30-33μ. Plate VI, fig. 4.

Plankton in shallow marsh water. Johnson County, July. (P).

5. *Trachelomonas elegans* Conrad

Deflandre, 1926, p. 526, fig. 67.

Lorica subspherical, brownish, rather thin, with fine perforations and radiating, bristle-like spines; flagellum longer than the lorica; length of lorica 9-10μ; width 8-9.5μ. Plate VI, fig. 22.

Plankton from shallow water of marsh. Johnson County, June. (P).

6. *Trachelomonas ensifera* Daday

Lemmermann, 1913, p. 154, fig. 304.

Lorica globose or transversely oval, smooth, with the anterior end extending into a neck-like elongation, tapering posteriorly into a heavy, long, pointed spine-like termination; cells 75-80μ long. Plate VI, figs. 6, 7.

Plankton from Iowa River. Johnson County, July. (P).

7. *Trachelomonas hispida* (Perty) Stein

Lemmermann, 1913, p. 149, fig. 272.

Lorica oval, thickly set with short spines; neck short or sometimes wanting; chromatophores 8-10; flagellum 1.5-2 times the length of the lorica; length 20-42μ, width 15-26μ. Plate VI, fig. 8.

Plankton in shallow marsh water. Johnson County, June. (P). Iowa City, Johnson County. (E).

var. a—*coronata* Lemmermann. Skvortzow, 1925, p. 302, fig. 6.

Lorica oval, coverel with short spines; flagellum opening encircled with somewhat larger spines, very sharply pointed; lorica 20-35μ long; 15-25μ wide. Plate VI, fig. 9.

Plankton in stagnant water, Johnson County, July. (P).

var. b—*punctulatum* Skvortzow, 1925, p. 303, fig. 10.

Lorica oval, brown, with numerous punctations; flagellum opening encircled by short, sharp spines; 16.6-21μ in diameter. Plate VI, fig. 11.

Plankton in Iowa River, Johnson County. (P).
County, July. (P). Previously reported from North Manchuria.

var. c—*verrucosa* Drezepolski, 1925, p. 216, fig. 39a.

Lorica oval to subglobose, dark brown in color, covered with very blunt spines or warts; flagellum opening wide, surrounded by a short collar; several chromatophores; pigment spot conspicuous; length 23-25μ, width 15-18μ. Plate VI, fig. 12.

Plankton in Iowa River, Johnson County, July. (P).

var. d—*crenulatocollis* (Maskell) Skvortzow, 1925, p. 302, fig. 4.

Lorica oval, brown, covered with numerous short, sharp spines; flagellum opening in a tubular neck which is somewhat broader than long and is serrated at the margin, the serrations sometimes being long and curved; lorica 15-26μ wide; 20-40μ long; neck 3μ long. Plate VI, fig. 10.

Plankton in shallow water of a marshy pond, Johnson County, July. (P).

8. *Trachelomonas horrida* Palmer

Lemmermann, 1913, p. 150, fig. 276.

Lorica broadly oval, densely set with stout, sharply pointed spines, the sides of the spines parallel for most of their length and then suddenly converging to form a short point; neck stout with an expanded mouth, the margin of which is undulated; length of lorica about 40μ. Plate VI, fig. 5.

Fresh water, Johnson County, October. (E).

var. *paucispina* var. nov.

Lorica oval, furnished with a much fewer number and shorter spines than in the type; flagellum aperture without a collar; length 39μ, width 29μ. Plate VI, fig. 26.

Plankton in shallow water of marsh. Johnson County, July. (P).

9. *Trachelomonas obovata* Stokes

Deflandre, 1926, p. 698, figs. 423, 429.

Lorica ovoid, broadly rounding anteriorly, frequently somewhat flattened at the anterior end, attenuated gradually to the posterior end which is somewhat rounding but narrowed; surface covered with short, irregularly disposed spines, also with spiral striations of fine scrobiculations extending from left to right; flagellum pore rather broad, with a short collar, denticulate at the margin or with a circlet of somewhat larger spines; length 24-30μ; width 18-19μ. Plate VI, fig. 21.

Plankton in shallow water of marsh, Johnson County, July. (P).

10. *Trachelomonas piscatoris* (Fischer) Stokes

Lemmermann, 1913, p. 149, fig. 271.

Lorica subcylindric, narrowed anteriorly into a thick neck which is toothed or denticulate, sometimes spiny, at the margin of the opening; surface evenly covered with rather fine spines; flagellum 1.5-2 times the length of the cell; lorica 25-40μ long. Plate VI, fig. 19.

Generally distributed. (E).

11. *Trachelomonas planctonica* Swirenko

Drezepolski, 1925, p. 220, fig. 75.

Lorica oval to ovate, slightly tapering at the posterior end, extended anteriorly into a rather long neck which tapers from base to apex, rim of neck smooth, or sometimes irregularly serrate; lorica yellow-brown in color, finely but conspicuously punctate; length of lorica 34.5μ, width 18.4μ; length of neck 6.9μ, width of neck at base 6.9μ, 4.8μ wide at the top. Plate VI, fig. 15.

Plankton in marsh, Iowa County, May. (P).

12. *Trachelomonas Raciborski* Woloszynska

Lemmermann, 1913, p. 150, fig. 279.

Lorica broadly oval, with rather stout spines in the anterior and posterior regions; flagellum opening with a thickened rim, but without a neck; flagellum up to 3 times the lorica in length; lorica 40μ long; width 30μ. Plate VI, fig. 13.

Plankton in shallow swamp, Dickinson County, July. (P).

var. *punctata* var. nov.

Lorica smaller than in the type; dark brown in color; finely but conspicuously punctate; spines stouter, scattered in the anterior region, confined to a circlet about the pole of the posterior end, 8 usually showing in a side view; length 24-30μ, width 13-15μ. Plate VI, fig. 14.

Plankton from swamp water, Johnson County, June and October. (P).

To be compared with *Trachelomonas Raciborski* var. *incerta* Drez., from which it differs in having a larger size and larger and more numerous spines than given by Drezepolski, 1925.

13. *Trachelomonas reticulata* Klebs

Lemmermann, 1913, p. 151, fig. 293.

Lorica ovate, tapering to a point posteriorly, surface densely punctate and with numerous fine markings; flagellum twice as long as the lorica; pigment spot usually visible; length 26μ, width 17μ. Plate VI, fig. 16.

Plankton from a small bog, Iowa County, May. (P).

14. *Trachelomonas rugulosa* Stein

Deflandre, 1926, p. 581, fig. 89.

Lorica spherical, subspherical or broadly ellipsoid, sometimes ovoid, covered with spiral, anastomosing striations; flagellum opening wide, rarely with a short collar; membrane brownish or brownish-red; diameter of lorica 18-23μ. Plate VI, fig. 20.

Plankton from a ditch of standing water, Johnson County, June. (P).

15. *Trachelomonas spinosa* Stokes

Lemmermann, 1913, p. 149, fig. 268.

Lorica oval, uniformly covered with conspicuously long spines which are decidedly recurved or posteriorly directed except in the upper one-third of the lorica where they are shorter and project more or less at right angles from the surface; flagellum opening without a collar; length of lorica 26.2μ, width about 23μ. Plate VI, fig. 17.

Plankton from marsh. Johnson County, October. (P).

16. *Trachelomonas superba* Swirenko

Deflandre, 1926, p. 657, fig. 261, 269, 273.

Lorica ellipsoid, provided with conical, robust spines of variable length; flagellum pore with or without an annular thickening, sometimes furnished with a circlet of spines of variable length, or at times with a distinct collar; membrane rather thick, finely punctate, brownish or yellowish-brown; stigma large; chromatophores disc-like; length of lorica 46-55μ, width 36-39μ. Plate VI, fig. 25.

Plankton in marsh. Johnson County, June. (P).

17. *Trachelomonas volvocina* Ehrenberg

Lemmermann, 1913, p. 145, fig. 246.

Lorica globose, smooth; flagellum opening with a thickened margin, rarely with a short collar; flagellum length 2-3 times that of the lorica; 2 pyrenoids; 7-21μ in diameter. Plate VI, fig. 18.

Plankton in a small pool cut off from a marsh. Johnson County, July. (P).

CRYPTOGLENA Ehrenberg

Cells free-swimming, elongate-ovate, with a firm periplast; one flagellum; two band-like chromatophores extending longitudinally in the cell; pigment spot in anterior end; nucleus posterior.

1. *Cryptoglena pigra* Ehrenberg

Lemmermann, 1913, p. 156, fig. 309; Edmondson, 1906, p. 44, fig. 83.

Cells ovate in front view, somewhat flattened dorso-ventrally, truncate and slightly notched or bilobed anteriorly, sides convex, tapering to a sharp point; in side view oval; flagellum equal to the cell in length; cells 6-9.5μ wide, 11-15μ long. Plate VI, fig. 28.

Not abundant in Iowa. (E).

TURBINELLA Deflandre, 1927

Turbinella ænigmatica Deflandre

Deflandre, 1927, p. 74, figs. 805, 807, 808.

Cell spherical, gray-blue in color; contents granular, homogeneous, inclosed by a turbinated envelope which is extended anteriorly into a collar-like prolongation and posteriorly into a somewhat longer, conical, hollow, straight caudus; sides provided with deep furrows and ridges running circular about the cell; membrane rather thick, hyaline, furnished with longitudinal striations perpendicular to the furrows; cell 25-39μ in diameter; 50-52μ long; caudus 16-20μ long. Plate VI, fig. 27.

Deflandre questionably designates this curious organism with this nomenclature and places it near the genus *Trachelomonas.* It appears in my plankton collections frequently in the spring and early summer. I have never observed the organism in motion, but its peculiar shape and markings clearly identify it with the form described by Deflandre (5). Drezepolski (6) also makes reference to a somewhat similar form which he designates as *Heteronema* sp. (Drezepolski, 1926, fig. 175). Since describing this species Deflandre has published a notice (Archives de Bot. 1:222, 1927) in which he identifies the form as the encysted condition of a protozoan, *Podophrya fixa*, the life cycle of which has lately been followed out by E. Penard.

Family **Peranemaceæ**

NOTOSOLENUS Stokes

Cells firm, strongly compressed, dorsally concave, ventrally convex; two flagella, one obliquely directed forward and one trailing flagellum; one large and one accessory vacuole.

1. *Notosolenus apocamptus* Stokes

Lemmermann, 1913, p. 172, fig. 361; Edmondson, 1906, p. 49, fig. 82.

Cells ovate, pointed anteriorly, broadly rounded posteriorly; dorsal furrow narrow; swimming flagellum 1.5 times the length of the cell. Trailing flagellum one-half the length of the cell; cell 6.5-10.5μ long. Plate VII, fig. 9.

Rare in ponds. Johnson County. (E).

ENTOSIPHON Stein

Cells rigid, with a firm periplast that is longitudinally striated, ribbed or furrowed; two flagella with basal granule and periplast, one swimming and one trailing; a mouth-like opening in the anterior end from which extends inwardly a narrow tubular pharynx; one large and several accessory vacuoles.

1. *Entosiphon sulcatum* (Duj.) Stein

Lemmermann, 1913, p. 173, fig. 367; Edmondson, 1906, p. 48, fig. 81.

Cell oval, rounded at the anterior end; periplast with 4-8 longitudinal ribs; swimming flagellum as long as the cell; trailing flagellum a little longer; pharynx long and tubular, reaching to the posterior end of the cell; length of cell 20-25μ, width 10-15μ. Plate VII, figs. 1-2.

Frequent. (E).

ANISONEMA Dujardin

Cells metabolic or firm, with a definite periplast; a longitudinal furrow on the ventral surface; two flagella, one swimming and the other trailing; oral opening back of the point of flagella attachment in the ventral furrow; two vacuoles; nucleus on the right.

1. *Anisonema acinus* Dujardin

Lemmermann, 1913, p. 172, fig. 369; Edmondson, 1906, p. 47, fig. 78.

Cells firm, ovate, somewhat compressed dorso-ventrally; membrane smooth or striated; the left side of the ventral furrow conspicuously swollen or extended; swimming flagellum not as long as the cell; trailing flagellum two times the length of the cell with a thickened tip; cell 25-40μ long, 16-22μ wide. Plate VII, fig. 8.

Widely distributed in pond water. (E).

2. *Anisonema ludibundum* S. K.

Edmondson, 1906, p. 47, fig. 79.

Cell oval, the two flagella attached back from the anterior end on one side; contractile vacuoles several (or 1); about 10μ long.

Fresh water. (E). Fayette County. (W).

3. *Anisonema truncatum* Stein

Lemmermann, 1913, p. 173, fig. 373; Edmondson, 1906, p. 48, fig. 80.

Cell firm, short, ovate; membrane smooth; swimming flagellum equal to the cell in length; trailing flagellum more than two times the length of the cell; cells 20μ wide, 60μ long. Plate VII, fig. 7.

Rare in Johnson County. (E).

PETALOMONAS Stein

Cells oval and flattened dorso-ventrally, conspicuously asymmetrical, often with curiously shaped processes; periplast firm; one flagellum, arising from an anterior, ventral oral aperture; two vacuoles, usually on the right side; nucleus on the left side.

1. *Petalomonas mediocanellata* Stein

Lemmermann, 1913, p. 164, fig. 349; Edmondson, 1906, p. 46, fig. 77.

Cells broadly ovate, showing a furrow in the dorsal and ventral view, dorsal furrow narrow; broadly rounded posteriorly; tapering to a point anteriorly; the left side of the ventral furrow extended posteriorly; flagellum equal to the length of the cell. Plate VII, fig. 10.

Frequent. (E).

HETERONEMA Stein

Cell with a firm periplast covered with numerous longitudinal striations; two flagella, one extended forward and one trailing behind, or directed backward, both arising from a mouth-like opening at the anterior end; one large, and one small, accessory vacuole; multiplication by cell-division; feeding habits animal-like.

1. *Heteronema spirale* Klebs

Lemmermann, 1913, p. 169, fig. 360.

Cell nearly cylindric, with 5-6 spiral turns; membrane smooth; trailing flagellum about three-fourths the length of the cell; cell 40-42μ (45μ) long, 24-30μ wide. Plate IV, fig. 13.

Shallow water of a marsh. Johnson County, July. (P).

2. *Heteronema acus* (Ehrenberg) Stein

Lemmermann, 1913, p. 169, fig. 354; Edmondson, 1906, p. 46, fig. 76.

Cells fusiform, tapering to a blunt point posteriorly; membrane spirally striated or smooth; swimming flagellum sometimes longer than the cell; trailing flagellum one-half the length of the cell; cell 45-50μ long, 8-20μ wide. Plate V, fig. 10.

Fresh water. Johnson County, Keokuk County. (E).

Family **Astasiaceæ**

ASTASIA Dujardin

Cells, elongate, highly metabolic, membrane striated; one flagellum arising from the anterior end; eye spot usually absent.

1. *Astasia trichophora* Ehrenberg

Edmondson, 1907, p. 45, figs. 72-73.

Cells elongate, broadly rounded posteriorly, tapering to a narrow, sharply rounded, anterior end; flagellum long, thick; contractile vacuole in the anterior end; length of body extended 30-60μ. Plate VII, figs. 3, 4.

Common among algæ. (E). Fayette County. (W).

DISTIGMA Ehrenberg

Cells highly metabolic, membrane longitudinally striated; 2

flagella (one very short) arising from an opening leading into a long pharynx.

1. *Distigma proteus* Ehrenberg

Lemmermann, 1913, p. 161, fig. 336.

Cells elongate, fusiform, highly plastic; major flagellum one-half the length of the cell; accessory flagellum very short; paramylon body cylindric; length 46-110μ. Plate VII, fig. 5.

Fresh water. (E).

Class CRYPTOMONADINEÆ

Order CRYPTOMONADALES

Family **Cryptomonadaceæ**

CRYPTOMONAS Ehrenberg, 1838

Cells naked; periplast firm, flattened dorso-ventrally; dorsal margin convex, ventral margin concave; anterior end usually somewhat oblique and bilobed; furrow passing obliquely over the anterior end and produced into a curved gullet lined with trichocysts reaching down into the posterior end; two cilia arising from the ventral side of the gullet; chromatophores brownish, parietal, usually one or two at the ventral and dorsal margins; pyrenoid centrally placed; one to three contractile vacuoles.

1. *Cryptomonas ovata* Ehrenberg

Pascher, 1913, p. 107, figs. 168-169; Edmondson, 1906, p. 51, fig. 87.

Cells ovate or oval, with a conspicuous lip-like, lateral extension at the anterior end; two band-like chromatophores, parietal, on either side of the cell; gullet opening broad; cells 20-80μ long, 6-20μ wide, 5-18μ thick. Plate VII, fig. 6.

In aquaria jars, botany laboratory. March. (P). Widely distributed. (E).

Family **Chilomonadaceæ**

CHILOMONAS Ehrenberg

Cells laterally compressed, elongate-ovate in front view; anterior end broad, with an obtuse lip-like extension at one side; tapering posteriorly to a narrowly rounded end; two short flagella inserted on the ventral side behind the pharynx; nucleus large and near the center of the cell. (For a complete description see Pascher 1913, p. 108).

1. *Chilomonas paramæcium* Ehrenberg

Pascher, 1913, p. 109, fig. 171; Edmondson, 1906, p. 50, fig. 86.

Cells 20-40μ long. Plate VII, fig. 11.

Widely distributed. (E).

Family **Nephroselmidiaceæ**

NEPHROSELMIS Stein

Cells kidney-shaped, strongly compressed laterally, broadly rounding on the ventral side; narrowly oval in optical section; periplast firm with a central median furrow, at the bottom of which two flagella are attached; two parietal chromatophores; two contractile vacuoles and a pyrenoid below the median furrow; nucleus dorsal. (For a complete description see Pascher 1913, p. 111.)

1. *Nephroselmis olivacea* Stein

Pascher, 1913, p. 111, fig. 174; Edmondson, 1906, p. 49, fig. 84.

Cells 15μ wide, 23μ long; characteristics of the genus. Plate VI, fig. 29.

Rare in ponds. (E).

Class PERIDINEÆ

Family **Gymnodiniaceæ**

HEMIDINIUM Stein, 1883

Cell ellipsoidal or asymmetrically ellipsoid; girdle incomplete, median to premedian, forming a descending left spiral of half a turn or less; sulcus in the hypocone; chromatophores yellowish brown.

1. *Hemidinium nasutum* Stein

Lebour, 1925, p. 20, fig. 7.

Body asymmetrically oval; girdle median, a descending left spiral of half a turn; sulcus confined to the hypocone, reaching to the posterior pole; chromatophores yellow or brown; nucleus posterior; length 24-28μ. Plate X, figs. 10-12.

Abandoned quarry pond, Johnson County, March. (P).

GYMNODINIUM Stein

Cells with a descending left spiral, displaced less than one-fifth of the length of the body, sometimes forming a complete circle around the body; sulcus sometimes long, extending from apex to posterior end, or short, located in either cone or partly in both; chromatophores present or not; sometimes with pigment granules; surface of membrane smooth, with striations, furrows, or ridges.

1. *Gymnodinium palustre* Schilling

Schilling, 1913, p. 16, fig. 11.

Cells ellipsoidal; girdle median, not displaced; anterior end rounding-conical, posterior end broadly truncate; epicone distinctly longer than the hypocone; chromatophores round, yellow to dark brown; 44μ long, 37.5μ wide. Plate X, fig. 13.

Shallow marsh water, Johnson County, May and June. (P).

2. *Gymnodinium vorticella* Stein

Schilling, 1913, p. 20, fig. 19.

Cells broadly ovoid; the epicone high and conical, much longer than the hypocone which is broadly rounding posteriorly; girdle postmedian, displaced about one-half of its width; sulcus short, extending into the epicone and almost to the extremity of the hypocone; pigment spot posterior in the sulcus; 23-24μ long, 20-21μ wide. Plate X, fig. 14.

Swamps, Johnson County, May. (P).

Family **Peridiniaceæ**

CERATIUM Schrank, 1793

Cells furnished with a heavy armor of areolated plates, separated by narrow sutures, the ventral surface with a rhomboidal hyaline area; cells strongly asymmetric, flattened dorso-ventrally, extending anteriorly into a long (or short) apical horn and posteriorly into two or three antapical processes which may be longer or shorter than the apical horn; transverse furrow approximately horizontal around the cell but not passing through the ventral unsculptured area; epitheca and hypotheca nearly equal in size but dissimilar in form, the apical process being made up of a number of apical plates, one of the posterior processes consisting of but one antapical plate; the other process of one or two antapicals; other plates as in *Peridinium*; chromatophores small, yellowish brown in color; no pigment spot.

1. *Ceratium hirundinella* O. F. M.

Schilling, 1913, p. 55, fig. 62.

Cells with heavy plates; apical horn relatively long with subparallel margins and a truncate apex; 2-3 antapical horns, shorter and somewhat stouter than the apical horn, sharply pointed; plates with pores, reticulations and spines; length 95-400μ. Plate VIII, fig. 1.

Plankton from pools and ponds. Johnson County, May; Dickinson County, July. (P).

forma *carinthiaceum* (Zederbauer) Schilling, 1913, p. 57, fig. 64a.

Cell body thick and short in comparison to the length of the horns; anterior horn short conical, extending to the right of a line drawn longitudinally through the center of the cell; left posterior horn usually short. Plate VIII, fig. 3.

Quarry pond; Johnson County, May. (P).

forma *robustum* (Amberg) Schilling, 1913, p. 58, fig. 65d, 65e.

Cells with relatively long narrow horns, the left posterior horn being narrow and sharply pointed; length 270-310μ, width 45-50μ. Plate VIII, fig. 2.

Quarry pond; Johnson County, May. (P).

PERIDINIUM Ehrenberg, 1830

Cells subglobose or ovoid, furnished with a heavy armor consisting of a definite number of plates, separated by narrow (rarely wide) intercalary bands which are often striated; end view reniform; transverse furrow slightly spiral with projecting rims, dividing the cell into unequal parts, the epitheca or anterior part being larger than the hypotheca or posterior part; longitudinal furrow broad, extending up into the epitheca for a short distance; plating of the epitheca consists of eleven to fourteen sections of which those nearest the apex are designated as the apicals and those adjoining the transverse furrow the precingulars, sometimes one to three intervening plates on the dorsal side known as the intercalary plates; hypotheca usually with seven plates, two antapicals at the apex and five postcingulars adjoining the transverse furrow; chromatophores numerous, small, disc-like, brownish in color; pigment spot usually not present.

1. *Peridinium cinctum* Ehrenberg

Schilling, 1913, p. 46, fig. 52.

Cell globose or ovate, the epitheca and hypotheca of unequal size, the former being larger than the latter; plates with pores and separated by broad intercalary bands; total number of plates 21 of which 14 compose the epitheca and 7 the hypotheca; plate arrangement not symmetrical in the epitheca, the rhomboidal cell not extending to the apex but cut off at the top by the coming together of two opposite apical plates, these two apical plates and three other apical plates more toward the dorsal side bounding a 5-sided plate at the vertex, of these three apical plates one lies to the right and two to the left of the plate at the vertex; to either side of the rhomboidal plate extend 3 precingulars which meet a large 5-sided precingular on the dorsal side; the longitudinal furrow begins at the base of the rhomboidal plate and extends through the transverse furrow to the posterior end of the cell; posterior plates arranged according to the usual plan for the genus; chromatophores brown; eye-spot absent; length 45.8μ, width 43.4μ. Plate IX, figs. 1-4.

Pond. Dickinson County, July. (P).

2. *Peridinium Marssonii* Lemmermann

Schilling, 1913, p. 48, fig. 55.

Cells globose to ovate, slightly flattened dorso-ventrally; epitheca and hypotheca broadly rounding at the posterior end; individual plates concave, separated by broad intercalary bands with high edges; pores lacking; plates edged with spines which are more numerous in the posterior region; total number of plates 18, of which 11 compose the epitheca and 7 the hypotheca; in anterior view the plating shows a decided asymmetry, with the rhomboidal plate displaced to the left somewhat; to the left of the truncated end of the rhomboidal plate is adjoined a large 6-sided dorsal apical plate and to the right of the rhomboidal plate two additional apical plates, one dorsal and one ventral, these 2 adjoining a larger dorsal apical plate; 6 precingulars extending around to the large 5-sided dorsal apical plate; posterior plating consists of 2 large antapicals (of which the one on the left is larger) and 5 postcingulars; chromatophores disc-like, parietal; length 47-50μ, width 40-42μ, about 32μ thick. Plate IX, figs. 5-8.

Quarry pond, Johnson County, July. (P).

3. *Peridinium pusillum* (Penard) Lemmermann

Schilling, 1913, p. 40, fig. 45.

Cells ovate, dorso-ventrally compressed; the epitheca considerably larger than the hypotheca; anterior end conical, posterior briefly rounded; plates with fine areolations and without intercalary bands; total number of plates 20, of which 13 make up the epitheca and 7 the hypotheca; the plating of the epitheca consists of a six-sided apical plate at the vertex, joined at its ventral margin by a broad rhomboidal apical plate, at each of its four lateral margins by a 5-sided apical plate and dorsally by a large, 6-sided precingular; from the ventral rhomboidal apical plate extend on either side 3 precingulars which adjoin the large 6-sided dorsal precingular; posterior plating consists of two antapical plates bounded by 5 postcingulars; chromatophores yellowish-green; length 18-24μ, width 13-20μ. Plate IX, figs. 13-16.

Drainage Canal. Dickinson County, July. (P).

4. *Peridinium quadridens* Stein

Schilling, 1913, p. 37, fig. 41.

Cells elongate-ovate; epitheca and hypotheca of unequal size; the anterior end cupola in shape, ending in a blunt point; the hypotheca shorter than the epitheca and broadly truncated with two large spines at the posterior and a shorter spine on either side just below the transverse furrow; plates smooth on the upper surface (or with pores); the zones between the individual plates wide, without striations; plates 20 in number, of which 13 form the epitheca and 7 the hypotheca; the pole of the anterior end formed by the junction of four apical plates which are strongly produced, two on the right and two on the left side, being concave to make a short horn of the vertex; on the ventral side the rhomboidal plate lies between and adjoins two of these 4 central apical plates; dorsal to the 4 central plates is adjoined another 5-sided apical plate; extending from the rhomboidal plate right and left are 3 precingulars which adjoin a seventh precingular at the dorsal side; the two lateral precingulars being much larger than the others; the hypotheca plating consists of five postcingulars and two broad antapicals; each of the two lateral postcingulars and the two antapicals bearing a rather heavy conical spine; chromatophores dark brown; pigment spot conspicuous in the longitudinal furrow; length about 33μ, width 26μ. Plate IX, figs. 9-12.

Slough. Monona County, July. (P).

5. *Peridinium tabulatum* (Ehrenberg) Clap. and Lachm.

Schilling, 1913, p. 34, fig. 38.

Cells globose to ovate, flattened dorso-ventrally; the epitheca and hypotheca of unequal size, the anterior end somewhat produced and tapering with two spines at the apex; posterior broadly rounding, without spines; the transverse furrow winding to the left and conspicuously excavated, with narrow lists; longitudinal furrow extended into the epitheca a short distance; plates with reticular markings and fine spines which are conspicuous at the margin of the theca; intercalary bands broad with striations; total number of plates 21, of which 14 make up the epitheca and 7 the hypotheca; plates in epitheca show 7 apicals, the rhomboidal cell joined at each upper side by an apical plate; dorsal to these three plates are 4 more apical plates of which two are dorsal apicals and paired, separating the other two apicals which are lateral; extending right and left from the ventral sides of the rhomboidal plate are 3 precingulars, adjoining at the back with a 4-sided dorsal precingular; posterior plating consisting of two large antapicals surrounded by five postcingulars, the precingulars at the side and the one at the back being very large; chromatophores yellow-brown; pigment spot not present; length 48μ, width 43.5μ. Plate X, figs. 1, 2.

Lakes. Dickinson County, July. (P).

6. *Peridinium Westii* Lemmermann

Schilling, 1913, p. 47, fig. 53.

Cells nearly globose; epitheca and hypotheca approximately equal in size; plates separated by rather broad bands with many striæ; theca with many tortuous and branched lists; transverse furrow conspicuously left-handed; total number of plates 21, of which 14 make up the epitheca and 7 the hypotheca; anterior plating consisting of 2 ventral, 2 median and 2 dorsal apical plates which are so arranged as to appear crowded to the right of the vertex; from the rhomboidal apical plate, which lies ventrally to the other six apicals, extend right and left 3 precingulars which adjoin at the back with a large 5-sided dorsal precingular, 7 precingulars in all; posterior plating consisting of two broad antapicals, of which the one to the right is larger than the one to the left, surrounded by 5 postcingulars, the dorsal postcingular being the largest; chromatophores brown in color; length of theca 44-52μ, width 42.5-52μ. Plate X, figs. 3-5.

Drainage Canal. Dickinson County, July. (P).

7. *Peridinium Willei* Huitfeld-Kass

Schilling, 1913, p. 45, fig. 51.

Cells globose, flattened dorso-ventrally, the epitheca usually larger and more elongate than the hypotheca; armor strong, with fine pores and reticulations; intercalary bands with striæ; transverse furrow wound to the left, deeply concave with the edges of the lists and of the plates set with spines; longitudinal furrow extending into the epitheca for a short distance, in the hypotheca broadening posteriorly and reaching entirely to the pole where it terminates in two short spines; total number of plates 21, of which 14 make up the epitheca and 7 the hypotheca; anterior plating consisting of a broad rhomboidal plate, above which is a pair of lateral apicals which adjoin on their dorsal sides two other lateral apicals and a dorsal apical, the dorsal apical lying between these other two lateral apicals; these latter three (the dorsal and the two lateral apicals) forming a row extending right and left which adjoins dorsally with an arched dorsal apical or intercalary apical which is nearly as long as the combined length of the row of three apicals adjoining it; extending right and left from the almost three-sided rhomboidal apical are 3 precingulars which adjoin at the back with a large dorsal precingular; posterior plating consists of two very broad antapicals surrounded by 5 postcingulars; length of theca 51-61μ, width 53-64μ. Plate IX, figs. 17-20.

Drainage Canal. Dickinson County, July. (P).

GONYAULAX Diesing, 1866

Cell spherical, polyhedral or broadly fusiform, sometimes dorsoventrally flattened; epitheca usually broadly rounding, sometimes truncate, symmetrically or not, but never pointed; hypotheca broadly rounded or pointed, either symmetrical or not; transverse furrow usually median, displaced distally from one to seven times its width, sometimes with an overhang; longitudinal furrow extending for a short distance into the epitheca, broadening distally and reaching almost to the posterior pole; epitheca consisting of from one to six apical plates, one to three anterior intercalaries, six precingulars; six girdle plates; hypotheca consisting of six postcingulars, one posterior intercalary and one antapical; surface either smooth or roughened, sometimes with spines; furrows with lists, which may be ribbed or spiny or without lists; plates with pores; chromatophores yellow to dark brown in color.

1. *Gonyaulax palustris* Lemmermann

Schilling, 1913, p. 31, fig. 35.

Cells globose; hypotheca and epitheca about equal in size; longitudinal furrow broad, extending a little distance into the anterior [illegible] ... Plate [illegible], figs. [illegible].

Drainage Canal. Dickinson County, July [illegible].

BIBLIOGRAPHY

1. 1884. Bessey, C. E. Preliminary List of Zygophytes, Protophytes, Oophytes, and Carophytes of the Ames Flora. Bull. Ia. Agr. College, pp. 134-148.
2. 1907. Buchanan, R. E. Notes on the Algæ of Iowa. Proc. Ia. Acad. of Sci. 14:47-84.
3. 1909. Collins, F. S. The Green Algæ of N. A. Tufts College Studies. Scientific Series, vol. 2, No. 3.
4. 1926. Deflandre, M. G. Monographie du Genre Trachelomonas Ehr. Revue Generale de Botanique, 38.
5. 1927. ———— Ibid. (ibid.) 39.
6. 1925. Drezepolski, Roman. Przyczynek Do Znajomosci Polskich Euglenin. Polskiego Towarzystwa Przyrodnikow im. Kopernika. Tom 50. Zesz. 1. p. 1-270. Six plates.
7. 1906. Edmondson, C. H. Protozoa of Iowa. Proc. Davenport Acad. of Sci. 11:1-124.
8. 1905. Fink, Bruce. Notes on Iowa Algæ. Proc. Ia. Acad. of Sci. 12: 21-27.
9. 1920. Hodgetts, W. J. Notes on Freshwater Algæ. I-IV. New Phytol. 19:254-263.
10. 1925. Lebour, M. V. The Dinoflagellates of Northern Seas. Plymouth.
11. 1927. Pascher, A. Volvocales. Heft 4. Die Süsswasserflora Deut., Oster. und der Schweiz. Jena.
12. 1913. Pascher, A. and Lemmermann, E. Flagellatæ 2; Heft 2. Die Süsswasserflora Deut., Oster. und der Schweiz. Jena.
13. 1913. Schilling, A. J. Dinoflagellatæ (Peridineæ) Heft 3. A. Pascher; Die Süsswasserflora Deut., Oster. und der Schweiz. Jena.
14. 1925. Skvortzow, B. W. On *Trachelomonas hispida* (Perty) Stein and its varieties. New Phytol. 24:299-305.
15. 1920. Smith, G. M. Phytoplankton of the Inland Lakes of Wisconsin. Part I. Wisconsin Geological Survey. Bull. No. 57.
16. 1924. ———— The Plankton Algæ of the Palisades Interstate Park. Roosevelt Wild Life Forest Experiment Station. Vol. 2, No. 2.
17. 1926. ———— The Plankton Algæ of the Okoboji Region. Trans. Am. Micro. Soc. Vol. 45, No. 3.
18. 1927. West, G. S. and Fritsch, F. E. British Freshwater Algæ. Ed. 2. Cambridge.
19. 1908. Wilson, Guy West. Some Protozoa from Fayette, Iowa. Proc. Ia. Acad. Sci. 15: 169-171.

PLATE I

Fig. 1. Synura uvella (x 320).

2. S. Adamsii (x 460).

3. Dinobryon calyciforme (x 760).

4. D. divergens (x 525).

5. D. sociale (x 525).

6. D. sertularia (x 400).

7. D. stipitatum (x 675).

8. Gonium sociale (x 450).

9. Gonium pectorale (x 500).

PLATE I

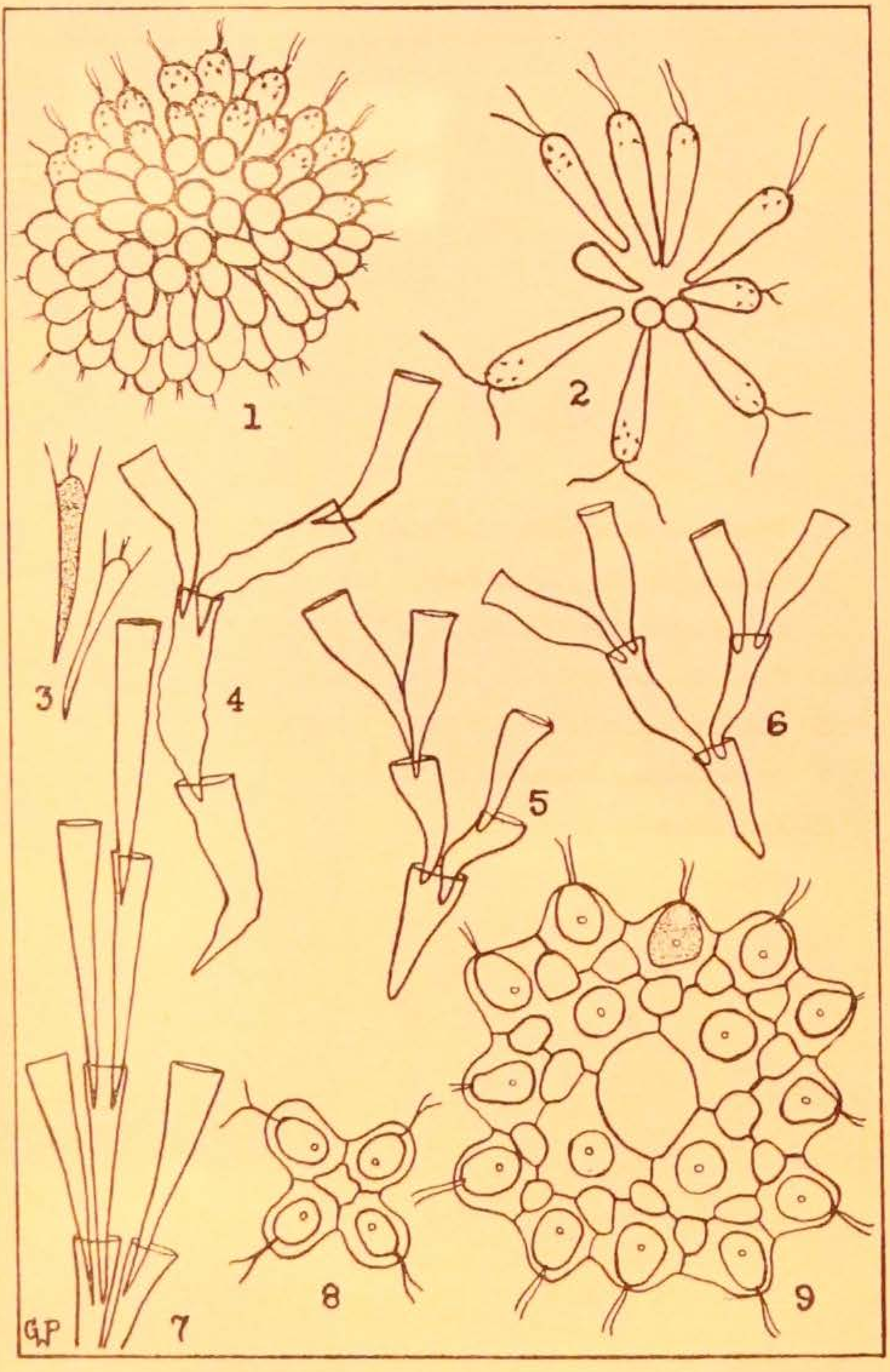

PLATE II

Fig. 1. Pleodorina illinoisensis, after Kofoid (x 300).

2. Eudorina elegans, after Fritsch (x 475).

3. Pandorina morum (x 500).

4. Pleodorina californica (x 160).

5, 6. Phacotus lenticularis, after Stein (x 1000).

7, 8. Pyramidomonas inconstans (x 1000).

9. Platydorina caudatum (x 500).

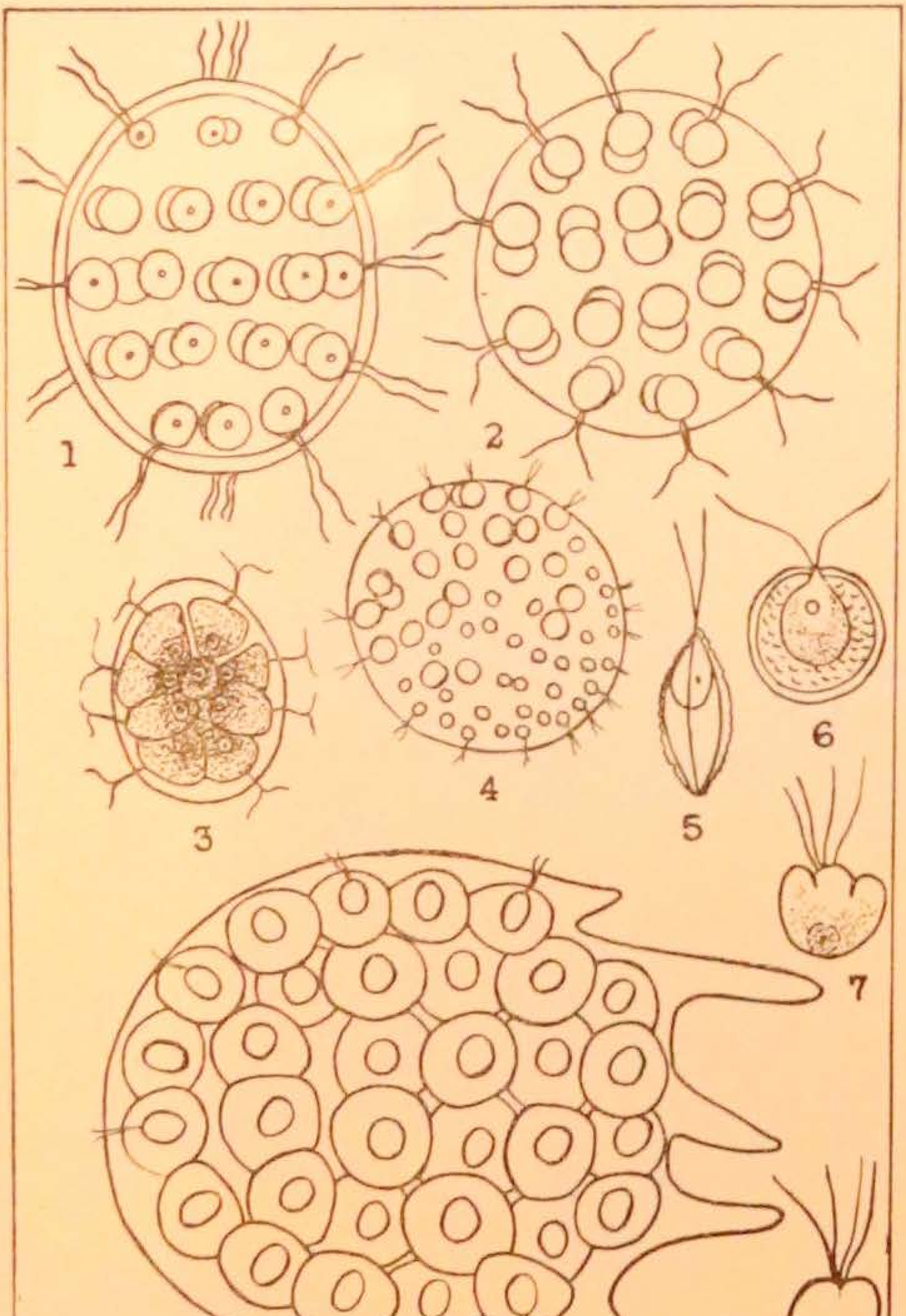
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PLATE III

Fig. 1. Volvox aureus (x 310).

2. V. mononæ (x 300).

3. V. globator, adapted from G. M. Smith (x 266).

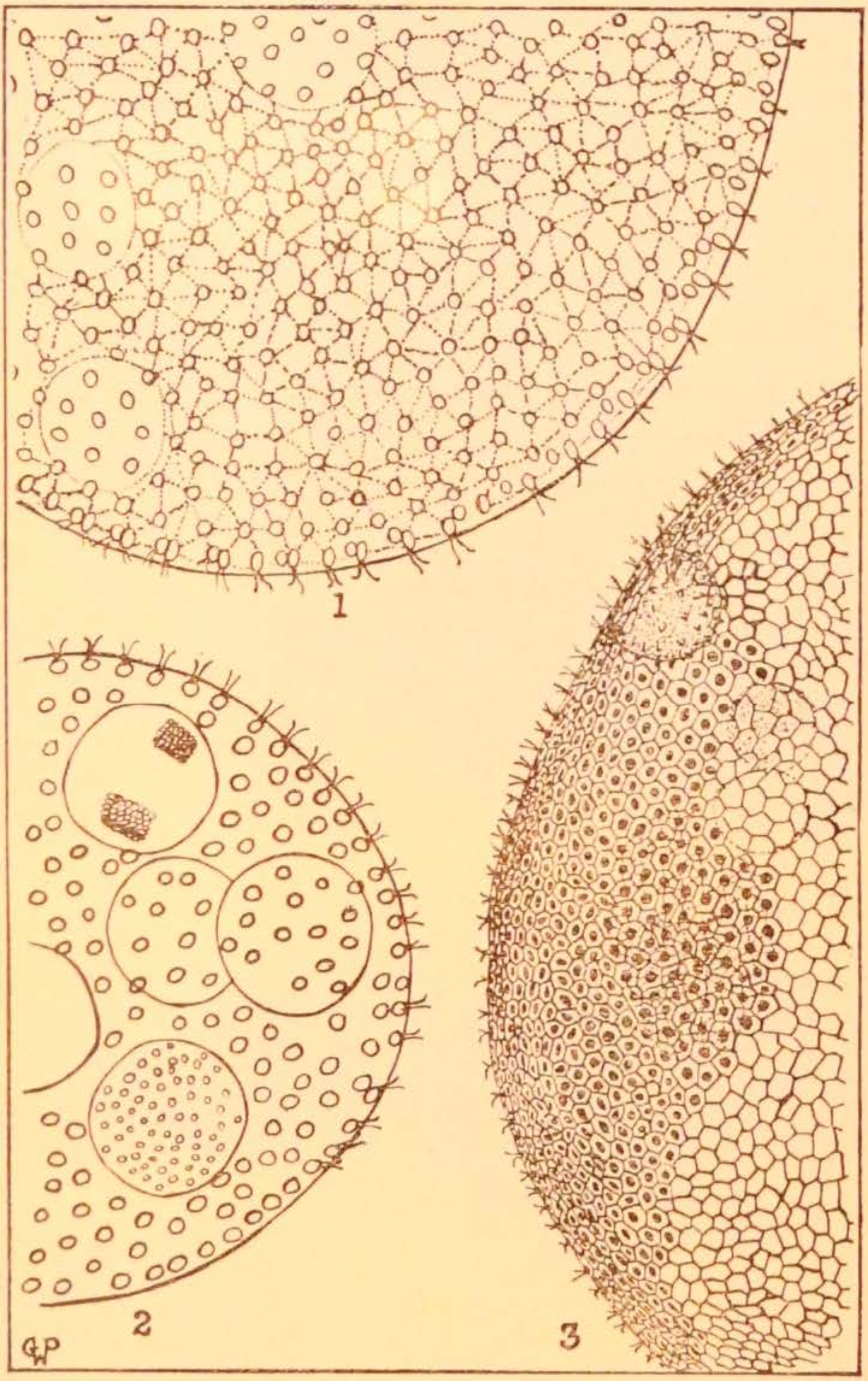
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PLATE IV

Fig. 1, 2. Chlamydomonas Ehrenbergii (x 900).

3. C. globosa (x 1000).

4, 5. C. anglica (x 760).

6. C. Snowii (x 2000).

7. Euglena acus (x 410).

8. E. spirogyra (x 650).

9. E. proxima (x 640).

10. E. deses (x 650).

11. E. pisciformis (x 500).

12. E. acutissima (x 760).

13. Heteronema spirale (x 510).

14. Euglena viridis (x 620).

15. E. sanguinea (x 650).

16. E. elongata (x 760).

PLATE IV

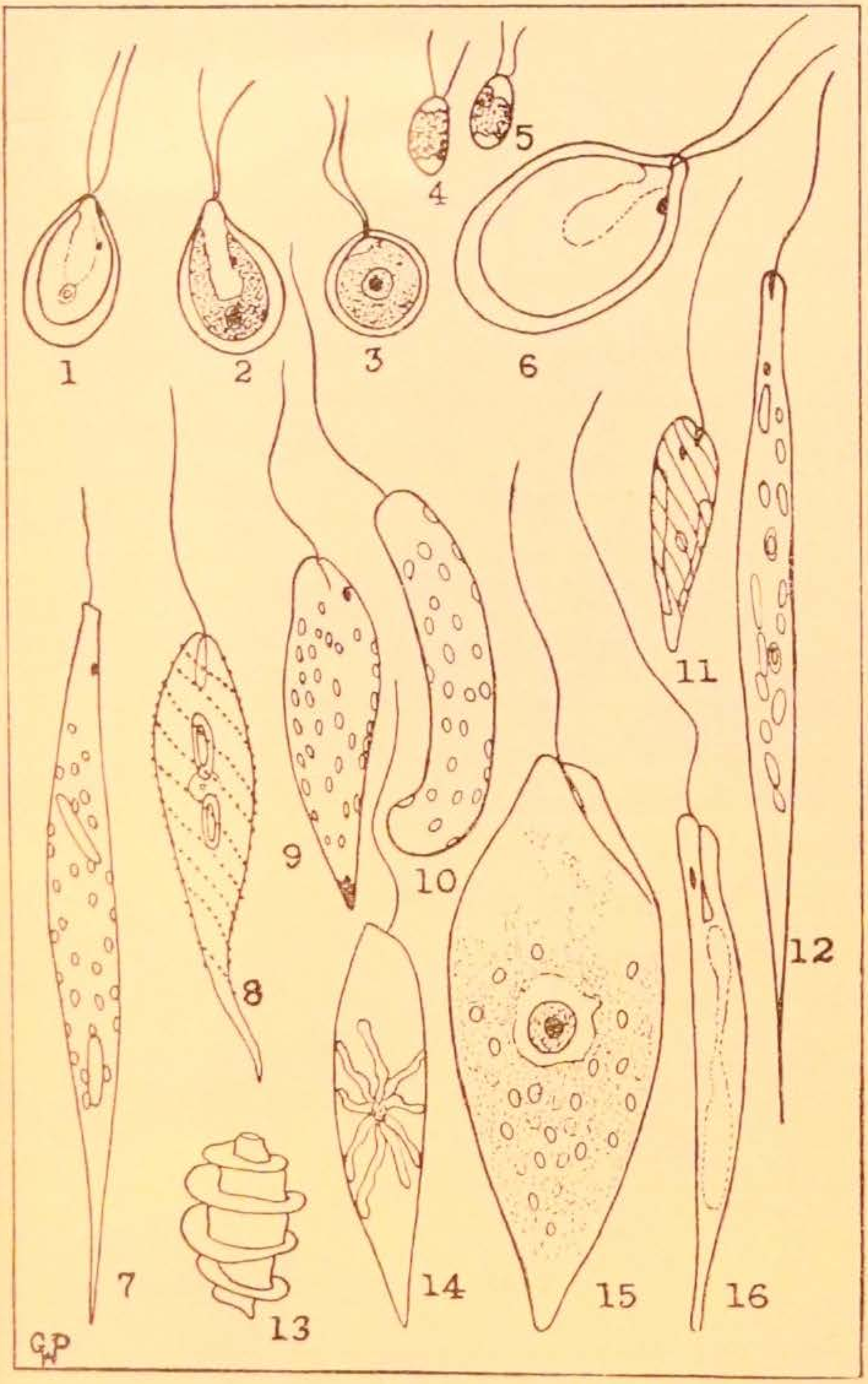

PLATE V

Fig. 1. Phacus brevicauda (x 530).

2, 3. Pteromonas angulosa, after West (x 1000).

4, 5. P. angulosa, (P. cordiformis Stein) (x 640).

6. Phacus pyrum (x 800).

7. Lepocinclis fusiformis (x 1000).

8. L. ovum (x 560).

9. Phacus acuminata (x 780).

10. Heteronema acus, after Edmondson (x 1000).

11, 12. Pteromonas aculeata (x 650).

13. Phacus longicauda (x 460).

14. P. pleuronectes (x 810).

15, 16. P. longicauda var. torta (x 500).

17. Euglena spiroides (x 320).

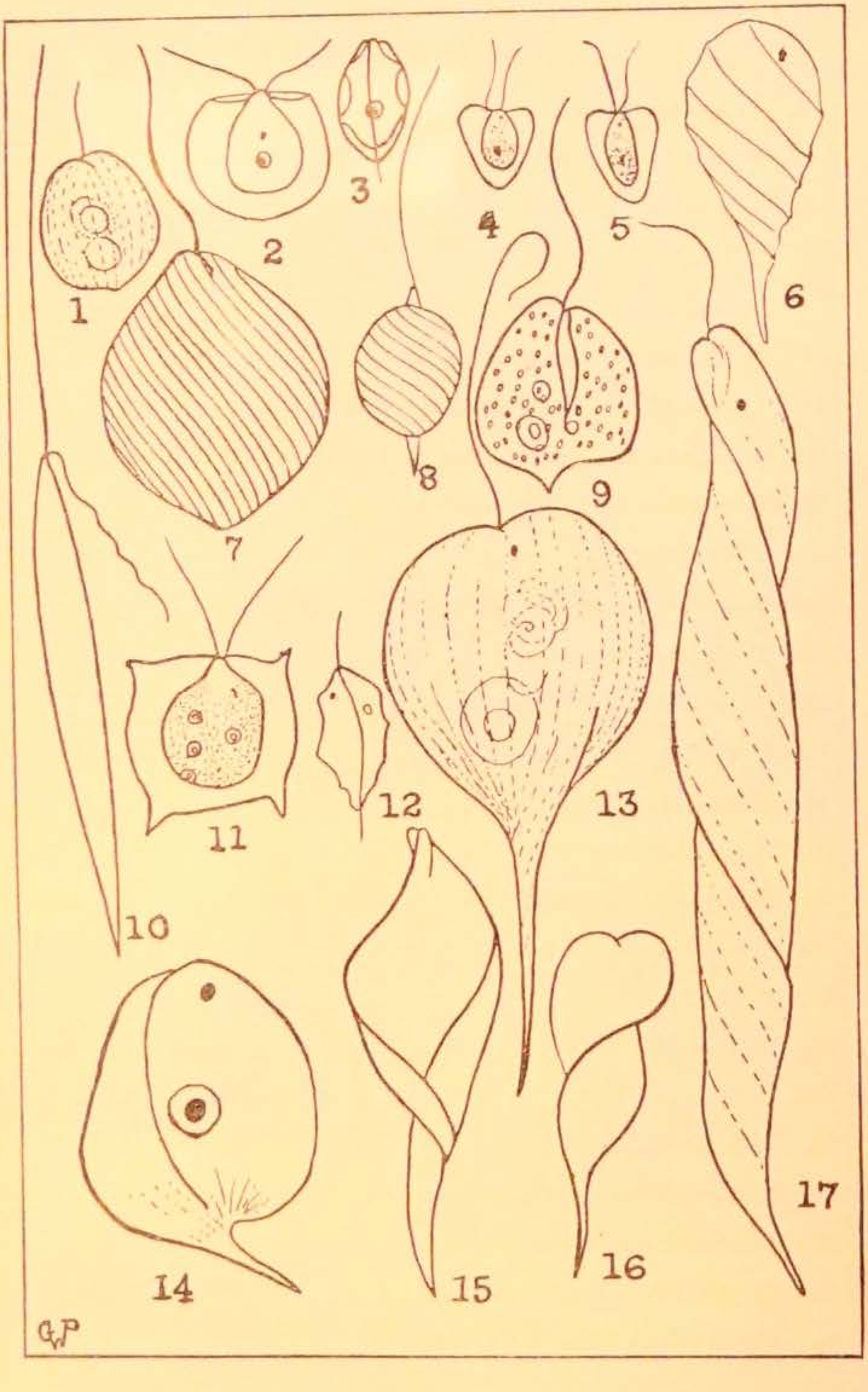
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PLATE VI

Fig. 1. Trachelomonas abruptum var. Bonnieri (x 835).
2. T. affinis var. levis (x 515).
3. T. armata (x 500).
4. T. armata var. Steinii (x 500).
5. T. horrida (x 700).
6, 7. T. ensifera (x 625).
8. T. hispida (x 500).
9. T. hispida var. coronata (x 500).
10. T. hispida var. crenulatocollis (x 760).
11. T. hispida var. punctulatum (x 675).
12. T. hispida var. verrucosa (x 690).
13. T. Raciborski (x 710).
14. T. Raciborski var. punctata var. nov. (x 865).
15. T. planctonica (x 720).
16. T. reticulata (x 850).
17. T. spinosa (x 650).
18. T. volvocina (x 560).
19. T. piscatoris (x 700).
20. T. rugulosa (x 700).
21. T. obovata (x 700).
22. T. elegans (x 1000).
23. T. abrupta (x 700).
24. T. allia (x 700).
25. T. superba (x 470).
26. T. horrida var. paucispina var. nov. (x 690).
27. Turbinella ænigmatica (x 710).
28. Cryptoglena pigra (x 1000).
29. Nephroselmus olivacea (x 1000).

PLATE VI

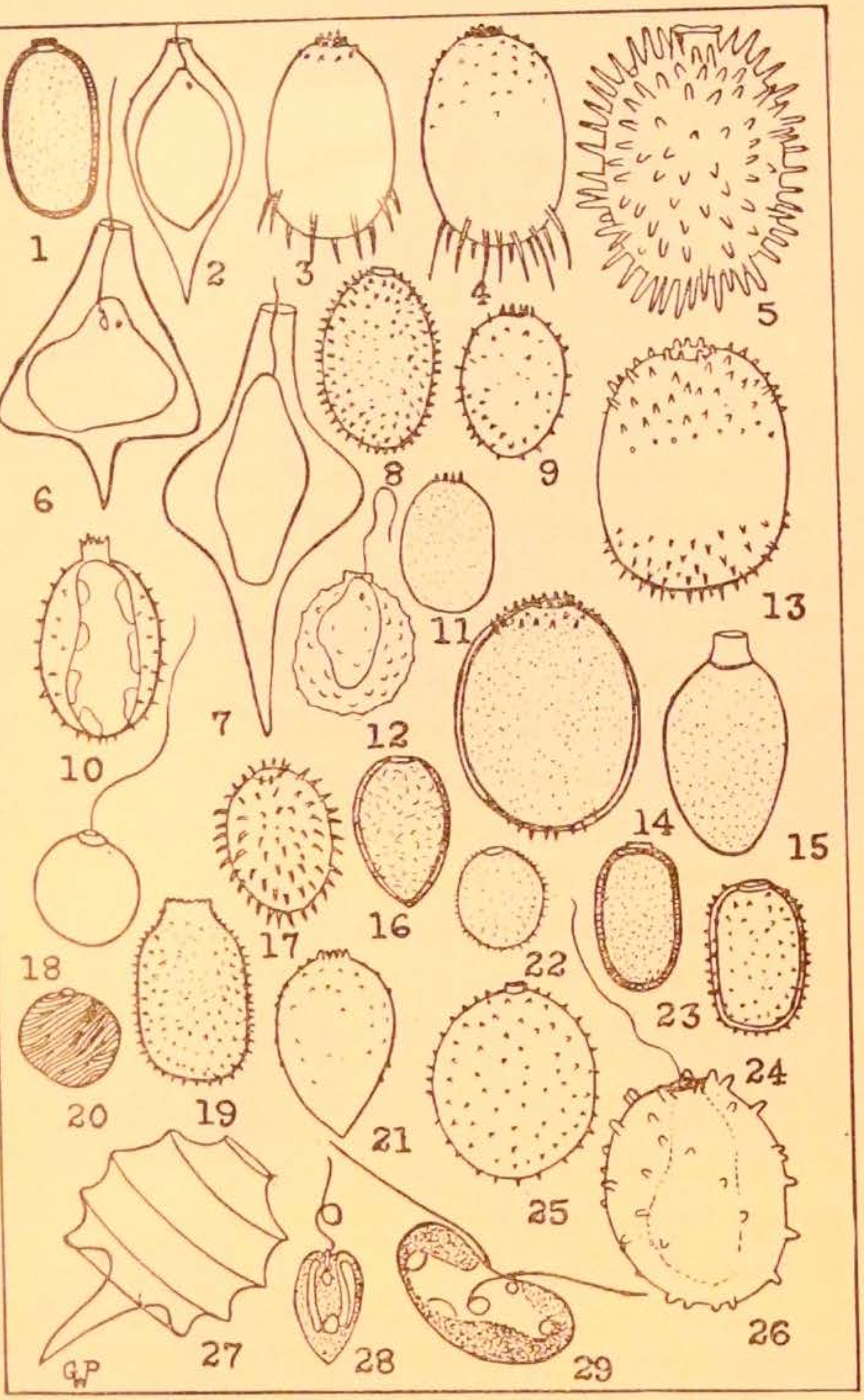
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PLATE VII

Fig. 1. Entosiphon sulcatum, after Edmondson (x 1500).

2. E. sulcatum, after Stein (x 934).

3, 4. Astasia trichophora, after Edmondson (x 930).

5. Distigma proteus, after Lemmermann (x 667).

6. Cryptomonas ovata, after Pascher (x 1200).

7. Anisonema truncatum, after Stein (x 650).

8. A. acinus, after Lemmermann (x 667).

9. Notosolenus apocamptus, after Edmondson (x 2000).

10. Petalomonas mediocanellata, after Klebs (x 500).

11. Chilomonas paramæcium, after Butschli (x 2000).

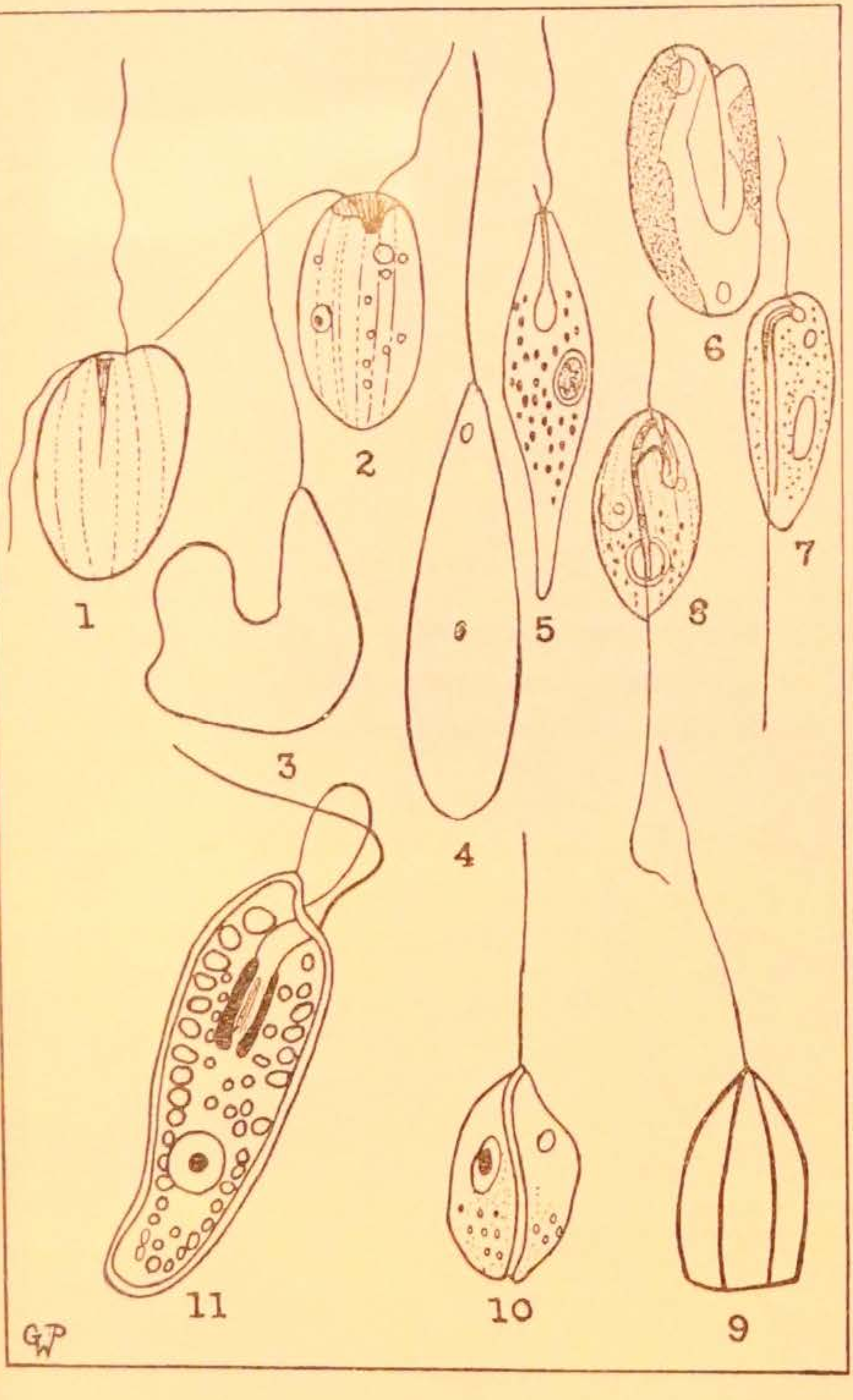
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PLATE VIII

Fig. 1. Ceratium hirundinella (x 500).

2. C. hirundinella forma robustum (x 500).

3. C. hirundinella forma carinthiacum (x 500).

PLATE VIII

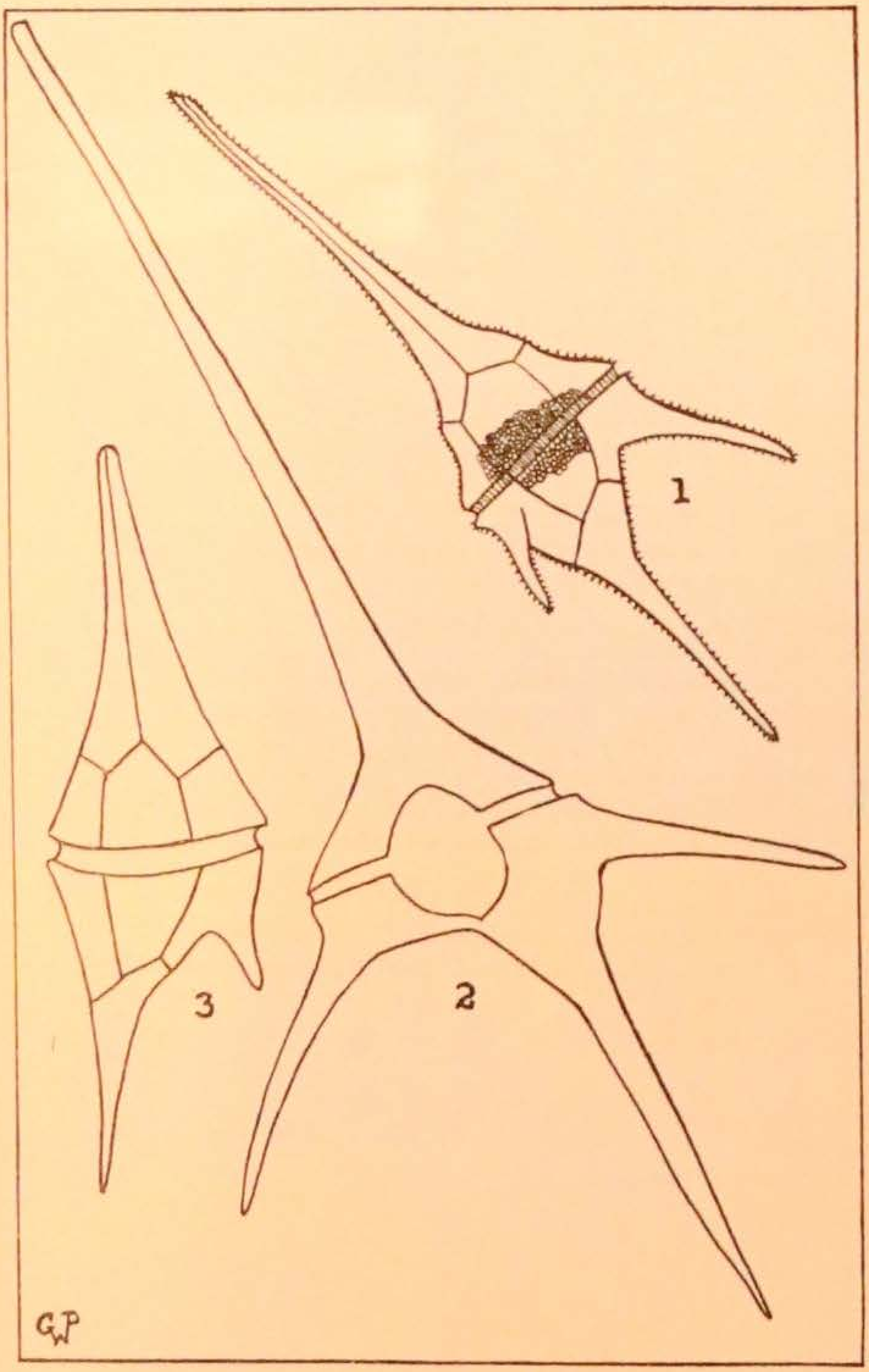

PLATE IX

Figs. 1-4. Peridinium cinctum.
1.-dorsal; 2.-ventral (x 744).
3.-anterior; 4.-posterior, after Schilling.

Figs. 5-8. P. Marssonii.
5.-dorsal; 6.-ventral; 7.-apical; 8.-antapical,
all after Schilling (x about 380).

Figs. 9-12. P. quadridens.
9.-dorsal; 10.-ventral (x 630).
11.-apical; 12.-antapical, after Schilling.

Figs. 13-16. P. pusillum.
13.-dorsal; 14.-ventral (x 680).
15.-apical; 16.-antapical, after Lemmermann.

Figs. 17-20. Peridinium Willei.
17.-dorsal; 18.-ventral (x 600).
19.-apical; 20.-antapical, after Schilling (x ?).

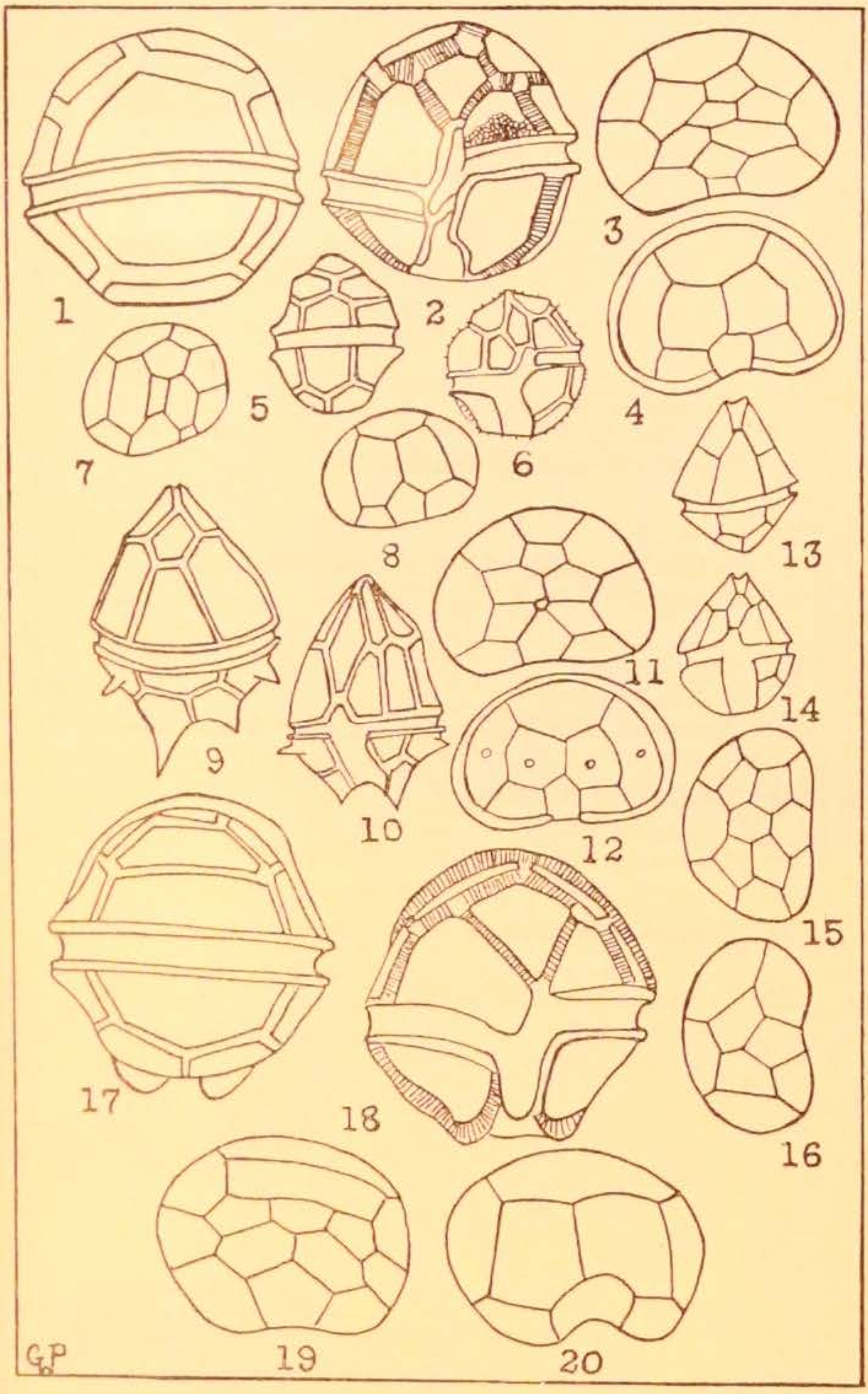
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PLATE X

Figs. 1-2. Peridinium tabulatum.
1.-ventral (x 930).
2.-antapical, after Lindemann.

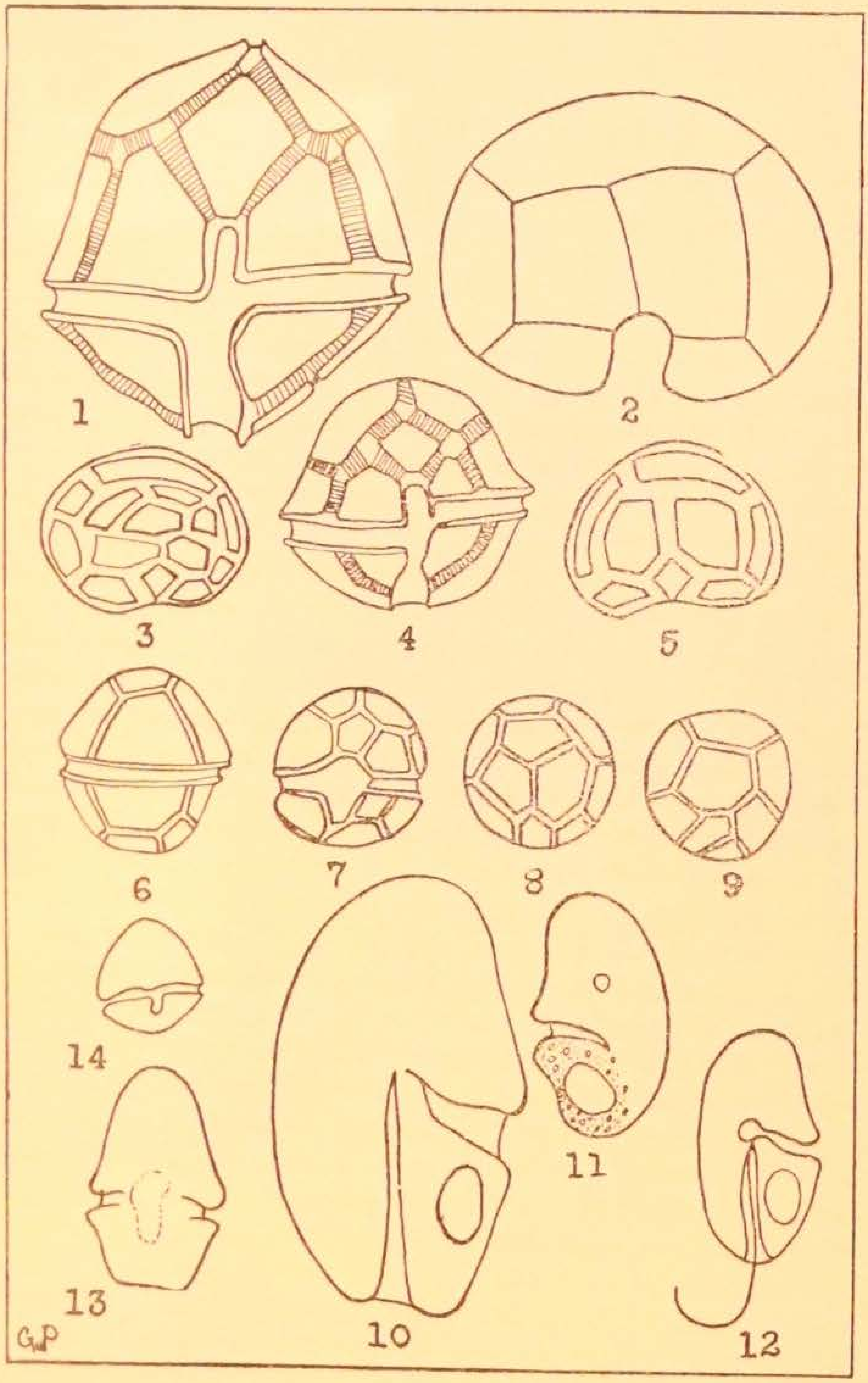
Figs. 3-5. P. Westii.
3.-apical; 5.-antapical, after Lemmermann (x ?).
4.-ventral (x 560).

Figs. 6-9. Gonyaulax palustre.
6.-dorsal (x 660).
7.-ventral; 8.-apical; 9.-antapical, after Lemmermann (x ?).

Figs. 10-12. Hemidinium nasutum.
10.-ventral (x 730).
11.-dorsal; 12.-ventral, after Stein (x ?).

Fig. 13. Gymnodinium palustre, ventral (x 565).

Fig. 14. G. vorticella, ventral (x 600).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THE FOLIAR TRANSPIRING POWER OF THE PONDWEED (POTAMOGETON NATANS)

A. L. Bakke

Ample experimental proof of the existence of a transpiration stream in aquatic plants has been submitted by Sauvageau (10), Thoday and Sykes (11), and Snell (9). Bergerstein in his monograph on transpiration has called attention to the early work of Unger[1] performed in 1862 upon *Potamogeton crispus* and *Ranunculus fluitans* and that of Hochreutiner[2] on *Ranunculus aquatilis, Potamogeton pectinatus, P. crispus, P. densus* where they were able to demonstrate water movement. In their measurements of the water outgo, only a portion of the plant was employed. It was necessary to use some reagent which would make the path as well as the extent of transpiration visible. Otis (8) determined the transpiration of such marsh plants as *Scirpus validus, S. americanus, Pontederia cordata, Sagittaria latifolia, Acorus calamus, Sparganium eurycarpum, Typha latifolia*, and *Castalia odorata*. Of the citations given, there is a general agreement to the effect that emersed plants transpire large amounts of water. The necessary rapid movement is conditioned by the extent of the leaf surface. In the experiments quoted the plants are not in their regular habitat but are either decapitated or lifted from their original place of adjustment. Both, however, show that water is eliminated rapidly. It occurred to the writer that it would be desirable to gain additional information on the water relations of submerged plants. The resistance to the passage of water should be at least as valuable, as direct readings obtained by methods employed previously. It will be remembered that this question of the resistance of leaves to transpirational water loss was first substantiated by Livingston (4) using the hygrometric paper, cobalt chloride, where the time in which it takes the blue cobalt chloride paper to become pink when placed in contact with a

[1] Unger, F. Neue Untersuchungen über die Transpiration der Pflanzen. Sitzb. d. kk. Akad. der Wissensch. Wien. 44:181-327, 1862.

[2] Hochreutiner, G. Physiologie des plantes aquatiques du Rhone et du de Genéve. Revue gén. de Botanique. 8:258-264, 1896.

leaf surface is compared with the time required to make a similar change over a standard water evaporating surface. The original method has been further elaborated and improved by Bakke (1) and by Livingston and Shreve (6). The use of hygrometric paper in investigations on the transpiration of plants is sufficiently familiar so that the method need not be described here. Reference may readily be made to the original articles. In dealing with *Potamogeton natans* it is clear from the beginning that it would not be possible to use the same form of apparatus to determine the time required to change the hygrometric paper from blue to pink when

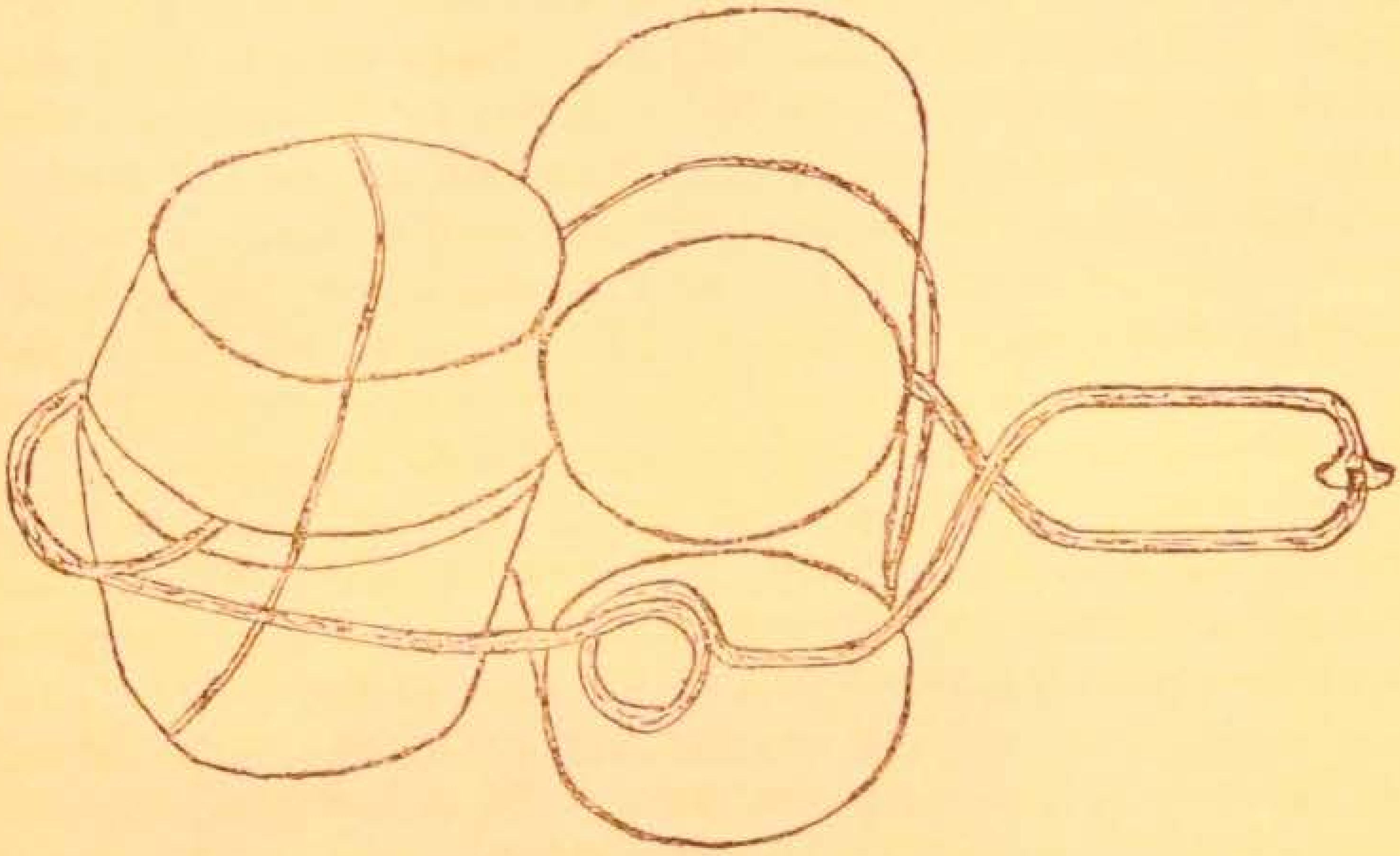

Fig. 1 General sketch of devised floating clip to measure the foliar transpiring power of floating leaves.

the cobalt paper is attached to the leaf surface. In order to facilitate matters, a special form of floating clip was devised where four large corks, two flat and two of the usual dimensions were attached to a regular cover glass forceps by means of a thin copper wire. On one of the ends a circular disc of tin, 1 cm. in diameter was soldered, so that the other end would firmly press again the disc. If a cover slip is inserted between the disc and the other point, the cover slip will not be broken but at the same time is secure. The clip is so adjusted that it will float upon the water surface. (See fig. 1). The construction is made clearer by the detailed mechanical drawing (fig. 2). The possibility of using a cover slip in attaching cobalt chloride papers so that measurements of the foliar transpiring power might be made was first suggested to me by Dr. Shive of the New Jersey Agricultural Experiment Station long before active investigation on the foliar transpiring power of aquatic plants had been thought of. The method consists in taking a cover slip and cutting out an annulet or washer made from black mending tape so that the outside is the same as that of the cover slip while the inside

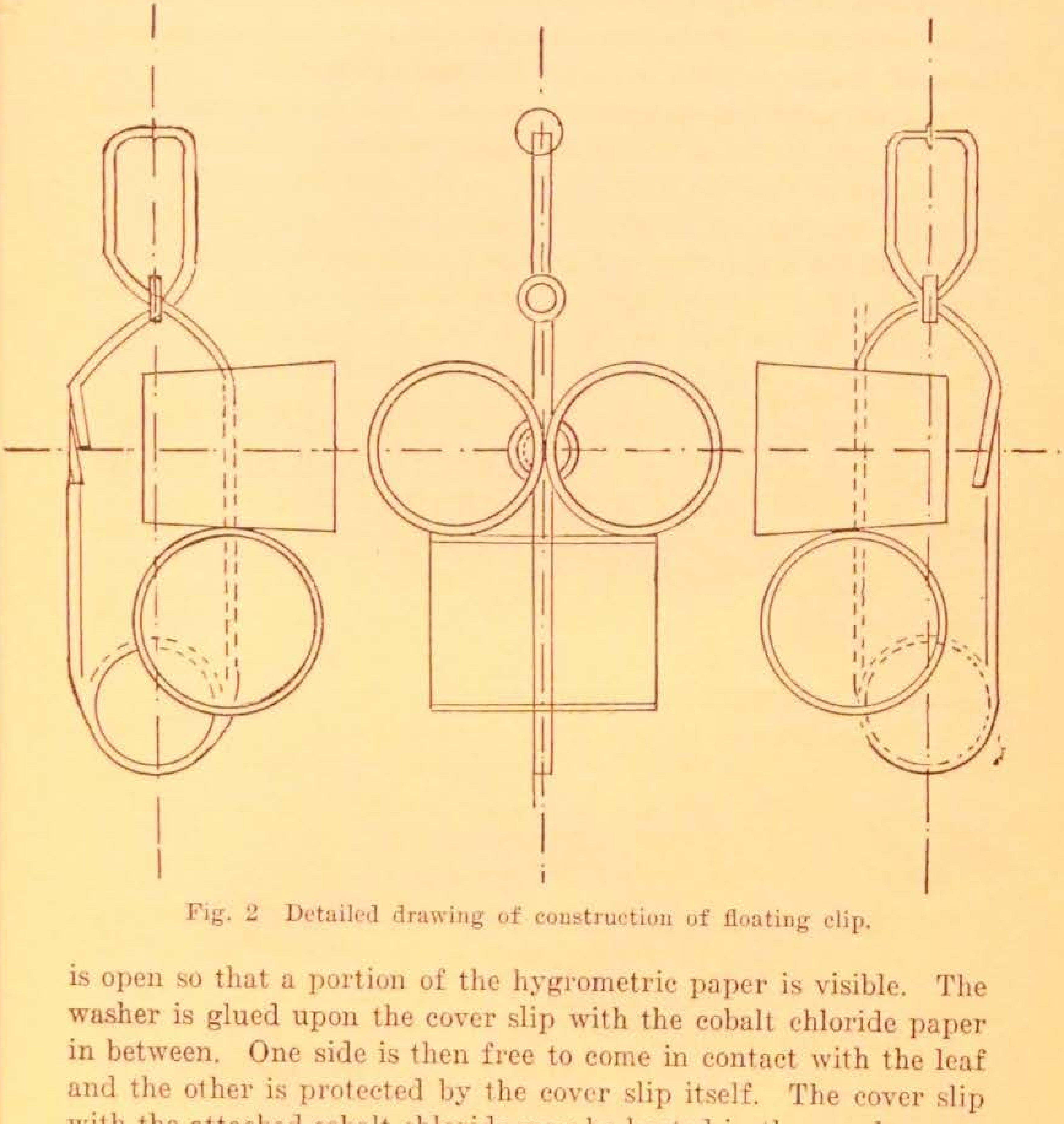

Fig. 2 Detailed drawing of construction of floating clip.

is open so that a portion of the hygrometric paper is visible. The washer is glued upon the cover slip with the cobalt chloride paper in between. One side is then free to come in contact with the leaf and the other is protected by the cover slip itself. The cover slip with the attached cobalt chloride may be heated in the usual way as for the regular method until the blue color is produced. The slip, of course, is so attached that the covered portion faces upward. By means of the floating clip the special form of cobalt paper carrier is held in place upon the leaf surface, and prevents it from being submerged or wetted. At first the tripartite paper as recommended by Livingston and Shreve (6) was used but later it was found that reliable results could be obtained by using the simple paper.

The work was done at the Lakeside Laboratory of the University of Iowa during the summer of 1923 and 1924. My thanks are due Drs. Wylie and Stromsten for placing at my disposal the facilities of the laboratory. *Potamogeton natans* was chosen because it was the most accessible plant during the season of 1923.

In addition to the equipment specified, floating clips, and cobalt chloride slips, it was, of course, necessary to have a means of heating the papers so that the color would be changed from pink to blue. For this purpose an acetylene lantern proved very satisfactory. Otherwise the apparatus and manipulations are the same as have been submitted in previous work upon the foliar transpiring power of plants. A row boat which can be securely anchored is another prerequisite. The data as obtained are submitted in the following table.

TRANSPIRING POWER OF THE FLOATING LEAVES OF *POTAMOGETON NATANS.*

Date	Time	Average foliar transpiring power
1923		
July 12	1:40 P.M.	0.595
July 12	4:00 P.M.	0.595
July 13	5:00 A.M.	0.818
July 13	9:00 A.M.	0.545
July 13	3:00 P.M.	0.556
July 13	5:00 P.M.	0.758
1924		
August 8	8:00 A.M.	0.882
August 8	2:00 P.M.	0.750
August 8	5:00 P.M.	0.687
August 8	10:00 A.M.	0.812

The data given for the foliar transpiring power of *Potamogeton natans* for the years 1923 and 1924 do not show a great deal of deviation. The highest point noticed in the data of the first year is at 5 p.m. For 1924 the data from time to time do not diverge as much as during the year previous. It may be said that both sets of data were taken on clear days when the evaporation power of the air was quite high. However there is not the variation experienced for *Helianthus* and *Xanthium* by Bakke and Livingston. The figures for 1924 show no agreement whatsoever between the highest evaporation and the maximum transpiration. The maximum evaporation as measured from a Livingston cylindrical form of standardized atmometer gave the highest value at about 2 p.m. while the maximum transpiring power was obtained at some time previous. One thing will be certain and that is that the movement of the stomata was small and the resistance to the passage of water slight.

In order to determine whether or not the stomata are nonfunctioning as far as the opening and closing of the guard cells are concerned, sections of a number of leaves of this pond weed were fixed in absolute alcohol according to the method of Lloyd (7). From various samples taken at different times for both 1923 and 1924, it was found that the guard cells were open throughout. The average

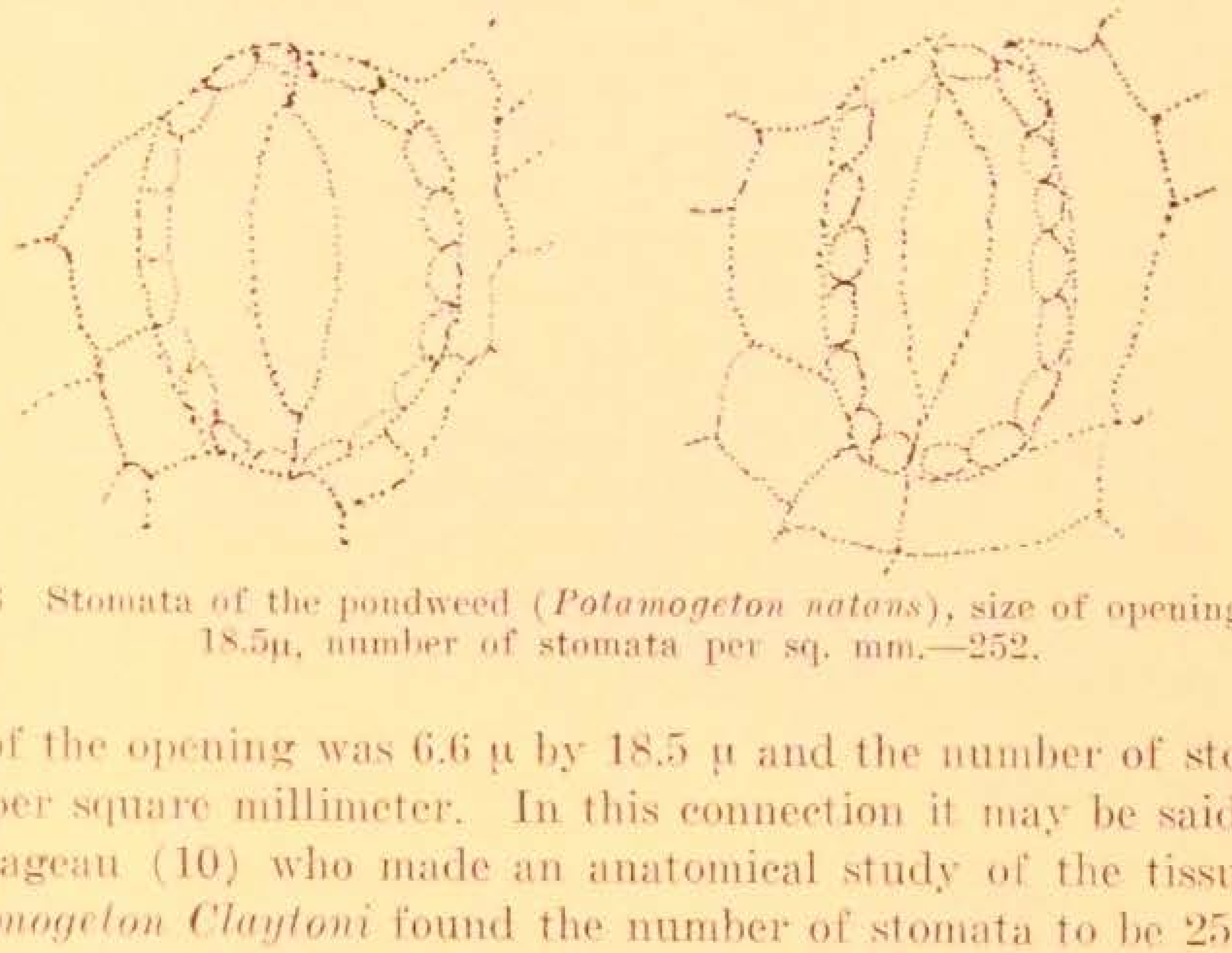

Fig. 3 Stomata of the pondweed (*Potamogeton natans*), size of opening 6.6μ-18.5μ, number of stomata per sq. mm.—252.

size of the opening was 6.6 μ by 18.5 μ and the number of stomata 252 per square millimeter. In this connection it may be said that Sauvageau (10) who made an anatomical study of the tissues of *Potamogeton Claytoni* found the number of stomata to be 255 per square millimeter of leaf surface.

From this study it is apparent that by the specially constructed apparatus the cobalt chloride method may readily be used to determine the foliar transpiring power of such aquatic plants as *Potamogeton natans*. It is also clear from the data given that the resistance to the passage of water is slight.

LITERATURE CITED

1. Bakke, A. L. Studies on the transpiring power of plants as indicated by the method of standardized hygrometric paper. Jour. Ecol. 2:145-173, 1914.
2. Bakke, A. L. and Livingston, B. E. Further studies on the foliar transpiring power of plants. Physiol. Res. 2:51-71, 1916.
3. Bergerstein, A. Die Transpiration der Pflanzen. Jena 1904, 1920.
4. Livingston, B. E. The resistance offered by leaves to transpirational water loss. Plant World 16:1-35, 1913.
5. Livingston, B. E. Atmometry and the porous cup atmometer. Plant World 18:21-30, 51-74, 95-111, 143-149, 1915.
6. Livingston, B. E. and Shreve, E. B. Improvements in the method for determining the transpiring power of plant surfaces by hygrometric paper. Plant World 19:287-309, 1916.
7. Lloyd, F. E. The physiology of the stomata. Carnegie Inst. Wash. Pub. 82, Washington, 1908.
8. Otis, C. R. The transpiration of emersed water plants: Its measurement and its relationships. Bot. Gaz. 58:457-494, 1913.
9. Snell, K. Der Transpirationstrom der Wasserpflanzen. Ber. Deut. Bot. Gesel. 30:361-362, 1912.
10. Sauvageau, Camille. Feuilles des Monocotylédones aquatiques. Ann. des Sci. Nat. Bot. 13:103-296, 1891.
11. Thoday, D. and Sykes, N. G. Preliminary operations on the transpiration current in submerged water plants. Ann. of Botany 23:635-637, 1909.