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PROTOZOA OF THE DEVIL'S LAKE COMPLEX, NORTH DAKOTA

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1. INTRODUCTION

Several reports previously issued[2] have described the physiographic and chemical characteristics of Devil's Lake situated in Ramsey County, North Dakota. In a recent paper Dr. R. T. Young,[3] of the University of North Dakota, has indicated something of the possibilities and limitations of the lake from a biological point of view, as well as the general scope of the work already accomplished in that direction. It will only be necessary, therefore, to set forth a few of the specific features of this water area which may have some bearing on the report to follow.

[1] The investigations included in this report were carried on at the State Biological Station of North Dakota.

[2] Biennial Report of the State Biological Station of North Dakota, 1911–12.

Pope, T. E. B. Devil's Lake, North Dakota, a study of physical and biological conditions, with a view to the acclimatization of fish. U. S. Bureau of Fisheries Document 634, 1908.

Simpson, H. E. The Physiography of the Devil's-Stump Lake Region, North Dakota. Sixth Biennial Report of the State Geological Survey of North Dakota, 1912.

Upham, W. The Glacial Lake Agassiz, Mon. 25, U. S. Geological Survey, 1895.

[3] Young, R. T. The Work of the North Dakota Biological Station at Devil's Lake. The Scientific Monthly, December, 1917.

The origin of Devil's Lake may be traced to glacial action and at an early period the united waters of this region must have covered a very large area. In 1883 the United States Geological Survey estimated the area of the lake at 125 square miles, and at that time it had a depth of 60 feet, while at the present time its area is about one-half and its maximum depth one-third that of thirty-seven years ago. By a gradual drying up of the lake and the establishment of certain roadways, it has been divided into four larger bodies of water and a number of smaller ones. These four divisions have been designated as the Western Section, Main Lake, East Lake and Lamoreau Bay. To the southwest of Lamoreau Bay is situated Stump Lake, in times past connected with the main body and included in the complex for purposes of this report. Within recent years Big and Little Mission Lakes have been entirely cut off from the main lake at its southeast border, and parallel with the southwest border of the main lake are a number of smaller lakes, which at one time were parts of the common body of water. The concentration of the water of these lakes approaches or exceeds that of the main lake. Locally they are designated as lakes "C," "N," and "O." A limited survey of these lakes was made in connection with the preparation of this report.

A general recession of the lake by evaporation has naturally resulted in an increased salinity which, although varying considerably with the seasons and localities, amounts to approximately 1% at the present time. The solids are, for the most part, sulphates of sodium and magnesium and sodium chloride. The following table represents the relative amounts of salts as determined by the United States Bureau of Chemistry from samples of water taken in June, 1906:[4]

	Parts per Million
Calcium bicarbonate	119.8
Magnesium bicarbonate	647.6
Magnesium carbonate	167.0
Magnesium sulphate	1,470.0
Sodium sulphate	4,758.9
Sodium chloride	1,354.0
Total	8,517.3

[4] Pope, T. E. B. Devil's Lake, North Dakota, a study of physical and biological conditions, with a view to the acclimatization of fish. Bureau of Fisheries Document 634, 1908.

The following analysis was made by the United States Bureau of Chemistry in 1907, from samples taken at Station 6, East Lake:[4]

	Parts per Million
Carbonic acid ion	154.9
Bicarbonic acid ion	555.6
Silica	44.0
Chlorin	1,122.0
Iron	16.4
Calcium	31.2
Magnesium	601.6
Sulphuric acid ion	6,254.4
Sodium	2,725.3
Potassium	250.0

The concentration of the water from East Lake was somewhat higher than that from any one of five other localities, the analyses of which were made at the same time.

In the shallower parts and about the borders of the lake the ditch grass, *Ruppia maritima*, forms luxuriant growths, while the greater portion of the bottom is covered with a thick layer of ooze. In 1901 Dr. Heath,[5] then of the Department of Chemistry of the University of North Dakota, made the following analysis of the ooze from the bottom of Creel Bay, an arm of the main lake:

Volatile (mostly organic matter)	28.80%
SiO_2	27.43%
Insoluble sulphates	12.78%
Fe_2O_3 and Al_2O_3	13.11%
Calcium	8.97%
Magnesium	0.47%
Manganese	0.026%

Moore ('17),[6] in concluding a list of algae from Devil's Lake, says: "Excluding the diatoms, of which there seems to be a considerable number of species, the algal flora of Devil's Lake can hardly be said to be recorded as a rich one." This investigator attributes the almost total absence of certain groups of algae to the high content of salts in the water, but, in general, he finds the algal flora typically a fresh water one and showing little or no effect of the concentration of water.

[5] From unpublished notes.

[6] Moore, G. T. Preliminary list of algae in Devil's Lake, North Dakota. Annals of the Missouri Botanical Garden 4; 293–303, November, 1917.

Biological studies of Devil's Lake made by the United States Bureau of Fisheries in 1908 indicate the presence of four vertebrate inhabitants of the lake, namely: a stickleback, *Eucalia inconstans;* a minnow, *Pimephales promelas;* the hellbender, *Crytobranchus alleghaniensis;* and the leopard frog, *Rana pipens.* Among the metazoan invertebrates reported are crustaceans, rotifers, nematodes, a flat worm, an arachnid and a number of species of insects. One may collect the shells of at least fifteen molluscs from the water line on the shore, but no living forms have been taken from the lake. Sponges, coelenterates, polyzoans and annelids are apparently entirely absent.

Investigations of the protozoan fauna of the Devil's Lake complex were undertaken as a part of the general biological survey of that water area. Although, in many respects, this fauna was found to be such as one might expect in a fresh water lake of similar depth, yet some very pronounced differences were disclosed. The almost total absence of shell-bearing rhizopods may possibly find its explanation in the chemical analysis of the water. *Arcella vulgaris* Ehrenberg, a very constant and usually abundant form in fresh water, was rarely observed and two species of *Difflugia*, which are among the most common protozoa in lakes where there is considerable ooze, were taken only in situations where the salinity of the water must have been materially reduced by the in-seepage of surface water. A species of *Euglypha* was taken in the overflow of the lake water from the fish tank. The only other shelled rhizopod observed was a single specimen of *Cyhoderia ampulla* Leidy, taken from the main lake.

The fact that the ooze at the bottom of the lake at times has been found to be entirely free from oxygen might also be a contributing factor to the scarcity of these usually common bottom-dwelling rhizopods of the shell-bearing type, although the presence of the larvae of a certain midge in this ooze as well as the work of Birge and Juday in Wisconsin,[7] where a considerable number of animals were found at the bottom of lakes in the absence of oxygen, would hardly seem to make this factor one of great importance.

Experiments of a preliminary character, recorded at the end of the taxonomic part of this report, indicate that certain protozoa having

[7] Birge and Juday, The Inland Waters of Wisconsin; Wisconsin Geological and Natural History Survey, 1911.

adjusted themselves to fresh water conditions are not, in all cases at least, readily adaptable to the waters of Devil's Lake.

The writer wishes to acknowledge his indebtedness to Dr. R. T. Young, Director of the State Biological Station of North Dakota, whose co-operation made this report possible, and to Mr. E. G. Moberg for his valuable assistance in collecting material.

2. Taxonomy

SUBPHYLUM SARCODINA
CLASS RHIZOPODA
SUBCLASS AMOEBAE
ORDER GYMMAMOEBIDA

Family Amoebidae

Genus Amoeba Ehrenberg, 1831

Amoeba proteus (Rösel).

Der kleine Proteus Rösel, Insecten Belustigung, 1755, tab. 101.

Amoeba proteus Leidy, Pr. Ac. Nat. Sc., 1878.

Occurrence.—Associated with *Ruppia* in Whipple Bay, Creel Bay, Minnewaukon Bay, Six-mile Bay, East Lake, and also taken from the east side of the main lake and from the overflow of lake water from the fish tank near the laboratory.

Amoeba radiosa Ehrenberg.

Amoeba radiosa Ehrenberg, Abh. Akad. Wiss., Berlin, 1830.

Occurrence.—Rarely observed. Taken with *Ruppia* from Minnewaukon Bay, also from Big Mission Lake.

Amoeba limax Dujardin.

Amoeba limax Dujardin, Histoire Naturelle des Zoophytes Infusoires, Paris, 1841.

Occurrence.—Associated with *Ruppia* and algae at the head of Creel Bay, Big Mission Lake (numerous), Little Mission Lake (numerous), and the east side of the main lake (numerous).

Amoeba verrucosa Ehrenberg.

Amoeba verrucosa Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Observed but once, from material taken along the east side of Creel Bay.

Amoeba guttula Dujardin.

Amoeba guttula Dujardin, Histoire Naturelle des Zoophytes Infusoires, Paris, 1841.

Occurrence.—Taken from algae near Brannon's Island, from both ooze and floating algae in Creel Bay, from the east side of the main lake, and from sediment on rocks near the Station.

Amoeba striata Pènard.

Amoeba striata Pènard, Études sur les Rhizopodes d'eau douce. Mem. Soc. Phys. et Hist. Nat. Geneve, 1890.

Occurrence.—One specimen only observed in plant infusion from Stump Lake.

Amoeba vitraea (Hertwig and Lesser).

Dactylosphaerium vitraem Hertwig and Lesser, Ueber Rhizopoden und denselben nahestehende Organismen. Arch. Mikr. Anat. Vol. 10, Suppl., 1874.

Occurrence.—Taken from the east side of Creel Bay.

ORDER TESTACEA

FAMILY ARCELLIDAE

Genus Difflugia Leclerc, 1815

Difflugia pyriformis Perty.

Difflugia pyriformis Perty, Zur Kenntniss kleinster Lebensformen in der Schweiz, 1852.

Occurrence.—Only observed from Big Mission Lake in a location where fresh water seeps into the lake.

Difflugia constricta Ehrenberg.

Difflugia constricta Ehrenberg, Abh. Akad. Wiss. Berlin, 1841.

Occurrence.—Taken from Big Mission Lake in the same situation as the preceding species, and also from the head of Creel Bay near the entrance of a sewer.

Genus Arcella Ehrenberg, 1830

Arcella vulgaris Ehrenberg.

Arcella vulgaris Ehrenberg, Abh. Akad. Wiss. Berlin, 1830.

Occurrence.—Taken in ooze from the head of Creel Bay and from near the station, also from Big Mission Lake near the in-seepage of fresh water; abundant in the latter locality.

FAMILY EUGLYPHIDAE

Genus Cyphoderia Schlumberger, 1845

Cyphoderia ampulla (Ehrenberg).

Difflugia ampulla Ehrenberg, Bericht Preuss. Akad. Wiss., 1840.

Occurrence.—One specimen only has been observed. Taken from Whipple Bay among *Ruppia*.

Genus Euglypha Dujardin, 1841

Euglypha alveolata Dujardin.

Euglypha alveolata Dujardin, Histoire Naturelle des Zoophytes Infusoires, 1841.

Occurrence.—Taken from the overflow of lake water from the fish-tank near the Station. Observed but once.

SUBCLASS HELIOZOA
ORDER APHROTHORACIDA

Genus Actinophrys Ehrenberg, 1830

Actinophrys sol Ehrenberg.

Actinophrys sol Ehrenberg, Abh. Akad. Wiss., Berlin, 1830.

Occurrence.—Rarely observed, taken from among *Ruppia* in Minnewaukon Bay.

SUBPHYLUM MASTIGOPHORA
CLASS ZOOMASTIGOPHORA
SUBCLASS LISSOFLAGELLATA
ORDER MONADIDA

FAMILY RHIZOMASTIGIDAE

Genus Cercomonas Dujardin, 1841

Cercomonas sp. Figures 1–3, Plate XVIII.

Probably *Cercomonas longicauda* Dujardin. Very plastic with caudal filament often developed. Diameter, when spherical, 10μ

Occurrence.—Observed in infusions from Stump Lake only.

FAMILY HETEROMONADIDAE

Genus Monas Müller, 1786

Monas sp. Figures 4, 5, Plate XVIII.

Very plastic. Diameter, when spherical, 20μ. May represent *Monas fluida* Dujardin.

Occurrence.—In the ooze from Creel Bay.

Monas sp. Figure 8, Plate XVIII.

Length 9μ; body persistent in form, anterior region very granular. Corresponds in some degree to *Monas irregularis* Perty.

Occurrence.—In the ooze from Creel Bay. From a stale culture of *Ruppia*, Creel Bay.

Monas sp. Figure 7, Plate XVIII.

Body moderately plastic. Length, when extended, 15-18μ. Possibly same as figures 4 and 5.

Occurrence.—In the ooze from Creel Bay.

ORDER HETEROMASTIGIDA

FAMILY HETEROMITIDAE

Genus Heteromita Dujardin, 1841

Heteromita globosa (Stein).

Bodo globosus Stein, Der Organismus des Infusionthiere, Abth. 3, 1878.

Occurrence.—In dredged material from Creel Bay.

Heteromita sp. Figure 6, Plate XVIII.

But little of detail determined. Length 5μ. The form probably represents *Heteromita ovata* Dujardin.

Occurrence.—Taken from ooze on rocks near the Station.

ORDER POLYMASTIGIDA

FAMILY POLYMASTIGIDAE

Genus Trepomonas Dujardin, 1841

Trepomonas agilis Dujardin.

Trepomonas agilis Dujardin, Histoire Naturelle des Zoophytes Infusoires, 1841.

Occurrence.—Taken from Big Mission Lake, Whipple Bay, from the ooze of the main lake and from the east side of the main lake. Abundant in the latter locality.

ORDER EUGLENIDA

FAMILY EUGLENIDAE

Genus Euglena Ehrenberg, 1830

Euglena viridis Ehrenberg.

Euglena viridis Ehrenberg Abh. Akad. Wiss., Berlin, 1830.

Occurrence.—Observed from Minnewaukon Bay, Big Mission Lake, in the ooze from Creel Bay and from the east side of the main lake.

Euglena desus Ehrenberg.

Euglena desus Ehrenberg, Abh. Akad. Wiss., Berlin, 1830.

Occurrence.—Minnewaukon Bay, Six-mile Bay, near Brannon's Island, Big Mission Lake, Little Mission Lake, East Lake, and the ooze from the main lake.

Genus Phacus Dujardin, 1841

Phacus pyrum (Ehrenberg).

Euglena pyrum Ehrenberg, Abh. Akad. Wiss., Berlin, 1830.

Occurrence.—Minnewaukon Bay, Creel Bay, Big Mission Lake (numerous), and the east side of the main lake.

Genus Eutreptia Perty, 1852

Eutreptia viridis Perty.

Eutreptia viridis Perty, Zur Kenntniss kleinster Lebensformen in der Schweiz, 1852.

Occurrence.—From the surface among *Ruppia*, Big Mission Lake.

FAMILY ASTASIIDAE

Genus Astasia Ehrenberg, 1830

Astasia tricophora (Ehrenberg).

Trachelius tricophorus Ehrenberg, Abh. Akad. Wiss., Berlin, 1830.

Occurrence.—Among Ruppia from Whipple Bay, from Creel Bay, in the ooze from Big Mission Lake, and among algae near Brannon's Island.

FAMILY PERANEMIIDAE

Genus Petalomonas Stein, 1859

Petalomonas mediocanellata Stein.

Petalomonas mediocanellata Stein, Der Organismus der Infusionsthiere, 1878.

Occurrence.—Taken from the surface of Big Mission Lake and from the ooze of the main lake.

Petalomonas sp. Figure 10, Plate XVIII.

Has some resemblance to *Petalomonas ervilia* Stein. Conspicuous groove entire length of the body. Length 36μ.

Occurrence.—From the ooze of Creel Bay.

Genus Heteronema Dujardin, 1841

Heteronema acus (Ehrenberg).

Astasia acus Ehrenberg, Abh. Akad. Wiss., Berlin, 1830.

Occurrence.—From Six-mile Bay and from the ooze of Creel Bay.

Genus Anisonema Dujardin, 1841

Anisonema grande (acinus) (Ehrenberg).

Bodo grandis Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Anisonema acinus Dujardin, Histoire Naturelle des Zoophytes Infusoires, 1841.

Occurrence.—Among *Ruppia* and algae at the head of Creel Bay.

Genus Notosolenus Stokes, 1884

Notosolenus sp. Figure 9, Plate XVIII.

Length about 15μ.

Occurrence.—From Whipple Bay, Stump Lake and from the overflow of the fish-tank near the Station.

ORDER CHLOROFLAGELLIDA

FAMILY TETRAMITIDAE

Genus Tetraselmis Stein, 1878

Tetraselmis cordiformis (Carter).

Cryptoglena cordiformis Carter, Annals of Natural History 1858.

Occurrence.—Taken from Stump Lake only.

FAMILY POLYTOMIDAE

Genus Polytoma Ehrenberg, 1838

Polytoma uvella Ehrenberg.

Polytoma uvella Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Found at the head and along the east side of Creel Bay.

FAMILY TRIMASTIGIDAE

Undetermined genus

Undetermined species. Figures 11, 12, Plate XVIII.

Description.—Body elongate, somewhat compressed, slightly plastic, attenuated posteriorly; surface marked longitudinally by several conspicuous ridges; flagella three in number arising from the anterior extremity, equal and equalling the body in length; nucleus and contractile vacuole unobserved. Length 20μ.

Occurrence.—Numerous among *Ruppia* from Creel Bay.

FAMILY CHLAMYDOMONADIDAE

Genus Chlamydomonas Ehrenberg, 1833

Chlamydomonas pulvisculus Ehrenberg.

Chlamydomonas pulvisculus Ehrenberg, Abh. Akad. Wiss., Berlin, 1833.

Occurrence.—Taken from the head of Creel Bay.

SUBCLASS DINOFLAGELLIDA
ORDER DINIFERIDA

FAMILY PERIDINIIDAE

Genus Glenodinium Ehrenberg, 1832

Glenodinium pulvisculus Ehrenberg.

Glenodinium pulvisculus Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Taken from the surface and from the ooze at the bottom of Creel Bay.

SUBPHYLUM INFUSORIA
CLASS CILIATA
ORDER HOLOTRICHA

FAMILY ENCHELINIDAE

Genus Holophrya Ehrenberg, 1831

Holophrya ovum Ehrenberg.

Holophrya ovum Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Among algae from Creel Bay.

Holophrya sp. Figure 13, Plate XVIII.

Resembling *Holophrya ovum* Ehrenberg but much smaller. Length 30-40μ.

Occurrence.—In the ooze from Creel Bay.

Genus Urotricha Claparède and Lachmann, 1858

Urotricha labiata, new species, Figure 14, Plate XVIII.

Description.—Body ovate, about twice as long as broad, equally rounded at both extremities. Cilia covering the entire body, arranged in longitudinal rows and vibrating independently. A very fine seta, nearly as long as the body, extending from the posterior extremity. Mouth anterior, subterminal, beneath a prominent, lobe-like lip. Nucleus central. Contractile vacuole posterior. Reproduction by transverse fission. Length of body about 30μ.

Occurrence.—Taken from numerous localities in Devil's Lake.

Genus Prorodon Ehrenberg, 1833

Prorodon teres Ehrenberg.

Prorodon teres Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Among *Ruppia* and algae of Big Mission Lake and the main lake.

Prorodon edentatus Claparède and Lachmann.

Prorodon edentatus Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—Infusions of *Ruppia* from Big Mission Lake and Minnewaukon Bay.

Prorodon griseus Claparède and Lachmann.

Prorodon griseus Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—Taken from Stump Lake only.

Genus Enchelys Ehrenberg, 1838

Enchelys sp. Figure 15, Plate XVIII.

Length from 15-20μ.

Occurrence.—Ooze from the main lake and from the overflow of lake water from the fish-tank.

Genus Spathidium Dujardin, 1841

Spathidium spatula Dujardin.

Spathidium spatula Dujardin, Histoire Naturelle des Zoophytes Infusoires, 1841.

Occurrence.—Among algae from the head of Creel Bay.

Spathidium sp. Figure 16, Plate XVIII.

A very long, narrow and flattened form. Length 120μ.

Occurrence.—Taken from infusions from the head of Creel Bay.

Spathidium sp. Figure 17, Plate XVIII.

A much shorter form than the preceding, with a conspicuous collar about the oral extremity. Length 30μ.

Occurrence.—From the ooze of the main lake.

Undetermined Genus[8]

Undetermined species. Figures 1, 2, Plate XIX.

Description.—Body elongate, plastic, slightly compressed dorso-ventrally, inflated posteriorly, narrow anteriorly, rounded at both extremities; cilia of uniform length arranged in longitudinal rows, covering the entire surface; aperture a narrow slit diagonally placed, sub-terminal; contractile vacuole posterior; nucleus concealed; endoplasm completely filled with green chloroplasts. Length 90μ.

Occurrence.—From the surface of the main lake and from among *Ruppia* and algae.

Genus Chaenia Dujardin, 1841

Chaenia teres Dujardin.

Chaenia teres Dujardin, Histoire Naturelle des Zoophytes Infusoires. 1841.

Occurrence.—Among algae from the head of Creel Bay.

Genus Mesodinium Stein, 1862

Mesodinium pulex (Claparède and Lachmann).

Halteria pulex Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—A common form on the surface and in the ooze of the main lake.

[8] The form is treated here with doubt as to its taxonomic position.

Genus Didinium Stein, 1859

Didinium nasutum (Müller).

Vorticella nasutum Müller, Animalcula Infusoria Fluviatilia et Marina, 1786.

Occurrence.—Among *Ruppia* from Minnewaukon Bay, Whipple Bay, and from the east side of the main lake.

Genus Lacrymaria Ehrenberg, 1830

Lacrymaria olor Ehrenberg.

Lacrymaria olor Ehrenberg, Abh. Akad. Wiss., Berlin, 1830.

Occurrence.—Among *Ruppia* in Creel Bay.

Lacrymaria truncata Stokes.

Lacrymaria truncata Stokes, Ann. and Mag. Nat. Hist., June, 1885.

Occurrence.—Among *Ruppia* from the north end of the main lake.

Lacrymaria cohnii Kent.

Lacrymaria cohnii Kent, A Manual of the Infusoria, 1881–1882.

Occurrence.—In an infusion from Stump Lake.

Lacrymaria lagenula Claparède and Lachmann.

Lacrymaria lagenula Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—In ooze from the main lake.

FAMILY TRACHELINIDAE

Genus Lionotus Wrzesniowski, 1870

Lionotus fasciola (Ehrenberg).

Amphileptus fasciola Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Abundant in many parts of the main lake, also taken from Stump Lake and Big Mission Lake.

Lionotus sp. Figure 3, Plate XIX.

A very small species. Length about 40μ. Often seen in conjugation.

Occurrence.—Among algae from Creel Bay.

Genus Amphileptus Ehrenberg, 1830

Amphileptus meleagris (Ehrenberg).

Trachelius meleagris Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Amphileptus meleagris Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—Taken in Stump Lake and from algae at the head of Creel Bay.

FAMILY CHLAMYDODONTIDAE

Genus Nassula Ehrenberg, 1838

Nassula rubens (Perty).

Cyclogramma rubens Perty, Zur Kenntniss kleinster Lebensformen in der Schweiz, 1852.

Nassula rubens Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—From the overflow of lake water from the fish-tank near the Station.

Nasula ornata Ehrenberg.

Nasula ornata Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Taken from Lake "N" only.

Genus Chilodon Ehrenberg, 1833

Chilodon cucullulus (Müller).

Colpoda cucullulus Müller, Animalcula Infusoria Fluviatilia et Marina, 1786.

Occurrence.—Infusions of algae from Creel Bay, Big Mission Lake, and Whipple Bay.

Chilodon caudatus Stokes.

Chilodon caudatus Stokes, Am. Jour. Sci. 29, April, 1885.

Occurrence.—Among *Ruppia* from Minnewaukon Bay.

Genus Aegyria Claparède and Lachmann, 1858

Aegyria pusilla (?) Claparède and Lachmann.

Aegyria pusilla Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—Among algae near the Station.

FAMILY CHILIFERIDAE

Genus Glaucoma Ehrenberg, 1830

Glaucoma scintillans Ehrenberg.

Glaucoma scintillans Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—In algae infusion from near Brannon's Island.

Glaucoma margaritaceum (Ehrenberg).

Cyclidium margaritaceum Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Cinetochilum margaritaceum Perty, Zur Kenntniss kleinster Lebensformen in der Schweiz, 1852.

Occurrence.—Very abundant. From the ooze of Creel Bay, the surface of Creel Bay, Stump Lake, and near Brannon's Island in the main lake.

Genus Leucophrys Ehrenberg, 1830

Leucophrys patula (Müller).

Trichoda patula Müller, Animalcula Infusoria Fluviatilia et Marina, 1786.

Occurrence.—One specimen only observed, from the east side of the main lake. A very typical specimen.

Genus Frontonia Ehrenberg, 1838

Frontonia leucas Ehrenberg.

Frontonia leucas Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Taken from the east side of the main lake and from East Lake. Abundant in Six-mile Bay and Minnewaukon Bay.

Genus Loxocephalus Eberhard, 1868

Loxocephalus granulosus Kent.

Loxocephalus granulosus Kent, A Manual of the Infusoria, 1881–1882.

Occurrence.—Taken only in the ooze of Big Mission Lake near the in-seepage of fresh water.

Genus Uronema Dujardin, 1841

Uronema marinum Dujardin.

Uronema marinum Dujardin, Histoire Naturelle des Zoophytes Infusoires, 1841.

Occurrence.—One of the most common species in the lake. Abundant everywhere both at the surface and in the ooze.

Genus Colpidium Stein, 1868

Colpidium putrinum Stokes.

Colpidium putrinum Stokes, Ann. and Mag. Nat. Hist. Feb., 1886.

Occurrence.—From algae at the east side of Creel Bay.

Genus Tillina Gruber, 1879

Tillina saprophila Stokes.

Tillina saprophila Stokes, Am. Nat., Feb., 1884.

Occurrence.—Taken only in the overflow of lake water from the fish-tank near the station.

FAMILY PARAMAECIDAE

Genus Paramaecium Müller, 1786

Paramaecium trichium Stokes.

Paramaecium trichium Stokes, Am. Naturalist, 19, May, 1885.

Occurrence.—From near the mouth of a sewer at the head of Creel Bay, and from ooze near the rock pile in the main lake.

Paramaecium caudatum Ehrenberg.

Paramaecium caudatum Ehrenberg. Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Taken from Big Mission Lake near the in-seepage of fresh water.

FAMILY PLEURONEMIDAE

Genus Cyclidium Ehrenberg, 1838

Cyclidium glaucoma Ehrenberg.

Cyclidium glaucoma Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Abundant everywhere, at the surface and in the ooze in all parts of the lake.

Cyclidium litomesum Stokes.

Cyclidium litomesum Stokes, Am. Monthly Micro. Jour., 6, Dec. 1884.

Occurrence.—Numerous in infusions from the head of Creel Bay and in the ooze from the main lake.

Genus Pleuronema Dujardin, 1841

Pleuronema chrysalis (Ehrenberg).

Paramaecium chrysalis Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Pleuronema crassa Dujardin, Histoire Naturelle des Zoophytes Infusoires, 1841.

Occurrence.—Observed in infusions from Stump Lake only.

ORDER HETEROTRICHA

FAMILY PLAGIOTOMIIDAE

Genus Metopus Claparède and Lachmann, 1858

Metopus sigmoides (Müller).

Trichoda sigmoides Müller, Animalcula Infusoria Fluviatilia et Marina, 1786.

Occurrence.—Common in dredged material from Minnewaukon Bay, Creel Bay, and the main lake. Abundant in East Lake.

Genus Spirostomum Ehrenberg, 1835

Spirostomum ambiguum Ehrenberg.

Spirostomum ambiguum Ehrenberg, Abh. Akad. Wiss., Berlin, 1835.

Occurrence.—Observed in dredged material from Creel Bay.

FAMILY HALTERIDAE

Genus Halteria Dujardin, 1841

Halteria grandinella (Müller).

Trichoda grandinella Müller, Animalcula Infusoria Fluviatilia et Marina, 1786.

Halteria grandinella Dujardin, Histoire Naturelle des Zoophytes Infusoires, 1841.

Occurrence.—Common in infusions of *Ruppia* and algae from Whipple Bay and Creel Bay and in the ooze of the main lake.

ORDER HYPOTRICHA

FAMILY OXYTRICHIDAE

Genus Uroleptus[9] *Ehrenberg, 1831*

Uroleptus agilis Englemann.

Uroleptus agilis Englemann, Zeit. Wiss. Zool., Bd. 11, 1861.

Occurrence.—From the ooze of the main lake, also from Six-mile Bay.

Uroleptus rattulus (?) Stein.

Uroleptus rattulus Stein, Der Organismus der Infusionsthiere, 1859.

Occurrence.—Among *Ruppia* from Whipple Bay.

Genus Oxytricha[9] *Ehrenberg, 1830*

Oxytricha fallax Stein.

Oxytricha fallax Stein, Der Organismus der Infusionsthiere, 1859.

Occurrence.—Among algae from Creel Bay.

Oxytricha pellionella (Müller).

Trichoda pellionella Müller, Animalcula Infusoria Fluviatilia et Marina, 1786.

Oxytricha pellionella Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Taken from *Ruppia* near the Station, Big Mission Lake, Whipple Bay, north end of Creel Bay, and the ooze from the fish-tank after being flooded by lake water.

Oxytricha parvistyla Stein.

Oxytricha parvistyla Stein, Der Organismus der Infusionsthiere, 1859.

Occurrence.—Among *Ruppia* near the Station.

Oxytricha bifaria Stokes.

Oxytricha bifaria Stokes, Ann. and Mag. Nat. Hist., Aug., 1887.

Occurrence.—Abundant in Creel Bay, also taken from Whipple Bay.

[9] Further study would, no doubt, result in the determination of other species of the genus than those listed.

Genus Histrio Sterki, 1878

Histrio erethysticus Stokes.

Histrio erethysticus Stokes, Proc. Am. Philos. Soc. 24; 126, 1887.

Occurrence.—Among *Ruppia* from near the Station.

Genus Stylonychia Ehrenberg, 1830

Stylonychia notophora Stokes.

Stylonychia notophora Stokes, Ann. and Mag. Nat. Hist. June, 1885.

Occurrence.—With algae from Creel Bay.

Genus Holosticha Wrzesniowski, 1877

Holosticha vernalis (?) Stokes.

Holosticha vernalis Stokes, Ann. and Mag. Nat. Hist., Aug., 1887.

A form bearing considerable resemblance to Stokes' species was occasionally observed. Length 140μ.

Occurrence.—Among *Ruppia* from the main lake.

Genus Pleurotricha Stein, 1859

Pleurotricha lanceolata (Ehrenberg).

Stylonychia lanceolata Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Pleurotricha lanceolata Stein, Der Organismus der Infusionsthiere, 1859.

Occurrence.—Taken at the head of Creel Bay.

Genus Tachysoma Stokes, 1887

Tachysoma parvistyla Stokes.

Tachysoma parvistyla Stokes, Ann. and Mag. Nat. Hist. Aug., 1887.

Occurrence.—Observed in infusions from Stump Lake only.

FAMILY EUPLOTIDAE

Genus Euplotes Ehrenberg, 1831

Euplotes charon (Müller).

Trichoda charon Müller, Animalcula Infusoria Fluviatilia et Marina, 1786.

Euplotes charon Ehrenberg, Die Infusionsthiere als Volkommene Organismen, 1838.

Occurrence.—Abundant among infusions of *Ruppia* and algae from many parts of the main lake, and also from East Lake.

Euplotes patella (Müller).

Kerona patella Müller, Animalcula Infusoria Fluviatilia et Marina, 1786.

Euplotes patella Ehrenberg, Die Infusionsthiere als Volkommene Organismen, 1838.

Occurrence.—Found in Stump Lake, Big Mission Lake, East Lake and in numerous localities in the main lake.

Genus Aspidisca Ehrenberg, 1830

Aspidisca costata (Dujardin).

Coccudina costata Dujardin, Histore Naturelle des Zoophytes Infusoires, 1841.

Occurrence.—Taken in Whipple Bay; numerous among *Ruppia* in Minnewaukon Bay and also on the east side of the main lake.

ORDER PERITRICHA

FAMILY VORTICELLIDAE

Genus Vorticella Linnaeus, 1767

Vorticella telescopica Kent.

Vorticella telescopica Kent, a Manual of the Infusoria, 1881–1882.

Occurrence.—Among *Ruppia* at the north end of the main lake.

Vorticella convallaria Linnaeus.

Vorticella convallaria Linnaeus, Systema Naturae, Ed. 12, 1767.

Occurrence.—Attached to diatoms in the main lake, also among *Ruppia* in Big Mission Lake.

Vorticella octavo Stokes.

Vorticella octavo Stokes, Ann. and Mag. Nat. Hist., June, 1885.

Occurrence.—Among *Ruppia* at the north end of the main lake.

Vorticella microstoma Ehrenberg.

Vorticella microstoma Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Taken at the east side of the main lake.

Vorticella sp. Figure 4, Plate XIX.

A very common form, resembling *Vorticella rabdostyloides* Kellicott but is considerably smaller and the body is transversely striated. Length of stalk 12μ, with the diameter of the body nearly the same.

Occurrence.—Attached to floating diatoms.

Vorticella sp. Figure 5, Plate XIX.

A species with more elongate body than the preceding but also transversely striate. Length of body 28μ, stalk 68μ.

Occurrence.—Attached to floating diatoms.

Genus Gerda Claparède and Lachmann, 1858

Gerda annulata, new species. Figure 10, Plate XIX.

Description.—Body elongated, cylindrical, of nearly equal diameter throughout, curved when extended; surface finely striate transversely; a prominent annular ridge present usually about one-fourth the distance from the posterior extremity; peristome border revolute, disc slightly elevated; contractile vacuole conspicuous; nucleus not observed. Length of body, extended, 80μ.

Occurrence.—Among algae and *Ruppia* from the north end of the main lake.

Genus Epistylis Ehrenberg, 1830

Epistylis plicatilis Ehrenberg.

Epistylis plicatilis Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—From the east side of Creel Bay.

Epistylis branchiophila Perty.

Epistylis branchiophila Perty, Zur Kenntniss kleinster Lebensformen in der Schweiz, 1852.

Occurrence.—Among algae near the head of Creel Bay.

Genus Carchesium Ehrenberg, 1838

Carchesium epistylidis Claparède and Lachmann.

Carchesium epistylidis Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—Among algae from Creel Bay.

Genus Zoothamnium Ehrenberg, 1838

Zoothamnium alterans Claparède and Lachmann.

Zoothamnium alterans Claparède and Lachmann, Études sur les Infusoires et les Rhizopodes, 1858.

Occurrence.—Among *Ruppia* and algae from Stump Lake.

Zoothamnium sp. Figure 6, Plate XIX.

Stalk very stout, zooids smooth, usually 2-8 in a colony. Length of stalk 216μ, of zooid 64μ.

Occurrence.—From Stump Lake, East Lake, Creel Bay, Whipple Bay, and from the main lake. Attached to algae or *Ruppia*. A fairly common form.

Genus Vaginocola Lamarck, 1816

Vaginocola crystallina Ehrenberg.

Vaginocola crystallina Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Numerous among algae from East Lake, also taken from Stump Lake and from the north end of the main lake.

Genus Cothurnia Ehrenberg, 1831

Cothurnia imberbis Ehrenberg.

Cothurnia imberbis Ehrenberg, Die Infusionsthierchen als Volkommene Organismen, 1838.

Occurrence.—Commonly attached to floating diatoms, from dredged material and also among *Ruppia* in Creel Bay. Also taken from Stump Lake.

Cothurnia curva Stein.

Cothurnia curva Stein, Der Organismus der Infusionsthiere, 1859.

Occurrence.—Among *Ruppia* at the north end of the main lake.

CLASS SUCTORIA

FAMILY PODOPHRYIDAE

Genus Podophrya Ehrenberg, 1838

Podophrya libera Perty.

Podophrya libera Perty, Zur Kenntniss kleinster Lebensformen in der Schweiz, 1852.

Occurrence.—Numerous at east side of the main lake.

Podophrya sp. Figure 9, Plate XIX.

Bears some slight resemblance to *Podophrya cyclopum* Claparède and Lachmann. The lobulated border may have represented a reproductive phase or possibly was abnormal. Total height 60μ, stalk 20μ.

Occurrence.—Attached to algae from the main lake. Several specimens were observed by Dr. R. T. Young.

Genus Sphaerophrya Claparède and Lachmann, 1858

Sphaerophrya magna Maupas.

Sphaerophrya magna Maupas, Arch. de Zoologie Experimentale, tom 9, Nov., 1881.

Occurrence.—From Stump Lake and the east side of the main lake.

FAMILY ACINETIDAE

Genus Acineta Ehrenberg, 1838

Acineta sp. Figure 7, Plate XIX.

Body triangular in broad view, compressed; endoplasm very granular, nucleus concealed. Total height 50μ, stalk 20μ. This species resembles, in some degree, *Acineta lemnarum* Stein.

Occurrence.—From floating material in the main lake and also among algae from Stump Lake.

Acineta sp. Figure 8, Plate XIX.

Body oval, slightly broader distally, greatly compressed; endoplasm granular concealing the nucleus and contractile vacuole.

Total height 60-72μ, stalk about 15μ.

Occurrence.—Attached to algae from Stump Lake. Commonly feeding on *Uronema*.

3. EXPERIMENTS

Preliminary experiments in transferring protozoa from fresh water to the concentrated water of Devil's Lake and vice versa.

In order to test the reactions of certain protozoa taken from other sources to the more concentrated waters of Devil's Lake a series of simple experiments were carried out by which forms of protozoa common to fresh water were transferred directly into the more saline water of the lake.

Infusions from a small body of fresh water near the southern boundary of the main lake were prepared and certain protozoa which readily appear in cultures were used in the tests.

By placing a drop of the fresh water culture on one end of a microscopic slide and a drop of lake water near the middle of the slide and, with a needle, drawing out from each drop toward the other a narrow channel of water until the two met, the protozoa were conducted from the fresh water drop into that of the lake water. To eliminate possible influence of the fresh water a series of drops of lake water were used and the organisms rapidly transferred from one to the other until they reached a pure medium of lake water.

The waters from the two sources were kept at a uniform temperature and the effect of the change of environment thus brought about was carefully noted by the activity of the organisms.

In similar manner the transference of certain protozoa from lake water to fresh water was accomplished and the effect of such change observed as hereinafter noted.

A. Transference of protozoa from fresh water to lake water.

1. Paramaecium sp. A specimen of a species, probably *Paramaecium caudatum* Ehrenberg, commonly occurring in the fresh water was removed to the pure lake water with the following results: An immediate change occurred in the organism. The body became greatly compressed dorso-centrally with erratic movements at first which soon gave way to a more steady, forward movement with slow rotations on the long axis. A noticeable change also occurred in the contractile vacuoles. The normal rhythmic collapse of the vacuoles ceased after a few minutes and they became greatly dilated and distorted. After ten minutes of rotary movements the organism became quiet with the cilia of the periphera and the oral groove still active. Many non-contractile vacuoles filled the endoplasm. Death occurred at the end of twelve minutes.

A second specimen, after showing the same flattening of the body, moved in circles for six minutes then assumed the forward movement with rotations on the long axis. In eighteen minutes the organism became quiet with a highly vacuolated endoplasm and the cilia of the oral groove vibrating feebly. Death occurred in twenty-six minutes.

A third specimen after exhibiting similar physical and physiological changes came to complete rest in twenty-two minutes. Death resulted in twenty-five minutes.

A fourth specimen showed similar responses and died in fifteen minutes.

Seven specimens were then transferred at the same time. Six of these, after exhibiting similar responses as the preceding, were dead at the end of ten minutes. One, after reacting in like manner, died at the end of eighteen minutes.

2. Stylonychia sp. Several tests with a species of *Stylonychia* were carried out. Unusual responses were less quickly manifested by *Stylonychia* than *Paramaecium* when brought into contact with the lake water. Commonly after five or six minutes of normal movements a rapid whirling over and over of the body occurred gradually subsiding into complete rest. Death occurred in all specimens in from sixteen to thirty-two minutes.

Reactions of similar character were obtained from *Paramaecium* and *Stylonychia* by the introduction of small quantities of NaCL into the fresh water in which they were normally living.

3. Metopus sp. A short type of *Metopus*, common in fresh water, was transferred to the saline lake water. The most noticeable change was an almost immediate flattening of the body. Normal rotary movements continued for eight minutes when the organism came to rest with the cilia of the surface still more or less active. Death occurred at the end of fifteen minutes.

Numerous individuals of this species were used in successive experiments with reactions similar in each case. Death resulted in all specimens in from eleven to eighteen minutes.

B. Transference of protozoa from the concentrated lake water to fresh water.

1. Uroleptus sp. The form used was one of the elongated types. More than sixty specimens were used in the tests. With few exceptions but with considerable degree of variation, the following reactions were very evident: After a period of from ten to fifteen minutes contact with the fresh water, during which time more or less normal activities were maintained, the organisms came to rest with the cilia still in motion. The cell bodies became shortened and dilated, in

many instances assuming a spherical form. After enduring this state of depression for from ten to fifteen minutes the organisms showed signs of recovery. The bodies gradually assumed an elongated form and normal activities reappeared. Within a period of one hour and twenty-five minutes from the time the organisms were first introduced into the fresh water all, with the exception of a few which failed to survive the state of depression, had fully recovered and were responding in a normal manner.

Considerable variation in the effect of the change was noted. Of those surviving some were slightly affected and wholly recovered in forty-five minutes, some in sixty minutes, while others required the longer time noted above.

2. Euplotes patella (Müller). Numerous individuals of this species were transferred as in the preceding experiment. The effect in this case was an immediate one. As soon as contact was made with the fresh water the cell bodies became swollen and distorted, losing the longitudinal striations and all resemblance to normal individuals. During this state of depression the organisms were at rest with the cirri in feeble motion. After a period of fifteen minutes the cells began to resume movements although in a distorted condition. In fifteen minutes more the longitudinal striations reappeared and soon after normal responses were entirely restored.

3. Uronema marinum Dujardin. The transferrence of this species from the lake water to fresh water resulted in no apparent state of physical depression and no diminished or unusual responses to stimuli could be detected. The species is commonly recognized as both a marine and fresh water form.

4. Summary and Conclusions

Summary of the Groups of Protozoa Recorded

Sarcodina	13 species
Mastigophora	22 "
Infusoria	76 "
Total	111 species

Conclusions

1. The proportion of the number of species of the three groups of protozoa recognized in Devil's Lake corresponds favorably with the same in a typical fresh water lake.

2. A most noticeable feature of the study of this fauna is the apparent total absence of numerous forms universally found in fresh water. The dearth of shell-bearing rhizopods was mentioned in the introduction. Many common species of flagellates and ciliates were, at no time during the survey, observed in the concèntrated waters of the lake.

3. The subdivisions of the classes of protozoa are fairly well represented in Devil's Lake. Two new species are described in the report but with the exception of the facts mentioned in the preceding paragraph, the protozoan fauna of Devil's Lake cannot be considered an unusual one.

4. Experiments of the interchange of protozoa between fresh water and the lake water seem to indicate that the organisms of the lake may adjust themselves to fresh water conditions with more readiness than can the forms accustomed to a fresh water environment accommodate themselves to the concentrated water of the lake.

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Plate XIX

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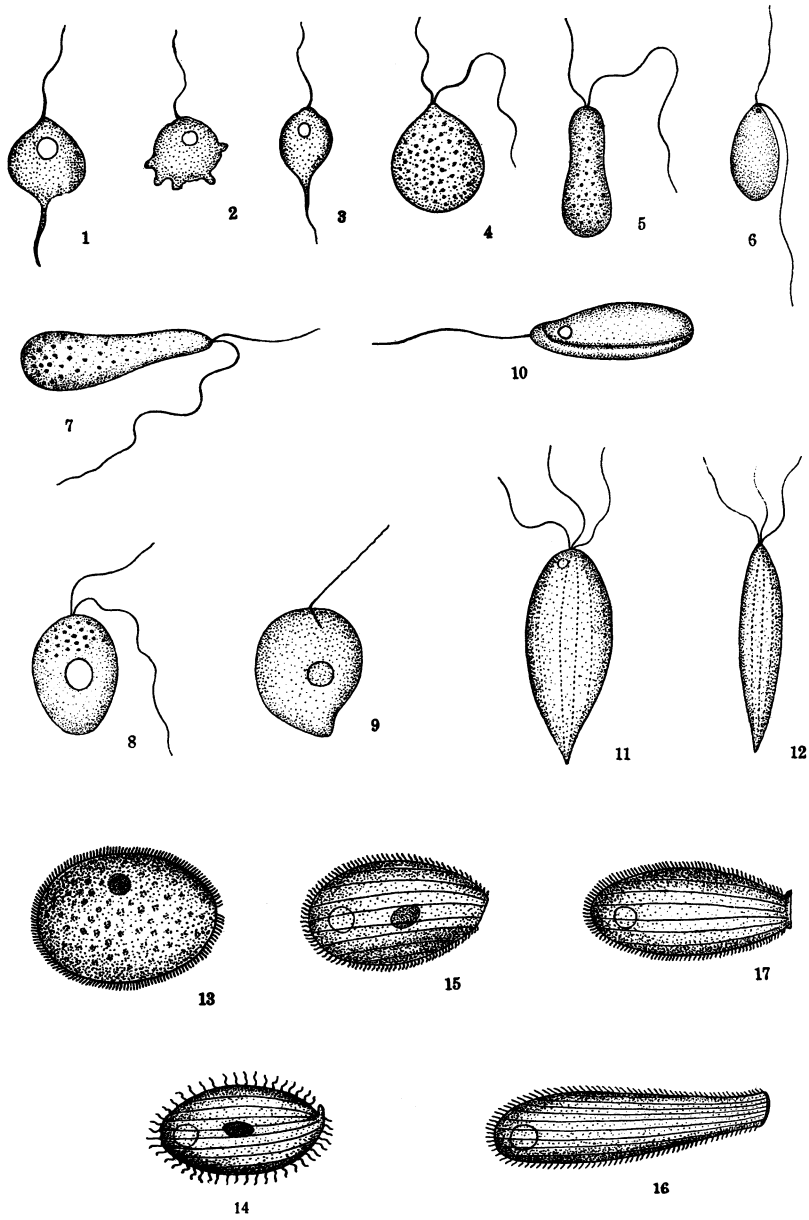

PLATE XVIII

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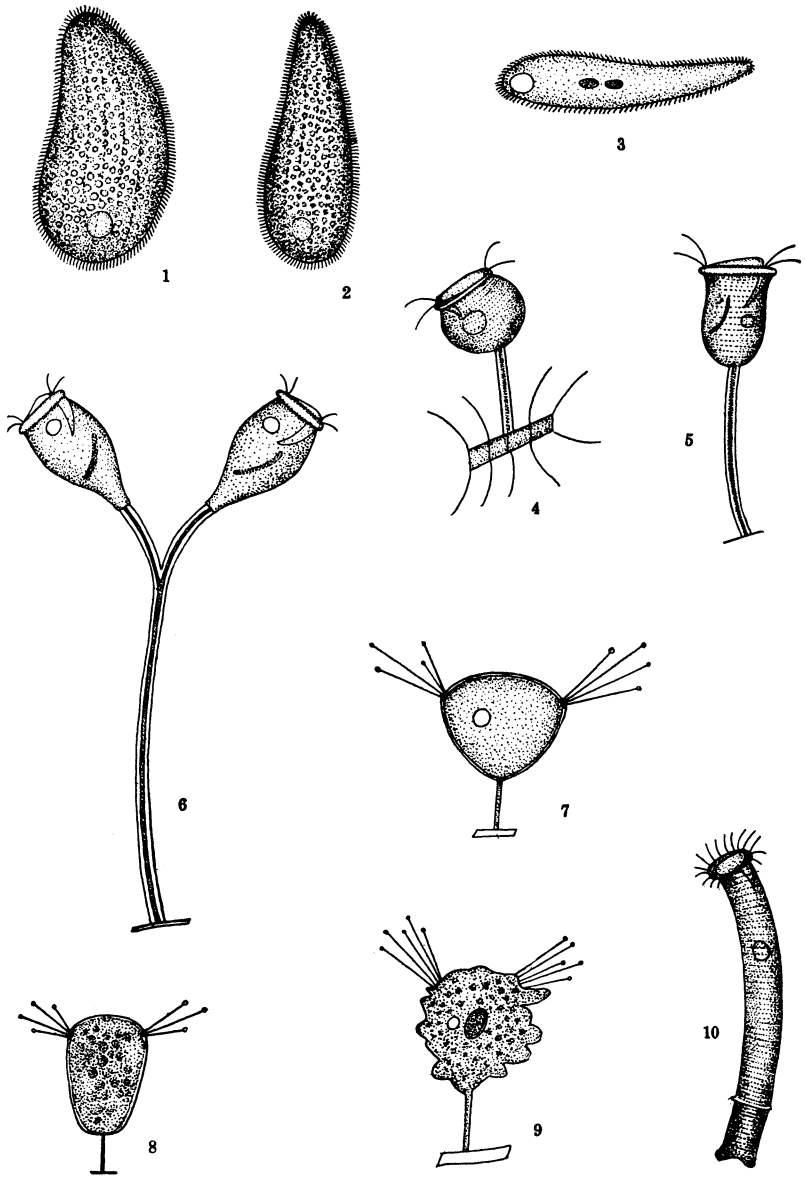

PLATE XIX

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