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A taxonomic investigation of the algae of the Brigham Young University Campus, Provo, Utah

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A TAXONOMIC INVESTIGATION OF THE ALGAE OF THE BRIGHAM YOUNG UNIVERSITY CAMPUS, PROVO, UTAH

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INTRODUCTION

Algal studies in Utah have been neglected in the past. Because of this, the species of algae occurring here are not well known. This paper represents a taxonomic investigation of the algae of the Brigham Young University campus, and provides baseline data which will be of value for future algal ecological research.

The goals of this study were: first and primarily, to collect and identify algae from selected localities on the Brigham Young University campus; second, to investigate certain physical and chemical parameters at selected collecting localities; and third, to determine the seasonal distribution and habitat preference of the algae encountered.

PREVIOUS STUDIES OF UTAH ALGAE

The algae of Utah are basically known from studies of restricted geographical areas. Thus, this review discusses several papers according to geographical area studies or to their specific contribution.

Great Salt Lake

One of the most fascinating bodies of water in the state is the Great Salt Lake. This large, extremely salty lake was first mentioned botanically by Farlow (1879) who published a description of the blue-green algae *Polycystis packardii* (=*Aphanotheca packardii*). Later, Rothpletz (1892) mentioned certain genera of blue-green algae occurring in the Great Salt Lake in connection with the formation of peculiar ooliths on certain shores. Talmage (1900) also mentioned algae in the Great Salt Lake by stating that at least three species of blue-green algae occurred there as well as certain living diatoms.

A more thorough study of the algae of this lake was done by Daniels (1917). In this paper Daniels reported several species of algae in the lake as well as experimental results on salinity tolerance of a halophilous *Chlamydomonas* sp.

Kirkpatrick (1934) reported on algal collections from the Great Salt Lake. Several Cyanophyta, two Chlorophyta and two diatoms were reported in this paper. At least some of these algae were thought to be native to the lake, although Kirkpatrick did not rule out the possibility that some of them were washed to the lake from surrounding regions.

Patrick (1936) reported the results of diatom studies of the Great Salt Lake. In this paper, several diatoms species were reported as occurring in brackish water at the lake margin. However, Patrick found no evidence of a living diatom flora occurring in the lake proper.

Utah Lake

Utah Lake is a shallow, eutrophic desert lake and one of the largest freshwater lakes in the Western United States. Few published reports have appeared dealing with the algal flora of this lake.

Tanner (1930, 1931) published an incomplete list of algal species found in Utah Lake as part of a general biological survey of the lake. These papers contain the only diatom genera recorded to date, with the exception of four species reported by Harding (1970). Snow (1932) made a comprehensive study of the littoral algae of Utah Lake. This study was very well done and still represents the most complete information available on the algae of this lake.

Harding (1970, 1971) published two reports on the planktonic algae presently found in Utah Lake. These papers compliment the earlier paper of Snow (1932).

Other Lakes

One of the earliest detailed algal studies in Utah was made by Norrington (1925). In this paper Norrington reported on algae collected from lakes and streams of the Wasatch and Uinta Mountains of Utah. One hundred and one genera of algae were listed in this paper which contained 198 species.

Snow and Stewart (1939) and Snow (1940) studied the algae of Mirror Lake in the Uinta Mountains of southeastern Utah. Seven algal classes were listed although many of the included organisms were not keyed to species due to the lack of available literature. Snow (1940) reported 85 species of algae in 65 genera from this lake.

Clark (1956) studied Bear Lake phytoplankton with emphasis on techniques rather than on the natural populations. As a general observation, the plankton populations of Bear Lake were found to be composed of very small cells with diatoms comprising less than 5% of the total population.

Pratt (1957) reported on algal studies of Salem Pond between 1955 and 1957. Of the genera studied, _Oscillatoria_ and _Navicula_ reached their maximum population numbers in March and again in September. _Pediastrum_, _Scenedesmus_, _Merismopedia_ and _Cosmarium_ reached their peaks in August, and _Asterionella_, _Ceratium_ and _Dinobryon_ reached their maxima from September to November

Coombs (1964) made a floristic and ecological survey of the algal flora of the western Uinta Mountains and adjacent areas. Coombs studied several habitats including lakes, ponds and streams. In the rivulets of this area desmids were predominant followed by other Chlorophyta, diatoms and blue-green algae. In the lakes and ponds of this region most species were Desmidiaceae followed by less abundant Zygnemataceae, Ulothricales. Diatoms, Cyanophyta, other Chrysophyta and non-filamentous green algae were found to be intermingled with the filamentous Chlorophyta. This population pattern varied in the other habitats sampled in that desmids were proportionately less important.

Palmer (1968) reported a taxonomic and ecological survey of the algae of Lilly Lake in the Uinta Mountains of Utah. This survey treated algal periodicity and distribution as related to chemical and physical microenvironments in the lake. This relatively complete paper reported 208 species of algae from this small mountain lake.

Rivers and Streams

Harrison (1926) reported on algal studies done in Washington County, Utah. He listed 18 genera and 40 species of algae from various habitats in this southern Utah county.

Piranian (1937) listed the organisms collected from the Bear River at the Bear River Bay Migratory Waterfowl Refuge. Included were 16 species of Cyanophyta, 37 species of diatoms and 26 species of Chlorophyta.

Young (1947, 1948) reported on periphyton of the Ogden River, Weber Co., Utah. Algae in this report included mats of *Vaucheria* sp. and *Cladophora glomerata* with small Chlorophyta (mostly Tetrasporales), Desmidaceae, *Diatoma vulgare*, *Navicula* sp., *Fragillaria virescens*, *Gomphonema* sp., *Amphora ovalis* and *Tabellaria* sp. intermingled in the algal mats.

Clark (1958) investigated the phytoplankton of the Logan River, Utah, in one of the few studies of the algae of mountain streams of the western United States. Clark concluded that this stream did not support an euplanktonic flora and other sources which are adapted for survival in flowing water made up the plankton of this stream.

Smith (1959) studied the effects of pollution on the Weber River, Utah. This study dealt with the general nature of the equatic resources of the river, certain unique features of the river as an aquatic habitat, the degree and kinds of pollution entering the river and the effect of these pollutants on the water and biology of the river.

Miller (1959) investigated the pollution of the Price River, Carbon County, Utah. He pointed out the only algae encountered were small amounts of Chaetophora elegans and Cladophora sp. All aquatic vascular plants were absent. The lack of plant life in the Price River was found to be due to two principle factors. First, the turbid water which carried a high silt load had an important scouring effect on the river bottom; and second, the river contained high levels of pollution with accompanying reduction of dissolved oxygen by bacteria and corresponding increase in carbon dioxide.

Flowers (1959) reported on algae collected from brooks, ponds and wet sandstone cliffs in the Glen Canyon Drainage System. Flowers found many smaller planktonic species in stagnant pools, predominently Chlorococcales and diatoms. These plants were very seasonal in occurrence exhibiting three periods of flux during the year. In this report 40 species and 12 genera without specific names were listed.

Gaufin, Smith and Dotson (1960) surveyed the aquatic biology of the Green River and its tributaries within the Flaming Gorge Reservoir Basin. These authors reported eight Cyanophyta, three Chrysophyta other than diatoms, 11 Chlorophyceae, one Charophyceae and one Rhodophyta.

Squires, Rushforth and Endsley (in press) studied the Huntington River, Emery County, Utah to establish baseline data for future determination of changes in the aquatic environment of this drainage caused by construction and operation of a large coal fired power station there. Chemical, physical and algal studies were included in this report. Five divisions of algae containing approximately 250 species were reported in this paper.

Springs

Foster (1960) reported on an eight-month survey of Hot Springs, Salt Lake County, Utah. Four genera of Cyanophyta and four genera of diatoms (*Navicula*, *Cymbella*, *Cyrosigma* and *Nitzschia*) were reported in the water of this spring.

McCoard (1967) studied the mosses and algae of Cascade Springs, Wasatch County, Utah. This study was primarily ecological in nature and twelve genera containing fourteen species of algae were reported.

Reservoirs

Chatwin (1956) studied the phytoplankton of Deer Creek Reservoir with particular reference to their vertical distribution. Chemical and physical data as well as descriptions were presented in this paper.

Rich (1960) studied Hyrum Reservoir in Northern Utah. Water chemical data and their relationship to organisms occurring there were presented in this paper, although algal studies were minimal.

Glenn (1969) studied the plankton associations of a portion of Flaming Gorge Reservoir for the year 1968-1969. *Ceratium hirundinella*, *Fragilaria crotonensis*, *Stephanodiscus hantzschii*, *Diatoma anceps*, *Dinobryon sertularia* and *Asterionella formosa* were all prevalent there at different times of the year.

Taxonomic Papers

Flowers (undated A and B) mimeographed two pamphlets which have been helpful in Utah algal studies. These pamphlets are a guide to *Common Utah Algae* and *The Blue-Green Algae of Utah*. They represent a starting point for the taxonomic study of Utah's algae.

Future algal studies in Utah are necessary in order to understand, and thereby protect and manage our valuable aquatic resources. These studies are further necessary to provide information on a major group of plants which are presently poorly known in the western United States.

METHODS

Collection

Several collection stations were selected at different sites on the Brigham Young University campus. Collections were made at these sites from October 1971 through August 1972. Samples were collected at two week intervals for chemical, physical and biological determinations.

Sampling sites were selected along a stream, in the Botany Department arboretum pond and in the botanical greenhouses. These sites included some from the water, some from the sediments at the bottom of the stream and pond and some from the soil. These localities were established to determine seasonal and habitat distribution of the algae of the Brigham Young University campus.

Three stream localities were established to study those algae which prefer flowing water. These sampling stations were established in the irrigation stream which encircles the B.Y.U. campus. The first was immediately east of the Richards Physical Education Building. The second was beside Campus Drive between the Abraham Smoot Administration Building and the Heritage Halls student dormitories. The last stream station was between the Widtsoe Life Science Building and the Cluff Plant Science Laboratory.

The arboretum pond, which is commonly called the Botany pond, is the largest pool on campus, although it is still rather small with a surface area of about 400 square feet. This pond was sampled at several sites on its perimeter and near the center.

The B.Y.U. Botany Department greenhouses were also sampled. Algal samples were collected from the walls of the buildings, the walls of pots and benches, the surface of the soil of some pots and benches and some water filled depressions in the soil and pots. Soil for soil diatom studies was also collected in the greenhouses.

Total light, water and air temperature, dissolved oxygen content, pH and therefore plankton populations may vary with the time of day. Thus, in this study collections were consistently made as close to noon as possible. The arboretum pond was sampled first and then streams sites 1, 2 and 3 in that order. Total field collection time was approximately two hours.

Chemical and Physical Analyses

Chemical and physical sampling was initiated in November 1971 in the arboretum pond. Similar sampling at stream site 2 was added in March 1972 and the remaining stream sites were added in April 1972. Sampling and measurements were made during each collection until this study was terminated in August 1972. Chemical and physical analyses of the stream were initiated later than those of the pond since the stream was dry through the winter and early spring months.

Physical and chemical measurements were performed in the field or on samples of water collected in the field and returned to the laboratory. Tests were generally run immediately or on the following day. In no case were the samples allowed to stand under refrigeration for more than 24 hours.

Temperature.--Water and air temperatures were recorded during each collection in degrees centigrade.

Color.--Color of water samples collected was determined using the colorimeter in a Hach model DR-EL Portable Water Engineer's Laboratory. Color was determined by the APHA platinum-cobalt standard method (Amer. Pub. Health Assoc., 1971).

Turbidity.--Turbidity was measured using the colorimeter in the Hach DR-EL. Turbidity was measured directly and is expressed as Jackson Turbidity Units (JTU).

All chemical analyses except pH determination were performed using a Hach model DR-EL Portable Water Engineer's Laboratory. These analyses were done utilizing standard methods and procedures (Amer. Publ. Health Assoc., 1971).

Chemical tests performed included tests for alkalinity, carbon dioxide, dissolved oxygen, hardness (total), nitrates and phosphates (poly and meta). Hydrogen ion cencentration using a Sargent-Welch model PBL pH meter.

Biological Analyses

Biological collections were made for phytoplankton (floating algae), phycoperiphyton and visible attached algae, endedaphic algae (in the soil) and epedaphic algae (on the surface of soil).

Phytoplankton.--Qualitative phytoplankton samples were collected using a 67 u mesh plankton net. The net was thrown and pulled in the water so that it sank just slightly below the surface of the water. Care was taken to keep the net off of the bottom of the pond and slightly down from the surface of the pool so that bottom sediments and large floating algal mats and leaves did not enter the sample.

These samples were collected in 30 ml vials, and three samples of this type were made each collection. These three samples were mixed, returned to the laboratory and concentrated by centrifugation. As soon as possible after collection, the samples were examined using a Zeiss RA research microscope with Nomarski interference phase-contrast accessories. Cyanophyta and Chlorophyta were identified, described and photographed and recorded according to locality of collection.

The remaining sample was used to prepare permanent diatom slides.

Permanent diatom slides for this study were made by placing a sample in concentrated sulfuric acid. Since this acid is a strong oxidant, all organic matter was thus oxidized. Occasionally more than one acid treatment was necessary if the organic content was high.

The sample was then washed three times with distilled water with concentration by centrifugation after each wash. The sample was then washed twice with 95% ethyl alcohol. Finally, 100% ethyl alcohol was added to the sample, and the cleaned diatom frustules were finally mounted directly in Pleurax (Hannah, 1949).

Phycoperiphyton.--Phycoperiphyton samples were collected on glass slides which were allowed to stay in the water at the collection site for approximately three weeks. These algae were also collected by scraping or squeezing litter, fallen leaves, stones or large *Spirogyra* or *Vaucheria* mats. These samples were returned to the laboratory, concentrated and examined under the microscope. Permanent diatom slides were prepared from phycoperiphyton samples after the living algae had been identified.

<u>Endedaphic Algae</u>.--Diatoms occurring in the soil of the greenhouses were studied by collecting different samples of soil from several collecting sites. These samples were collected from each collecting station within 5 centimeters of the soil surface. These were mixed and permanent diatom slides were made. Procedures for making permanent diatom slides from soil samples were modified slightly due to the high amount of organic substances in the soil. Concentrated sulfuric acid was used at least twice followed by three distilled water rinses, three 95% ethyl alcohol rinses and a single rinse in 100% ethyl alcohol.

<u>Epedaphic Algae</u>.--Epedaphic algae were collected in the greenhouse where they formed mats on the surface of the soil, on benches and in pots. Samples were collected, brought to the laboratory, identified and photographed.

Fig. 1.--Arboretum pond, November 3, 1972

Fig. 2.--Stream site 1, November 3, 1972

Fig. 3.--Stream site 2, November 3, 1972

Fig. 4.--Stream site 3, November 3, 1972

PHYSICAL-CHEMICAL DESCRIPTION OF B.Y.U. CAMPUS

This discussion treats certain aspects of the project only. Detailed results of the chemical and physical analyses are to be found in Appendix I, and results of the biological analyses are presented under Taxonomy.

Temperature

Although water temperature fluctuation in a shallow lake may be rather great, it never fluctuates as much as air temperature. Thus, the yearly temperature fluctuation in the arboretum pond varied from a low of 0^oC to a high of 20^oC.

During the winter when the water temperature reached 0^oC an ice layer formed on the surface of the pond. This ice layer was relatively thin and formed and melted several times through the winter months.

Throughout the study the water temperature on the surface of the pond was approximately the same as that of the bottom, and in no case was stratification evidenced. This is expected due to the shallowness of the pond, its small size and the wind which was an effective mixing agent.

Water temperature extremes are limiting to some algal species. However, day length, water chemistry and other ecological factors interact closely with temperature to determine what algal species may develop. Thus, algal populations often vary according to the season of the year, especially in temperate regions, reflecting the effects of temperature and interrelated factors. Low winter water temperature apparently was a limiting factor for many species encountered in this study except for some species of diatoms. Thus, some diatoms were definite cold water species and these produced their maximum population in the pond. It is likely that one reason these cold water diatoms grow well is due to the availability of nutrients during cold periods since competition for nutrients is decreased.

Cold water algae in this study included Cymbella cistula, Synedra ulna var. subaequalis, Melosira varians, Nitzschia linearis and Nitzschia signomoidea.

Light

Light is a very important ecological factor due to its necessity for photosynthesis and thus growth. Both total light available and day length appear to be important in determining algal populations. Thus some species occur in high light intensity regions of a given habitat while others occur in low light regions. Likewise, some species reach maximum development under long days whereas others develop better under short day lengths.

However, probably most algae prefer relatively high light intensity in the aquatic environment. Thus, Transeau (1916) observed that several algae occurred in shaded portions of streams, although they did not reproduce there. Likewise, Butcher (1946) indicated that in the first five days of colonization of submerged slides by periphyton, the number of algae appearing was greater when the total amount of sunlight was greater. This suggests that when other factors are constant higher light intensity will induce algal growth.

In the present study maximum algal development occurred in the late spring and summer, and total biomass was much greater in the summer months. Most of this large development of summer algal growth was due to Cyanophyta and Chlorophyta with *Spirogyra* spp. being the dominant algae.

It is interesting that several species of algae, mostly diatoms, were collected growing under very low light conditions. These included *Synedra acus*, *Surirella ovata* and *Surirella angustata*. However, large algal populations, including diatoms were generally noted in nonshaded localities and low populations were noted for shady localities. This is true for all algae, and was especially noteworthy in the stream. Thus, significantly fewer algal genera were collected from stream sites one and two in the spring and summer. This was perhaps in part due to a higher water temperature at these sites, but was largely due to the many trees and bushes along the sides of the stream at these localities. This reduced the total light available at the stream and therefore limited or at least reduced the occurrence of algae present.

It must be noted that light intensity and duration are intimately connected with temperature and other ecological factors and hence are difficult to separate from these factors. However, there seems little question that algal periodicity is dependent at least in large part on changes in available light.

Current

Current is an important factor in determining algal distribution. Thus, if the current is fast many algae are unable to develop, especially planktonic or weakly attached forms. Likewise, if no current exists the flora is most often entirely different, with planktonic forms prevalent and attached species reduced.

It is uncommon for small streams to develop their own planktonic algal flora (Whiteford and Schumacher, 1963). The reasons for this are not entirely clear but certainly are related to chemical and current factors. The stream examined in this study exhibited no euplankton, and the only plankton present were forms released from the periphyton. Most algae encountered in the stream were collected from a thin layer of periphyton on stones at the bottom of the stream.

Color

True water color is that color which is inherent within the water itself. This color results from colloidal or dissolved substances such as metallic ions (iron and manganese), humus or peat or industrial wastes.

In the arboretum pond the water showed very little color with readings above 50 units occurring only in March, July and August. Turbidity also showed a slight increase during these collections, and it is likely that these increases were due to wind at the time of collection causing biological decomposition products and litter to be displaced from the bottom of the pond.

A second likely source of color in this pond is irrigation and ground water in the arboretum which drains into the pond. This water carries with it dissolved humic materials which affect the color of the pond water.

Turbidity

Turbidity is caused by suspended matter in water such as silt, clay, finely divided organic and inorganic substances, plankton and other microscopic organisms. In nature all water contains suspended substances, although the amount varies widely.

Turbidity was consistently close to 40 units (JTU) in the arboretum pond. These relatively low turbidity values occurred since the pond contained little suspended matter and a somewhat small planktonic population.

From his study of western Lake Erie, Chandler (1942) noted that maximum turbidity occurred in the summer and autumn due to plankton production. This was predicted for the arboretum pond, but plankton development never reached levels high enough to significantly effect turbidity. As previously mentioned, turbidity was probably most significantly effected by wind created currents stirring up bottom sediments. Since turbidity levels were so low in the arboretum pond, it is evident that this factor was of little importance in determining the quantity of light available for algal development.

Turbidity levels were also consistently very low in the stream sites (not exceeding 21 JTU) during sampling. However, periods of high turbidity were occasionally observed in the stream at other times. These arose from runoff following certain heavy rain falls. This condition was rapidly changed until the stream was clear again, and no lasting effects were noted. However, it is likely that some channel scouring may occur under such conditions.

Hydrogen Ion Concentration

The pH of water often greatly influences the species of algae which make up a flora. Thus, waters with different pH values often have different algal floras. This effect of pH on the flora is both a direct,and perhaps more importantly, an indirect effect by altering the solubility of several important substances in the water.

In natural waters, pH is always influenced by the substrate of the drainage. Thus, Prescott (1951, 1956) noted that if the substrate is low in calcium the aquatic environment will generally have a pH below 7.0 Conversely if the substrate is shale or limestone the high content of calcium in the drainage waters will generally allow a pH above 7.0 . The reason for this is that calcium carbonate reacts with CO_2 in the water forming calcium bicarbonate which becomes slightly ionized in water to yield hydroxyl ions.

The waters sampled through this study were basic at all sites. The pH ranged from 7.3 to 8.8 in the arboretum pond and from 7.7 to 8.4 in the stream. This is due to the limestone substrate in the drainage of the stream and pond.

The water of the stream on campus was somewhat more alkaline than in the arboretum pond probably due to the greater biological oxidation in this pond with concurrent formation of large amounts of degradation products which lowered the pH to some extent.

In this study the pH value of the arboretum pond and stream did not show much variation throughout the study suggesting that these waters were highly buffered and were not subjected to appreciable pollution. The common buffering agents in waters are calcium and magnesium carbonates, and the campus waters contained the calcium monocarbonate and calcium bicarbonate. Thus, it is likely that when carbon dioxide was withdrawn from the water by photosynthesis, some of the bicarbonate dissociated into monocarbonate and carbon dioxide. Likewise, if carbon dioxide was added to the water by decomposition of organic matter by bacteria or by respiration of algae or zooplankton, some or all of it combined with monocarbonate to form bicarbonate. Thus, waters with such a buffering system exhibit a narrow range of pH fluctuation.

The lower pH values recorded for the arboretum pond during the summer were somewhat unexpected since the pH is generally higher in a pond in the later summer (Prescott, 1951) due to the removal of much of the half-bound carbon dioxide by photosynthesis. These low pH values were likely due to the removal of *Spirogyra* spp. mats from the arboretum pond by grounds keepers in charge of this garden. This removal caused a drastic reduction in photosynthesis in the pond, thereby allowing carbon dioxide to accumulate to a greater extent than normal thus influencing the pH of the water.

Carbon Dioxide

Carbon dioxide undoubtedly is an important substance for plant growth due to the requirement of CO_2 in photosynthesis. The growth of diatoms and other algae may be stimulated by added CO_2 concentration. For instance, Patrick (1948) mentioned that *Nitzschia linearis* and *Surirella biseriata* demonstrated improved growth when the CO_2 concentration was increased, and Eddy (1927) noted the same phenomenon for *Synedra* sp. It is interesting that the development of *N. linearis* paralleled these results at stream site two. Thus, in March when the carbon dioxide value reached its maximum development, the maximum development of *N. linearis* was likewise noted. In April the carbon dioxide level dropped sharply and the number of N. *linearis* likewise decreased sharply.

The arboretum pond consistently demonstrated a high level of CO_2 (the maximum being 11 P.P.M. and minimum 4 P.P.M.). This high CO_2 concentration is one important reason for the heavy algal growth in this pond. These high levels originated in part from direct dissolution of organic matter by bacteria and fungi, since decomposition occurred constantly and rapidly, especially during summer months.

Another important source of CO_2 available for photosynthesis is bicarbonate alkalinity. In regard to this Smith (1950) pointed out that dissolved calcium bicarbonate may be utilized directly as a source of carbon dioxide for photosynthesis, thus explaining the increased algal growth under conditions of high bicarbonate concentration. This phenomenon was noted for the arboretum pond where the bicarbonate alkalinity was high (up to 260 P.P.M.) and certainly contributed to the high algal populations there.

Dissolved Oxygen

Two principle sources of dissolved oxygen were present at the sites in this study. These were from absorption directly from the atmosphere and from photosynthesis by plants occurring in the water.

The dissolved oxygen content increased greatly during spring and summer months especially in the arboretum pond due to the increased photosynthetic activities by the aquatic vegetation. Thus, in April and May *Spirogyra* sp. reached its maximum population in this pond forming large mats and the dissolved oxygen level reached its peak during the same time. The dissolved oxygen decreased rapidly in July and August since most Spirogyra sp. was removed from the pond by the arboretum gardeners. The high dissolved oxygen levels for January and February were probably due to the greater ability of water to absorb oxygen at low temperatures.

Dissolved oxygen levels were high in all stream localities throughout this study. This was due to the rapid current of the stream which allowed readily for the absorption of oxygen. Likewise, the abundant algal and vascular plant vegetation in the stream was partially responsible for these high levels, particularly at site three, where especially abundant vegetation occurred.

Smith (1950) pointed out that it is difficult to correlate the seasonal changes in dissolved oxygen and carbon dioxide with the periodicity of the algal flora. However, undoubtedly dissolved oxygen is not a limiting factor to algal growth at the sites examined in this study.

Silica

Silica is necessary for diatom growth (Chu, 1943). Generally speaking, alkaline waters often contain a high silica content which is one important reason for the development of large diatom populations in such waters.

The silica content in the arboretum pond was very high throughout the study, ranging from 27 P.P.M. to 81 P.P.M. This high silica content was certainly one reason for the abundant diatom growth in this pond.

Nitrates

Patrick (1948) stated that nitrates in oligotrophic waters are often low and may be difficult to detect by standard analytical methods. Conversely, in eutrophic waters nitrate content is relatively high, often one to two P.P.M. The nitrate content of the arboretum pond was rather low throughout this study, although other conditions of this pond indicated eutrophic conditions.

Nitrates were higher in the summer than that in the winter due to two factors. First, bacterial decomposition of organic substances is high in the summer, resulting in the release of nitrates. Second the summer was a time of irrigation runoff which was relatively high in nitrates from fertilizers and decomposing organic products.

Some diatoms such as *Diatoma vulgare*, *Nitzschia linearis* and *Surirella ovata* seem to favor high concentrations of nitrate, whereas some species such as *Melosira granulata* prefer low nitrate concentrations. In July and August, *Diatoma vulgare* was dominant at all sites of the stream when the nitrates were at a maximum concentration of from 2.5 P.P.M. to 3.9 P.P.M. Likewise *Nitzschia linearis* and *Surirella ovata* were prominent during periods of high nitrate levels especially at stream site two.

Soil Diatoms

The study of soil algae and soil diatoms in particular has largely been neglected in the past. Consequently, not much is known concerning the distribution of soil diatoms or their role in the ecosystem. The possibility exists that these organisms are extremely important perhaps generally and certainly locally, and further studies are definitely needed to determine their ecologic role.

Lund (1945) pointed out that it is difficult to determine factors which influence the growth of soil diatoms in nature. This is the case since these factors are often controlled by the firmness of the surface of the soil, soil texture, water content and temperature all of which are seasonal, or may change drastically even during a single day.

Several research workers have noted that soil diatoms tend to be smaller than their counterparts in water. Geitler (1932) proposed that this is due to the greater ability of small diatoms to absorb water and nutrients directly from the soil particles through a surface firm of water. Lund (1945) on the other hand noted that smaller diatoms in the soil have a greater ability to move when conditions become adverse, and the larger diatoms are the first to die under dry conditions. Hence, Lund suggested that the small sized diatoms were favored by natural selection due to their greater mobility.

In this study 16 genera and 33 species of soil diatoms were found. Most of these were very small, including *Nitzschia amphibia*, *Nitzschia fonticola*, *Amphora normani* and *Achnanthes minutissima*. However, some large species such as *Pinnularia gentilis* (132u x 22u) and *Cymatopleura solea* (85u x 20u) were present. The likely explanation for the occurrence of these large diatoms is that growth conditions were especially favorable for diatoms in the greenhouses since the soil received a regular high amount of water due to irrigation. Hence, any selective advantage for smaller soil diatoms would be reduced.

TAXONOMIC ALGOLOGY

Division CHRYSOPHYTA

Class BACILLARIOPHYCEAE (DIATOMEAE)

Order CENTRALES

Family COSCINODISCACEAE

Genus MELOSIRA C. A. Agardh

Description.--Cells drum-shaped to cylindrical, united end to end to form long filamentous colonies; valve rectangular to square in girdle view; sulcus present or absent, if absent, entire girdle ornamented, if present, portion of girdle below sulcus wihtout ornamentation; connecting zone present or absent; punctae present on both girdle and valve, fine to coarse; valve circular in valve view, with or without marginal teeth, flat or convex.

Melosira distans (Ehr.) Kutzing

Pl. 1, Fig. 11.

Description.--Cells cylindrical; valve in girdle view about 14u long by 6u wide, united into long filaments; sulcus present, very narrow; connecting zone evident, spined; punctae aligned forming striae; striae evident, longitudinal, straight or slanting, 12 in 10u; valve in valve view punctate; punctae scattered.

Discussion.--*M. distans* was found only in the arboretum pond and was very rare.

Melosira granulata (Ehrenberg) Ralfs

Pl. 1, Figs. 4-6.

Description.--Cells cylindrical; valve in girdle view 14-18u long by 4-10u wide, united end to end forming long filaments; sulcus present, narrow; girdle punctate; punctae large, coarse, 10-11 in 10u, forming straight or slightly irregular striae; striae 7-9 in 10u; valve in valve view coarsely denticulate on margin, with scattered, indistinct punctae.

Discussion.--M. granulata was found in low numbers in the arboretum pond and at all stream sites. This taxon varies rather widely in size but is distinguished by its very coarse, large punctae.

Melosira italica (Ehr.) Kutzing

Pl. 1, Figs. 7-8, 12.

Description.--Cells cylindrical; 14-38u long by 5-18u wide in girdle view, united into long filaments; sulcus present, rectangular, narrow; connecting zone evident, denticulate; punctae evident, forming oblique striae; striae 9-12 in 10u; valve in valve view with evident, long teeth; punctae fine.

Discussion.--M. italica occurred in the arboretum pond and at all stream sites. This species is similar to Melosira crenulate (Ehr.) Kutz. but has more evident punctae which are obliquely aligned.

Melosira varians C. A. Agardh

Pl. 1, Figs. 9-10.

Description.--Cells capsule-shaped; 20-30u long by 12-15u wide in girdle view, united into twos or long filaments; punctae very faint, girdle appearing smooth; valve in valve view slightly convex, punctate; punctae of two sizes; small punctae rather aligned, large punctae scattered.

Discussion.--M. varians was collected at all collecting localities. This taxon was the most common diatom throughout this study and was especially prominent during the winter in the arboretum pond. M. varians may be distinguished by its rather large size, smooth cell wall and the absence of spines in the connecting zone.

Genus CYCLOTELLA Kutzing

Description.--Cells discoid or drum shaped, usually solitary, occasionally forming short chains; intercalary bands absent; valve round; valve ornamentation in two zones, outer zone with radiate striae or punctae, inner zone smooth or with scattered punctae.

Cyclotella bodanica Eulenstein

Pl. 1, Fig. 1.

Description.--Cells discoid; valve round, 19-28u in diameter, with central and peripheral zones; central zone with scattered coarse punctae; outer zone striate; striae prominent, 10 in 10u; prominent spines present on inner edge of margin between peripheral striae.

Discussion.--C. bodanica was found in the arboretum pond and in the stream, but was never prominent. This species is similar to Cyclotella comta (Ehr.) Kutz., differing by having a flat rather than convex central zone and coarser striae.

<u>Cyclotella</u> <u>meneghiniana</u> Kutzing

Pl. 1, Figs. 2-3.

<u>Description</u>.--Cells discoid; valve round, 11-14u in diameter, with central and peripheral zones; central zone with very fine punctae, appearing nearly smooth; striae confined to outer zone, 8-9 in 10u; border often appearing scalloped; ornamentation absent between peripheral striae.

<u>Discussion</u>.--<u>C</u>. <u>meneghiniana</u> occurred in the arboretum pond and at stream sites one and two. It was one of the most common diatoms in this study and demonstrated many size variations. This species is distinguished by the broad striae in the outer zone and the nearly smooth central area.

Genus STEPHANODISCUS Ehrenberg

<u>Description</u>.--Cells discoid or drum-shaped, intercalary bands absent; valve striate; striae punctate; punctae multiseriate near margin, uniseriate approaching central area; central area distinct or indistinct, punctate; submarginal spines present, distinct; valve face in girdle view undulate, swollen in the center, abruptly constricted near margin.

<u>Stephanodiscus</u> <u>niagarae</u> Ehrenberg

Pl. 2, Fig. 1.

<u>Description</u>.--Cells discoid; valve round, 37-47u in diameter, divided into central and peripheral zones; central zone with irregularly scattered

punctae; outer zone striate; striae punctate; punctae in 3-5 rows, 14-15 in 10u; spines evident, submarginal.

Discussion.--S. niagarae was found in rather low numbers in the arboretum pond and at all stream sites, and was collected throughout the year. S. niagarae is similar to Stephanodiscus astrae (Ehr.) Grun. which differs by having 2-3 rows of puncta in the marginal region, and marginal rather than submarginal spines.

Order PENNALES

Family FRAGILARIACEAE

Genus ASTERIONELLA Hassall

Description.--Cells united in stellate colonies, septae and intercalary bands absent; valve linear, with swollen, rounded poles; pole attached to other cells of colony larger than opposite pole; pseudoraphe very narrow, indistinct; striae transverse, very fine.

Asterionella formosa Hassall

Pl. 2, Fig. 3.

Description.--Valve 70-100u long by 4-5u wide, linear, with swollen, rounded poles; poles unequal in size; pseudoraphe very narrow, linear, nearly indistinct; striae very fine, about 25 in 10u.

Discussion.--A. formosa occurred only rarely at all stream sites. This species forms stellate colonies naturally but the frustules observed in this study were most often separate. The source of this diatom in the stream is not known but it is certainly unnatural in occurrence there.

Genus HANNAEA Patrick

Description.--Cells solitary; valve curved, assymmetrical to apical plane, symmetrical to transapical plane; dorsal margin convex, ventral margin concave; poles swollen, rounded or capitate; pseudoraphe evident, narrow; central area evident, transversely widened to ventral margin.

Hannaea arcus var. amphioxys (Rabh.) Patrick

Pl. 11, Fig. 3.

Description.--Valve 31u long by 6u wide, with rostrate, somewhat capitate poles; dorsal margin convex, ventral margin concave, slightly swollen between poles and midvalve, forming undulations; pseudoraphe evident, very narrow; central area unilateral, reaching ventral margin; striae linear, 14 in 10u.

Discussion.--H. arcus var. amphioxys was collected only once from stream site two. This taxon is distinguished by the unilateral central area and triundulate ventral margin.

Genus DIATOMA Bory

Description.--Cells united into linear or zigzag colonies; valve ovate, linear, lanceolate or elliptical, with rounded or swollen-capitate poles; costae evident, thickened, internal, most extend across entire valve; pseudoraphe very narrow or indistinct; striae linear, finely punctate, between costae; valve in girdle view rectangular to linear; intercalary bands occasionally present.

Diatoma anceps (Ehr.) Kirchner

Pl. 2, Fig. 4.

Description.--Valve 28u long by 5u wide, linear to slightly lanceolate, with rounded-capitate poles; costae straight, 5 in 10u; striae fine, about 18 in 10u, interrupted by narrow pseudoraphe.

Discussion.--D. anceps was collected from stream sites one and two.

Diatoma hiemale var. mesodon (Ehr.) Grunow

Pl. 2, Fig. 5.

Description.--Valve 12-19u long by 6-10u wide, elliptical, with rounded poles; transverse costae 3-5 in 10u; striae fine, 18-20 in 10u, interrupted by narrow indistinct pseudoraphe.

Discussion.--D. hiemale var. mesodon was collected rarely from stream site one. This species is similar to Diatoma vulgare var. ovalis (Fricke) Hustedt, but has coarser transverse costae.

Diatoma tenue var. elongatum Lyngbye

Pl. 2, Fig. 6.

Description.--Valve 46-74u long by 3-4u wide, linear, with rounded, slightly swollen poles; costae extending width of valve, 7-9 in 10u; striae fine, interrupted by very narrow often indistinct pseudoraphe.

Discussion.--D. tenue var. elongatum occurred at all collecting sites in the stream and in the arboretum pond. It was especially common during spring months in the stream.

Diatoma vulgare Bory

Pl. 2, Figs. 7-8.

Description.--Cells forming zigzag colonies; valve 25-40u long by

10-13u wide, elliptic with broadly rounded poles, slightly but evidently constricted below poles; costae mostly extending entire valve width, 6-8 in 10u; striae linear, about 2-3 between costae, interruped by narrow pseudoraphe.

Discussion.--D. vulgare occurred at all localities in the stream and was especially prominent in May.

Genus FRAGILARIA Lyngbye

Description.--Cells usually aggregated into various colonies; valve linear, lanceolate, elliptical to rounded, some medianly constricted or biconstricted; poles rounded, capitate, cuneate, attenuate to rostrate; pseudoraphe present or absent, linear to broadly lanceolate; central area varied or absent, occasionally unilateral; striae linear or wide, occasionally cross-lined, parallel to radiate.

Fragilaria brevistriata var. inflata (Pant.) Hustedt

Pl. 2, Fig. 9.

Description.--Valve 18u long by 5u wide, lanceolate, with broadly rostrate poles; pseudoraphe broadly lanceolate; striae short, radiate, 14 in 10u.

Discussion.--F. brevistriata var. inflata was collected only from the arboretum pond and was rare. This diatom is similar to Synedra parasitica (W. Sm.) Hust. differing by the broad lanceolate pseudoraphe and the short, coarse striae.

Fragilaria capucina var. mesolepta Rabenhorst

Pl. 2, Fig. 10.

Description.--Valve 32-34u long by 3-6u wide, linear, constricted at midvalve and below rounded poles; pseudoraphe narrow, linear; central area extending to valve margin; striae parallel throughout valve length, 16-17 in 10u.

Discussion.--F. capucina var. mesolepta was collected rarely only from the arboretum pond and at stream site two. This diatom is somewhat similar to Synedra rumpens Kutz., but differs in the median constriction.

Fragilaria construens var. venter (Ehr.) Grunow

Pl. 2, Fig. 11.

Description.--Valve 6-14u long by 4-6u wide, elliptic-rhombic to elliptic-rounded, with obtuse rounded poles; pseudoraphe distinct, lanceolate, striae radiate, cross-lined, 14-16 in 10u.

Discussion.--F. construens var. venter occurred in the arboretum pond and at all stream collecting sites but was never prominent in this study.

Fragilaria crotonensis Kitton

Pl. 2, Fig. 12.

Description.--Valve 54-107u long by 3-4u wide, linear, gradually swollen approaching midvalve, with somewhat swollen, rounded poles; pseudoraphe very narrow, nearly indistinct; central area reaching valve margin, rectangular, longer than broad; striae parallel, 14-16 in 10u.

Discussion.--F. crotonensis occurred in the arboretum pond and all sites in the stream. It first appeared in the early summer but was always present in low numbers.

<u>Fragilaria</u> <u>leptostauron</u> Hustedt

Pl. 2, Fig. 13.

<u>Description</u>.--Valve 13-22u long by 9-12u wide, strongly swollen at midvalve forming cross-shape; poles rounded; pseudoraphe distinct, linear-lanceolate; striae coarse, radiate throughout most of valve, irregular in length at midvalve, 8-12 in 10u.

<u>Discussion</u>.--<u>F</u>. <u>leptostauron</u> was a common diatom in this study, but was never present in high numbers. It occurred in the arboretum pond and in the stream, especially during the summer as well as in the greenhouse soil. This diatom showed some variation, especially in the degree of median expansion.

<u>Fragilaria</u> <u>vaucheriae</u> (Kutz.) Peters

Pl. 3, Figs. 1-2.

<u>Description</u>.--Valve 15-25u long by 3-5u wide, linear or linear-lanceolate to elliptical; poles rounded, swollen rostrate; pseudoraphe linear, narrow, abruptly widened at central area; central area unilateral; margin swollen on central area side; striae parallel to radiate, 12-17 in 10u.

<u>Discussion</u>.--<u>F</u>. <u>vaucheria</u> occurred in the arboretum pond and in the stream. It was a common diatom in this study but was never collected in large numbers. This taxon shows several variations in valve shape but may be distinguished by the swollen margin at the unilateral central area.

Genus MERIDION C. A. Agardh

Description.--Cells aggregated to form fan-shaped colonies; valve cuneate, with thickened internal transverse costae; costae mostly extending completely across valve; raphe absent; pseudoraphe present, indistinct; striae fine, between costae, interrupted medianly by pseudoraphe.

Meridion circulare var. constrictum (Ralfs) van Heurck

Pl. 3, Figs. 3-4.

Description.--Valve 13-35u long by 5-11u wide, cuneate, one pole large, swollen capitate, opposite pole smaller, rounded; pseudoraphe linear, indistinct; costae 3-6 in 10u; striae 15-17 in 10u.

Discussion.--M. circulare var. constrictum was collected from stream sites two and three, but was rare in this study. This taxon is distinguished by the large capitate pole and small rounded opposite pole, although a good deal of variation in frustule size and shape occurs.

Genus SYNEDRA Ehrenberg

Description.--Cells solitary or forming stellate colonies; valve lanceolate to very long linear, occasionally biconstricted; poles rounded, capitate, cuneate or swollen; pseudoraphe distinct, very narrow; central area rectangular, quadrate, lanceolate or rounded, bilateral or unilateral; striae radiate or parallel, opposite or alternate, interrupted by pseudoraphe.

Synedra acus Kutzing

Pl. 3, Fig. 5.

Description.--Valve 92-113u long by 3-4u wide, linear gradually tapering to rounded-capitate poles; pseudoraphe linear, becoming wider near midvalve; central area evident, longer than broad; striae parallel throughout valve length, 12-13 in 10u.

Discussion.--S. acus occurred in the arboretum pond and stream sites one and three. This diatom may occasionally be confused with some varieties of Synedra ulna (Nitz.) Ehr., although the gradually tapering valve shape of S. acus is diagnostic.

Synedra capitata Ehrenberg

Pl. 3, Fig. 6.

Description.--Valve 211-325u long by 7-8u wide, linear, with swollen cuneate-capitate poles; pseudoraphe linear, narrow; central area absent; striae parallel throughout most of valve, slightly radiate near poles, 9-14 in 10u.

Discussion.--S. capitata occurred in the arboretum pond, but was never found in large numbers. This species is distinguished by the swollen wedge-shaped poles and the absence of a central area.

Synedra fasciculata (Ag.) Kutzing

Pl. 3, Fig. 7.

Description.--Valve 118-124u long by 4-5u wide, linear, with tapering, rounded, somewhat rostrate to slightly swollen poles; pseudoraphe wide, linear, central area absent; striae short but not marginal, parallel throughout valve length, 9-12 in 10u.

Discussion.--S. fasciculata was collected from the arboretum pond and stream site two, but was never prominent. The wide pseudoraphe is a distinctive characteristic of this species.

Synedra parasitica (W. Sm.) Hustedt

Pl. 3, Fig. 8.

Description.--Valve 11-24u long by 5-7u wide, rhombic-lanceolate, with sharply tapering, small rostrate poles; pseudoraphe lanceolate; striae linear, radiate, 15-20 in 10u.

Discussion.--S. parasitica was found in the arboretum pond, the greenhouse soil and at stream site two. This diatom may be confused with Fragilaria construens (Ehr.) Grun. or Fragilaria brevistriata var. inflata Grun., which are similar in some respects. However, these three diatoms may be separated based upon polar shape and striation.

Synedra parasitica var. subconstricta (Grun.) Hustedt

Pl. 3, Figs. 9-10.

Description.--Valve 16-32u long by 3-5u wide, strongly constricted at midvalve, tapering to long rostrate poles pseudoraphe wide, linear-lanceolate; striae short, parallel throughout valve length, 15-17 in 10u.

Discussion.--S. parasitica var. subconstricta was found in the arboretum pond and at stream sites two and three. This taxon was somewhat variable in median constriction with some being strongly constricted and others being less constricted. This diatom is similar to Fragilaria construens var. binodis (Ehr.) Grun. but differs in pseudoraphe shape.

Synedra rumpens Kutzing

Pl. 3, Fig. 11.

Description.--Valve 20-40u long by 3-4u wide, linear-lanceolate, gradually tapering to swollen, rounded-capitate poles; pseudoraphe narrow; central area reaching valve margin, longer than broad; striae parallel throughout valve length, 13-14 in 10u.

Discussion.--S. rumpens occurred in the arboretum pond, stream site two and the greenhouse soil, but was never prominent.

Synedra ulna var. subaequalis (Grun.) van Heurck

Pl. 3, Fig. 14.

Description.--Valve 170-205u long by 4-7u wide, long linear, somewhat constricted below long attenuated-rostrate, occasionally swollen poles; central area absent; pseudoraphe linear, very narrow; striae coarse, parallel throughout most of valve length, radiate near poles, 8-10 in 10u.

Discussion.--S. ulna var. subaequalis occurred in the arboretum pond and at stream sites one and two, and was most common during winter months.

Synedra ulna (Nitz.) Ehrenberg

Pl. 4, Fig. 1.

Description.--Valve 83-194u long by 6-8u wide, linear, gradually attenuated to rostrate, rounded poles, pseudoraphe linear, very narrow; central area reaching or near reaching valve margin, rectangular to quadrate, occassionally absent; striae coarse, alternate, parallel, 9-12 in 10u.

Discussion.--S. ulna was a very common diatom in this study and occurred in the arboretum pond and at all stream sites throughout the study period. This taxon has many variations, and striae number is critical for identification.

Synedra ulna var. constricta str.

Pl. 3, Fig. 12.

Description.--Valve 85-100u long by 7-8u wide, linear, slightly constricted at midvalve, with rostrate poles; pseudoraphe linear, narrow, widened at central area; central area longer than broad, reaching valve margin; striae linear, parallel throughout valve length, 10-11 in 10u.

Discussion.--S. ulna var. constricta occurred only at the stream site two in low numbers. This taxon showed only a slight median constriction, rather than being strongly constricted as reported by other authors.

Synedra ulna var. ramesi (Herb.) Hustedt

Pl. 3, Fig. 13.

Description.--Valve 54u long by 10u wide, linear, constricted at midvalve, with long rostrate poles; pseudoraphe linear, widened near central area; central area reaching valve margin, bordered by one to two very short striae; striae parallel throughout most of valve, slightly radiate near poles, 10-11 in 10u.

Discussion.--S. ulna var. ramesi was collected only once from stream site one during this study. This taxon is shorter and wider than the other varieties of S. ulna and demonstrates an evident median constriction and long rostrate poles.

Family EUNOTIACEAE

Genus EUNOTIA Ehrenberg

Description.--Cells solitary or forming filaments; valve bent or curved;

dorsal margin convex, often undulate; ventral margin straight to concave; raphe short, excentric, not extending throughout valve length; striae linear, parallel throughout most of valve length.

Eunotia curvata (Kutz.) Lagerst

Pl. 4, Fig. 2.

Description.--Valve 68u long by 4u wide, arc-shaped; dorsal and ventral margins parallel or slightly tapering to small, rounded poles, polar nodule small; raphe nearly indistinct; transverse striae evident, coarse, 13 in 10u.

Discussion.--E. curvata was collected only once from the arboretum pond.

Family ACHNANTHACEAE

Genus ACHNANTHES Bory

Description.--Cells naviculoid, solitary or united into dendroid or bundle-like colonies; valve linear, lanceolate, elliptical, slightly sigmoid or biconstricted, with rostrate, rounded, attenuated, or capitate poles; raphe present on one valve only; raphe straight but often bent somewhat at poles; axial area linear or lanceolate; central area narrow; transversely widened or rounded, often present only on raphe valve; striae strongly to slightly radiate, equal or different in number on both valves, linear or punctate.

Achnanthes lanceolata (Breb.) Grunow

Pl. 4, Figs. 4-6.

Description.--Valve 10-31u long by 4-8u wide, lanceolate to elliptical, with broadly rounded poles; raphe straight; axial area linear; central area rectangular, nearly reaching valve margins, containing irregular number of short, marginal striae; striae broadly linear, radiate, 12-17 in 10u; pseudoraphe valve similar to raphe valve except without central area and with U-shaped area on one side at midvalve.

Discussion.--A. lanceolata occurred in low numbers in the arboretum pond, at all sites of stream and in the greenhouse soil.

Achnanthes lanceolata var. dubia Grunow

Pl. 4, Fig. 3.

Description.--Valve 15-23u long by 5-7u wide, broadly lanceolate to elliptical with large rostrate to capitate poles; raphe straight, somewhat broader near midvalve; axial area narrow; central area rounded; striae linear, radiate throughout valve length, sometimes absent on one side at midvalve, 12-16 in 10u; pseudoraphe valve similar to raphe valve except large U-shaped area present on one side at midvalve.

Discussion.--A. lanceolata var. dubia occurred in the arboretum pond and at stream sites two and three, but was never prominent.

Achnanthes minutissima Kutzing

Pl. 4, Fig. 7.

Description.--Valve 6-11u long by 2-3u wide; raphe valve linear to lanceolate with broadly rounded poles; axial area narrow, linear; central area rectangular to irregular, transversely widened; raphe broader near midvalve; striae radiate, short and irregular in central area; pseudoraphe valve with narrow, somewhat lanceolate axial area; striae radiate throughout valve length, about 30 in 10u.

Discussion.--A. minutissima was found in the arboretum pond, at all sites of the stream and in the greenhouse soil. This species was relatively common throughout this study.

Genus COCCONEIS Ehrenberg

Description.--Cells solitary, often epiphytic; valve elliptical to elliptic-rounded, to apical and transapical planes, sometimes arched along apical axis; raphe present on one valve, pseudoraphe on opposing valve; ornamentation differing on raphe and pseudoraphe valves; raphe valve striate, hyaline ring occasionally present near valve margins; raphe median; pseudoraphe valve striate; striae punctate, curved-radiate; pseudoraphe narrow, linear.

Cocconeis pediculus Ehrenberg

Pl. 4, Figs. 8-9.

Description.--Valve 21-25u long by 15-22u wide, broadly elliptical, nearly round; raphe valve with narrow axial area; raphe slightly broader near central area; central area small, rounded; striae radiate, bent toward poles except at midvalve, 18-23 in 10u; hyaline ring around valve margin; pseudoraphe valve with narrow, linear pseudoraphe; striae forming longitudinal undulate rows, 18-23 in 10u.

Discussion.--C. pediculus occurred in the arboretum pond, all sites of the stream and in the greenhouse soil. This species was common during winter months in the arboretum pond and became even more common during the summer in the stream. It was collected as an epiphyte on other algae or from scrapings of stones on the substrate.

Cocconeis placentula var. euglypta (Ehr.) Cleve

Pl. 4, Fig. 10.

Description.--Valve 15-25u long by 8-15u wide, narrowly elliptical; raphe valve with two hyaline rings and one or two rows of punctate around valve margin; axial area narrow; central area small, rounded; pseudoraphe valve with narrow, linear-lanceolate pseudoraphe; striae broken into 4-5 dash-shaped punctae; punctae 19-24 in 10u, aligned forming 4-5 longitudinal undulate rows.

Discussion.--C. placentula var. euglypta was found in the arboretum pond, the stream and in the greenhouse soil. It was especially common in the winter. This diatom is distinguished by the aligned punctae forming 4 to 5 undulate longitudinal rows.

Cocconeis placentula var. lineata (Ehr.) van Heurck

Pl. 4, Figs. 11-12.

Description.--Valve 18-35u long by 9-25u wide, elliptical with broadly rounded poles; raphe valve with two hyaline rings and one or two rows of punctae around valve margin; raphe straight; axial area linear to slightly lanceolate; central area small, rounded to irregularly widened; striae evidently punctate, radiate, 17-20 in 10u; pseudoraphe valve with linear or slighlty lanceolate pseudoraphe; central area absent; striae coarsely punctate, forming several longitudinal rows, 21-22 in 10u.

Discussion.--C. placentula var. lineata was collected from all localities in this study and was one of the most common diatoms encountered. This variety is similar to the nominate variety but differs by demonstrating a longer elliptical valve shape and coarser punctae.

Genus RHOICOSPHENIA Grunow

Description.--Cells in girdle view wedge-shaped, curved; poles truncate; striae coarse; longitudinal septae present; valve lanceolate, assymetrical to transapical plane; raphe valve with lanceolate central area; axial area very narrow; striae linear, parallel throughout most of valve, convergent at poles; pseudoraphe valve similar to raphe valve.

Rhoicosphenia curvata (Kutz.) Grunow

Pl. 5, Figs. 1-2.

Description.--Cell in girdle view 18-28u long by 5-10u wide, curved; poles cuneate; valve clavate; raphe valve axial area linear; central area small, rounded; striae essentially parallel, broadly linear, crossed by perpendicular line, regularly shortened to form central area, 8-9 in 10u near central area, 12 in 10u near poles.

Discussion.--R. curvata was collected in the arboretum pond, at all sites of the stream, and in the greenhouse soils. This diatom was frequenlty collected during this study, but was never abundant. It reached its maximum during winter months in the arboretum pond. This diatom is generally seen in girdle view, only rarely appearing in valve view.

Family NAVICULACEAE

Genus ANOMOEONEIS Pfitzer

Description.--Cells solitary; valve lanceolate, rhombic or elliptic, occasionally with median swelling; raphe straight, occasionally with sickle-shaped polar fissures, curved in same direction; axile area narrow; striae punctate, discontinuous, interrupted by non-punctate spaces; central area variable, symmetrical or assymmetrical, rhombic, circular or unilateral.

Anomoeoneis sphaerophora (Ehr.) Pfitzer

Pl. 5, Fig. 3.

Description.--Valve 70-73u long by 19-20u wide, broadly linear-elliptic, with capitate to swollen rostrate poles; axial area broad, bordered by single row of punctae; raphe straight, slightly broader at central nodule, sickle-shaped at poles, curved in same direction at both poles; striae punctate, mostly parallel, unequal in length, 15-19 in 10u; central area transverse, unilateral, extending to valve margin.

Discussion.--A. sphaerophora occurred in the arboretum pond and at stream site two. This diatom was the only Anomoeoneis collected, and it was distinguished by the rostrate poles, unilateral central area and irregular striation.

Genus CALONEIS Cleve

Description.--Cells solitary; valve symmetrical about both transapical and apical planes, linear or lanceolate, occasionally biconstricted; raphe straight, with distinct terminal fissures; axial area linear-lanceolate to irregular; central area variable; transverse striae continuous, non-punctate, crossed by one or two longitudinal lines near valve margin.

Caloneis ventricosa (Ehr.) Meister

Pl. 5, Fig. 4

Description.--Valve 53u long by 12u wide, biconstricted, with broadly cuneate poles; axial area lanceolate, narrowed near poles; central area elliptic; raphe straight, somewhat broad, bent slightly at central nodule; striae linear, slightly radiate throughout valve length, 18 in 10u; longitudinal band crossing striae near valve margin.

Discussion.--C. ventricosa was collected only in the arboretum pond and was represented by a single specimen.

Genus DIPLONEIS Ehrenberg

Description.--Cells solitary; valve broadly linear-elliptical, median constriction present or absent; raphe extending entire valve length, bisecting siliceous rib; rib bordered longitudinally by longitudinal canal; axial area present or absent, variable in shape when present; transverse costae radiate throughout valve, one to two rows of alveoli between costae; alveoli variable in shape as pores, squares etc.

Diploneis oblongella (Naeg. ex Kutz.) Ross

Pl. 5, Fig. 5.

Description.--Valve 16-23u long by 5-8u wide, broadly elliptic with rounded poles; longitudinal canal narrow, with single row of punctae; raphe contained in siliceous rib, not swollen at central nodule; central area elliptic; transverse costae radiate throughout valve, 16-19 in 10u; single row of chambers between costae.

Discussion.--D. oblongella was very rare in the pond but was occasionally common in greenhouse soils. This taxon is distinguished by the shape and size of the valve and the single row of alveoli between the costae.

Genus FRUSTULIA C. A. Agardh

Description.--Cells solitary; valve solitary, naviculoid, linear to lanceolate, with longitudinal and transverse striae; raphe straight, enclosed in median siliceous ribs which combine at polar nodule; central area elongated or rounded.

Frustulia vulgaris (Thwaites) DeToni

Pl. 5, Fig. 6.

Description.--Valve 45-48u long by 8-10u wide, linear to lanceolate with short rostrate-rounded poles; axial area narrow; central area rounded-elliptical; striae evidently punctate, punctae aligned vertically and horizontally; transverse striae about 28 in 10u; longitudinal striae about 30 in 10u.

Discussion.--F. vulgaris occurred in the arboretum pond and at stream site two, but was very rare.

Genus GYROSIGMA Hassall

Description.--Cells solitary, intercalary bands and septae absent; valve lanceolate to elliptic, slighlty to strongly sigmoid, with attenuate rounded, long rostrate or broadly rounded poles; axial area linear; central area small, rounded or elliptic; raphe sigmoid; polar raphe ends forked; central raphe ends curved in different directions; striae punctate; punctae forming perpendicular transverse and longitudinal rows.

Gyrosigma spencerii (Quek.) Griff. & Henfr.

Pl. 5, Fig. 7.

Description.--Valve 90-98u long by 12-13u wide, lanceolate, sigmoid, with curved, somewhat attenuate rounded poles; raphe slighlty sigmoid, excentric near poles; distal raphe ends forked; proximal raphe ends hooked in opposition directions; axial area narrow; central area small, elliptic; striae obviously punctate; punctae aligned both horizontally and vertically; transverse striae about 20 in 10u; longitudinal striae about 19 in 10u.

Discussion.--*G. spencerii* occurred in the stream at sites one, two and three. This taxon has been often collected in Utah but was very rare in this study.

Genus NAVICULA Bory

Description.--Cells solitary, without intercalary bands or septa, rectangular in girdle view; valve always symmetrical, linear, lanceolate or elliptic to nearly rounded, occasionally with median expansion; axial area linear to broad, somewhat lanceolate; raphe straight; central area circular, rectangular or irregularly transverse, never extending to valve margin, occasionally with single isolated punctum; striae punctate, fine to coarse, occasionally bent, often shortened along margins of central area; poles rounded, rostrate, capitate or attenuated to rounded or pointed ends.

Navicula capitata Ehrenberg

Pl. 5, Fig. 8.

Description.--Valve 12-20u long by 6-8u wide, elliptic-lanceolate, with large capitate poles; polar nodules widened, transverse to valve margin; axial area narrow, slightly broader at midvalve; central area small, rounded, striae coarse, crosslined, radiate at midvalve, parallel or convergent at poles, 8-10 in 10u.

Discussion.--N. capitata occurred only in the stream at site three and was rare. This taxon is easily distinguished by the large capitate poles, valve shape and the very coarse, crosslined striae.

Navicula cryptocephala Kutzing

Pl. 5, Fig. 9.

Description.--Valve 19-35u long by 4-8u wide, lanceolate, with rostrate-capitate poles; axial area linear, narrow; central area small, irregularly rounded; striae radiate at midvalve, convergent near poles, 15-16 in 10u.

Discussion.--N. cryptocehpala was collected at all stream sites. This taxon may be confused with N. rhynchocephala Kutz. although N. cryptocephala is smaller and has finer striae. This diatom was collected often in this study but was never abundant.

Navicula cryptocephala var. veneta (Kutz.) Rabenhorst

Pl. 5, Fig. 10; Pl. 6, Fig. 9.

Description.--Valve 15-22u long by 3-6u wide, linear, lanceolate to lanceolate, with acute poles; axial area narrow; central area small, rounded; striae radiate at midvalve, parallel at poles, 15-16 in 10u.

Discussion.--N. cryptocephala var. veneta was collected infrequently in the arboretum pond and the stream. This taxon differs somewhat from diatoms referred to this species by some other authors since it does not show rostrate or attenuate poles. However, striae number central area and valve size all agree with N. cryptocephala var. veneta.

Navicula cuspidata (Kutz.) Kutzing

Pl. 5, Figs. 11-12.

Description.--Valve 69-128u long by 19-28u wide, lanceolate, with rounded or somewhat attenuate-rounded poles; axial area linear, narrow; central area not differentiated; raphe distinct, straight; striae punctate; punctae aligned to form perpendicular transverse and longitudinal striae; transverse striae parallel, about 12-15 in 10u; longitudinal striae 24-26 in 10u.

Discussion.--N. cuspidata occurred often in the arboretum pond, but was never present in large numbers.

Navicula elginensis (Greg.) Ralfs

Pl. 6, Fig. 1.

Description.--Valve 25-41u long by 8-14u wide, broadly linear-lanceolate, with prominent rostrate-capitate poles; axial area narrow, linear; central area transversely widened, irregularly rectangular; striae radiate at midvalve, parallel at poles, 9-11 in 10u.

Discussion.--N. elginensis was collected from arboretum pond, the greenhouse and stream sites one and two. This species was common but was not present in large numbers.

Navicula laevissima Kutzing

Pl. 6, Figs. 2-3.

Description.--Valve 19-27u long by 7-8u wide, broadly linear to rectangular, with broadly rounded poles, expanded somewhat medianly;

axial area narrow, linear; central area transversely widened, formed by irregularly shortened striae; striae linear, raidate 22-24 in 10u.

Discussion.--N. laevissima was found in low numbers at stream site two. This species is similar to N. pupula var. rectangularis (Greg.) Grun., with which it may be confused. However, this latter species has a length to breadth ratio of about 4 to 1 whereas N. laevissima has a length to breadth ratio of about 3 to 1.

Navicula lanceolata (Ag.) Kutzing

Pl. 6, Figs. 4-6.

Description.--Valve 36-55u long by 9-10u wide, lanceolate, with rounded or rostrate poles; axial area narrow; central area round, about half of valve width in diameter; striae radiate, linear, slightly bent near axial area, 10-14 in 10u.

Discussion.--N. lanceolata occurred in the arboretum pond, the greenhouses and the stream. This diatom exhibited several variations in valve shape but was distinguished by striae number and angle and the shape of the central area. N. lanceolata was common in this study.

Navicula mutica Kutzing

Pl. 6, Fig. 7.

Description.--Valve 10-15u long by 6-8u wide, broadly lanceolate, with rounded poles; valve margin entire; axial area narrow, somewhat broadened near midvalve; central area rather large, irregularly rectangular, with one isolated punctum; striae evidently punctate, radiate throughout valve length, very short in central area, 19-20 in 10u.

Discussion.--N. mutica was found at stream site two and in the greenhouses, but was very rare in this study.

Navicula oblonga (Kutz.) Kutzing

Pl. 6, Fig. 8.

Description.--Valve 110-148u long by 17-20u wide, linear to linear-lanceolate, with broadly rounded poles, slighlty constricted below poles, slightly swollen at midvalve, axial area distinct, rather wide; central area rhombic to rounded, occupying from 1/3 to 1/2 valve diameter; raphe straight, wide; striae linear, bent near valve margins, radiate throughout valve length, 7-8 in 10u.

Discussion.--N. oblonga was only collected from the arboretum pond. This taxon is easy confused with some species of Pinnularia, and has been classified in this genus by some earlier workers.

Navicula placentula (Ehr.) Grunow fo. rostrata A. Mayer

Pl. 6, Fig. 10.

Description.--Valve 40u long by 14u wide, elliptic-lanceolate, with obtuse rostrate poles; axial area rather wide; central area small, rounded; striae linear, radiate throughout valve length, 9-10 in 10u.

Discussion.--N. placentula fo. rostrata was collected from the arboretum pond only once during this study.

Navicula pupula Kutzing

Pl. 6, Fig. 11.

Description.--Valve 24-30u long by 7-8u wide, linear-lanceolate, with broadly rounded poles, evidently constricted below poles; axial area narrow, wider at midvalve; polar nodules widened perpendicular to margin of valve; central area transversely widened, rectangular or irregular, not reaching valve margins; striae radiate throughout most of valve, nearly parallel near poles, irregularly long and short at central area, 24-25 in 10u.

Discussion.--N. pupula occurred in the arboretum pond and in the stream, but was not common in this study.

Navicula pygmaea Kutzing

Pl. 7, Fig. 1.

Description.--Valve 32u long by 13u wide, elliptical, with rounded truncate poles; striae about 24 in 10u, radiate throughout valve length, interrupted to form lateral area between axial area and valve margin; axial area narrow; central area small, rectangular, reaching lateral area; lateral area curved, uniting at central and polar area.

Discussion.--N. pygmaea was collected in one sample from the arboretum pond. The specimen from this study differs from those assigned to N. pygmaea by other authors in the shape of the poles. N. pygmaea generally has rounded rather than truncate-rounded poles. However, the present specimen agrees with all other characteristics of this taxon.

Navicula rhynchocephala Kutzing

Pl. 7, Fig. 2.

Description.--Valve 36-43u long by 7-9u wide, lanceolate, with rostrate-capitate poles; axial area narrow, linear; central area irregularly rounded, about 1/3 valve width in diameter; striae radiate throughout most of valve, parallel at poles, 12-14 in 10u.

Discussion.--*N. rhynchocephala* was found uncommonly at stream sites two and three. This species is similar to *N. cryptocephala* Kutz. but is larger with a larger central area and coarser striae.

Navicula tripunctata (O. F. Mull.) Bory

Pl. 7, Fig. 3.

Description.--Valve 37-55u long by 8-10u wide, broadly linear, with rounded poles; axial area narrow; central area transversely widened, rectangular; striae radiate at midvalve, parallel at poles, 11-12 in 10u.

Discussion.--*N. tripunctata* occurred in the arboretum pond, at all sites in the stream and in the greenhouses. This species was common in the stream during the summer months and was common in the greenhouse soils in June and July.

Genus NEIDIUM Pfitzer

Description.--Cells solitary; valve naviculoid, symmetrical to transapical and apical planes, linear, lanceolate, elliptic or undulate, with rounded, rostrate, capitate or cuneate poles; axial area usually very narrow; central area generally small, rounded, elliptic, rectangular or rhombic; raphe straight, generally forked at poles and curved in opposite directions at central area; striae evidently punctate, parallel to radiate, broken by one or more longitudinal band along valve margin, axial area or between margin and axial area.

Neidium affine (Ehr.) Pfitzer

Pl. 7, Fig. 4.

Description.--Valve 54u long by 12u wide, broadly linear to linear-lanceolate, with large rostrate-capitate poles, raphe straight, broad, gradually narrowed near poles and central area, bent in opposite directions in central area, forked at poles; central area transversely widened, elliptical to rectangular; axial area wide, slightly swollen between poles and central area; longitudinal band single, submarginal; striae evidently punctate; parallel, about 24 in 10u.

Discussion.--N. affine was collected only once from stream site two.

Neidium binode (Ehr.) Hustedt

Pl. 7, Fig. 5.

Description.--Valve 29u long by 9u wide, elliptical, strongly constricted at midvalve, with protracted narrow rostrate poles; axial area narrow; raphe straight, uniform in size; central area small, rounded or elliptic; striae evidently punctate, radiate throughout valve length, about 25 in 10u; longitudinal band single, marginal, only in valve undulations.

Discussion.--N. binode was collected at stream site three and was rare in this study. This species is easily distinguished by the characteristic valve shape, the fine striae and the marginal longitudinal band.

Neidium iridis (Ehr.) Cleve

Pl. 7, Fig. 6.

Description.--Valve 98-110u long by 24-35u wide, broadly lanceolate to elliptic-lanceolate, with obtuse to rounded poles; raphe broad, gradually narrowing toward central and polar areas, bent in opposite directions at central area, forked at poles; central area transversely widened, rectangular; axial area rather wide, slightly wider at poles; striae evident punctate, radiate throughout valve length, 14-16 in 10u; longitudinal band single, marginal.

Discussion.--*N. iridis* was found only in the arboretum pond, and was rather infrequent during this study.

Genus PINNULARIA Ehrenberg

Description.--Cells solitary, naviculoid, rectangular in girdle view; valves linear, elliptic to lanceolate, with broadly rounded, cuneate or capitate poles; axial area prominent, narrow to widened; central area round or rhombic; raphe complex or simple, often undulate; striae generally broad, crossed by narrow to broad longitudinal band.

Pinnularia brebissonii (Kutz.) Rabenhorst

Pl. 7, Fig. 7.

Description.--Valve 32-44u long by 8-11u wide, broadly linear to elliptical, with rounded poles; raphe simple, straight, proximal ends bent in different directions; axial area narrow, gradually widened at midvalve; central area transversely widened, reaching valve margin; striae radiate throughout valve length, 12-14 in 10u.

Discussion.--*P. brebissonii* was collected from the arboretum pond, the greenhouses and stream site two in low numbers.

<u>Pinnularia gentilis</u> (Donk.) Cleve

Pl. 7, Fig. 8.

<u>Description</u>.--Valve 132u long by 22u wide, broadly linear, with broadly rounded poles; axial area wide, about one-third of valve width in diameter, expanded near midvalve; raphe complex, polar fissures sickle-shaped; central area widened; striae radiate throughout valve length, crossed by broad indistinct longitudinal band, 6 in 10u.

<u>Discussion</u>.--<u>P</u>. <u>gentilis</u> was collected from the greenhouse soil only once during this study.

<u>Pinnularia viridis</u> (Nitz.) Ehrenberg

Pl. 7, Fig. 9.

<u>Description</u>.--Valve 104-143u long by 15-20u wide, broadly linear-elliptical, with rounded poles; axial area less than one-fourth of valve width in diameter; raphe complex, sometimes undulate; polar fissures sickle-shaped; central area rounded; striae broadly linear, radiate throughout most of valve, parallel near poles, crossed by wide longitudinal band, about 8 in 10u.

<u>Discussion</u>.--<u>P</u>. <u>viridis</u> occurred in the arboretum pond rather frequently, and at the stream site two, but was never present in large numbers.

Genus STAURONEIS Ehrenberg

<u>Description</u>.--Cells solitary, intercalary bands occasionally present; valve lanceolate with rostrate, rounded or capitate poles; axial area linear; raphe straight, narrow to rather broad; central area transverse,

reaching valve margins, variable in shape; striae finely punctate, radiate or parallel.

Stauroneis smithii Grunow

Pl. 7, Fig. 10.

Description.--Valve 24-26u long by 6-8u wide, lanceolate, with short rostrate poles; intercalary bands (pseudoseptae) present near poles; axial area narrow, linear; central area (fascia) transverse, bilateral; striae very finely punctate, sometimes difficult to resolve, about 27 in 10u.

Discussion.--S. smithii occurred in the arboretum pond and the stream. It was very rare but easily distinguished by the transverse fascia and distinctive shape of the valve.

Family GOMPHONEMACEAE

Genus GOMPHONEMA C. A. Agardh

Description.--Cells solitary, without intercalary bands or septae; valve assymetrical about the apical plane, symmetrical about the transapical plane, cuneate, ovoid, clavate, linear, lanceolate, elliptic or biconstricted; poles broadly rounded, rostrate, swollen or cuneate, unequal in size; axial area narrow or broad, linear, raphe straight, simple or complex; central area generally small, rounded or transverse, occasionally unilateral, some with isolated punctum; striae linear, punctate.

Gomphonema acuminatum Ehrenberg

Pl. 8, Fig. 1.

Description.--Valve 39-45u long by 12-14u wide, clavate, constricted below cuneate, acuminate apical pole; basal pole attenuated; axial area narrow; central area very small, rounded, with a single isolated punctum; striae punctate, 10-12 in 10u.

Discussion.--G. acuminatum was collected only from the arboretum pond and was very rare.

Gomphonema acuminatum var. coronatum (Ehr.) Rabenhorst

Pl. 8, Figs. 2-3.

Description.--Valve 36-46u long by 12-15u wide, deeply constricted below cuneate, acuminate apical pole; basal pole long attenuated; central area small, somewhat unilateral with an isolated punctum; striae punctate, radiate only at midvalve, 9-11 in 10u.

Discussion.--G. acuminatum var. coranatum was found only rarely at stream site two. This taxon is distinguished by the wedge-shaped, acuminate apical pole and the deep subapical constriction. It differs from the nominate variety by being more attenuate and demonstrating a deeper subapical constriction.

Gomphonema angustata var. sarcophagus (Gregory) Grunow

Pl. 8, Fig. 4.

Description.--Valve 26u long by 7u wide, linear-lanceolate; apical pole short, narrow rostrate; basal pole short attenuated; axial area evident, rather wide, central area unilateral, formed by single shorted striae, isolated punctum present; striae coarse, linear, distant from each other, slightly radiate or irregular throughout valve length, 6 in 10u.

Discussion.--G. angustata var. sarcophagus was only found at stream site two during this study. This taxon is distinguished by valve shape, striae number and central area.

Gomphonema constrictum Ehrenberg

Pl. 8, Fig. 5.

Description.--Valve 26-37u long by 5-16u wide, clavate, strongly constricted below large rounded-truncate apical pole; basal pole attenuated, axial area narrow; central area irregular, with single isolated punctum; striae punctate, alternately longer and shorter at central area, strongly radiate at midvalve, 9-14 in 10u.

Discussion.--G. constrictum was common in the arboretum pond and at stream site two both in the periphyton and phytoplankton. It was most prevaelnt in the late spring at stream site two.

Gomphonema intricatum Kutzing

Pl. 8, Fig. 6-7.

Description.--Valve 42-62u long by 5-12u wide, linear-lanceolate, expanded at midvalve; apical pole rounded; basal pole attenuated; axial area distinct, wide; central area unilateral, with isolated punctum; striae evidently punctate, 7-9 in 10u.

Discussion.--G. intricatum was collected from the arboretum pond, stream site two and greenhouse soils but was never common during this study. The central area of this diatom varies somewhat with some specimens having a single stria and others lacking a stria.

Gomphonema olivaceum (Lyngbye) Kutzing

Pl. 8, Figs. 8-10.

Description.--Valve 12-21u long by 5-6u wide, ovoid-clavate, with short attenuated basal pole and broadly rounded apical pole axial area narrow; central area irregular, without isolated punctum; striae linear, radiate throughout valve length, 10-14 in 10u.

Discussion.--G. olivaceum occurred in the arboretum pond and all sites in the stream. It was a very common diatom throughout this study especially in the early summer at stream sites one and two.

Gomphonema olivaceum var. calcarea Cleve

Pl. 8, Fig. 11.

Description.--Valve 33u long by 6u wide, linear-clavate, slightly expanded at midvalve; apical pole rounded-truncate; basal pole rather long attenuated; axial area narrow; central area transversely widened, without isolated punctum; striae linear, radiate at midvalve, parallel near poles, 10 in 10u.

Discussion.--G. olivaceum var. calcarea was collected from the arboretum pond and the stream sites two and three. This variety differs from the nominate variety in shape and size.

Gomphonema parvulum (Kutz.) Grunow

Pl. 8, Fig. 12-13.

Description.--Valve 19-22u long by 5-6u wide, clavate-lanceolate, with attenuated basal pole and cuneate or cuneate-rounded apical pole; axial area very narrow; central area small, rounded, with single isolated punctum; striae linear, slightly radiate throughout valve length, 12-14 in 10u.

Discussion.--G. parvulum occurred at all collecting sites. It was a very common diatom throughout this study especially in early summer at stream sites one and two.

Gomphonema parvulum var. micropus (Kutz.) Cleve

Pl. 8, Fig. 14.

Description.--Valve 18u long by 6u wide, clavate-lanceolate; apical pole rounded-truncate; basal pole attenuated; axial area narrow; central area nearly undifferentiated, single isolated punctum present; striae radiate at midvalve, parallel near poles, 11 in 10u.

Discussion.--G. parvulum var. micropus occurred rarely at stream site one and in the arboretum pond. The B.Y.U. specimens have a smaller central area and slightly different valve shape than others referred to this variety but fit other characteristics closely.

Family CYMBELLACEAE

Genus AMPHORA Ehrenberg

Description.--Cells solitary, broadly elliptic, with rounded poles in girdle view; valve faces not parallel, both visible in girdle view; valve in valve view lunate, striate; raphe present, curved, excentric, fully developed along entire valve; axial area narrow; central area evident, usually small, rounded.

Amphora normani Rabenhorst

Pl. 9, Fig. 3.

Description.--Cell 20-27u long by 4-10u wide in girdle view, long elliptic with rounded, truncate poles; intercalary striae on girdle evident, about 22-26 in 10u, finely cross lined.

Discussion.--A. normani occurred in the greenhouse soils; the arboretum pond and at stream sites two and three. It was collected associated with A. ovalis Kutz. from which it was distinguished by its valve shape, intercalary striae and striae number. It was a common diatom in the soil, being exceeded in numbers only by Hantzschia amphioxys (Ehr.) Grun.

Amphora ovalis Kutzing

Pl. 9, Figs. 1-2.

Description.--Cell 20-42u long by 11-25u wide in girdle view, broadly elliptic with rounded, truncate poles; valve, lunate with rounded, blunt poles; ventral margin strongly concave; dorsal margin slightly convex; raphe curved, arc-like; axial area excentric, closest to ventral margin; central area unilateral, only on ventral side of valve; striae evidently punctate, slightly radiate throughout valve, 14-15u in 10u.

Discussion.--A. ovalis occurred in the arboretum pond, in the stream and in the greenhouse soils, although it never was present in large numbers. From examining periphyton slides in the arboretum pond, this species was found to be an early colonizer.

Genus CYMBELLA C. A. Agardh

Description.--Cells solitary, without intercalary bands or septae; valve naviculoid, symmetrical about the transapical plane, assymmetrical about the apical plane, linear, lanceolate, elliptic to semielliptic, or lunate; poles round, rostrate, capitate or attenuated; raphe straight or bent, linear, excentric or median; axial area linear or lanceolate, narrow to wide; central area usually distinct, rounded or rhombic; striae radiate, punctate or cooss-lines.

Cymbella affinis Kutzing

Pl. 9, Fig. 4.

Description.--Valve 28-30u long by 8-9u wide, semilanceolate; dorsal margin strongly convex; ventral margin nearly straight; poles capitate, bent; axial area narrow, curved, widening at midvalve to form narrow central area; isolated punctum present on ventral side of central area; raphe wide, undulate near central nodule; striae coarse, cross lined, 9-12 in 10u.

Discussion.--C. affinis was collected from the arboretum pond, the greenhouse and stream sites two and three. This species is rather variable, especially concerning characteristics of the poles.

Cymbella aspera (Ehr.) Cleve

Pl. 9, Fig. 5.

Description.--Valve 147-185u long by 32-36u wide, semilinear-lanceolate; dorsal margin very convex, ventral margin straight with slight median swelling; poles rounded; raphe broad, slightly bent at central nodule; axial area wide; central area small rounded; striae narrow, punctate, without crosslines, 8-9 in 10u; isolated punctum absent.

Discussion.--C. aspera occurred in the arboretum pond and at stream site two. This taxon is similar to C. lanceolate (Ehr.) van Heur. in size, striae number and valve shape but has a consistently wider axial area. C. aspera was rare in this study.

Cymbella cistula (Hemprich) Grunow

Pl. 9, Figs. 6-7.

Description.--Valve 50-88u long by 16-28u wide, semielliptical; dorsal margin strongly convex, ventral margin nearly straight with slight median expansion; axial area narrow; central area small, elliptical, with two to five ventral isolated punctae; raphe broad nearly median, bent at central nodule; striae punctate, 7-8 in 10u.

Discussion.--C. cistula occurred in the arboretum pond, the greenhouse soils and at stream site two. It was one of the most common diatoms during winter months in the pond. This species demonstrated wide variation in shape, and in the number of isolated punctae. C. cistula is easily distinguished by the two to five isolated punctae in the central area.

Cymbella ehrenbergii Kutzing

Pl. 10, Fig. 1.

Description.--Valve 97-106u long by 26-34u wide, only somewhat cymbelloid, rhombic to elliptic; poles short attenuate rounded, differing in size; axial area wide, straight, widened at midvalve; central area rounded; raphe wide, nearly straight, striae slightly radiate, evidently punctate, 7 in 10u.

Discussion.--C. ehrenbergii was found rarely in the arboretum pond. This taxon is easily distinguished by its size, shape and axial area.

Cymbella heteropleura (Ehr.) Kutzing

Pl. 10, Fig. 2.

Description.--Valve 170u long by 48u wide, elliptic-lanceolate; dorsal margin more convex than ventral margin; poles rostrate; slightly constricted on dorsal margin; axial area wide, curved; central area rounded; raphe linear, curved; striae punctate, radiate throughout valve, 7-8 in 10u.

Discussion.--C. heteropleura was collected as a single specimen from the arboretum pond. This taxon is rather similar to Cymbella hauckii van Heur. which is, however, smaller and with finer striae.

Cymbella mexicana (Ehr.) A. Schmidt

Pl. 10, Figs. 3.

Description.--Valve 84-119u long by 20-27u wide, semicircular to semi-elliptical; dorsal margin strongly convex, ventral margin slightly concave, with slight median expansion poles rounded, truncate; raphe broad, curved; axial area broad, wider at midvalve; central area round; striae rough, punctate with square punctae, alternately long and short in central area, 7-8 in 10u; isolated punctum present in center of central nodule.

Discussion.--C. mexicana was found in the arboretum pond especially during winter months. It was occasionally quite common during these months. This species may be distinguished by the coarse and square punctae and by the isolated punctum in the center of the central nodule between the raphe ends.

Cymbella prostrata (Berk.) Cleve

Pl. 10, Fig. 4.

Description.--Valve 27-50u long by 9-17u wide, semicircular to semi-elliptical; dorsal margin strongly convex, ventral margin slightly to strongly swollen; poles rounded; axial area rather wide; central area rounded, without isolated punctae; raphe only slightly excentric, somewhat bent at central area and poles; striae with evident cross-lines, 7-9 in 10u.

Discussion.--C. prostrata was found in the arboretum pond and at stream site one during the early summer. It was very rare being collected only two or three times.

Cymbella tumida (Berb.) van Heurck

Pl. 10, Fig. 5.

Description.--Valve 70u long by 20u wide, semicircular to semielliptical; dorsal margin strongly convex, ventral margin concave, strongly expanded at midvalve; poles rostrate, bent toward ventral margin; axial area wide, curved, uniform in width; central area small, rounded; raphe broad, excentric; striae punctate, radiate throughout valve, 7-8 in 10u.

Discussion.--C. tumida was represented from a single collection in the arboretum pond. This specimen does not fit C. tumida particularly well and it may be a new species. Even though it is uncommon on the B.Y.U. campus, it has been collected many times from Utah Lake, Utah.

Cymbella tumidula Grunow

Pl. 10, Fig. 6.

Description.--Valve 25-30u long by 8-9u wide; dorsal margin strongly convex, ventral margin slightly convex, indented near rostrate poles; raphe excentric, straight, slightly bent at central nodule; axial area norrow; central area small, round; striae linear, slightly radiate throughout valve, 13-14 in 10u.

Discussion.--C. tumidula was collected only from the arboretum pond where it was rare. This species is similar to C. ventricosa Kutz. in some aspects, differing chiefly by valve shape, raphe characteristics and the size and shape of the central area.

Cymbella turgida Gregory

Pl. 10, Fig. 7.

Description.--Valve 45-47u long by 11-13u wide, semilanceolate; dorsal margin strongly convex; ventral margin nearly straight, swollen at midvalve; poles acutely rounded; raphe excentric, straight throughout most of valve, bent at central nodule; axial area narrow, slightly widened to form small central area; isolated punctae absent; striae punctate, 7-8 in 10u.

Discussion.--C. turgida was collected from the arboretum pond and stream site three.

Cymbella ventricosa Kutzing

Pl. 11, Figs. 1-2.

Description.--Valve 18-45u long by 6-11u wide, semielliptic; dorsal margin strongly convex, ventral margin straight or slightly swollen in midregion; poles acutely rounded; axial area linear to slightly lanceolate; central area small, rounded; raphe straight, excentric; striae punctate, parallel to radiate, 11-13 in 10u.

Discussion.--*C. ventricosa* was one of the most common diatoms in this study, and was found in the arboretum pond and at all sites of the stream.

Family EPITHEMIACEAE

Genus EPITHEMIA Brebisson

Description.--Cells solitary, with intecalary bands or septae, rectangular in girdle view; valve slightly to strongly curved; ventral margin straight to concave, dorsal margin convex; poles broadly rounded or capitate; raphe and axial area marginal near poles, then in V-shaped extension toward midvalve; transverse septae appear as costae; striae distinctly punctate, alternating between costae.

Epithemia sorex Kutzing

Pl. 11, Figs. 4-5.

Description.--Valve 24-49u long by 7-14u wide, with attenuated, capitate poles; dorsal margin strongly convex, strongly constricted below poles; ventral margin nearly straight to slightly concave, V-shaped median axial area extension reaching nearly to dorsal margin; costae 6-8 in 10u, alternating with two strongly punctate striae.

Discussion.--*E. sorex* was collected from the arboretum pond and stream sites two and three but was never prominent. This species was the most common _Epithemia_ in this study.

Epithemia turgida (Ehrenberg) Kutzing

Pl. 11, Fig. 6.

Description.--Valve 54-120u long by 9-17u wide; dorsal margin strongly convex; ventral margin concave; poles rounded to slightly capitate or truncate; V-shaped median axial area extension shallow, less than ½ of valve width, costae 3-5 in 10u, alternating with 2-3 strongly punctate striae.

Discussion.--_E. turgida_ was found only in the arboretum pond and was collected rarely.

Epithemia turgida var. _granulata_ (Ehr.) Grunow

Pl. 11, Figs. 7-8.

Description.--Valve 61-68u long by 7-10u wide with bent, capitate poles; dorsal margin strongly concave; ventral margin straight but constricted below poles; V-shaped axial area extension shallow, less than ½ valve width; costae 2-4 in 10u, alternating with 2-3 strongly punctate striae.

Discussion.--_E. turgida_ var. _granulata_ was collected only from the arboretum pond. It is distinguished from the nominate variety by its large capitate poles.

Genus RHOPALODIA Mueller

Description.--Cells solitary, broadly linear to elliptical in girdle view, slightly swollen in midregion with broadly rounded, obtuse poles.

valve lunate with curved apices, dorsal margin convex; ventral margin nearly straight; axial area reaching convex margin; costae transverse, alternating with fine striae.

Rhopalodia gibba (Ehr.) O. Mueller

Pl. 11, Fig. 9.

Description.--Valve in girdle view 68-102u long by 19-28u wide, rectangular, somewhat swollen in middle portion, with broadly rounded poles; costae evident, parallel at midvalve, radiate at poles, 7-8 in 10u; punctae in rows on girdle, 15-16 in 10u; striae generally two between costae; valve lunate, curved at poles.

Discussion.--R. gibba occurred in the arboretum pond and at stream site three, but was never very prevalent. This taxon is probably the most common Rhopalodia in Utah.

Family NITZSCHIACEAE

Genus HANTZSCHIA Grunow

Description.--Cells solitary; valve linear-lanceolate, medianly constricted, finely striate, with rounded, capitate rostrate or attenuate-capitate poles; raphe present, concealed in keel; keel marginal, epithecal and hypothecal keels directly opposite.

Hantzschia amphioxys (Ehr.) Grunow

Pl. 11, Fig. 10.

Description.--Valve 26-50u long by 5-7u wide, lanceolate-arcuate, with short rostrate poles; dorsal margin convex; ventral margin somewhat convex but indented at midvalve; raphe marginal, enclosed in keel; keel on ventral margin, punctate, keel punctae irregular in size and spacing, 7-8 in 10u; striae linear, distant, fine, 15-19 in 10u.

Discussion.--*H. amphioxys* occurred in the greenhouse soils, the arboretum pond and in the stream. This diatom along with *Amphora normani* Rabh. was the most prevalent soil diatom in this study.

Hantzschia amphioxys fo. *capitata* Mueller

Pl. 11, Fig. 11.

Description.--Valve 26-36u long by 5-7u wide, broadly linear-arcuate, abruptly constricted below swollen capitate poles; dorsal margin convex; ventral margin slightly convex but indented at midvalve; keel on ventral margin, punctate; keel punctae irregular in size and spacing, 8-10 in 10u; striae linear, distinct, fine, about 20 in 10u.

Discussion.--*H. amphioxys* fo. *capitata* was collected from greenhouse soils. This diatom may be distinguished from the nominate variety by its extended capitate poles and the abrupt constrictions just below the poles.

Genus NITZSCHIA Hassall

Description.--Cells solitary, straight, curved, or undulate; valve linear, lanceolate, narrowly elliptic or sigmoid, some with median constriction; poles rounded, rostrate; capitate or attenuate; raphe not evident, concealed in keel; keel punctate, marginal to nearly median; striae fine to coarse, parallel throughout valve length.

Nitzschia amphibia Grunow

Pl. 12, Figs. 1-2.

Description.--Valve 11-15u long by 3-5u wide, elliptic-lanceolate, with rounded acute poles; keel punctae marginal, distinct, irregular in size, 7-8 in 10u; striae distinctly punctate, 17-20 in 10u.

Discussion.--N. amphibia was found in the arboretum pond and the greenhouse. N. amphibia was not common during this study.

Nitzschia dissipata (Kutz.) Grunow

Pl. 12, Figs. 3-4.

Description.--Valve 17-53u long by 3-5u wide, linear to linear-lanceolate, with abruptly acute-rounded poles; striae very fine, indistinct; keel slightly excentric, not marginal; keel punctae distinct, 7-8 in 10u.

Discussion.--N. dissipata occurred in the arboretum pond, the stream and the greenhouse soils, but was never present in large numbers. N. dissipata is similar to Nitzschia palea (Kutz.) Wm. Smith although the former is generally larger, with coarser keel punctae and an excentric rather than marginal keel.

Nitzschia fonticola Grunow

Pl. 12, Fig. 5.

Description.--Valve 11-18u long by 3-5u wide, linear-elliptical, with subrostrate to attenuate poles; keel marginal; keel punctae distinct, 12-13 in 10u; striae very fine, nearly indistinct.

Discussion.--N. fonticola was found at all collecting sites. This diatom is very small and was common in the soil.

Nitzschia hungarica Grunow

Pl. 12, Figs. 6.

Description.--Valve 60-88u long by 7-9u wide, linear, with acute cuneate poles; striae fine, distinct, 18-21 in 10u, interrupted by a wide fold on valve surface; keel marginal; keel punctae distinct, 10-12 in 10u.

Discussion.--N. hungarica occurred only in the arboretum pond. This taxon is distinguished by the wide fold on the surface of the valve which interrupts the striae. This species was rare in this study.

Nitzschia linearis (Agardh) Wm. Smith

Pl. 12, Figs. 7-8.

Description.--Valve 105-127u long by 5-6u wide, linear, with attenuate rounded poles; constricted at midvalve along one margin; striae very fine; keel marginal; keel punctae distinct, irregular in size and spacing, 10-13 in 10u.

Discussion.--N. linearis occurred at all collecting sites, and was most prevalent during the winter. This diatom is somewhat variable in polar shape, but is distinguished by its great length and the distinct median constriction on one side of the valve.

Nitzschia palea (Kutzing) Wm. Smith

Pl. 12, Fig. 9.

Description.--Valve 14-29u long, by 2-3u wide, linear to linear-lanceolate with rostrate poles; striae indistinct, keel marginal; keel punctae distinct, 10-12 in 10u.

Discussion.--*N. palea* was very common in this study. This diatom occurred in the arboretum pond, the stream and the greenhouses.

Nitzschia sigma Wm. Smith

Pl. 12, Figs. 10-11.

Description.--Valve 118-200u long by 5-11u wide, slightly sigmoid, with acute attenuated poles; striae very fine, 25-30 in 10u; keel marginal; keel punctae distinct, 7-10 in 10u.

Discussion.--*N. sigma* occurred only in the arboretum pond and was very rare. The length of this species varied widely from 118 to 200u. *Nitzschia sigmoidea* (Nitz.) Wm. Smith, another sigmoid *Nitzschia*, may be confused with *N. sigma*. These taxa differ in polar shape and *N. sigma* has finer keel punctae and is generally much smaller.

Nitzschia sigmoidea (Nitzsch) Wm. Smith

Pl. 12, Fig. 12

Description.--Cells 330-350u long by 10-15u wide, linear, sigmoid, with rounded, truncate poles in girdle view; valve linear with abruptly narrowed, cunate, recurved poles; striae fine, 23-27 in 10u; keel submarginal, keel punctae distinct, 6-9 in 10u.

Discussion.--*N. sigmoidea* occurred in the arboretum pond and stream. This diatom was very common in the arboretum pond during the winter months.

Nitzschia tryblionella Hantzsch

Pl. 12, Fig. 13.

Description.--Valve 70-98u long by 18-21u wide, elliptic to linear-elliptic, with tapering, obtuse poles; large longitudinal fold evident on valve surface; striae coarse, about 5 in 10u; keel marginal; keel punctae 8-10u.

Discussion.--N. tryblionella was found only in the arboretum pond. This diatom is characterized by its linear-elliptical shape, coarse striae and the evident longitudinal fold on the valve surface.

Family SURIRELLACEAE

Genus CYMATOPLEURA Wm. Smith

Description.--Cells solitary; valve linear-lanceolate to elliptic, often longitudinally undulate, with broad, short marginal costae; raphe short, not evident, concealed in keel; transverse striae interrputed by linear to lanceolate pseudoraphe.

Cymatopleura solea (Breb.) Wm. Smith

Pl. 13, Figs. 6-8.

Description.--Cells in girdle view linear with undulate margins; valve 80-130u long by 10-25u wide, broadly linear-lanceolate, gradually constricted at midregion, with obtuse, cuneate poles; raphe marginal, not evident, concealed in keel; marginal costae about 7 in 10u; striae narrow, linear, about 28 in 10u, interrupted by linear, very narrow pseudoraphe.

Discussion.--C. solea occurred in the arboretum pond, in the stream and in the greenhouse soils. This species was a common spring and summer diatom in the arboretum pond. This taxon is distinguished by its distinctive shape, both in valve and girdle views.

Genus SURIRELLA Turpin

Description.--Cells solitary; valve in girdle view usually rectangular; valve linear, ovate, elliptic, spiral, rounded, or occasionally with median constriction; poles rounded or cuneate; pseudoraphe evident, linear or lanceolate; furrowed; raphe marginal, concealed in keel; keel punctate; costae present, often only marginal; striae fine but evident, between costae, interrupted by pseudoraphe.

Surirella angustata Kutzing

Pl. 13, Figs. 1-2.

Description.--Valve 30-32u long by 6-8u wide, broadly linear, with cuneate poles; pseudoraphe linear-lanceolate; costae parallel at midvalve, radiate at poles, 6-7 in 10u; striae very fine.

Discussion.--S. angustata occurred in the stream and in the greenhouse soil. This diatom was especially common during later winter and spring in the stream.

Surirella ovalis Brebisson

Pl. 13, Fig. 3.

Description.--Valve 24-41u long by 11-22u wide, ovate with one broadly rounded pole and one cuneate-rounded pole; pseudoraphe linear, narrow; costae marginal, short, 5-7 in 10u; striae linear, 16-19 in 10u.

Discussion.--S. ovalis was collected from the arboretum pond and the stream. It was especially common during late winter. This taxon is similar to Surirella ovata Kutzing but differs by having short marginal costae.

Surirella ovata var. pinnata Wm. Smith

Pl. 13, Fig. 4.

Description.--Valve 33u long by 10u wide, elongate ovoid, with nearly equal, broadly rounded poles; costae evident, reaching pseudoraphe, parallel throughout most of valve, radiate near poles, 6 in 10u; pseudoraphe very narrow; striae very fine.

Discussion.--S. ovata var. pinnata was found only once from stream site two.

Surirella robusta Ehrenberg

Pl. 13, Fig. 5.

Description.--Valve 157-210u long by 46-80u wide, ovate with broadly rounded apical pole and cuneate-rounded basal pole; pseudoraphe wide, lanceolate; costae very coarse, about 2 in 10u; striae finer.

Discussion.--S. robusta was collected rather often from the arboretum pond but was never prominent. This diatom is very large and easily distinguished. The B.Y.U. specimens are somewhat more elongate and with a narrower pseudoraphe than others placed in this species.

Class XANTHOPHYCEAE

Order VAUCHERIALES

Family VAUCHERIACEAE

Genus VAUCHERIA DeCandolle

Description.--Plants filamentous, coenocytic; filaments irregularly branched, usually with rhizoids, cross walls only below reproductive structures and in response to wounding; chloroplasts numerous, small, spherical pyrenoid present or absent; plant mass often dark green, felt-like mats, aquatic or terrestrial. Asexual reproduction by zoospores; sexual reproduction oogamous; plants rarely monoecious, generally dioecious.

Vaucheria geminata (Vaucher) DeCandolle

Pl. 18, Figs. 1-3.

Description.--Plants aquatic or terrestrial; filaments cylindric, irregularly branched, 75-80u in diameter; oogonia ovate, paired on side branch, sessile or very short stalked, 75u in diameter, dark colored at maturity; antheridia on same side branch, cylindric hooked; zygospore three layered.

Discussion.--*V. geminata* occurred in the arboretum in temporary puddles and on the surface of the soil beneath greenhouse benches. It was prominent in the winter in the greenhouse, but never produced gametangia there.

Vaucheria sessilis (Vaucher) DeCandolle

Pl. 18, Figs. 4-5.

Description.--Plants aquatic or terrestrial; filaments long cylindric, irregularly branched, 38-90u in diameter; asexual reproduction by zoospores; zoosporangia terminating filaments; sexual reproduction oogamous; oogonium ovate to oblong, 95u to 100u in diameter, sessile on main filament, dark colored at maturity; zygospore three layered.

Discussion.--*V. sessilis* occurred in the arboretum in temporary puddles where it formed deep green felt-like mats. This alga was not prevalent during this study.

Division CYANOPHYTA

Class MYXOPHYCEAE

Order CHROOCOCCALES

Family CHROOCOCCACEAE

Genus CHROOCOCCUS Naegeli

Description.--Plants unicellular or colonial; cells ovate, spherical, rod-shaped or semicircular; colonies with 2-64 cells, within gelatinous sheath; sheath usually hyaline, often repeatedly lamellate due to cell divisions; cell contents homogeneous or granulate; often blue-green; plants aquatic or terrestrial.

Chroococcus rufescens (Kutz.) Naegeli

Pl. 18, Fig. 7.

Description.--Plants colonial, usually with 2-4 cells enclosed in lamellate sheath; cells 4-7u in diameter, without individual sheathes; cell contents granulate, blue-green.

Discussion.--*C. rufescens* was found in the greenhouse forming mats on the walls of pots. This alga was not common in this study, and most green mats on the walls of pots were *Chlorococcum humicola* (Naeg.) Rabenhorst.

Order OSCILLATORIALES

Family OSCILLATORIACEAE

Genus LYNGBYA Agardh

Description.--Plants multicellular, filamentous; trichomes unbranched, cylindric, solitary or aggregated, straight or twisted, enclosed in sheath, sheath thin at first, later thick, colored (yellow to brown or red, blue to purple red) or colorless; apex attenuated or straight; apical cell broadly rounded or capitate, with or without calyptra.

Lyngbya aestuarii (Mertens) Liebmann

Description.--Trichome straight or cured, 15u in diameter, sheath firm, roughened, yellow brown; apex slightly tapered; apical cell rounded, occasionally with slightly thickened outer wall; cell disk-shaped, blue-green to olive, not constricted at crosswalls.

Discussion.--L. aestuarii was found in the greenhouse forming brownish mats on the surface of soil in some pots.

Lyngbya martensiana Meneghini

Pl. 18, Fig. 8.

Description.--Trichomes straight to somewhat bent, 6u in diameter; sheath think, colorless, occasionally roughened; apex straight, not tapered; apical cell broadly rounded, without calyptra; cells discoid, shorter than wide; pale blue-green in color; cross walls not constricted.

Discussion.--L. martensiana was found in the greenhouse forming blue-green mats on the soil of pots. It was distinguished by its colorless evident sheath, trichome shape and size and the straight apex.

Genus OSCILLATORIA Vaucher

Description.--Trichomes unbranched, cylindric, solitary or aggregated, straight to somewhat flexed or widely curved, without or rarely with very delicate sheath, often oscillating, especially in anterior portion; apex straight or bent, tapering or straight, apical cell bluntly rounded or capitate; calyptra present or absent; cross walls constricted or straight; cell contents homogeneous or granular, variable in color; gas vacuoles present or absent. Reproduction by trichome fragmentation (cell division).

<u>Oscillatoria amphibia</u> Agardh

<u>Description</u>.--Trichomes straight or slightly curved, about 2.8u in diameter; apex straight, not tapered, sometimes slightly curved; apical cell rounded, not tapered or capitate, without calyptra; cells subquadrate to rather elongate, generally 2-4 times as long as broad, not constricted at cross walls; cell contents homogenous, with few granules at cross walls, pale blue-green.

<u>Discussion</u>.--<u>O</u>. <u>amphibia</u> was found in the greenhouses associated with other algae forming blue-green mats on moist soil.

<u>Oscillatoria angustissima</u> West & West

<u>Description</u>.--Trichomes very slender, straight or curved, 1.5u in diameter; apex straight, not tapered; end cell rounded, not capitate; cells not constricted at crosswalls; cell contents mostly colorless; gas vacuoles absent.

<u>Discussion</u>.--<u>O</u>. <u>angustissima</u> was found in the greenhouse as thin, blue-green mats and associated with other blue-green and green algae. It was the smallest species of <u>Oscillatoria</u> collected in this study and was distinguished by its small size and pale color. This alga often demonstrated an oscillating movement when observed with the

microscope.

Oscillatoria animalis Ag. ex Gomont

Pl. 18, Figs. 9-10.

Description.--Trichomes straight or slightly curved, 3-7u in diameter; apex tapered, strongly bent, sometimes hook-shaped; apical cell attenuated, pointed; cells quadrate to subquadrate, not constricted at crosswalls; cell contents somewhat granulate, blue-green.

Discussion.--O. animalis was found in the greenhouse forming rather homogenous blue-green mats or mixed with other algae on the surface of moist soils.

Oscillatoria cruenta Grunow

Description.--Trichomes straight, rarely slightly curved, 7-12u in diameter; apex straight; apical cell broadly rounded, hemisperical, not tapered; other cells subquadrate; end walls not constricted.

Discussion.--O. cruenta occurred in the greenhouse forming dark green mats. It was similar to O. limosa although smaller, and was distinguished by its non-constricted end walls, straight apex and rounded apical cell.

Oscillatoria limosa C. A. Agardh

Description.--Trichomes straight, about 17u in diameter; apex straight; apical cell broadly to flatly rounded, occasionally with slightly thickened outer wall; cells cylindrical, not constricted at crosswalls cell contents granular at cross walls, olive green to brown.

Discussion.--O. limosa was found in the greenhouse, associated with other algae forming dark green mats in pots. It was also found in standing water.

Oscillatoria princeps Vaucher

Pl. 19, Figs. 1-2.

Description.--Trichomes straight, often solitary, 50-60u in diameter apex tapered, slightly bent, occasionally abruptly constricted below capitate or rounded apical cell; calyptra absent; cells not constricted at cross walls, rectangular or discoid, cell contents homogenous, dark blue-green.

Discussion.--O. princeps was collected from the arboretum pond and stream site two. In the arboretum pond it was often entangled with Spirogyra spp.

Oscillatoria sancta (Kutz.) Gomont

Pl. 19, Fig. 3.

Description.--Trichomes straight or curved, often solitary, 13-16u in diameter; apex straight or slightly tapered; apical cell rounded to slightly capitate; calyptra present; cells slightly constricted at cross walls; cell contents granulate at cross walls, gray-green to pale green.

Discussion.--O. sancta was collected from stream site two mixed with filamentous green algae. It also was found on moist soil and walls in the greenhouses. O. sancta was easily confused with O. limosa Ag. since the constriction of the cross walls was often only slight, and the calyptra was often indistinct.

Oscillatoria tenuis C. A. Agardh

Pl. 19, Fig. 4.

Description.--Trichomes straight or occasionally slightly curved at the apices, 6.5-12u in diameter; apex straight, not tapered; apical cell broadly rounded, sometimes with thickened outer wall; cells slightly constricted at cross walls.

Discussion.--O. tenuis occurred in the greenhouse, mixed with other algae often forming blue-green mats.

Genus PHORMIDIUM Kutzing

Description.--Plants filamentous; trichomes unbranched, aggregated by gelatinous sheathes, sometimes encrusted with calcium carbonate, not readily separated from each other; cells cylindric to somewhat barrel-shaped; apical cell rounded to capitate, with or without calyptra; cell contents homogenous to granulate; individual sheathes thin, colorless, sometimes not readily evident. Reproduction by trichome fragmentation (cell division).

Phormidium inundatum Kutzing

Pl. 19, Fig. 5.

Description.--Trichomes enclosed by thin, colorless sheath, straight, 5-6u in diameter, tapering near apices, aggregated forming small bundles; not capitate; cells not constricted at end walls; cell contents granulate, green to blue-green.

Discussion.--P. inundatum was found in the greenhouse entangled with

Oscillatoria sancta (Kutz.) Gom. forming a dark brown-green mat floating on water in pots.

Order NOSTOCALES

Family NOSTOCACEAE

Genus ANABAENA Bory

Description.--Plants filamentous; filaments solitary or aggregated into blue-green mats, straight or coiled, with or without sheath; cells spherical, cylindric or barrel-shaped; heterocysts cylindric, ovate or spherical, scattered in filament; akinetes round to ovate, adjacent to heterocysts or remote from them.

Anabaena variabilis Kutzing

Pl. 19, Figs. 6-7.

Description.--Filaments bent but not twisted, entangled, forming tough, gelatinous mats, without individual sheaths; cells elliptic to oblong about 7.5u in diameter; heterocyst ovate, same diameter as vegetative cells.

Discussion.--A. variabilis occurred in the greenhouse as gelatinous mats on a cement floor beneath a leak in a water faucet.

Family SCYTONEMATACEAE

Genus TOLYPOTHRIX Kutzing

Description.--Plants filamentous, enclosed in firm, thin to thick muscilaginous sheath, occurring solitary mixed with other algae or forming mats; filaments falsely branched; false branches arising near heterocyst, long, flexible, easily broken; cells narrow, quadrate or cylindric, compressed at cross wall; heterocysts single or in a series, quadrate or oblong.

<u>Tolypothrix</u> <u>penicillata</u> (Ag.) Thuret

Pl. 19, Fig. 8.

<u>Description</u>.--Filaments dark brown, repeatedly false branched, penicillate, usually entangled with other algae; trichomes 15u in diameter; sheath thin, colorless; cells quadrate; heterocysts single.

<u>Discussion</u>.--<u>T</u>. <u>penicillata</u> occurred in the greenhouse entangled with <u>Vaucheria</u> <u>geminata</u> (Vaucher) DeCandolle and <u>Anabaena</u> <u>variabilis</u> Kutzing. It was never prominent in this study and was represented only be a few specimens.

Division CHLOROPHYTA

Class CHLOROPHYCEAE

Order TETRASPORALES

Family PALMELLACEAE

Genus PALMELLA Lyngbye

Description.--Plants unicellular, forming shapeless gelatinous macroscopic colonies; cells spherical, not ordered in colony; chloroplast bell or cup-shaped; pyrenoid single.

Palmella mucosa Kutzing

Description.--Colonies macroscopic, gelatinous, bright green; cells spherical, 7-8u in diameter; chloroplast parietal, covering most or all of cell wall; pyrenoid single.

Discussion.--*P. mucosa* was found at stream site two during late spring. This alga formed bright green gelatinous expansions on stones on the stream bottom. It was occasionally attached only by part of the thallus with the apical part of the thallus streaming in the current. The cells of *P. mucosa* show no orderly arrangement in the colony.

Genus SPHAEROCYSTIS Chodat

Description.--Plants spherical colonies of from 4 to 32 cells in gelatinous envelope; cells spherical; individual sheaths occasionally evident; chloroplast cup or bell-shaped, occasionally covering entire cell wall; pyrenoids single.

<u>Spherocystis</u> <u>schroeteri</u> Chodat

<u>Description</u>.--Colonies of from 4 to 32 cells in gelatinous envelope, containing both small, recently divided cells and older, larger cells; chloroplast bell-shaped, covering entire cell wall in young cells, with single pyrenoid.

<u>Discussion</u>.--<u>S</u>. <u>schroeteri</u> was collected from the greenhouse where it occurred on the soil surface in damp pots. This taxon was distinguished by the clusters of cells enclosed by hyaline sheaths, and by the colonies containing closters of young smaller cells as well as larger mature cells.

Order CHLOROCOCCALES

Family CHLOROCOCCACEAE

Genus CHARACIUM

<u>Description</u>.--Plants unicellular; cells solitary or aggregated, minute, oblong, fusiform, round or curved, with round or pointed apices, attached, stipitate or sessile, often epiphytic; chloroplast one to several, usually scattered in cell; pyrenoid one to several.

<u>Characium</u> <u>ambiguum</u> Hermann

Pl. 14, Fig. 1.

<u>Description</u>.--Cells about 4u in diameter by 26u long, solitary, fusiform-lanceolate, slightly bent at apex, short stipitate, epiphyte on filamentous algae; chloroplast generally single; pyrenoid present or absent.

Discussion.--*C. ambiguum* occurred as an epiphyte in the arboretum pond and temporary arboretum waters. This alga was especially prevalent on filaments of *Mougeotia genuflexa* (Dillw.) C. A. Agardh. It was distinguished by its size and shape.

Genus CHLOROCOCCUM Fries

Description.--Plants unicellular; cells spherical, generally uninucleate; cell wall very thin, without ornamentation; chloroplast parietal or bell-shaped, with one or more pyrenoid; reproduction by zoospores.

Chlorococcum humicola (Naegeli) Rabenhorst

Pl. 14, Fig. 2

Description.--Plants unicellular; cells spherical, 5-10u in diameter, uninucleate; cell wall thin, without decoration; chloroplast parietal or bell-shaped, sometimes covering entire cell wall, with one pyrenoid; reproduction by zoospores.

Discussion.--*C. humicola* was collected from the greenhouse, mixed with other algae as green films on the soil surface of pots and benches. It also formed light-green films on walls and wooden benches. *C. humicola* resembles *Chlorella* sp. but differs by its thin cell wall and terrestrial habit.

Family OOCYSTACEAE

Genus CHLORELLA Beyerinck

Description.--Plants unicellular; cells small, oval, spherical or ellipsoid, solitary to aggregated; chloroplast parietal, cup-shaped usually with pyrenoid, occasionally without; reproduction by 4 or 8 nonmotile daughter cells (autospores).

Chlorella vulgaris Beyerinck

Pl. 14, Figs. 3-4.

Description.--Cells small, spherical or ellipsoid by compression, 4-12u in diameter, solitary or aggregated; chloroplast parietal, cup-shaped without pyrenoid; cell wall thick.

Discussion.--C. vulgaris occurred in the greenhouse in standing water. It grew profusely in some nutrient solution bottles which were used for plant physiological experiments. This alga reproduces by autospores which were noted during this study.

Family SCENEDESMACEAE

Genus SCENEDESMUS Meyen

Description.--Plants colonial, coenobic; coenobia planar, uniseriate or biseriate, often composed of 4 or 8 cells (in multiples of 2); cells oblong, ovoid, fusiform or curved, connected on lateral margin or irregularly connected, with or without terminal or lateral spines or teeth usually on outside cells; chloroplast parietal, covering most of cell; pyrenoid usually single.

Scenedesmus denticulatus Lagerheim

Pl. 14, Fig. 5.

Description.--Coenobium 4 or 8 celled, uniseriate; cells 13u long by 5u wide, with 1-4 short spines or teeth, on end walls; other walls smooth.

Discussion.--*S. denticulatus* occurred in the arboretum pond. It was not common in this study and was usually collected with *S. quadricauda* var. *quadrispina* G. M. Smith.

Scenedesmus quadricauda var. *quadrispina* G. M. Smith

Pl. 14, Fig. 6.

Description.--Coenobium 4 or 8 celled, uniseriate, cells about 11u long by 4u wide, elliptical to oblong; terminal cells with one long generally curved spine at each apex, inner cells without spines.

Discussion.--*S. quadricauda* var. *quadrispina* was found in the arboretum pond and in temporary puddles in the arboretum. This alga was common in the standing waters examined during this study.

Family HYDRODICTYACEAE

Genus PEDIASTRUM Meyer

Description.--Plants colonial, coenobic; coenobia free floating, round or disc-shaped, perforate or nonperforate, with cells in multiples of four; cell smooth or lobed, multinucleate; central and marginal cells the same or different shapes, chloroplast single, reticulate, covering entire or part of cell wall; pyrenoid single.

Pediastrum boryanum (Turp.) Meneghini

Pl. 14, Fig. 7.

Description.--Colonies generally about 55u in diameter, nearly circular, nonperforate; inner cells 5-6 angled, not bilobed, slightly concave on outer margin; marginal cells polygonal, outer margin bilobed, forming two setae; notch between setae narrow to widened.

Discussion.--P. boryanum was found several times in the arboretum pond but was not common during this study

Pediastrum tetras (Ehr.) Ralfs

Pl. 14, Fig. 8

Description.--Colonies light green, quadrangular to polyagonal, nonperforate, composed of four or eight cells; marginal and central cells about 6-8u in diameter (central cells frequently absent); bilobed or cleft, connected by colorless matrix.

Discussion.--P. tetras was uncommon in this study and was found in the arboretum in puddles and on very moist soil. Specimens of this species generally were four celled.

Order ULOTRICHALES

Family PROTOCOCCACEAE

Genus PROTOCOCCUS C. A. Agardh

Description.--Plants unicellular or forming small clusters, occasionally forming simple filaments; cells rounded or elliptic; cell wall thick; chloroplast parietal, generally dense, covering entire cell wall; pyrenoids generally one; reproduction by cell division.

Protococcus viridis C. A. Agardh

Discription.--Plants unicellular or forming small clumps; cell 5-7u in diameter, rounded or compressed-angular; cell wall thick; chromatophore parietal, covering most of cell wall; one pyrenoid generally present or none; reproduction by cell division.

Discussion.--P. viridis was found commonly in the greenhouse where it grew on the surface of pots, benches and the soil. This alga may be confused with Chlorococcum or Chlorella, except that it is subaeral and contains a cup-shaped or parietal chloroplast. Also, cells of P. viridis are often clustered and angular due to cell division.

Family ULOTRICHACEAE

Genus STICHOCOCCUS Naegeli

Description.--Plants multicellular, filamentous; filaments unbranched; cells cylindrical to quadrate, uninucleate, not tightly bound together, occasionally found singly; chloroplast parietal, often covering half or less of cell wall, with or without single pyrenoid.

Stichococcus bacillaris Naegeli

Description.--Filament unbranched, easily fragmented; cells uninucleate, short, cylindric, slightly constricted at cross wall, 2-5u in diameter by 4-5u long; chloroplast pale green, parietal, not covering more than half of cell length; pyrenoid absent.

Discussion.--S. bacillaris occurred in the greenhouse on moist surfaces of pots and benches. It was usually associated with other algae forming dark green films. The cells of S. bacillaris are easily separated to form short filaments or solitary cells. The chloroplast partially covers the wall on only one side of the cell.

Stichococcus scopulinus Hazen

Description.--Filament unbranched; cells about 3-4u in diameter by

14u long, cylindrical, not constricted at cross wall; chloroplast elliptical, parietal; pyrenoid indistinct.

Discussion.--S. scopulinus was collected from the greenhouse on the surface of some very moist pots. It occurred mixed with other green and blue-green algae. S. scopulinus is larger than S. bacillaris Naegeli and smaller and with more cylindric cells than S. subtilis (Kutz.) Klercker.

Stichococcus subtilis (Kutz.) Klercker

Pl. 14, Figs. 9-10.

Description.--Filaments long, unbranched; cells quite quadrate to elogate, not constricted at cross walls, 6-8u wide by 7-18u long; chloroplast elliptical, parietal, with or without single pyrenoid.

Discussion.--S. subtilis was found in the greenhouse under similar conditions as S. bacillaris Naegeli and S. scopulinus Hazen. It was also collected from tanks of standing water where it occurred as long filaments.

Genus ULOTHRIX Kutzing

Description.--Plants multicellular, filamentous; filaments unbranched, errect, with or without sheath, not tapering toward apex, often with basal holdfast cell; vegetative cells quadrate to long cylindric, uninucleate; chloroplast band-shaped, one per cell, covering part or all of cell wall, with one or more pyrenoid.

Ulothrix zonata (Weber & Mohr) Kutzing

Description.--Filaments unbranched, bright green; cells quadrate to cylindric, broader than long, about 40u wide by 30u long, slightly constricted at cross walls; basal host-fast present; chloroplast a narrow median band; pyrenoids several; cell wall thick, with firm, thin sheath.

Discussion.--*U. zonata* was collected from the greenhouse from deep green masses in some moist pots.

Order CHAETOPHORALES

Family APHANOCHAETACEAE

Genus APHANOCHAETA A. Braun

Description.--Plants multicellular, filamentous; filaments branched, creeping, often epiphytic on other filamentous algae; vegetative cells cylindric to swollen, oblong; setae present on some cells; setae with bulbous base.

Aphanochaete repens A. Braun

Pl. 15, Fig. 1.

Description.--Filaments small, cylindric, prostrate on other filamentous algae, irregularly branched; cells 6-10u in diameter, 1-2 times longer than wide, cylindric to irregular; setae long, slender, arising from swollen base.

Discussion.--*A. repens* occurred in the arboretum in standing puddles and was usually epiphytic on Oedogonium sp.

Family CHAETOPHORACEAE

Genus CHAETOPHORA Schrank

Description.--Plants multicellular, filamentous, enclosed in firm muscilage; filaments branched, attenuated to apex; vegetative cells cylindric to slightly swollen; chloroplast parietal, covering entire wall in young cells, occasionally stellate in older cells; pyrenoids one or more.

Chaetophora incrassata (Kudson) Hazen

Description.--Plants multicellular, filamentous, enclosed in rahter firm muscilage; filaments branched; branches small, occuring on all sides of main axis as dense, curved fascicles; apical cell of filament long tapered to broadly acute; vegetative cells uninucleate, cylindric to slighlty swollen, about 11u wide by 60u long; chloroplast single, covering entire cell wall in young cells; somewhat band-shaped in older cells; pyrenoid single.

Discussion.--C. incrassata was found only at stream site two. It was attached to stones on the stream bottom, especially in rapidly flowing water. This species was distinguished by its small side branches forming dense fascicles.

Genus STIGEOCLONIUM Kutzing

Description.--Plants multicellular, filamentous; filaments branched; main axes, large, with irregular, small, opposite to alternate branches; branch apices long attenuated, hair-like; cell wall firm, with outer layer of mucilage; vegetative cells uninucleate, cylindric to slightly swollen; chloroplast a single transverse band, covering most of cell wall, with or without pyrenoid; asexual reproduction by zoospores.

Stigeoclonium lubricum (Dillw.) Kutzing

Description.--Filaments branched; branches opposite to somewhat whorled, slender, with attenuated apcies; main axis up to 16u in diameter, larger than branches, with quadrate or broadly cylindric, slightly swollen cells; chloroplast a single transverse band covering most of cell in main axis to entire cell in branches; cell with thin gelatinous sheath.

Discussion.--S. lubricum was collected from stream site two. This alga was attached to stones on the stream bottom.

Order OEDOGONIALES

Family OEDOGONIACEAE

Genus OEDOGONIUM Link

Description.--Plants multicellular, filamentous; filaments long cylindric, unbranched, solitary or forming mats, usually erect, forming tufts, basal cell, a swollen holdfast; other cells cylindric, with ring-like caps or scars at cross walls; chloroplast reticulate, throughout entire cell, usually diffuse and indistinct; pyrenoids scattered on chloroplast. Asexual reproduction by cell division; sexual reproduction oogamous; oogonia spherical to ovate, often several in a filament; antheridia produced in series in same or different filament as oogonia, producing antherozoids; both macandrous and nanandrous species known.

Oedogonium sp.

Pl. 14, Fig. 11.

Description.--Filaments long cylindric, unbranched; some cross walls showing ring-like apical caps; vegetative cells cylindric, about 76u long by 38u wide; chloroplast diffuse throughout cell; pyrenoids numerous

Discussion.--Oedogonium sp. was found in temporary waters of the arboretum. It occurred in the autumn but did not produce gametangia. Thus, since the determination of Oedogonium species is dependent upon characteristics of the reproductive cells, this alga was not specifically identified.

Order CLADOPHORALES

Family CLADOPHORACEAE

Genus CLADOPHORA Kutzing

Description.--Plants multicellular, filamentous; filaments repeatedly branched; branches smaller than main axis, tapered to apices, alternate, opposite or dichotomous; plant attached to substrate by well defined rhizoidal cells; vegetative cells multinucleate, cylindrical or somewhat swollen, much longer than broad, with thick, generally lamellate walls; pyrenoids several; chloroplast parietal, reticulate.

Cladophora glomerata (L.) Kutzing

Pl. 15, Figs. 2-3.

Description.--Plant attached to stones or other substrate in flowing water; branches regular, repeatedly branched, often aggregated near plant apex, somewhat tapering to rounded or attenuated apical cell; cells cylindric, 35-75u in diameter, 225-475u long, multinucleate; pyrenoids numerous; asexual reproduction by zoospores; zoosporangia commonly terminating branches.

Discussion.--C. glomerata was found at stream site two throughout the study. It became prominent during winter months but was curtailed by low water. This alga preferred flowing water and formed green, feathery tufts streaming from stones on the stream bottom.

Order ZYGNEMATALES

Family ZYGNEMATACEAE

Genus MOUGEOTIA (C. A. Agardh) Whittrock

Description.--Plants multicellular, filamentous; filaments free, long cylindrical; cells long, cylindrical, often several times as long as broad, with lens-shaped end walls; chloroplast one per cell, an axial band or plate with single row of pyrenoids in center of plastid. Sexual reproduction by conjugation; zygote formed in conjugation tube.

Mougeotia genuflexa (Dillw.) C. A. Agardh

Pl. 15, Fig. 4.

Description.--Filaments long cylindric; cells cylindrical, about 25u by 70u; chloroplast a median rod or plate with single row of pyrenoids. Sexual reproduction by lateral or scalariform conjugation; zygospore formed in conjugation tube, ovoid, brownish.

Discussion.--M. genuflexa was collected from the arboretum pond entangled with Spirogyra spp. and at stream site two on stones. This alga became common at stream site two during periods of shallow, slow water.

Genus SPIROGYRA Link

Description.--Plants multicellular, filamentous; filaments long cylindric, unbranched; cells long or short cylindric; end walls plane, replicate or semireplicate; chloroplasts 1-16 per cell, parietal, ribbon-shaped, spiral or strongly bent. Sexual reproduction by lateral or scalariform conjugation; conjugation tubes from both or just one gametangium; zygospore elliptic, ovoid to cylindric ovoid; spore wall smooth or ornamented (corrugate, reticulate, pitted or punctate); fertile cell swollen or similar to vegetative cell.

Spirogyra dubia Kutzing

Pl. 15, Figs. 5-6.

Description.--Filaments long cylindric; vegetative cells 70-163u long by 42-65u wide, usually 2-3 times diameter in length; end walls plane; chloroplasts two.

Discussion.--S. dubia was found in the arboretum pond and some temporary puddles in the arboretum. Fertile specimens were not collected and this species was thus determined only on the basis of vegetative characteristics. S. dubia was a very common alga throughout the year.

Spirogyra jugalis (Fl. Dan.) Kutzing

Pl. 15, Figs. 7-8; Pl. 16, Figs. 1-2.

Description.--Filaments large, cylindrical; cells 250-450u long by 70-92u wide; end walls plane; chloroplasts 4. Conjugation lateral or scalariform, conjugation tubes formed by both gametangia; fertile cells cell cylindric, slightly swollen; zygospore elliptic, about 180-220u long by 70u wide; spore wall smooth.

Discussion.--*S. jugalis* occurred in the arboretum pond throughout the year, and was especially prevalent in late spring.

Spirogyra neglecta (Hall.) Kutzing

Pl. 16, Fig. 3.

Description.--Filaments long cylindric, vegetative cells 150-225u long by 60-70u wide; chloroplasts three, slender; end walls plane.

Discussion.--*S. neglecta* was collected from arboretum pond and other arboretum waters where it occurred with other species of *Spirogyra*. Fertile specimens were not collected during this study.

Spirogyra porticalis (Muell.) Cleve

Pl. 16, Figs. 4-7.

Description.--Filaments long cylindric; cells 42-145u long by 35-45u wide; end walls plane; chloroplast one, broad, dentate, making 3-5 turns in cell. Sexual reproduction by conjugation, conjugation tubes formed by both gametangia; fertile cell usually swollen; zygospore ovate-elliptic, yellowish-brown, about 60u long by 30u wide; spore wall smooth.

Discussion.--*S. porticalis* was found in the arboretum pond and other arboretum waters throughout the year. During winter months this species grew on the bottom of the pond in evident green patches. This alga developed rapidly in the spring with fertilization occurring in late spring.

Genus ZYGNEMA C. A. Agardh

Description.--Plants multicellular, filamentous; filaments unbranched, cylindric; cells short cylindric, often nearly quadrate; chloroplasts two, stellate; pyrenoid large, one in center of each chloroplast. Sexual reproduction by scalariform or lateral conjugation; zygospore in conjugation tube or one gametangium with smooth or decorated, generally three layered wall.

Zygnema insigne (Hass.) Kutzing

Pl. 17, Fig. 1.

Description.--Cells short cylindric, about 30u wide by 35u long; chloroplasts two, stellate, each with large central pyrenoid. Sexual reproduction by scalariform or lateral conjugation; zygospore forming in one gametangia.

Discussion.--*Z. insigne* occurred in the arboretum in puddles and damp areas and was never prominent in this study.

Family DESMIDIACEAE

Genus CLOSTERIUM Nitzsch

Description.--Plants unicellular; cells elongate, arcuate or crescent-shaped, rarely nearly straight, composed of two semicells; poles broadly rounded, attenuated, rostrate or acute, cell walls often ornamented, porate; chloroplasts one or more in each semicell, variable in shape, often with numerous longitudinal ridges; pyrenoids aligned in a single row on chloroplast; terminal vacuole present, containing one to many gypsum crystals.

Closterium lanceolatum Kutzing

Pl. 17, Fig. 2.

Description.--Cells about 400u long by 50u wide, solitary, lanceolate, not constricted at midcell, nearly straight along axis, one side slightly mor convex than opposite; poles acute, blunt; terminal vacuoles with several moving gypsum granules; cell wall smooth; chloroplasts one in each semicell, folded, forming 3-8 plications; pyrenoids numerous, in single axial row.

Discussion.--C. lanceolatum was found infrequently in the arboretum in temporary puddles of water. This desmid was distinguished by its straight, lanceolate shape, its cell wall and length to width ratio.

Closterium moniliferum (Bory) Ehrenberg

Pl. 17, Figs. 3-4.

Description.--Cells 180-300u long by 38-45u wide, curved, gradually tapering to small, rounded poles, slightly swollen at middle of ventral margin; terminal vacuoles with several moving gypsum granules; chloroplast one in each semicell, plicate; pyrenoids large, conspicuous.

Discussion.--C. moniliferum occurred in the arboretum in temporary waters, and was rather common in this study. This desmid is similar to Closterium ehrenbergii Menegh. except for being considerably smaller.

Genus COSMARIUM Corda

Description.--Plants unicellular; cells constricted at middle forming two semicells; semicells connected by isthmus, oval, elliptic, semicircular, rectangular or rhombic; poles rounded to truncate; chloroplasts one to several in each semicell, with one or two pyrenoids; cell wall smooth or granulate. Sexual reproduction by conjugation.

Cosmarium botrytis Bory

Pl. 17, Fig. 5.

Description.--Cells about 54u long by 45u wide, only slightly longer than wide, rough, with pearly granules forming denticulate margin; median constriction deep, forming linear notch on each side of isthmus; isthmus very narrow; semicells truncate-pyramidate, with broad base, grandually narrowed to truncate pole; pyrenoid single, central.

Discussion.--C. botrytis was found in temporary waters of the arboretum. It was usually collected with other algae such as Spirogyra spp. but was not common during this study.

Cosmarium perforatum Lund

Pl. 17, Fig. 6.

Description.--Cells about 30u long by 28u wide, only slightly longer than wide; median constriction rather shallow, sinus narrow, slightly angled, open outward; isthmus elongate, about half as wide as cell width; semicell semicircular to elliptical; cell wall granulate; margins dentate; chloroplast one per semicell with single, central pyrenoid.

Discussion.--C. perforatum was found in the arboretum in temporary puddles. It was not common in this study.

Genus PENIUM Brebisson

Description.--Plants unicellular; cells cylindrical, lanceolate, or elliptical, with or without constriction at midcell; margins entire; poles rounded, attenuated or truncate; cell wall smooth or granulate; chloroplasts usually one in each semicell, rarely more than one, plicate; terminal vacuoles absent.

<u>Penium</u> <u>navicula</u> Brebisson

Pl. 17, Fig. 7.

<u>Description</u>.--Cells about 200u long by 55u wide, generally about 4 times longer than broad, broadly lanceolate, tapering to truncate-rounded poles, without median constriction or terminal vacuoles; chloroplast single in each semicell, plicate.

<u>Discussion</u>.--<u>P</u>. <u>navicula</u> was found in the arboretum in puddles and was not common in this study. It was distinguished by its broadly lanceolate shape (much like the diatom Navicula) and the lack of a median constriction.

Division EUGLENOPHYTA

Order EUGLENALES

Family EUGLENACEAE

Genus EUGLENA Ehrenberg

<u>Description</u>.--Plants unicellular; cells solitary, fusiform to spindle-shaped, usually broadly rounded at anterior pole, attenuated at posterior pole, often changing shape in movement; flagellum present, anterior; periplast striate or plain, plastic to rather rigid;

chloroplasts numerous, disc or rod-shaped; pyrenoids present or absent; eye-spot present, anterior. Reproduction by cell division.

Euglena acus Ehrenberg

Pl. 17, Figs. 8-9.

Description.--Cells 18-30u long by 75-105u, long fusiform; anterior pole blunt, truncate; posterior pole gradually tapering, attenuated; flagellum single, periplast with finely spiral striae; paramylom bodies numerous, rod-like; chloroplasts numerous discoid; eyespot single, red, usually evident.

Discussion.--E. acus was found in the arboretum temporary waters, but was not common in this study. This alga changed shapes readily while moving.

Genus PHACUS Dujardin

Description.--Plants unicellular; cells solitary, ovate, pyriform or fusiform, with one evident anterior flagellum; caudus present, long or short; periplast regid, with spiral striations or longitudinal rows of granules; chloroplasts numerous, disc-shaped; paramylon bodies rounded, sometimes ring-shaped, marginal; eyespot present, near flagellum. Reproduction usually by longitudinal division.

Phacus acuminatus Stokes

Pl. 17, Fig. 10.

Description.--Cells about 15-20u by 17-23u, ovate; flagellum single; periplast longitudinally striate; posterior pole rounded, with short caudus; paramylum bodies two, large, chloroplasts numerous, discoid.

Discussion.--*P. acuminatus* occurred in the arboretum pond and other standing waters. It was not common during this study.

Explanation of PLATE I

Figure 1.--Cyclotella bodanica Eulenst.. Valve view.

Figure 2.--Cyclotella meneghiniana Kutz.. Valve view.

Figure 3.--Cyclotella meneghiniana Kutz.. Valve view.

Figure 4.--Melosira granulata (Ehr.) Ralfs. Girdle view.

Figure 5.--Melosira granulata (Ehr.) Ralfs. Girdle view.

Figure 6.--Melosira granulata (Ehr.) Ralfs. Girdle view.

Figure 7.--Melosira italica (Ehr.) Kutz.. Girdle view.

Figure 8.--Melosira italica (Ehr.) Kutz.. Girdle view.

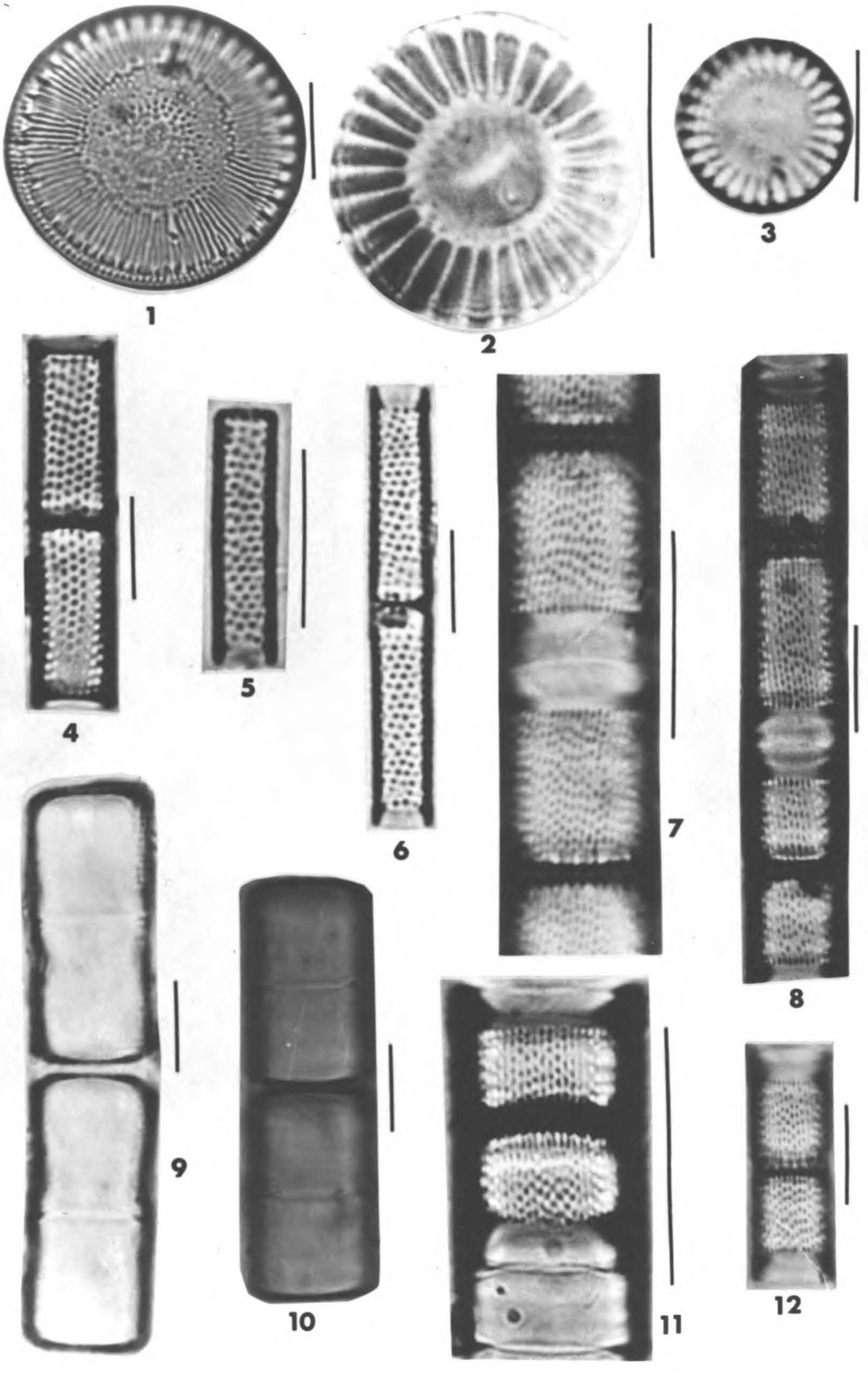
Figure 9.--Melosira varians C. A. Ag.. Girdle view.

Figure 10.--Melosira varians C. A. Ag.. Girdle view.

Figure 11.--Melosira distans (Ehr.) Kutz.. Girdle view.

Figure 12.--Melosira italica (Ehr.) Kutz.. Girdle view.

Each scale represents 10 u.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Explanation of PLATE II

Figure 1.--Stephanodiscus niagarae Ehr. Valve view.

Figure 2.--Stephanodiscus niagarae Ehr. Valve view.

Figure 3.--Asterionella formosa Hassall. Valve view.

Figure 4.--Diatoma anceps (Ehr.) Kirch.. Valve view.

Figure 5.--Diatoma hiemale var. mesodon (Ehr.) Grun.. Valve view.

Figure 6.--Diatoma tenue var. elongatum Lyngb.. Valve view.

Figure 7.--Diatoma vulgare Bory. Valve view.

Figure 8.--Diatoma vulgare Bory. Valve view.

Figure 9.--Fragilaria brevistriata var. inflata (Pant.) Hust.. Valve view.

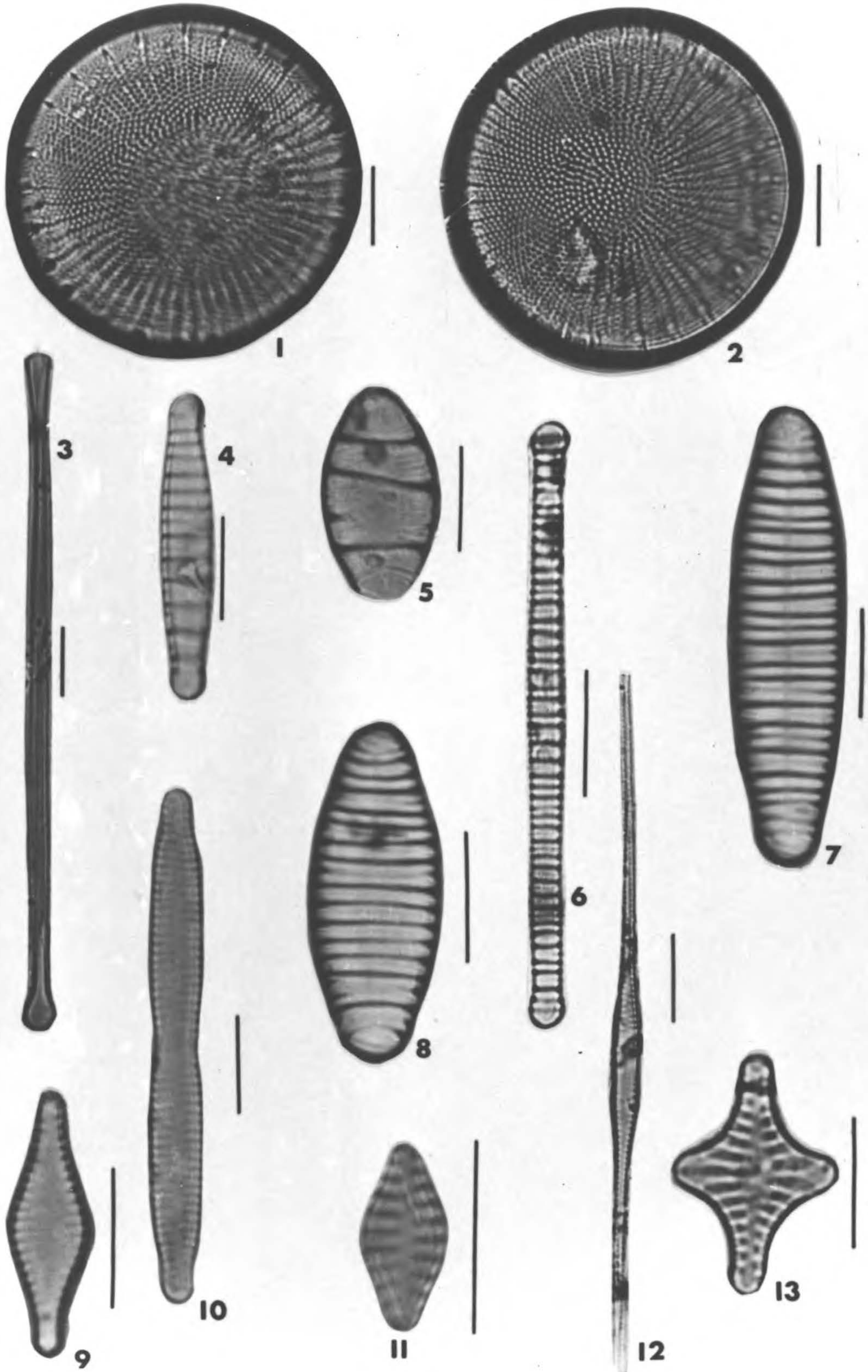
Figure 10.--Fragilaria capucina var. mesolepta Rabh.. Valve view.

Figure 11.--Fragilaria construens var. venter (Ehr.) Grun.. Valve view.

Figure 12.--Fragilaria crotonensis Kitton. Valve view.

Figure 13.--Fragilaria leptostauron (Ehr.) Hust.. Valve view.

Each scale represents 10 u.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Explanation of PLATE III

Figure 1.--Fragilaria vaucheriae (Kutz.) Peters.. Valve view.

Figure 2.--Fragilaria vaucheriae (Kutz.) Peters.. Valve view.

Figure 3.--Meridion circulare var. constrictum (Ralf.) v. Heur.. Valve view.

Figure 4.--Meridion circulare var. constrictum (Ralf.) v. Heur.. Valve view.

Figure 5.--Synedra acus Kutz.. Valve view.

Figure 6.--Synedra capitata Ehr.. Valve view.

Figure 7.--Synedra fasciculata (Ag.) Kutz.. Valve view.

Figure 8.--Synedra parasitica (W. Sm.) Hust.. Valve view.

Figure 9.--Synedra parasitica var. subconstricta (Grun.) Hust.. Valve view.

Figure 10.--Synedra parasitica var. subconstricta (Grun.) Hust.. Valve view.

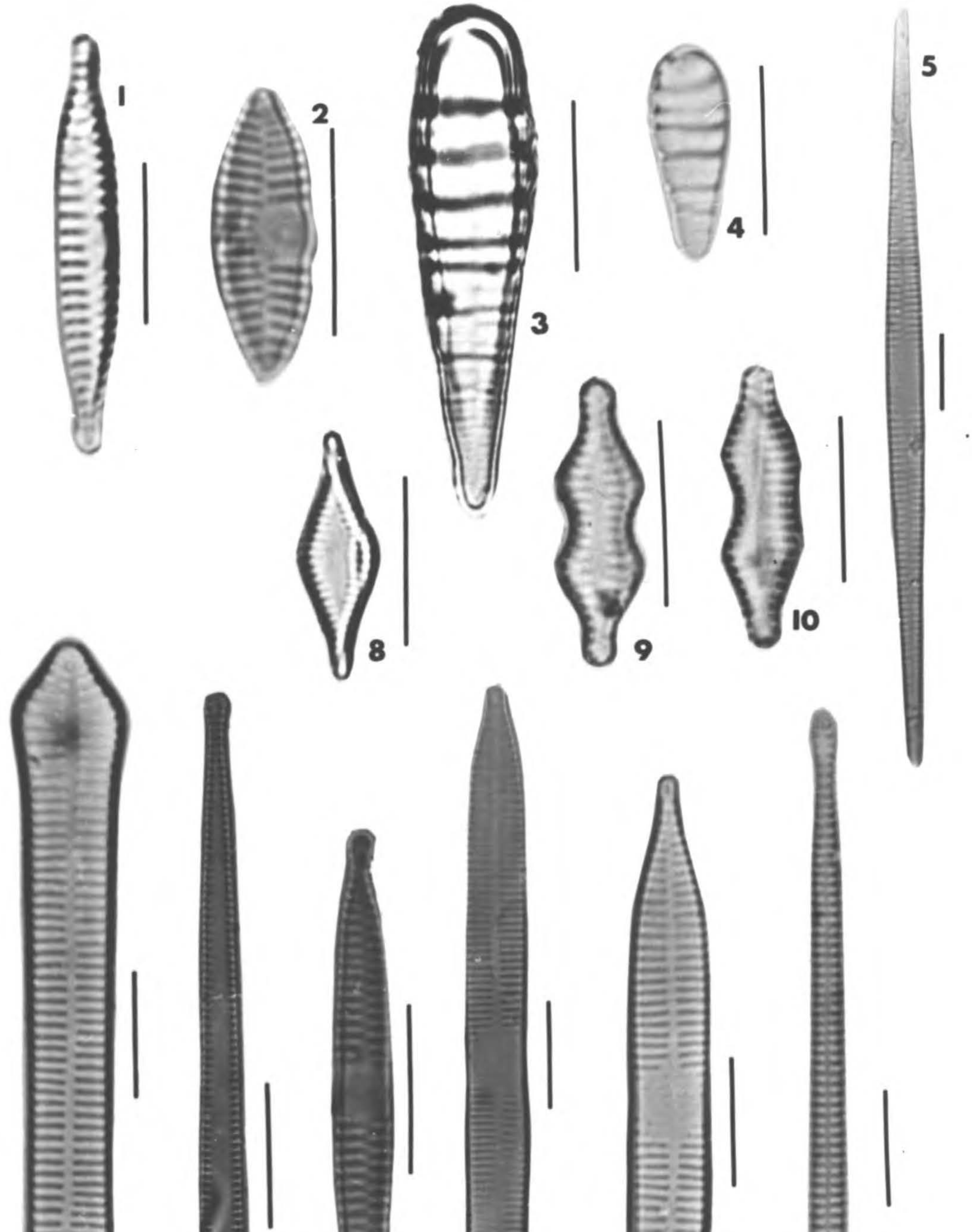
Figure 11.--Synedra rumpens Kutz.. Valve view.

Figure 12.--Synedra ulna var. contracta str.. Valve view.

Figure 13.--Synedra ulna var. ramesi (Hèrib) Hust.. Valve view.

Figure 13.--Synedra ulna var. subaequalis (Grun.) V. H.. Valve view.

Each scale represents 10 u.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Explanation of PLATE IV

Figure 1.--Synedra ulna var. ulna (Nitz.) Ehr.. Valve view.

Figure 2.--Eunotia curvata (Kutz.) Lagerst.. Valve view.

Figure 3.--Achnanthes lanceolata var. dubia Grun.. Pseudoraphe valve.

Figure 4.--Achnanthes lanceolata (Breb.) Grun.. Pseudoraphe valve.

Figure 5.--Achnanthes lanceolata (Breb.) Grun.. Pseudoraphe valve.

Figure 6.--Achnanthes lanceolata (Breb.) Grun.. Raphe valve.

Figure 7.--Achnanthes minutissima Kutz.. Raphe valve.

Figure 8.--Cocconeis pediculus Ehr.. Pseudoraphe valve.

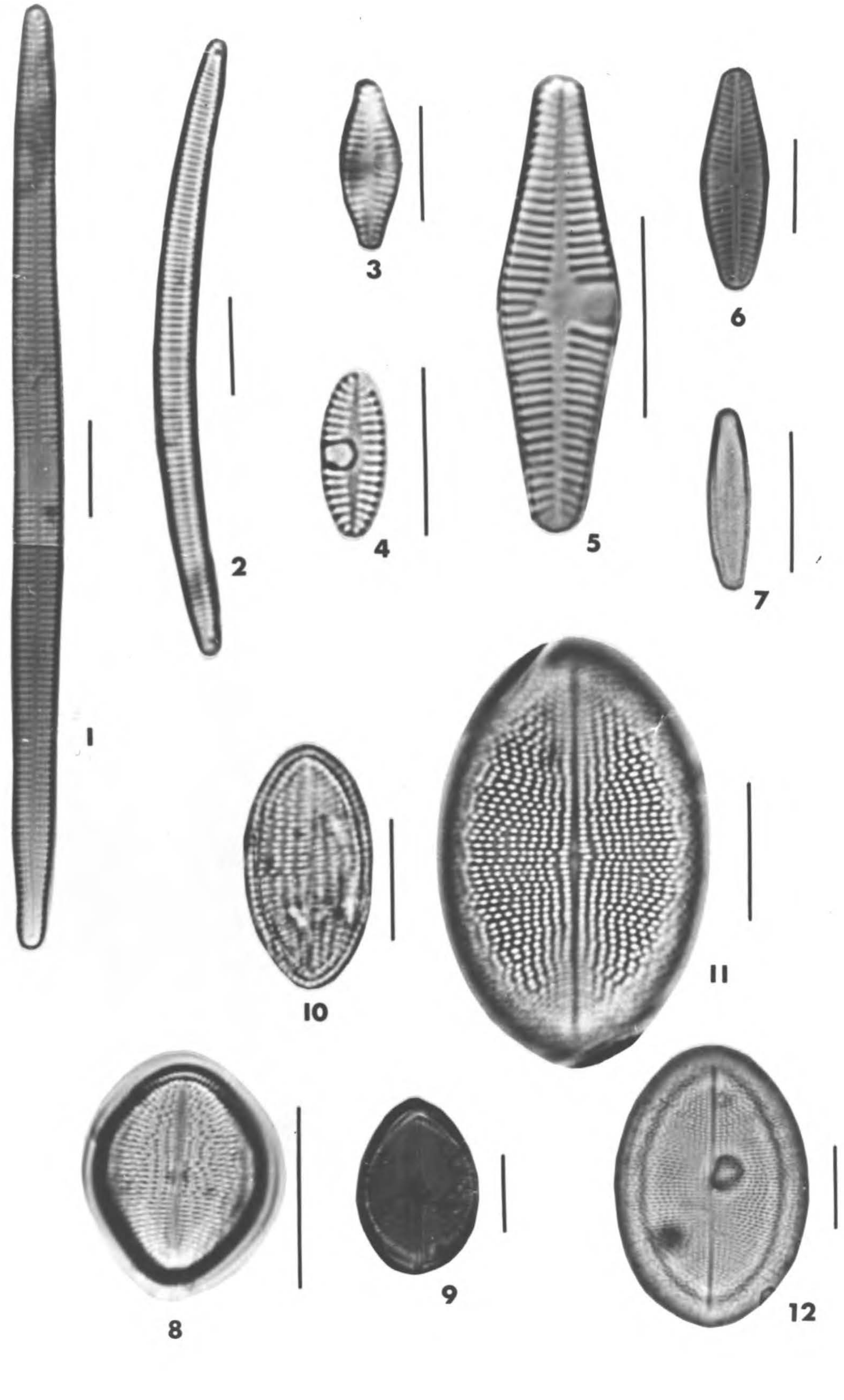
Figure 9.--Cocconeis pediculus Ehr.. Raphe valve.

Figure 10.--Cocconeis placentula var. euglypta (Ehr.) Cl.. Pseudoraphe valve.

Figure 11. Cocconeis placentula var. lineata (Ehr.) V. H.. Pseudoraphe valve.

Figure 12.--Cocconeis placentula var. lineata (Ehr.) V. H.. Raphe valve.

Each scale represents 10 u.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Explanation of PLATE V

Figure 1.--Rhoicosphenia curvata (Kutz.) Grun. ex Rabh.. Girdle view.

Figure 2.--Rhoicosphenia curvata (Kutz.) Grun. ex Rabh.. Valve view.

Figure 3.--Anomoeoneis sphaerophora (Kutz.) Pfitz.. Valve view.

Figure 4.--Caloneis ventricosa (Ehr.) Meist.. Valve view.

Figure 5.--Diploneis oblongella (Naeg. ex Kutz.) Ross. Valve view.

Figure 6.--Frustulia vulgaris (Thwaites) DeT.. Valve view.

Figure 7.--Gyrosigma spencerii (Quek.) Griff. & Henfr.. Valve view.

Figure 8.--Navicula capitata Ehr.. Valve view.

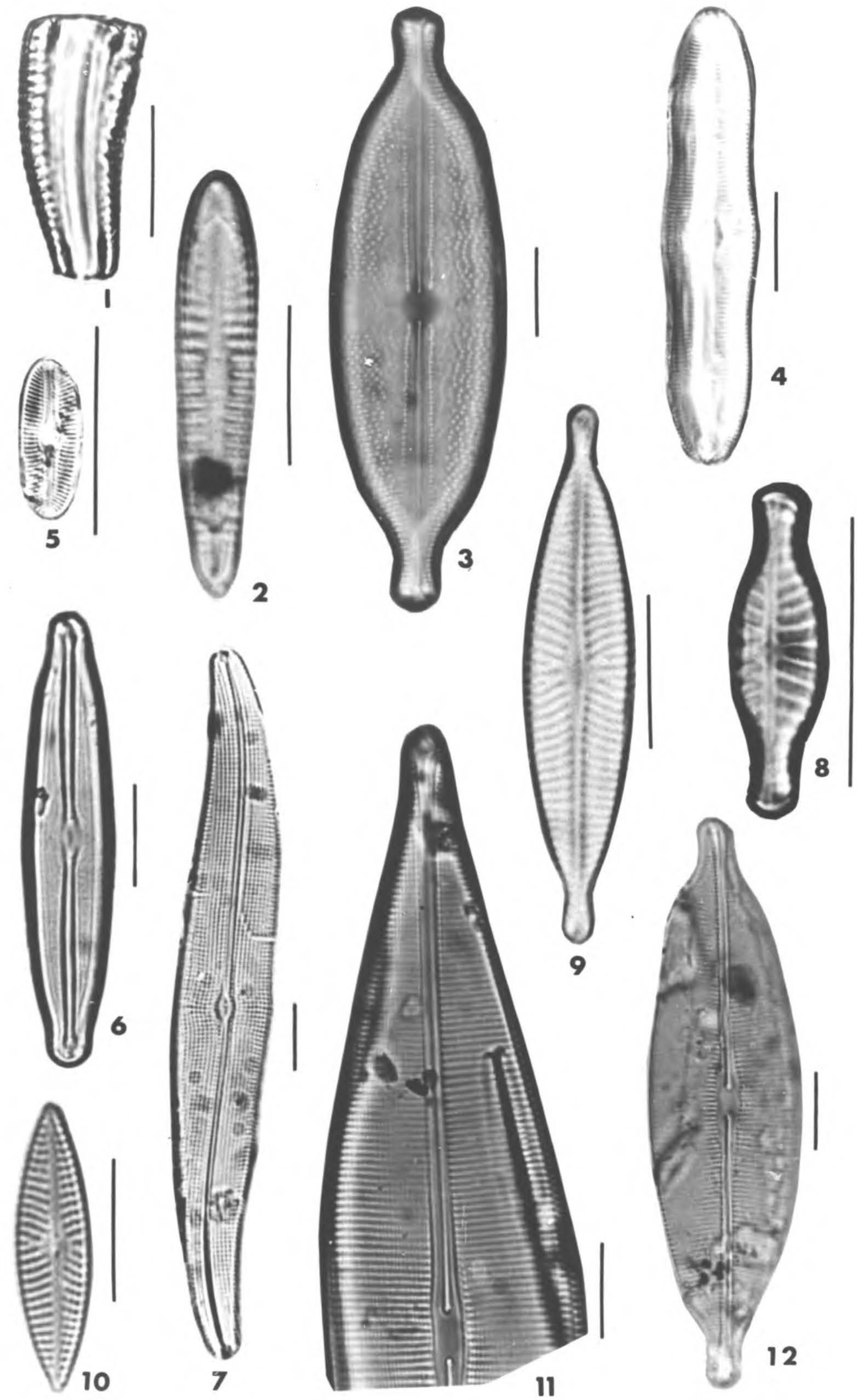
Figure 9.--Navicula cryptocephala Kutz.. Valve view.

Figure 10.--Navicula cryptocephala var. veneta (Kutz.) Rabh.. Valve view.

Figure 11.--Navicula cuspidata (Kutz.) Kutz.. Valve view.

Figure 12.--Navicula cuspidata (Kutz.) Kutz.. Valve view.

Each scale represents 10 u.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Explanation of PLATE VI

Figure 1.--Navicula elginensis (Greg.) Ralfs. Valve view.

Figure 2.--Navicula laevissima Kutz.. Valve view.

Figure 3.--Navicula laevissima Kutz.. Valve view.

Figure 4.--Navicula lanceolata (Ag.) Kutz.. Valve view.

Figure 5.--Navicula lanceolata (Ag.) Kutz.. Valve view.

Figure 6.--Navicula lanceolata (Ag.) Kutz.. Valve view.

Figure 7.--Navicula mutica Kutz.. Valve view.

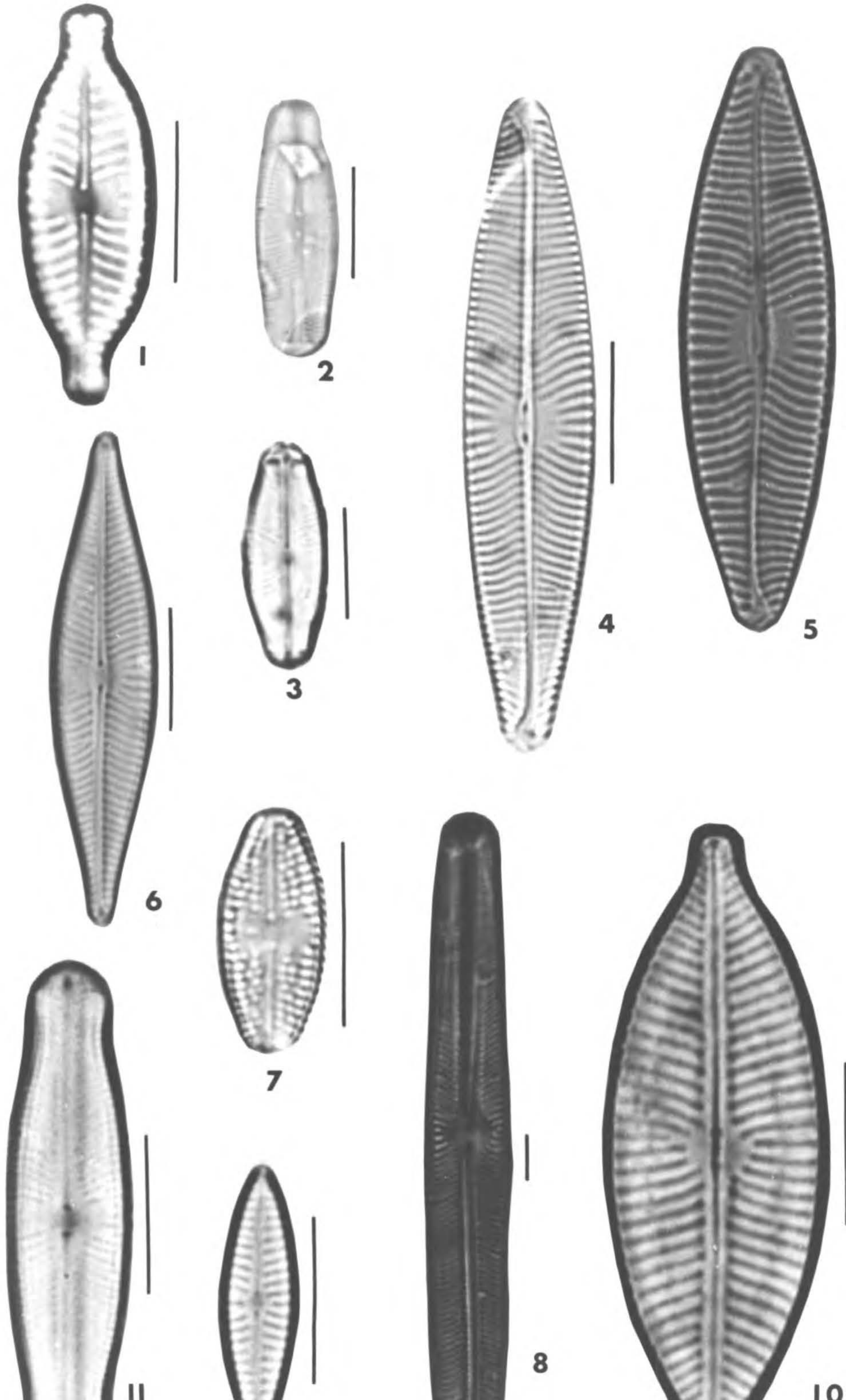
Figure 8.--Navicula oblonga (Kutz.) Kutz.. Valve view.

Figure 9.--Navicula cryptocephala var. veneta (Kutz.) Rabh.. Valve view.

Figure 10.--Navicula placentula fo. rostrata A. Mayer. Valve view.

Figure 11.--Navicula pupula Kutz.. Valve view.

Each scale represents 10 u.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Explanation of PLATE VII

Figure 1.--*Navicula pygmaea* Kutz.. Valve view.

Figure 2.--*Navicula rhynochocephala* Kutz.. Valve view.

Figure 3.--*Navicula tripunctata* (O. F. Mull.) Bory. Valve view.

Figure 4.--*Neidium affine* (Ehr.) Pfitz.. Valve view.

Figure 5.--*Neidium binode* (Ehr.) Hust.. Valve view.

Figure 6.--*Neidium iridis* (Ehr.) Cl.. Valve view.

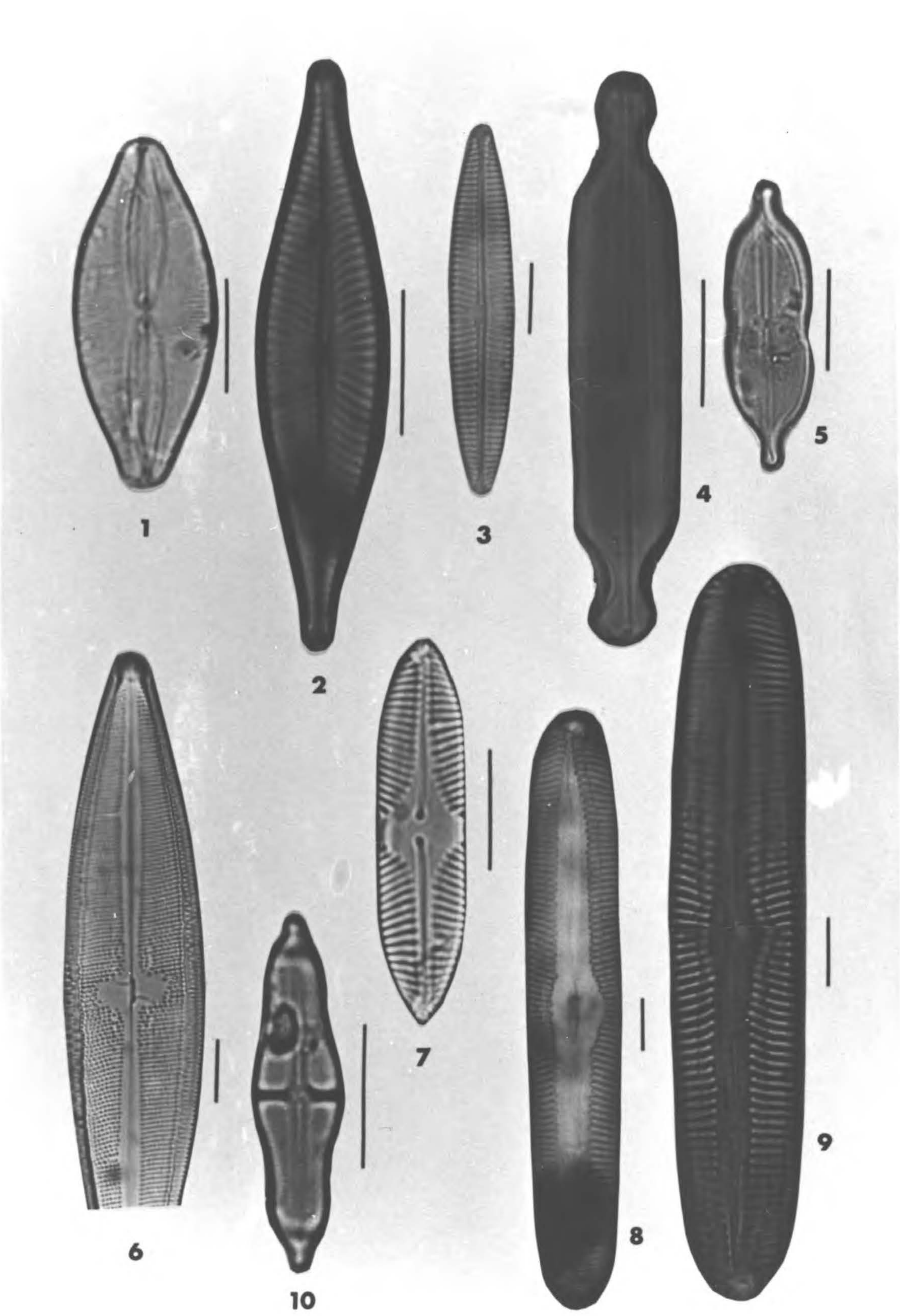
Figure 7.--*Pinnularia brebissonii* (Kutz.) Rabh.. Valve view.

Figure 8.--*Pinnularia gentilis* (Donk.) Cl.. Valve view.

Figure 9.--*Pinnularia viridis* (Kutz.) Ehr.. Valve view.

Figure 10.--*Stauroneis smithii* Grun.. Valve view.

Each scale represents 10 u.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Explanation of PLATE VIII

Figure 1.--Gomphonema acuminatum Ehr.. Valve view.

Figure 2.--Gomphonema acuminatum var. coronatum (Ehr.) W. Sm.. Valve view.

Figure 3.--Gomphonema acuminatum var. coronatum (Ehr.) W. Sm.. Valve view.

Figure 4.--Gomphonema angustatum var. sarcophagus (Greg.) Grun.. Valve view.

Figure 5.--Gomphonema constrictum Ehr.. Valve view.

Figure 6.--Gomphonema intricatum Kutz.. Valve view.

Figure 7.--Gomphonema intricatum Kutz.. Valve view.

Figure 8.--Gomphonema olivaceum (Lyngbye) Kutz.. Valve view.

Figure 9.--Gomphonema olivaceum (Lyngbye) Kutz.. Valve view.

Figure 10.--Gomphonema olivaceum (Lyngbye) Kutz.. Valve view.

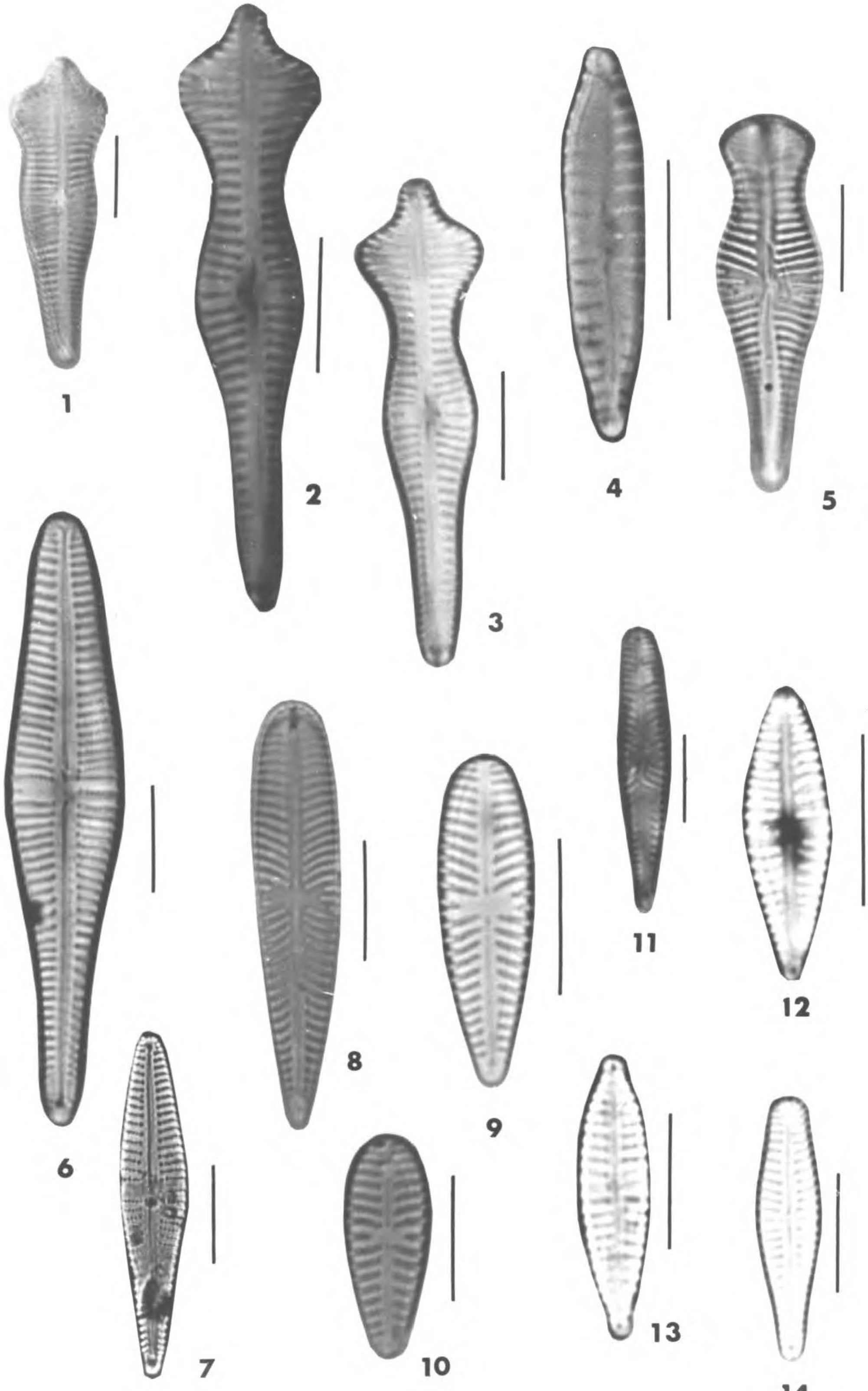
Figure 11.--Gomphonema olivaceum var. calcarea Cl.. Valve view.

Figure 12.--Gomphonema parvulum (Kutz.) Grun.. Valve view.

Figure 13.--Gomphonema parvulum (Kutz.) Grun.. Valve view.

Figure 14.--Gomphonema parvulum var. micropus (Kutz.) Cl.. Valve view.

Each scale represents 10 u.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Explanation of PLATE IX

Figure 1.--Amphora ovalis Kutz.. Girdle view.

Figure 2.--Amphora ovalis Kutz.. Valve view.

Figure 3.--Amphora normani Rabh.. Girdle view.

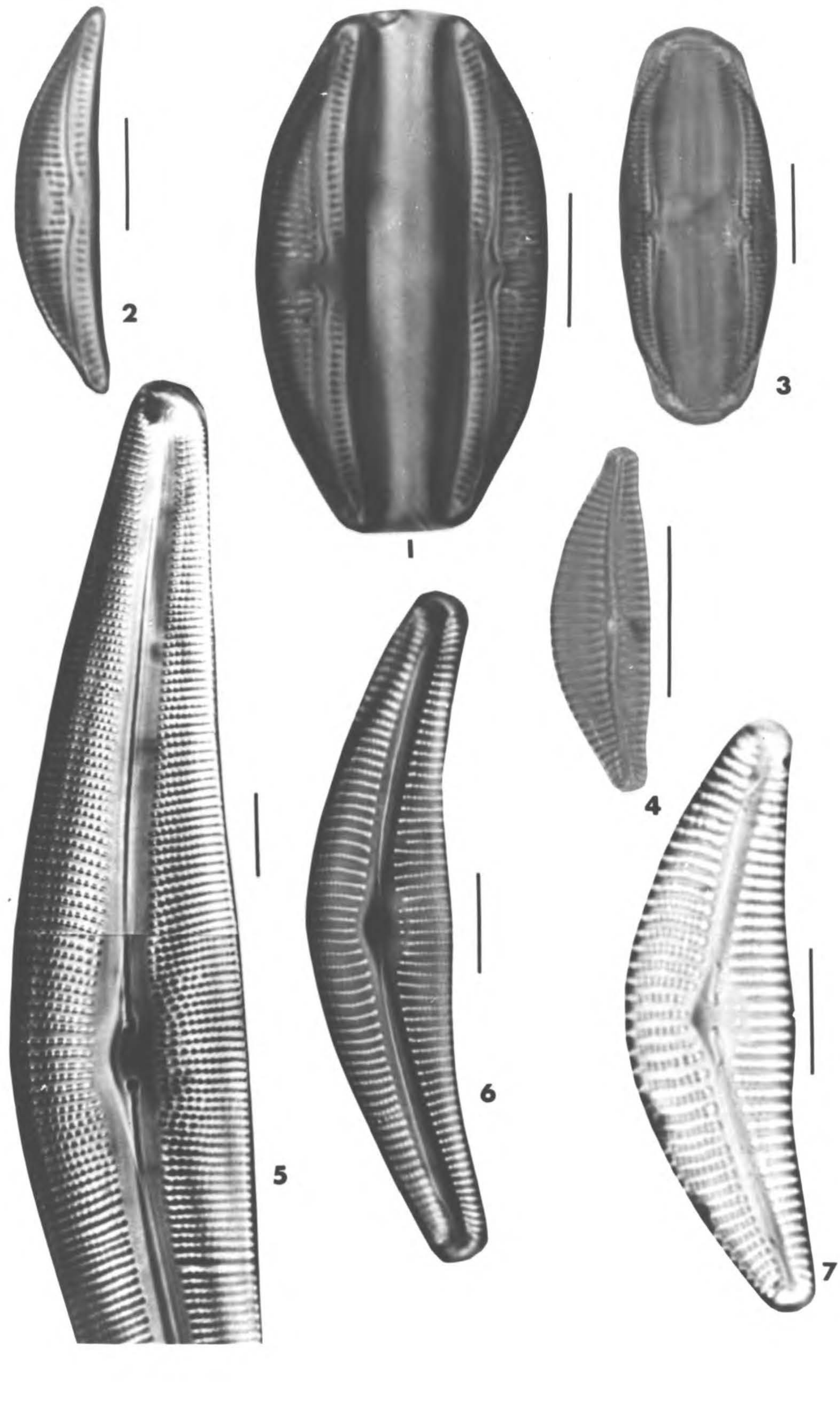
Figure 4.--Cymbella affinis Kutz.. Valve view.

Figure 5.--Cymbella aspera (Ehr.) Cl.. Valve view.

Figure 6.--Cymbella cistula (Hemprich) Grun.. Valve view.

Figure 7.--Cymbella cistula (Hemprich) Grun.. Valve view.

Each scale represents 10 u.



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Explanation of PLATE X

Figure 1.--Cymbella ehrenbergii Kutz.. Valve view.

Figure 2.--Cymbella heteropleura (Ehr.) Kutz.. Valve view.

Figure 3.--Cymbella mexicana (Ehr.) A. Schmidt. Valve view.

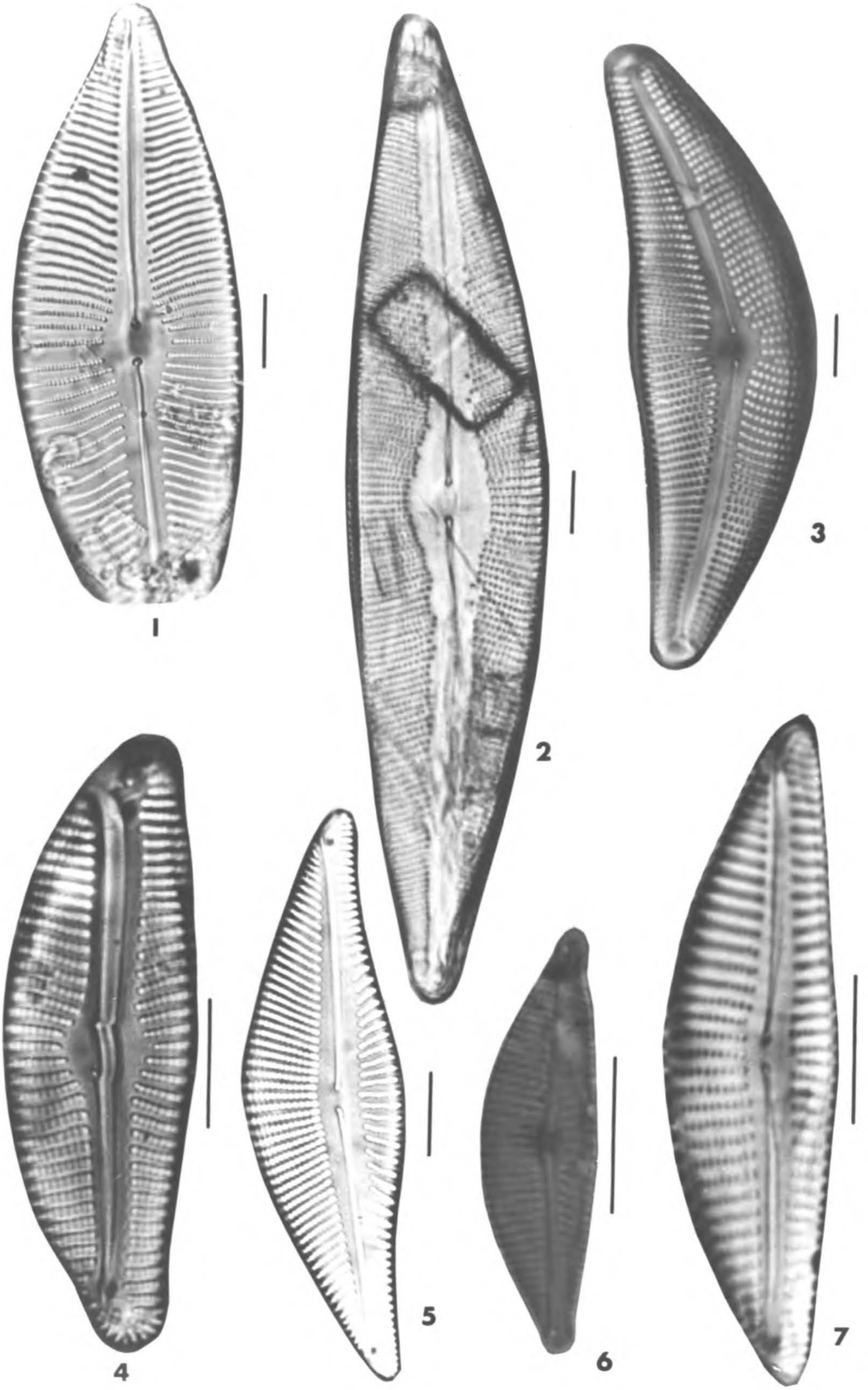
Figure 4.--Cymbella prostrata (Berk.) Cl.. Valve view.

Figure 5.--Cymbella tumida (Berb.) v. Heur.. Valve view.

Figure 6.--Cymbella tumidula Grun.. Valve view.

Figure 7.--Cymbella turgida Greg.. Valve view.

Each scale represents 10 u.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Explanation of PLATE XI

Figure 1.--Cymbella ventricosa Kutz.. Valve view.

Figure 2.--Cymbella ventricosa Kutz.. Valve view.

Figure 3.--Hannaea arcus var. amphioxys (Rabh.) Patr.. Valve view.

Figure 4.--Epithemia sorex Kutz.. Valve view.

Figure 5.--Epithemia sorex Kutz.. Valve view.

Figure 6.--Epithemia turgida (Ehr.) Kutz.. Valve view.

Figure 7.--Epithemia turgida var. granulata (Ehr.) Grun.. Valve view.

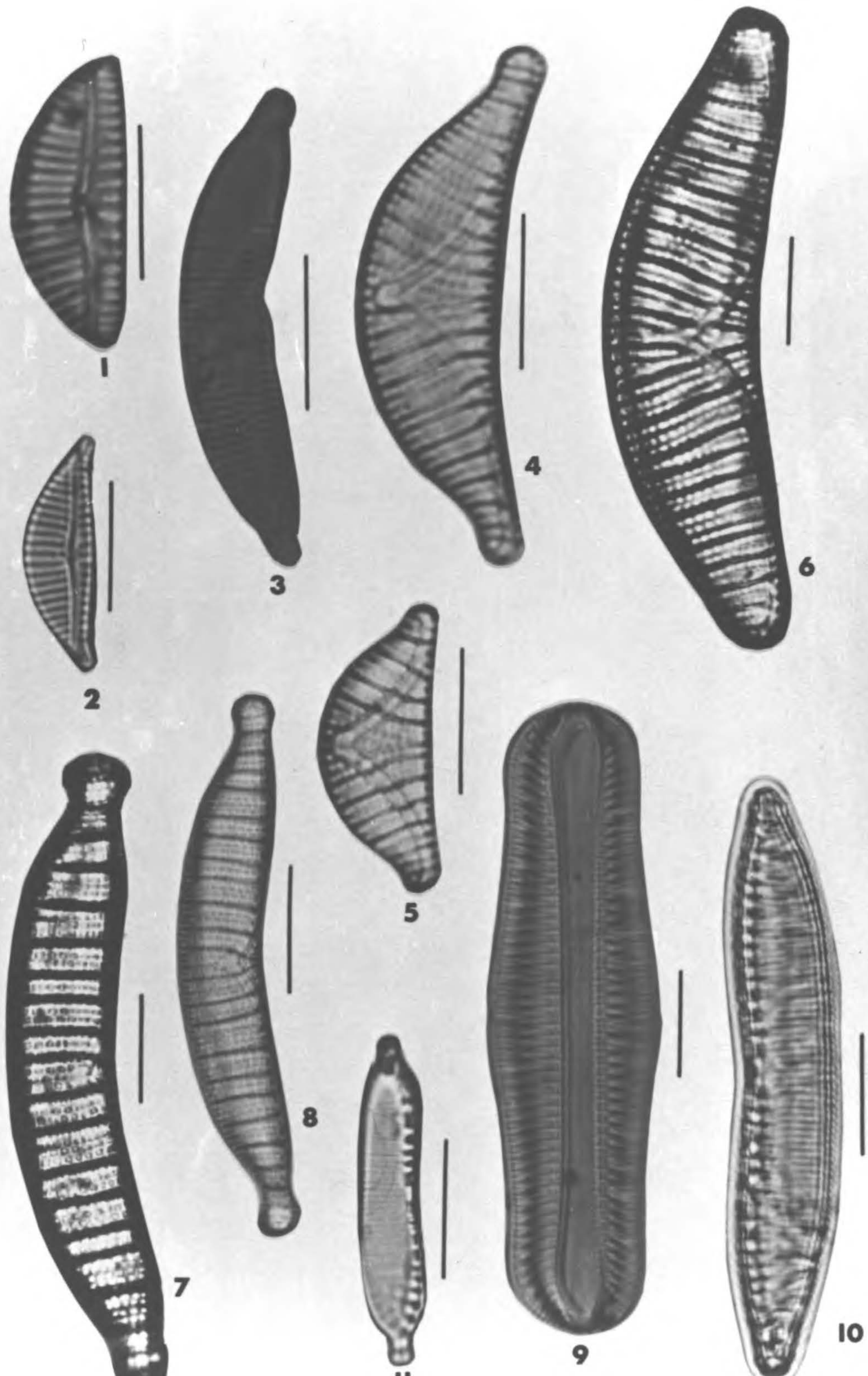
Figure 8.--Epithemia turgida var. granulata (Ehr.) Grun.. Valve view.

Figure 9.--Rhopalodia gibba (Ehr.) O. Mull.. Girdle view.

Figure 10.--Hantzschia amphioxys (Ehr.) Grun.. Valve view.

Figure 11.--Hantzschia amphioxys fo. capitata Mull.. Valve view.

Each scale represents 10 u.



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Explanation of PLATE XII

Figure 1.--Nitzschia amphibia Grun.. Valve view.

Figure 2.--Nitzschia amphibia Grun.. Valve view.

Figure 3.--Nitzschia dissipata (Kutz.) Grun.. Valve view.

Figure 4.--Nitzschia dissipata (Kutz.) Grun.. Valve view.

Figure 5.--Nitzschia fonticola Grun.. Valve view.

Figure 6.--Nitzschia hungarica Grun.. Valve view.

Figure 7,--Nitzschia linearis W. Sm.. Valve view.

Figure 8.--Nitzschia linearis W. Sm.. Valve view.

Figure 9.--Nitzschia palea (Kutz.) W. Sm.. Valve view.

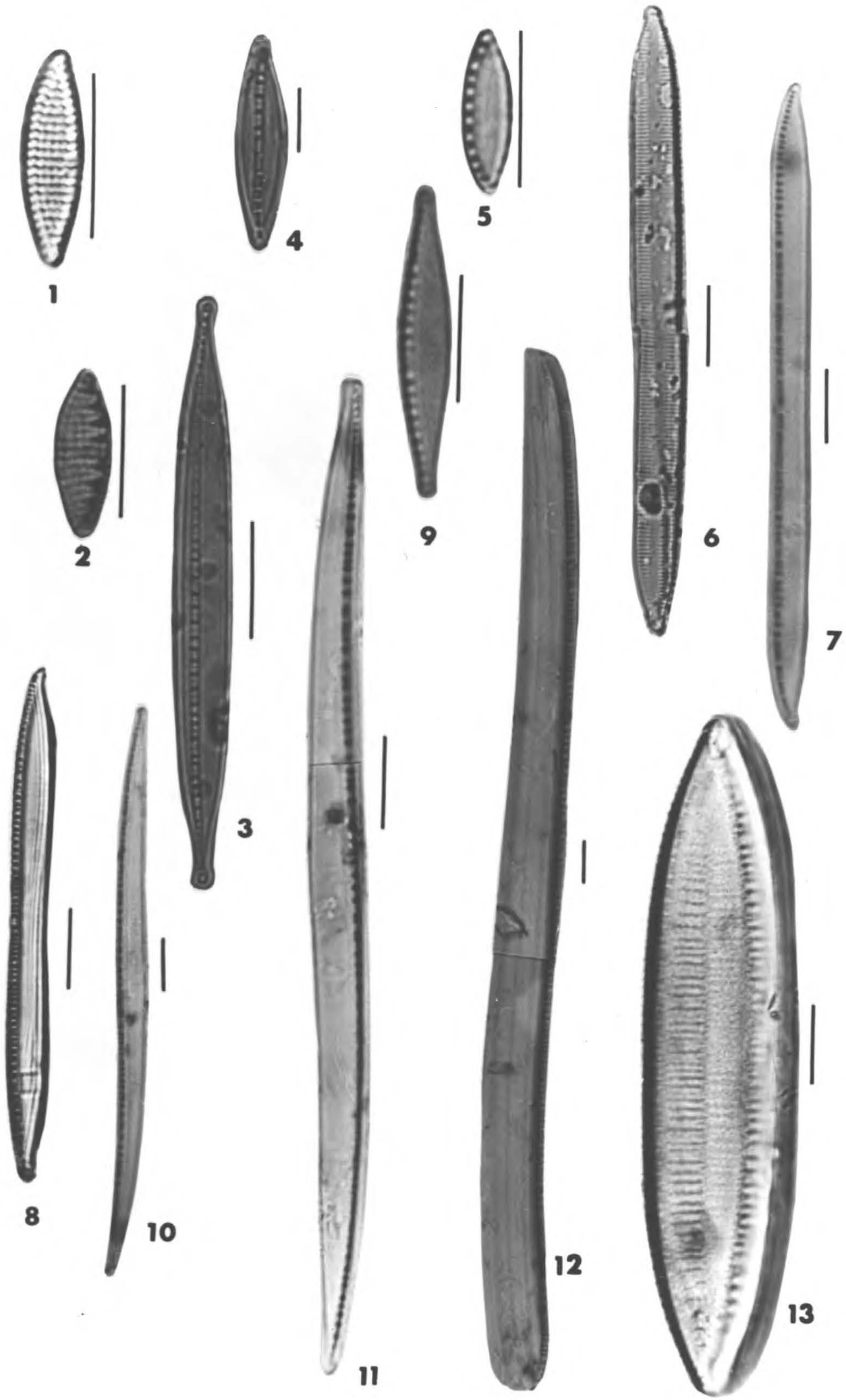
Figure 10.--Nitzschia sigma (Kutz.) W. Sm.. Valve view.

Figure 11.--Nitzschia sigma (Kutz.) W. Sm.. Valve view.

Figure 12.--Nitzschia sigmoidea (Ehr.) W. Sm.. Valve view.

Figure 13.--Nitzschia tryblionella Hantz.. Valve view.

Each scale represents 10 u.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Explanation of PLATE XIII

Figure 1.--*Surirella angustata* Kutz.. Valve view.

Figure 2.--*Surirella angustata* Kutz.. Valve view.

Figure 3.--*Surirella ovalis* Breb.. Valve view.

Figure 4.--*Surirella ovata* var. *pinnata* W. Sm.. Valve view.

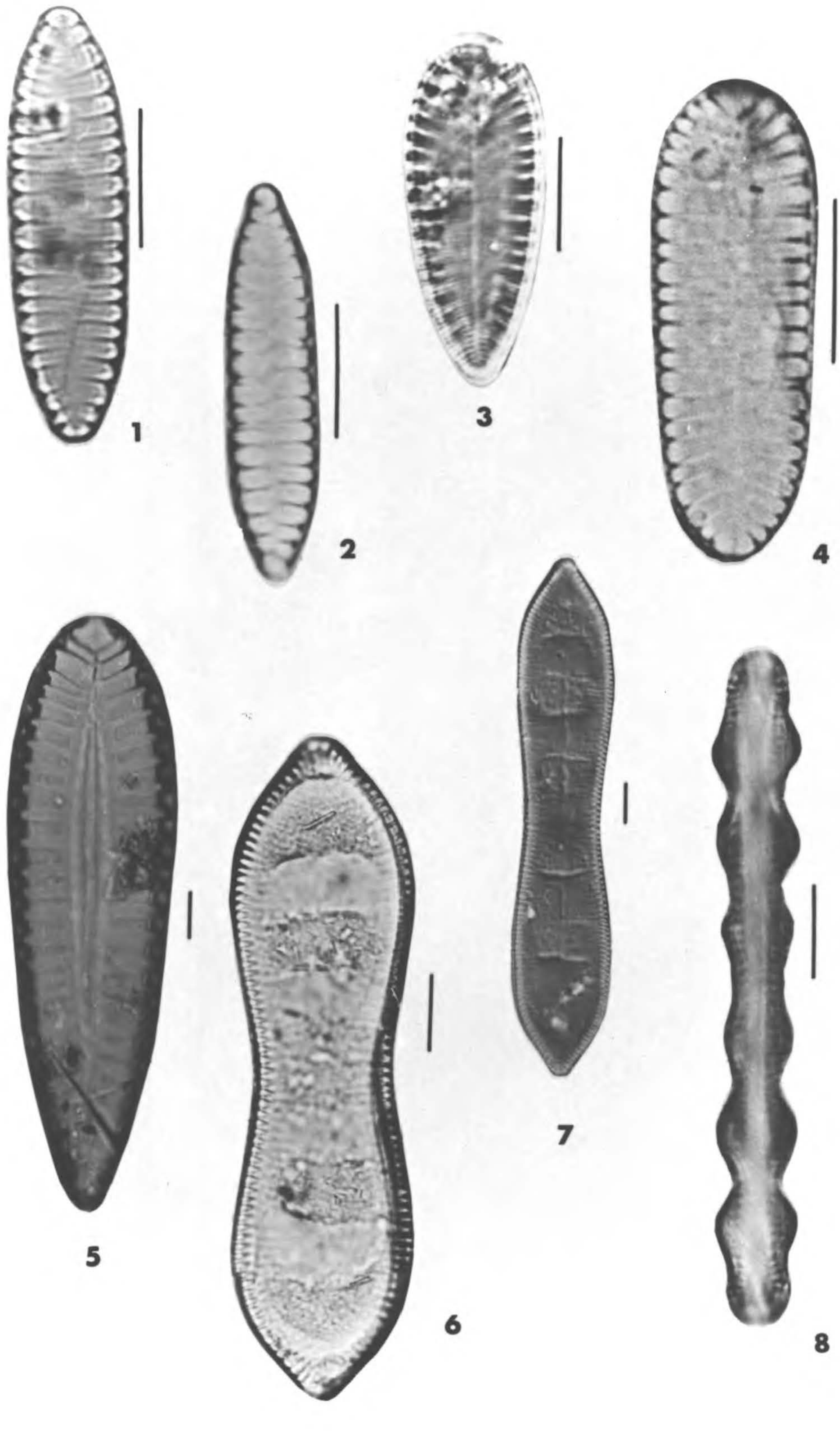
Figure 5.--*Surirella robusta* Ehr.. Valve view.

Figure 6.--*Cymatopleura solea* (Breb.) W. Sm.. Valve view.

Figure 7.--*Cymatopleura solea* (Breb.) W. Sm.. Valve view.

Figure 8.--*Cymatopleura solea* (Breb.) W. Sm.. Girdle view.

Each scale represents 10 u.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Explanation of PLATE XIV

Figure 1.--Characium ambigiuum Hermann. Cell 26u by 4u.

Figure 2.--Chlorococcum humicola (Naeg.) Rabenhorst. Cell 6u in diameter.

Figure 3.--Chlorella vulgaris Beyerinck. Cells 10-12u in diameter.

Figure 4.--Chlorella vulgaris Beyerinck. Cells 5-11u in diameter.

Figure 5.--Scenedesmus denticulatus Lagerheim. Colony 7u by 28u.

Figure 6.--Scenedesmus quadricauda var. quardrispina (Chod.) G. M. Smith. Colony 45u by 11u.

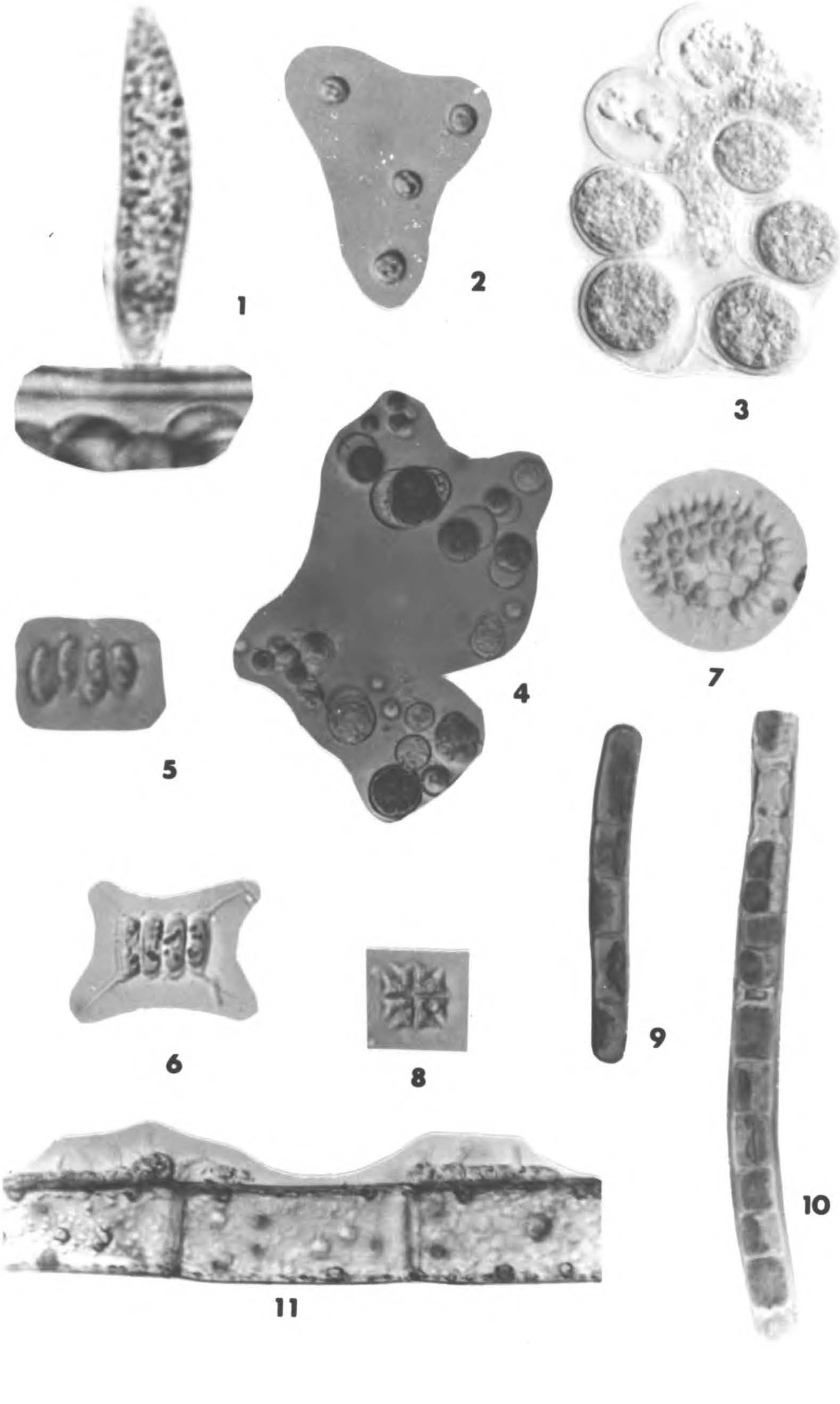
Figure 7.--Pediastrum boryanum (Turp.) Meneghini. Colony 55u in diameter.

Figure 8.--Pediastrum tetras (Ehr.) Ralfs. Colony 7.5u in diameter.

Figure 9.--Stichococcus subtilis (Kutz.) Klercker. Cell 6u broad.

Figure 10.--Stichococcus subtilis (Kutz.) Klercker. Cell 8u broad.

Figure 11.--Oedogonium sp. Cell 76u by 38u.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Explanation of PLATE XV

Figure 1.--Aphanochaete repens A. Braun. Cell 8u by 6u.

Figure 2.--Cladophora glomerata (L.) Kutzing. Cell 245u by 50u. Zoosporangium releasing zoospores.

Figure 3.--Cladophora glomerata (L.) Kutzing. Cell 250u by 75u.

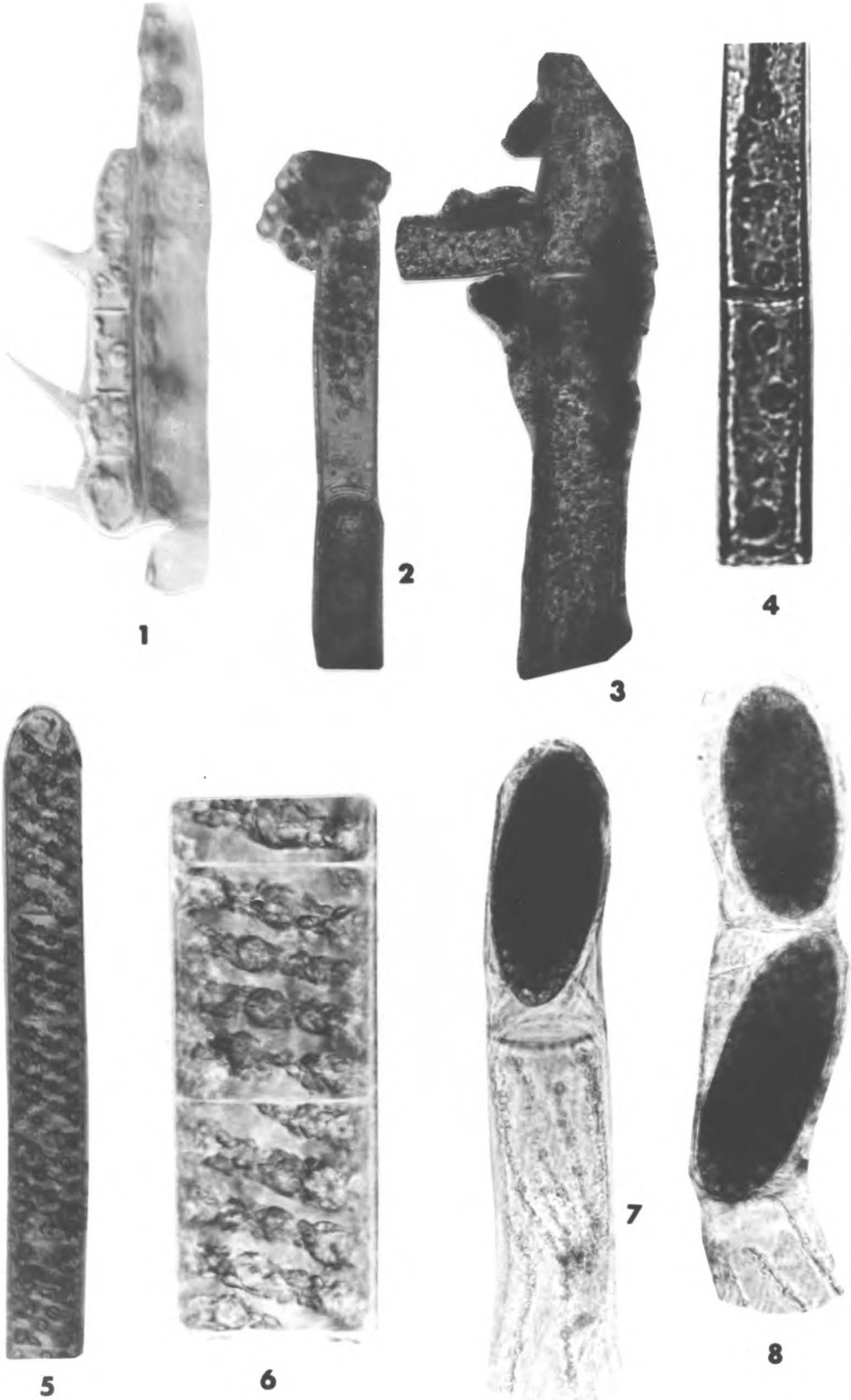
Figure 4.--Mougeotia genuflexa (Dillw.) C. A. Agardh. Cell 70u by 25u.

Figure 5.--Spirogyra dubia Kutzing. Vegetative cell 70u by 45u.

Figure 6.--Spirogyra dubia Kutzing. Vegetative cell 85u by 65u.

Figure 7.--Spirogyra jugalis (Fl. Dan.) Kutzing. Filament with zygospore. Vegetative cell 250u by 85u, zygospore 200u by 70u.

Figure 8.--Spirogyra jugalis (Fl. Dan.) Kutzing. Filament with zygospore. Vegetative cell 250u by 85u, zygospores 180u by 70u and 220u by 70u.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Explanation of PLATE XVI

Figure 1.--*Spirogyra jugalis* (Fl. Dan.) Kutzing. Vegetative cell 250u by 85u.

Figure 2.--*Spirogyra jugalis* (Fl. Dan.) Kutzing. Filament with zygospore. Vegetative cell 340u by 92u, zygospore 200u by 70u.

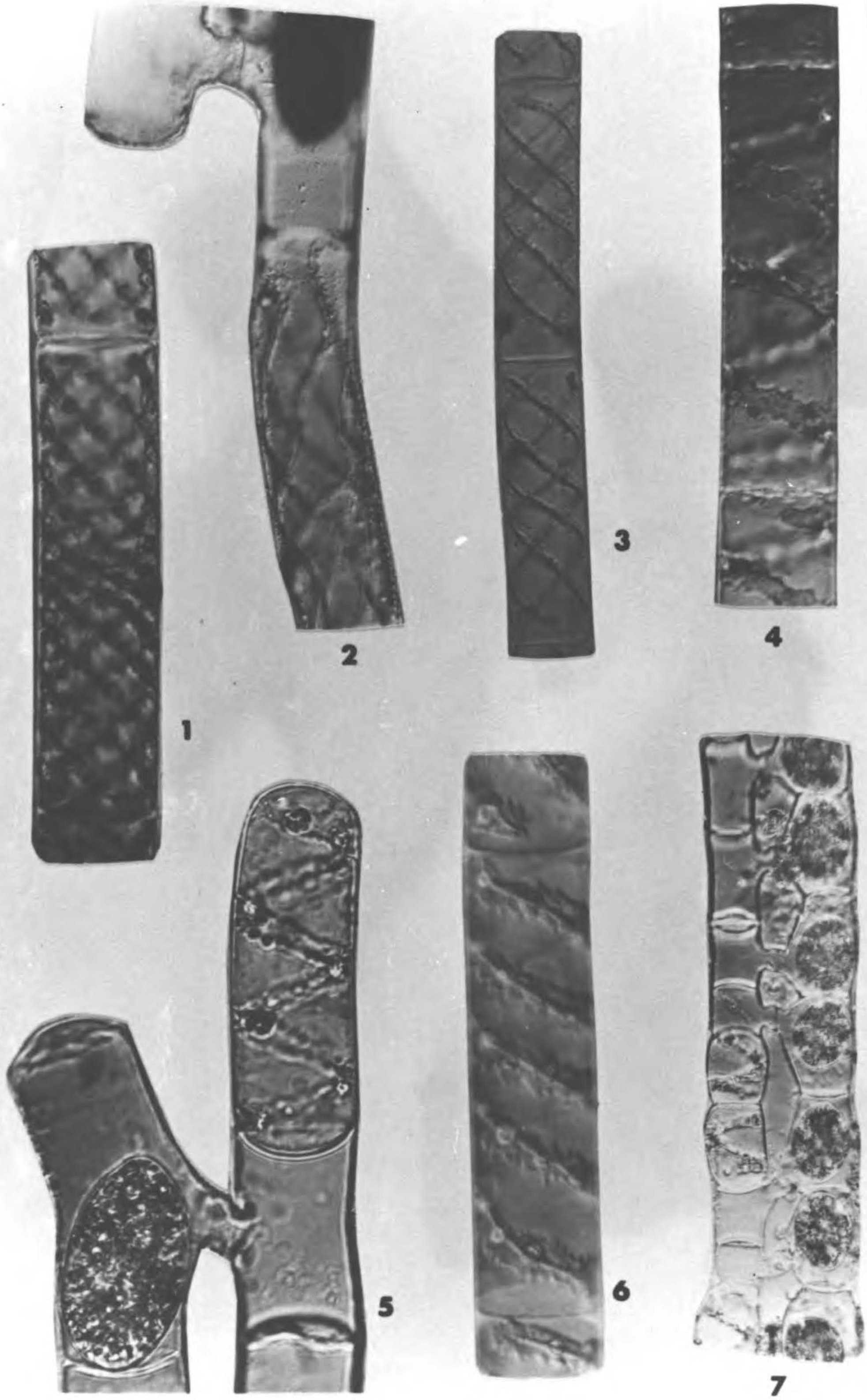
Figure 3.--*Spirogyra neglecta* (Hass.) Kutzing. Vegetative cell 225u by 70u.

Figure 4.--*Spirogyra porticalis* (Muell.) Cleve. Vegetative cell 145u by 35u.

Figure 5.--*Spirogyra porticalis* (Muell.) Cleve. Filament with zygospores. Vegetative cell 100u by 38u, zygospores 60u by 30u.

Figure 6.--*Spirogyra porticalis* (Muell.) Cleve. Vegetative cell 152u by 38u.

Figure 7.--*Spirogyra porticalis* (Muell.) Cleve. Filament with zygospore. Vegetative cell 42u by 38u, zygospore 50u by 30u.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Explanation of PLATE XVII

Figure 1.--*Zygnema insigne* (Hass.) Kutzing. Cell 35u by 30u.

Figure 2.--*Closterium lanceolatum* Kutzing. Cell 400u by 50u.

Figure 3.--*Closterium moniliferum* (Bory) Ehrenberg. Cell 250u by 45u.

Figure 4.--*Closterium moniliferum* (Bory) Ehrenberg. Cell 180u by 38u.

Figure 5.--*Cosmarium botrytis* Meneghini. Cell 54u by 45u.

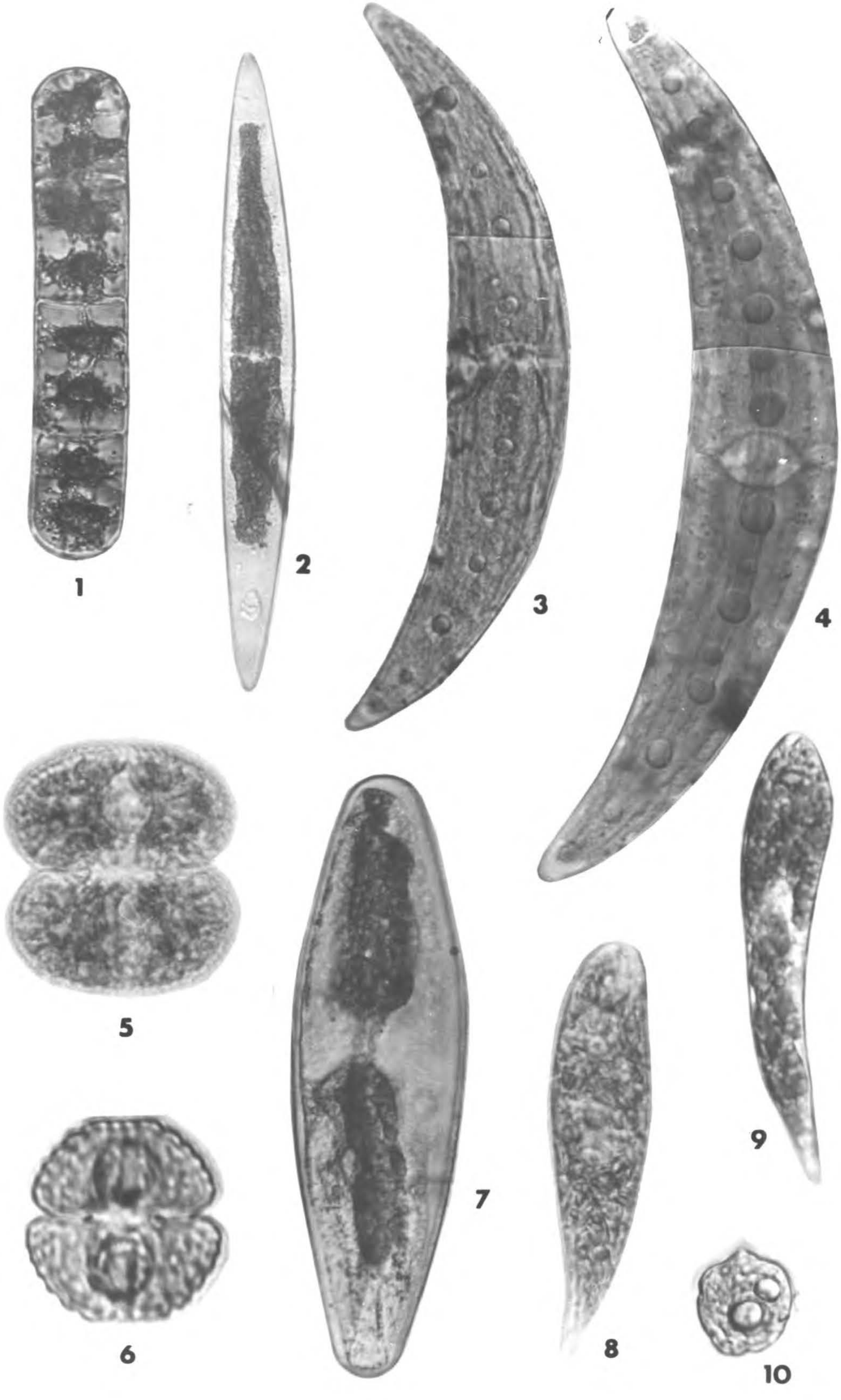
Figure 6.--*Cosmarium perforatum* Lund.. Cell 30u by 28u.

Figure 7.--*Penium navicula* Breb.. Cell 200u by 55u.

Figure 8.--*Euglena acus Ehrenberg*. Cell 105u by 18u.

Figure 9.--*Euglena acus* Ehrenberg. Cell 75u by 30u.

Figure 10.--*Phacus acuminata* Stokes. Cell 23u by 20u.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Explanation of PLATE XVIII

Figure 1.--*Vaucheria geminata* (Vaucher) DeCandolle. Vegetative filament 75u in diameter, oogonium 77u in diameter.

Figure 2.--*Vaucheria geminata* (Vaucher) DeCandolle. Oogonium 80u in diameter.

Figure 3.--*Vaucheria geminata* (Vaucher) DeCandolle. Vegetative filament 76u in diameter.

Figure 4.--*Vaucheria sessilis* (Vaucher) DeCandolle. Vegetative filament 38u in diameter, oogonium 96u in diameter.

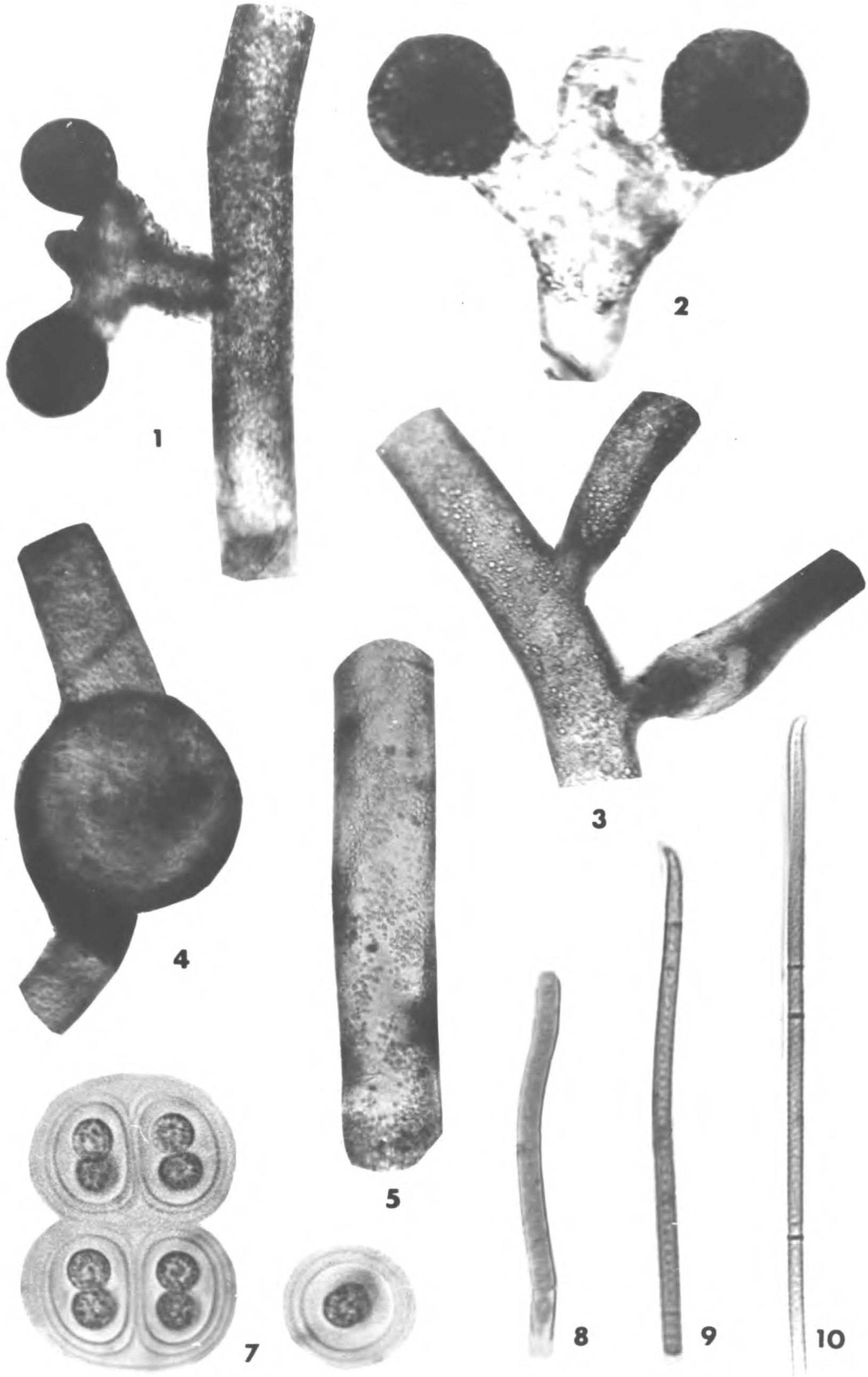
Figure 5.--*Vaucheria sessilis* (Vaucher) DeCandolle. Vegetative Filament 43u in diameter.

Figure 7.--*Chroococcus rufescens* (Kutz.) Naegeli. Cell 6u in diameter

Figure 8.--*Lyngbya martensiana* Meneghini. Cell 6u broad.

Figure 9.--*Oscillatoria animalis* C. A. Agardh. Cell 4u broad.

Figure 10.--*Oscillatoria animalis* C. A. Agardh. Cell 6u broad.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Explanation of PLATE XIX

Figure 1.--Oscillatoria princeps Vaucher. Cell 52u broad.

Figure 2.--Oscillatoria princeps Vaucher. Cell 57u broad.

Figure 3.--Oscillatoria sancta (Kutz.) Gomont. Cell 15u broad.

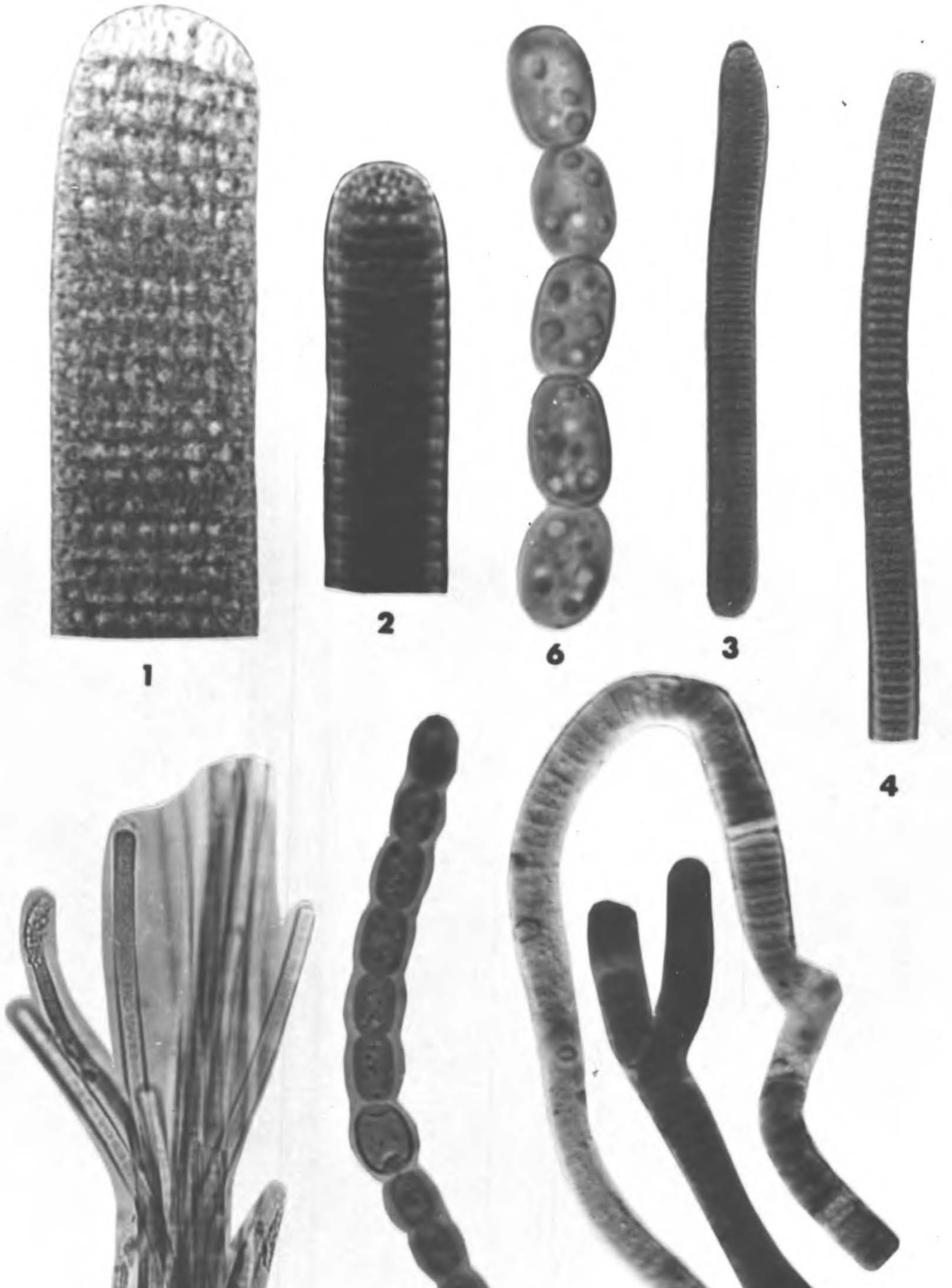
Figure 4.--Oscillatoria tenuis C. A. Agardh. Cell 12u broad.

Figure 5.--Phormidium inundatum Kutzing. Cell 6u broad.

Figure 6.--Anabaena variabilis Kutzing. Cell 11u by 7.5u.

Figure 7.--Anabaena variabilis Kutzing. Cell 11u by 7.5u.

Figure 8.--Tolypothrix penicillata (Ag.) Thur.. Cell 15u broad.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CONCLUSIONS

Sixty-eight genera and 160 species of algae were identified and described in this study. This flora consisted of 27 genera and 36 species of Chlorophyta, 2 genera and 2 species of Euglenophyta, 32 genera and 106 species of Bacillariophyceae, 1 genus and 2 species of Chrysophyta excluding diatoms and 6 genera and 14 species of Cyanophyta. Diatoms were the predominant algae in this study at all sites studied.

The Brigham Young University arboretum pond is an excellent habitat for the growth of algae. This pond contained high levels of dissolved silica (27-81 PPM), bicarbonates, carbon dioxide (8-68 PPM) and oxygen (5-12 PPM) which supported a high population of diatoms throughout the winter and spring and Chlorophyta (especially *Spirogyra dubia* Kutzing, *S. jugalis* (Fl. Dan.) Kutzing, *S. neglecta* (Hass.) Kutzing and *S. porticalis* (Muell.) Cleve) through the late spring and summer.

The diatom flora of the arboretum pond was dominated by *Melosira varians* C. A. Ag., *Synedra parasitica* var. *subconstricta* (Grun.) Hust., *S. ulna* (Nitz.) Ehr., *S. ulna* var. *subaequalis* (Grun.) v. Heur., *Cocconeis pediculus* Ehr., *C. placentula* var. *lineata* (Ehr.) v. Heur., *Anomoeoneis sphaerophora* (Kutz.) Pfitz., *Cymbella cistula* (Hemprich) Grun., *Nitzschia linearis* W. Sm., *N. sigmoidea* (Ehr.) W. Sm., and *Cymatopleura solea* (Breb.) W. Sm..

Several species of diatoms, especially of *Navicula*, *Cymbella* and *Nitzschia* were restricted only to this pond during this study.

These were Navicula cuspidata (Kutz.) Kutz., N. odiosa Wallace, N. placentula var. rostrata A. Mayer, N. pupula Kutz., N. pygmaea Kutz., Cymbella heteropleura (Ehr.) Kutz., C. mexicana (Ehr.) A. Schmidt., C. prostrata (Berk.) Cl., C. tumida (Breb.) v. Heur., C. tumidula Grun., C. turgida Greg., Nitzschia hungarica Grun., N. sigma (Kutz.) W. Sm., and N. tryblionella Hantz.. Other species restricted to this locality were Melosira distans (Ehr.) Kutz., Fragilaria brevistriata var. inflata (Pant.) Hust., Synedra capitata Ehr., Eunotia curvata (Kutz.) Lagerst, Caloneis ventricosa (Ehr.) Meist., Neidium iridis (Ehr.) Cl., Gomphonema acuminatum Ehr., Epithemia turgida (Ehr.) Kutz., E. turgida var. granulata (Ehr.) Grun. and Rhopalodia gibba (Ehr.) O. Mull..

The Brigham Young University botanical greenhouses represented rather specialized environmental conditions. Thus, several parameters such as light, water and temperature were controlled and demonstrated little fluctuation. The algal flora of the greenhouses was dominated by Protococcus viridis C. A. Agardh, Chlorococcum humicola (Naeg.) Rabenhorst, Oscillatoria sancta (Kutz.) Gomont, Amphora normani Rabh. and Hantzschia amphioxys (Ehr.) Grun..

Several species of algae were collected only from the greenhouses. These were Lyngbya aestuarii (Mertens) Liebmann, L. martensiana Meneghini, Oscillatoria angustissima West & West, O. animalis C. A. Agardh, O. cruenta Grun., O. limosa (Roth) C. A. Agardh, O. sancta (Kutz.) Gomont and O. tenuis C. A. Agardh, Phormidium inundatum Kutzing, Anabaena variabilis Kutzing, Tolypothrix penicillata (Ag.) Thur., Stichococcus bacillaris Naegeli, S. scopulinus Hazen, S. subtilis (Kutz.) Klercker and Chlorella vulgaris Beyerinck.

Sixteen genera and 33 species of diatoms were collected from the soil in the greenhouses during this study. Hantzschia amphioxys (Ehr.) Grun. and Amphora normani Rabh. were the most common soil diatoms. Achnanthes lanceolata (Breb.) Grun., Navicula tripunctata (O. F. Mull.) Bory, Hantzschia amphioxys var. capitata Mull. and Nitzschia palea (Kutz.) W. Sm. were also quite common. Pinnularia gentilis (Donk.) Cl. was the only diatom restricted to the soil during this study.

The stream surrounding the Brigham Young University campus had higher levels of nitrates, phosphates, dissolved oxygen (6-10 PPM), alkalinity (120-260 PPM) and carbon dioxide (6-44 PPM) than the arboretum pond but demonstrated fewer species of algae.

The stream flora was dominated by Stephanodiscus niagare Ehr., Diatoma vulgare Bory, D. tenue var. elongatum Lyngb., Cocconeis pediculus Ehr., C. placentula var. euglypta (Ehr.) Cl., Navicula tripunctata (O. F. Mull.) Bory, Gomphonema olivaceum (Lyngbye) Kutz. and Nitzschia sigmoidea (Ehr.) W. Sm..

Species restricted to this stream during this study were Diatoma hiemale var. mesodon (Ehr.) Grun. at stream site one, Hannaea arcus var. amphioxys (Rabh.) Patr., Synedra ulna var. constricta Østr., Navicula laevissima Kutz., N. mutica Kutz., Neidium affine (Ehr.) Pftiz., Gomphonema acuminatum var. coronatum (Ehr.) W. Sm., G. angustata var. sarcophagus (Greg.) Grun., Palmella mucosa Kutz., and Chaetophora incrassata (Huds.) Hazen at stream site two and Navicula capitata Ehr. at stream site three.

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APPENDIX I

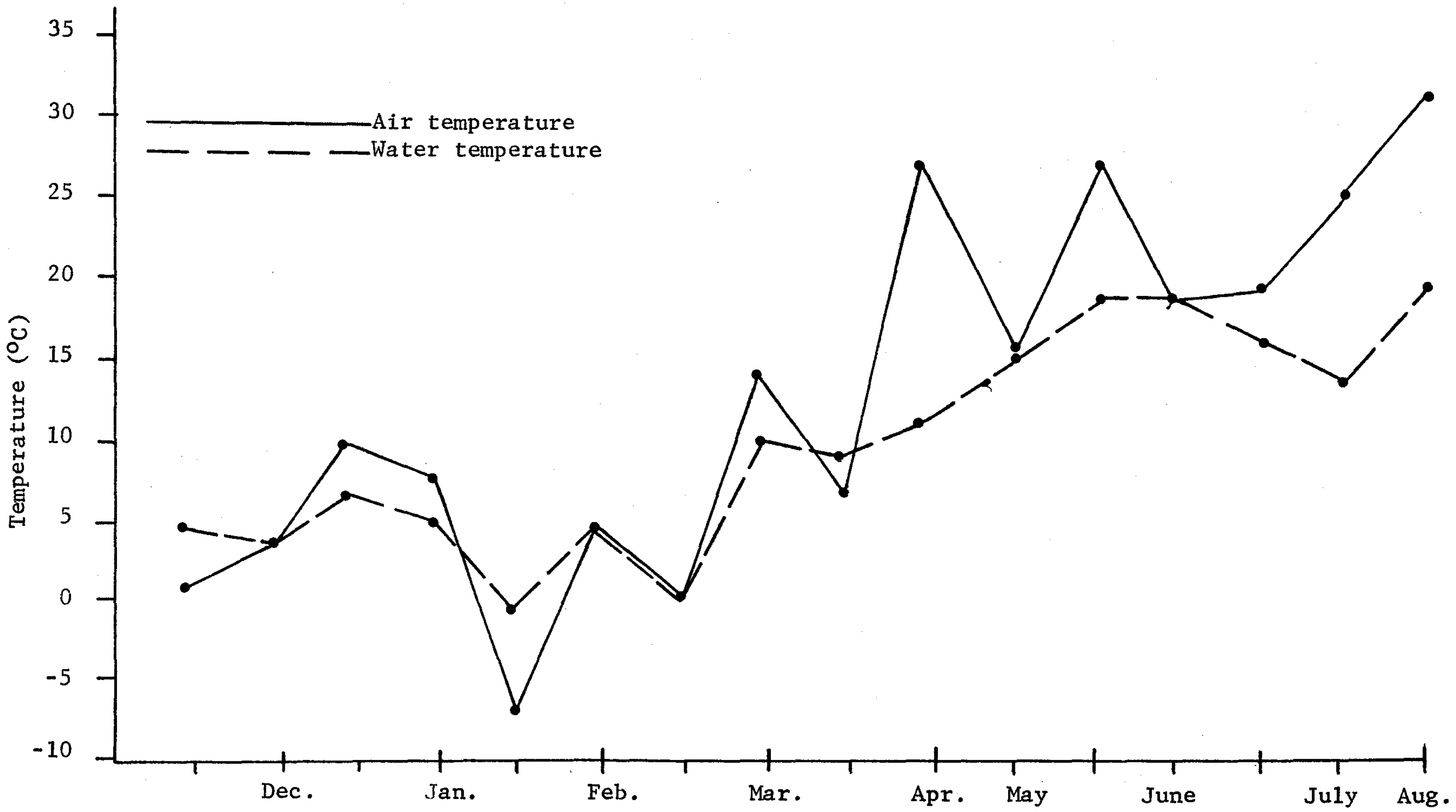

Fig. 5.--Temperature data for the B.Y.U. arboretum pond, 1971-1972.

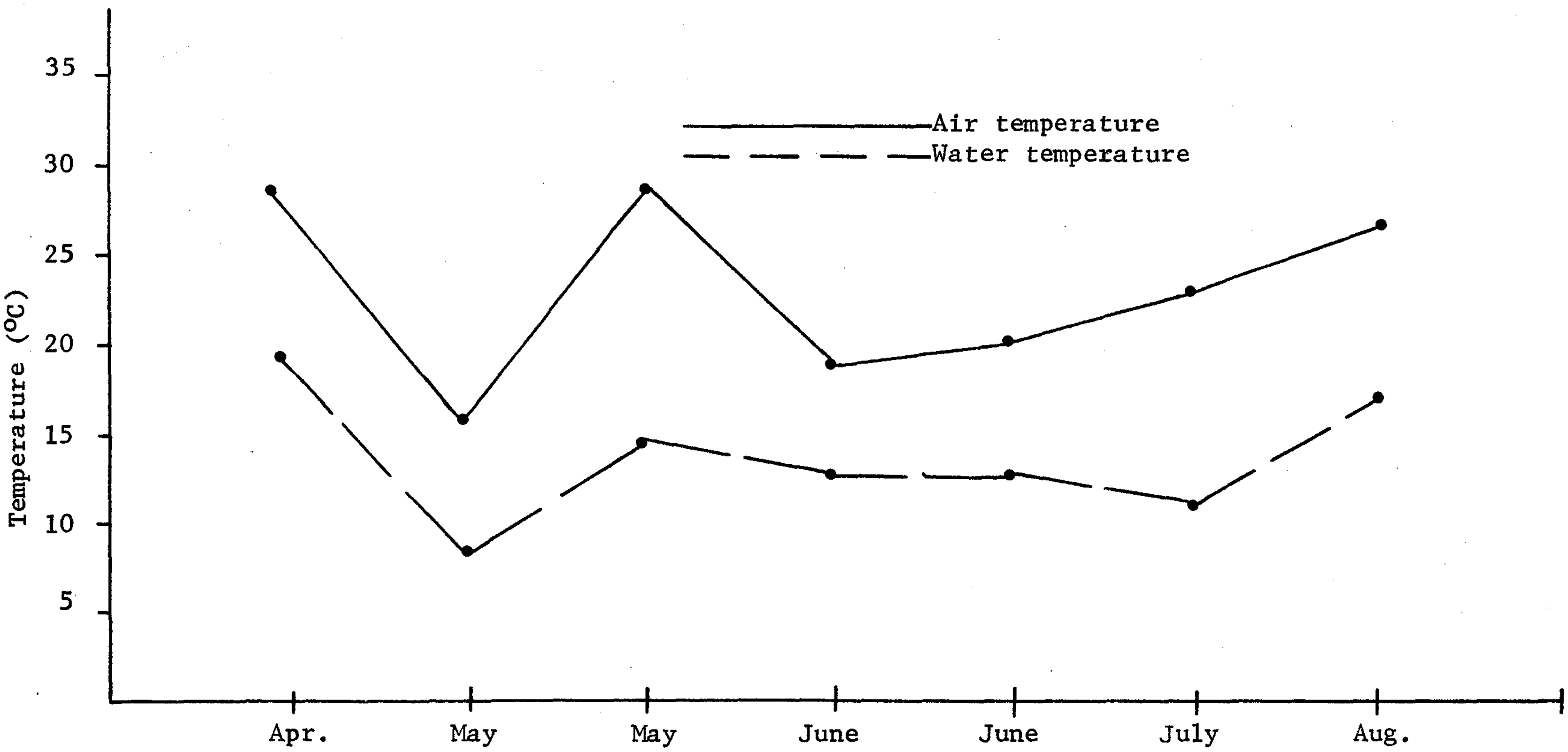

Fig. 6.--Temperature data for the B.Y.U. stream (site 1), 1972.

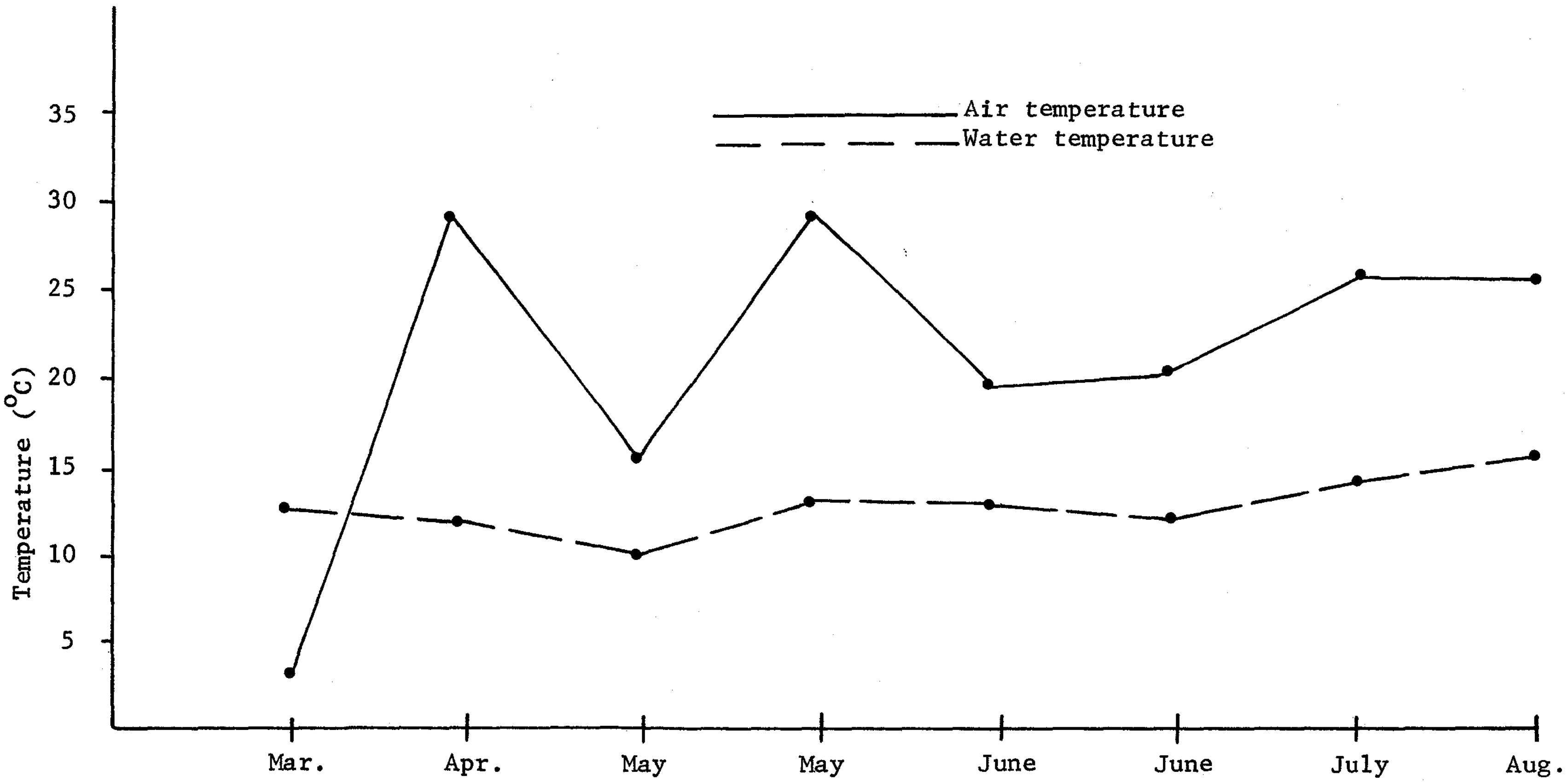

Fig. 7.--Temperature data for the B.Y.U. stream (site 2), 1972.

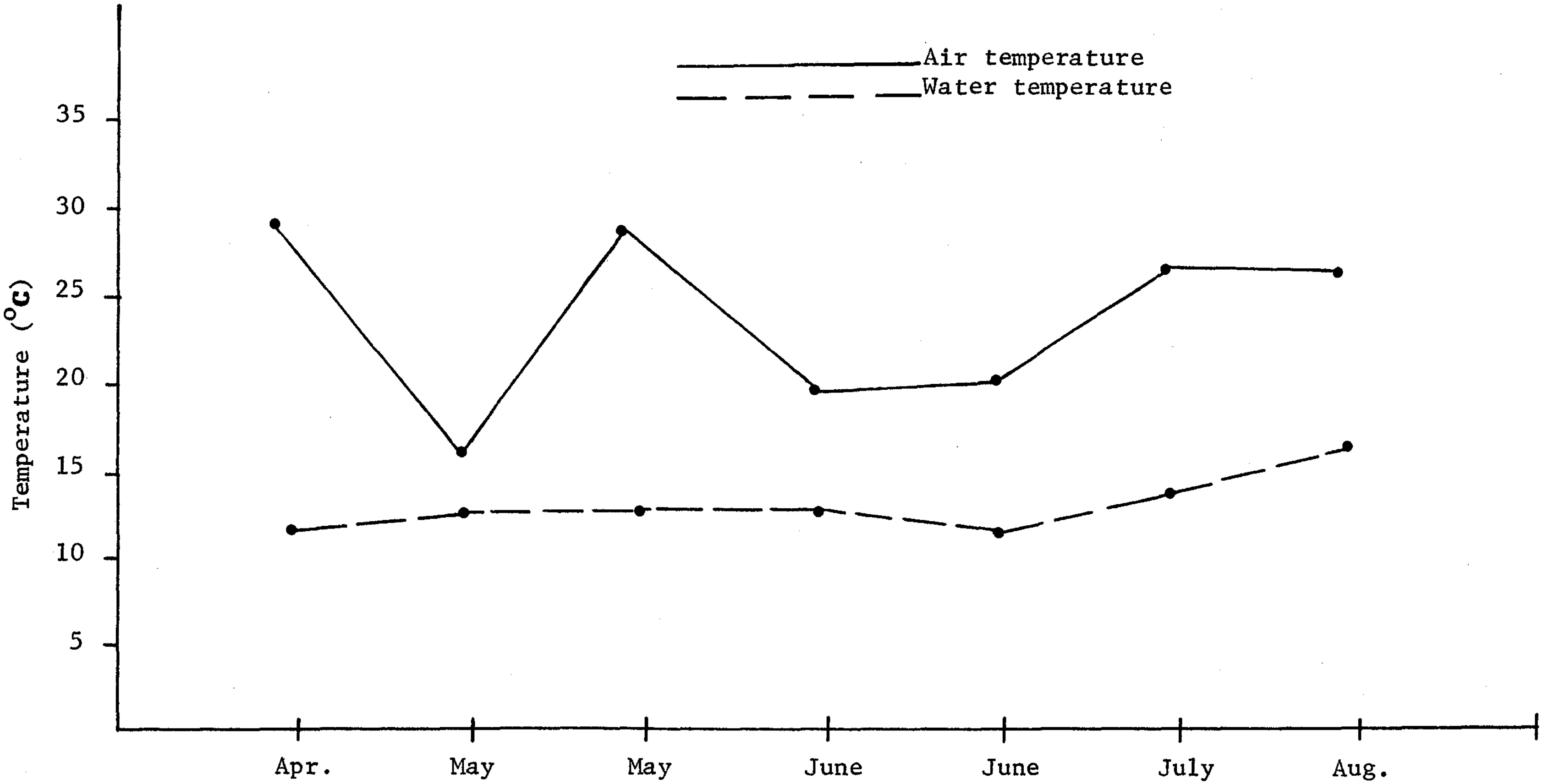

Fig. 8.--Temperature data for the B.Y.U. stream (site 3), 1972.

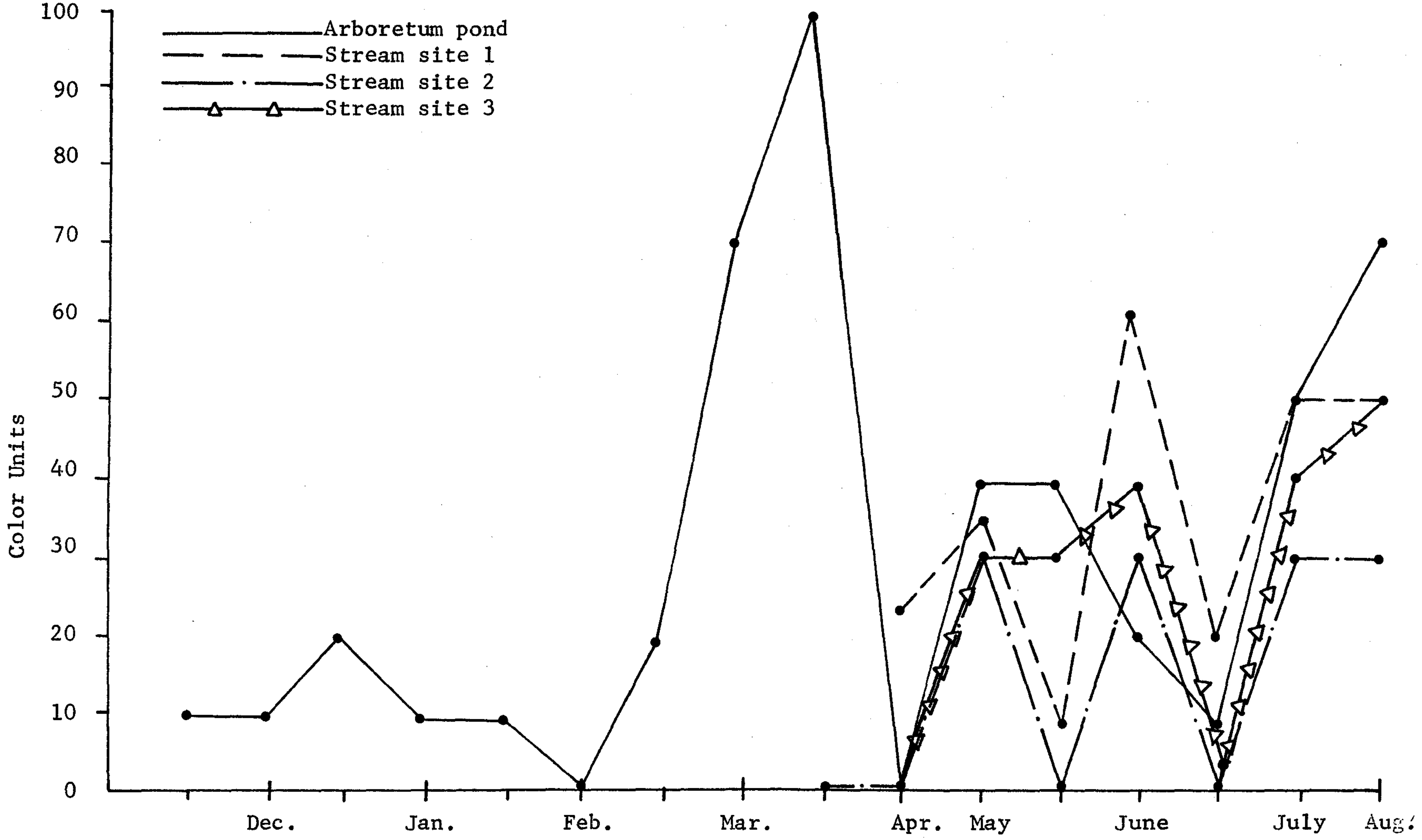

Fig. 9.--Color data for the B.Y.U. arboretum pond and stream, 1971-1972.

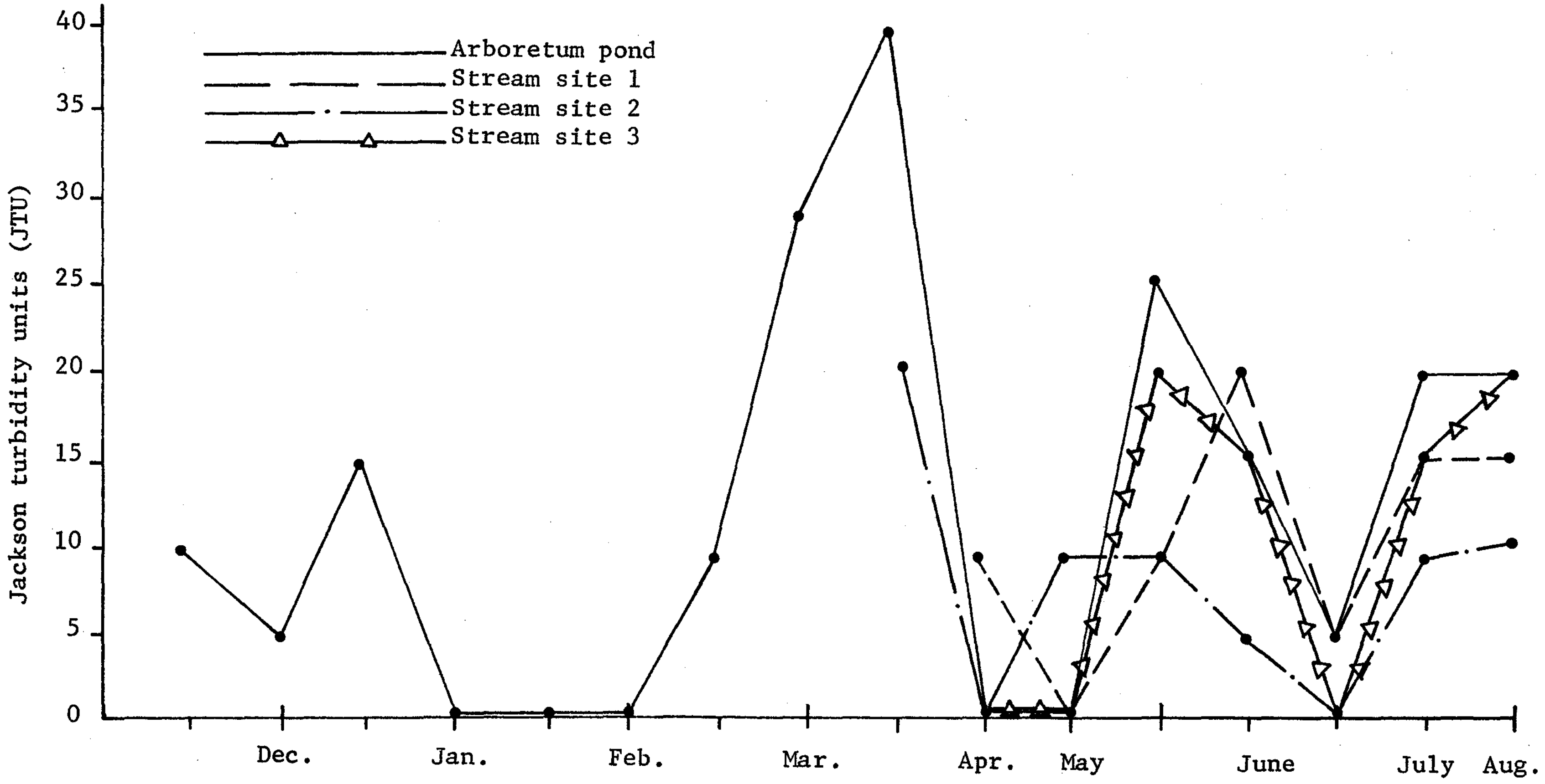

Fig. 10.--Turbidity data for the B.Y.U. arboretum pond and stream, 1971-1972.

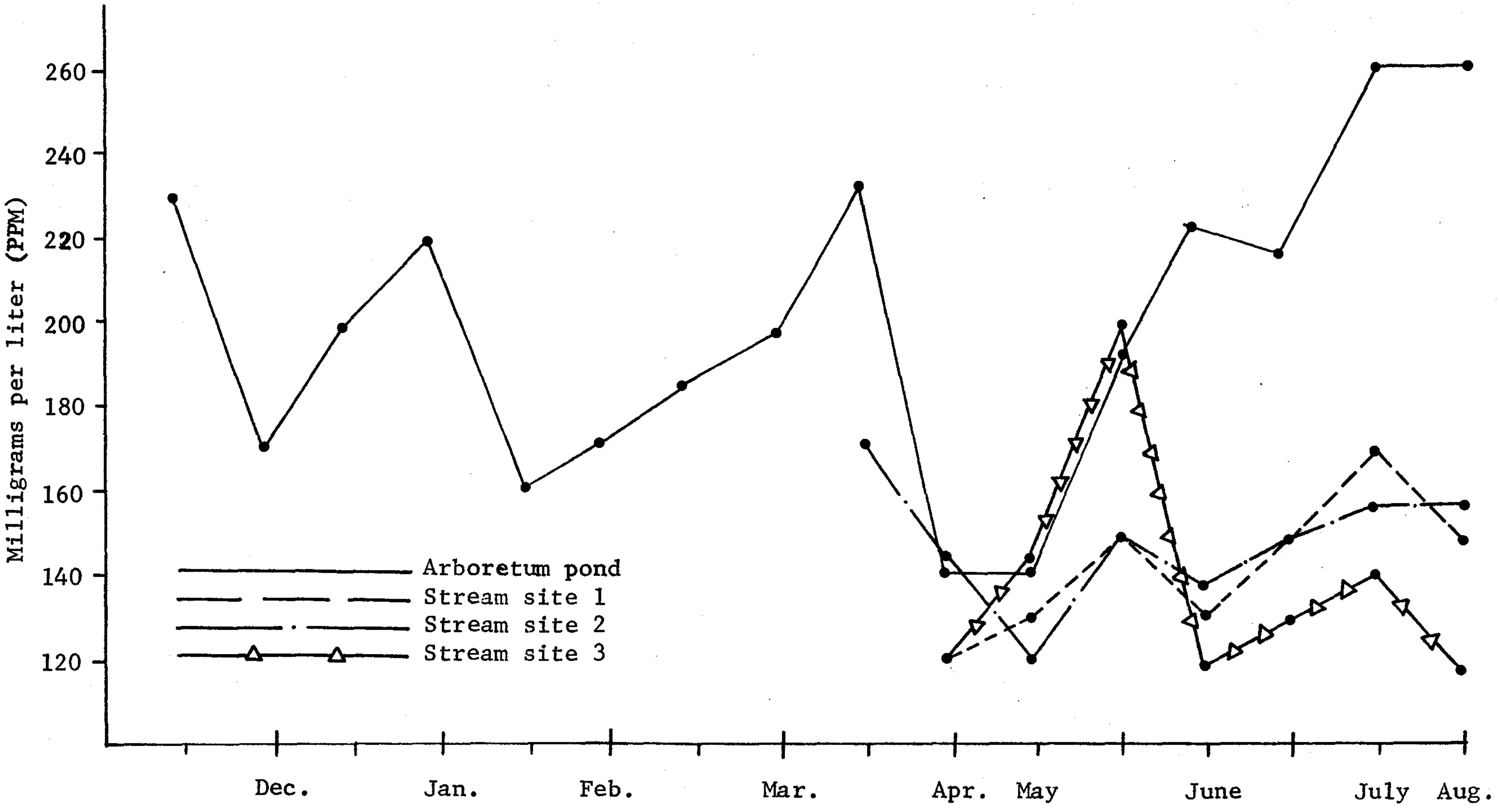

Fig. 11.--Alkalinity (bicarbonate) data for the B.Y.U. arboretum pond and stream, 1971-1972.

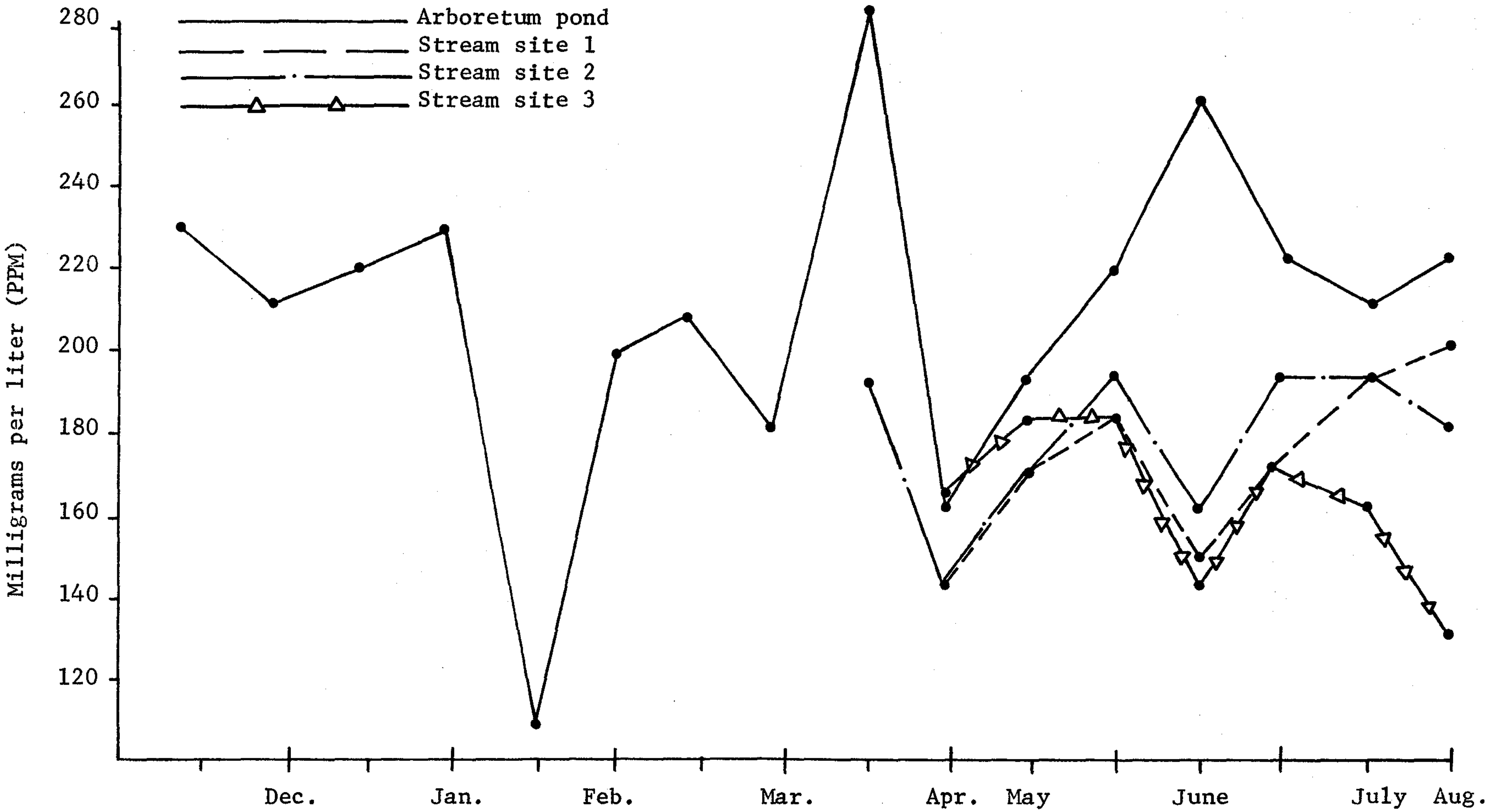

Fig. 12.--Hardness (total) data for the B.Y.U. arboretum pond and stream, 1971-1972.

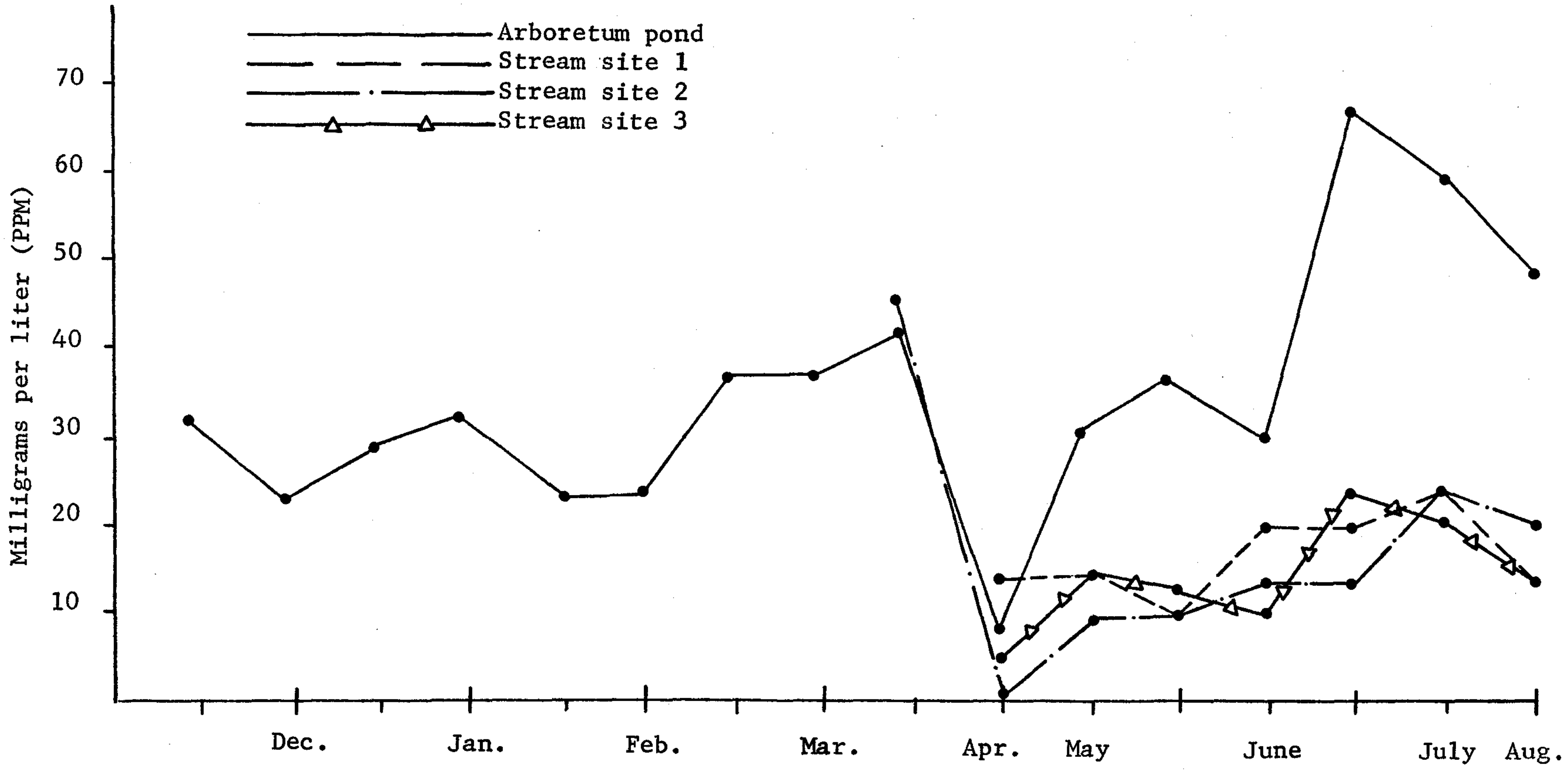

Fig. 13.--Carbon dioxide data for the B.Y.U. arboretum pond and stream, 1971-1972.

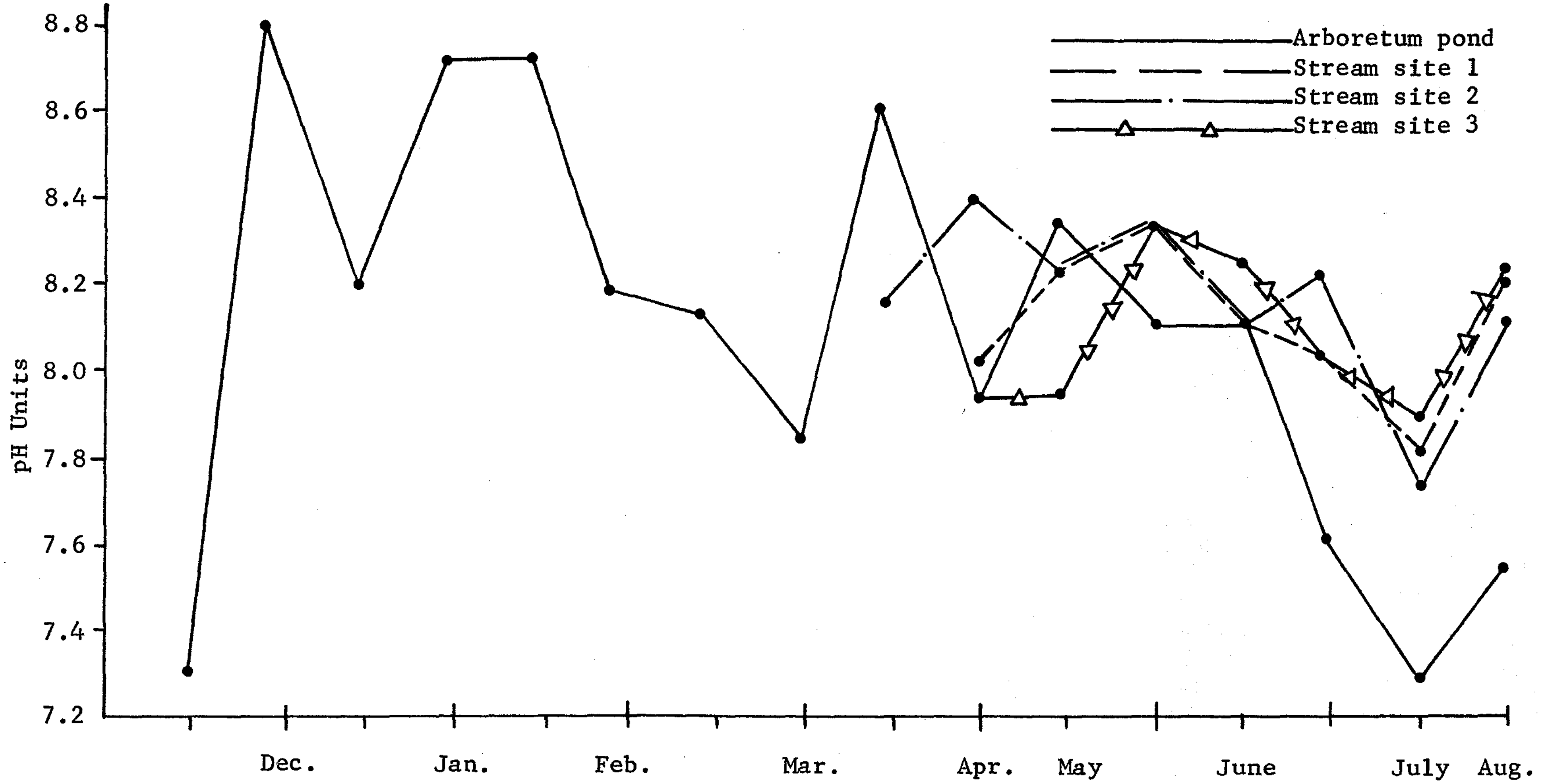

Fig. 14.--Hydrogen ion concentration data for the B.Y.U. arboretum pond and stream, 1971-1972.

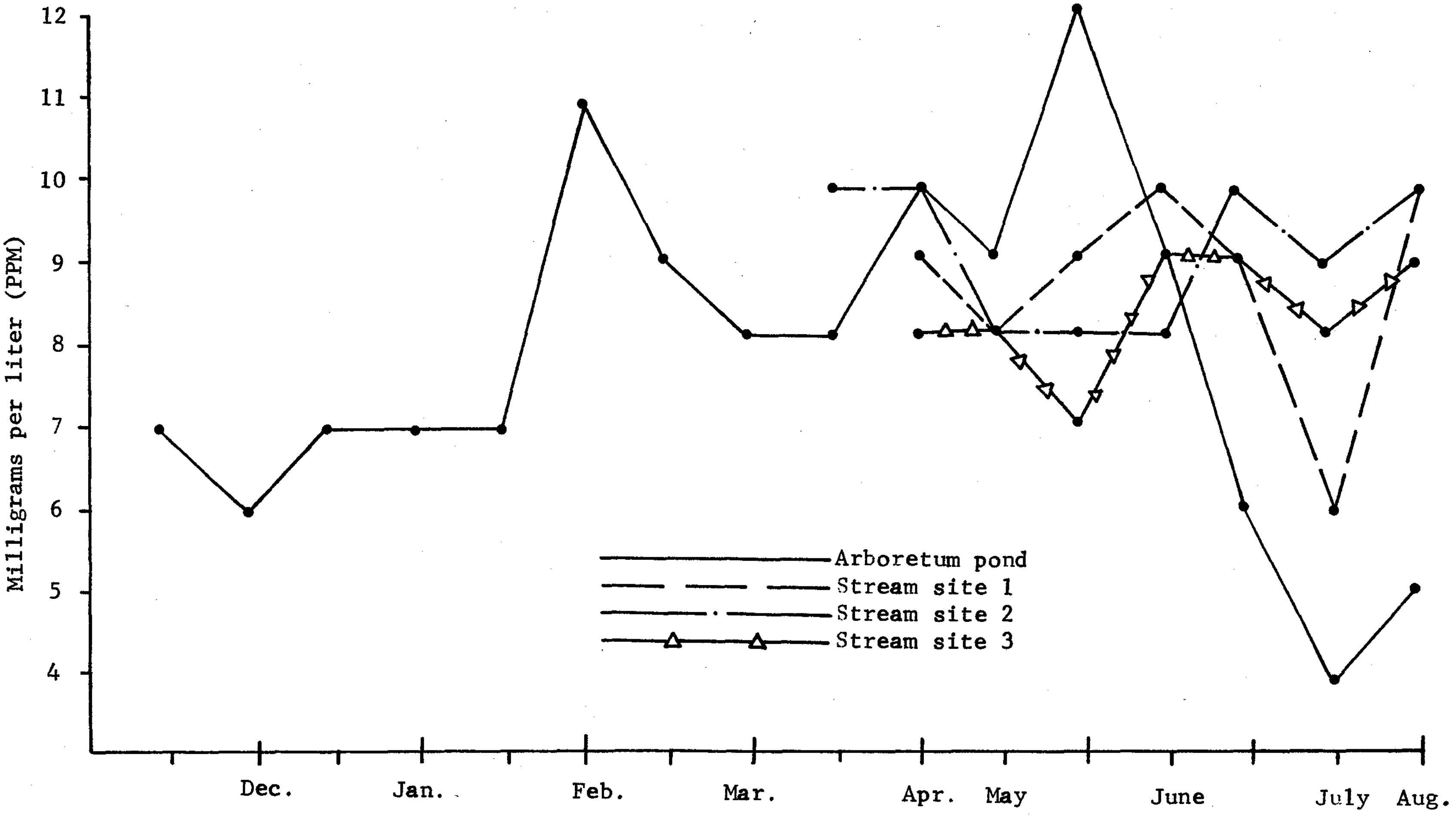

Fig. 15.--Dissolved oxygen data for the B.Y.U. arboretum pond and stream, 1971-1972.

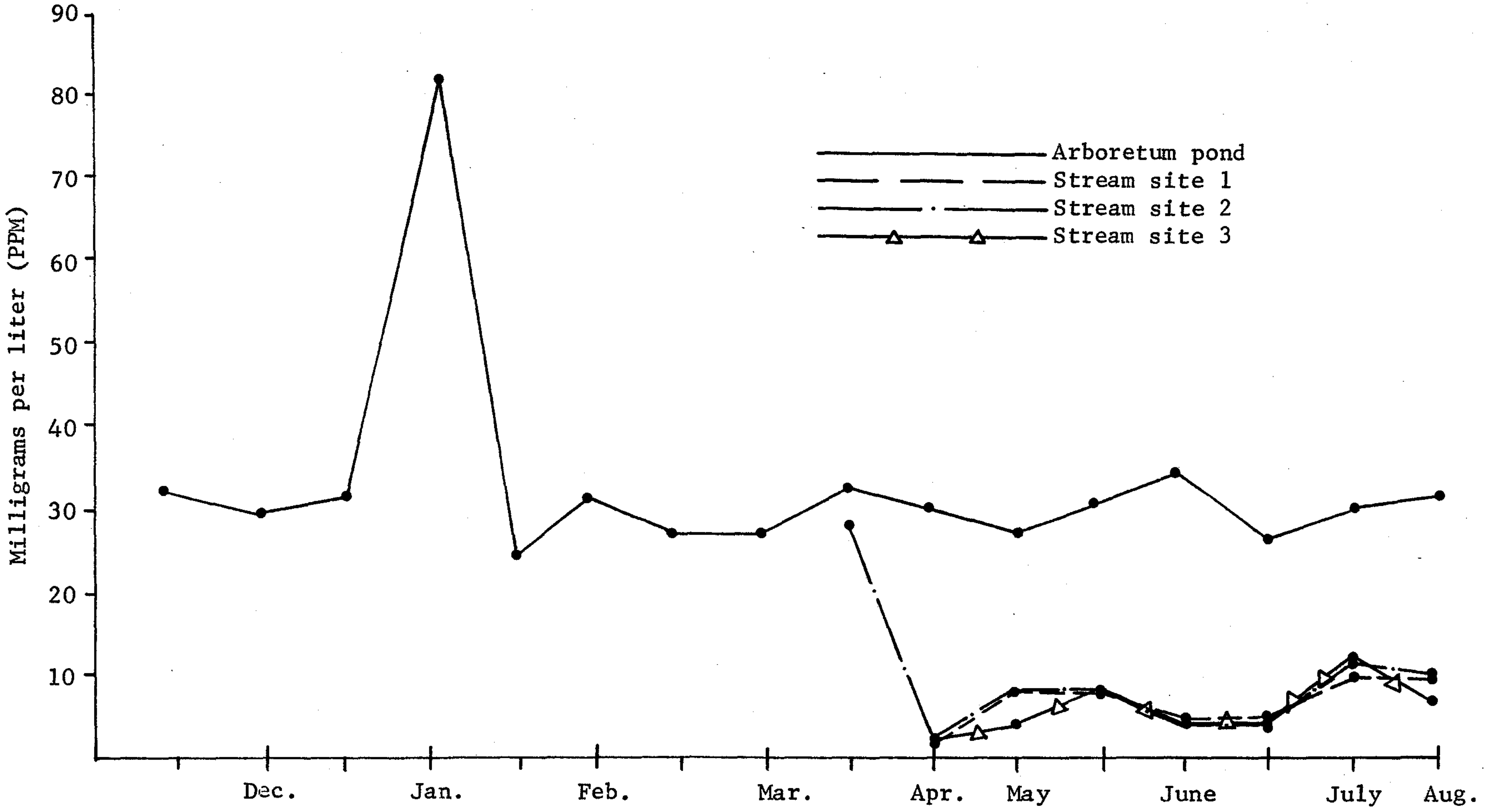

Fig. 16.--Silica data for the B.Y.U. arboretum pond and stream, 1971-1972.

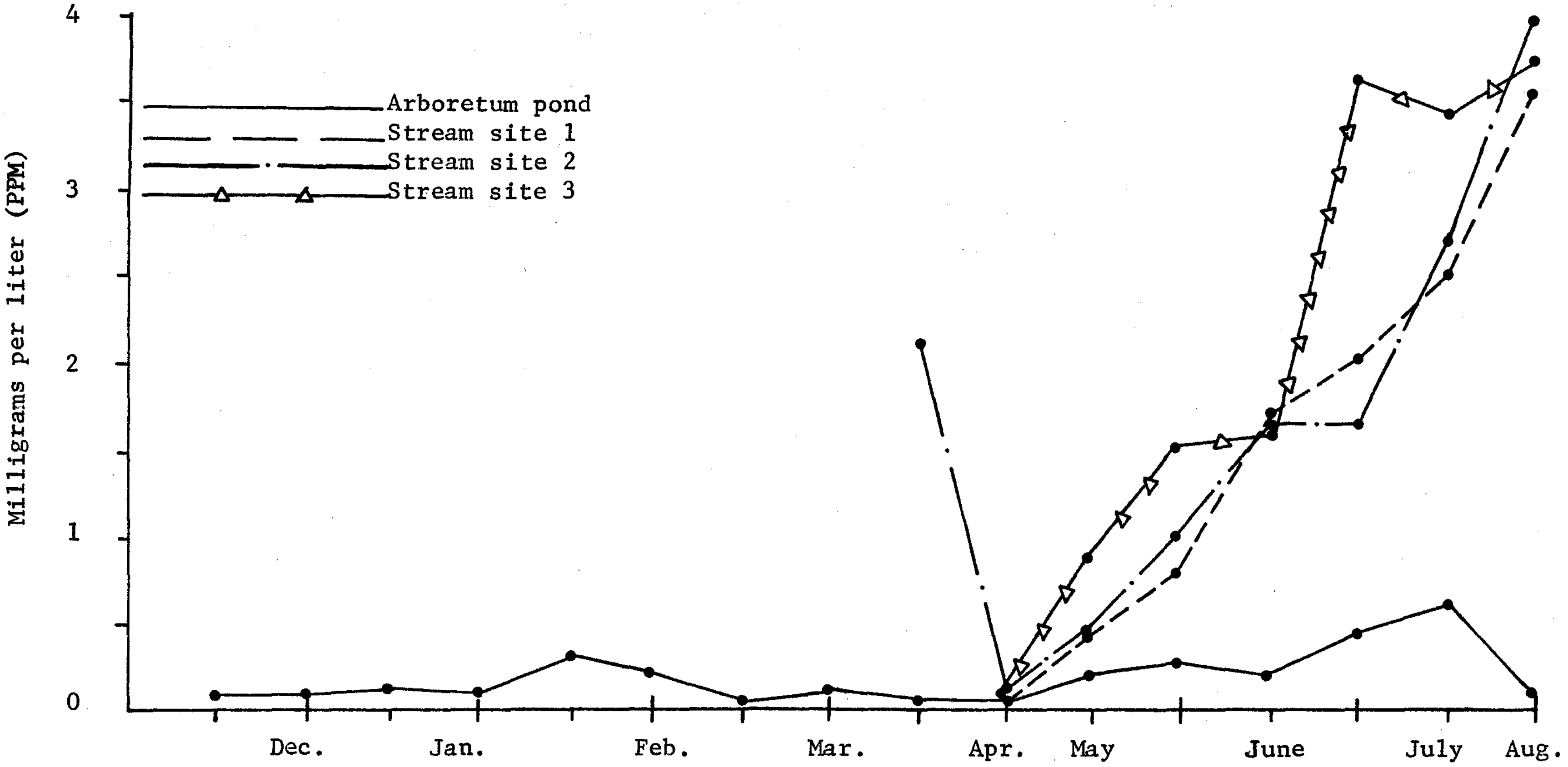

Fig. 17.--Nitrate data for the B.Y.U. arboretum pond and stream, 1971-1972.

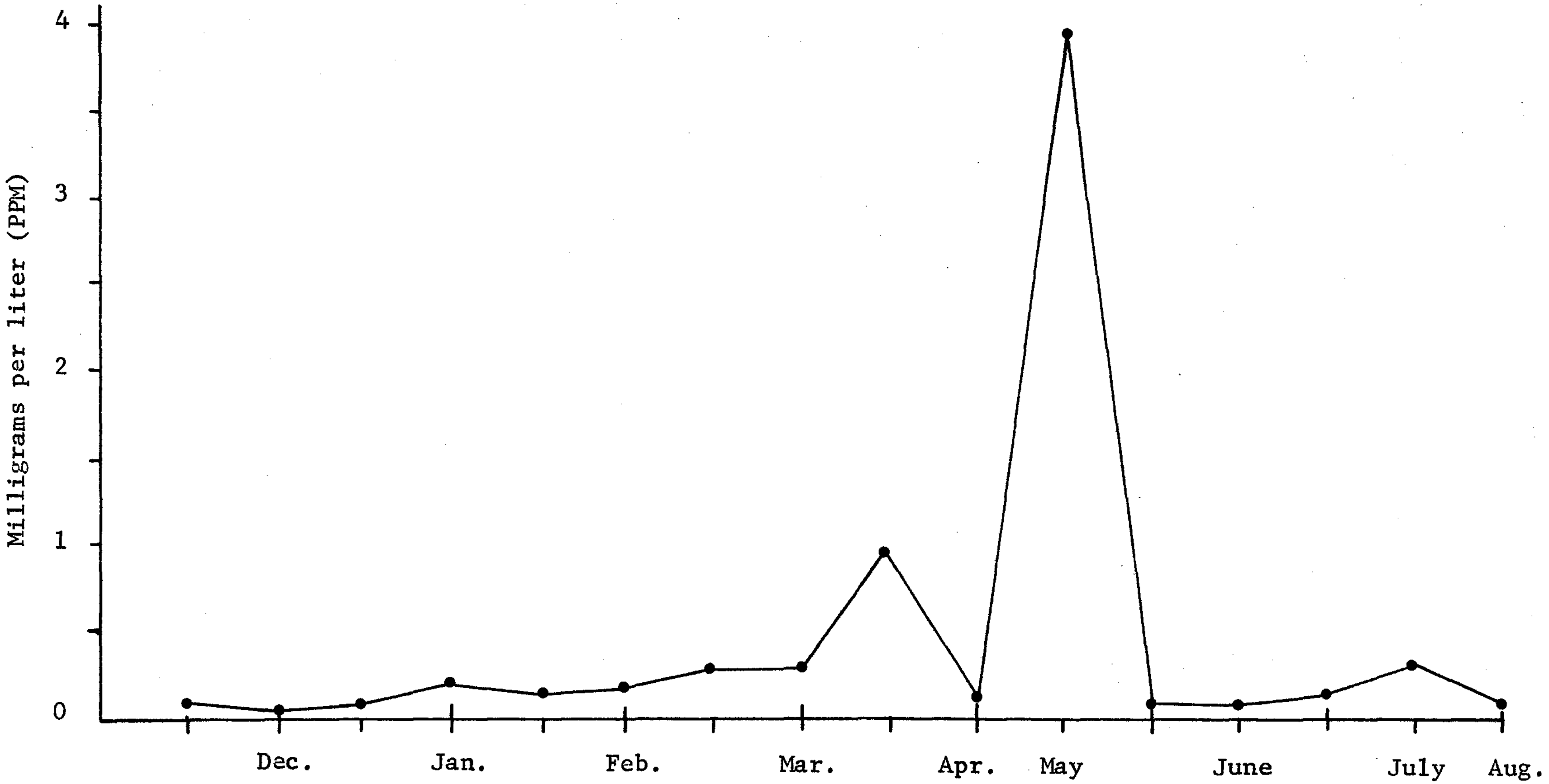

Fig. 18.--Phosphate (total) data for the B.Y.U. arboretum pond, 1971-1972.

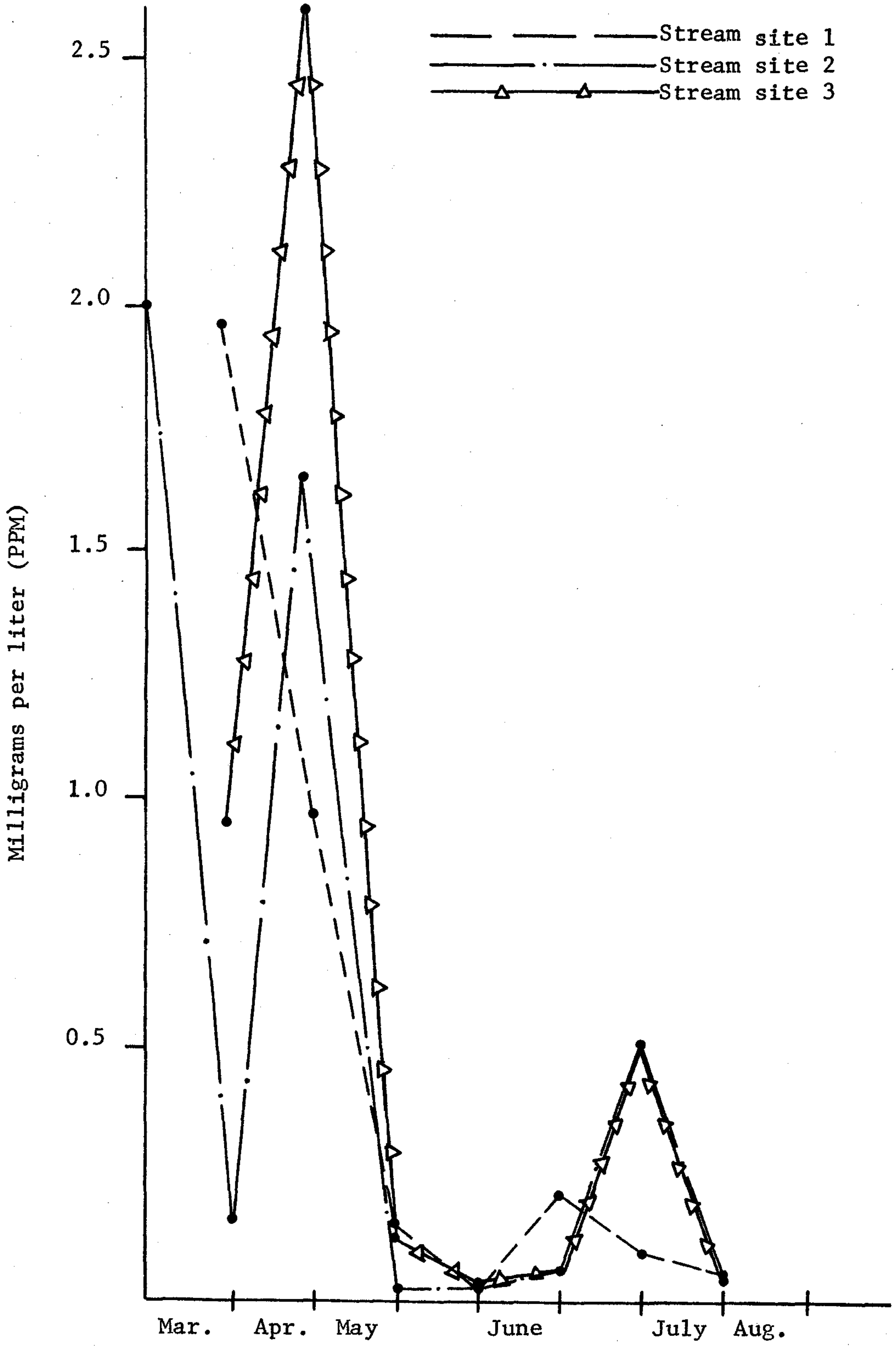

Fig. 19.--Phosphate (total) data for B.Y.U. stream, 1972.

APPENDIX II

TABLE 1.-- SEASONAL DISTRIBUTION OF DIATOMS IN THE BRIGHAM YOUNG UNIVERSITY ARBORETUM POND, 1971-1972.

Species Collected on Campus	Date								
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Melosira distans (Ehr.) Kutz.				x					
M. granulata (Ehr.) Ralfs			x	x			x	x	
M. italica (Ehr.) Kutz.		x	x	x	x	x	x	x	x
M. varians C. A. Ag.	x	x	x	x	x	x	x	x	x
Cyclotella bodanica Eulenst.			x				x		
C. meneghiniana Kutz.		x	x		x	x		x	
Stephanodiscus niagare Ehr.			x	x	x			x	
Asterionella formosa Hassall	Collected only at stream sites 1, 2 & 3.								
Hannaea arcus var. *amphioxys* (Rabh.) Patr.	Collected only at stream site 2.								
Diatoma anceps (Ehr.) Kirch.	Collected only at stream sites 1 & 2.								
D. hiemale var. *mesodon* (Ehr.) Grun.	Collected only at stream site 1.								
D. tenue var. *elongatum* Lyngb.		x							
D. vulgare Bory	Collected only at stream sites 1, 2 & 3								
Fragilaria brevistriata var. *inflata* (Pant.) Hust				x					
F. capucina var. *mesolepta* Rabh.				x	x				
F. construens var. *venter* (Ehr.) Grun.		x	x	x	x			x	x
F. crotonensis Kitton						x		x	
F. leptostauron (Ehr.) Hust.	x	x				x	x		x
F. vaucheria (Kutz.) Peters.			x					x	x
Meridion circulare var. *constrictum* (Ralf.) v. Heur.	Collected only at stream sites 2 & 3.								
Synedra acus Kutz.			x			x			
S. capitata Ehr.			x	x	x	x	x	x	x
S. fasciculata (Ag.) Kutz.			x	x		x	x		x
S. parasitica (W. Sm.) Hust.			x	x		x	x		x
S. parasitica var. *subconstricta* (Grun.) Hust.	x	x	x	x	x	x	x	x	x

TABLE 1.--*Continued*.

Species Collected on Campus	Date								
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Synedra rumpens Kutz.			x					x	x
S. ulna var. *subaequalis* (Grun.) v. Heur.	x	x	x	x	x	x	x		
S. ulna var. *constricta* Østr.	Collected only at stream site 2.								
S. ulna var. *ramesi* (Hérib) Hust.	Collected only at stream site 1.								
S. ulna var. *ulna* (Nitz.) Ehr.	x	x	x	x	x	x	x	x	x
Eunotia curvata (Kutz.) Lagerst			x	x			x		
Achnanthes lanceolata (Breb.) Grun.	x	x	x	x	x		x	x	x
A. lanceolata var. *dubia* Grun.		x	x						
A. minutissima Kutz.			x	x			x		x
Cocconeis pediculus Ehr.	x	x	x	x	x	x	x	x	x
C. placentula var. *euglypta* (Ehr.) Cl.				x		x	x		
C. placentula var. *lineata* (Ehr.) v. Heur.	x	x	x	x	x	x	x	x	x
Rhoicosphenia curvata (Kutz.) Grun. ex Rabh.	x		x	x	x	x			x
Anomoeoneis sphaerophora (Kutz.) Pfitz.			x	x	x	x	x	x	x
Caloneis ventricosa (Ehr.) Meist.			x		x				
Diploneis oblongella (Naeg. ex Kutz.) Ross			x						
Frustulia vulgaris (Thwaites) DeT.			x			x			
Gyrosigma spencerii (Quek.) Griff. & Henfr.	Collected only at stream sites 1, 2 & 3.								
Navicula capitata Ehr.	Collected only at stream site 3.								
N. cryptocephala Kutz.	Collected only at stream sites 1, 2 & 3.								
N. cryptocephala var. *veneta* (Kutz.) Rabh.			x						
N. cuspidata (Kutz.) Kutz.	x	x	x	x	x		x	x	
N. elginensis (Greg.) Ralfs			x				x	x	x
N. laevissima Kutz.	Collected only at stream site 2.								
N. lanceolata (Ag.) Kutz.						x	x	x	
N. mutica Kutz.	Collected only at stream site 2.								

TABLE 1.--Continued.

Species Collected on Campus	Date								
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Navicula oblonga (Kutz.) Kutz.			x	x	x				x
N. odiosa Wallace			x						
N. placentula var. rostrata A. Mayer			x		x		x		
N. pupula Kutz.		x	x	x				x	x
N. pygmaea Kutz.					x	x			
N. rhynchocephala Kutz.	Collected only at stream sites 2 & 3.								
N. tripunctata (O. F. Mull.) Bory				x					
Neidium affine (Ehr.) Pfitz.	Collected only at stream site 2.								
N. binode (Ehr.) Hust.	Collected only at stream site 3.								
N. iridis (Ehr.) Cl.			x	x	x		x	x	
Pinnularia brebissonii (Kutz.) Rabh.						x	x		
P. gentilis (Donk.) Cl.	Collected only in greenhouse soil.								
P. viridis (Kutz.) Ehr.		x	x	x	x		x	x	
Stauroneis smithii Grun.			x		x				
Gomphonema acuminatum Ehr.			x	x	x			x	
G. acuminatum var. coronatum (Ehr.) W. Sm.	Collected only at stream site 2.								
G. angustata var. sarcophagus (Greg.) Grun.	Collected only at stream site 2.								
G. constrictum Ehr.		x	x	x	x	x	x	x	x
G. intricatum Kutz.			x						
G. olivaceum (Lyngbye) Kutz.					x				
G. olivaceum var. calcarea Cl.									x
G. parvulum (Kutz.) Grun.							x		
G. parvulum var. micropus (Kutz.) Cl.							x		
Amphora normani Rabh.			x	x	x	x	x	x	
A. ovalis Kutz.	x	x	x	x	x	x	x		x
Cymbella affinis Kutz.			x	x					x

TABLE 1.--*Continued*.

Species Collected on Campus	Date								
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Cymbella aspera (Ehr.) Cl.	x		x		x			x	
C. cistula (Hemprich) Grun.	x	x	x	x	x	x	x	x	x
C. ehrenbergii Kutz.				x	x		x		
C. heteropleura (Ehr.) Kutz.			x						
C. Mexicana (Ehr.) A. Schmidt.	x	x	x	x		x	x		
C. prostrata (Berk.) Cl.							x		
C. tumida (Berb.) v. Heur.	x								
C. tumidula Grun.				x					
C. turgida Greg.			x	x	x		x		
C. ventricosa Kutz.			x				x	x	
Epithemia sorex Kutz.			x	x	x	x	x	x	x
E. turgida (Ehr.) Kutz.			x	x	x		x	x	x
E. turgida var. *granulata* (Ehr.) Grun.			x				x		x
Rhopalodia gibba (Ehr.) O. Mull.			x	x	x		x		
Hantzschia amphioxys (Ehr.) Grun.			x	x					
H. amphioxys var. *capitata* Mull.	Collected only in greenhouse soil.								
Nitzschia amphibia Grun.				x			x	x	x
N. dissipata (Kutz.) Grun.	x								
N. fonticola Grun.						x			
N. hungarica Grun.						x			
N. linearis W. Sm.	x		x	x		x	x	x	x
N. palea (Kutz.) W. Sm.	x	x	x	x		x	x	x	x
N. sigma (Kutz.) W. Sm.		x	x	x					
N. sigmoidea (Ehr.) W. Sm.	x	x	x	x	x	x		x	x
N. tryblionella Hantz.			x	x	x	x	x	x	x
Cymatopleura solea (Breb.) W. Sm.	x	x	x	x	x	x	x	x	x

TABLE 1.--*Continued*.

Species Collected on Campus	Date								
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Surirella ovalis Breb.			x		x				
S. ovata var. *pinnata* W. Sm.	Collected only at stream sites 2 & 3.								
S. robusta Ehr.			x	x	x		x	x	

TABLE 2.--SEASONAL DISTRIBUTION OF DIATOMS IN THE BRIGHAM YOUNG UNIVERSITY STREAM SITE TWO, 1971-1972.

Species Collected on Campus	Date							
	Dec.	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Melosira distans (Ehr.) Kutz.	Collected only in arboretum pond.							
M. granulata (Ehr.) Ralfs	x			x	x	x		
M. italica (Ehr.) Kutz.			x	x				
M. varians C. A. Ag.	x	x	x	x	x	x	x	x
Cyclotella bodanica Eulenst.					x	x	x	x
C. meneghiniana Kutz.				x		x		
Stephanodiscus niagare Ehr.	x	x	x	x	x	x	x	x
Asterionella formosa Hassall				x				
Hannaea arcus var. *amphioxys* (Rabh.) Patr.	x							
Diatoma anceps (Ehr.) Kirch.	x	x						
D. hiemale var. *mesodon* (Ehr.) Grun.	Collected only at stream site 1.							
D. tenue var. *elongatum* Lyngb.				x	x			
D. vulgare Bory	x	x		x	x	x	x	x
Fragilaria brevistriata var. *inflata* (Pant.) Hust.	Collected only in arboretum pond.							
F. capucina var. *mesolepta* Rabh.				x				
F. construens var. *venter* (Ehr.) Grun.			x			x		
F. crotonensis Kitton				x	x		x	x
F. leptostauron (Ehr.) Hust.		x				x		
F. vaucheria (Kutz.) Peters.		x	x	x		x		
Meridion circulare var. *constrictum* (Ralf.) v. Heur.	x							
Synedra acus Kutz.	Collected only in arboretum pond & stream sites 1,3.							
S. capitata Ehr.	Collected only in arboretum pond.							
S. fasciculata (Ag.) Kutz.	x							
S. parasitica (W. Sm.) Hust.				x				
S. parasitica var. *subconstricta* (Grun.) Hust.	x	x	x			x		x

TABLE 2.--*Continued*.

Species Collected on Campus	Date							
	Dec.	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Synedra rumpens Kutz.	x		x					
S. ulna var. *subaequalis* (Grun.) v. Heur.	x	x						
S. ulna var. *constricta* Østr.	x							
S. ulna var. *ramesi* (Hérib) Hust.	Collected only in arboretum pond.							
S. ulna var. *ulna* (Kutz.) Ehr.	x	x	x	x	x	x		x
Eunotia curvata (Kutz.) Lagerst	Collected only in arboretum pond.							
Achnanthes lanceolata (Breb.) Grun.	x	x	x		x	x	x	
A. lanceolata var. *dubia* Grun.	x	x	x			x		
A. minutissima Kutz.	x	x				x	x	x
Cocconeis pediculus Ehr.	x	x	x	x	x	x	x	x
C. placentula var. *euglypta* (Ehr.) Cl.	x	x			x	x	x	x
C. placentula var. *lineata* (Ehr.) v. Heur.	x	x		x		x	x	x
Rhoicosphenia curvata (Kutz.) Grun. ex Rabh.	x	x	x	x			x	x
Anomoeoneis sphaerophora (Kutz.) Pfitz.			x					
Caloneis ventricosa (Ehr.) Meist.	Collected only in arboretum pond.							
Diploneis oblongella (Naeg. ex Kutz.) Ross	Collected only in arboretum pond and greenhouse soil.							
Frustulia vulgaris (Thwaites) DeT.				x				
Gyrosigma spencerii (Quek.) Griff. & Henfr.	x							
Navicula capitata Ehr.	Collected only at stream site 3.							
N. cryptocephala Kutz.				x		x	x	x
N. cryptocephala var. *veneta* (Kutz.) Rabh.	x							
N. cuspidata (Kutz.) Kutz.	Collected only in arboretum pond.							
N. elginensis (Greg.) Ralfs			x					
N. laevissima Kutz.				x				
N. lanceolata (Ag.) Kutz.	x	x				x	x	x
N. mutica Kutz.		x						

TABLE 2.--*Continued*.

Species Collected on Campus	Date							
	Dec.	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Navicula oblonga (Kutz.) Kutz.	Collected only in arboretum pond.							
N. odiosa Wallace	Collected only in arboretum pond.							
N. placentula var. *rostrata* A. Mayer	Collected only in arboretum pond.							
N. pupula Kutz.	Collected only in arboretum pond.							
N. pygmaea Kutz.	Collected only in arboretum pond.							
N. rhynchocephala Kutz.							x	
N. tripunctata (O. F. Mull.) Bory	x	x			x	x	x	x
Neidium affine (Ehr.) Pfitz.	x							
N. binode (Ehr.) Hust.	Collected only at stream site 3.							
N. iridis (Ehr.) Cl.	Collected only in arboretum pond.							
Pinnularia brebissonii (kutz.) Rabh.	x			x				
P. gentilis (Donk.) C.	Collected only in greenhouse soil.							
P. viridis (Kutz.) Ehr.				x				
Stauroneis smithii Grun.	x	x						
Gomphonema acuminatum Ehr.	Collected only in arboretum pond.							
G. acuminatum var. *coronatum* (Ehr.) W. Sm.	x							
G. angustata var. *sarcophagus* (Greg.) Grun.		x					x	
G. constrictum Ehr.	x			x				
G. intricatum Kutz.				x				
G. olivaceum (Lyngb.) Kutz.		x	x	x		x	x	x
G. olivaceum var. *calcarea* Cl.		x						
G. parvulum (Kutz.) Grun.	x	x		x	x		x	
G. parvulum var. *micropus* (Kutz.) Cl.	Collected only in arboretum pond and stream site 1.							
Amphora normani Rabh.		x	x					
A. ovalis Kutz.			x				x	
Cymbella affinis Kutz.					x		x	

TABLE 2.--*Continued*.

Species Collected on Campus	Date							
	Dec.	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Cymbella aspera (Ehr.) Cl.			x					
C. cistula (Hemprich) Grun.		x						
C. ehrenbergii Kutz.	Collected only in arboretum pond.							
C. heteropleura (Ehr.) Kutz.	Collected only in arboretum pond.							
C. mexicana (Ehr.) A. Schmidt.	Collected only in arboretum pond.							
C. prostrata (Berk.) Cl.	Collected only in arboretum pond & stream site 1.							
C. tumida (Berb.) v. Heur	Collected only in arboretum pond.							
C. tumidula Grun.	Collected only in arboretum pond.							
C. turgida Greg.	Collected only in arboretum pond & stream site 2							
C. ventricosa Kutz.	x	x	x		x	x	x	x
Epithemia sorex Kutz.			x					
E. turgida (Ehr.) Kutz.	Collected only in arboretum pond							
E. turgida var. *granulata* (Ehr.) Grun.	Collected only in arboretum pond.							
Rhopalodia gibba (Ehr.) O. Mull.	Collected only in arboretum pond & stream site 3.							
Hantzschia amphioxys (Ehr.) Grun.						x		
H. amphioxys var. *capitata* Mull.	Collected only in greenhouse soil.							
Nitzschia amphibia Grun.	Collected only in arboretum pond & greenhouse soil.							
N. dissipata (Kutz.) Grun.						x	x	
N. fonticola Grun.	x		x				x	
N. hungarica Grun.	Collected only in arboretum pond.							
N. linearis W. Sm.	x	x		x	x		x	x
N. palea (Kutz.) W. Sm.	x		x	x	x		x	
N. sigma (Kutz.) W. Sm.	Collected only in arboretum pond.							
N. sigmoidea (Ehr.) W. Sm.	x	x	x	x	x	x	x	x
N. tryblionella Hantz.	Collected only in arboretum pond.							
Cymatopleura solea (Breb.) W. Sm.			x	x		x		

TABLE 2.--*Continued*.

Species Collected on Campus	Date							
	Dec.	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Surirella angustata Kutz.	x	x		x	x	x		
S. ovalis Breb.	x	x	x	x	x	x	x	x
S. ovata var. *pinnata* W. Sm.	x							
S. robusta Ehr.	Collected only in arboretum pond & stream site 1							

TABLE 3.--SEASONAL DISTRIBUTION OF DIATOMS IN THE BRIGHAM YOUNG UNIVERSITY STREAM SITES ONE AND THREE, 1972.

Species Collected on Campus	Site 1					Site 3				
	Apr.	May	Jun.	Jul.	Aug.	Apr.	May	Jun.	Jul.	Aug.
Melosira distans (Ehr.) Kutz.	Not collected here.					Not collected here.				
M. granulata (Ehr.) Ralfs			x	x		x	x	x		
M. italica (Ehr.) Kutz.				x		x		x		
M. varians C. A. Ag.	x	x	x	x	x	x	x	x	x	x
Cyclotella bodanica Eulenst.			x			x				
C. meneghiniana Kutz.			x			Not collected here.				
Stephanodiscus niagare Ehr.	x	x	x	x	x	x	x	x	x	
Asterionella formosa Hassall				x		x	x	x		
Hannaea arcus var. *amphioxys* (Rabh.) Patr.	Not collected here.					Not collected here.				
Diatoma anceps (Ehr.) Kirch.					x	Not collected here.				
D. hiemale var. *mesodon* (Ehr.) Grun.			x			Not collected here.				
D. tenue var. *elongatum* Lyngb.		x				x	x			
D. vulgare Bory	x	x	x	x	x	x	x	x	x	x
Fragilaria brevistiana var. *inflata* (Pant.) Hust.	Not collected here.					Not collected here.				
F. capucina var. *mesolepta* Rabh.	Not collected here.					Not collected here.				
F. construens var. *venter* (Ehr.) Grun.	Not collected here.					Not collected here.				
F. crotonensis Kitton		x				x	x	x	x	x
F. leptostauron (Ehr.) Hust.			x				x	x		
F. vaucheria (Kutz.) Peters.		x	x	x			x	x		x
Meridion circulare var. *constrictum* (Ralf.) v. Heur.	Not collected here.								x	
Synedra acus Kutz.				x					x	
S. capitata Ehr.	Not collected here.					Not collected here.				
S. fasciculata (Ag.) Kutz.	Not collected here.					Not collected here.				
S. parasitica (W. Sm.) Hust.	Not collected here.					Not collected here.				
S. parasitica var. *subconstricta* (Grun.) Hust.	Not collected here.					x				

TABLE 3.--*Continued*.

Species Collected on Campus	Site 1					Site 3				
	Apr.	May	Jun.	Jul.	Aug.	Apr.	May	Jun.	Jul.	Aug.
Synedra rumpens Kutz.	Not collected here.					Not collected here.				
S. ulna var. *subaequalis* (Grun.) v. Heur.		x				Not collected here.				
S. ulna var. *constricta* Østr.	Not collected here.					Not collected here.				
S. ulna var. *ramesi* (Hérib) Hust.		x				Not collected here.				
S. ulna var. *ulna* (Kutz.) Ehr.		x	x	x		x	x	x		x
Eurotia curvata (Kutz.) Lagerst	Not collected here.					Not collected here.				
Achnanthes lanceolata (Breb.) Grun.			x		x		x	x	x	x
A. lanceolata var. *dubia* Grun.	Not collected here.					x				
A. minutissima Kutz.					x	x	x	x	x	x
Cocconeis pediculus Ehr.	x	x	x	x	x	x	x	x	x	x
C. placentula var. *euglypta* (Ehr.) Cl.		x	x		x	x	x	x	x	x
C. placentula var. *lineata* (Ehr.) v. Heur.			x	x	x	x	x			
Rhoicosphenia curvata (Kutz.) Grun. ex Rabh.	x		x	x	x	x	x	x	x	x
Anomoeoneis sphaerophora (Kutz.) Pfitz.	Not collected here.					Not collected here.				
Caloneis ventricosa (Ehr.) Meist.	Not collected here.					Not collected here.				
Diploneis oblongella (Naeg. ex Kutz.) Ross	Not collected here.					Not collected here.				
Frustulia vulgaris (Thwaites) DeT.	Not collected here.					Not collected here.				
Gyrosigma spencerii (Quek.) Griff. & Henfr.	x	x	x		x	x	x	x	x	
Navicula capitata Ehr.	Not collected here.							x		
N. cryptocephala Kutz.			x	x	x	x	x		x	x
N. cryptocephala var. *veneta* (Kutz.) Rabh.					x	x				
N. cuspidata (Kutz.) Kutz.	Not collecteddhere.					Not collected here.				
N. elginensis (Greg.) Ralfs	x					Not collected here.				
N. laevissima Kutz.	Not collected here.					Not collected here.				
N. lanceolata (Ag.) Kutz.		x	x	x	x	x	x	x	x	x
N. mutica Kutz.	Not collected here.					Not collected here.				

TABLE 3.--Continued.

Species Collected on Campus	Site 1					Site 3				
	Apr.	May	Jun.	Jul.	Aug.	Apr.	May	Jun.	Jul.	Aug.
Navicula oblonga (Kutz.) Kutz.	Not collected here.					Not collected here.				
N. odiosa Wallace	Not collected here.					Not collected here.				
N. placentula var. rostrata A. Mayer	Not collected here.					Not collected here				
N. pupula Kutz.	Not collected here.					Not collected here.				
N. pygmaea Kutz.	Not collected here.					Not collected here.				
N. rhynchocephala Kutz.	Not collected here.							x		
N. tripunctata (O. F. Mull.) Bory	x	x		x	x	x	x	x	x	x
Neidium affine (Ehr.) Pfitz.	Not collected here.					Not collected here.				
N. binode (Ehr.) Hust.	Not collected here.					x		x		x
N. iridis (Ehr.) Cl.	Not collected here.					Not collected here.				
Pinnularia brebissonii(Kutz.) Rabh.	Not collected here.					Not collected here.				
P. gentilis (Donk.) Cl.	Not collected here.					Not collected here.				
P. viridis (Kutz.) Ehr.	Not collected here.					Not collected here.				
Stauroneis smithii Grun.				x		x	x	x		
Gomphonema acuminatum Ehr.	Not collected here.					Not collected here.				
G. acuminatum var. coronatum (Ehr.) W. Sm.	Not collected here.					Not collected here.				
G. angustata var. sarcophagus (Greg.) Grun.	Not collected here.					Not collected here				
G. constrictum Ehr.	Not collected here.					Not collected here.				
G. intricatum Kutz.	Not collected here.					Not collected here				
G. olivaceum (Lyngb.) Kutz.	x	x	x	x	x	x	x	x		x
G. olivaceum var. calcarea Cl.	Not collected here.						x			
G. parvulum (Kutz.) Grun.	x					x				
G. parvulum var. micropus (Kutz.) Cl.					x	Not collected here				
Amphora normani Rabh.	Not collected here.									x
A. ovalis Kutz.					x	x	x			
Cymbella affinis Kutz.	Not collected here.						x			

TABLE 3.--Continued.

Species Collected on Campus	Site 1					Site 3				
	Apr.	May	Jun.	Jul.	Aug.	Apr.	May	Jun.	Jul.	Aug.
Cymbella aspera (Ehr.) Cl.	Not collected here.					Not collected here.				
C. cistula (Hemprich) Grun.	Not collected here.					Not collected here.				
C. ehrenbergii Kutz.	Not collected here.					Not collected here.				
C. heteropleura (Ehr.) Kutz.	Not collected here.					Not collected here.				
C. mexicana (Ehr.) A. Schmidt.	Not collected here.					Not collected here.				
C. prostrata (Berk.) Cl.					x	Not collected here.				
C. tumida (Berb.) v. Heur.	Not collected here.					Not collected here.				
C. tumidula Grun.	Not collected here.					Not collected here.				
C. turgida Greg.	Not collected here.						x			
C. ventricosa Kutz.		x	x	x	x	x	x	x	x	
Epithemia sorex Kutz.	Not collected here.							x		
E. turgida (Ehr.) Kutz.	Not collected here.					Not collected here.				
E. turgida var. granulata (Ehr.) Grun.	Not collected here.					Not collected here.				
Rhopalodia gibba (Ehr.) O. Mull.	Not collected here.						x			
Hantzschia amphioxys (Ehr.) Grun.			x	x			x			
H. amphioxys var. capitata Mull.	Not collected here.					Not collected here				
Nitzschia amphibia Grun.	Not collected here.					Not collected here				
N. dissipata (Kutz.) Grun.			x	x		x	x	x	x	
N. fonticola Grun.			x		x		x			
N. hungarica Grun.	Not collected here.					Not collected here				
N. linearis W. Sm.		x				x	x	x	x	
N. palea (Kutz.) W. Sm.	x	x		x		x	x	x	x	
N. sigma (Kutz.) W. Sm.	Not collected here.					Not collected here				
N. sigmoidea (Ehr.) W. Sm.	x	x		x	x	x	x	x	x	x
N. tryblionella Hantz.	Not collected here.					Not collected here.				
Cymatopleura solea (Breb.) W. Sm.	x		x	x		x	x	x	x	

TABLE 3.--Continued.

Species Collected on Campus	Site 1					Site 3				
	Apr.	May	Jun.	Jul.	Aug.	Apr.	May	Jun.	Jul.	Aug.
Surirella angustata Kutz.	x	x	x	x		x		x		
S. ovalis Breb.	x	x	x			x	x	x	x	x
S. ovata var. pinnata W. Sm.	Not collected here.								x	
S. robusta Ehr.			x			Not collected here				

TABLE 4.--DIATOMS OCCURRING IN THE SOIL IN THE BRIGHAM YOUNG UNIVERSITY GREENHOUSE, 1972.

Species	Date					
	Jan.	Feb.	May	Jun.	Jul.	Aug.
Melosira varians C. A. Ag.	R					R
Fragilaria leptostauron (Ehr.) Hust.			R		R	
F. varesces Ralfs						R
Synedra parasitica (W. Sm.) Hust.						R
S. rumpens Kutz.			R			
Achnanthes lanceolata (Breb.) Grun.	C		A	C		R
A. minutissima Kutz.				R	R	R
Cocconeis pediculus Ehr.					R	
C. placentula var. *euglypta* (Ehr.) Cl.						R
C. placentula var. *lineata* (Ehr.) v. Heur.			R	R		R
Rhoicosphenia curvata (Kutz.) Grun. ex Rabh.					R	
Diploneis oblongella (Naeg. ex Kutz.) Ross			R	C		
Navicula elginensis (Greg.) Ralfs						R
N. lanceolata (Ag.) Kutz.	R		R			
N. mutica Kutz.		R				
N. tripunctata (O. F. Mull.) Bory			R	C	C	R
Pinnularia brebissonii (Kutz.) Rabh.					R	
P. gentilis (Donk.) Cl.						R
Gomphonema intricatum Kutz.						R
G. parvulum (Kutz.) Grun.	R		R	R	R	
Amphora normani Rabh.	A	C	A	C	R	C
A. ovalis Kutz.			R			
Cymbella affinis Kutz.		R				
C. cistula (Hemprich) Grun.			R			
Hantzschia amphioxys (Ehr.) Grun.	A	C	A		C	C

TABLE 4.--*Continued*.

Species	Date					
	Jan.	Feb.	May	Jun.	Jul.	Aug.
Hantzschia amphioxys var. *capitata* Mull.		R		C	C	
Nitzschia amphibia Grun.				R		
N. dissipata (Kutz.) Grun.		R		R	R	R
N. fonticola Grun.		R	R	R		
N. linearis W. Sm.			R			
N. palea (Kutz.) W. Sm.	C	C	C	C		C
Cymatopleura solea (Breb.) W. Sm.					R	
Surirella angustata Kutz.			R			

Key: Abundant - A, Common - C, Rare - R

APPENDIX III

ALGAE COLLECTED FROM BRIGHAM YOUNG UNIVERSITY CAMPUS
OCTOBER 1971 - AUGUST 1972

I. Division Chlorophyta

A. Class Chlorophyceae
1. Order Chlorococcales
a) Family Chlorococcaceae
Characium ambigiuum Hermann
Chlorococcum humicola (Naeg.) Rabenhorst
b) Family Palmellaceae
Palmella mucosa Kutzing
Sphaerocystis schroeteri Chodat
c) Family Oocystaceae
Chlorella vulgaris Beyerinck
d) Family Scenedesmaceae
Scenedesmus denticulatus Lagerheim
S. quadricauda var. *quadrispina* (Chod.) G. M. Smith
e) Family Hydrodictyaceae
Pediastrum boryanum (Turp.) Meneghini
P. tetras (Ehreb.) Ralfs
2. Order Ulotrichales
a) Family Protococcaceae
Protococcus viridis C. A. Agardh
b) Family Ulotrichaceae
Stichococcus bacillaris Naegeli
S. scopulinus Hazen
S. subtilis (Kutz.) Klercker
Ulothrix zonata (Weber & Mohr) Kutzing
3. Order Chaetophorales
a) Family Aphanochaetaceae
Aphanochaete repens A. Braun
b) Family Chaetophoraceae
Chaetophora incrassata (Huds.) Hazen
Stigeoclonium lubricum (Dillw.) Kutzing
4. Order Oedogoniales
a) Family Oedogoniaceae
Oedogonium sp.
5. Order Cladophorales
a) Family Cladophoraceae
Cladophora glomerata (L.) Kutzing
6. Order Zygnematales
a) Family Zygnemataceae
Mougeotia genuflexa (Dillw.) C. A. Agardh
Spirogyra dubia Kutzing
S. jugalis (Fl. Dan.) Kutzing

S. neglecta (Hass.) Kutzing
S. porticalis (Muell.) Cleve
Zygnema insigne (Hass.) Kutzing
b) Family Desmidiaceae
Closterium lanceolatum Kutzing
C. moniliferum (Bory) Ehrenberg
Cosmarium botrytis Meneghini
C. perforatum Lund.
Penium navicula Breb.

II. Division Euglenophyta

A. Class Euglenophyceae
1. Order Euglenales
a) Family Euglenaceae
Euglena acus Ehrenberg
Phacus acuminata Stokes

III. Division Chrysophyta

A. Class Xanthophyceae
1. Order Vaucheriales
a) Family Vaucheriaceae
Vaucheria geminata (Vaucher) DeCandolle
V. sessilis (Vaucher) DeCandolle

B. Class Bacillariophyceae
1. Order Centrales
a) Family Coscinodiscaceae
Melosira distans (Ehr.) Kutz.
M. granulata (Ehr.) Ralfs
M. italica (Ehr.) Kutz.
M. varians C. A. Ag.
Cyclotella bodanica Eulenst.
C. meneghiniana Kutz.
Stephanodiscus niagare Ehr.
2. Order Pennales
a) Family Frgailariaceae
Asterionella formosa Hassall
Hannaea arcus var. amphioxys (Rabh.) Patr.
Diatoma anceps (Ehr.) Kirch.
D. hiemale var. mesodon (Ehr.) Grun.
D. tenue var. elongatum Lyngb.
D. vulgare Bory
Fragilaria brevistriata var. inflata (Pant.) Hust.
F. capucina var. mesolepta Rabh.
F. construens var. venter (Ehr.) Grun.
F. crotonensis Kitton
F. leptostauron (Ehr.) Hust.
F. vaucheria (Kutz.) Peters.
Meridion circulare var. constrictum (Ralf.) v Heur.

Synedra acus Kutz.
S. capitata Ehr.
S. fasciculata (Ag.) Kutz.
S. parasitica (W. Sm.) Hust.
S. parasitica var. subconstricta (Grun.) Hust.
S. rumpens Kutz.
S. ulna var. subaequalis (Grun.) v. Heur.
S. ulna var. constracta Østr.
S. ulna var. ramesi (Hérib) Hust.
S. ulna var. ulna (Nitz.) Ehr.

b) Family Eunotiaceae
Eunotia curvata (Kutz.) Lagerst

c) Family Achnanthaceae
Achnanthes lanceolata var. dubia Grun.
A. lanceolata var. lanceolata (Breb.) Grun.
A. minutissima Kutz.
Cocconeis pediculus Ehr.
C. placentula var. euglypta (Ehr.) Cl.
C. placentula var. lineata (Ehr.) v. Heur.
Rhoicosphenia curvata (Kutz.) Grun. ex Rabh.

d) Family Naviculaceae
Anomoeoneis sphaerophora (Kutz.) Pfitz.
Caloneis ventricosa (Ehr.) Meist.
Diploneis oblongella (Naeg. ex Kutz.) Ross
Frustulia vulgaris (Thwaites) DeT.
Gyrosigma spencerii (Quek.) Griff. & Henfr.
Navicula capitata Ehr.
N. cryptocephala Kutz.
N. cryptocephala var. veneta (Kutz.) Rabh.
N. cuspidata (Kutz.) Kutz.
N. elginensis (Greg.) Ralfs
N. laevissima Kutz.
N. lanceolata (Ag.) Kutz.
N. mutica Kutz.
N. oblonga (Kutz.) Kutz.
N. odiosa Wallace
N. plancentula var. rostrate A. Mayer
N. pupula Kutz.
N. pygmaea Kutz.
N. rhynchocephala Kutz.
N. tripunctata (O. F. Mull.) Bory
Neidium affine (Ehr.) Pfitz.
N. binode (Ehr.) Hust.
N. iridis (Ehr.) Cl.
Pinnularia brebissonii (Kutz.) Rabh.
P. gentilis (Donk.) Cl.
P. viridis (Kutz.) Ehr.
Stauroneis smithii Grun.

e) Family Gomphonemaceae
Gomphonema acuminatum Ehr.
G. acuminatum var. coronatum (Ehr.) W. Sm.

_G_. _angustata_ var. _sarcophagus_ (Greg.) Grun.
_G_. _constrictum_ Ehr.
_G_. _intricatum_ Kutz.
_G_. _olivaceum_ (Lyngbye) Kutz.
_G_. _olivaceum_ var. _calcarea_ Cl.
_G_. _parvulum_ (Kutz.) Grun.
_G_. _parvulum_ var. _micropus_ (Kutz.) Cl.

f) Family Cymbellaceae
Amphora _ovalis_ Kutz.
_A_. _normani_ Rabh.
Cymbella _affinis_ Kutz.
_C_. _aspera_ (Ehr.) Cl.
_C_. _cistula_ (Hemprich) Grun.
_C_. _ehrenbergii_ Kutz.
_C_. _heteropleura_ (Ehr.) Kutz.
_C_. _mexicana_ (Ehr.) A. Schmidt.
_C_. _prostrata_ (Berk.) Cl.
_C_. _tumida_ (Berb.) v. Heur.
_C_. _tumidula_ Grun.
_C_. _turgida_ Greg.
_C_. _ventricosa_ Kutz.

g) Family Epithemiaceae
Epithemia _sorex_ Kutz.
_E_. _turgida_ (Ehr.) Kutz.
_E_. _turgida_ var. _granulata_ (Ehr.) Grun.
Rhopalodia _gibba_ (Ehr.) O. Mull.

h) Family Nitzschiaceae
Hantzschia _amphioxys_ (Ehr.) Grun.
_H_. _amphioxys_ var. _capitata_ Mull.
Nitzschia _amphibia_ Grun.
_N_. _dissipata_ (Kutz.) Grun.
_N_. _fonticola_ Grun.
_N_. _hungarica_ Grun.
_N_. _linearis_ W. Sm.
_N_. _palea_ (Kutz.) W. Sm.
_N_. _sigma_ (Kutz.) W. Sm.
_N_. _sigmoidea_ (Ehr.) W. Sm.
_N_. _tryblionella_ Hantz.

i) Family Surirellaceae
Cymatopleura _solea_ (Breb.) W. Sm.
Surirella _angustata_ Kutz.
_S_. _ovalis_ Breb.
_S_. _ovata_ var. _pinnata_ W. Sm.
_S_. _robusta_ Ehr.

IV. Division Cyanophyta

A. Class Myxophyceae
1. Order Chroococcales
a) Family Chroococcaceae
Chroococcus _rufescens_ (Kutz.) Naegeli

2. Order Oscillatoriales
   a) Family Oscillatoriaceae
      Lyngbya aestuarii (Mertens) Liebmann
      L. martensiana Meneghini
      Oscillatoria amphibia C. A. Agardh
      O. angustissima West & West
      O. animalis C. A. Agardh
      O. cruenta Grun.
      O. limosa (Roth) C. A. Agardh
      O. princeps Vaucher
      O. sancta (Kutz.) Gomont
      O. tenuis C. A. Agardh
      Phormidium inundatum Kutzing
3. Order Nostocales
   a) Family Nostocaceae
      Anabaena variabilis Kutzing
   b) Family Scytonemataceae
      Tolypothrix penicillata (Ag.) Thur.

APPENDIX IV

ALGAL SPECIES REGISTER

A TAXONOMIC INVESTIGATION OF THE ALGAE OF THE BRIGHAM YOUNG UNIVERSITY CAMPUS, PROVO, UTAH

Cheng Mou-Sheng

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M. S. Degree, April 1973

ABSTRACT

A taxonomic investigation of the algal flora of the Brigham Young University campus was conducted from October 1971 to August 1972.

This algal flora consisted of 27 genera and 36 species of Chlorophyta, 2 genera and 2 species of Euglenophyta, 32 genera and 106 species of Bacillariophyceae (including 16 genera and 33 species of soil diatoms), 1 genus and 2 species of Chrysophyta excluding diatoms and 6 genera and 14 species of Cyanophyta. Diatoms were the predominent algae in this study. *Chlorococcum humicola*, *Vaucheria geminata*, *Amphora normani*, *Hantzschia amphioxys* and *Oscillatoria sancta* were prominent in the greenhouses. In the arboretum pond, *Melosira varians*, *Synedra ulna* var. *subaequalis* and *Cymbella cistula* were abundant in the winter whereas *Spirogyra dubia*, *Spirogyra jugalis* and *Spirogyra porticalis* grew throughout the year, especially in the late spring. *Diatoma tenue* var. *elongatum*, *Diatoma vulgare*, *Cocconeis pediculus* and *Gomphonema parvulum* were prominent stream algae in the early summer. *Cladophora glomerata* grew in large numbers at stream site two in the winter.