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THE PHYTOPLANKTON COMMUNITIES
OF NINE LAKES, WAIKATO, NEW ZEALAND:
A COMPARATIVE STUDY OF FLORISTICS,
SEASONAL DYNAMICS AND THE INFLUENCE
OF HERBIVORY

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VOLUME III

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Coscinodiscaceae

*Aulacosira distans*23. *A. granulata* 308*A. g. var. angustissima**Cyclotella meneghiniana**C. stelligera*

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Diatomaceae

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Euglenaceae

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LIST OF ABBREVIATIONS

AODC	acridine orange direct count
C.V.	coefficient of variation
DHM	dissolved humic material
GALD	greatest axial linear dimension
I.D.	internal diameter
ISI	important species index
LC	limnocorral
n	sample size
ns	not significant
pu	plankton unit
r	value of the correlation coefficient
SD	standard deviation
SE	standard error
SGALD	second greatest axial linear dimension
SK	skewness statistic
yr BP	years before present
#	tentative identification due to lack of electron microscopical observations

APPENDIX I

A TAXONOMIC GUIDE TO THE NEW ZEALAND FRESHWATER PLANKTONIC

BLUE-GREENS (CYANOPHYTA/CYANOBACTERIA)

Etheredge & Pridmore (in press)

**The freshwater planktonic
Blue – Greens
(Cyanophyta / Cyanobacteria)
of
New Zealand
A taxonomic guide**

by

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WELLINGTON 1987

The freshwater planktonic Blue - Greens (Cyanophyta/Cyanobacteria) of New Zealand:
A taxonomic guide

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R. D. Pridmore, Water Quality Centre, MWD, Hamilton

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PREFACE

The aim of this book is to encourage further research into all facets of the biology of planktonic blue-greens (Cyanophyta/Cyanobacteria) in New Zealand lakes. Although the presence of these microscopic organisms was first recorded in New Zealand in 1888 by Nordstedt, and since that time has been confirmed in a very large number of lakes, little detail is known about their taxonomy or ecology. Generally, interest has been aroused only when lake-users have complained of discoloured water, thick scums or pungent odours. However, planktonic blue-greens can play major roles within lake ecosystems, particularly in terms of primary production and nitrogen fixation. A greater understanding of the ecology of this group demands accurate taxonomic information, and it is hoped that this book will fulfil this need.

The blue-greens date back some 3000 million years, and thus in terms of longevity must rank as one of the most successful life forms. Like the bacteria, they are prokaryotic, and thus lack membrane-bounded organelles such as nuclei, chloroplasts and mitochondria. Consequently, some microbiologists (e.g., Stanier *et al.* 1971, 1978) have rejected their traditional placement within the Plant Kingdom (Cyanophyta), and sought to classify them as bacteria (Cyanobacteria). However, there are significant differences between these two diverse groups. In particular, the blue-greens, in common with eukaryotic algae, contain chlorophyll *a*, whereas photosynthetic bacteria do not; furthermore, the latter do not produce oxygen during photosynthesis. It is important, therefore, to recognise the blue-greens as a unique group of organisms which shares affinities with both the bacteria and the algae. To classify them solely as one or the other, is equally incorrect.

Traditionally, the taxonomy of the blue-greens has been developed by phycologists working under the provisions of the International Code of Botanical Nomenclature (e.g., Geitler 1932; Desikachary 1959; Prescott 1962; Fott 1971). Under this system, emphasis is placed on the identification of field specimens, and morphological differences are employed to distinguish between taxa. Holotypes are represented preferably by herbarium specimens, but alternatively by descriptions and illustrations. Some bacteriologists, however, have attempted recently to develop a classification scheme using blue-greens grown in culture (e.g., Stanier *et al.* 1971; Kenyon *et al.* 1972; Rippka *et al.* 1979). Such workers consider the traditional field-orientated classification system to be inappropriate for laboratory cultures, because some morphological characters which are used to distinguish natural populations are not evident in culture or fall within the range exhibited by a single laboratory strain. Furthermore, bacteriologists require living type material to understand the genetic, physiological and biochemical properties of each taxon. However, as axenic cultures are not recognised as valid holotype material under the Botanical Code (Voss *et al.* 1983), it has been proposed that the taxonomy of the blue-greens be brought under the rules of the International Code of Nomenclature of Bacteria (Stanier *et al.* 1978). Obviously, ratification of this proposal would aid bacteriologists but hinder the work of field phycologists (e.g. see Lewin 1976, 1978; Bourrelly 1979; Geitler 1979). The following compromise, suggested by Golubic (1979), has considerable merit:

- 1 New taxonomic descriptions should be documented by (a) a fixed specimen of a natural population, (b) an axenic culture accompanied by a fixed sample of the natural (mixed) population of the source and a similarly fixed sample of the holotype isolate, or (c) photographic and iconographic documentation if neither of the above options is possible.
- 2 Organisms isolated in axenic cultures should be provided with a nomenclatorial reference based on the Geitlerian system of taxonomy that links them with natural populations (with known location and date) to the best of present technical ability.

The taxonomic arrangement of Desikachary (1959) is used in this text, in preference to the system of nomenclature proposed by Drouet & Daily (1956) and Drouet (1968, 1973, 1978, 1981). Drouet, after studying a very large number of herbarium specimens, including many holotypes, reduced the number of blue-green taxa from more than 5000 to less than 70. This work has been severely criticised for oversimplification without the necessary experimental evidence (e.g., Baker & Bold 1970; Stanier *et al.* 1971; Stam & Venema 1977). We do not recommend its use, although it has been of value in highlighting the variability which exists within the blue-greens. However, as some New Zealand phycologists (e.g., Chapman *et al.* 1957) have used the system, we have included a nomenclatorial comparison in Appendix II.

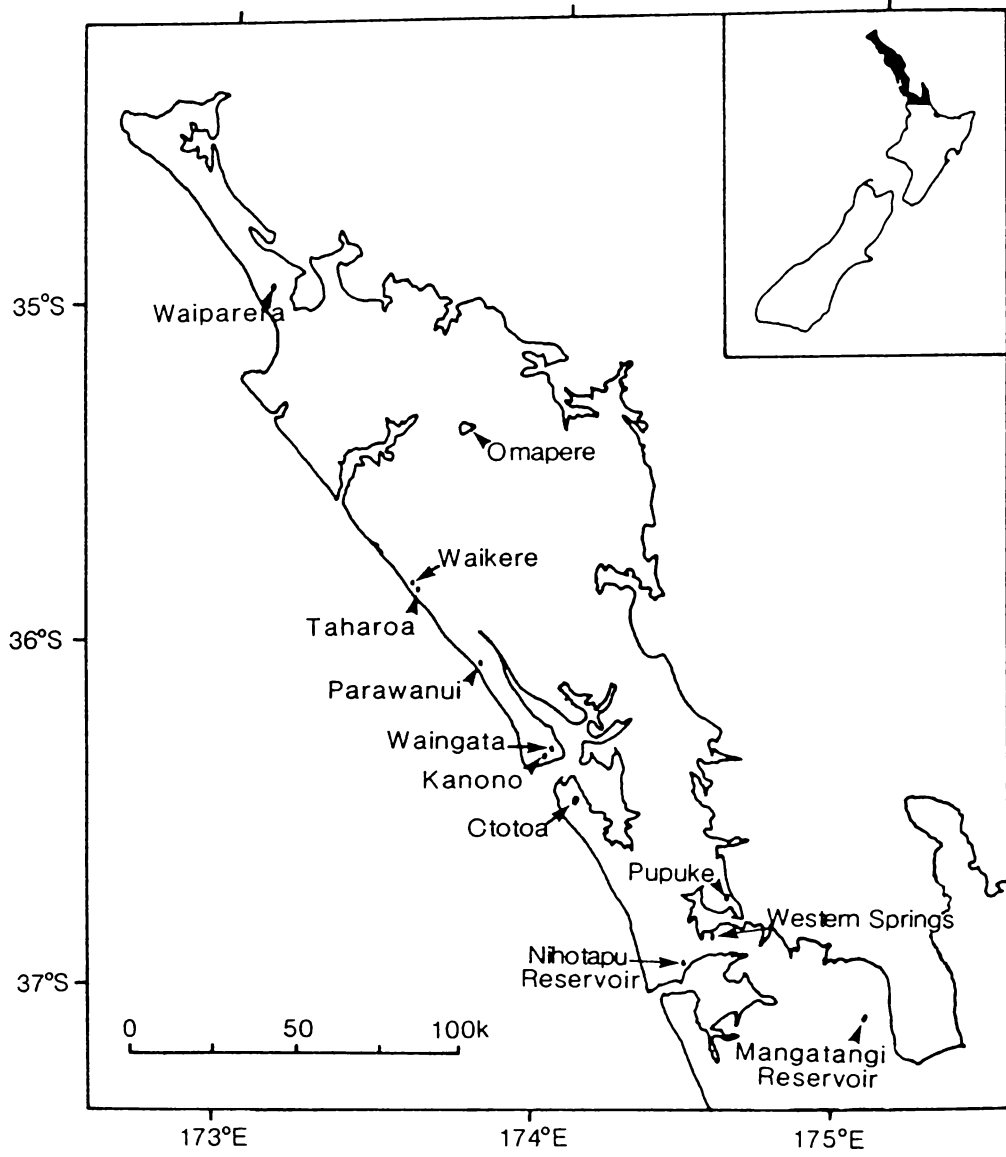
Keys are provided for the various taxonomic categories (i.e., order, family, genus, species) whenever two or more taxa must be distinguished. Keys to species do not include infraspecific taxa (i.e., varieties, forms); descriptions of such taxa follow that of the type.

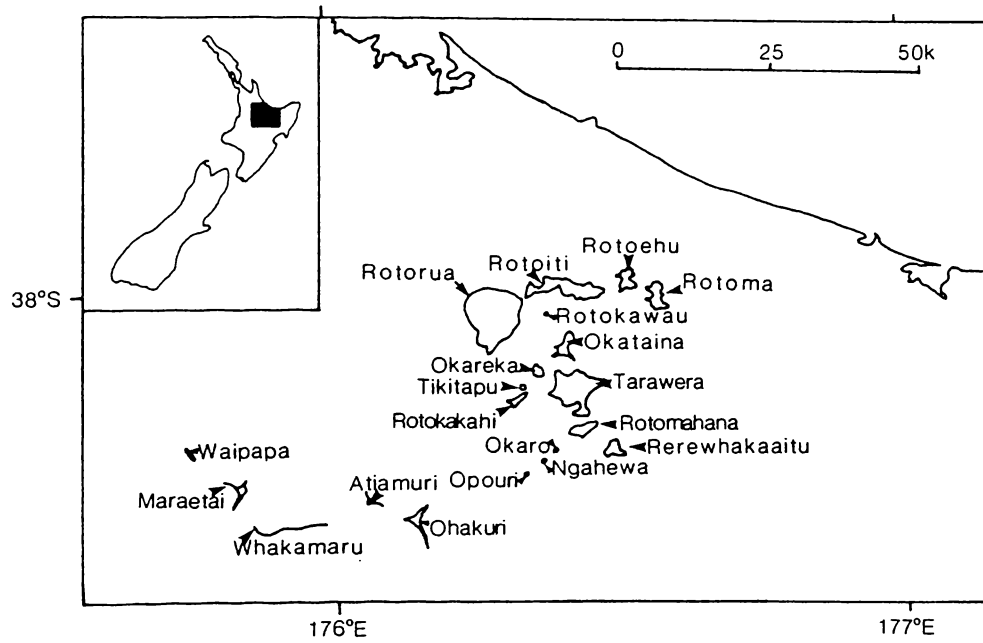
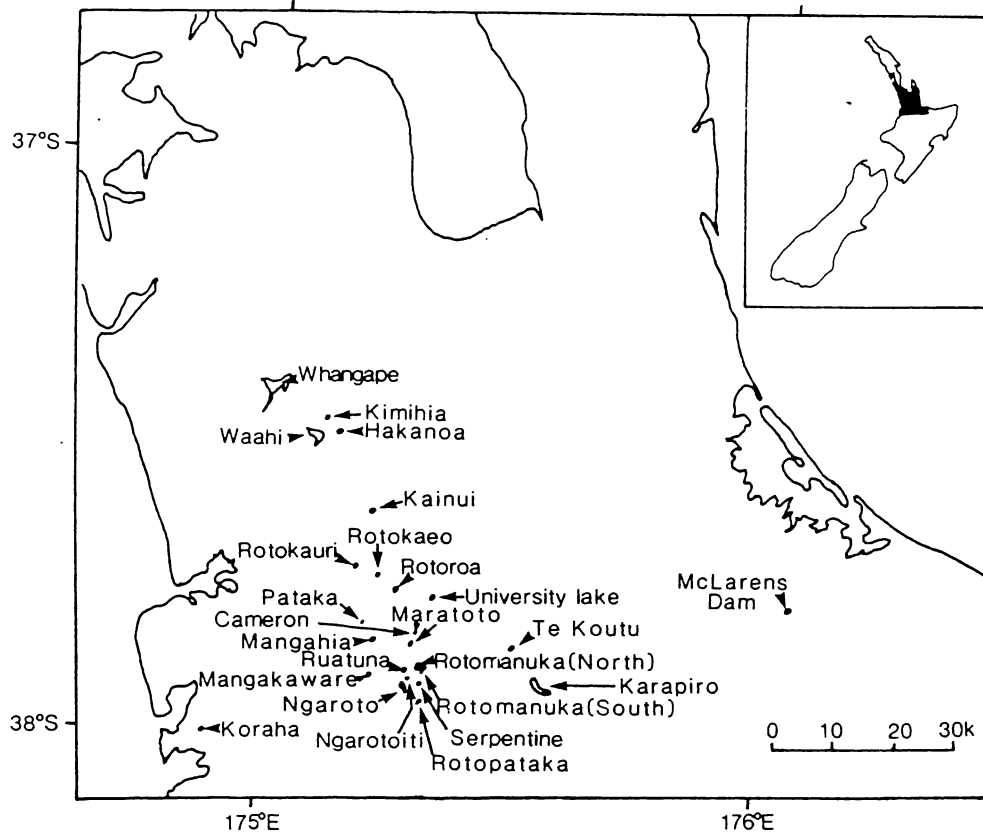
In this text, we give descriptions of 104 taxa of planktonic blue-greens reported from New Zealand lakes. We have observed all but 27 of these, and therefore most of the descriptions and illustrations are our own. Care has been taken to ensure that the specimen illustrated is typical for the taxon. The descriptions and illustrations of previously recorded taxa, which we have not observed ourselves, are clearly referenced to distinguish them from our own work. Our descriptions and illustrations are based on observations made (using light microscopy) of specimens collected during a survey of 77 New Zealand lakes from May 1983 to February 1986 [see Etheredge & Pridmore (1984) for further details]. Taxa were identified by reference to Lemmermann (1910), Smith (1920), Geitler (1932), Huber-Pestalozzi (1938), Forest (1954), Desikachary (1959), Prescott (1962), and Cocke (1967). Any discrepancies between our observations and descriptions given in the above works are noted. According to Article 13 of the Botanical Code (Voss *et al.* 1983), the nomenclature of the Chroococcales begins with Linnaeus (1753), whilst that of the heterocystous blue-greens begins with Bornet & Flahault (1886–1888). All parts of Bornet & Flahault's revision are treated as having been published simultaneously on 1 January 1886. The valid nomenclature of the Oscillatoriaceae commences with Gomont (1892a, b), and both parts of this monograph are treated as having been published simultaneously on 1 January 1892. When citing these authors, we have also included the actual date of publication in parentheses. Synonyms are given only when we are confident that the reported names represent the same taxonomic description. The taxonomic works of Bornet & Flahault (1886–1888), Gomont (1892), Drouet & Daily (1956), Drouet (1968, 1973, 1978, 1981), Komárková-Legnerová (1969), Bourrelly (1970), Fott (1971), Whitford & Schumacher (1973), and Nordin & Stein (1980) were used, in addition to the reference manuals listed above, to compile the lists of synonyms.

We have been unable to verify many distribution records because the majority of phycologists in New Zealand have not kept photographs, drawings or preserved specimens of recorded taxa. For this reason we have sought to keep our records separate from those of others. The localities where we found a particular taxon are given after its description in the text; other records are listed in a separate category below. A few reported taxa and their locations have been omitted simply because we were not confident in the work, the locations given were imprecise, or we questioned the planktonic nature of the particular organism. The checklists of New Zealand algae (Chapman *et al.* 1957; Flint 1966a; Sarma & Chapman 1975; Cassie 1984) proved extremely useful in compiling our list of taxa and in tracing early work on the New Zealand blue-greens.

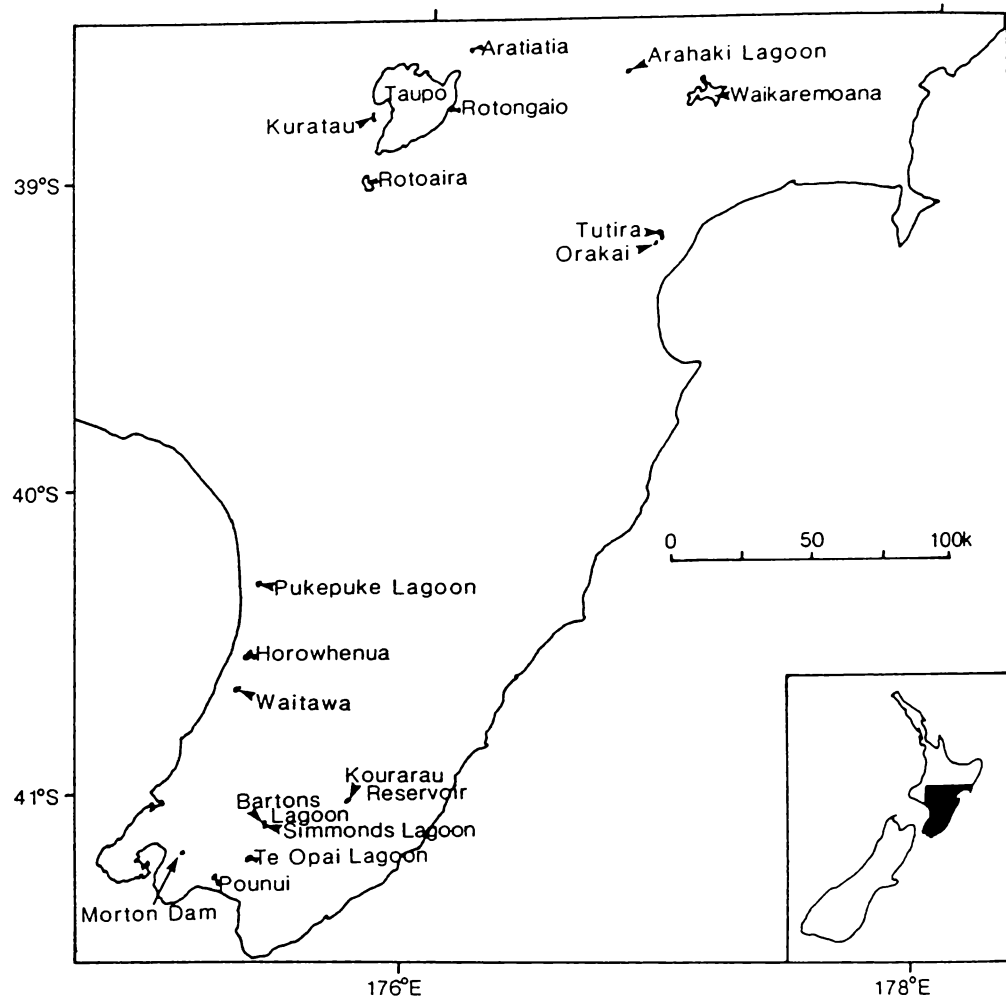
LOCATIONS OF LAKES

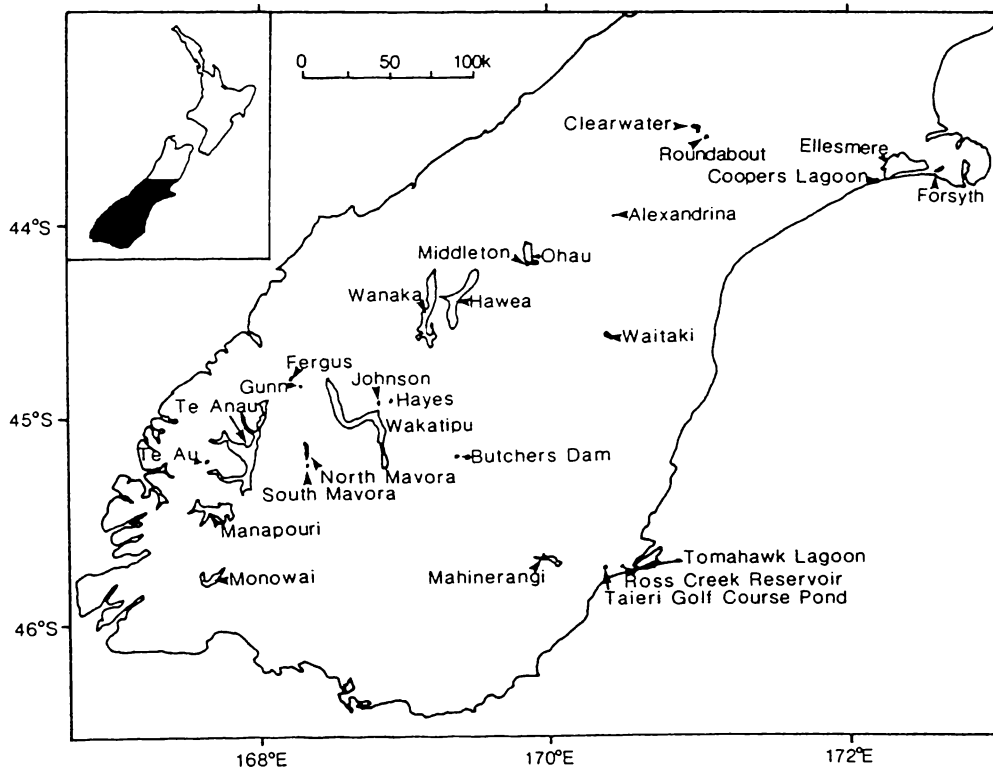
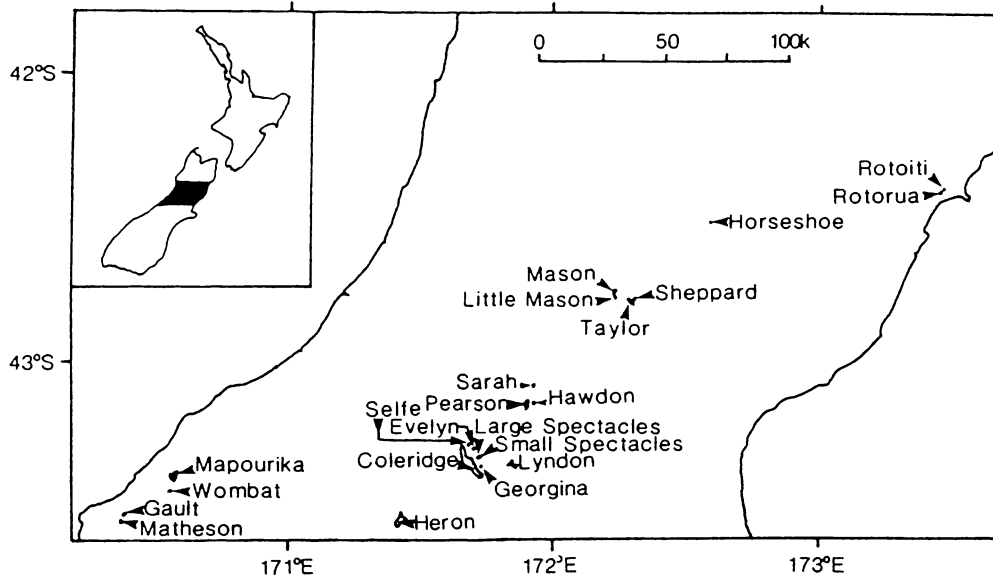
Lakes: Northland





Lakes: Southern North Island





SYSTEMATIC TREATMENT

Key to Genera Reported From New Zealand

- | | | |
|--|---------|--|
| 1. Thallus filamentous (Order Nostocales)* | .. | 2 |
| 1. Thallus not filamentous (Order Chroococcales)* | | 17 |
| 2. Heterocyst(s) usually present, terminal and/or
intercalary | | 3 |
| 2. Heterocyst(s) absent | .. | 12 |
| 3. Trichomes markedly tapered; distinct basal/distal
differentiation | | 4 |
| 3. Trichomes not markedly tapered; no distinct
basal/distal differentiation | | 5 |
| 4. Trichomes falsely branched; basal portions
enclosed within common sheath | | Dichothrix (p. 48) |
| 4. Trichomes unbranched; radiately arranged;
enclosed within common sheath | | Gloeotrichia (p. 48) |
| 5. Trichomes falsely branched | .. | Tolypothrix (p. 50) |
| 5. Trichomes not branched | .. | 6 |
| 6. Intercalary heterocyst(s) absent | .. | 7 |
| 6. Intercalary heterocyst(s) present | .. | 8 |
| 7. Heterocysts terminal; adjacent to akinetes | .. | Cylindrospermum (p. 44) |
| 7. Heterocysts terminal; remote from akinetes | .. | Anabaenopsis (in part)
(p. 42) |
| 8. Heterocysts intercalary; paired | .. | Anabaenopsis (in part)
(p. 42) |
| 8. Heterocyst(s) intercalary; single | .. | 9 |
| 9. Vegetative cells much broader than long | .. | Nodularia (p. 44) |
| 9. Vegetative cells as long or longer than broad or
spherical | | 10 |
| 10. Trichomes tapered at both ends; sometimes
lying parallel in fascicles | | Aphanizomenon (p. 43) |
| 10. Trichomes not tapered at both ends; not
lying parallel in fascicles | | 11 |
| 11. Trichomes in firm colonial envelopes | .. | Nostoc (p.46) |
| 11. Trichomes not in firm colonial envelopes | .. | Anabaena (p.35) |
| 12. Trichomes regularly spiralled/coiled | .. | 13 |
| 12. Trichomes straight, bent or curved; never
regularly spiralled/coiled | | 14 |

*Care should be taken with members of the **Entophysalidaceae** (order **Chroococcales**) which have linear cell arrangements and appear filamentous. No planktonic representatives of this family have been reported from New Zealand. A key to the **Entophysalidaceae** is given in Desikachary (1959, p. 159).

13. Trichomes with distinct crosswalls **Arthrospira** (p. 18)
13. Trichomes unicellular in appearance (if using light microscopy) **Spirulina** (p. 34)
14. Sheaths distinct 15
14. Sheaths not evident 16
15. Sheaths laterally confluent .. **Phormidium** (p. 33)
15. Sheaths not laterally confluent .. **Lyngbya** (p. 19)
16. Trichomes conspicuously tapered to a fine point at one or both ends **Raphidiopsis** (p. 47)
16. Trichomes not conspicuously tapered or only apically so **Oscillatoria** (p. 22)
17. Cells arranged in single layer near periphery of colonial envelope 18
17. Cells not arranged in single layer near periphery of colonial envelope 19
18. Cells in gelatinous matrix with radiating strands **Gomphosphaeria** (p. 61)
18. Cells in gelatinous matrix without radiating strands **Coelosphaerium** (p. 58)
19. Colonies plate-like; cells in rectilinear series .. **Merismopedia** (p. 62)
19. Colonies not plate-like; cells not in rectilinear series 20
20. Cells considerably longer than broad .. 21
20. Cells not considerably longer than broad .. 22
21. Cells narrowly fusiform; pointed at one or both ends **Dactylococcopsis** (p. 58)
21. Cells not narrowly fusiform; not pointed at one or both ends **Rhabdoderma** (p. 67)
22. Cells ovoid, ellipsoidal, or cylindrical .. 23
22. Cells spherical or sub-spherical .. 24
23. Individual cell sheaths not evident .. **Aphanothece** (p. 54)
23. Individual cell sheaths distinct .. **Gloeothece** (p. 60)
24. Colonies usually combined to form expanded masses **Gloeocapsa** (p. 60)
24. Colonies not combined to form expanded masses 25
25. Colonies usually ≤ 8 cells, rarely up to 32 cells .. **Chroococcus** (p.55)
25. Colonies many-celled 26
26. Cells remotely and evenly distributed within colony **Aphanocapsa** (p. 53)
26. Cells crowded within colony .. **Microcystis** (p. 64)

NOSTOCALES

Thallus filamentous; unbranched or falsely branched; with or without heterocysts; reproduction by trichome fragmentation, hormogonia or akinetes.

CLASSIFICATION OF REPORTED TAXA

Family	Oscillatoriaceae Arthrospira platensis (Nordstedt) Gomont Arthrospira tenuis Bruehl & Biswas Lyngbya bipunctata Lemmermann Lyngbya birgei G.M. Smith Lyngbya cryptovaginata Schkorbatow Lyngbya epiphytica Hieronymus Lyngbya hieronymusii Lemmermann Lyngbya lacustris Lemmermann Lyngbya limnetica Lemmermann Lyngbya limnetica f. minor Geitler Lyngbya martensiana Meneghini Lyngbya putealis Montagne Oscillatoria agardhii Gomont Oscillatoria angustissima W. & G.S. West Oscillatoria annae van Goor Oscillatoria articulata Gardner Oscillatoria bornetii Zukal Oscillatoria chlorina Kuetzing Oscillatoria cortiana Meneghini Oscillatoria curviceps C.A. Agardh Oscillatoria formosa Bory de Saint-Vincent Oscillatoria geminata Meneghini Oscillatoria guttulata van Goor Oscillatoria iwanoffiana (Nygaard) Geitler Oscillatoria jatorvensis Vouk Oscillatoria lacustris (Klebahn) Geitler Oscillatoria limnetica Lemmermann Oscillatoria limosa C.A. Agardh Oscillatoria mougeotii Kuetzing Oscillatoria okeni var. gracilis (Kuetzing) Forti Oscillatoria ornata Kuetzing Oscillatoria planctonica Woloszynska Oscillatoria princeps Vaucher Oscillatoria rubescens de Candolle
--------	--

- Oscillatoria sancta** Kuetzing
Oscillatoria splendida Greville
Oscillatoria subbrevis Schmidle
Oscillatoria subtilissima Kuetzing
Oscillatoria tenuis C.A. Agardh
Oscillatoria tenuis var. **tergestina** (Kuetzing) Rabenhorst
Phormidium mucicola Naumann & Huber-Pestalozzi
Phormidium rotheanum var. **capitatum** Desikachary
Spirulina laxa G.M. Smith
Spirulina major Kuetzing
- Family **Nostocaceae**
- Anabaena aequalis** Borge
Anabaena affinis Lemmermann
Anabaena aphanizomenoides Forti
Anabaena circinalis Rabenhorst
Anabaena flos-aquae (Lyngbye) de Brébisson
Anabaena macrospora Klebahn
Anabaena miniata Skuja
Anabaena oscillarioides Bory de Saint-Vincent
Anabaena solitaria Klebahn
Anabaena sphaerica var. **tenuis** G.S. West
Anabaena spiroides Klebahn
Anabaena spiroides var. **crassa** Lemmermann
Anabaena spiroides var. **tumida** Nygaard
Anabaena tenericaulis Nygaard
Anabaena verrucosa Boye-Petersen
Anabaenopsis arnoldii Aptekarj
Aphanizomenon flos-aquae (Linnaeus) Ralfs
Cylindrospermum minutissimum Collins
Nodularia harveyana (Thwaites) Thuret†
Nodularia implexa (Bornet & Flahault) Bourrelly*
Nodularia spumigena Mertens†
Nostoc commune Vaucher
Raphidiopsis mediterranea Skuja
- Family **Rivulariaceae**
- Dichothrix gypsophila** (Kuetzing) Bornet & Flahault
Gloeotrichia echinulata (J.E. Smith) Richter
Gloeotrichia natans (Hedwig) Rabenhorst
- Family **Scytonemataceae**
- Tolypothrix penicillata** (Agardh) Thuret
Tolypothrix tenuis Kuetzing

*doubtful taxon

†emend. Nordin & Stein (1980)

Oscillatoriaceae

Trichomes unbranched; sometimes tapered in apical region; apical cell rounded or capitate; without heterocysts or akinetes; with or without sheath; reproduction by trichome fragmentation and hormogonia.

Key To Reported Genera

- | | | |
|--|---------|-----------------------------|
| 1 Trichomes regularly spiralled/coiled | .. | 2 |
| 1 Trichomes straight, bent or curved; never regularly spiralled/coiled | .. .. . | 3 |
| 2 Trichomes with distinct crosswalls | .. .. | Arthrospira (p. 18) |
| 2 Trichomes unicellular in appearance (if using light microscopy) | .. .. . | Spirulina (p. 34) |
| 3 Sheaths distinct | .. | 4 |
| 3 Sheaths not evident | .. | Oscillatoria (p. 22) |
| 4 Sheaths laterally confluent | .. | Phormidium (p. 33) |
| 4 Sheaths not laterally confluent | .. | Lyngbya (p. 19) |

ARTHROSPIRA Stizenberger ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 246.

Trichomes multicellular; cylindrical; loosely and regularly coiled; very slightly or not tapered towards apex; apical cell broadly rounded; without sheath; crosswalls distinct.

Key To Reported Species

- | | | |
|------------------------------------|----|---------------------|
| 1. Cells 6–8 μm broad | .. | A. platensis |
| 1. Cells 1.5–2 μm broad | .. | |

A. tenuis

Arthrospira platensis (Nordstedt) Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 247.

Not observed by authors; Appendix I, Fig. 76a,b.

Description after Desikachary (1959, p. 190). Trichomes more or less regularly coiled; windings 26–36 μm broad; distance between windings 43–57 μm ; very slightly or not tapered towards apex; apical cell broadly rounded; crosswalls slightly constricted, granular. Cells 6–8 μm broad, 2–6 μm long.

Synonyms: **Arthrospira jenneri** var. **platensis** (Nordstedt) Guarrera & Kuehnemann

Oscillatoria platensis (Nordstedt) Bourrelly

Spirulina platensis (Nordstedt) Geitler

Location: L. Rotoiti [N.I.] (Cassie 1974, 1975).

Arthrospira tenuis Bruehl & Biswas, 1922*Journal of the Department of Science of Calcutta University 4 (botany): 7.*

Fig. 1

Trichomes of 3½ or 4 loosely wound coils; windings 17 µm broad; distance between windings 20–26 µm. Cells 1.5–2 µm broad, 2–3 µm long.

Synonyms: **Oscillatoria tenuis** (Bruehl & Biswas) Bourrelly

Spirulina tenuis (Bruehl & Biswas) Geitler

Location: L. Ohakuri (this study).

LYNGBYA C.A. Agardh ex Gomont, 1892*nom. cons., non Sommerfelt, 1826**Annales des sciences naturelles, série 7, botanique 16: 118.*

Filaments solitary or aggregated forming flocculent masses; unbranched; straight, curved or twisted; sheath firm, generally hyaline, sometimes yellowish with age, usually extended beyond trichome; crosswalls with or without constrictions. Cells variously coloured; contents homogeneous or granular; with or without gas vacuoles.

Key To Reported Species

- | | | |
|---|----|-----------------------------------|
| 1. Epiphytic upon other algae | .. | L. epiphytica |
| 1. Not epiphytic upon other algae | .. | 2 |
| 2. Trichomes constricted at crosswalls | .. | 3 |
| 2. Trichomes not constricted at crosswalls | .. | 4 |
| 3. Cells 3–4 µm broad .. | .. | L. cryptovaginata |
| 3. Cells 10–12 µm broad | .. | L. putealis |
| 4. Cells ≤ 2 µm broad | .. | 5 |
| 4. Cells > 2 µm broad .. | .. | 6 |
| 5. Single granule present on either side of crosswall | | L. bipunctata |
| 5. Single granule not present on either side of crosswall | .. | 7 |
| 6. Cells 5–10 µm broad | .. | L. martensiana |
| 6. Cells > 10 µm broad .. | .. | 8 |
| 7. Sheath thick; filament 4–5 µm broad | .. | L. lacustris |
| 7. Sheath thin; filament 0.6–2 µm broad .. | .. | L. limnetica (plus 1 var.) |
| 8. Cells 11–13 µm broad | .. | L. hieronymusii |
| 8. Cells 18–23 µm broad | .. | L. birgei |

Lyngbya bipunctata Lemmermann, 1899

Forschungsberichte aus der Biologischen Station zu Ploen 7: 133.

Fig. 2

Filaments solitary; narrow; loosely but regularly coiled; sheath hyaline, thin; crosswalls not constricted, large single granule on either side. Cells 1-1.5 μm broad, 4-6 μm long; contents homogeneous.

Location: L. Clearwater (this study).

Lyngbya birgei G.M. Smith, 1916

Bulletin of the Torrey Botanical Club 43: 482.

Not observed by authors; Appendix I, Fig. 77a,b.

Description after Desikachary (1959, p. 296) and Prescott (1962, p. 482). Filaments solitary; straight; 20-24 μm broad; sheath hyaline, firm, rarely lamellated; crosswalls not constricted. Cells 18-23 μm broad, 2-2.5 μm long; contents homogeneous or with gas vacuoles.

Location: L. Rotorua [N.I.] (Cassie 1969, 1974, 1975).

Lyngbya cryptovaginata Schkorbatow, 1923

Notulae systematicae ex Instituto cryptogamico Horti botanici petropolitani 2: 88.

Fig. 3

Filaments solitary; straight; 5-6 μm broad; sheath hyaline, thin; crosswalls constricted. Cells almost quadrate; 3-4 μm broad, 3-4 μm long; gas vacuoles present.

Locations: L. Rerewhakaaitu, Rotokakahi (this study).

Lyngbya epiphytica Hieronymus, 1900

In: O. Kirchner, in A. Engler & K. Prantl, *Die natuerlichen pflanzenfamilien 1*. W. Englemann. Leipzig. p. 67.

Fig. 4

Filaments in tight or loose spiral around other algae; 1-2 μm broad; sheath hyaline, very thin; crosswalls not constricted. Cells 1-2 μm broad, 1-2 μm long; contents homogeneous.

Note: this species should not be confused with **Lyngbya epiphytica** Wille, which is synonymous with both **Lyngbya nordgaardii** Wille and **Lyngbya willei** Setchell & Gardner.

Locations: L. Rotoma (this study).
L. Tikitapu (Thomasson 1974).

Lyngbya hieronymusii Lemmermann, 1905*Forschungsberichte aus der Biologischen Station zu Ploen* 12: 146.

Fig. 5

Filaments solitary; straight or slightly curved; 13–14 μm broad; sheath hyaline, firm, thick; crosswalls not constricted, granular. Cells 11–13 μm broad, 2–4 μm long; contents finely granular, gas vacuoles present.

Locations: L. Rotorua (N.I.) (this study).
L. Ohakuri (Cassie 1969); Rotomahana (Thomasson 1960, 1974);
Rotorua [N.I.] (Cassie 1969, 1974, 1975).

Lyngbya lacustris Lemmermann, 1898*Botanisches centralblatt* 76: 154.

Not observed by authors; not illustrated.

Description after Geitler (1932, p. 1046). Filaments solitary; straight or slightly curved; 4–5 μm broad; sheath hyaline, thick; crosswalls not constricted. Cells 1.5 μm broad, 1.5–5 μm long.

Locations: L. Okareka (Thomasson 1974).

Lyngbya limnetica Lemmermann, 1898*Botanisches centralblatt* 76: 154.

Fig. 6

Filaments solitary; straight or slightly curved; 1–2 μm broad; sheath hyaline, thin; crosswalls not constricted. Cells 1–2 μm broad, 1–3 μm long; contents granular.

Locations: L. Hakanoa, Hawdon, Kainui, Kimihia, Mangahia, Mangakaware, Maratoto, Ngahewa, Okataina, Okareka, Ototoa, Pupuke, Rerewhakaaitu, Rotokakahi, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa (N.I.), Rotorua (N.I.), Sarah, Selfe, Tikitapu, Waahi; Simmond's Lagoon (this study).
L. Okareka (Thomasson 1974).

Lyngbya limnetica f. *minor* Geitler & Ruttner, 1935.*Archiv fuer hydrobiologie, supplement* 14: 475.

Not observed by authors; not illustrated; see figure for type.

Description after Huber-Pestalozzi (1938, p. 248). Differs from type in that cells are longer and narrower; cells 0.6–0.8 μm broad, 3–8 μm long.

Locations: L. Okareka (Thomasson 1974).

Lyngbya martensiana Meneghini ex Gomont, 1892*Annales des sciences naturelles, série 7, botanique 16: 145.*

Fig. 7

Filaments long; flexuous; forming tangled mat; sheath hyaline, firm, thick, lamellated; crosswalls not constricted, granular. Cells 5–10 μm broad, 2–3 μm long; contents homogeneous or granular.

Note: This species should not be confused with **Lyngbya martensiana** Rabenhorst [see Gomont (1892), p. 145].

Locations: L. Clearwater, Koraha, Rotorua (N.I.) (this study).
L. Rerewhakaaitu (Chapman & Clayton 1975).

Lyngbya putealis Montagne ex Gomont, 1892*Annales des sciences naturelles, série 7, botanique 16: 143.*

Fig. 8

Filaments long; flexuous; often entangled at base; sheath hyaline, thin; crosswalls conspicuously constricted, not granular [Geitler (1932, p. 1063) and Desikachary (1959, p. 318) describe crosswalls as 'sometimes granular']. Cells 10–12 μm broad, 4–9 μm long; contents granular.

Location: L. Heron (this study).

OSCILLATORIA Vaucher ex Gomont, 1892*Annales des sciences naturelles, série 7, botanique 16: 198.*

Trichomes solitary or in flocculent masses; unbranched; cylindrical; straight, bent or variously curved; sometimes tapered toward apex; apical cell rounded or capitate, with or without calyptra; sheath not obvious; crosswalls with or without constrictions; exhibit oscillatory or gliding movements. Cells cylindrical to disciform; contents homogeneous or granular, gas vacuoles may be present.

Key To Reported Species

- | | | |
|--|-------|-----------------------|
| 1. Trichomes in fascicles | .. | 2 |
| 1. Trichomes not in fascicles | .. .. | 3 |
| 2. Cells 5–7 μm broad, apical cell usually elongate | .. .. | O. lacustris |
| 2. Cells 7–8 μm broad; apical cells not elongate | | O. iwanoffiana |
| 3 Trichomes constricted at crosswalls | .. | 4 |
| 3. Trichomes not constricted at crosswalls | .. | 12 |
| 4. Apical cells conical | .. | O. formosa |
| 4. Apical cells not conical | .. | 5 |

5. Apical cells capitate .. **O. sancta**
5. Apical cells not capitate .. 6
6. Apical cells obtuse .. 7
6. Apical cells not obtuse 8
7. Crosswalls distinctly constricted; cells 1/3 as long as broad **O. okeni (var. only)**
7. Crosswalls slightly constricted; cells squarish .. **O. cortiana**
8. Trichomes 1.5 μm broad **O. limnetica**
8. Trichomes $> 1.5 \mu\text{m}$ broad .. 9
9. Crosswalls pellucid **O. geminata**
9. Crosswalls not pellucid .. 10
10. Crosswalls granular .. 11
10. Crosswalls not granular **O. annae**
11. Crosswalls very slightly constricted; cells 6–8 μm broad **O. tenuis** (plus 1 var.)
11. Crosswalls constricted; cells 8–10 μm broad .. **O. ornata**
12. Cell contents pale, almost hyaline; conspicuous quadrangular vacuoles .. **O. bornetii**
12. Cell contents not pale; no conspicuous vacuoles 13
13. Cells 16–60 μm broad .. **O princeps**
13. Cells $< 16 \mu\text{m}$ broad 14
14. Crosswalls markedly thickened **O. articulata**
14. Crosswalls not markedly thickened .. 15
15. Cells $\leq 1.5 \mu\text{m}$ broad .. 16
15. Cells $> 1.5 \mu\text{m}$ broad .. 17
16. Cells 0.6 μm broad; crosswalls not constricted **O. angustissima**
16. Cells 1.5 μm broad; crosswalls indistinct .. **O. subtilissima**
17. Apical cell with calyptra .. 18
17. Apical cell without calyptra .. 19
18. Cells 10–15 μm broad .. **O. limosa**
18. Cells 6–8 μm broad .. **O. rubescens**
19. Cells 9–14 μm broad .. **O. curviceps**
19. Cells $< 9 \mu\text{m}$ broad 20
20. Trichomes briefly or gradually tapered .. 21
20. Trichomes not tapered 22

21. Trichomes briefly tapered; cells 4–6 μm broad .. **O. agardhii**
21. Trichomes gradually tapered; cells 2–3 μm broad .. **O. splendida**
22. Cells $\geq 5 \mu\text{m}$ broad .. 23
22. Cells $< 5 \mu\text{m}$ broad .. 24
23. Cells 5–6 μm broad; without gas vacuoles;
necridia common **O. subbrevis**
23. Cells 5–7 μm broad; gas vacuoles present;
without necridia **O. mougeotii**
24. Cells with gas vacuole(s) 25
24. Cells without gas vacuoles 26
25. Cells with 1 conspicuous gas vacuole **O. planctonica**
25. Cells with several conspicuous gas vacuoles **O. guttulata**
26. Cells 3–5 μm long; crosswalls pellucid **O. chlorina**
26. Cells 2–3 μm long; crosswalls not pellucid **O. jasorvensis**

Oscillatoria agardhii Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 205.

Fig. 9

Trichomes solitary or entangled; straight or slightly curved; briefly tapered towards apex; apical cell convex or bluntly conical, rarely capitate, with or without calyptra; crosswalls not constricted, granular. Cells 4–6 μm broad, 2.5–4 μm long; contents coarsely granular, gas vacuoles present.

Synonym: **Oscillatoria agardhii** f. **gomontii** Elenkin

Locations: L. Mangahia, Rotokauri (this study).

Oscillatoria angustissima W. & G.S. West, 1897

Journal of botany (London) 35: 300.

Not observed by authors; Appendix I, Fig. 78.

Description after Geitler (1932, p. 965) and Prescott (1962, p. 485). Trichomes entangled; often bent in apical region; not tapered towards apex; apical cell bluntly rounded, without calyptra; crosswalls not constricted. Cells 0.6 μm broad, 1½–2 times longer than broad.

Location: L. Rerewhakaaitu (Chapman & Clayton 1975).

Oscillatoria annae van Goor, 1918

Recueil des travaux botaniques néerlandais 15: 289.

Not observed by authors; Appendix I, Fig. 79a,b.

Description after Desikachary (1959, p. 203). Trichomes often bent in apical region; usually tapered towards apex; apical cell rounded, without calyptra; crosswalls slightly constricted. Cells 7.5–8 μm broad; 1.5–3(4) μm long. The New Zealand specimens viewed by Cassie & Freeman (1980) were slightly broader; 10.2–11.5 μm .

Locations: L. Kanono (Cassie & Freeman 1980); Waingata (Cassie & Freeman 1980).

Oscillatoria articulata Gardner, 1927

Memoirs of the New York Botanical Garden 7: 34.

Fig. 10

Trichomes solitary or entangled; straight, flexuous or coiled; not tapered towards apex; apical cell rounded, without calyptra; crosswalls markedly thickened. Cells usually squarish, 2.5–3 μm broad; contents homogeneous or finely granular.

Synonym: **Oscillatoria grunowiana** var. **articulata** (Gardner) Drouet.

Locations: L. Ngaroto, Rotomanuka North, Rotorua (N.I.) (this study).

Oscillatoria bornetii Zukal, 1894

Bericht der Deutschen botanischen Gesellschaft 12: 260.

Not observed by authors; Appendix I, Fig. 80a,b.

Description after Prescott (1962, p. 486). Trichomes more or less straight; often bent or slightly sigmoid in apical region; not tapered towards apex; apical cell rounded, without calyptra; crosswalls not constricted. Cells (10)–12–16 μm broad, 3.7–4 μm long; vacuoles large, quadrangular.

Synonyms: **Lyngbya bornetii** Zukal

Oscillatoria bornetii (Zukal) Forti

Locations: L. Manapouri (Thomasson 1980); Mapourika (Flint 1979).

Oscillatoria chlorina Kuetzing ex Gomont, 1892

Annales des sciences naturelles, série 7, botaniques 16: 223.

Fig. 11

Trichomes straight or slightly curved; delicate; not tapered towards apex; apical cell rounded, without calyptra; crosswalls pellucid, not constricted. Cells 3–4 μm broad, 3–5 μm long; contents very finely granular.

Synonym: **Oscillatoria tenuis** var. **chlorina** (Kuetzing) Playfair

Locations: L. Clearwater, Karapiro, Pupuke (this study).

Oscillatoria cortiana Meneghini ex Gomont, 1892*Annales des sciences naturelles, série 7, botanique 16: 231.*

Fig. 12

Trichomes slightly bent at apex; tapering towards apex; apical cell obtuse, up to 11 μm long, without calyptra; crosswalls slightly constricted. Cells squarish; 5–6 μm broad; contents granular.

Synonym: **Oscillatoria cortiana** (Pollini) Meneghini

Locations: L. Whangape (this study).

L. Rotomahana (Thomasson 1974).

Oscillatoria curviceps Agardh ex Gomont, 1892*Annales des sciences naturelles, série 7, botanique 16: 213.*

Fig. 13

Trichomes more or less straight; curved in apical region; not tapered towards apex; apical cell broadly rounded, without calyptra; crosswalls not constricted, frequently granular. Cells 9–14 μm broad, 3–4 μm long; contents granular. Desikachary (1959, p. 209) notes that end of trichome may be spirally coiled; we have not observed this characteristic.

Locations: L. Clearwater, Kainui, Serpentine (this study).

Oscillatoria formosa Bory de Saint-Vincent ex Gomont, 1892*Annales des sciences naturelles, série 7, botanique 16: 230.*

Not observed by authors; Appendix I, Fig. 81a,b.

Description after Prescott (1962, p. 487). Trichomes straight; curved in apical region; slightly tapered towards apex; apical cell conical, without calyptra; crosswalls constricted, granular. Cells 4–6 μm broad, 2.5–5 μm long.

Synonym: **Oscillatoria mougeotii** Bory de Saint-Vincent

Location: Western Springs (Johnstone 1972).

Oscillatoria geminata Meneghini ex Gomont, 1892*Annales des sciences naturelles, série 7, botanique 16: 222.*

Fig. 14

Trichomes straight or flexuous; not tapered towards apex; apical cell rounded, without calyptra; crosswalls pellucid, constricted. Cells 3–4 μm broad, 3–10 μm long; contents finely granular with several large, conspicuous granules.

Locations: L. Kainui, Pounui, Pupuke, Rotoaira, Rotomanuka North (this study).

Oscillatoria guttulata van Goor, 1918

Recueil des travaux botaniques néerlandais 15: 255.

Fig. 15

Trichomes straight or slightly curved; not tapered towards apex; apical cell rounded, without calyptra; crosswalls indistinct, not constricted. Cells 3–4 μm broad, 4–6 μm long; gas vacuoles very conspicuous.

Locations: L. Ngaroto, Rotoiti (N.I.) (this study).
L. Okareka (Thomasson 1974).

Oscillatoria iwanoffiana (Nygaard) Geitler, 1932

In: L. Rabenhorst, Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz 14. Akademische Verlagsgesellschaft M.B.H. Leipzig. p. 955.

Not observed by authors; Appendix I, Fig. 82a,b.

Description after Huber-Pestalozzi (1938, p. 234). Trichomes lying in free-floating fascicle, 50–100 μm broad, 650–900 μm long; straight; apical cell not elongated; crosswalls constricted. Cells (5)·7–8·(9) μm broad, 2–5 μm long; gas vacuoles conspicuous.

Synonyms: **Skujaella iwanoffiana** (Nygaard) de Toni
Trichodesmium iwanoffiana Nygaard

Locations: L. Tarawera (Thomasson 1974); Tikitapu (Thomasson 1974).

Oscillatoria jasorvensis Vouk, 1919

Prirodoslovna istrazivanja Hrvatske i slavonske potaknuta Matematicko—prirodoslovnim razredom Jugoslovenske akademije znanosti i umjetnosti 14: 133.

Fig. 16

Trichomes straight; bent in apical region; not tapered towards apex; apical cell rounded, without calyptra; crosswalls not constricted. Cells 3 μm broad, 2–3 μm long; contents granular.

Locations: L. Pupuke, Rotokauri, Wanaka (this study).

Oscillatoria lacustris (Klebahn) Geitler, 1925

In: A. Pascher, *Die Suesswasser-flora Deutschlands, Oesterreichs und der Schweiz* 12. G. Fischer, Jena. p. 362.

Fig. 17

Trichomes lying in free-floating fascicles; straight; not tapered towards apex; apical cell usually elongated, without calyptra; crosswalls constricted. Cells compressed; 5-7 μm broad, 3-7 μm long; gas vacuoles conspicuous.

Synonyms: **Skujaella lacustris** (Klebahn) de Toni

Trichodesmium lacustre Klebahn

Locations: L. Whangape (this study).

L. Sarah (Flint 1938); Taupo (Thomasson 1960; Flint 1975).

Oscillatoria limnetica Lemmermann, 1900

Bericht der Deutschen botanischen Gesellschaft 18: 310.

Fig. 18

Trichomes usually straight; not tapered towards apex; apical cell rounded, without calyptra; crosswalls constricted. Cells 1.5 μm broad, 4-12 μm long; contents homogeneous.

Synonym: **Oscillatoria splendida** var. *limnetica* (Lemmermann) Playfair

Locations: L. Cameron, Clearwater, Forsyth, Gault, Hakanoa, Heron, Kainui, Karapiro, Kimihia, Mangahia, Mangakaware, Maratoto, Ngaroto, Ohakuri, Okareka, Omapere, Pearson, Pounui, Rerewhakaaitu, Rotoaira, Rotoehu, Rotoiti (N.I.), Rotokakahi, Rotokauri, Rotoma, Rotomanuka North, Rotomanuka South, Rotorua (N.I.), Ruatuna, Serpentine, Te Koutu, Waahi, Whangape; Cooper's Lagoon, Simmond's Lagoon (this study).

L. Okareka (Thomasson 1974); Okataina (Thomasson 1974); Rotoiti [N.I.] (Cassie 1974, 1975); Rotoma (Thomasson 1974); Rotomahana (Thomasson 1974); Rotomanuka North (Etheredge 1983 unpub.); Rotorua (Cassie 1974, 1975); Te Anau (Thomasson 1980).

Oscillatoria limosa C.A. Agardh ex Gomont, 1892.

Annales des sciences naturelles, série 7, botanique 16: 210.

Fig. 19

Trichomes more or less straight; not tapered towards apex; apical cell broadly rounded, slightly thickened outer membrane; crosswalls not constricted, usually granular. Cells 10-15 μm broad, 2-4 μm long; contents granular. Desikachary (1959, p. 206) and Prescott (1962, p. 489) give breadth ranges of 11-22 μm and 12-20 μm , respectively.

Synonyms: **Oscillatoria limosa** (Dillwyn) Agardh

Oscillatoria limosa (Roth) Agardh

Locations: L. Heron, Kimihia, Mangahia, Mangakaware, Pupuke, Rotokauri, Rotoroa (N.I.), Rotorua (N.I.), Ruatuna (this study).
L. Mapourika (Flint 1979); Okareka (Thomasson 1974); Okataina (Thomasson 1974); Rotoehu (Cassie 1978); Rotoiti [N.I.] (Cassie 1974, 1975); Rotoma (Thomasson 1974); Whakamaru (Cassie 1974); Wombat (Flint 1979).

Oscillatoria mougeotii Kuetzing ex Forti, 1907

In: G.B. de Toni, *Sylloge algarum omnium hucusque cognitarum* 5. Published by author. Padua. p. 149.

Fig. 20

Trichomes straight or slightly curved; not tapered towards apex; apical cell broadly rounded, without calyptra; crosswalls not constricted. Cells 5–7 μm broad, 2–3 μm long; gas vacuoles present.

Note: this species should not be confused with **Oscillatoria mougeotii** Bory de Saint-Vincent or **Oscillatoria mougeotii** Stizenberger, which are synonymous with **Oscillatoria formosa** Bory de Saint-Vincent and **Phormidium favosum** (Bory de Saint-Vincent) Gomont, respectively.

Synonym: **Oscillatoria mougeotii** (Kuetzing) Forti

Locations: L. Ngaroto, Ohakuri, Rotoaira (this study).
L. Rotokawau [by Rotorua] (Thomasson 1974).

Oscillatoria okeni var. **gracilis** (Kuetzing) Forti, 1907

In: G.B. de Toni, *Sylloge algarum omnium hucusque cognitarum* 5. Published by author. Padua. p. 184.

Not observed by authors; not illustrated.

Description after Geitler (1932, p. 969). Trichomes straight; slightly bent in apical region; tapered towards apex; apical cell obtuse or subconical, up to 8 μm long, without calyptra; crosswalls distinctly constricted. Cells 4–5 μm broad, 1/3 as long as broad.

Note: the type, **Oscillatoria okeni** C.A. Agardh, has not been observed in New Zealand. Cell measurements for the type are larger; 5.5–9 μm broad (Desikachary 1959, p. 231).

Location: L. Mapourika (Flint 1979)

Oscillatoria ornata Kuetzing ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 214.

Fig. 21

Trichomes curved or spiralled in apical region; slightly or not tapered towards apex; apical cell rounded, without calyptra; crosswalls constricted, granular. Cells 8–10 μm broad, 2–3 μm long; contents granular.

Location: L. Clearwater (this study).

Oscillatoria planctonica Woloszynska, 1912

Bulletin international de l'Academie des sciences et des lettres de Cracovie, série B, sciences naturelles 1911: 530.

Fig. 22

Trichomes straight or slightly curved; not tapered towards apex; apical cell rounded, without calyptra; crosswalls not constricted. Cells 2–3 μm broad, 2–3 μm long; conspicuous gas vacuole in centre.

Locations: L. Clearwater, Kainui, Ngaroto, Pounui, Rotokauri, Rotomanuka North (this study).

Oscillatoria princeps Vaucher ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 206.

Not observed by authors; Appendix I, Fig. 83.

Description after Desikachary (1959, p. 210). Trichomes mostly straight; bent in apical region; slightly or briefly tapered towards apex; apical cell broadly rounded, slightly capitate, with or without calyptra; crosswalls not constricted. Cells (16)·25–50·(60) μm broad, 3.5–7 μm long.

Locations: L. Rotoiti [N.I.] (Cassie 1974, 1975); Rotorua [N.I.] (Cassie 1974).

Oscillatoria rubescens de Candolle ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 204.

Fig. 23

Trichomes solitary, sometimes forming reddish-purple fascicles; straight; slightly or

not tapered towards apex; apical cell capitate, with calyptra; crosswalls not constricted, granular. Cells 6–8 μm broad, 2–4 μm long; gas vacuoles numerous.

Locations: L. Forsyth, Kimihia; Cooper's Lagoon (this study).
L. Okataina (Thomasson 1974); Rotoiti [N.I.] (Cassie 1974, 1975).

Oscillatoria sancta Kuetzing ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 209.

Fig. 24

Trichomes straight or slightly curved; slightly tapered towards apex; apical cell capitate, with calyptra; crosswalls constricted, markedly granular. Cells 10–20 μm broad, 2.5–6 μm long; contents granular.

Synonym: **Oscillatoria sancta** (Kuetzing) Gomont

Locations: L. Pupuke, Sarah; Te Opai Lagoon (this study).
L. Okareka (Thomasson 1974); Okataina (Thomasson 1974).

Oscillatoria splendida Greville ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 224.

Fig. 25

Trichomes straight or flexuous; gradually tapered towards apex; apical cell capitate, without calyptra; crosswalls not constricted, sometimes sparsely granular. Cells 2–3 μm broad, 3–9 μm long; contents homogeneous.

Locations: L. Clearwater, Heron, Kainui, Kimihia, Mangahia, Maratoto, Ngaroto, Rotokauri, Rotorua (N.I.); Nihotapu Reservoir (this study).
L. Okataina (Thomasson 1974); Western Springs (Loach unpub., as cited in Chapman *et al.* 1957).

Oscillatoria subbrevis Schmidle, 1901

Botanische Jahrbuecher fuer Systematik, Pflanzengeschichte und Pflanzengeographie 30: 243.

Fig. 26

Trichomes usually straight; not tapered towards apex; apical cell rounded, without calyptra; crosswalls not constricted. Cells 5–6 μm broad, 1–2 μm long; contents granular, necridia usually present.

Locations: L. Clearwater, Heron, Kainui, Kimihia, Mangahia, Mangakaware, Ngaroto, Ototoa, Pounui, Rerewhakaaitu, Rotokakahi, Rotokauri, Rotomanuka North, Rotomanuka South, Rotorua (N.I.), Ruatuna, Serpentine, Tarawera, Te Koutu, Whangape; Cooper's Lagoon, Tomahawk Lagoon (this study).

Oscillatoria subtilissima Kuetzing ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 240.

Not observed by authors; Appendix I, Fig. 84.

Description after Desikachary (1959, p. 215). Trichomes solitary or a few together; straight or curved; crosswalls indistinct. Cells 1-1.5 μm broad.

Location: L. Ellesmere (Lineham 1983 unpub.).

Oscillatoria tenuis C.A. Agardh ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 220.

Fig. 27

Trichomes straight or slightly flexuous in apical region; not tapered towards apex; apical cell rounded to deeply convex, sometimes with calyptra; crosswalls very slightly constricted, granular. Cells 6-8 μm broad, 3-5 μm long; contents granular. Lemmermann (1910, p. 110), Geitler (1932, p. 959), Desikachary (1959, p. 222) and Huber-Pestalozzi (1938, p. 235) give cell breadth of 4-10 μm ; Prescott (1962, p. 491) gives (4)-5-8-(10) μm .

Locations: L. Clearwater, Evelyn, Georgina, Heron, Mangakaware, Pupuke, Rotoaira (N.I.), Rotokaeo, Rotokauri, Rotoma, Rotomanuka North, Rotorua (N.I.), Rotorua (N.I.), Ruatuna, Sarah, Te Koutu, University of Waikato; McLarens Falls Dam; Cooper's Lagoon (this study).

L. Mapourika (Flint 1979); Rotoiti [N.I.] (Cassie 1974, 1975); Rotorua [N.I.] (Cassie 1974, 1975).

Oscillatoria tenuis var. *tergestina* (Kuetzing) Rabenhorst ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 221.

Not observed by authors; not illustrated; see figure for type.

Description after Huber-Pestalozzi (1938, p. 235). Differs from type in that cells are narrower, 4-6 μm broad; Prescott (1962, p. 492) gives breadth measurement of 5.5-6 μm . Desikachary (1959, p. 223) questions the validity of this taxon, because cell measurements are so similar to type.

Synonym: **Oscillatoria tenuis** var. *tergestina* (Kuetzing) Elenkin

Locations: L. Mapourika (Flint 1979); Matheson (Flint 1979).

PHORMIDIUM Kuetzing ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 156.

Thallus of unbranched filaments. Filaments parallel or entangled; sheaths hyaline, usually confluent. Trichomes cylindrical; often briefly tapered in apical region; apical cell conical, capitate or bluntly pointed, with or without calyptra; crosswalls with or without constrictions.

Key to Reported Species

1. Cells 1–2 μm broad; filaments associated with mucilage of other blue-greens **P. mucicola**
1. Cells (2.6):8–10 μm broad; filaments not associated with mucilage of other blue-greens **P. rotheanum** (var. only)

Phormidium mucicola Naumann & Huber-Pestalozzi, 1929

In: Huber-Pestalozzi & Naumann, *Bericht der Deutschen botanischen Gesellschaft* 47: 67.

Fig. 28

Filaments associated with mucilage of other blue-greens (**Microcystis aeruginosa**, **Chroococcus limneticus**); 5–15 μm long; scattered; sheath thin, confluent. Trichomes not tapered toward apex; apical cell rounded, without calyptra; crosswalls slightly constricted. Cells 1–2 μm broad, 2–3 μm long; contents granular.

Synonym: **Pseudanabaena mucicola** (Naumann & Huber-Pestalozzi) Schwabe.

Locations: L. Rerewhakaaitu, Rotomanuka South; Mill Pond (this study).
L. Rotoma (Thomasson 1974); Rotorua [N.I.](Thomasson 1974); Te Anau (Thomasson 1980).

Phormidium rotheanum var. **capitatum** Desikachary, 1959

Cyanophyta. Indian Council of Agricultural Research, New Delhi. p. 258.

Not observed by authors; Appendix I, Fig. 85a,b.

Description after Desikachary (1959, p. 258). Filaments more or less straight to regularly spiralled/coiled; 9–12 μm broad; sheath thin, hyaline, sometimes confluent. Trichomes slightly or not tapered towards apex; apical cell capitate, somewhat flat to broadly conical or rounded; crosswalls constricted, granular. Cells 8–10 μm broad, 1.5–2.7 μm long. Cell measurements recorded in New Zealand by Cassie & Freeman (1980) are smaller; 2.6–3 μm broad, 0.4–0.6 μm long.

Note: the type **Phormidium rotheanum** Itzigsohn has not been observed in New Zealand. Cell measurements for the type are longer (2.7–4 μm long, 8–11 μm broad); the type is tapered towards the apex, but not regularly spiralled/coiled or capitate [Desikachary (1959), p. 258]. Drouet (1968) considers the differences between **P. rotheanum** and **P. rotheanum** var. **capitatum** warrant separation at the generic level; he classifies them as **Schizothrix mexicana** Gomont and **Microcoleus lyngbyaceus** (Kuetzing) Crouan, respectively.

Location: L. Kanono (Cassie & Freeman 1980).

SPIRULINA Turpin ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 249.

Trichomes unicellular in appearance if using light microscopy (crosswalls obvious if using electron microscopy); cylindrical; regularly spiralled/coiled, spirals compact or loose; usually not tapered towards apex; apical cell often rounded; without sheath. Cell contents homogeneous or granular.

Key to Reported Species

1. Distance between spiral windings 3–4 μm . . **S. major**
 1. Distance between spiral windings 12–20 μm . . **S. laxa**

Spirulina laxa G.M. Smith, 1916

Bulletin of the Torrey Botanical Club 43: 481.

Fig. 29

Trichomes 2 μm broad; loosely spiralled; windings 4–6 μm broad; distance between windings 12–20 μm . Cell contents homogeneous.

Synonym: **Oscillatoria laxa** (G.M. Smith) Bourrelly

Locations: L. Clearwater, Kimihia, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa (N.I.), Ruatuna; Arahaki Lagoon (this study).

Spirulina major Kuetzing ex Gomont, 1892

Annales des sciences naturelles, série 7, botanique 16: 251.

Fig. 30

Trichomes 1–1.5 μm broad; loosely spiralled; windings 3–4 μm broad; distance between windings 3–4 μm . Cell contents homogeneous.

Synonym: **Oscillatoria major** (Kuetzing) Bourrelly

Locations: L. Ngaroto, Rotoehu, Tarawera (this study).

L. Ellesmere (Lineham 1983 unpub.); Rotomahana (Thomasson 1974).

Nostocaceae

Trichomes unbranched; sometimes tapered in apical region; with or without sheath; heterocysts usually present; reproduction by trichome fragmentation, hormogonia or akinetes.

Key to Reported Genera

- | | | |
|---|----|---|
| 1 Trichomes without heterocysts . . | .. | .. Raphidiopsis (p. 47) |
| 1 Trichomes usually with heterocysts | .. | 2 |
| 2 Trichomes without intercalary heterocyst(s) | .. | 3 |
| 2 Trichomes with intercalary heterocyst(s) | .. | 4 |
| 3 Heterocyst terminal; adjacent to akinete . . | .. | .. Cylindrospermum (p. 44) |
| 3 Heterocyst terminal; remote from akinete | .. | .. Anabaenopsis (in part)
(p. 42) |
| 4 Heterocysts intercalary; paired | .. | .. Anabaenopsis (in part)
(p. 42) |
| 4 Heterocyst(s) intercalary; single | .. | .. 5 |
| 5 Trichomes tapered at both ends; sometimes lying parallel in fascicles | .. | .. Aphanizomenon (p. 43) |
| 5 Trichomes not tapered at both ends; not lying parallel in fascicles | .. | .. 6 |
| 6 Vegetative cells much broader than long | .. | .. Nodularia (p. 44) |
| 6 Vegetative cells as long or longer than broad or spherical | .. | .. 7 |
| 7 Trichomes in firm colonial envelopes | .. | .. Nostoc (p. 46) |
| 7 Trichomes not in firm colonial envelopes | .. | .. Anabaena (p. 35) |

ANABAENA Bory de Saint-Vincent ex Bornet & Flahault, 1886 ['1888']

Annales des sciences naturelles, série 7, botanique 7: 224.

Trichomes solitary or in flocculent masses; straight, circinate, flexuous or spiralled/coiled; sheath soft, usually inconspicuous. Vegetative cells spherical, barrel-shaped, ellipsoidal, quadrate or cylindrical; contents homogeneous or granular, with or without gas vacuoles. Heterocysts intercalary. Akinetes single or in catenate series; adjacent to or remote from heterocyst.

Key to Reported Species

- | | | |
|--|-------|--------------------------------------|
| 1. Trichomes straight or flexuous but not spiralled/coiled | .. .. | .. 2 |
| 1. Trichomes circinate, twisted, regularly or irregularly spiralled/coiled | .. .. | .. 3 |
| 2. Vegetative cells spherical or subspherical | .. | 4 |
| 2. Vegetative cells not spherical or subspherical | | 5 |
| 3. Trichomes regularly spiralled/coiled | .. .. | .. A. spiroides (plus 2 var.) |
| 3. Trichomes circinate or irregularly twisted | .. .. | .. 6 |
| 4. Vegetative cells 8 μm broad | .. | .. A. solitaria |
| 4. Vegetative cells < 8 μm broad | .. | 7 |
| 5. Wall of akinete verrucose | .. .. | .. A. verrucosa |
| 5. Wall of akinete not verrucose | .. .. | .. 8 |
| 6. Vegetative cells spherical; markedly flattened at poles; 8–10 μm broad | .. .. | .. A. circinalis |
| 6. Vegetative cells subspherical to ellipsoidal; 4–6 μm broad | .. .. | .. A. flos-aquae |
| 7. Akinetes single; remote from or adjacent to heterocyst; 16–20 μm long | .. .. | .. A. affinis |
| 7. Akinetes single or in series; on one or both sides of heterocyst; 8–18 μm long | .. .. | .. A. sphaerica (var. only) |
| 8. Vegetative cells \geq 3 μm broad | .. | 9 |
| 8. Vegetative cells < 3 μm broad | .. | 10 |
| 9. Akinetes spherical | .. .. | .. A. aphanizomenoides |
| 9. Akinetes not spherical | .. .. | .. 11 |
| 10. Akinetes 4–5 μm broad, 15–24 μm long; gas vacuoles usually present | .. .. | .. A. tenericaulis |
| 10. Akinetes 2–3 μm broad, 9–13 μm long; without gas vacuoles | .. .. | .. A. miniata |
| 11. Akinetes remote from heterocyst | .. .. | .. 12 |
| 11. Akinetes on both sides of heterocyst | .. .. | .. A. oscillarioides |
| 12. Akinetes cylindrical | .. .. | .. A. aequalis |
| 12. Akinetes spherical to ovoid | .. .. | .. A. macrospora |

Anabaena aequalis Borge, 1906*Arkiv för botanik* 6: 65.

Fig. 31

Trichomes straight. Vegetative cells barrel-shaped; 4–6 μm broad, 2–4 μm long; contents granular. Heterocysts 4–5 μm broad, 6–12 μm long. Akinetes single or in pairs; remote from heterocyst; 5–7 μm broad, 21–41 μm long [akinete measurements are from Huber-Pestalozzi (1938, p. 218) because akinetes were not present in our samples].

Locations: L. Koraha, Rotoaira (this study).

Anabaena affinis Lemmermann, 1897*Abhandlungen herausgegeben vom Naturwissenschaftlichen Verein zu Bremen* 14: 261.

Fig. 32

Trichomes straight or slightly flexuous; sheath wide, faintly discernible. Vegetative cells spherical; 5–6 μm broad; contents homogeneous or gas vacuoles present. Heterocysts spherical; 7–8 μm broad. Akinetes single; remote from or adjacent to heterocyst; broadly ovoid, truncately rounded poles; 10–11 μm broad, 16–20 μm long.

Synonym: **Anabaena catenula** var. **affinis** (Lemmermann) Geitler.

Locations: L. Clearwater, Evelyn, Georgina, Heron, Lyndon, Okataina, Pearson, Pounui, Rotoaira, Rotokakahi, Rotorua (N.I.), Sarah (this study).

L. Okareka (Thomasson 1974); Rotoiti [N.I.] (Thomasson 1974); Rotokawau [by Rotorua] (Thomasson 1974).

Anabaena aphanizomenoides Forti, 1911*Atti e memorie dell'Accademia d'agricoltura, scienze e lettere, arti e commercio di Verona, series 4, 12: 126.*

Fig. 33

Trichomes straight or slightly flexuous; apical cell usually tapered. Vegetative cells cylindrical or barrel-shaped; 3–4 μm broad, 3–5 μm long; contents homogeneous or gas vacuoles present. Heterocysts ellipsoidal, sometimes subspherical; 4–5 μm broad, 5–7 μm long. Akinetes usually single; spherical; 8–10 μm broad.

Synonym: **Anabaena aphanizomenoides** (Forti) Horecká & Komárek

Locations: L. Hakanoa, Karapiro, Ohakuri, Okataina, Pupuke, Rotoaira, Rotoehu, Tarawera, Tikitapu; Ross Creek Reservoir (this study).

L. Rotoehu (Cassie 1978); Rotoma (Cassie 1978).

Anabaena circinalis Rabenhorst ex Bornet & Flahault, 1886 ['1888']*Annales des sciences naturelles, série 7, botanique 7: 230.*

Fig. 34

Trichomes flexuous, circinate or irregularly twisted. Vegetative cells spherical or markedly flattened at poles; 8–10 μm broad; gas vacuoles usually present. Heterocysts spherical or subspherical; 8–9 μm broad. Akinetes usually not adjacent to heterocyst; cylindrical with rounded poles; 15–18 μm broad, up to 33 μm long. The most frequently recorded akinete measurements were 9–10 μm broad, 14–15 μm long; few mature akinetes were observed.

Synonyms: **Anabaena circinalis** (Kuetzing) Rabenhorst
Anabaena flos-aquae var. **circinalis** (Rabenhorst) Kirchner
Anabaena hassallii (Kuetzing) Wittrock

Locations: L. Hakanoa, Kainui, Karapiro, Mangahia, Mangakaware, Ngaroto, Ohakuri, Okaro, Omapere, Opuri, Rotoaira, Rotokakahi, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoma, Rotorua (N.I.), Taupo, Waahi, Whangape (this study).

L. Atiamuri (Magadza 1978); Karapiro (Hill 1975; Magadza 1978); Maraetai (Hill 1971 unpub., 1975); Morton Dam (Vidal & Maris-McArthur 1973); Ngahewa (Paerl 1979); Ohakuri (Cassie 1969; Hill 1971 unpub., 1975; Magadza 1978); Okareka (Thomasson 1974); Pupuke (Haughey 1969; Connor 1977); Rotoiti [N.I.] (Cassie 1969*, 1974, 1975); Rotomahana (Thomasson 1974); Rotongaio (Paerl 1979); Rotorua [N.I.] (Cassie 1969, 1974, 1975; Stout 1973; Thomasson 1974; Fish 1975; Kloos 1976 unpub.; White *et al.* 1978); Tarawera (Thomasson 1960); Taupo (Thomasson 1960; Flint 1975; Hill 1975; Connor 1977); Waipapa (Magadza 1978); Western Springs (Johnstone 1972); Whakamaru (Cassie 1974; Magadza 1978).

*Although identified as *Anabaena circinalis*, some of the specimens observed may have been *A. spiroides* (see Cassie 1978)

Anabaena flos-aquae (Lyngbye) de Brebisson ex Bornet & Flahault, 1886 ['1888']*Annales des sciences naturelles, série 7, botanique 7: 228.*

Fig. 35

Trichomes very flexuous or twisted in irregular spiral. Vegetative cells subspherical to ellipsoidal; 4–6 μm broad, 5–9 μm long; gas vacuoles usually numerous. Heterocysts subspherical or depressed at poles; 4–8 μm broad. Akinetes usually single, sometimes in short series near centre of trichome; usually adjacent to heterocyst; cylindrical with rounded poles; sides curved when mature; 7–9 μm broad, 18–30 μm long.

Synonym: **Anabaena lemmermannii** Richter

Locations: L. Forsyth, Kainui, Mangakaware, Ngaroto, Ohakuri, Okataina, Opouri, Pounui, Rerewhakaaitu, Rotoaira, Rotoehu, Rotokaeo, Rotokakahi, Rotomanuka North, Rotomanuka South, Rotorua (N.I.), Tarawera, Taupo, Tikitapu, Waahi; Te Opai Lagoon, Tomahawk Lagoon; Taieri Pond (this study).

L. Alexandrina (Stout 1981); Aratiatia (Hill 1970a unpub., 1971 unpub.); Butcher's Dam (Connor 1977); Ellesmere (Lineham 1983 unpub.); Hayes (Hill 1970b unpub.; Burns 1973, 1975; Burns & Mitchell 1974; Connor 1977); Horseshoe (Parsons 1985); Johnson (Burns 1973, 1975; Burns & Mitchell 1974; Connor 1977; Mitchell & Burns 1981); Mahinerangi (Mitchell & Galland 1981); Maraetai (Reid 1966; Connor 1977); Ngahewa (Flint 1975; Forsyth & McColl 1975; Kellar & Goldman 1979); Ohakuri (Hill 1970a unpub.); Okaro (Flint 1977; Dryden & Vincent 1986); Pupuke (Cassie 1979); Rotoehu (Cassie 1978); Rotoiti [N.I.] (Cassie 1969, 1974, 1975; Vincent *et al.* 1984); Rotomahana (Thomasson 1974); Rotorua [N.I.] (Stout 1973); Roundabout (Flint 1966b, 1975; Stout 1969; Connor, 1977); Tarawera (Thomasson 1974); Taupo (Hill 1970a unpub., 1970b unpub., 1971 unpub., 1975; Thomasson 1974); Tomahawk Lagoon (Mitchell 1971; Stout 1975; Flint 1975; Connor 1977).

Anabaena macrospora Klebahn, 1895

Forschungsberichte aus der Biologischen Station zu Ploen 3: 13;
Flora 80: 269.

Not observed by authors; Appendix I, Fig. 86a,b,c.

Description after Prescott (1962, p. 517). Trichomes straight or flexuous. Vegetative cells spherical or somewhat ellipsoidal; 5–6.5 μm broad, (5)–6–8(9) μm long. Heterocysts spherical; 6 μm broad. Akinetes remote from heterocyst; spherical to ovoid; 17–18.5 μm broad, 24–26 μm long.

Locations: L. Kanono (Cassie & Freeman 1980); Waingata (Cassie & Freeman 1980).

Anabaena miniata Skuja, 1956

Nova acta Regiae Societas Scientiarum Upsaliens, series 4, 16(3): 80.

Not observed by authors; Appendix I, Fig. 87.

Description after Skuja (1956, p. 80). Trichomes straight or slightly flexuous. Vegetative cells cylindrical; 4–11 μm long; central area delicately granulose, without gas vacuoles. Heterocysts cylindrical to ellipsoidal; 2 μm broad, 5–10 μm long. Akinetes usually single; remote from heterocyst; cylindrical with rounded or truncated poles; 2–3 μm broad, 9–13 μm long.

Locations: L. Rotoiti [N.I.] (Cassie 1974, 1975).

Anabaena oscillarioides Bory de Saint-Vincent ex Bornet & Flahault, 1886 ['1888']

Annales des sciences naturelles, série 7, botanique 7: 233.

Not observed by authors; Appendix I, Fig. 88a,b,c.

Description after Prescott (1962, p. 517). Trichomes usually straight. Vegetative cells barrel-shaped or truncate-spherical; 4–6 μm broad, 7.8–8 μm long. Heterocysts spherical or ovoid; 6–8 μm broad, (6)–9.2–(10) μm long. Akinetes on both sides of heterocyst (rarely on one side only); cylindrical; 8–10–(15.2) μm broad, 20–40–(76) μm long.

Locations: L. Ohakuri (Coulter *et al.* 1983); Rotongaio (Paerl 1978, 1979; Vincent 1980; Forsyth *et al.* 1983; Viner & Kemp 1983); Rotorua [N.I.](Paerl 1978); Taupo (Paerl 1978; Vincent 1980).

Note: recent work by R.D. Pridmore and C.S. Reynolds (Freshwater Biological Association, United Kingdom) has indicated that the *Anabaena* species presently in Lake Rotongaio is not *A. oscillarioides* Bory de Saint-Vincent. The identity of this species and of the strains earlier reported in Lake Rotongaio as *A. oscillarioides* is currently under investigation.

***Anabaena solitaria* Klebahn, 1895**

Flora 80: 270.

Fig. 36

Trichomes straight. Vegetative cells almost spherical; 8 μm broad; gas vacuoles present. Heterocysts broadly ellipsoidal; 8–10 μm broad. Akinetes single, on one or both sides of heterocyst or remote from heterocyst; 9–10 μm broad, 20–29 μm long.

Synonym: ***Anabaena catenula* var. *solitaria*** (Klebahn) Geitler

Locations: L. Ngaroto, Omapere, Rotoaira (this study).
L. Middleton (Thomasson 1980); Okataina (Thomasson 1974); Rotoma (Thomasson 1974); Tikitapu (Thomasson 1974).

***Anabaena sphaerica* var. *tenuis* G.S. West, 1907**

Journal of the Linnean Society of Botany 38: 171.

Fig. 37

Trichomes straight. Vegetative cells spherical to subspherical; 5 μm broad. Heterocysts subspherical; 5–6 μm broad. Akinetes single or in series; on one or both sides of heterocyst; 6–8 μm broad, 8–10 μm long [Huber-Pestalozzi (1938, p. 206) gives akinete measurements of 10 μm broad, 11–14 μm long].

Note: the type *Anabaena sphaerica* Bornet & Flahault has not been observed in New Zealand. Vegetative cells (5–6 μm broad), heterocysts (6–7 μm broad), and akinetes (8–12 μm broad, 12–18 μm long) are larger in the type [Huber-Pestalozzi (1938), p. 206].

Locations: Cooper's Lagoon (this study).

Anabaena spiroides Klebahn, 1895*Flora 80*: 268.

Fig. 38

Trichomes regularly spiralled/coiled; windings 45–60 μm broad; distance between windings 40–50 μm . Vegetative cells spherical; 6–8 μm broad; gas vacuoles numerous. Heterocysts subspherical; 6–8 μm broad. Akinetes usually adjacent to heterocyst; initially spherical, later elongated; 12–14 μm broad, 17–28 μm long.

Locations: L. Hakanoa, Ngahewa; Mill Pond (this study).
L. Karapiro (Hill 1975); Maraetai (Hill 1975); Ngahewa (Flint 1975; Forsyth & McColl 1975; Paerl & Kellar 1978; Kellar & Goldman 1979; Paerl 1979); Ngapouri (Flint 1975, 1977); Ohakuri (Hill 1969 unpub., 1975); Okareka (Flint 1975); Okaro (McColl 1972; Flint 1975, 1977; Paerl 1979; Dryden & Vincent 1986); Okataina (Flint 1975, 1977); Rotoehu (Cassie 1978); Rotoiti [N.I.] (Cassie 1978); Rotoiti [Kaikoura] (Flint 1975); Rotokakahi (McColl 1972; Flint 1975, 1977); Rotorua [Kaikoura] (Flint 1975); Rotorua [N.I.] (Cassie 1978); Taupo (Hill 1969 unpub., 1975); Waahi (Chapman 1981).

Anabaena spiroides var. **crassa** Lemmermann, 1898*Botanisches centralblatt* 76: 155.

Not observed by authors; not illustrated; see figure for type.

Description after Prescott (1962, p. 518). Differs from type in that vegetative cells (10–11.5 μm broad), heterocysts (10 μm broad, 12 μm long) and akinetes (19–20 μm broad, 25–30 μm long) are larger. Akinetes are remote from heterocysts.

Synonym: **Anabaena spiroides** f. **crassa** (Lemmermann) Elenkin.

Locations: L. Maraetai (Hill 1971 unpub.); Ngahewa (Kellar & Goldman 1979); Ohakuri (Hill 1969 unpub., 1971 unpub.); Okataina (Thomasson 1974); Whakamaru (Cassie 1974).

Anabaena spiroides var. **tumida** Nygaard, 1945

Dansk plantep plankton, en flora over de vigtigste ferskvandsformer. Gyldendal Kjøbenhavn. p. 17.

Figs. 39, 40

Differs from type in that trichome windings are narrower (30–50 μm) and the distance between windings is shorter (10–20 μm); vegetative cells (7–8 μm broad) and heterocysts (8–9 μm broad) are also larger. Akinetes are slightly smaller (10–12 μm broad, 17–21 μm long), often remote from heterocyst, sometimes in series, and are curved at one margin and almost straight at the other at maturity.

Locations: L. Hakanoa, Mangahia, Ngaroto, Tarawera, University of Waikato; Te Opai Lagoon (this study).
L. Okareka (Thomasson 1974); Okataina (Thomasson 1974); Rotorua [N.I.] (Thomasson 1974); Tarawera (Thomasson 1974).

Anabaena tenericaulis Nygaard, 1949

Kongelige Danske Videnskabernes Selskabs Biologiske Skrifter 7: 207.

Fig. 41

Trichomes straight or slightly flexuous; usually slightly narrowed towards apex. Vegetative cells cylindrical; 2–3 μm broad, 3–8 μm long; gas vacuoles usually present. Heterocysts cylindrical with rounded poles to ellipsoidal; 3 μm broad, 4–7 μm long. Akinetes single; remote from heterocyst; cylindrical with rounded poles; 4–5 μm broad, 15–24 μm long.

Locations: L. Ngaroto, Rotokakahi, Rotokauri, Rotomanuka South, Tarawera, Te Koutu, Whangape; Tomahawk Lagoon; Taieri Pond (this study).
L. Orakai (Flint 1975).

Anabaena verrucosa Boye-Petersen, 1928

The Botany of Iceland 2: 299.

Fig. 42

Trichomes straight. Vegetative cells quadrate to cylindrical with rounded poles; 2–4 μm broad, 3–5 μm long. Heterocysts cylindrical with rounded poles; 3–4 μm broad, 5–6 μm long. Akinetes usually single, sometimes in pairs; remote from heterocyst; cylindrical; 5–7 μm broad, 12–16 μm long; wall verrucose.

Locations: L. Pounui (this study).

Anabaenopsis Miller, 1923

Archiv Russkago protistologicheskagoobshchestva 2: 125.

Trichomes solitary; short; spiralled/coiled. Heterocysts terminal and/or intercalary, latter in pairs formed by unequal division of 2 adjoining vegetative cells. Akinetes intercalary; remote from heterocyst.

Anabaenopsis arnoldii Aptekarj, 1926

Notulae systematicae ex Instituto cryptogamico Horti botanici petropolitani 4: 54.

Not observed by authors; Appendix I, Fig. 89.

Description after Geitler (1932, p. 809). Trichomes solitary; regularly spiralled/coiled; 1/2 to 9 spirals; windings 25–58 µm broad; distance between windings 7–32 µm; sheath thick, hardly perceptible. Vegetative cells adpressed spherical, sometimes nearly ellipsoidal; 6.5–9 µm broad, 6.5–8.5 µm long; gas vacuoles present. Heterocysts intercalary and terminal; spherical and 5.8–7 µm broad or ellipsoidal and 7–9.2 µm broad, 8–10.5 µm long. Akinetes in pairs, sometimes single; intercalary; ellipsoidal; 10.4–11.5 µm broad, 11.5–14.5 µm long.

Locations: L. Forsyth (Flint 1975).

Aphanizomenon Morren ex Bornet & Flahault, 1886 ['1888']

Annales des sciences naturelles, série 7, botanique 7: 241.

Trichomes usually lying parallel in fascicles; more or less straight; slightly tapered at both ends; sheath absent. Heterocysts intercalary; usually single. Akinete single; located in mid-region of trichome; remote from heterocyst.

Aphanizomenon flos-aquae (Linnaeus) Ralfs ex Bornet & Flahault, 1886 ['1888']

Annales des sciences naturelles, série 7, botanique 7: 241.

Fig. 43

Trichomes sometimes lying parallel in fascicles, often solitary; straight or slightly flexuous; slightly tapered at both ends; terminal cells usually greatly lengthened. Vegetative cells cylindrical; 4–6 µm broad, 5–12 µm long; gas vacuoles numerous. Heterocysts located in mid-region of trichome; cylindrical; no distinct polar nodule; 5–7 µm broad, 7–18 µm long. Akinetes 6–8 µm broad, 35–80 µm long [akinetete measurements are from Smith (1920, p. 62) because akinetes were not present in our samples].

Locations: L. Heron, Pounui (this study).

L. Horowhenua (Cassie 1974); Kanono (Cassie & Freeman 1980); Manapouri (Thomasson 1980); Matheson (Flint 1966b, 1979; Connor 1977); Middleton (Thomasson 1980); Okareka (Thomasson 1974); Okataina (Thomasson 1974); Rotoehu (Cassie 1978); Rotoiti [N.I.] (Thomasson 1974); Tarawera (Thomasson 1960; Flint 1966b; Connor 1977); Taupo (Thomasson 1974); Tikitapu (Thomasson 1974).

CYLINDROSPERMUM Kuetzing ex Bornet & Flahault, 1886 ['1888']

Annales des sciences naturelles, série 7, botanique 7: 249.

Trichomes straight or flexuous; uniformly broad; embedded in almost imperceptible thin mucilage; crosswalls constricted. Vegetative cells cylindrical. Heterocysts terminal; at one or both ends. Akinetes single, rarely in series; adjacent to heterocyst; larger than vegetative cells.

Cylindrospermum minutissimum Collins, 1896

Erythea 4: 120.

Fig. 44

Trichomes loosely entangled. Vegetative cells 2–3 μm broad, 4–6 μm long. Heterocysts 3–4 μm broad, 6–9 μm long. Akinetes cylindrical; 6–9 μm broad, 20–30 μm long; slightly tumid, smooth wall.

Locations: L. Kimihia, Mangahia (this study).

NODULARIA Mertens ex Bornet & Flahault; emend. Nordin & Stein, 1980
nom. cons., non Link ex Lyngbye, 1819

Canadian journal of botany 58: 1211–1244.

Filaments solitary or in clusters; straight or flexuous; uniformly broad in vegetative state; sheath hyaline, sometimes confluent; crosswalls constricted. Vegetative cells distinctly broader than long; disc-shaped. Heterocysts intercalary; regularly spaced. Akinetes single, in pairs or in series; intercalary.

Key to Reported Species

- | | |
|---|---------------------|
| 1. Vegetative cells 3–6 μm broad; heterocysts 4–7 μm
broad | N. harveyana |
| 1. Vegetative cells 7–11 μm broad; heterocysts 8–11
μm broad | N. spumigena |

Nodularia harveyana (Thwaites) Thuret; emend. Nordin & Stein, 1980.

Canadian journal of botany 58: 1216.

Fig. 45

Filaments usually solitary; straight or flexuous; sheath thin. Vegetative cells 3–6 μm broad. Heterocysts spherical or subspherical; 4–7 μm broad. Akinetes spherical to subspherical; 4–8 μm broad.

- Synonyms: **Nodularia aerophila** Barbez
Nodularia harveyana f. *sphaerocarpa* (Elenkin) Elenkin
Nodularia harveyana var. *sphaerocarpa* (Bornet & Flahault) Elenkin
Nodularia harveyana var. *turicensis* (Cramer) Migula
Nodularia skujae Gonzales-Guerrero
Nodularia sphaerocarpa Bornet & Flahault
Nodularia spumigena var. *minor* Fritsch
Nodularia turicensis (Cramer) Hansgirg
- Locations: L. Ngahewa, Pounui, Rotokakahi, Rotorua (N.I.), Taupo; Simmond's Lagoon (this study).
 L. Rotoiti [N.I.] (Thomasson 1974).

Nodularia spumigena Mertens ex Bornet & Flahault; emend. Nordin & Stein, 1980

Canadian journal of botany 58: 1215–1216.

Fig. 46

Filaments solitary or clustered in gelatinous masses; sheath thick, hyaline. Vegetative cells 7–11 μm broad; gas vacuoles sometimes present. Heterocysts 8–11 μm broad. Akinetes single, in pairs or in series; 10–12 μm broad.

- Synonyms: **Spermosira litorea** var. *crassior* Forti
Nodularia major (Kuetzing) Kirchner
Nodularia spumigena Mertens
Nodularia spumigena var. *aerophila* Barbez
Nodularia spumigena f. *crassa* (Woronichin) Elenkin
Nodularia spumigena var. *crassa* Woronichin
Nodularia spumigena var. *genuina* Bornet & Flahault
Nodularia spumigena var. *hungarica* Hortobágyi
Nodularia spumigena var. *litorea* (Thuret) Bornet & Flahault
Nodularia spumigena var. *major* (Kuetzing) Bornet & Flahault
Nodularia spumigena var. *vacuolata* Fritsch
Nodularia willei Gardner
- Locations: L. Clearwater, Ellesmere, Forsyth (this study).
 L. Ellesmere (Hughes *et al.* 1974; Flint 1975; Connor 1977; Dodgshun 1981; Lineham 1983 unpub.); Forsyth (Flint 1969, 1970, 1975; Stout 1973; Hughes *et al.* 1974; Connor 1977); Okataina (Thomasson 1974); Rotoiti [N.I.] (Cassie 1974, 1975); Rotomahana (Thomasson 1974); Rotorua [N.I.] (Cassie 1969, 1974, 1975; Connor 1975); Taharoa (Sarma unpub., as cited in Sarma & Chapman 1975).

DOUBTFUL TAXON

Nodularia implexa (Bornet & Flahault) Bourrelly, 1970

Les algues d'eau douce 3. N. Boubée & Cie. Paris. p. 418.

Not observed by authors; not illustrated.

Description after Desikachary (1959, p. 430). Filaments often in fascicles; straight or curved; 5–10 μm long; crosswalls slightly constricted; sheaths thin, membranous, hyaline. Vegetative cells quadrate or cylindrical; 8–9 μm broad. Heterocysts quadrate to oblong. Akinetes 4–32 in series; 8–9 μm broad, 16–34 μm long.

This taxon was originally described as **Aulosira implexa** by Bornet & Flahault (1888). However, Nordin & Stein (1980) do not consider the description of **Aulosira implexa** to be within the generic limits of **Nodularia** Mertens ex Bornet & Flahault. Drouet (1973) places this taxon in **Scytonema hofmannii** Agardh.

Location: Western Springs (Johnstone 1972).

NOSTOC Vaucher ex Bornet & Flahault, 1886 ['1888']

Annales des sciences naturelles, série 7, botanique 7: 181.

Thallus spherical or amorphous. Filaments unbranched; flexuous, curved or entangled; enclosed by copious mucilage; sheath confluent with colonial mucilage, sometimes distinct. Vegetative cells spherical, barrel-shaped or cylindrical. Heterocysts intercalary, sometimes terminal. Akinetes single or in series; spherical to broadly ellipsoidal.

Nostoc commune Vaucher ex Bornet & Flahault, 1886 ['1888']

Annales des sciences naturelles, série 7, botanique 7: 203.

Fig. 47

Thallus firm; gelatinous; spherical when immature, later flattened, expanded, undulated; membranous or leathery; often torn, perforated; many centimeters in diameter. Filaments flexuous, entangled; sheath thick, usually distinct only at the periphery. Vegetative cells barrel-shaped or subspherical; 4–6 μm broad, 5–7 μm long. Heterocysts subspherical or spherical; 7–8.5 μm broad. Akinetes same shape and size as vegetative cells.

Synonyms: **Stratonostoc commune** (Vaucher) Elenkin

Locations: Arahaki Lagoon (this study).

L. Taupo (Armstrong 1935).

RAPHIDIOPSIS Fritsch & Rich, 1929

Transactions of the Royal Society of South Africa 18: 91.

Trichomes solitary; short; curved to weakly sigmoid or more or less straight; tapered to a fine point at one or both ends; without sheath; crosswalls with or without constrictions. Vegetative cells cylindrical; with or without gas vacuoles. Heterocysts absent. Akinetes single or in pairs in mid-region of trichome.

Raphidiopsis mediterranea Skuja, 1937

Hedwigia 77: 23.

Figs. 48, 49

Trichomes more or less straight, sometimes weakly sigmoid; tapered at both ends; 105–225 μm long [Desikachary (1959, p. 422) and Huber-Pestalozzi (1938, p. 180) give length range of 40–110 μm and 40–163 μm , respectively]; crosswalls indistinct, not constricted. Vegetative cells 2–3 μm broad, 10–16 μm long; with or without gas vacuoles. Akinetes single or in pairs; subterminal or intercalary; 2.8–3.4 μm broad, 6.7–9.3·(13.5) μm long [description and measurements of akinetes are from Desikachary (1959, p. 423) because akinetes were not present in our samples].

Locations: L. Rotoaira, Taupo (this study).

Rivulariaceae

Trichomes unbranched or falsely branched; markedly tapered from base to apex, usually from basal heterocyst; sheath firm, at least in basal portion, lamellated or homogeneous; reproduction by trichome fragmentation, hormogonia or akinetes.

Key to Reported Genera

- 1 Trichomes falsely branched; basal portions enclosed within common sheath **Dichothrix** (p. 48)
- 1 Trichomes unbranched; radiately arranged; enclosed within common sheath **Gloeotrichia** (p. 48)

DICHOTHRIX Zanardini ex Bornet & Flahault, 1886

Annales des sciences naturelles, série 7, botanique 3: 373.

Thallus of 2–6 trichomes within a common sheath for at least part of their length. Trichomes falsely branched; markedly tapered from base to apex; sheath thick or thin, hyaline or yellowish, homogeneous or lamellated, sometimes bulbous at base, tapered with trichome or flared towards apex to form a funnel; crosswalls with or without constrictions. Heterocysts basal, sometimes intercalary.

Dichothrix gypsophila (Kuetzing) Bornet & Flahault, 1886

Annales des sciences naturelles, série 7, botanique 3: 377.

Fig. 50

Filaments 15–18 μm broad; sheath lamellated, yellowish, funnelled towards apex. Trichomes 6–8 μm broad at base; markedly tapered from base to apex; crosswalls constricted. Vegetative cells barrel-shaped in basal region, as long as broad or longer in distal region. Heterocysts basal; hemispherical; 10 μm broad.

Synonyms: **Calothrix gypsophila** (Kuetzing) Thuret.

Locations: L. Clearwater (this study).
L. Pearson (Nordstedt 1888).

GLOEOTRICHIA J.G. Agardh ex Bornet & Flahault, 1886

Annales des sciences naturelles, série 7, botanique 4: 365.

Thallus of radiating trichomes; hemispherical, spherical or amorphous; colonial mucilage soft or firm, hyaline or yellow. Trichomes markedly tapered from basal hetero-

cyst to apex; sheaths often confluent. Vegetative cells increasing in length towards distal end of trichome. Heterocysts basal or intercalary. Akinetes usually single; adjacent to heterocyst; cylindrical.

Key to Reported Species

1. Mature colonies spherical or hemispherical . . . **G. echinulata**
 1. Mature colonies amorphous . . . **G. natans**

Gloeotrichia echinulata (J.E. Smith) Richter, 1894

Forschungsberichte aus der Biologischen Station zu Ploen 2: 31.

Fig. 51

Thallus spherical or hemispherical. Trichomes markedly tapered from basal heterocyst to a fine point which extends beyond periphery of colonial mucilage; sheaths confluent, extended over basal $\frac{1}{3}$ to $\frac{1}{2}$ of trichome. Vegetative cells hemispherical, spherical or barrel-shaped in basal region of trichome, 8–10 μm broad; cylindrical in mid-region of trichome; markedly elongated in apical region, 1–2 μm broad; gas vacuoles numerous. Heterocysts spherical; 8–10 μm broad. Akinetes adjacent to heterocyst; cylindrical; 10–18 μm broad, up to 50 μm long [description and measurements of akinetes are from Prescott (1962, p. 558) because akinetes were not present in our samples].

Synonym: **Gloeotrichia echinulata** (Smith & Sowerby) Richter

Locations: L. Pounui (this study).

L. Okareka (Kloos 1976 unpub.).

Gloeotrichia natans (Hedwig) Rabenhorst ex Bornet & Flahault, 1886

Annales des sciences naturelles, série 7, botanique 4: 369.

Not observed by authors; Appendix I, Fig. 90.

Description after Prescott (1962, p. 559). Immature thallus sessile, irregularly spherical; mature thallus free-floating, expanded, amorphous. Filaments at first somewhat radiate, becoming irregularly arranged and entangled with age; markedly tapered from basal heterocyst; basal sheath extended over about $\frac{1}{3}$ of trichome, lamellated, wrinkled, wide, funnel-shaped. Vegetative cells barrel-shaped or subspherical in basal region of trichome; becoming quadrate or subcylindrical distally; 7–10 μm broad. Heterocysts spherical or ovoid; 8–12 μm broad. Akinetes single; adjacent to heterocyst; 12–18 μm broad, up to 250 μm long; thick-walled.

Synonym: **Gloeotrichia natans** (Hedwig) Welwitsch.

Location: L. Okareka (Thomasson 1974); Rotoma (Thomasson 1974).

Scytonemataceae

Trichomes usually falsely branched; with or without heterocysts; sheath usually firm, definite, sometimes lamellated; reproduction by trichome fragmentation, hormogonia or akinetes.

TOLYPOTHRIX Kuetzing ex Bornet & Flahault, 1886 ['1887']

Annales des sciences naturelles, série 7, botanique 5: 118.

Trichomes sometimes solitary, more often forming cottony tufts/expansions; falsely branched; branches mostly long, flexuous, arising from just below heterocyst; sheath firm and thin, or somewhat gelatinous. Vegetative cells quadrate, cylindrical or barrel-shaped. Heterocysts single or in series; spherical, subspherical, cylindrical or quadrate. Akinetes usually in series; ovoid, ellipsoidal or subspherical.

Key to Reported Species

1. Thallus penicillate to caespitose; filaments many centimeters long **T. penicillata**
 1. Thallus caespitose; filaments \leq 2 cm long **T. tenuis**

Tolypothrix penicillata (Agardh) Thuret ex Bornet & Flahault, 1886 ['1887'].

Annales des sciences naturelles, série 7, botanique 5: 123.

Not observed by authors; Appendix I, Fig. 91.

Description after Desikachary (1959, p. 497). Thallus penicillate to caespitose or cushion-like. Filaments many centimeters long, 8–17 μm broad; repeatedly branched; sheath thin, close to trichome. Vegetative cells 4–13 μm broad. Heterocysts single; cylindrical, quadrate or spherical.

Synonyms: **Tolypothrix distorta** f. **penicillata** (Agardh) Kossinskaja.

Tolypothrix distorta var. **penicillata** (Agardh) Lemmermann

Location: L. Rerewhakaaitu (Chapman & Clayton 1975).

Tolypothrix tenuis Kuetzing ex Bornet & Flahault, 1886 ['1887']

Annales des sciences naturelles, série 7, botanique 5: 122.

Not observed by authors, Appendix I, Fig. 92.

Description after Desikachary (1959, p. 495). Thallus caespitose or cushion-like. Filaments (4)–6–17–(18) μm broad, up to 2 cm long; repeatedly branched; sheath thin, close to trichome, often lamellated. Vegetative cells quadrate; (4)–5–13 μm broad. Heterocysts single or 2–5 in series; cylindrical, rounded or discoid; 6–14 μm broad, 2.3–6 μm long.

Synonym: **Tolypothrix lanata** f. **tenuis** (Kuetzing) Cedergren

Locations L. Sarah (Flint 1938); Tarawera (Nordstedt 1888).

CHROOCOCCALES

Cells solitary or in colonies of definite or indefinite shape; without heterocysts or akinetes; reproduction primarily by binary fission, sometimes endospores.

CLASSIFICATION OF REPORTED TAXA

Family	<p>Chroococcaceae</p> <p>Aphanocapsa delicatissima W. & G.S. West</p> <p>Aphanocapsa elachista W. & G.S. West</p> <p>Aphanocapsa elachista var. conferta W. & G.S. West</p> <p>Aphanothece nidulans Richter</p> <p>Aphanothece stagnina (Sprengel) Braun</p> <p>Chroococcus dispersus (Keissler) Lemmermann</p> <p>Chroococcus dispersus var. minor G.M. Smith</p> <p>Chroococcus limneticus Lemmermann</p> <p>Chroococcus minor (Kuetzing) Naegeli</p> <p>Chroococcus minutus (Kuetzing) Naegeli</p> <p>Chroococcus turgidus (Kuetzing) Naegeli</p> <p>Coelosphaerium kuetzingianum Naegeli</p> <p>Dactylococcopsis acicularis Lemmermann*</p> <p>Dactylococcopsis irregularis G.M. Smith*</p> <p>Dactylococcopsis smithii R. & F. Chodat</p> <p>Gloeocapsa stegophila (Itzigsohn) Rabenhorst</p> <p>Gloeothece linearis var. composita G.M. Smith</p> <p>Gomphosphaeria lacustris Chodat</p> <p>Gomphosphaeria lacustris var. compacta Lemmermann</p> <p>Merismopedia elegans Braun</p> <p>Merismopedia elegans var. major G.M. Smith</p> <p>Merismopedia glauca (Ehrenberg) Naegeli</p> <p>Merismopedia minima Beck</p> <p>Merismopedia punctata Meyen</p> <p>Merismopedia tenuissima Lemmermann</p> <p>Microcystis aeruginosa Kuetzing</p> <p>Microcystis elabens (de Brébisson) Kuetzing</p> <p>Microcystis elabens var. minor Nygaard</p> <p>Microcystis flos-aquae (Wittrock) Kirchner†</p> <p>Microcystis minutissima W. West</p> <p>Microcystis pulverea (Wood) Forti</p> <p>Rhabdoderma lineare Schmidle & Lauterborn</p>
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*doubtful taxon

†possible growth form of *Microcystis aeruginosa* Kuetzing (see text)

Chroococcaceae

Unicellular or colonial; not filamentous or pseudofilamentous in colonial forms.

Key to Reported Genera

1. Cells arranged in a single layer near periphery of colonial envelope 2
1. Cells not arranged in a single layer near periphery of colonial envelope 3
 2. Cells in gelatinous matrix with radiating strands **Gomphosphaeria** (p. 61)
 2. Cells in gelatinous matrix without radiating strands **Coelosphaerium** (p. 58)
3. Colonies plate-like; cells in rectilinear series .. **Merismopedia** (p. 62)
3. Colonies not plate-like; cells not in rectilinear series 4
 4. Cells considerably longer than broad .. 5
 4. Cells not considerably longer than broad .. 6
5. Cells narrowly fusiform; pointed at one or both ends **Dactylococcopsis** (p. 58)
5. Cells not narrowly fusiform; not pointed at one or both ends **Rhabdoderma** (p. 67)
 6. Cells ovoid, ellipsoidal, or cylindrical .. 7
 6. Cells spherical or sub-spherical .. 8
7. Individual cell sheaths not evident .. **Aphanothece** (p. 54)
7. Individual cell sheaths distinct **Gloeothece** (p.60)
 8. Colonies usually combined to form expanded masses **Gloeocapsa** (p.60)
 8. Colonies not combined to form expanded masses 9
9. Colonies usually < 8 cells, rarely up to 32 cells .. **Chroococcus** (p. 55)
9. Colonies many-celled 10
 10. Cells remotely and evenly distributed within colony **Aphanocapsa** (p. 53)
 10. Cells crowded within colony **Microcystis** (p.64)

APHANOCAPSA Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamten Naturwissenschaften 10: 52.

Colonies spherical, ovoid, ellipsoidal or amorphous; many celled when mature. Cells evenly and remotely distributed within homogeneous, hyaline (sometimes yellowish) colonial mucilage. Cells spherical; contents homogeneous or finely granular; individual sheaths indistinct, confluent with colonial mucilage.

Key to Reported Species

- | | |
|--|--------------------------------------|
| 1. Cells 0.5–0.7 μm broad | .. A. delicatissima |
| 1. Cells 1.5–2 μm broad . . | .. A. elachista (plus 1 var.) |

Aphanocapsa delicatissima W. & G.S. West, 1912

Journal of the Linnean Society of Botany 40: 431

Fig. 52

Colonies spherical or ellipsoidal; 20–27 μm broad, up to 45 μm long. Cells 0.5–0.7 μm broad.

Synonym: **Microcystis pulverea** f. **delicatissima** (W. & G.S. West) Elenkin

Locations: L. Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa (N.I.) (this study).

Aphanocapsa elachista W. & G.S. West, 1894

Journal of the Linnean Society of Botany 30 : 276

Fig. 53

Colonies spherical or ellipsoidal; 25–40 μm broad, up to 50 μm long. Cells 1.5–2 μm broad; often arranged in pairs; contents homogeneous.

Synonyms: **Microcystis elachista** (W. & G.S. West) Starmach

Microcystis pulverea f. **elachista** (W. & G.S. West) Elenkin

Locations: L. Kainui, Mangahia, Ngaroto, Omapere, Ruatuna, Wanaka (this study).

L. Manapouri (Thomasson 1980); Mapourika (Flint 1979); Middleton (Thomasson 1980); Okareka (Thomasson 1974); Rotoiti [N.I.] (Thomasson 1974); Rotoma (Thomasson 1974); Rotomanuka North (Etheredge 1983 unpub.); Rotorua [N.I.] (Thomasson 1974); Sarah (Flint 1938); Taupo (Thomasson 1974); Te Anau (Thomasson 1980).

Aphanocapsa elachista var. *conferta* W. & G.S. West, 1912*Journal of the Linnean Society of Botany* 40 : 432

Fig. 54

Differs from type in that cells are more closely spaced within colony. Colonies may also be larger, $\geq 50 \mu\text{m}$ [see Desikachary (1959, p. 133), Huber-Pestalozzi (1938, p. 138), Prescott (1962, p. 453)], but we have not observed this distinction. Geitler (1932, p. 157) questions the validity of this taxon.

Synonym: **Microcystis pulverea** f. *conferta* (W. & G.S. West) Elenkin

Locations: L. Cameron, Clearwater, Forsyth, Georgina, Hawdon, Kimihia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa (N.I.), Ruatuna (this study).

APHANOTHECE Naegeli, 1849

nom. cons. (syn. prius **COCCOCHLORIS** C. Sprengel, 1807)

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamten Naturwissenschaften 10: 59.

Colonies spherical, oval, ellipsoidal or amorphous; many-celled when mature. Cells evenly distributed within firm, homogeneous colonial mucilage. Cells ellipsoidal to cylindrical with rounded poles; contents homogeneous or finely granular; individual sheaths indistinct, confluent with colonial mucilage.

Key to Reported Species

- | | |
|--|-----------------------|
| 1. Cells 1–1.5 μm broad, 2–3 μm long | .. A. nidulans |
| 1. Cells 3–5 μm broad, 4–7 μm long | .. A. stagnina |

Aphanothece nidulans Richter, 1884*Botaniska notiser* 1884: 128

Fig. 55

Colonies spherical or oval. Cells cylindrical with rounded poles; 1–1.5 μm broad, 2–3 μm long; contents homogeneous.

Synonyms: **Anacystis nidulans** (Richter) Drouet & Daily
Aphanothece saxicola f. *nidulans* (Richter) Elenkin
Coccochloris nidulans (Richter) Drouet & Daily

Locations: L. Hakanoa, Rotokauri (this study).
 L. Rotoma (Thomasson 1974).

Aphanothece stagnina (Sprengel) Braun, 1865

In: L. Rabenhorst, *Flora europaea algarum aquae dulcis et submarinae* 2. E. Kummer. Leipzig. p.66

Fig. 56

Colonies ellipsoidal, spherical or amorphous. Cells cylindrical with rounded poles; 3–5 μm broad, 4–7 μm long; contents homogeneous.

Note: colonies with larger cells (5–6.5 μm broad, 7.7–11 μm long) have been observed in other countries and classified by some phycologists [e.g., Smith (1920, p. 45), Prescott (1962, p. 469)] as **Aphanothece prasina** Braun. However, others [e.g., Desikachary (1959, p. 137), Huber-Pestalozzi (1938, p. 141)] consider that a separate taxon is unwarranted and simply give a larger range of cell measurements (3–6.5 μm broad, 4.5–11 μm long) with their taxonomic descriptions of **A. stagnina**.

Synonym: **Coccochloris stagnina** Sprengel

Locations: L. Clearwater (this study).

L. Okareka (Thomasson 1974).

CHROOCOCCUS Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamteten Naturwissenschaften 10: 45.

Cells occasionally solitary, more usually in colonies of 2–4–8 (sometimes 16–32). Cells spherical or subspherical (hemispherical after cell division); contents homogeneous or granular; individual sheaths homogeneous or lamellated.

Key to Reported Species

- | | | | |
|---|----|----|--------------------------------------|
| 1. Sheath lamellated | .. | .. | C. turgidus |
| 1. Sheath non-lamellated | .. | .. | .. 2 |
| 2. Cells or clusters of cells markedly isolated from one another | .. | .. | .. C. dispersus (plus 1 var.) |
| 2. Cells or clusters of cells not markedly isolated from one another | .. | .. | .. 3 |
| 3. Cells 2–3 μm broad | | .. | C. minor |
| 3. Cells >3 μm broad | .. | .. | .. 4 |
| 4. Cells 4–6 μm broad; cells single or in groups of 2–4 per colony | .. | .. | .. C. minutus |
| 4. Cells 6–12 μm broad; 4–32 per colony | | .. | C. limneticus |

Chroococcus dispersus (Keissler) Lemmermann, 1904*Arkiv för botanik* 2: 102

Fig. 57

Colonies of usually 4–16 cells. Cells single and widely separated from one another or arranged in small clusters isolated from one another; distance between single cells or cell clusters, 13–18 μm . Cells spherical; 3–4 μm broad.

Synonyms: **Chroococcus minor** var. **dispersus** Keissler

Gloeocapsa minor f. **dispersa** (Keissler) Hollerbach

Locations: L. Clearwater, Gault, Georgina, Kainui, Mangatangi, Mangakaware, Ngaroto, Opouri, Rotokauri, Rotomanuka North, Rotoroa (N.I.), Whangape (this study).

L. Ohau (Thomasson 1980); Rotoma (Thomasson 1974); Sarah (Flint 1938).

Chroococcus dispersus var. **minor** G.M. Smith, 1920*Bulletin of Wisconsin Geological and Natural History Survey* 57: 28.

Not illustrated; see figure for type.

Differs from type in that cells are smaller; cells 1.5–2.5 μm broad.

Synonym: **Gloeocapsa minima** f. **smithii** Hollerbach

Locations: L. Kainui, Mangahia, Maratoto, Ngaroto, Okareka, Ototoa, Rotokaeo, Rotokauri, Rotomanuka South, Waahi (this study).

Chroococcus limneticus Lemmermann, 1898*Botanisches centralblatt* 76: 153

Fig. 58

Colonies spherical or ovoid; 4–32 cells. Cells closely arranged and equidistant from one another or in groups of 2 or 4 with the groups in close proximity to each other. Cells spherical to subspherical; 6–12 μm broad; contents homogeneous; individual sheaths usually indistinct, confluent with hyaline colonial mucilage.

Synonyms: **Anacystis limnetica** (Lemmermann) Drouet & Daily

Chroococcus minutus var. **limneticus** (Lemmermann) Hansgirg

Gloeocapsa limnetica (Lemmermann) Hollerbach

Locations: L. Clearwater, Forsyth, Georgina, Kainui, Kimihia, Maratoto, Ngaroto, Opouri, Ototoa, Rerewhakaaitu, Rotokakahi, Rotokauri, Rotomanuka North, Rotoroa (N.I.), Ruatuna, University of Waikato, Waahi, Whangape; Nihotapu Reservoir; Arahaki Lagoon (this study).

L. Ototoa (Green 1973 unpub., 1976); Rotoiti [N.I.] (Thomasson 1960; Cassie 1974, 1975); Rotomanuka North (Etheredge 1983 unpub.); Rotorua [N.I.] (Cassie 1974, 1975); Sarah (Flint 1938).

Chroococcus minor (Kuetzing) Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamten Naturwissenschaften 10: 47.

Fig. 59

Cells single or in groups of 2 (rarely 4). Cells 2–3 μm broad; contents homogeneous; individual sheaths hyaline, non-lamellated.

Synonym: **Gloeocapsa minor** (Kuetzing) Hollerbach

Locations: L. Maratoto, Rotokauri, Rotomanuka North, Serpentine, Tikitapu (this study).

L. Maratoto (Etheredge 1983 unpub.).

Chroococcus minutus (Kuetzing) Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamten Naturwissenschaften 10: 46.

Fig. 60

Cells single or in groups of 2–4, enclosed by wide, non-lamellated, hyaline colonial sheath. Cells spherical to subspherical; 4–6 μm broad; contents homogeneous or finely granular.

Synonym: **Gloeocapsa minuta** (Kuetzing) Hollerbach

Locations: L. Clearwater, Mangakaware, Ngaroto, Rotokauri, Rotoroa (N.I.), Rotorua (N.I.); McLarens Falls Dam (this study).

L. Taharoa (Cassie & Freeman 1980); Waikere (Cassie & Freeman 1980).

Chroococcus turgidus (Kuetzing) Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamten Naturwissenschaften 10: 46.

Fig. 61

Colonies of 2–4 cells, enclosed by a wide, hyaline, lamellated colonial sheath. Cells ovoid or hemispherical; 8–32 μm broad; contents sometimes coarsely granular; individual sheaths distinct.

Synonym: **Gloeocapsa turgida** (Kuetzing) Hollerbach

Locations: L. Kimihia, Ngaroto, Rotokauri, Rotoroa (N.I.) (this study).

L. Rotoehu (Cassie 1978); Rotoma (Cassie 1978); Tikitapu (Thomasson 1974); Waikaremoana (Cassie 1978).

COELOSPHAERIUM Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamten Naturwissenschaften 10: 54.

Colonies spherical, ovoid, ellipsoidal or amorphous. Cells arranged in single layer near periphery of colonial envelope; colonial mucilage homogeneous or with gelatinous fibrils. Cells spherical, ovoid, ellipsoidal, subspherical or subpyriform; contents homogeneous or with numerous gas vacuoles.

Coelosphaerium kuetzingianum Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamten Naturwissenschaften 10: 54.

Fig. 62

Colonies spherical or ovoid (may appear ovate) with thin hyaline envelope; 22–72 μm broad. Cells spherical to subspherical; 2–4 μm broad; contents usually homogeneous, gas vacuoles sometimes present.

Locations: L. Clearwater, Coleridge, Ellesmere, Forsyth, Hawdon, Ohakuri, Pupuke, Rotokauri, Te Koutu (this study).
L. Ellesmere (Hughes *et al.* 1974; Connor 1977); Forsyth (Connor 1977); Rotomahana (Thomasson 1960; Flint 1966b); Rotorua [N.I.] (Cassie 1974, 1975); Tomahawk Lagoon (Connor 1977).

DACTYLOCOCCOPSIS Hansgirg, 1888

Notarisia 3: 590

Cells solitary or colonial, if colonial, enclosed by conspicuous ellipsoidal or fusiform gelatinous envelope. Cells fusiform, straight, sigmoid or slightly arcuate; contents homogeneous; individual sheaths inconspicuous, confluent with colonial mucilage.

Note: the original descriptions and drawings of the genus **Dactylococcopsis** are ambiguous (Komárek, 1969a), and numerous taxonomic problems have arisen as a consequence. The descriptions of several species correspond to those of algae from other genera, e.g., **Ankistrodesmus** and **Monoraphidium** (Chlorococcales, Chlorophyceae). Although some authors (e.g. Drouet & Daily, 1956) doubt the validity of this genus, Komárek (1969b) proposes that the name **Dactylococcopsis** Hansgirg ex R. & F. Chodat, 1925, be conserved with **D. smithii** R. & F. Chodat as the type species. **D. linearis** Geitler and **D. planctonica** Teiling are also included within the genus. **D. acicularis** Lemmermann and **D. irregularis** G.M. Smith, both of which have been recorded in New Zealand, are considered by Komárek (1969a) to be doubtful taxa.

Dactylococcopsis smithii R. & F. Chodat, 1925

Veroeffentlichungen des Geobotanischen Instituts, Eidgenoessische technische Hochschule Ruebel (Zurich) 3: 455.

Fig. 63

Colonies ellipsoidal or broadly fusiform; 4–16 cells, usually 8. Cells fusiform, straight or slightly arcuate; frequently paired and arranged end to end with one pole rounded and the other pointed; 2–4 μm broad, 10–12 μm long; contents homogeneous.

Synonym: **Dactylococcopsis raphidioides** Hansgirg sensu G.M. Smith (1920).

Locations: L. Pupuke, Rotorua (N.I.), Sarah, Wanaka (this study).
L. Ohakuri (Cassie 1969); Rotoiti [N.I.] (Cassie 1969, 1974, 1975);
Rotorua [N.I.] (Cassie 1969, 1974, 1975).

DOUBTFUL TAXA

Dactylococcopsis acicularis Lemmermann, 1900

Bericht der Deutschen botanischen Gesellschaft 18: 309.

Not illustrated.

Cells straight; markedly fusiform; poles attenuated to extremely fine points; 2–4 μm broad, 45–65 μm long; contents homogeneous.

An alga corresponding to this description was found by the authors in L. Clearwater, Mangahia, Mangakaware, Matheson, Ngaroto, Ototoa, Rotoehu, Rotokauri, Rotokawau (by Rotorua), Rotomanuka North, Te Koutu, Whangape, McLarens Falls Dam and Mill Pond, but was not considered to be a blue-green and was recorded as **Monoraphidium griffithii** (Berkeley) Komárková-Legnerová, 1969.

Locations: L. Pataka (Chapman & Boubeé 1977 unpub.); Rotoiti [N.I.] (Cassie 1978); Rotoma (Cassie 1978).

Dactylococcopsis irregularis G.M. Smith, 1922

Arkiv för botanik 17: 6.

Not illustrated.

Cells extremely fusiform; sharply curved or spiralled (no more than 2 rotations); 1–2 μm broad, 30–52 μm long; contents homogeneous.

An alga corresponding to this description was found by the authors at L. Cameron, Kainui, Karapiro, Kourarau, Maratoto, Mangahia, Mangakaware, Ngaroto, Ohakuri, Omapere, Ototoa, Rerewhakaaitu, Rotokauri, Rotomanuka North, Rotomanuka South, Rotorua (N.I.), Te Koutu, Waahi, Whangape, Mill Pond and Barton's Lagoon, but was not considered to be a blue-green and was recorded as **Monoraphidium irregulare** (G.M. Smith) Komárková-Legnerová, 1969.

Locations: L. Ngarotoiti (Chapman & Boubée 1977 unpub.); Okareka (Kloos 1976 unpub.); Rotomanuka North (Chapman & Boube 1977 unpub.); Rotopataka (Chapman & Boube 1977 unpub.).

GLOEOCAPSA Kuetzing, 1843
nom. cons. (syn. prius **BICHATIA** Turpin, 1827)

Phycologia generalis; oder, Anatomie, physiologie und systemkunde der tange. F.A. Brockhaus. Leipzig. p. 173.

Cells sometimes solitary, usually in clusters of 2-32 which may aggregate with other clusters to form large, mucilaginous, amorphous masses. Cells spherical; contents homogeneous or granular; individual sheaths thick, homogeneous or lamellated, sometimes pigmented.

Gloeocapsa stegophila (Itzigsohn) Rabenhorst, 1863

Kryptogamen—flora von Sachsen, der Ober—Lausitz, Thueringen und Nordboehmen, mit beruecksichtigung der benachbarten lander 1. E. Kummer. Leipzig. p. 72.

Not observed by authors; Appendix I, Fig. 93.

Description after Desikachary (1959, p. 119). Colonies spherical; 50-140 μm broad; 4-32 cells. Cells spherical; 3-4 μm broad; individual sheaths golden to orange-yellow to red, usually non-lamellated.

Locations: L. Parawanui (Cassie & Freeman 1980).

GLOEOTHECE Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamten Naturwissenschaften 10: 57.

Colonies small; often united to form amorphous gelatinous mass. Cells ellipsoidal or cylindrical; straight or curved; contents homogeneous or finely granular; individual sheaths distinct.

Gloeothece linearis var. **composita** G.M. Smith, 1920

Bulletin of Wisconsin Geological and Natural History Survey 57: 46.

Fig. 64

Colonies elongate; 12-14 μm broad, 25-38 μm long; 2-8 cells; sheaths of groups of

cells not confluent, non-lamellated. Cells cylindrical; 3 μm broad, 4–6 μm long; contents finely granular.

Note: the type, *Gloeothece linearis* Naegeli, has not been observed in New Zealand. Cell measurements for the type are longer and narrower; 1.2–2.5 μm broad, 10.5–18 μm long (Prescott, 1962, p. 462).

Synonym: **Rhabdoderma lineare** f. **compositum** (G.M. Smith) Hollerbach

Location: L. Forsyth (this study).

COMPHOSPHAERIA Kuetzing, 1836

Algarum aquae dulcis germanicarum 16. C.A. Schwetschkii & Son. Halis Saxonum. p. 151.

Colonies spherical, subspherical or ellipsoidal. Cells distributed peripherally; single, in pairs or groups of 4, situated at ends of gelatinous projections which radiate from a dense core at centre of colony; contents homogeneous, rarely granular; individual sheaths distinct or confluent with hyaline, homogeneous colonial envelope.

Gomphosphaeria lacustris Chodat, 1898

Bulletin de l'Herbier Boissier 6: 180.

Fig. 65

Colonies spherical or subspherical; up to 60 μm broad. Cells spherical or ellipsoidal; 1.5–2.5 μm broad, 2–3 μm long; contents homogeneous; individual sheaths confluent with colonial envelope.

Synonyms: **Coelosphaerium lacustre** (Chodat) Elenkin & Hollerbach

Coelosphaerium lacustre (Chodat) Ostefeld

Locations: L. Clearwater, Forsyth, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka South, Tarawera, Wanaka (this study).

L. Clearwater (Flint 1975); Ellesmere (Hughes *et al.* 1974; Flint 1975); Fergus (Flint 1975); Forsyth (Flint 1975); Georgina (Flint 1975); Gunn (Flint 1975; Thomasson 1980); Hawea (Flint 1975; Thomasson 1980); Large Spectacles (Flint 1975); Manapouri (Flint 1975; Thomasson 1980); Middleton (Thomasson 1980); Monowai (Flint 1975); North Mavora (Flint 1975); Okaro (McColl 1972; Flint 1975, 1977); Pearson (Flint 1975); Rotoehu (Cassie 1978); Rotoiti [N.I.] (Cassie 1978); Rotoma (Cassie 1978); Roundabout (Flint 1975); Selfe (Flint 1975); Sheppard (Flint 1975); Small Spectacles (Flint 1975); South Mavora (Flint 1975); Tarawera (Thomasson 1974); Taylor (Flint 1975); Te Anau (Flint 1975; Thomasson 1980); Te Au (Flint 1975); Waikaremoana (Cassie 1978); Waitaki (Flint 1975); Wakatipu (Lemmerman 1899; Flint 1975; Thomasson 1980); Wanaka (Flint 1975) Tomahawk Lagoon (Flint 1975).

Gomphosphaeria lacustris var. **compacta** Lemmermann, 1899

Abhandlungen herausgegeben vom Naturwissenschaftlichen Verein zu Bremen 16: 341.

Not illustrated; see figure for type.

Differs from type in more compact arrangement of longer cells; cells 1.5–2.0 μm broad, 4–6 μm long.

Synonym: **Gomphosphaeria compacta** (Lemmermann) Ström

Locations: L. Rotokauri (this study).

L. Wakatipu (Lemmerman 1899).

MERISMOPEDIA Meyen, 1839

Neues system der pflanzen-physiologie 3. Haude & Spenersche. Berlin. p. 440.

Colonies plate-like; 1 cell thick; quadrangular or with rolled margin; cells arranged in rectilinear series. Cells spherical to subspherical; contents usually homogeneous, gas vacuoles rare; individual sheaths usually confluent with hyaline, homogeneous colonial envelope.

Key to Reported Species

- | | |
|--|------------------------------------|
| 1. Cells \leq 2 μm broad .. | .. 2 |
| 1. Cells $>$ 2 μm broad .. | .. 3 |
| 2. Cells 0.5 μm broad | .. M. minima |
| 2. Cells 1.5–2 μm broad | .. M. tenuissima |
| 3. Cells 6–11 μm broad .. | .. M. elegans (plus 1 var.) |
| 3. Cells $<$ 6 μm broad | .. 4 |
| 4. Cells 3–5 μm broad, closely arranged | .. M. glauca |
| 4. Cells 2.5–3 μm broad, not closely arranged | .. M. punctata |

Merismopedia elegans A. Braun, 1849

In: F.T. Kuetzing, Species algarum. F.A. Brockhaus. Leipzig. p. 472.

Fig. 66

Cells spherical or broadly ovoid; compactly arranged; 6–8 μm broad; contents homogeneous. Rows of cells distorted with age.

Locations: L. Kainui, Rotomanuka North, Rotorua (N.I.) (this study).

L. Rotomanuka North (Etheredge 1983 unpub.).

Merismopedia elegans var. **major** G.M. Smith, 1920

Bulletin of Wisconsin Geological and Natural History Survey 57: 32.

Not observed by authors; not illustrated; see figure for type.

Description after Smith (1920, p. 32). Differs from type in that cells are broader; cells 10–11 µm broad.

Synonym: **Merismopedia major** (G.M. Smith) Geitler
Merismopedia smithii de Toni

Locations: L. Rotoiti [N.I.] (Cassie 1975); Rotorua (Cassie 1969, 1974).

Merismopedia glauca (Ehrenberg) Naegeli, 1849

Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft fuer die gesamen Naturwissenschaften 10: 55.

Fig. 67

Colonies of 4–16–32 cells. Cells hemispherical, spherical or ovoid; closely and regularly arranged; 3–5 µm broad; contents homogeneous.

Locations: L. Kuratau, Rotokauri, Rotomanuka North; McLarens Falls Dam; Cooper's Lagoon (this study).
L: Lyndon (Nordstedt 1888); Rotomahana (Thomasson 1974); Wakatipu (Lemmerman 1899; Flint 1975; Thomasson 1980); Wanaka (Thomasson 1980) Pukepuke Lagoon (Potts 1982).

Merismopedia minima Beck, 1897

Annalen des Kaiserlich—Koeniglich Naturhistorischen Museums (Wien) 12: 83.

Fig. 68

Colonies of 4–64 cells. Cells closely arranged; 0.5 µm broad.

Locations: L. Forsyth, Hakanoa, Kainui, Mangakaware, Ngaroto, Rotoiti (N.I.), Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa (N.I.), Ruatuna, Te Koutu, Whangape (this study).

Merismopedia punctata Meyen, 1839

Neues system der pflanzen—physiologie 3. Haude & Spenersche. Berlin. p. 440.

Fig. 69

Colonies of usually 4–64 cells. Cells spherical or hemispherical; not closely arranged; 2.5–3 µm broad; contents homogeneous.

- Synonym: **Merismopedia glauca** var. **punctata** (Meyen) Hansgirg
 Locations: L. Forsyth, Ngaroto; Cooper's Lagoon (this study).
 L. Ellesmere (Lineham 1983 unpub.).

Merismopedia tenuissima Lemmermann, 1898

Botanisches centralblatt 76: 154.

Fig. 70

Colonies of usually 16 cells. Cells spherical, hemispherical or ovoid; closely arranged; 1.5–2 μm broad; contents homogeneous.

- Locations: L. Forsyth, Gault, Hakanoa, Kimihia, Kuratau, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa (N.I.), Te Koutu, Whangape; McLarens Falls Dam; Cooper's Lagoon, Simmond's Lagoon (this study).
 L. Ellesmere (Lineham 1983 unpub.); Rotomanuka North (Etheredge 1983 unpub.).

MICROCYSTIS Lemmermann, 1910¹
nom. cons., non Kuetzing, 1833

Kryptogamen—flora der Mark Brandenburg 3. Gebrueder Borntraeger. Leipzig. p. 45.

Colonies spherical, ellipsoidal, elongate or amorphous; entire or perforated to give reticulate or clathrate masses. Cells densely aggregated within copious colonial mucilage. Cells spherical or ellipsoidal; gas vacuoles usually present.

Key to Reported Species

- | | | |
|---|---------|---------------------------------|
| 1. Colonies containing distinct groups of cells | .. | 2 |
| 1. Colonies, not containing distinct groups of cells | .. | 3 |
| 2. Cells 1.5–2 μm long | .. | M. minutissima |
| 2. Cells 3–8.5 μm long | .. | M. elabens (plus 1 var.) |
| 3. Cells 2–3 μm broad; no gas vacuoles | .. | M. pulverea |
| 3. Cells 3–4 μm broad; gas vacuoles usually numerous | .. .. . | 4 |
| 4. Colonies clathrate | .. | M. aeruginosa |
| 4. Colonies not clathrate | .. .. | M. flos-aquae |

¹Synonymous with **Polycystis** Kuetzing [e.g., Whitford & Schumacher (1973, p. 129)].

Microcystis aeruginosa Kuetzing, 1845–1871

Tabulae phycologicae; oder, Abbildungen der tange 1. W. Koehne. Nordhausen. p. 8.

Fig. 71

Colonies may exhibit considerable range of size and morphology, each form referable to a particular stage of the life cycle (see Reynolds *et al.*, 1981). Colonies spherical, saccate, or irregularly ovoid; reticulate or clathrate with maturity; maximum linear dimension 50–1000 μm . Colonial mucilage hyaline, homogeneous. Cells spherical; 3–4 μm broad; gas vacuoles usually numerous.

Synonyms: **Clathrocystis aeruginosa** (Kuetzing) Henfrey
Microcystis aeruginosa f. **aeruginosa** (Kuetzing) Elenkin
Polycystis aeruginosa Kuetzing

Locations: L. Hakanoa, Kainui, Mangakaware, Maratoto, Ngaroto, Rotokaeo, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa (N.I.), Rotorua (N.I.), Ruatuna, Te Koutu, University of Waikato, Waahi, Whangape (this study).

L. Horowhenua (Cassie 1974); Kanono (Cassie & Freeman 1980); Ohakuri (Hill 1969 unpub.; Cassie 1974); Okaro (Dryden & Vincent 1986); Rotoiti [N.I.] (Cassie 1974, 1975; Fish 1975); Rotoiti [Kaikoura] (Flint 1966b); Rotomanuka North (Etheredge 1983 unpub.); Rotorua [N.I.] (Cassie 1974, 1975; Kloos 1976 unpub.); Rotorua [Kaikoura] (Flint 1966b); Tutira (McCull 1978); Western Springs (Johnstone 1972).

Note: Several workers, using the classification system of Drouet & Daily (Appendix II), have reported **Anacystis cyanea** (Kuetzing) Drouet & Daily from New Zealand lakes. This taxon includes **M. aeruginosa** and **M. flos-aquae**. **A. cyanea** has been reported from Lakes Hakanoa (Flint 1975), Horowhenua (Flint 1975), Karapiro (Hill 1975), Little Mason (Bowden 1977), Maraetai (Hill 1975), Mason (Bowden 1977), Ohakuri (Cassie 1969; Hill 1975), Rotoiti [N.I.] (Cassie 1969; Chapman *et al.* 1971a, 1971b), Rotoiti [Kaikoura] (Flint 1966b, 1975; Connor 1977), Rotorua [N.I.] (Cassie 1969), Rotorua [Kaikoura] (Flint 1966b, 1975; Connor 1977), Waiparera (Flint 1975) and Waitawa (Flint 1975).

Microcystis elabens (de Brébisson) Kuetzing, 1846

Tabulae phycologicae; oder, Abbildungen der tange 1. W. Koehne. Nordhausen. p. 6.

Not observed by authors; not illustrated; see figure for **M. elabens** var. **minor**.

Description after Desikachary (1959, p. 97). Colonies spherical or flat and expanding; daughter colonies present when mature. Cells oblong; 2–4.5 μm broad, (3)4–8.5 μm long; gas vacuoles present.

Synonyms: **Anacystis elabens** (de Brébisson) Setchell & Gardner
Aphanothece conglomerata Richter
Aphanothece elabens (de Brébisson) Elenkin
Coccolchloris elabens (de Brébisson) Drouet & Daily
Microcystis elabens var. **major** Bachmann
Polycystis elabens (de Brébisson) Kuetzing

Location: L. Tikitapu (Thomasson 1974).

Microcystis elabens var. **minor** Nygaard, 1926

Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kjøbenhavn 82: 204.

Fig. 72

Differs from type in that cells are narrower and shorter; cells 1–2 μm broad, 3–5 μm long.

Synonym: **Microcystis elabens** Lemmermann

Location: L. Clearwater (this study).

Microcystis flos-aquae (Wittrock) Kirchner, 1900

In: A. Engler and K. Prantl, Die natuerlichen pflanzenfamilien 1. W. Englemann. Leipzig. p. 56.

Observed by authors, but considered a form of **Microcystis aeruginosa** Kuetzing [see Prescott (1962, p. 456), Reynolds *et al.* (1981)]; not illustrated.

Colonies spherical, ovoid, ellipsoidal, sometimes elongate; not clathrate. Colonial mucilage hyaline, homogeneous. Cells spherical; 3–4 μm broad; gas vacuoles usually numerous.

Synonyms: **Microcystis aeruginosa** f. **flos-aquae** (Wittrock) Elenkin

Polycystis flos-aquae Wittrock

Locations: L. Horowhenua (Cassie 1974); Maraetai (Reid 1966); Ohakuri (Hill 1969 unpub.; Cassie 1974); Rotoiti [N.I.] (Cassie 1974, 1975); Whakamaru (Cassie 1974).

Microcystis minutissima W. West, 1912

Proceedings of the Royal Irish Academy 31: 41.

Fig. 73

Colonies irregular; usually consist of several daughter colonies; maximum linear dimension 60 μm [Huber-Pestalozzi (1938, p. 136) gives 140 μm]. Cells ellipsoidal; 1–1.5 μm broad, 1.5–2 μm long; gas vacuoles sometimes present.

Synonym: **Aphanothece saxicola** f. **minutissima** (West) Elenkin

Locations: L. Ellesmere, Forsyth (this study).

L. Ellesmere (Lineham 1983 unpub.).

Microcystis pulverea (Wood) Forti, 1907

In: G.B. de Toni, Sylloge algarum omnium hucusque cognitarum 5. Published by author. Padua. p. 92.

Fig. 74

Colonies spherical or ellipsoidal. Cells spherical; 2–3 μm broad; no gas vacuoles.

Note: **M. pulverea** is included in **Microcystis incerta** Lemmermann by Prescott (1962). Others

[e.g., Smith (1920), Huber-Pestalozzi (1938), Desikachary (1959)] consider **M. incerta** a variety of **M. pulvereae** (i.e., **M. pulvereae** var. **incerta** (Lemmermann) Crow).

Synonyms: **Microcystis pulvereae** f. **pulvereae**(Wood) Elenkin

Microcystis pulvereae (Wood) Migula

Polycystis pulvereae (Wood) Forti

Polycystis pulvereae (Wood) Wolle

Locations: L. Koraha, Okaro, Rerewhakaaitu, Rotomanuka South, Rotoroa (N.I.), Te Koutu, Whangape; McLarens Falls Dam (this study).

L. Sarah (Flint 1938).

RHABDODERMA Schmidle & Lauterborn, 1900

In: W. Schmidle, *Bericht der Deutschen botanischen Gesellschaft* 18: 149.

Colonies ovoid or ellipsoidal. Cells ellipsoidal, cylindrical with rounded poles, arcuate or sigmoid; long axes point in same direction; contents homogeneous; individual sheaths confluent with hyaline, homogeneous colonial mucilage.

Rhabdoderma lineare Schmidle & Lauterborn, 1900

In: W. Schmidle, *Bericht der Deutschen botanischen Gesellschaft* 18: 149.

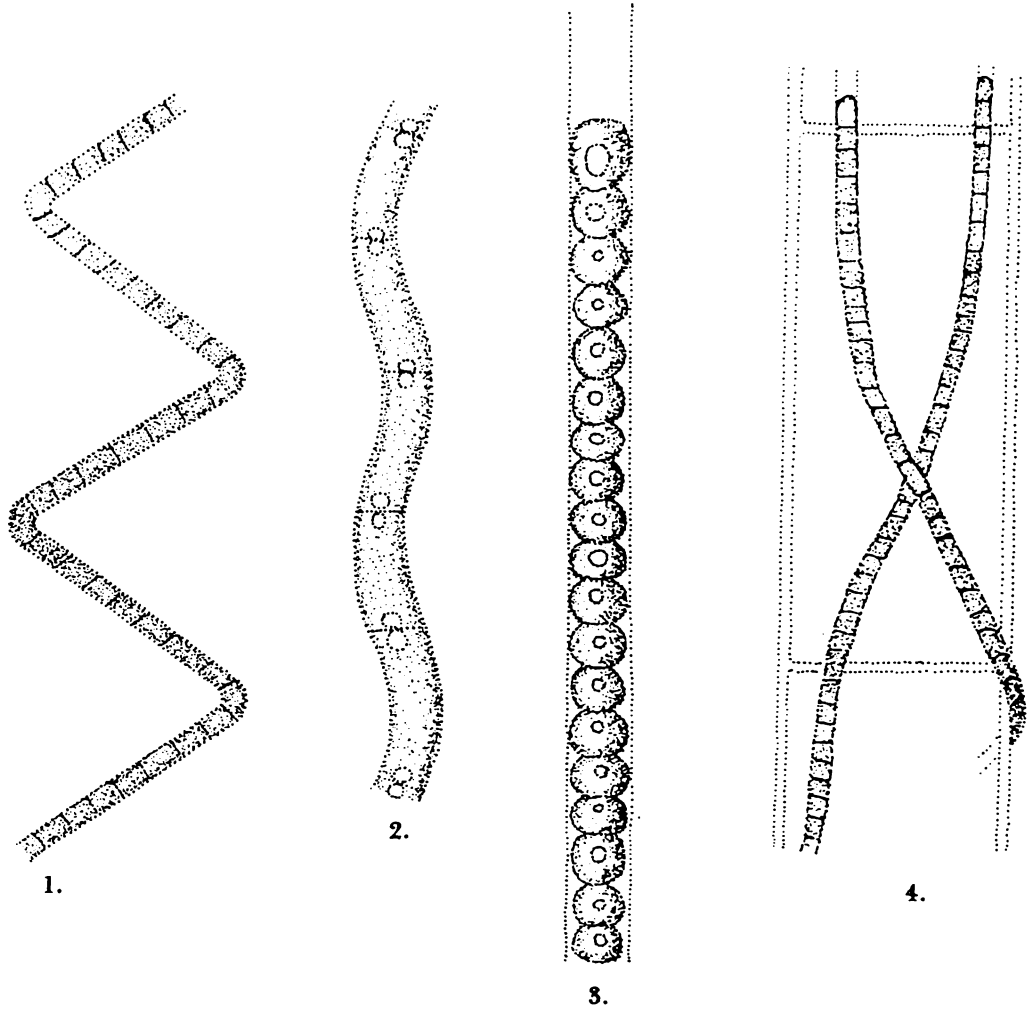
Fig. 75

Colonies broadly ellipsoidal. Cells almost straight to cylindrical with rounded poles; frequently arranged in series end to end; 1.5–2 μm broad, 8–9 μm long; contents homogeneous.

Synonym: **Synechococcus lineare** (Schmidle & Lauterborn) Komárek.

Locations: L. Rotokauri, Rotomanuka North, Whangape (this study).

FIGURES



Figs.

1. *Arthrospira tenuis* Bruehl & Biswas; 3mm = 2 μ m
2. *Lyngbya bipunctata* Lemmermann; 5mm = 1 μ m
3. *L. cryptovaginata* Schkorbatow; 3mm = 2 μ m . .
4. *L. epiphytica* Hieronymous; 5mm = 5 μ m

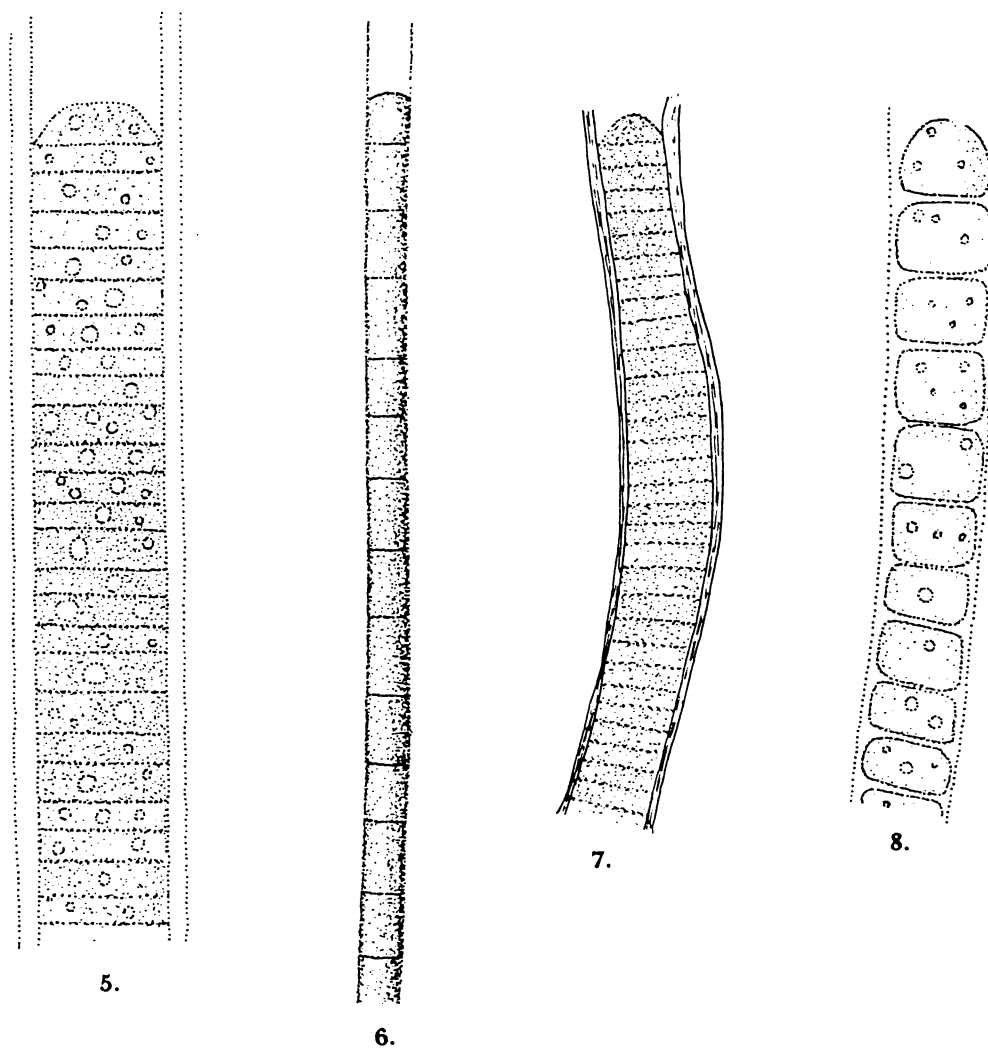
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Figs.

5. *Lyngbya hieronymusii* Lemmermann; 3mm = 2 μ m

6. *L. limnetica* Lemmermann; 3mm = 1 μ m

7. *L. martensiana* Meneghini; 5mm = 5 μ m

8. *L. putealis* Montagne; 5mm = 5 μ m ..

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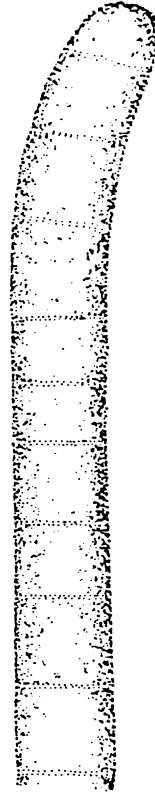
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Figs.

9. *Oscillatoria agardhii* Gomont; 5mm = 10 μ m . .

10. *O. articulata* Gardner; 3mm = 1 μ m

11. *O. chlorina* Kuetzing; 3mm = 1 μ m . .

12. *O. cortiana* Meneghini; 5mm = 5 μ m

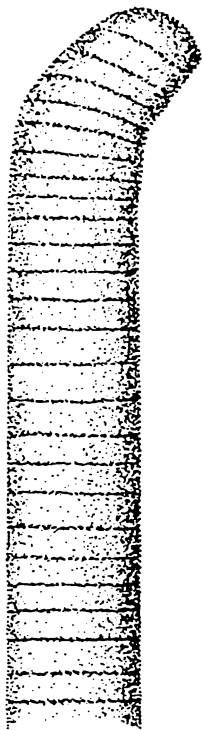
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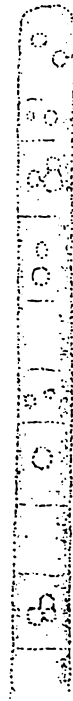
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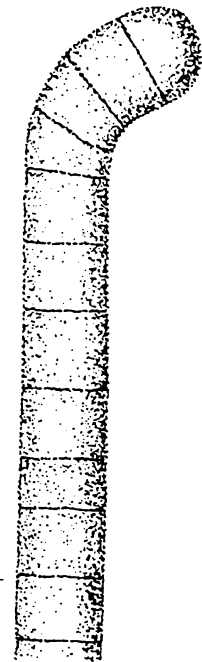
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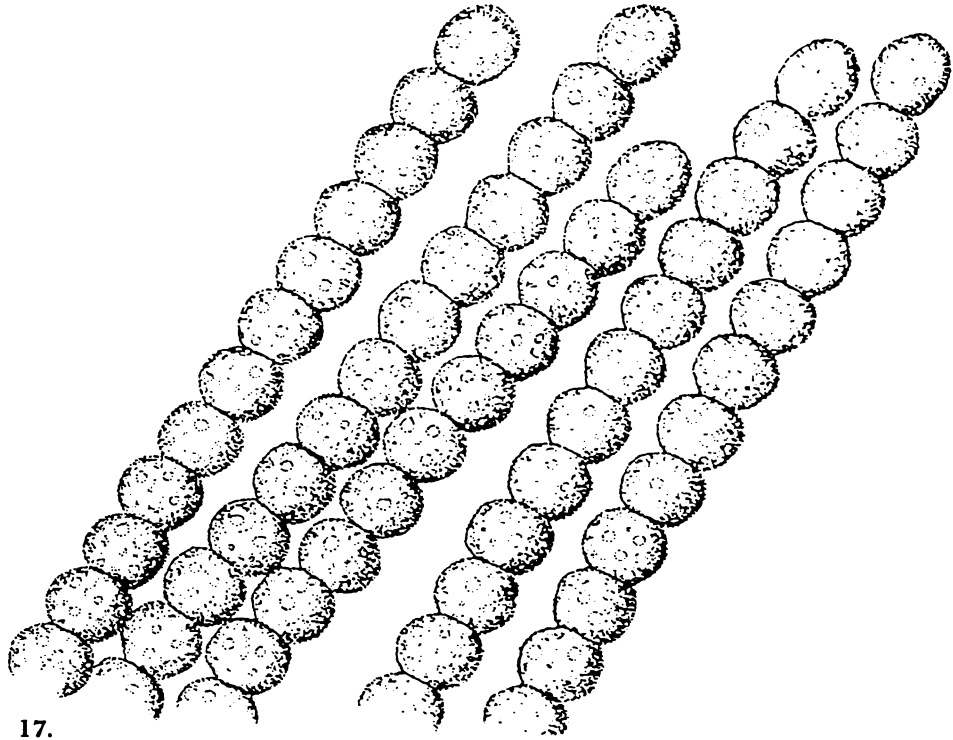
16.

Figs.

13. *Oscillatoria curviceps* C. A. Agardh; 5mm = 4 μ m
 14. *O. geminata* Meneghini; 5mm = 2 μ m
 15. *O. guttulata* van Goor; 3mm = 1 μ m
 16. *O. jasorvensis* Vouk; 3mm = 1 μ m

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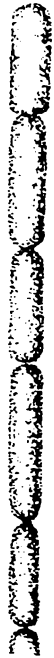
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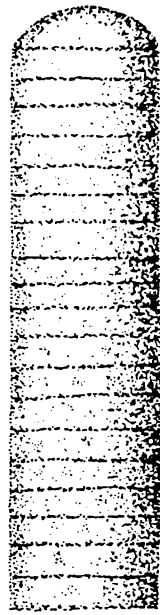
17. *Oscillatoria lacustris* (Klebahn) Geitler; 10mm = 5 μ m . .

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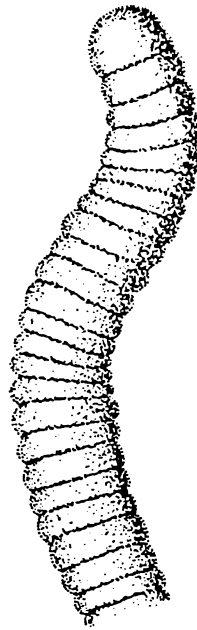
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18. *Oscillatoria limnetica* Lemmermann; $3\text{mm} = 1\mu\text{m}$
 19. *O. limosa* C. A. Agardh; $3\text{mm} = 2\mu\text{m}$
 20. *O. mougeotii* Kuetzing; $3\text{mm} = 2\mu\text{m}$
 21. *O. ornata* Kuetzing; $3\text{mm} = 2\mu\text{m}$. .
 22. *O. planctonica* Woloszynska; $3\text{mm} = 2\mu\text{m}$

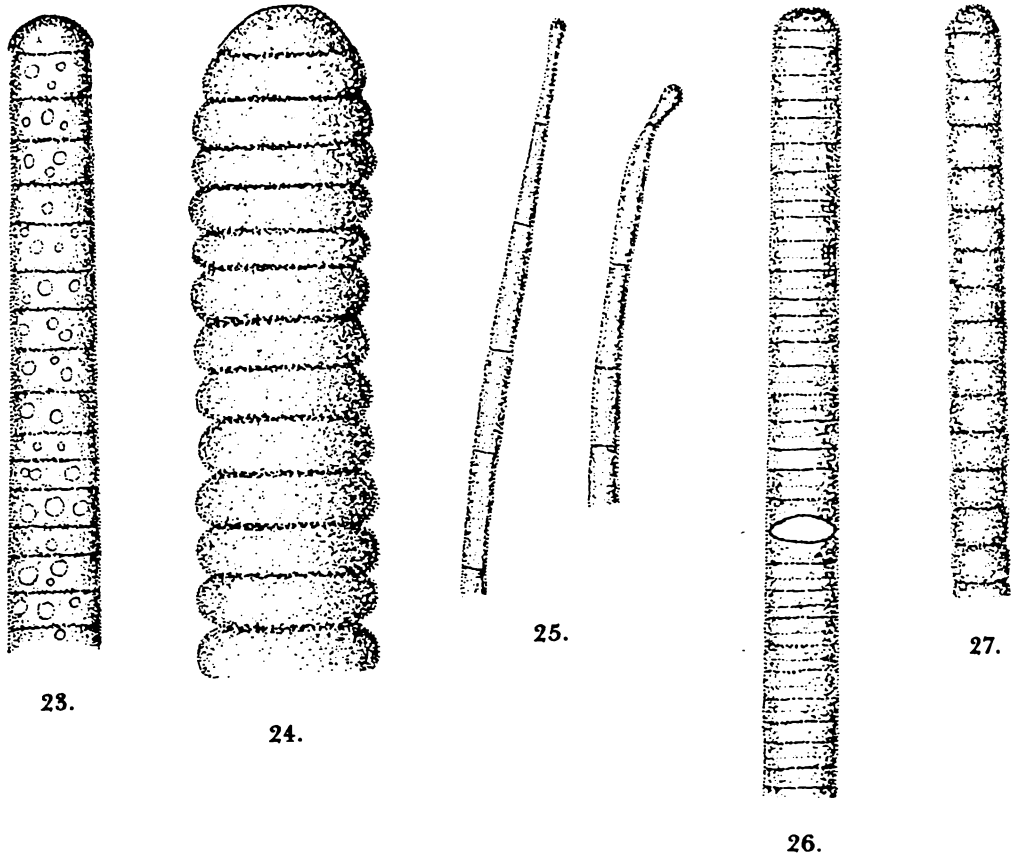
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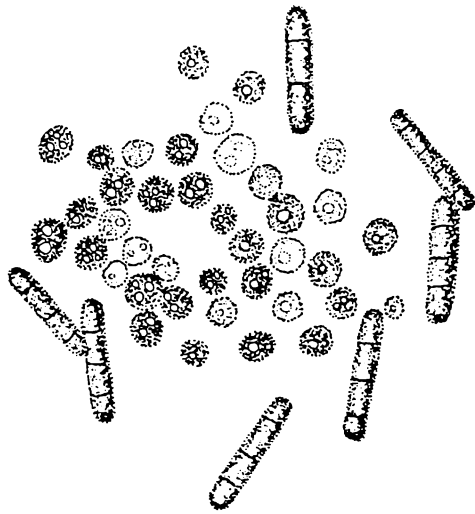
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24. <i>O. sancta</i> Kuetzing; 3mm = 2 μ m	31
25. <i>O. splendida</i> Greville; 3mm = 2 μ m . .	31
26. <i>O. subbrevis</i> Schmidle; 3mm = 2 μ m	31
27. <i>O. tenuis</i> C. A. Agardh; 5mm = 5 μ m	32



28.

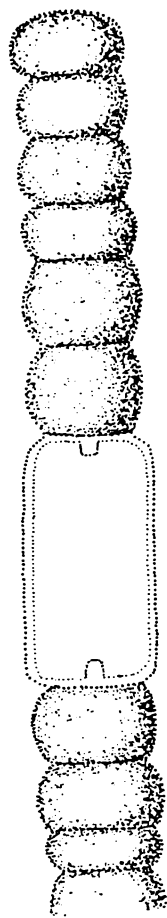


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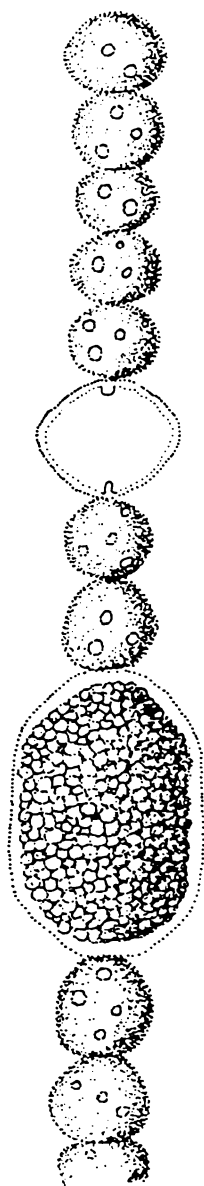


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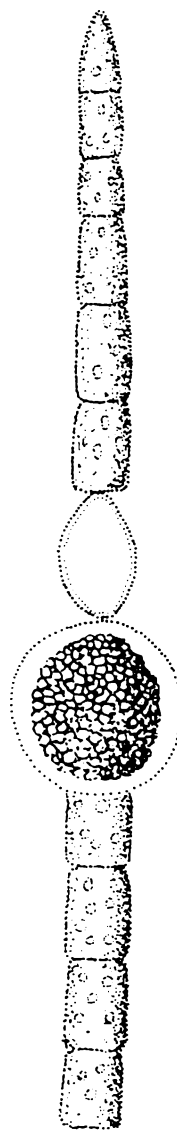
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28. <i>Phormidium mucicola</i> associated with <i>Microcystis aeruginosa</i> Naumann & Huber-Pestalozzi; 3mm = 2µm	33
29. <i>Spirulina laxa</i> G. M. Smith; 5mm = 5µm	34
30. <i>S. major</i> Kuetzing; 5mm = 5µm	34



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32.



33.

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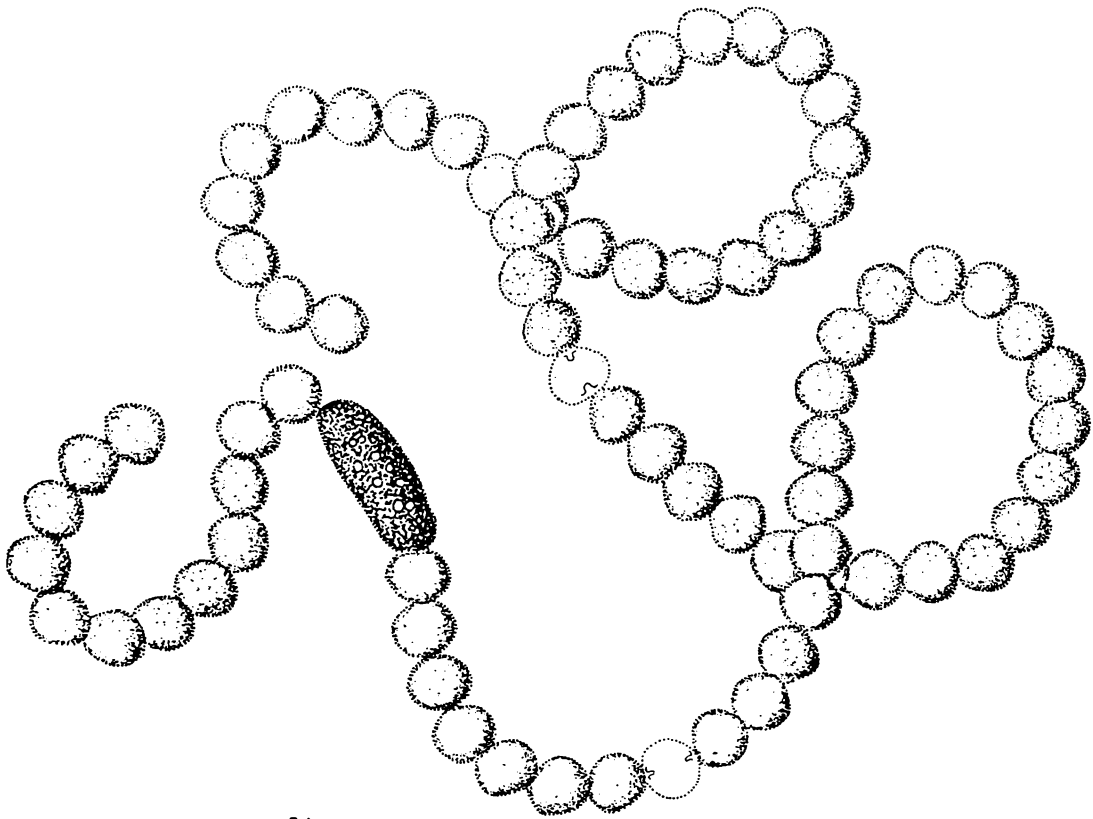
31. *Anabaena aequalis* Borge; 3mm = 1 μ m32. *A. affinis* Lemmermann; 5mm = 2 μ m33. *A. aphanizomenoides* Forti; 5mm = 2 μ m

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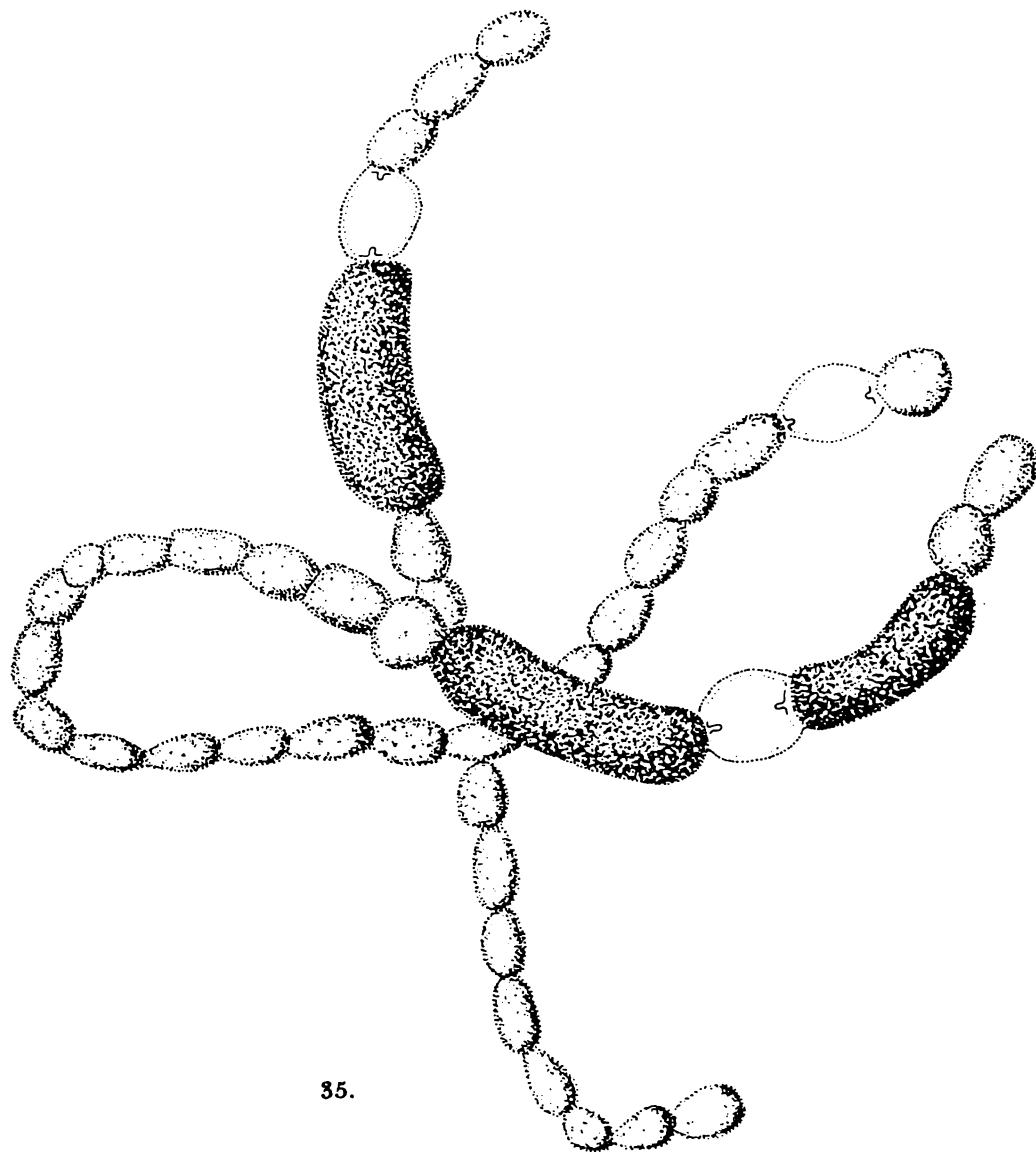
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34. *Anabaena circinalis* Rabenhorst; 4mm=4 μ m..

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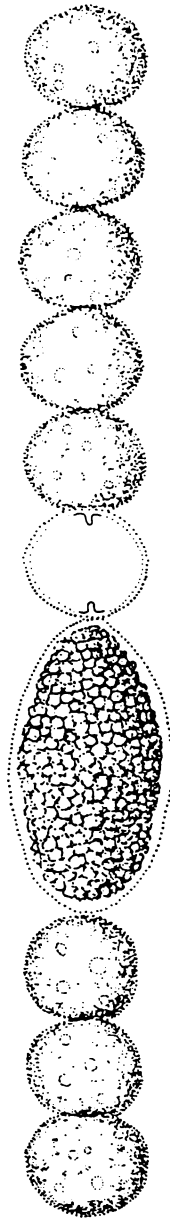
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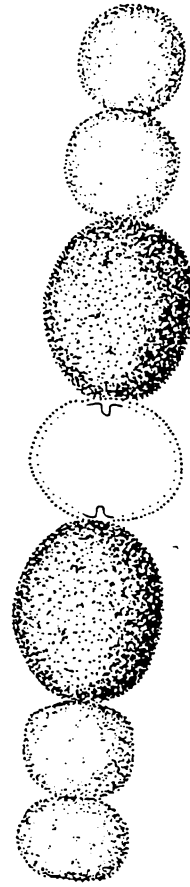
35. *Anabaena flos-aquae* (Lyngbye) de Brébisson; 3mm = 2 μ m

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36.



37.

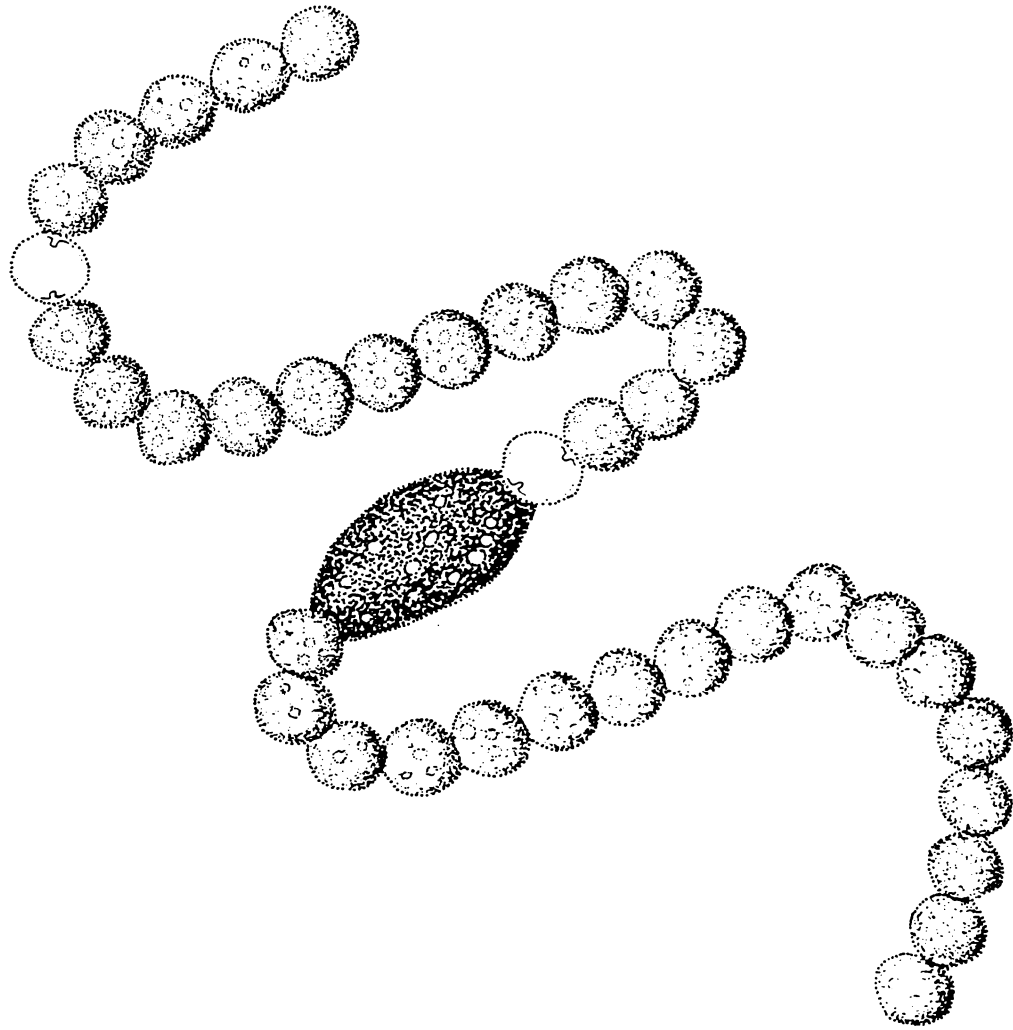
Figs.

36. *Anabaena solitaria* Klebahn; 10mm=5 μ m . .37. *A. sphaerica* var. *tenuis* G. S. West; 3mm=2 μ m

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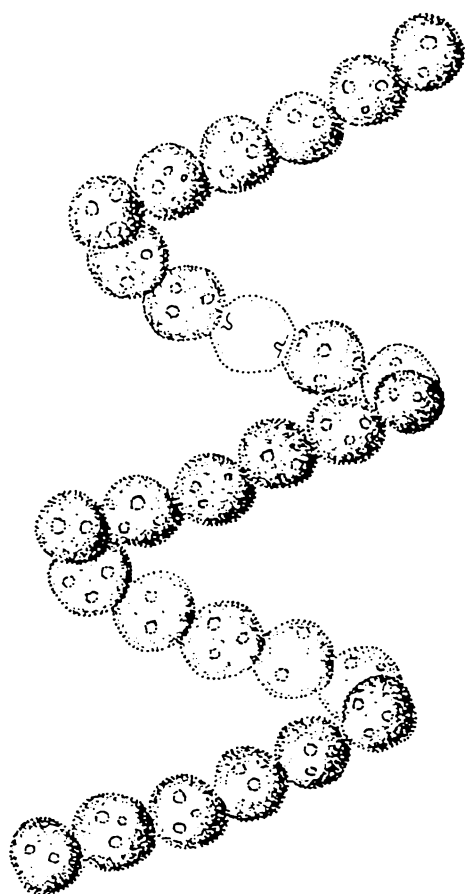
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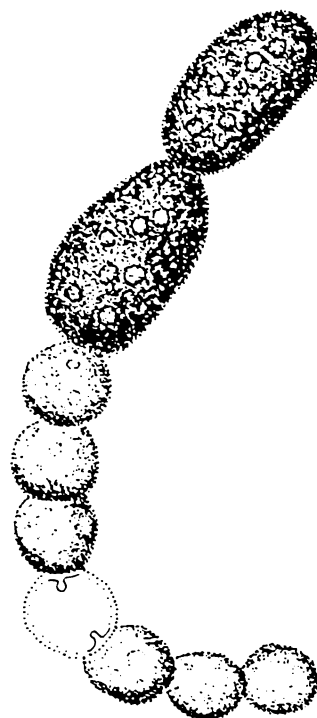


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Figs.
38. *Anabaena spiroides* Klebahn; 3mm = 2μm



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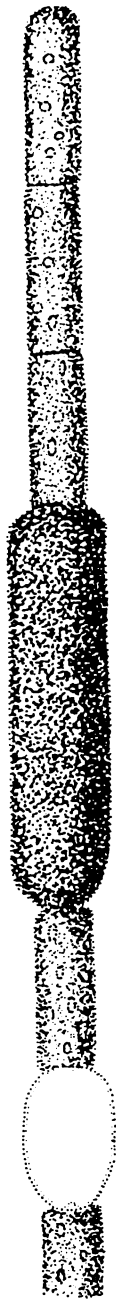
Figs.

39. *Anabaena spiroides* var. *tumida* Nygaard; 3mm=2 μ m . .40. *A. spiroides* var. *tumida* Nygaard; 3mm=2 μ m

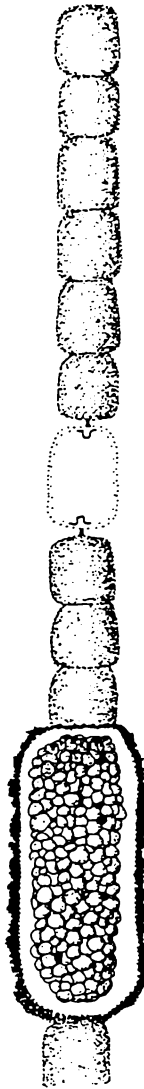
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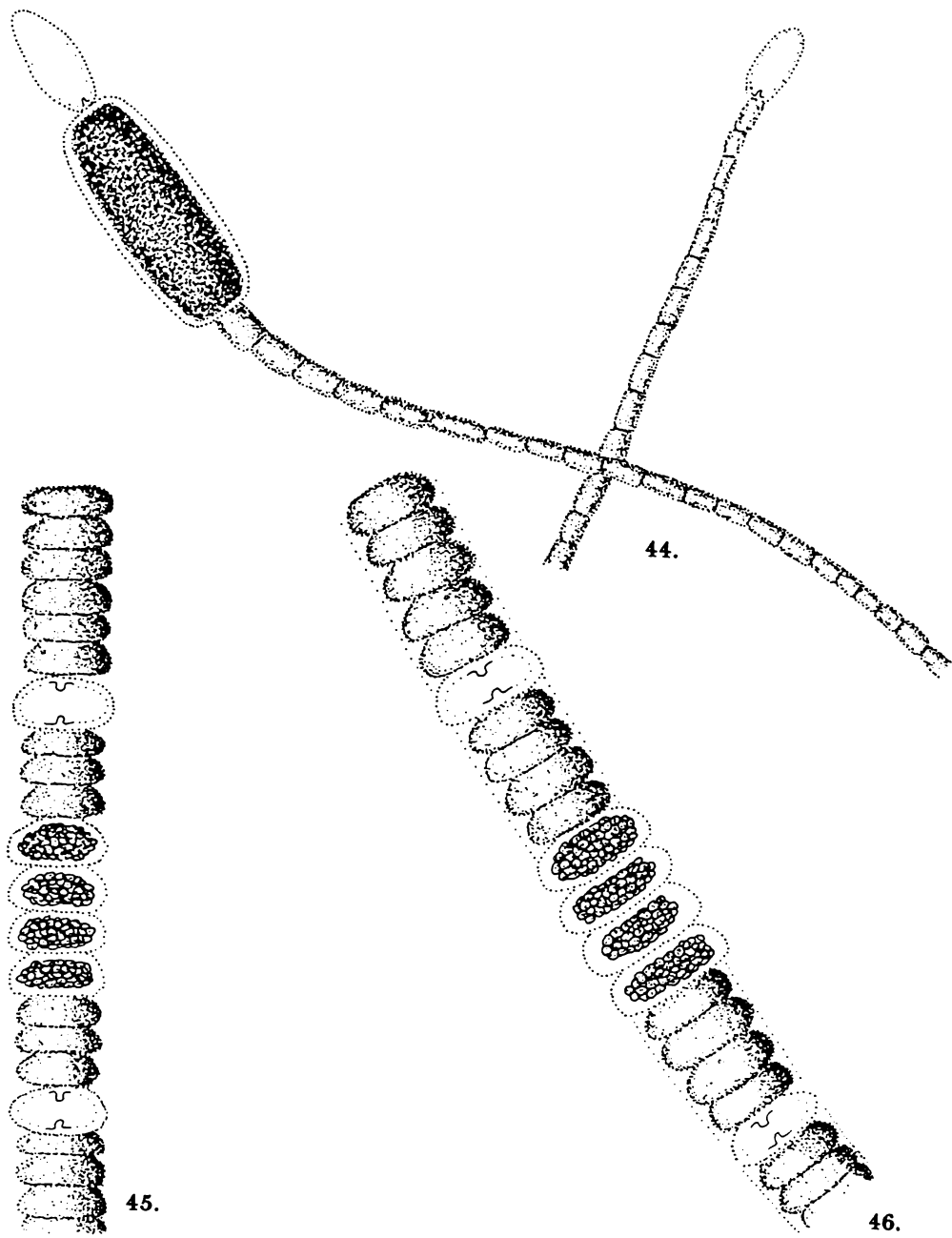
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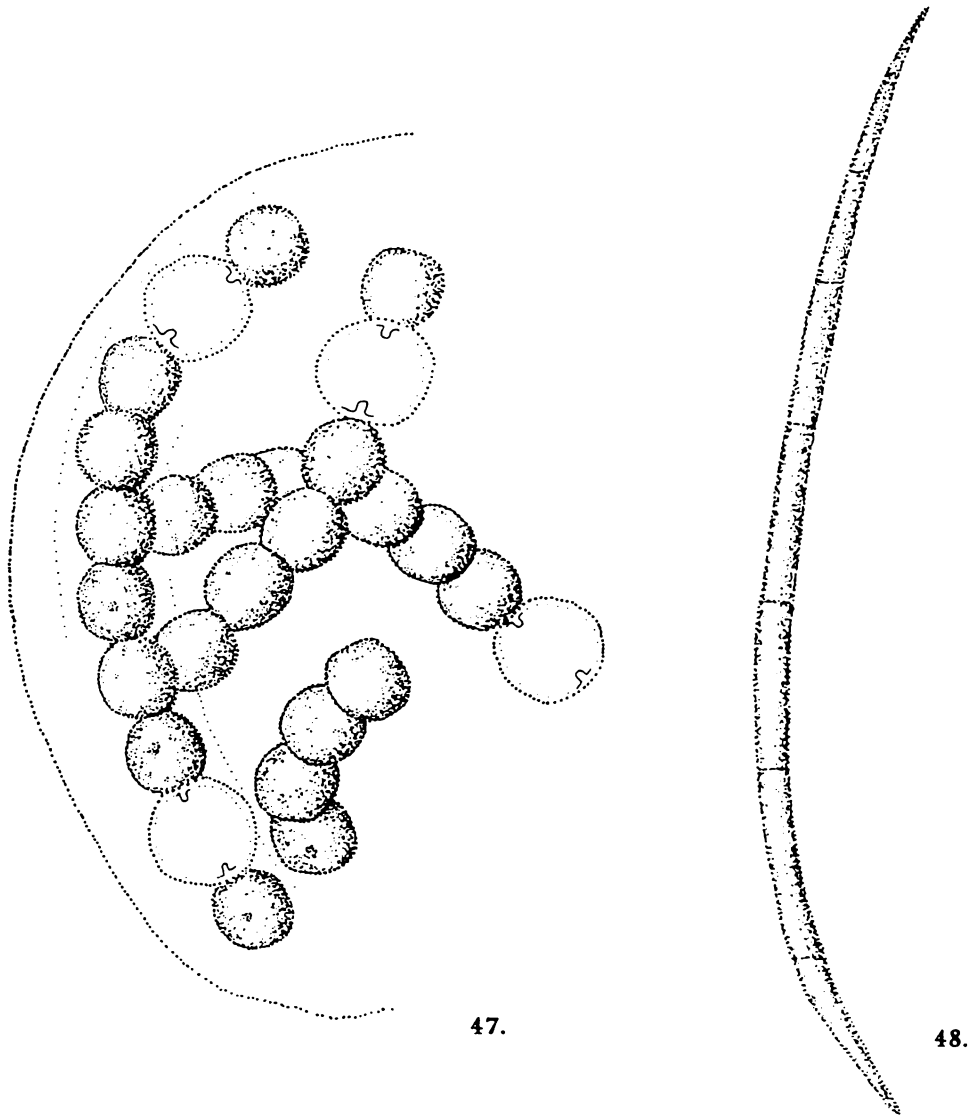
41. *Anabaena tenericaulis* Nygaard; 2.7mm = .9 μ m
 42. *A. verrucosa* Boye-Petersen; 3mm = 1 μ m . .
 43. *Aphanizomenon flos-aquae* (Linnaeus) Ralfs; 5mm = 5 μ m

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| 44. <i>Cylindrospermum minutissimum</i> Collins; 3mm = 2 μ m | 44 |
| 45. <i>Nodularia harveyana</i> (Thwaites) Thuret; 10mm = 5 μ m . . | 44 |
| 46. <i>N. spumigena</i> Mertens; 3mm = 2 μ m | 45 |



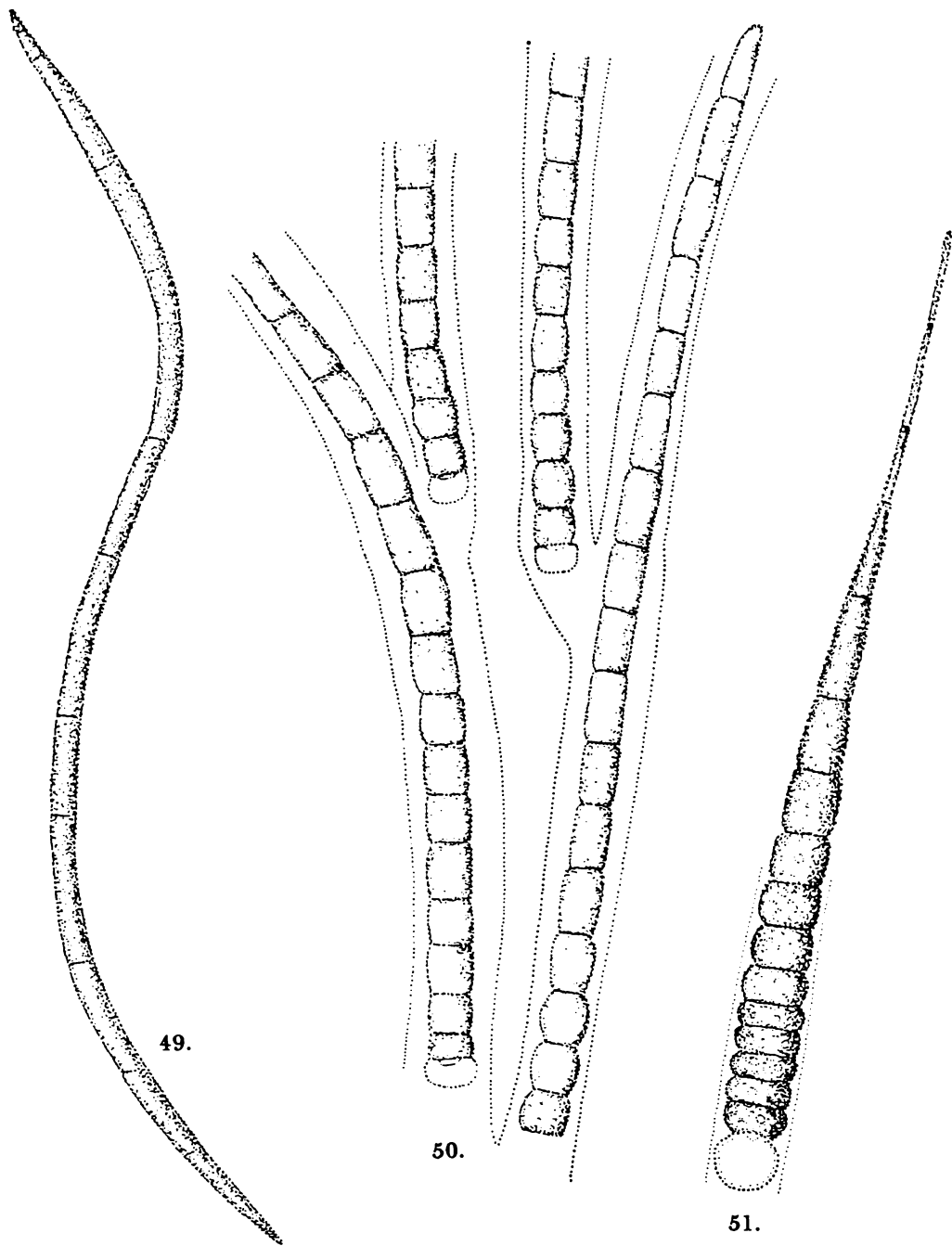
Figs.

47. *Nostoc commune* Vaucher; 10mm = 5 μ m48. *Raphidiopsis mediterranea* Skuja; 3mm = 2 μ m . .

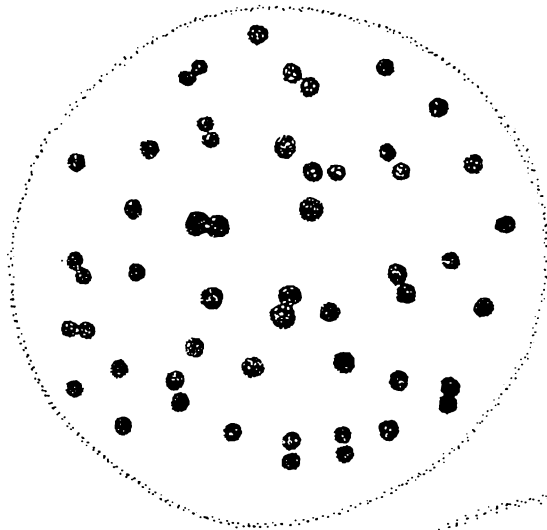
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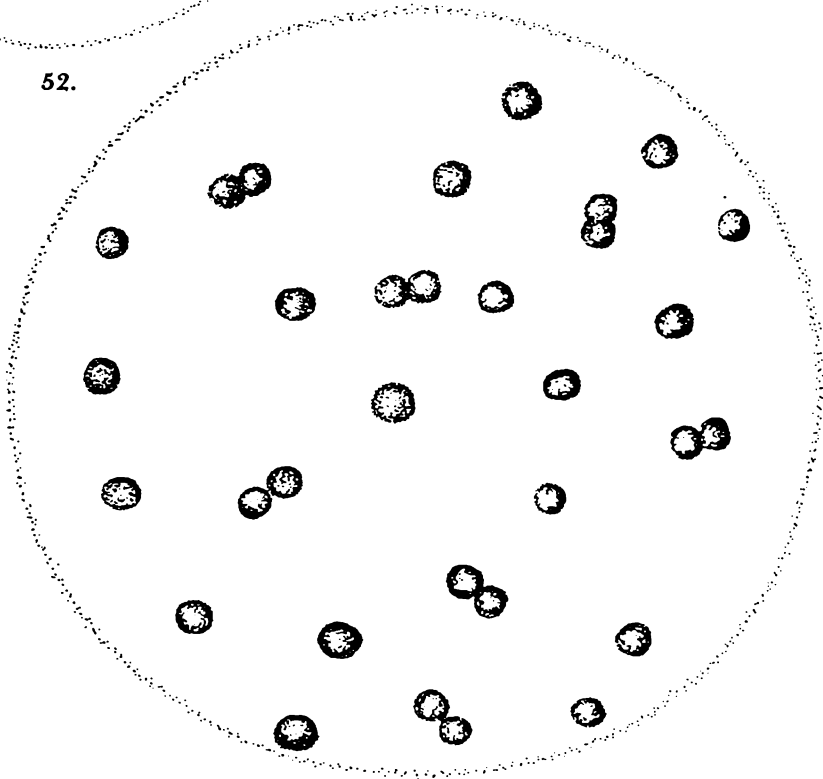
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|--|------|
| 49. <i>Raphidiopsis mediterranea</i> Skuja; 3mm=2 μ m | 47 |
| 50. <i>Dichothrix gypsophila</i> (Kuetzing) Bornet & Flahault; 3.75mm=3.75 μ m | 48 |
| 51. <i>Gloeotrichia echinulata</i> (J. E. Smith) Richter; 5mm=5 μ m | 49 |



52.



53.

Figs.

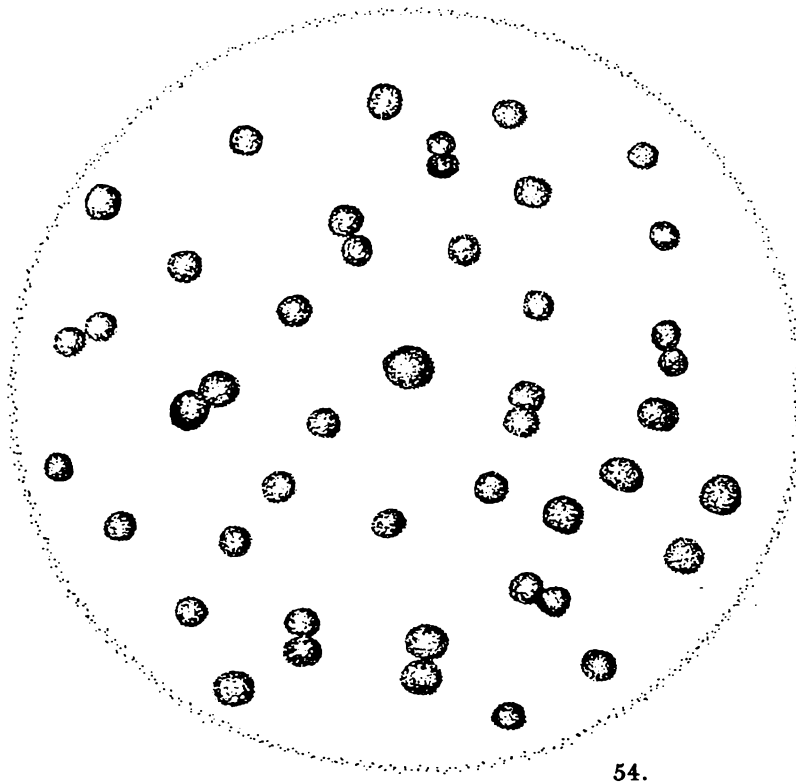
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52. *Aphanocapsa delicatissima* W. & G. S. West; 3mm = 1 μ m

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53. *A. elachista* W. & G. S. West; 3mm = 1 μ m

53

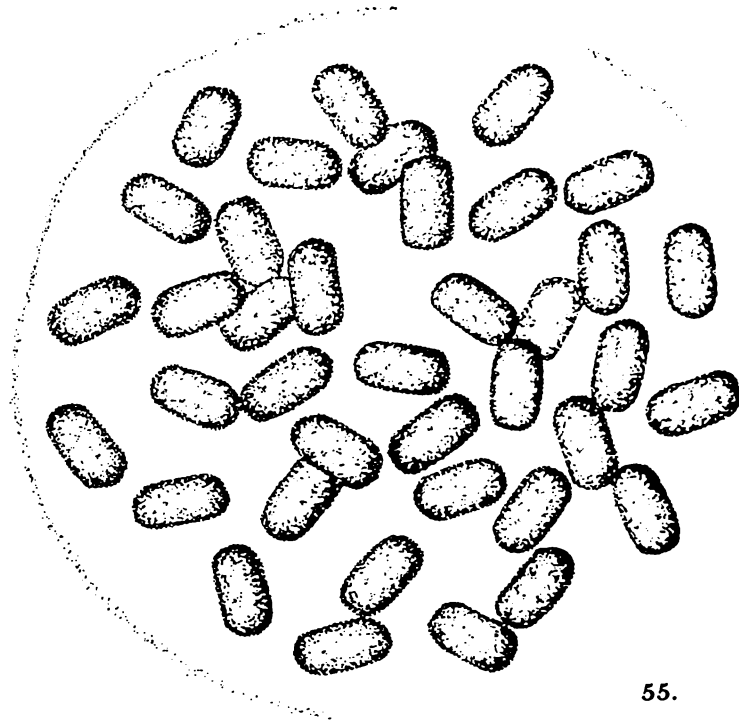


Figs.

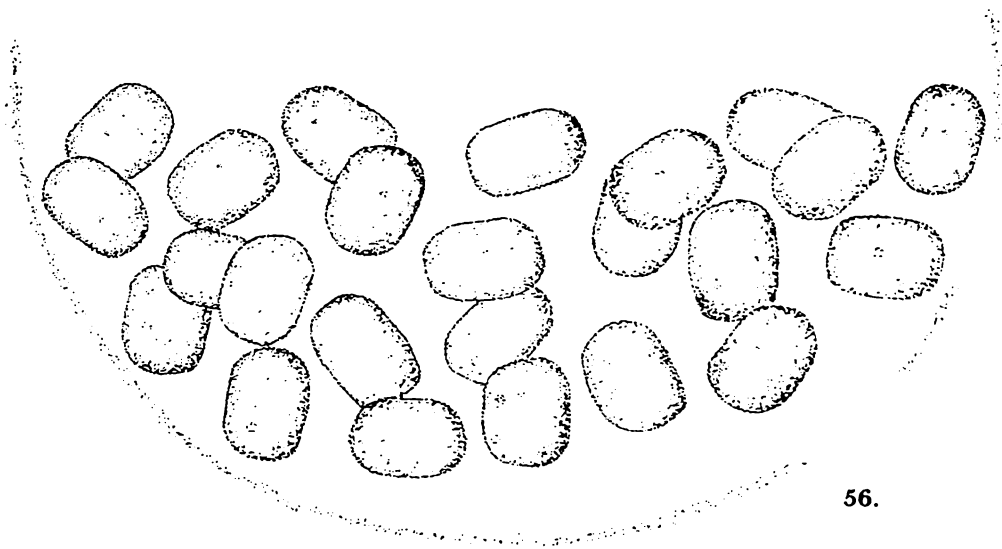
54. *Aphanocapsa elachista* var. *conferta* W. & G. S. West; 3mm = 1 μ m

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55.



56.

Figs.

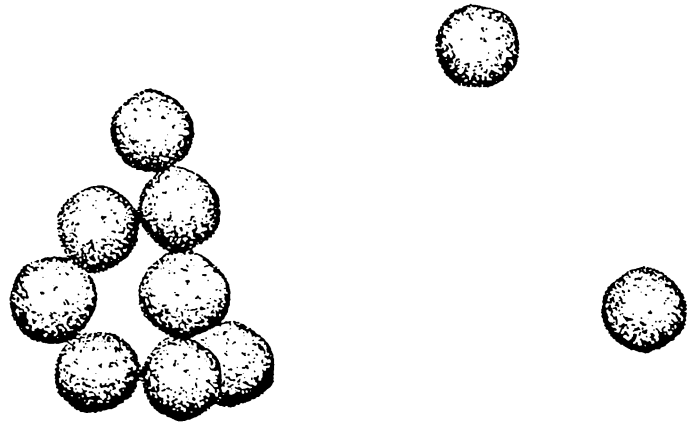
55. *Aphanothece nidulans* Richter; 4mm = 1µm

56. *A. stagnina* (Sprengel) Braun; 4mm = 1µm . .

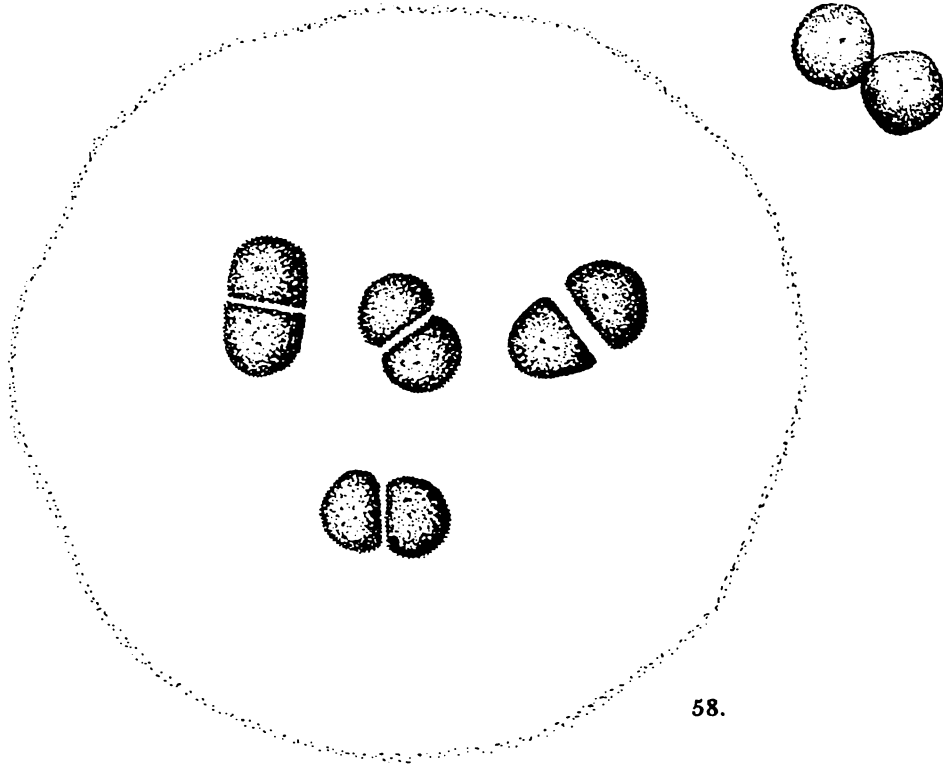
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57.



58.

Figs.

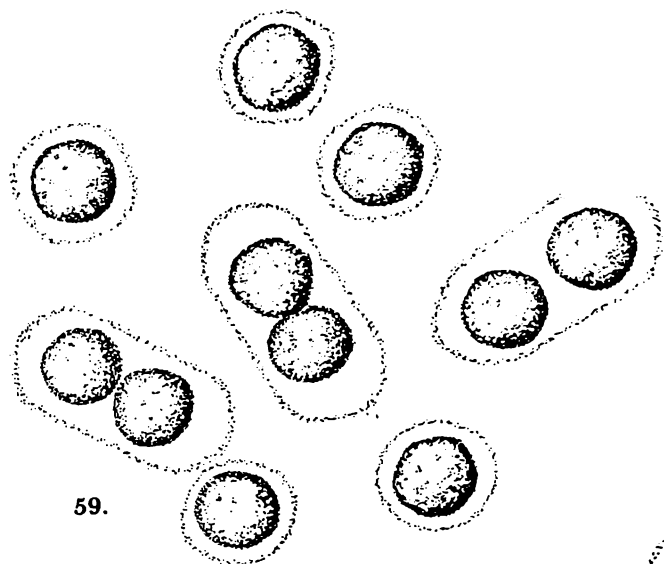
57. *Chroococcus dispersus* (Keissler) Lemmermann; 5mm = 2µm

58. *C. limneticus* Lemmermann; 10mm = 10µm . .

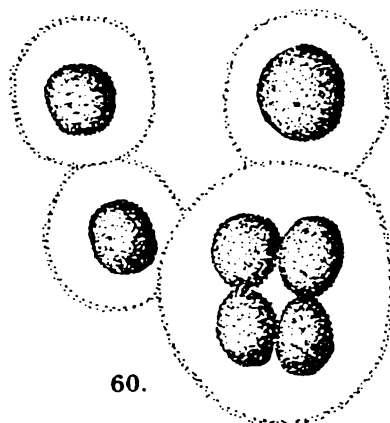
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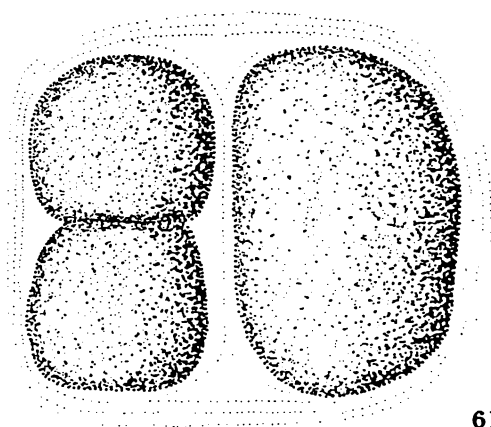
56



59.



60.



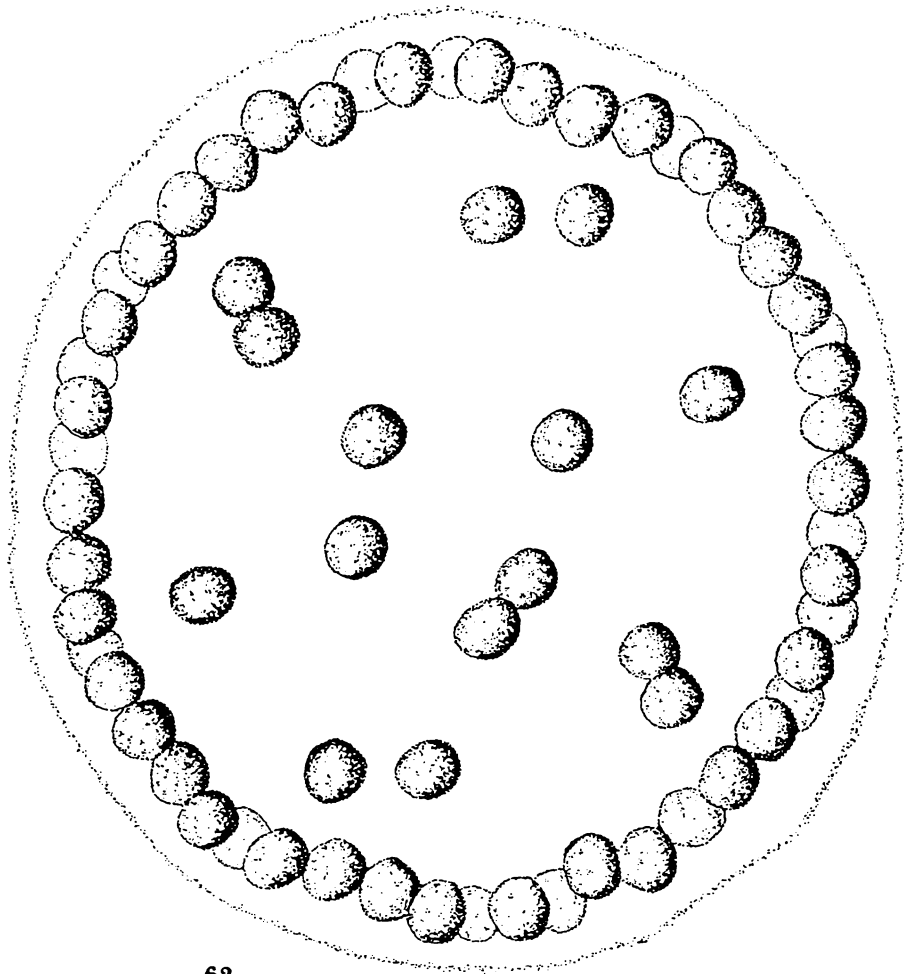
61.

Figs.

59. *Chroococcus minor* (Kuetzing) Naegeli; 5mm = 3 μ m
 60. *C. minutus* (Kuetzing) Naegeli; 10mm = 5 μ m
 61. *C. turgidus* (Kuetzing) Naegeli; 10mm = 10 μ m

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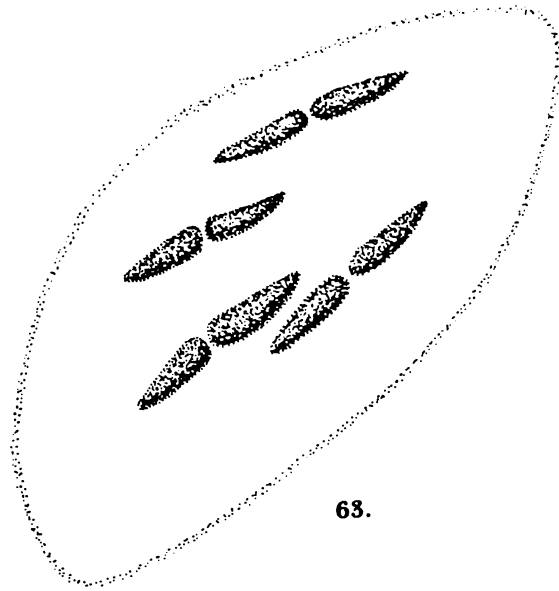
62.

Figs.

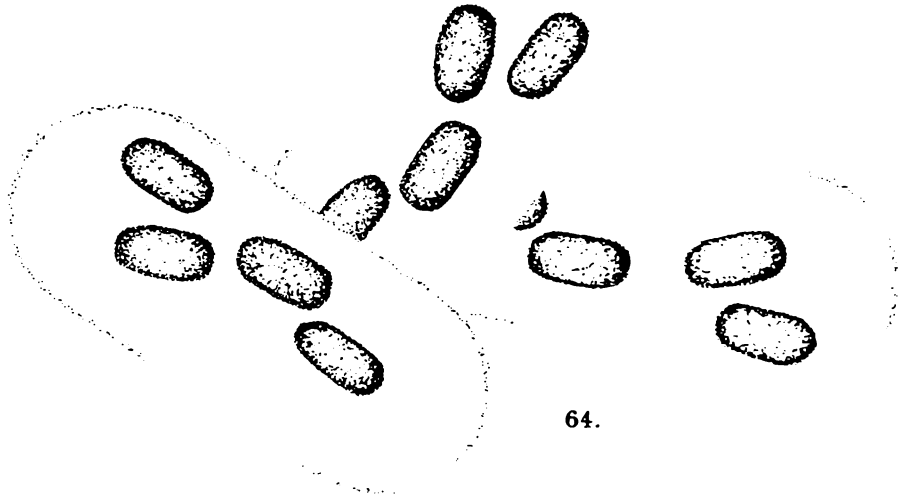
62. *Coelosphaerium kuetzingianum* Naegeli; 10mm=5 μ m ..

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63.



64.

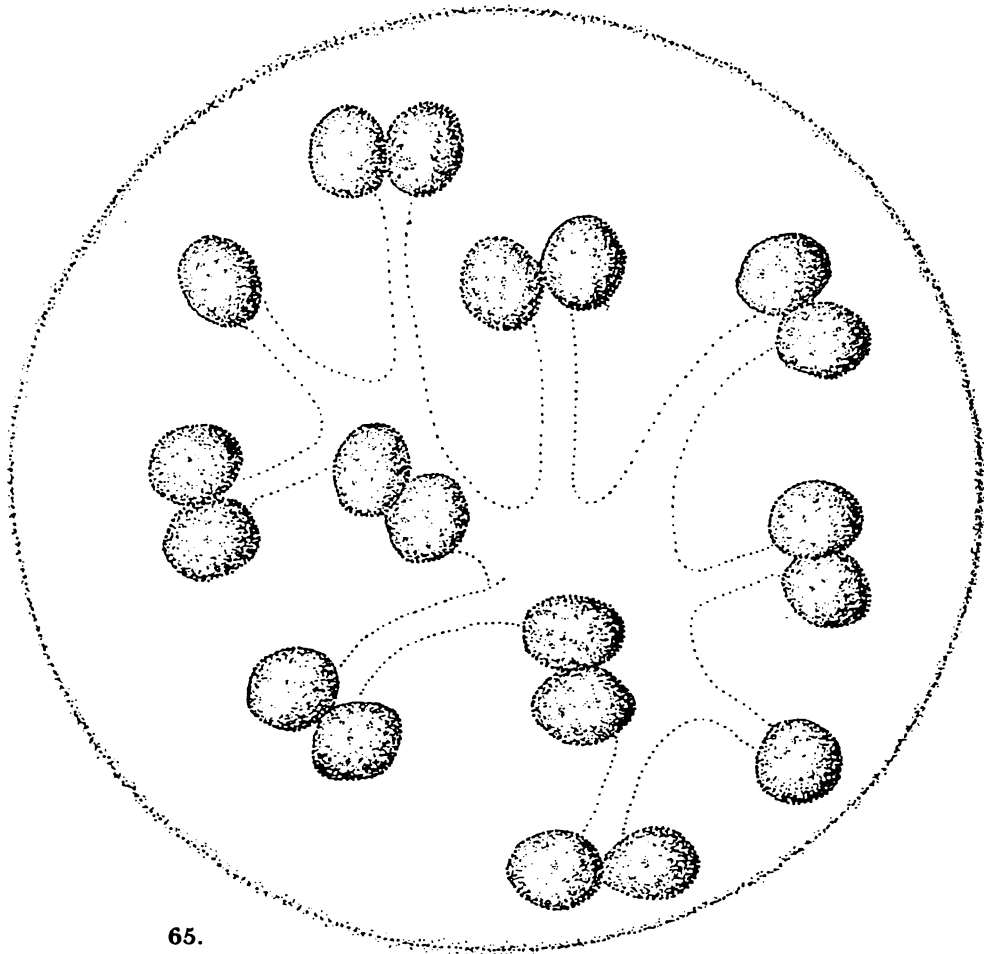
Figs.

63. *Dactylococcopsis smithii* R. & F. Chodat; 5mm=4 μ m . .64. *Cloethece linearis* var. *composita* G. M. Smith; 10mm=5 μ m

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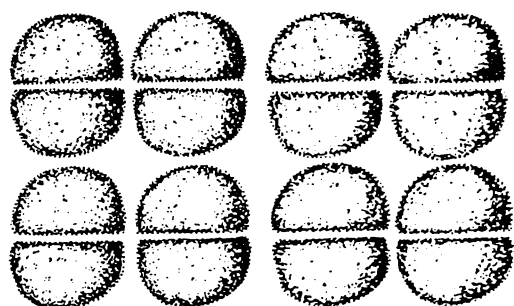
59

60

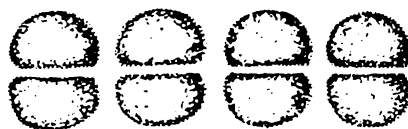


65.

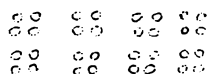
Figs.
65. *Gomphosphaeria lacustris* Chodat; 5mm = 1 μ m



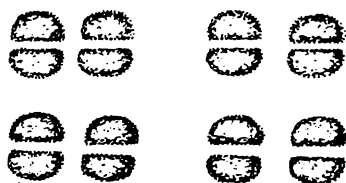
66.



67.



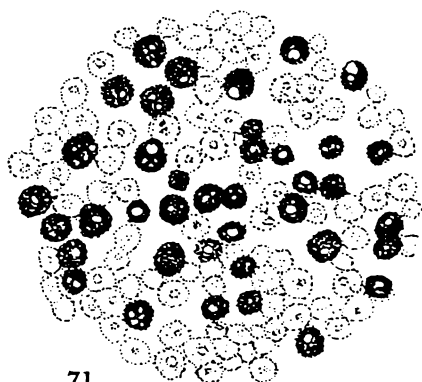
68.



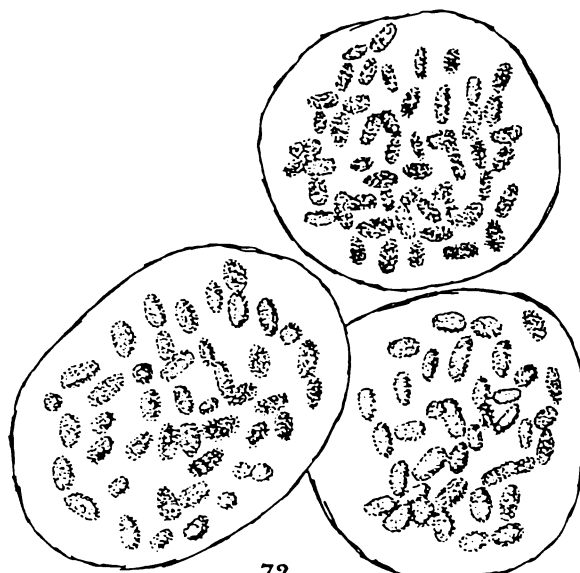
69.



70.



71.



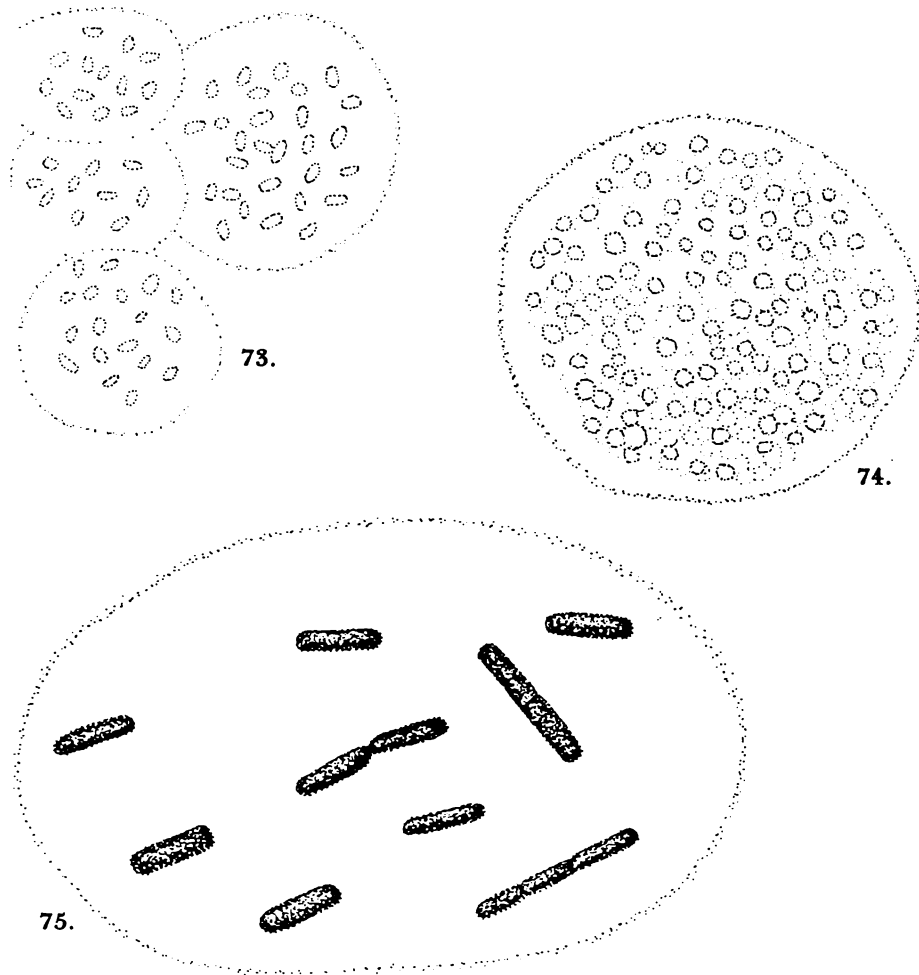
72.

Figs.

66. *Merismopedia elegans* Braun; 10mm = 5μm
 67. *M. glauca* (Ehrenberg) Naegeli; 10mm = 5μm
 68. *M. minima* Beck; 10mm = 5μm
 69. *M. punctata* Meyen; 10mm = 5μm . .
 70. *M. tenuissima* Lemmermann; 10mm = 5μm . .
 71. *Microcystis aeruginosa* Kuetzing; 10mm = 10μm
 72. *M. elabens* var. *minor* Nygaard; 10mm = 10μm

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73. <i>Microcystis minutissima</i> W. West; 10mm=10µm	66
74. <i>M. pulverea</i> (Wood) Forti; 10mm=10µm	66
75. <i>Rhabdoderma lineare</i> Schmidle & Lauterborn; 5mm=4µm	67

APPENDIX I FIGURES OF TAXA NOT
OBSERVED BY AUTHORS

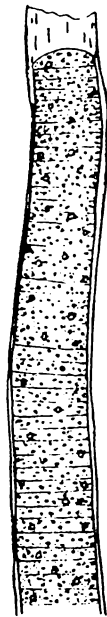
- Fig 76a,b *Arthrospira platensis* (Nordstedt) Gomont; (a) and (b) from Bourrelly (1970, p. 439), (a) 3 mm = 10 μ m, (b) 11 mm = 10 μ m.
- Fig 77a,b *Lyngbya birgei* G.M. Smith; (a) from Cocke (1967, p. 57), 5 mm = 10 μ m; (b) from Bourrelly (1970, p. 443), 11 mm = 10 μ m.
- Fig. 78 *Oscillatoria angustissima* W. & G.S. West; from Prescott (1962, p. 879), 15 mm = 10 μ m.
- Fig. 79a,b *O. annae* van Goore; (a) from Cassie & Freeman (1980, p. 308), 8 mm = 10 μ m; (b) from Desikachary (1959, p. 208), scale not given.
- Fig 80a,b *O. bornetii* Zukal; (a) and (b) from Prescott (1962, p. 877), (a) 7.5 mm = 10 μ m, (b) 5.9 mm = 10 μ m.
- Fig. 81a,b,c *O. formosa* Bory de Saint-Vincent; (a) from Desikachary (1959, p. 214), scale not given; (b) and (c) from Prescott (1962, p. 879), (b) 9 mm = 10 μ m, (c) 15 mm = 10 μ m.
- Fig. 82 *O. iwanoffiana* (Nygaard) Geitler; (a) and (b) from Huber-Pestalozzi (1938, p. 234-235), scales not given.



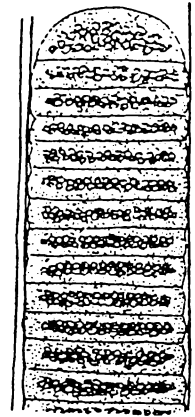
76a.



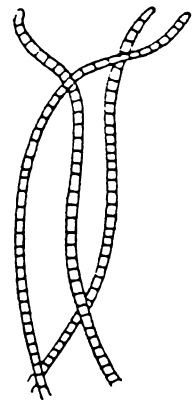
76b.



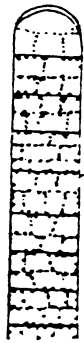
77a.



77b.



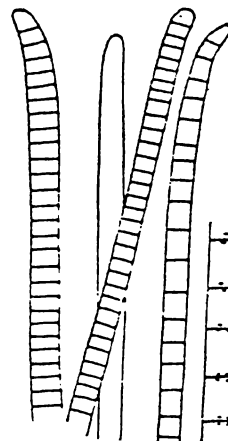
78.



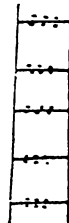
80a.



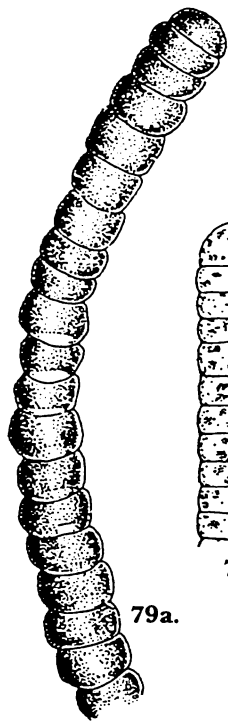
80b.



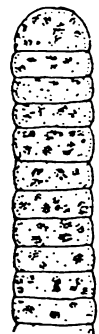
81b.



81c.



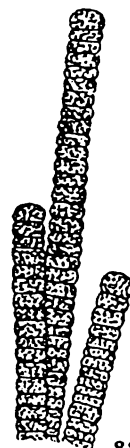
79a.



79b.



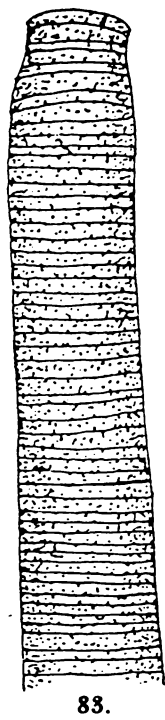
81a.



82.



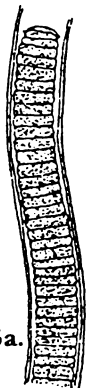
- Fig. 83 *Oscillatoria princeps* Vaucher; from Desikachary (1959, p. 204), scale not given.
- Fig. 84 *O. subtilissima* Kuetzing; from Cocke (1967, p. 39), 7 mm = 10 μm.
- Fig. 85a,b *Phormidium rotheanum* var. *capitatum* Desikachary; (a) and (b) from Desikachary (1959, p. 270), scales not given.
- Fig. 86a,b,c *Anabaena macrospora* Klebahn; (a), (b) and (c) from Prescott (1962, p. 895), (a) 12 mm = 10 μm; (b) and (c) 17.3 mm = 10 μm.
- Fig. 87 *A. miniata* Skuja; from Skuja (1976, p. 27), 6.7 mm = 10 μm.
- Fig. 88a,b,c,d *A. oscillarioides* Bory de Saint-Vincent; (a) from Fogg *et al.* (1973, p. 13), 4 mm = 10 μm; (b), (c) and (d) from Prescott (1962, p. 895), (b) and (c) 7.5 mm = 10 μm, (d) 6.2 mm = 10 μm.



83.



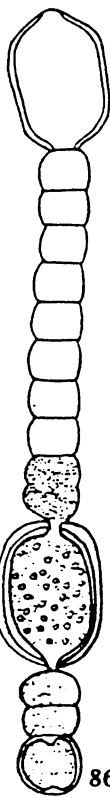
84.



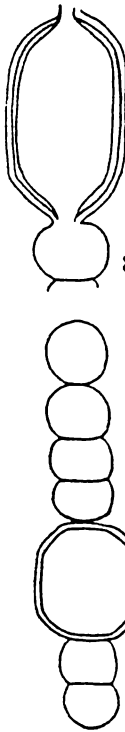
85a.



85b.

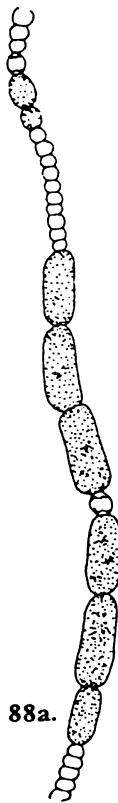


86a.

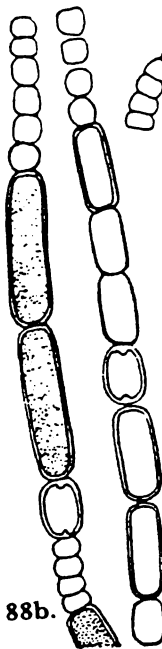


86b.

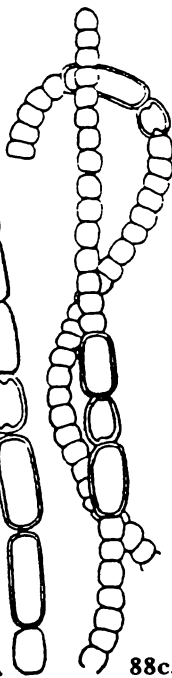
86c.



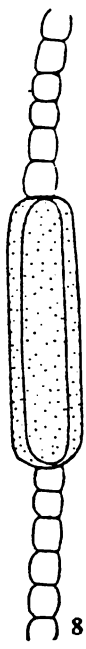
88a.



88b.



88c.

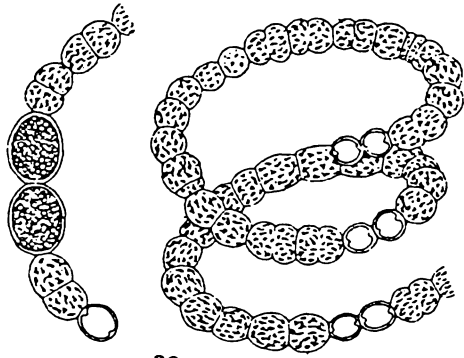


88d.

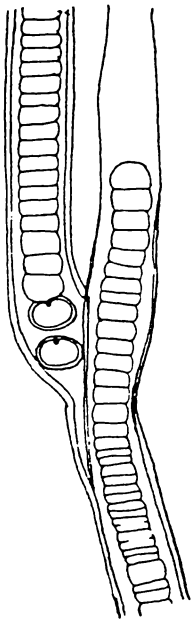


87.

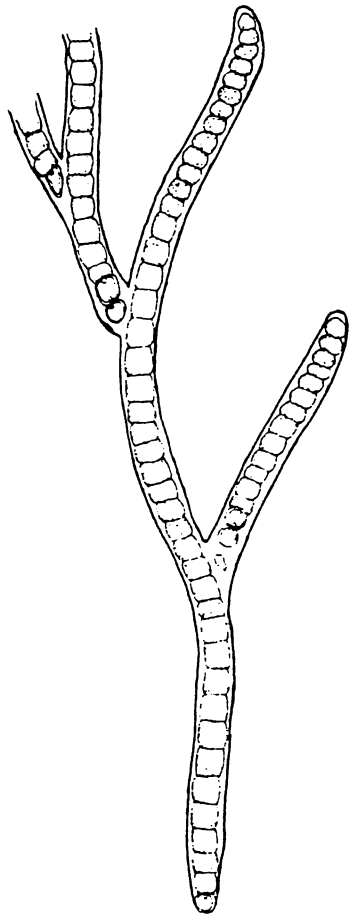
- Fig. 89 *Anabaenopsis arnoldii* Aptekarj; from Huber-Pestalozzi (1938, p. 184–185), scale not given.
- Fig. 90 *Gloeotrichia natans* (Hedwig) Rabenhorst; from Bourrelly (1970, p. 421), 13 mm = 10 μm.
- Fig. 91 *Tolypothrix penicillata* (Agardh) Thuret; from Desikachary (1959, p. 496), scale not given.
- Fig. 92 *T. tenuis* Kuetzing; from Cocke (1967, p. 117), 5 mm = 10 μm.
- Fig. 93 *Gloeocapsa stegophila* (Itzingsohn) Rabenhorst; from Desikachary (1959, p. 126), scale not given.



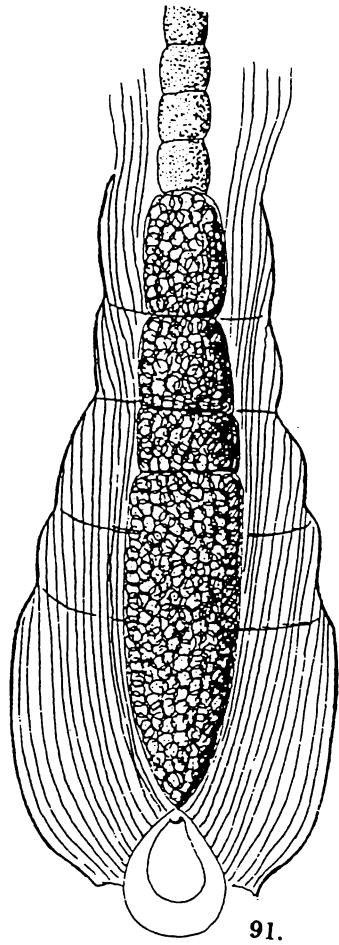
89.



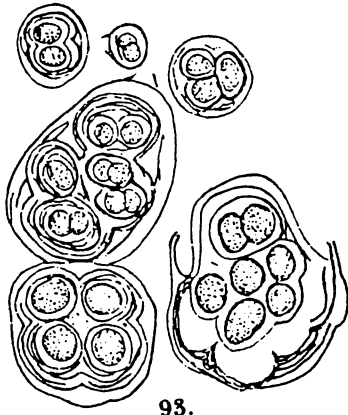
91.



92.



91.



93.

**APPENDIX II A COMPARISON OF NEW
ZEALAND BLUE-GREEN NOMENCLATURE USING
GEITLERIAN AND DROUET &
DAILY TAXONOMIC SYSTEMS**

Drouet & Daily (1956) and Drouet (1968, 1973, 1978, 1981) believe that many of the existing taxa of blue-greens are invalid, and thus have reduced greatly the number of taxa in their revision of the blue-greens. As stated in the preface many workers do not accept these changes. The following list compares the nomenclature used in this text with that given by Drouet & Daily (1956) and Drouet (1968, 1973, 1978, 1981).

This text

Anabaena aequalis Borge

Anabaena affinis Lemmermann
Anabaena aphanizomenoides Forti
Anabaena circinalis Rabenhorst
Anabaena flos-aquae (Lyngbye)
 de Brébisson
Anabaena macrospora Klebahn
Anabaena miniata Skuja
Anabaena oscillarioides Bory de Saint-Vincent
Anabaena solitaria Klebahn
Anabaena sphaerica f. *tenuis* G.S. West

Anabaena spiroides Klebahn
Anabaena spiroides var. *crassa* Lemmermann
Anabaena spiroides var. *tumida* Nygaard
Anabaena tenericaulis Nygaard

Anabaena verrucosa Boye-Petersen

Anabaenopsis arnoldii Aptekarj
Aphanizomenon flos-aquae (Linnaeus) Ralfs
Aphanocapsa delicatissima W. & G.S. West

Aphanocapsa elachista W. & G.S. West
Aphanocapsa elachista var. *conferta* W. & G.S. West
Aphanothece nidulans Richter
Aphanothece stagnina (Sprengel) Braun
Arthrospira platensis (Nordstedt) Gomont
Arthrospira tenuis Bruehl & Biswas
Chroococcus dispersus (Keissler) Lemmermann
Chroococcus dispersus var. *minor* G.M. Smith
Chroococcus limneticus Lemmermann
Chroococcus minor (Kuetzing) Naegeli
Chroococcus minutus (Kuetzing) Naegeli
Chroococcus turgidus (Kuetzing) Naegeli
Coelosphaerium kuetzingianum Naegeli

Drouet & Daily/Drouet

Anabaina oscillarioides Bory de Saint-Vincent
Nostoc commune Vaucher
Nostoc commune Vaucher
Nostoc commune Vaucher

?

Nostoc commune Vaucher
Nostoc commune Vaucher
Anabaina oscillarioides Bory de Saint-Vincent
Nostoc commune Vaucher
Anabaina oscillarioides Bory de Saint-Vincent
Nostoc commune Vaucher
Nostoc commune Vaucher
Nostoc commune Vaucher
Anabaina oscillarioides Bory de Saint-Vincent
Anabaina licheniformis Bory de Saint-Vincent
Nostoc commune Vaucher
Microcoleus vaginatus (Vaucher) Gomont
Anacystis incerta (Lemmermann) Drouet & Daily
Anacystis montana f. *montana* (Lightfoot) Drouet & Daily
Anacystis incerta (Lemmermann) Drouet & Daily
Anacystis marina (Hansgirg) Drouet & Daily
Coccochloris stagnina Sprengel
Microcoleus lyngbyaceus (Kuetzing) Crouan
Schizothrix calcicola (Agardh) Gomont
Anacystis thermalis f. *major* (Lagerheim) Drouet & Daily
Anacystis montana f. *minor* (Wille) Drouet & Daily
Anacystis thermalis f. *major* (Lagerheim) Drouet & Daily
Stichococcus subtilis (Kuetzing) Klerck
Coccochloris stagnina Sprengel
Anacystis dimidiata (Kuetzing) Drouet & Daily
Gomphosphaeria lacustris Chodat de Saint-Vincent

Cylindrospermum minutissimum Collins
Dactylococcopsis acicularis Lemmermann
Dactylococcopsis irregularis G.M. Smith
Dactylococcopsis smithii R. & F. Chodat
Dichothrix gypsophila (Kuetzing) Bornet & Flahault
Gloeocapsa stegophila (Itzigsohn) Rabenhorst
Gloeotheca linearis var. *composita* G.M. Smith
Gloeotrichia echinulata (J.E. Smith) Richter
Gloeotrichia natans (Hedwig) Rabenhorst
Gomphosphaeria lacustris Chodat
Gomphosphaeria lacustris var. *compacta* Lemmermann
Lyngbya bipunctata Lemmermann
Lyngbya birgei G.M. Smith
Lyngbya cryptovaginata Schkorbatow
Lyngbya epiphytica Hieronymus
Lyngbya hieronymusii Lemmermann
Lyngbya lacustris Lemmermann
Lyngbya limnetica Lemmermann
Lyngbya limnetica f. *minor* Geitler
Lyngbya martensiana Meneghini
Lyngbya putealis Montagne
Merismopedia elegans Braun
Merismopedia elegans var. *major* G.M. Smith
Merismopedia glauca (Ehrenberg) Naegeli
Merismopedia minima Beck
Merismopedia punctata Meyen
Merismopedia tenuissima Lemmermann
Microcystis aeruginosa Kuetzing
Microcystis elabens (de Brébisson) Kuetzing
Microcystis elabens var. *minor* Nygaard
Microcystis flos-aquae (Wittrock) Kirchner
Microcystis minutissima W. West
Microcystis pulvereae (Wood) Forti
Nodularia harveyana (Thwaites) Thuret
Nodularia implexa (Bornet & Flahault) Bourrelly
Nodularia spumigena Mertens
Nostoc commune Vaucher
Anabaina licheniformis Bory de Saint-Vincent
Ankistrodesmus falcatus (Corda) Ralfs
Ankistrodesmus falcatus (Corda) Ralfs
Coccochloris peniocystis (Kuetzing) Drouet & Daily
Calothrix parietina (Naegeli) Thuret
Anacystis montana f. *montana* (Lightfoot) Drouet & Daily
Coccochloris elabens (de Brébisson) Drouet & Daily
Calothrix parietina (Naegeli) Thuret
Calothrix parietina (Naegeli) Thuret
Gomphosphaeria lacustris Chodat
Gomphosphaeria lacustris Chodat
Schizothrix calcicola (Agardh) Gomont
Microcoleus lyngbyaceus (Kuetzing) Crouan
Microcoleus lyngbyaceus (Kuetzing) Crouan
Schizothrix calcicola (Agardh) Gomont
Microcoleus lyngbyaceus (Kuetzing) Crouan
Schizothrix calcicola (Agardh) Gomont
Schizothrix calcicola (Agardh) Gomont
Schizothrix calcicola (Agardh) Gomont
Microcoleus lyngbyaceus (Kuetzing) Crouan
Schizothrix mexicana Gomont
Agmenellum thermale (Kuetzing) Drouet & Daily
Agmenellum thermale (Kuetzing) Drouet & Daily
?²
Agmenellum quadruplicatum (Meneghini) de Brébisson
Agmenellum quadruplicatum (Meneghini) de Brébisson
Agmenellum quadruplicatum (Meneghini) de Brébisson
Anacystis cyanea (Kuetzing) Drouet & Daily
Coccochloris elabens (de Brébisson) Drouet & Daily
Coccochloris elabens (de Brébisson) Drouet & Daily
Anacystis cyanea (Kuetzing) Drouet & Daily
Anacystis incerta (Lemmermann) Drouet & Daily
Anacystis montana f. *minor* (Wille) Drouet & Daily
Nostoc spumigena (Mertens) Drouet
Scytonema hofmannii Agardh
Nostoc spumigena (Mertens) Drouet
Nostoc commune Vaucher

<i>Oscillatoria agardhii</i> Gomont	<i>Microcoleus vaginatus</i> (Vaucher) Gomont
<i>Oscillatoria angustissima</i> W. & G.S. West	<i>Schizothrix calcicola</i> (Agardh) Gomont
<i>Oscillatoria annae</i> van Goor	<i>Porphyrosiphon notarisii</i> (Meneghini) Kuetzing
<i>Oscillatoria articulata</i> Gardner	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria bornetii</i> Zukal	<i>Microcoleus irriguus</i> (Kuetzing) Drouet
<i>Oscillatoria chlorina</i> Kuetzing	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria cortiana</i> Meneghini	<i>Porphyrosiphon notarisii</i> (Meneghini) Kuetzing
<i>Oscillatoria curviceps</i> C.A. Agardh	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria formosa</i> Bory de Saint-Vincent	<i>Porphyrosiphon animalis</i> (Agardh) Drouet
<i>Oscillatoria geminata</i> Meneghini	<i>Schizothrix calcicola</i> (Agardh) Gomont
<i>Oscillatoria guttulata</i> van Goor	<i>Schizothrix arenaria</i> (Berkeley) Gomont
<i>Oscillatoria iwanoffiana</i> (Nygaard) Geitler	Nostocacea, with undeveloped spores
<i>Oscillatoria jasorvensis</i> Vouk	<i>Schizothrix calcicola</i> (Agardh) Gomont
<i>Oscillatoria lacustris</i> (Klebahn) Geitler	Nostocacea, with undeveloped spores and heterocysts
<i>Oscillatoria limnetica</i> Lemmermann	<i>Schizothrix calcicola</i> (Agardh) Gomont
<i>Oscillatoria limosa</i> C.A. Agardh	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria mougeotii</i> Kuetzing	?
<i>Oscillatoria okeni</i> var. <i>gracilis</i> (Kuetzing) Forti	<i>Microcoleus vaginatus</i> (Vaucher) Gomont
<i>Oscillatoria ornata</i> Kuetzing	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria planctonica</i> Woloszyńska	<i>Schizothrix calcicola</i> (Agardh) Gomont
<i>Oscillatoria princeps</i> Vaucher	<i>Oscillatoria princeps</i> Vaucher
<i>Oscillatoria rubescens</i> de Candolle	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria sancta</i> Kuetzing	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria splendida</i> Greville	<i>Porphyrosiphon splendidus</i> (Greville) Drouet
<i>Oscillatoria subbrevis</i> Schmidle	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria subtilissima</i> Kuetzing	<i>Schizothrix calcicola</i> (Agardh) Gomont
<i>Oscillatoria tenuis</i> C.A. Agardh	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Oscillatoria tenuis</i> var. <i>tergestina</i> (Kuetzing) Rabenhorst	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Phormidium mucicola</i> Naumann & Huber-Pestalozzi	<i>Schizothrix calcicola</i> (Agardh) Gomont
<i>Phormidium rotheanum</i> var. <i>capitatum</i> Desikachary	<i>Microcoleus lyngbyaceus</i> (Kuetzing) Crouan
<i>Raphidiopsis mediterranea</i> Skuja	<i>Loefgrenia anomala</i> Gomont ⁴
<i>Rhabdoderma lineare</i> Schmidle & Lauterborn	<i>Coccochloris peniocystis</i> (Kuetzing) Drouet & Daily
<i>Spirulina laxa</i> G.M. Smith	<i>Schizothrix calcicola</i> (Agardh) Gomont
<i>Spirulina major</i> Kuetzing	<i>Spirulina subsalsa</i> Oersted
<i>Tolypothrix pencillata</i> (Agardh) Thuret	<i>Scytonema hofmannii</i> Agardh
<i>Tolypothrix tenuis</i> Kuetzing	<i>Scytonema hofmannii</i> Agardh

¹Drouet (1978) gives *Microcoleus vaginatus* (Vaucher) Gomont for *Anabaina flos-aquae* (Linnaeus) Bory de Saint-Vincent

²Drouet & Daily (1956) give *Agmenellum quadruplicatum* (Meneghini) de Brebisson for *M. glauca* (Ehrenberg) Kuetzing

³Drouet (1968) gives *Microcoleus lyngbyaceus* (Kuetzing) Crouan for *O. mougeotii* Bory de Saint-Vincent

⁴This species was treated under the name *Raphidiopsis curvata* Fritsch & Rich in Drouet (1973, p. 197); Drouet (1981, p. 183, 184) considers *Loefgrenia anomala* Gomont to be the valid nomenclature.

GLOSSARY

- Adpressed:** flattened
- Akinete:** a thick-walled, asexual reproductive or resting cell.
- Amorphous:** without definite shape.
- Apex (Apical):** the growing tip of a trichome.
- Arcuate:** strongly curved or arched.
- Attenuate (Attenuated; Attenuation):** gradually tapering towards the apex.
- Basal:** at the base; opposite from distal.
- Binary fission:** reproduction of a unicell by division into two equal cells.
- Bulbous:** bulb-like; swollen at one end.
- Caespitose:** growing in dense tufts; forming a tangled mat.
- Calyptra:** a cap or thickened membrane on apical cell.
- Capitate:** with a head; enlarged at apex.
- Catenate:** in a series: joined together to form a chain.
- Circinate:** coiled, with apex innermost.
- Clathrate:** with openings.
- Colony:** an isolated group of similar cells which are joined together or simply enclosed in a common sheath or matrix.
- Confluent:** merging; as sheaths which merge and lose their identity.
- Conical:** with the shape of a geometrical cone.
- Constrict (Constricted):** surface wall of cell curved inward to meet the crosswall thus leaving grooves on the surface of the trichome.
- Convex:** curving outwards
- Crosswalls:** transverse walls in a trichome dividing it into cells.
- Cylindrical:** having the shape of a cylinder, i.e., elongated parallel-sided body, circular in transverse section.
- Disciform (Discoid):** having a circular flat body.
- Distal:** towards the apex; opposite from basal.
- Ellipsoid (Ellipsoidal):** of a solid object, elliptic in section or outline.
- Endospore:** reproductive structure formed by internal division of the protoplast.
- Epiphyte (Epiphytic):** plant growing on or attached to another plant, but not parasitic.
- False branch:** a lateral outgrowth initiated by a cross breakage of a filament, followed by the protrusion through the sheath of one or both of the broken ends of the trichome; a branch not formed by lateral cell division.
- Fascicle:** a bundle or cluster of filaments, usually more or less parallel.
- Fibril:** fine fibre; slender strand.
- Filament (Filamentous):** linear series of cells together with sheath.
- Flexuous:** wavy or more or less zig-zag; not firm or rigid.
- Flocculent:** cottony; loosely matted.
- Fusiform:** spindle-shaped; slenderly ellipsoidal.

Gas vacuole: false vacuoles; electron microscopy indicates that each contains hundreds of gas vesicles; usually light refracting.

Gelatinous: jelly-like.

Granulose (Granular; Granulated): having granules within the cytoplasm; granules along the crosswalls.

Hemisphere (Hemispherical): half a sphere.

Heterocyst: a specialised cell concerned with nitrogen-fixation in some filamentous blue-greens; larger, clearer, thicker-walled and often differing in shape from the vegetative cells.

Holotype: The one specimen or other element used by an author or designated by him/her as a nomenclatural type.

Homogeneous: similar throughout; not granulose.

Hormogonium (pl. Hormogonia; Hormogonous stage): a fragment of a trichome; a multicellular reproductive structure, usually released from the sheath.

Hyaline: translucent.

Intercalary: appearing between cells of trichome, rather than terminal or lateral.

Lamellate (Lamellated, Lamellose): layered.

Matrix: enveloping or surrounding mucilaginous material.

Membrane: a thin layer.

Mucilage: a gelatinous substance.

Necridium (pl. Necridia): a dead cell; common in some filamentous blue-greens; allows easy fragmentation.

Oblong: longer than broad, with parallel margins and rounded poles.

Obtuse: bluntly pointed to rounded apex.

Oscillatory: move to and fro between two points.

Oval: broadly elliptic.

Ovate: a plane shape resembling the longitudinal section of an egg; having the length greater than and up to twice as long as the width, with the greatest width below the middle.

Ovoid: a solid body which is ovate in longitudinal section.

Pellucid: transparent.

Penicillate: brush-like.

Periphery: outer or surrounding region.

Plankton (Planktonic): free-floating aquatic organism.

Polar Nodule: swelling or knob on inner wall of heterocyst.

Pyriform: pear-shaped.

Quadrate: squarish or rectangular.

Rectilinear: arranged in straight rows in two directions.

Reticulate: forming an irregular network.

Saccate: like a bag.

Sessile: attached.

Sheath: a covering of mucilage; lamellated or non-lamellated.

Sigmoid: s-shaped.

Sphere (Spherical): circular in outline along all planes.

Sub: nearly, as in subspherical.

Synonym: a systematic name which applies to the same taxon as another name.

Taxon (pl. Taxa): a taxonomic or classificatory group of any rank, e.g., family, genus, species, variety.

Terminal: borne at the end of a trichome or filament.

Thallus: a plant body which lacks differentiation into tissues.

Trichome: a row of cells minus an enveloping sheath.

Truncate (Truncately rounded): flat at the top; flatly rounded.

Tumid: swollen.

Type: a nomenclatural type; a designation of material (or illustration) by which later identifications can be judged.

Unicellular: single-celled.

Vegetative cell: cell not involved in reproduction.

Verrucose: warty.

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<i>lanata</i> f. <i>tenuis</i> (Kuetzing) Cedergren	50		
<i>penicillata</i> (Agardh) Thuret (Fig. 91)	50, 104, 110		
<i>tenuis</i> Kuetzing (Fig. 92)	50, 104, 110		
Trichodesmium iwanoﬀiana Nygaard	27		
<i>Trichodesmium lacustre</i> Klebahn ..	27		

APPENDIX II

PHYTOPLANKTON METHODOLOGY: SOME RECOMMENDATIONS

FOR ROUTINE ANALYSES

Etheredge (1985)

PHYTOPLANKTON METHODOLOGY : SOME RECOMMENDATIONS FOR
ROUTINE ANALYSES

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ABSTRACT

Methodology for quantitative phytoplankton analyses is reviewed and recommendations are made for precision techniques within specific areas, particularly cell volume calculations. It is suggested that the question of algal data storage using a standardised numerical coding system be addressed in the near future.

INTRODUCTION

The problems involved in studies of phytoplankton ecology are formidable. They arise mainly because phytoplankton communities are highly dynamic and markedly polyspecific (Sakshaug, 1980), and so exhibit a wide range of size classes, structural and morphological characteristics, and physiological and ecological attributes. Phytoplankton methodology has become so complex that no account can be comprehensive. This discussion will omit field sampling techniques and limit suggestions to laboratory methods, with specific emphasis on accurate quantitative analyses.

Biomass seems to be measured with increasing frequency, directly from proximate analyses (chlorophyll, ATP, carbon, nitrogen, etc.), but such measurements do not estimate phytoplankton concentration senso stricto. Rather, they provide a measurement of some constituent common to the entire community which reflects numerical abundance. Biomass measurements may supplement but cannot substitute for a numerical census (Smayda, 1978). Microscopical examination and enumeration of the phytoplankton are

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essential for investigations of:

- a phytoplankton-grazing relationships;
- b nutrient dynamics;
- c species or size-class contribution to production;
- d changes in trophic state-community structure relationships;
- e influence of phytoplankton size on optical properties of water.

If such investigations are to be of value, the quantitative analyses must be performed using standardised techniques and with the highest degree of accuracy that it is possible to achieve.

METHODOLOGY

Fixation, staining and storage

Following the collection of a sample all changes, both quantitative and qualitative, must be minimised, hence immediate preservation of the material is essential. The 2 most widely used fixatives are formaldehyde (neutralised and acidified) and Lugol's iodine (see Appendix).

Formaldehyde

Approximately 4 to 5 ml of formaldehyde are required for adequate preservation of a 100 ml water sample, however, if the cell density is particularly high (e.g., as a result of net hauls from eutrophic habitats) it may be necessary to add sufficient formaldehyde to make up at least 25% of the volume of the sample. Formaldehyde preservation offers 2 advantages. Samples may be stored successfully for many years without requiring further attention, and some internal structures which must be clearly visible for taxonomic purposes (e.g., in cryptomonads) are not masked. Similarly, the thecal structure of dinoflagellates remains clearly discernible. The disadvantages include the distortion of the shape of many species, especially naked forms; the bleaching of cellular material rendering it impossible to distinguish between pigmented and non-pigmented cells (and thus living and non-living phytoplankters); and the loss of flagella from flagellated species. Also, sedimentation of gas-vacuolate cyanophytes is not assured. These disadvantages will have a significant influence on identification, enumeration, and volume calculations, especially as naked flagellates are frequently of quantitative importance and may in fact dominate primary production.

Lugol's iodine

Approximately 2 ml of Lugol's iodine are necessary to fix a 100 ml water

sample which will then appear yellowish-light brown. Samples should be stored in glass bottles in preference to plastic containers as the latter remove the iodine from the solution (Thronsdon, 1978a). This preservative accelerates the sinking speed of the phytoplankton which is most desirable if sedimentation is the technique to be employed prior to enumeration. No loss of flagella occurs. The sample will have a shorter life span than if preserved with formaldehyde, because the iodine is gradually oxidised. This necessitates regular checking and the addition of more preservative when required. The samples must be stored in darkness. A major disadvantage of this technique is the uptake of iodine by other particles, both organic and inorganic. Paerl (1977) considered, after a comparison of counts from Lugol's iodine stained material with ^{14}C microautoradiographs, that the former technique did not permit differentiation between plankters that were $\leq 5\mu\text{m}$ in diameter and detritus. The second disadvantage is the masking of essential taxonomic structures as a result of overstaining (this can be partially remedied by the addition of sodium thiosulphate).

It is preferable that samples that are to be used for taxonomic analyses are collected in duplicate. One sample is fixed immediately as described above, and the second kept for a prompt examination (including measurements) of the live material. The containers for the latter should be only partially filled, transported at cool temperatures (2 to 6°C), and stored in darkness to inhibit metabolic activity. The viability of the phytoplankton is limited without special attention, e.g., the most fragile species may die within an hour (Thronsdon, 1978a).

Concentration of phytoplankton

Phytoplankton samples inevitably contain more organisms than it is reasonable to count and further subsampling is necessary. Subsampling is usually performed in 2 stages in which case the final data contain:

- a the variability of the population in the field;
- b the variability introduced when the subsample is extracted from the sample;
- c the variability produced when the final aliquot is taken from the subsample (Venrick, 1971).

Obviously it is important that the technique employed to concentrate the phytoplankton should involve the minimum of subsampling. The importance of

each level of subsampling as a source of error must be determined experimentally and routinely, in conjunction with the desired accuracy required of the analyses. These problems are discussed definitively by Venrick (1971, 1978a, b).

Three techniques are frequently used to concentrate phytoplankton but none is totally adequate:

- 1 Utermohl or sedimentation for enumeration by inverted microscopy;
- 2 membrane filtration;
- 3 centrifugation.

Utermohl technique or sedimentation for enumeration by inverted microscopy

This is the preferred method for the determination of phytoplankton population dynamics and community structure (Lund, *et al.*, 1958; Utermohl, 1958; Hasle, 1978a; Wetzel & Likens, 1979; Rott, 1981). The standard technique involves settling (after a thorough but gentle mixing) a known volume of sample onto the bottom plate of a sedimentation chamber and later counting the organisms in replicate transects. Two modifications are frequently used. Firstly, counting is performed at 2 magnifications, i.e., smaller and more abundant organisms are counted at a high magnification whilst larger and rarer species are counted at a low magnification, and usually over the entire bottom plate. Secondly, several chambers of differing volumes (e.g., 5 to 100 ml) are employed, with different taxa being counted in different chambers depending on their abundance. This latter modification is not recommended because of the introduction of further variability with each subsample.

If maximum precision and accuracy are to be maintained, special attention must be given to both sedimentation time and the random distribution of the organisms on the basal plate. However, despite the wide usage of the sedimentation technique, few authors state the settling time employed and even fewer include experimental support or specific reasons for a particular choice of time (Furet & Benson-Evans, 1982). The results of a detailed investigation into the times required to obtain complete sedimentation of fixed algae prior to enumeration are presented in Table 1. From these results a settling time of 48 h (8 cm d^{-1}) in a 16 cm vertical column at 20°C for phytoplankton that have been fixed in Lugol's iodine is suggested, but only if small diatoms are absent or insignificant. If this

TABLE 1 : Mean cell numbers, their volume and the cumulative percentage of each group for phytoplankton sedimented out of a 16 cm water column (100 ml measuring cylinder), with 1% Lugol's solution added as a fixative. After Furet & Benson-Evans (1982).

Species	I.C.V.	24 h		48 h		96 h		192 h	
		N	V	N	V	N	V	N	V
CHLOROPHYTA									
Ankistrodesmus gracillius (Reinsch) Korschikov	0.05	26.3	2.5	2.4	0.2	0.0	0.0	0.0	0.0
Closterium ehrenbergii Meneghini	15.00	3.7	56.6	0.0	0.0	0.0	0.0	0.0	0.0
Monoraphidium tortile (M. et G.S. West) Legnerova	0.06	11.2	0.7	1.6	0.2	0.0	0.0	0.0	0.0
Scenedesmus spp.	0.32	454.1	142.4	34.0	11.0	0.0	0.0	0.0	0.0
Percentage		92.9	94.9	100.0	100.0	100.0	100.0	100.0	100.0
BACILLARIOPHYTA CENTRALES									
Cyclotella meneghiniana Kutzling	1.09	144.0	160.0	30.5	32.3	0.0	0.0	0.0	0.0
Stephanodiscus tenuis Hustedt	0.29	16.2	4.7	234.1	68.0	61.4	17.8	0.0	0.0
Thalassiosira fluviatilis Hustedt	0.09	4205.7	357.4	1200.0	101.8	1336.7	123.2	41.5	3.6
Percentage		60.4	60.1	80.9	83.3	99.4	99.6	100.0	100.0
PENNALES									
Achnanthes lanceolata (Brebisson) Grunow	0.18	35.7	14.6	7.6	3.1	4.3	1.7	0.0	0.0
A. minutissima Kutzling	0.11	56.7	3.3	58.1	3.7	32.5	2.1	7.1	0.5
Cocconeis placentula Ehrenberg	3.00	57.2	171.0	11.8	36.1	4.2	12.6	0.0	0.0
Cymbella ventricosa Kutzling	0.90	125.6	13.4	15.2	13.7	0.0	0.0	0.0	0.0
Diatoma vulgare var producta Grunow	6.48	27.3	177.1	5.2	33.8	6.1	47.4	0.0	0.0
Gomphonema parvulum Kutzling	0.41	29.2	12.2	5.6	2.4	0.0	0.0	0.0	0.0
Gyrosigma acuminatum Kutzling	22.50	16.0	359.8	0.0	0.0	0.0	0.0	0.0	0.0
Navicula cryptocephala Kutzling	0.70	166.4	120.4	2.4	1.7	0.0	0.0	0.0	0.0
N. viridula Kutzling	6.09	58.5	356.6	50.8	310.6	1.7	10.4	0.0	0.0
Nitzschia dissipata (Kutzling) Grunow	0.77	41.1	31.6	0.0	0.0	0.0	0.0	0.0	0.0
N. palea (Kutzling) M. Smith	0.36	80.8	28.8	56.4	15.3	5.2	1.8	0.0	0.0
Synedra ulna var danica Kutzling	8.82	16.0	141.1	3.8	44.2	0.0	0.0	0.0	0.0
Percentage		67.6	73.9	88.1	96.3	93.2	99.9	100.0	100.0

Key: N, number of organisms.ml⁻¹ of original river water sample; V, volume in µm³.10³.ml⁻¹ of original river water sample; 24 h, organisms sedimented in the first 24 h (100 ml and 16 cm height); 48 h, organisms not sedimented in the first 24 h but sedimented in the next 48 h; 96 h, organisms not sedimented in the first 48 h but sedimented in the next 96 h; 192 h, organisms not sedimented in the first 96 h but sedimented in the next 192 h; I.C.V., Individual cell volume of each species in µm³.10³; Results, average of 3 cylinders. 3 replicates (9 counts for each settling time).

Utermohl's own recommendations of counting about 100 individuals of the most important species (Utermohl, 1958) is frequently used.

The counting procedures for the inverted microscope usually follow that of Utermohl (1958) and employ either cross or vertical diameter transects. The ratio of the area of the bottom of the chamber to that of one diameter transect is $\pi n/4$ where n is the ratio between the diameter of the chamber and the width of the diameter transect, thus the total number of each species in the chamber is calculated by multiplying $\pi n/4$ by the numbers found in the diameter transect (Hasle, 1978d).

TABLE 2 : Precision obtained at 0.95 confidence limits at differing size of counts. After Lund *et al.* (1958).

Number of organisms counted	Approximate 0.95 confidence limits	
	As percentage of count	Range
4	<u>+100%</u>	0-8
16	<u>+50%</u>	8-24
100	<u>+20%</u>	80-120
400	<u>+10%</u>	360-440
1600	<u>+5%</u>	1520-1680
10,000	<u>+2%</u>	9800-10,200
40,000	<u>+1%</u>	39,600-40,400

Alternatively, the number of each species within random fields of view (determined by a random number co-ordinate corresponding to the X- and Y-translation of the mechanical stage) can be counted.

It must be emphasised that expected error estimates are based on the assumption of random distribution. An estimation of the error associated with variance within the chamber, has been attempted by Sandgren & Robinson (1984). They identified a consistent 'edge effect', i.e., a non-random settling pattern, independent of cell size or population density. The magnitude of the peripheral settling bias was such that estimates of

density were biased by an average of 10.3% if all fields were considered random subsamples from the same population, rather than an equal number from populations, i.e., peripheral and central. Obviously, a similar bias would arise from density estimates using transects. It is recommended therefore, that a stratified sampling approach be taken with random fields being counted from both central and peripheral compartments. These are distinguished by a circle marked on the base plate describing one-half the radius of the chamber.

All phytoplankters, excluding empty or 'dead' cells, must be included in the counts, even if some are unidentifiable. The criterion for classifying a cell as 'dead' is an arbitrary one, but generally if it contains at least one-half of the usual cellular contents for that species it may be categorised as 'alive'.

It is suggested that phytoplankton be counted and recorded as plankton units, i.e., independent units (Chandler, 1940; Lewis, 1976). These units may then be unicells, colonies, or filaments, and provide a standardisation which allows meaningful comparisons between different research programmes to be made. Counts must be made, however, of numbers of cells per coenobium, colony or filament to enable a mean to be calculated prior to the conversion to biomass data. The minimum number suggested is 10 counts per species per sample.

Calculation of biomass

An immense range of cell size is exhibited by phytoplankton. For example, measurements of phytoplankton taken from Lake Rotomanuka, near Hamilton, throughout 1979, produced mean volumes which ranged from 15 μm^3 (Monoraphidium minutum) to 51301 μm^3 (Ceratium hirundinella). Routine estimations of standing stock as cell densities are obviously inadequate and can be misleading. This is exemplified in Figs. 1 and 2. For example, the major algal groups occurring in Lake Rotomanuka throughout 1979, were, according to their contribution to the total number of plankton units ml^{-1} , the chrysophytes (I), dinoflagellates (II), and the greens (V). However, if importance is based on contribution to the total volume of phytoplankton, then the community was completely dominated by the dinoflagellates (II). Cell densities should, therefore, be used as the initial step in providing

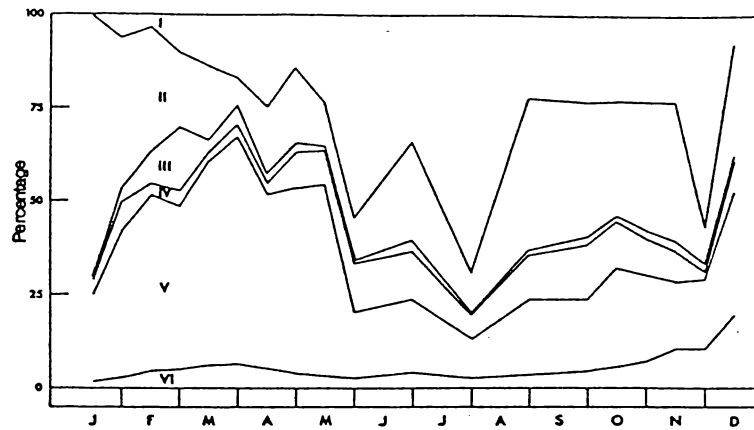


Fig. 1: Seasonal fluctuations in the percentage contributions of the major algal groups to the total number of plankton units ml^{-1} in Lake Rotomanuka, 1979. Key: I, Chrysophyceae; II, Cryptophyceae and Dinophyceae; III, Cyanophyceae; IV, Diatomophyceae; V, Euchlorophyceae and Zygothryx; VI, Euglenophyceae

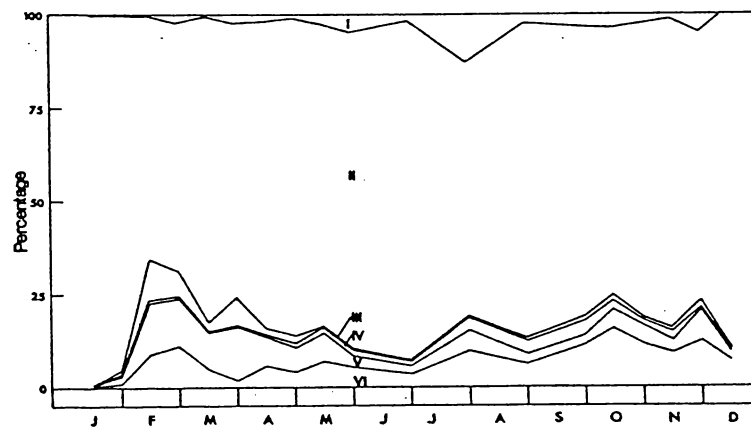


Fig. 2: Seasonal fluctuations in the percentage contributions of the major algal groups to the total volume of phytoplankton in Lake Rotomanuka, 1979. Key, same as for Fig. 1.

is not the case, then a settling time of 4 cm d⁻¹ is recommended. It is most probable that many past studies will have underestimated abundance, and therefore volume, especially of the nanoplankton (Furet & Benson-Evans, 1982).

The residual buoyancy properties of the gas-vacuolate cyanophytes (e.g., Microcystis aeruginosa) may result in incomplete sedimentation (Box, 1981). Preservation with Lugol's iodine usually ensures total sedimentation, but if densities are high then other methods such as ultrasonic disintegration of the colonies, alkaline hydrolysis, or heat treatment (see Appendix), will be necessary prior to settling (e.g., Humphries & Widjaja, 1979).

Utermohl (1958) designed a filling chamber ("Fullkammer") which supposedly ensured a random distribution of the phytoplankton on the bottom plate. This technique was disputed by Nauwerck (1963) who considered it impossible to consistently achieve random distribution. Unfortunately, algologists continue to ignore this problem and either assume random distribution or assume that counting replicate transects alleviates the sampling bias. To achieve random distribution, it is recommended that 5 ml of distilled water are first added to the chamber followed by the preserved sample, which is dripped onto the water surface in a pattern mimicking a regularly perforated filling chamber (Sandgren & Robinson, 1984).

Membrane filtration

Several methods of similar principle are regularly used to concentrate phytoplankton onto filters [for further details of this technique see Fournier (1978)]. The advantages of this method include: speed; permanent samples; easy storage in comparison to liquid samples; organisms may be examined directly with high magnification light microscopy, scanning electron microscopy or embedded for transmission electron microscopy. The disadvantages, however, are of considerable significance: organisms cannot be physically manipulated to aid identification; the question of random distribution on the membrane has not been adequately resolved; many small species are deformed, ruptured or destroyed by the rigours of filtration. This technique cannot be recommended as a general method for assessing phytoplankton abundance because of this clear bias towards the more robust members of the community. It may, however, be suitable for monitoring a specific component of the plankton or if the losses of small delicate forms are of no serious consequence (Fournier, 1978).

Centrifugation

Phytoplankton may be concentrated by batch or continuous centrifugation, but reports on the reliability of the method are varied (Thronsdon, 1978b). This, together with the inevitable damage imposed on colonial forms and naked flagellates, indicates that the technique does not warrant further discussion.

Identification

The appropriate taxonomic level for identification is determined by the overall objectives of the investigation. Whilst encouragement should be given to identify a phytoplankter to the lowest taxonomic level, time, and capability of the researcher, together with the limitations set by methods of preservation and concentration, are all major factors to be considered (Hasle, 1978b).

Unidentifiable phytoplankters should be recorded in a broadly designated group, e.g., 'monads' or 'small diatoms', and descriptions made which may allow a later taxonomic assignment.

Many diatom genera are identifiable to the specific level by a characteristic colonial shape, setae or processes, or gross cellular morphology. Others require specific observations of valve structure before identification is possible. Resolution of this frustular ornamentation is frequently masked by cellular contents and consequently oxidation of this organic material is essential. Methods for cleaning include UV radiation, enzymes, combustion and chemicals (see Appendix). Some diatoms may be examined successfully in water mounts, but it is generally preferable to embed them in a medium of high refractive index. (See Appendix). It must be emphasised that these techniques facilitate accurate identification, but no quantitative analyses should be made from such preparations because of the inability to distinguish between live and dead taxa (Wilson & Holmes, 1981).

The dinoflagellates, like the diatoms, may frequently be one of the major components of the biomass, yet their taxonomy remains problematical. The physiological and structural diversity of the group makes a choice of handling techniques complicated (Taylor, 1976). The taxonomy of the athecate or naked forms must be based on fresh material to avoid the

'round-up' response which occurs when preservatives are added, and which hinders observations of girdle and sulcal furrows. The complete 'plate pattern' is required for critical taxonomy of the thecate forms, hence empty thecae provide the best material due to the lack of interference by the cell contents. Holmes (1967) has used a combination of UV radiation and hydrogen peroxide to clean these species, but the technique is complicated by the need for an elaborate cooling system.

In a number of genera (e.g., Mallomonas and Synura) of the Chrysophyceae, the cells are covered with minute silica scales, the ultrastructure of which provides an accurate and distinctive phenotypic character. Since there is considerable variability in the cell morphology of a single species, classification with light microscopy alone is impossible (Bradley, 1966; Nicholls, 1982). Modern taxonomy of the genera must be founded on electron microscopy of both scales and bristles.

It is also recommended that records are made of other structures of taxonomic and ecological significance such as cysts, akinetes, zygospores, palmelloid stages, and indications of fungal infestations.

Counting

Counting represents the final stage in the subsampling process. The problem of how many cells to count to give acceptable levels of precision has received considerable attention. Obviously, it need be no greater than the precision of the replicate field samples, which is frequently poor as a result of the heterogeneous nature of the populations. Consequently, it is preferable to make rather imprecise estimates on several replicate samples than to make a precise count of a single sample (Venrick, 1978a).

It is possible to calculate the number of organisms to be counted to achieve a desired level of precision, if the distribution of phytoplankton on the basal plate has been shown to be random (χ^2 Test; Fisher, 1944) (see Table 2). The precision of the count varies indirectly as the square root of the number counted, thus to obtain any degree of increase in precision it becomes necessary to make very much larger counts, e.g., to obtain twice the precision, 4 times the number of organisms must be counted (Lund et al., 1958). Generally, a relative error (standard error expressed as a per cent of the mean) of 20% is acceptable (Hobro & Willen, 1977), and

more meaningful data in the form of species and community biomass. These calculations assume that the algae have a specific gravity of 1 g cm^{-3} .

A minimum of 10 individuals per species per sample are chosen at random and linear measurements are recorded. Spines, projections and gelatinous envelopes are not included in the measurements. By applying stereometric formulae which most closely approximate the species' shape (computations often involve the use of composite shapes) the volume of each individual is calculated and hence a mean volume per species can be derived. Average linear dimensions should not be used to calculate the mean cell volume.

Coding systems

Many types of ecological questions can only be answered efficiently by using a computer to record and subsequently analyse the data, in which case it is usual to code for each species rather than use full Linnean nomenclature (Whitton *et al.*, 1979). It is recommended therefore that algologists in New Zealand introduce a standardised numerical coding system for algae in the immediate future and thus forestall the accumulation of valuable data in a variety of non-exchangeable systems. Such a system would presumably contain the indexed list of species numbers and provide coding facilities for various life cycle stages, size categories, morphological criteria other than size, uncertain identifications, and percentages of dead cells. It would also enable links to be made between culture collection data and classical systematics (Hall, 1972).

SUMMARY

- a Fresh material should be used for critical taxonomy.
- b Lugol's iodine is the most suitable preservative.
- c Techniques for concentration must employ the minimum of subsampling.
- d The sedimentation or Utermohl technique is recommended for quantitative analyses.
- e Approximately 5 ml of distilled water should be added to the chamber prior to the addition of the sample.
- f Random distribution of phytoplankton on the basal plate of the chamber cannot be assumed. Statistical testing of replicate transects may indicate random distribution whilst an edge effect could still be present.
- g A stratified sampling approach within the chamber is recommended.

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- h Phytoplankton should be counted as plankton units. One hundred individuals of each of the major species should be counted.
- i Cell abundance data should not be used as an estimate of standing stock.
- j Average linear cell dimensions should not be used to calculate mean cell volumes.
- k A standardised numerical coding system for New Zealand phytoplankton data is required.

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APPENDIX

Formaldehyde.

- a Neutralised formaldehyde : 20% aqueous solution of formaldehyde neutralised with 100 g of hexamethylenetetramine to 1 l.
- b Acidified formaldehyde : mix equal amounts of 40% formaldehyde and concentrated acetic acid.

Neutralised formaldehyde is the better preservative if diatoms are the dominant taxon in the sample.

Lugol's Iodine.

Dissolve 100 g of potassium iodide in 1 l of distilled water. Add 50 g of iodine crystals, followed by 100 ml of glacial acetic acid.

Sedimentation of algae

- a Ultrasonic disintegration of colonies
Sonicate the sample in the band of 200 KC s^{-1} for 1 min (Okino, 1973). See also Reynolds & Jaworski (1978).
- b Alkaline hydrolysis
Add 4 ml of 0.01 M KOH to 1 ml aliquots of algal suspension and hydrolyse at 80°C for 5 min.
- c Heat treatment
Heat at 80°C for 15 min followed by 30 s vortex-mixing.

Cleaning diatoms.

Gently heat the sample with 30% hydrogen peroxide for ca. 30 min. The volume required needs to be determined experimentally as it varies depending on the amount and type of organic material present in the sample.

Diatom preparations.

- a Clean coverslips with alcohol to remove any oil.
- b With a pipette place 1 to 4 drops of cleaned sample on coverslip.
Use pipette to spread water.
- c Dry over gentle heat or leave overnight.
- d Add 2 to 4 drops of resin, e.g., Hyrax (refractive index 1.63).
- e Dry over gentle heat or leave over night. Protect from dust.
- f Adjust a hot plate to ca. 200°C and clean and mark microscope slides.
- g Heat slides leaving one end off plate for easy handling.
- h Place slide face down on prepared coverslip. Turn it over quickly when the resin melts enough to stick, and replace the slide on the hotplate.
- i Heat until resin has spread under entire coverslip. Do not boil. Gently tap coverslip to remove any bubbles. Cool the slide, seal with nail varnish and affix a permanent label (Hasle, 1978c).

APPENDIX IIIMEANINGS OF THE NAMES OF THE STUDY LAKES*

Kainui	=	a lot of food
Mangahia	=	stream with fish
Mangakaware	=	forgotten stream
Maratoto	=	blood-coloured water
Ngaroto	=	the lake/lakes
Rotokauri	=	kauri (<i>Agathis australis</i> Salisbury) lake
Rotomanuka	=	manuka (<i>Leptospermum scoparium</i> J.R. & G. Forster) lake
Rotoroa	=	long lake

* Meanings are tentative because circumstances leading to the original applications of these names are unknown.

This item is
no longer
available.

7/2/07 mm

APPENDIX IV

RESULTS OF PHYTOPLANKTON COUNTS (PU ML⁻¹) OF SAMPLES COLLECTED FROM THE NINE STUDY LAKES, JULY 1983 TO JULY 1984

This Appendix is held in the library, University of Waikato.

Each species is coded using the key described in Appendix VII. The taxonomic arrangement to familial level follows Bourrelly (1966, 1968, 1970); species are arranged alphabetically within genera.

APPENDIX VSUPPLEMENTARY TAXONOMIC LITERATURE

CHLOROPHYTA

Euchlorophyceae

Chlorococcales

Philipose (1967).

Chlorophyceae

Hindák (1977, 1980, 1984).

Ankistrodesmus

Belcher & Swale (1962); Legnerová (1965); Komárková-Legnerová (1969); Hindák (1970); Komárek & González (1982); Marvan *et al.*, (1984).

Coelastrum

Sodomková (1972).

Crucigenia

Komárek (1974); Flint & Bullock (1976).

Crucigeniella

Komárek (1974).

Dictyosphaerium

Komárek & Perman (1978).

Elakatothrix

Hindák (1962).

Kirchneriella

Marvan *et al.*, (1984).

Lagerheimia

Hindák (1983).

Monoraphidium

Komárková-Legnerová (1969); Hindák (1970); Heynig & Krienitz (1982); Krienitz *et al.*, (1983); Marvan *et al.*, (1984).

Oocystis

Řeháková (1969); Fott (1976).

Pediastrum

Sulek (1969); Parra (1979, 1984).

Quadriluga

Marvan *et al.*, (1984).

Raphidocelis

Hindák (1977); Komárek (1979); Marvan *et al.*, (1984).

Scenedesmus

Hortobágyi (1959, 1960a, b); Hegewald (1978); Hegewald *et al.*, (1980); Hindák (1979).

Tetraedron

Claus (1963); Kováčik (1975a, b); Kováčik & Komárek (1976); Compère (1977).

Tetrastrum

Ahlstrom & Tiffany (1934); Komárek (1974).

Volvox

Pringsheim (1970).

Westella

Komárek (1974).

Zygophyceae**Desmidiaceae**

West & West (1904, 1905, 1908, 1912); West *et al.*, (1923); Prescott *et al.*, (1972, 1975, 1977); Scott & Prescott (1961); Ružička (1977).

Actinotaenium

Teiling (1954); Thomasson (1973).

Closterium

Croasdale & Flint (1986).

Cosmarium

Krieger & Gerloff (1962, 1965, 1969); Thomasson (1973).

Euastrum

Croasdale & Flint (1986).

Micrasterias

Croasdale & Flint (1986).

Pleurotaenium

Croasdale & Flint (1986).

Staurastrum

Thomasson (1960, 1972, 1974b).

Stauroidesmus

Teiling (1948, 1967); Thomasson (1973).

CHROMOPHYTA**Chrysophyceae**

Bourrelly (1957).

Synuraceae

Takahashi (1978); Wee (1982).

Bicosoeca

Klug (1936); Hilliard (1971).

Chrysococcus

Lackey (1938); Belcher (1969).

Chryso-sphaerella

Bradley (1966); Asmund (1973); Nicholls (1980).

Dinobryon

Krieger (1930); Ahlstrom (1937); Asmund (1955); Hilliard (1968).

Mallomonas

Krieger (1930); Asmund (1959); Bradley (1966); Nicholls (1982).

Synura

Fott & Ludvík (1957); Bradley (1966); Asmund (1968).

Diatomophyceae

Patrick & Reimer (1966, 1975); Foged (1978, 1979); Germain (1981).

Acanthoceras

Simonsen (1979).

Asterionella

Körner (1970).

Aulacosira

Simonsen (1979).

Cyclotella

Lowe (1975).

Hantzschia

Mann (1977).

Fragilaria

Lange-Bertalot (1980).

Synedra

Round (1979).

Tabellaria

Knudson (1952, 1953a & b); Koppen (1975).

Xanthophyceae

Ettl (1978).

Centrtractus

Krienitz & Heynig (1983).

Peroniella

Mohlenbrock & Dillard (1963).

Pseudostaurastrum

Silva (1979).

Tetraedriella

Silva (1979); Krienitz & Heynig (1984).

CYANOPHYTA**Cyanophyceae**

Geitler (1932); Desikachary (1959); Cocke (1967).

Anabaena
Kantz & Bold (1969).

Chroococcus
Padmaja (1972).

Microcystis
Reynolds *et al.*, (1981).

EUGLENOPHYTA

Euglenophyceae

Astasia
Pringsheim (1942).

Euglena
Johnson (1944); Conrad & Meel (1952); Gojdics (1953); Pringsheim (1956); Leedale *et al.*, (1965a, b); Haughey (1970).

Lepocinclis
Conrad (1934).

Menoidium
Pringsheim (1942).

Phacus
Pochmann (1942); Allegre & Jahn (1943).

Strombomonas
Deflandre (1930); Conrad & Meel (1952).

Trachelomonas
Pringsheim (1953); Conrad & Meel (1952); Weik & Mohlenbrock (1963); Islam & Muniruzzaman (1981).

PYRRHOPHYTA

Cryptophyceae

Cryptomonas
Pringsheim (1968); Anton & Duthie (1981).

Dinophyceae

Playfair (1920); Eddy (1930); Lefèvre (1932); Schiller (1933, 1937)

RAPHIDOPHYTA

Raphidophyceae

Vacuolaria
Spencer (1971); Heywood (1983).

APPENDIX VI

PHOTOGRAPHS OF SOME PHYTOPLANKTON SPECIES FOUND IN
THE NINE STUDY LAKES, JULY 1983 TO JULY 1984

Plate 12

1. *Eudorina elegans*
2. *Gonium pectorale*
- 3a. *Pandorina morum*
- 3b. *Pandorina morum*
4. *Ankyra judayi*
5. *Characium ornithocephalum*
- 6a. *Tetraedron minimum*
- 6b. *Tetraedron minimum* emerging from old mother cell
7. *Ankistrodesmus bernardii*
8. *A. bibraianus*

Scale:

- | | |
|---------------|-------------------|
| 1, 2, 3b, 5-8 | 1 cm = 10 μ m |
| 3a, 4 | 1 cm = 20 μ m |

Plate 12.

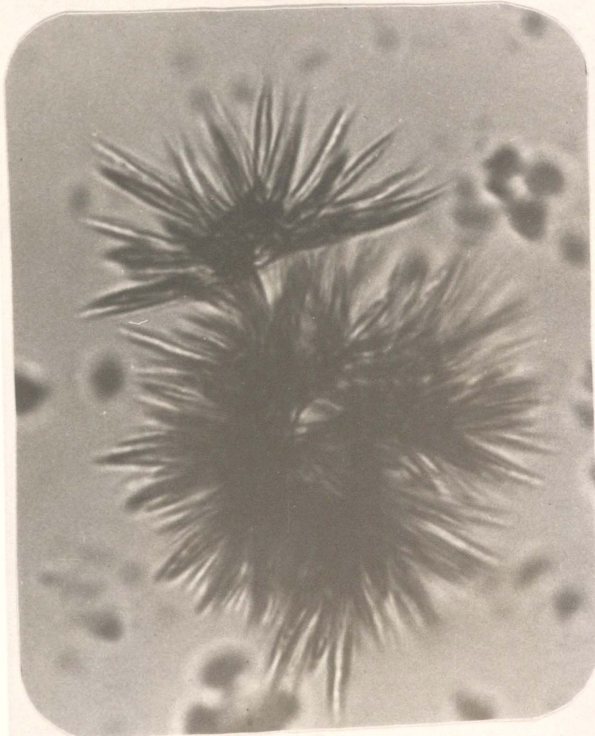
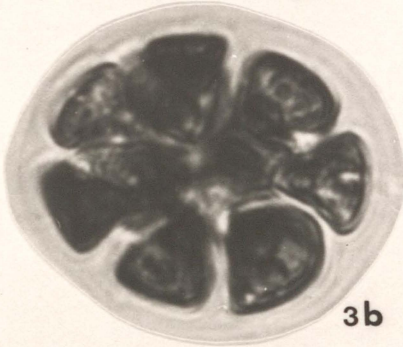
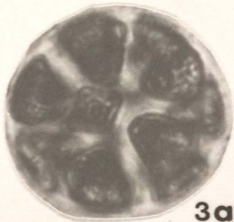
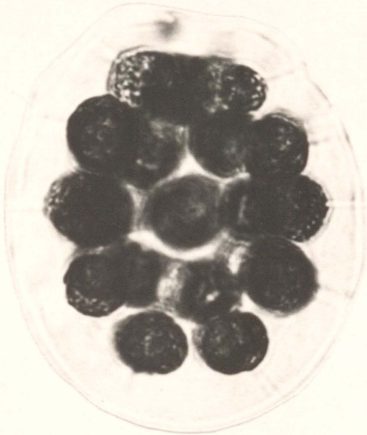


Plate 13

1. *Ankistrodesmus falcatus*
2. *A. fasciculatus*
- 3a. *A. gracilis*
- 3b. *A. gracilis*
4. *A. spiralis*
- 5a. *Kirchneriella lunaris*
- 5b. *Kirchneriella lunaris*

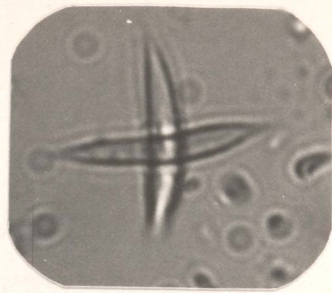
Scale:

- | | |
|--------------|-------------------|
| 1, 3a, 3b | 1 cm = 5 μ m |
| 2, 4, 5a, 5b | 1 cm = 10 μ m |

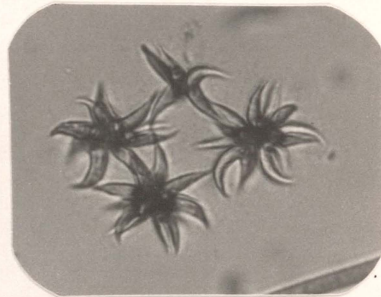
Plate 13.



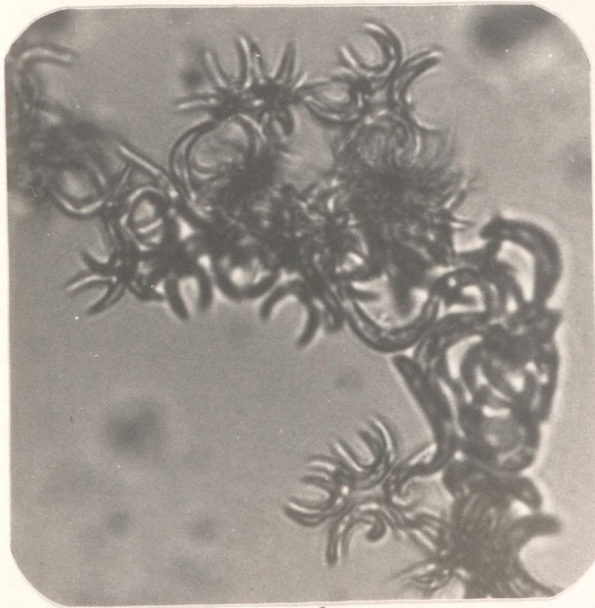
1



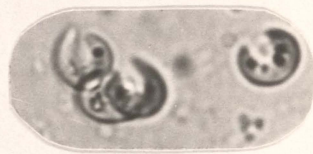
2



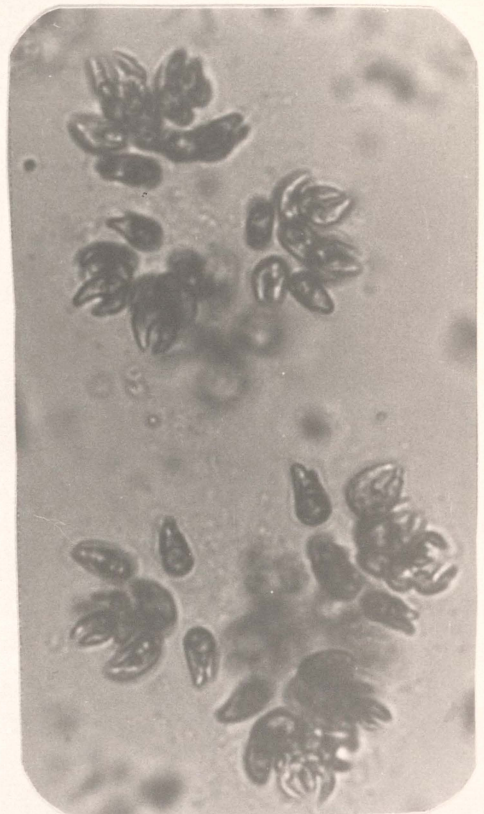
3a



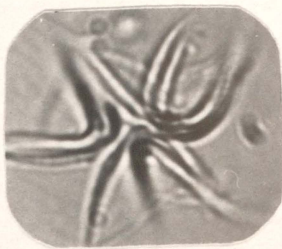
3b



5a



5b



4

Plate 14

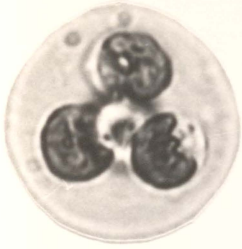
1. *Kirchneriella obesa* var. *aperta*
- 2a. *Lagerheimia ciliata*
- 2b. *Lagerheimia ciliata*
3. *Lagerheimia citrifomis*
4. *Monoraphidium contortum*
5. *Monoraphidium griffithii*
6. *Monoraphidium irregulare*
7. *Monoraphidium komarkovae*
8. *Nephrocytium agardhianum*
9. *Nephrocytium agardhianum*
10. *Oocystis solitaria*
11. *Raphidocelis contorta*
12. *Micractinium pusillum*

Scale:

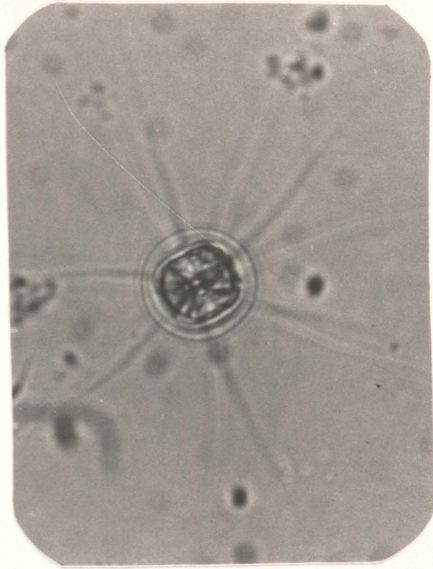
1-12

1 cm = 10 μ m

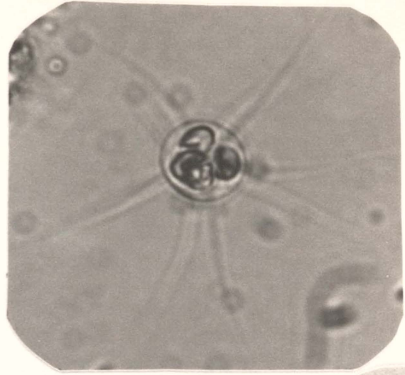
Plate 14.



1



2a



2b



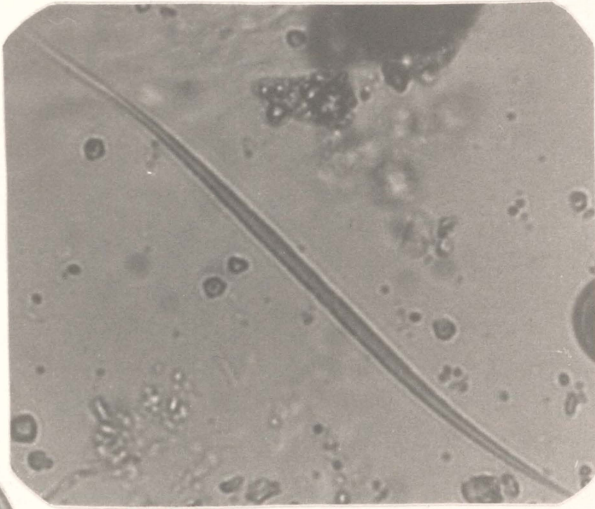
3



6



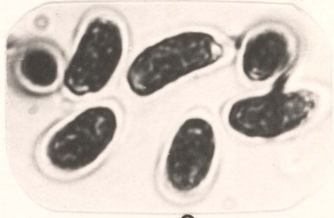
7



5



8



9



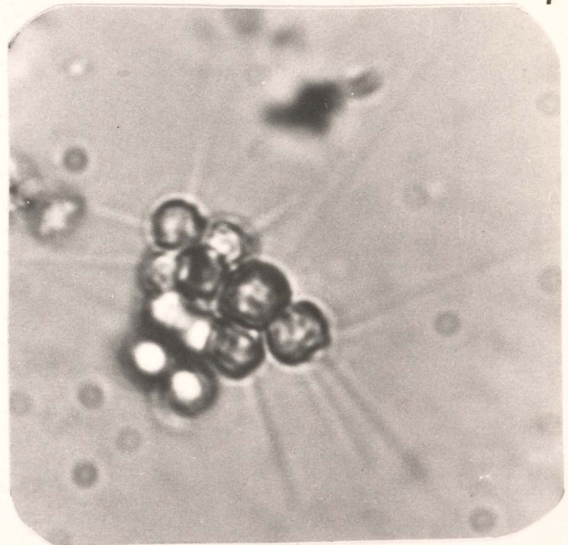
4



10



11



12

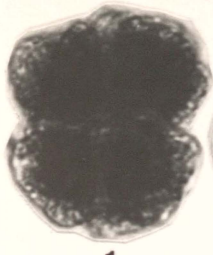
Plate 15

1. *Botryococcus braunii*
2. *Dimorphococcus lunatus*
- 3a. *Actinastrum hantzschii*
- 3b. *Actinastrum hantzschii*
4. *Coelastrum microporum*
- 5a. *Scenedesmus acuminatus* - 4-celled coenobium
- 5b. *Scenedesmus acuminatus* - 8-celled coenobium
6. *Scenedesmus acuminatus* var. *minor*
7. *Scenedesmus acutus*
8. *S. intermedius*
9. *S. obtusus* - 8-celled coenobium
10. *S. opoliensis*
11. *S. opoliensis*

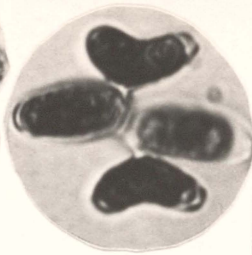
Scale:

1-3a, 5a-6, 8-11	1 cm = 10 μ m
3b-4, 7	1 cm = 15 μ m
9	1 cm = 5 μ m

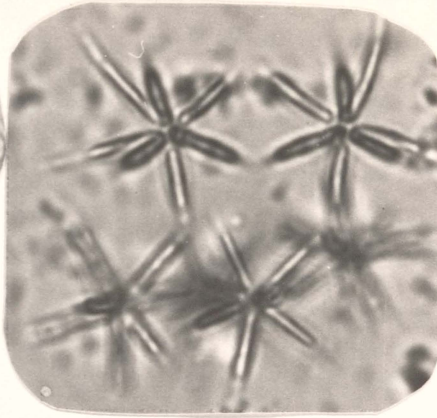
Plate 15.



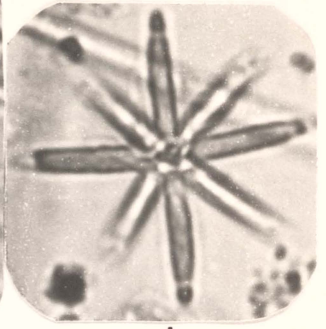
1



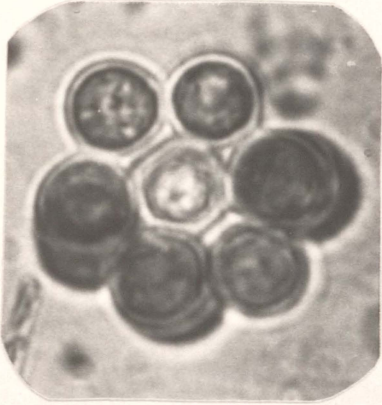
2



3a



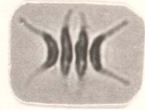
3b



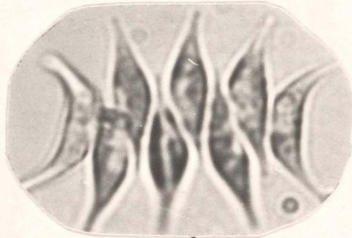
4



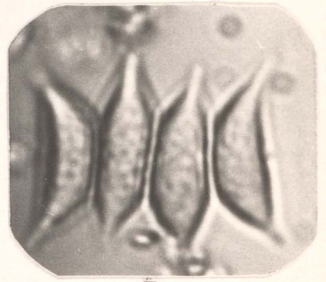
5a



6



5b



7



8



9



11



10

Plate 16

1. *Scenedesmus protuberans*
2. *Scenedesmus quadricauda* (after Etheredge [1983])
3. *Scenedesmus sempervirens*
4. *Tetrastrum heteracanthum*
5. *Tetrastrum staurogeniaforme*
6. *Tetrastrum triangulare*
7. *Pediastrum angulosum*
8. *P. boryanum* - considered by some phycologists (e.g., Huber-Pestalozzi *et al.*, 1983, p. 296) to warrant varietal status (*P. b.* var. *longicorne* Reinsch).
9. *P. duplex*
10. *P. duplex*

Scale:

1-6, 8-10

1 cm = 10 μm

7

1 cm = 15 μm

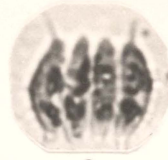
Plate 16.



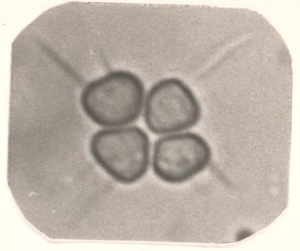
1



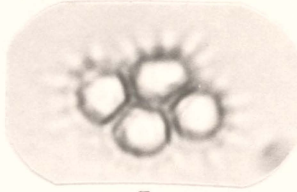
2



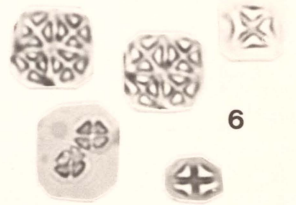
3



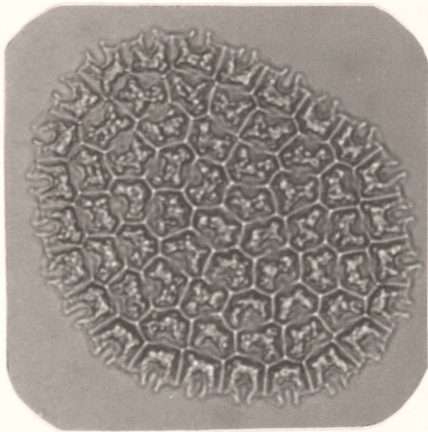
4



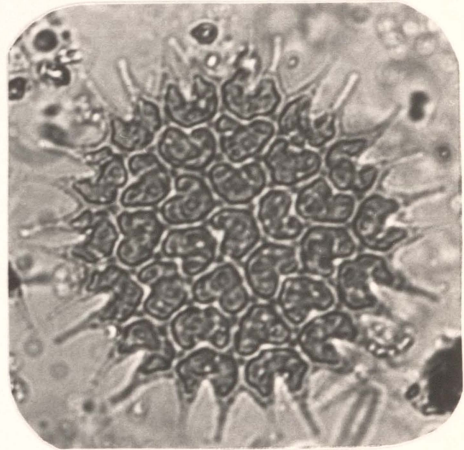
5



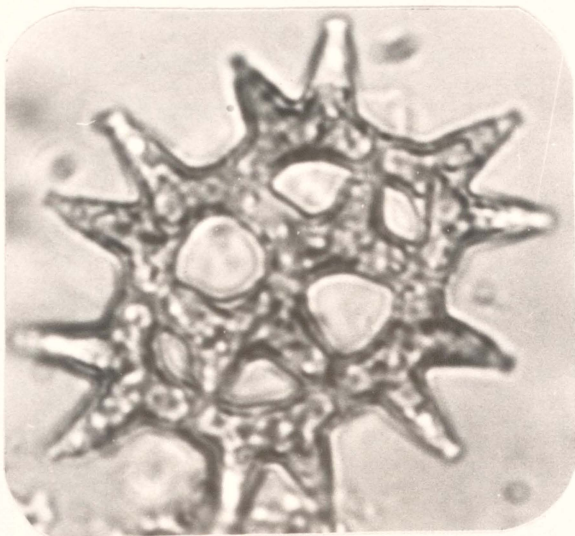
6



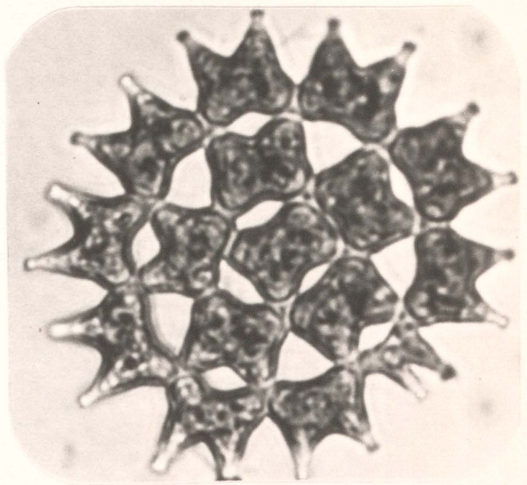
7



8



9



10

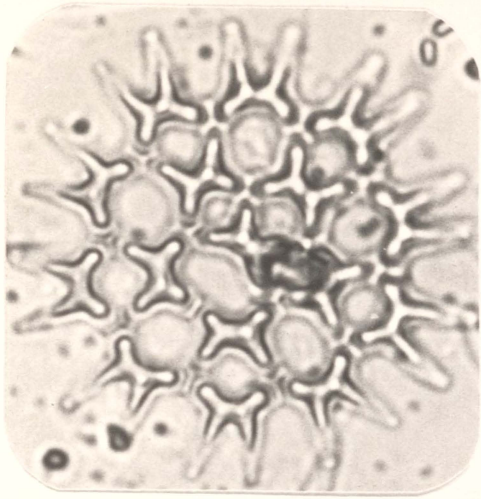
Plate 17

1. *Pediastrum duplex* - considered by some phycologists (e.g., Huber-Pestalozzi *et al.* , 1983) to warrant varietal status (*P. d.* var. *gracillimum* W. & G.S. West).
- 2a. *P. tetras* - 8-celled coenobium; considered by some phycologists to warrant varietal status [*P. t.* var. *tetraodon* (Corda) Hansgirg]. However, as the critical diagnostic features remain unclear (Parra, 1979; Huber-Pestalozzi *et al.* , 1983), this distinction has not been used in the present study.
- 2b. *P. tetras* - 4-celled coenobium
- 2c. *P. tetras* - 4-celled coenobium
3. *Sorastrum spinulosum*
4. *Elakatothrix gelatinosa*
5. *Oedogonium undulatum*
6. *Mougeotia* sp. A
7. *Mougeotia* sp. B
8. *Mougeotia* sp. C
9. *Gonatozygon brebissonii*
10. *Zygnema* sp.
11. *Netrium digitus*

Scale:

1, 3-8	1 cm = 10 μm
2a-2c	1 cm = 15 μm
9	1 cm = 20 μm
10-11	1 cm = 30 μm

Plate 17.



1



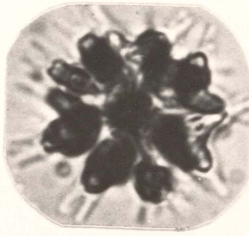
2a



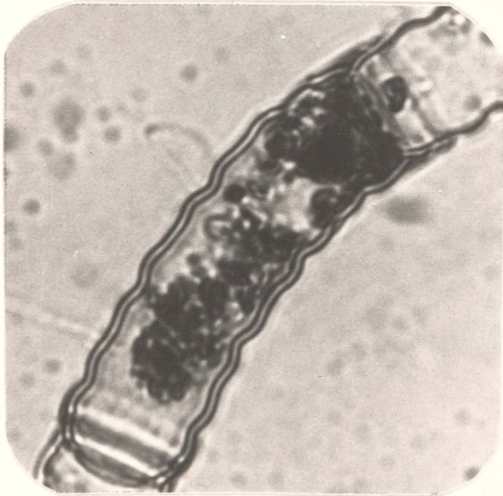
2b



2c



3



5



6



7



4



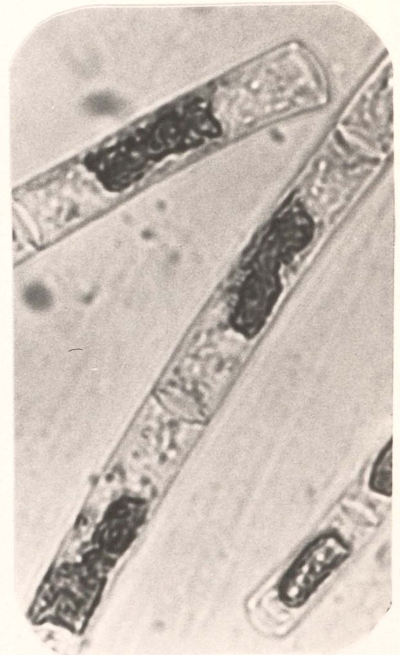
9



10



11



8

Plate 18

1. *Closterium acutum* var. *linea*
2. *Closterium acutum* var. *variabile*
3. *Closterium diana* var.
pseudodiana
4. *Closterium gracile*
5. *Closterium leibleinii*
6. *Closterium moniliferum*
7. *Closterium parvulum*
8. *Closterium setaceum*
9. *Cosmarium amplum*
10. *Cosmarium laeve*

Scale:

1	1 cm = 14 μ m
2, 4, 7	1 cm = 10 μ m
3	1 cm = 25 μ m
5, 6, 8	1 cm = 20 μ m
9	1 cm = 7 μ m

Plate 18.

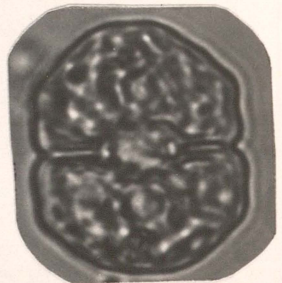
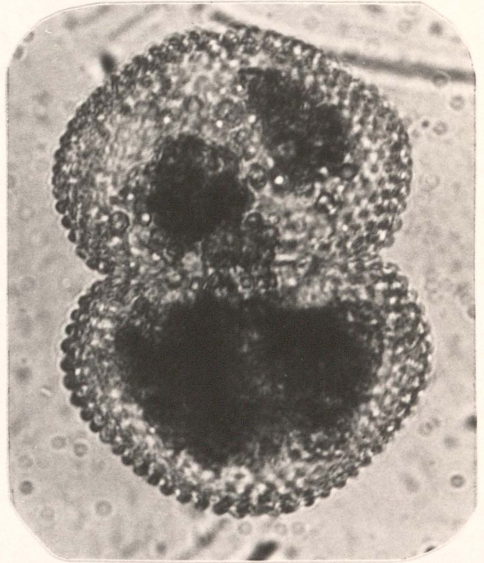
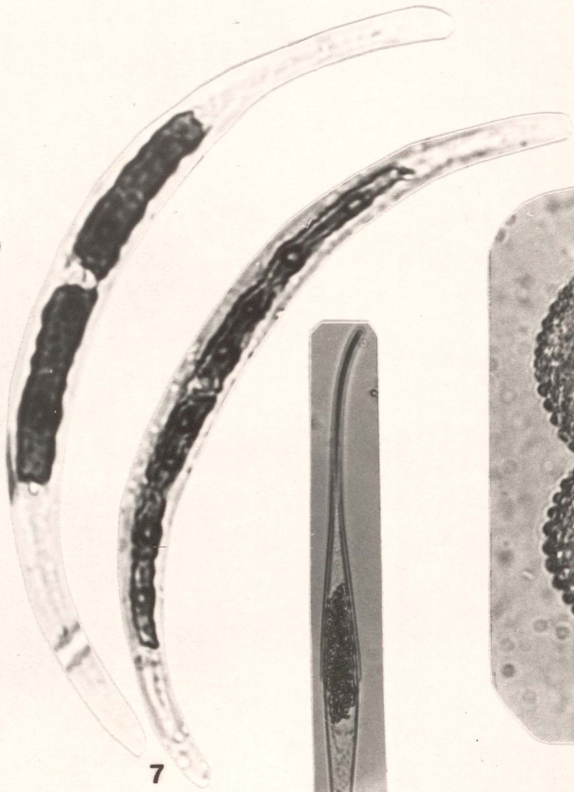
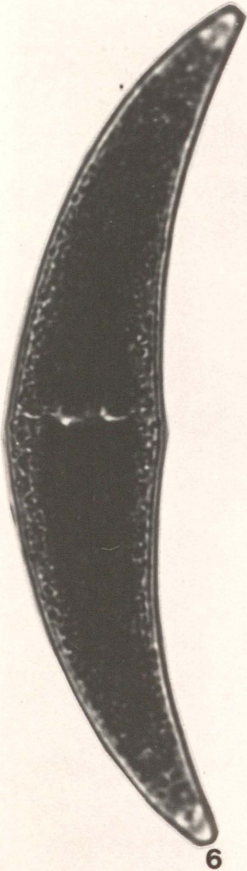
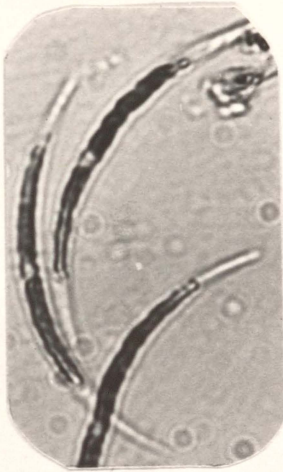
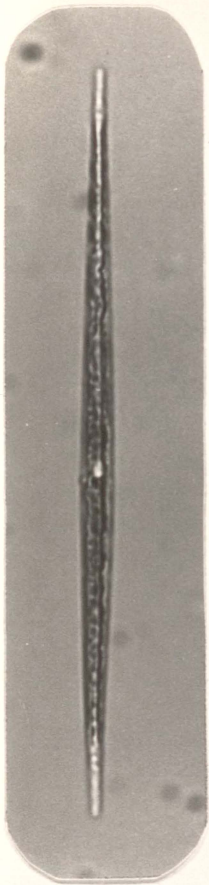


Plate 19

1. *Desmidium baileyi*
2. *Euastrum praemorsum*
3. *Euastrum verrucosum*
4. *Hyalotheca dissiliens*
5. *Micrasterias decemdentata* - an exceedingly variable species, sometimes closely resembling *M. zeylandica* Fritsch (Croasdale & Flint, 1986).
6. *Pleurotaenium minutum*
7. *Pleurotaenium trabecula*
8. *Spondylosium planum*
9. *Staurastrum avicula* (after Etheredge [1983])
10. *Staurastrum cingulum* var. *obesum*

Scale:

1, 9, 10	1 cm = 10 μ m
2	1 cm = 5 μ m
3	1 cm = 20 μ m
4	1 cm = 25 μ m
5	1 cm = 15 μ m
6	1 cm = 18 μ m
7	1 cm = 50 μ m
8	1 cm = 7 μ m

Plate 19.

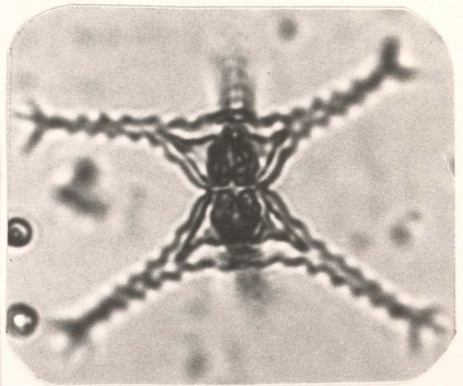
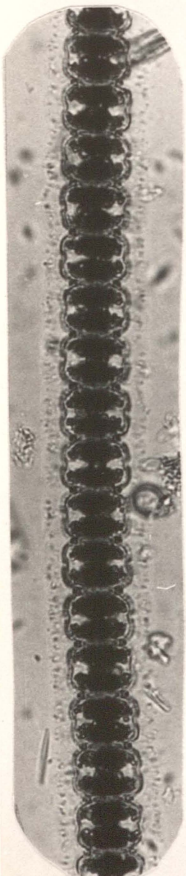
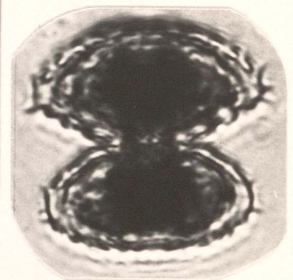
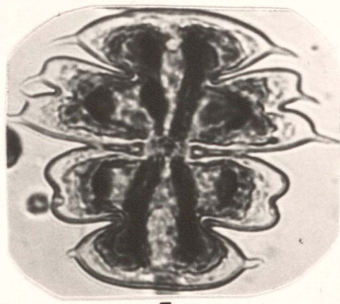
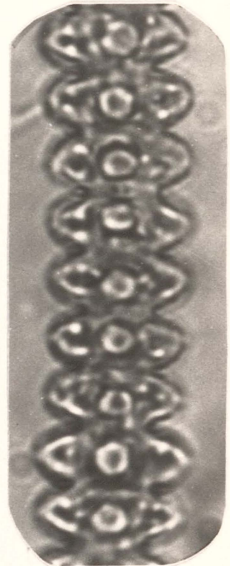
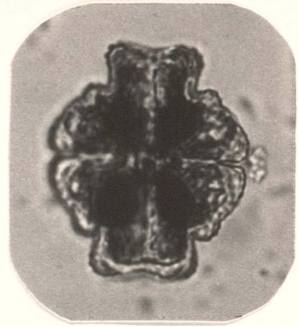
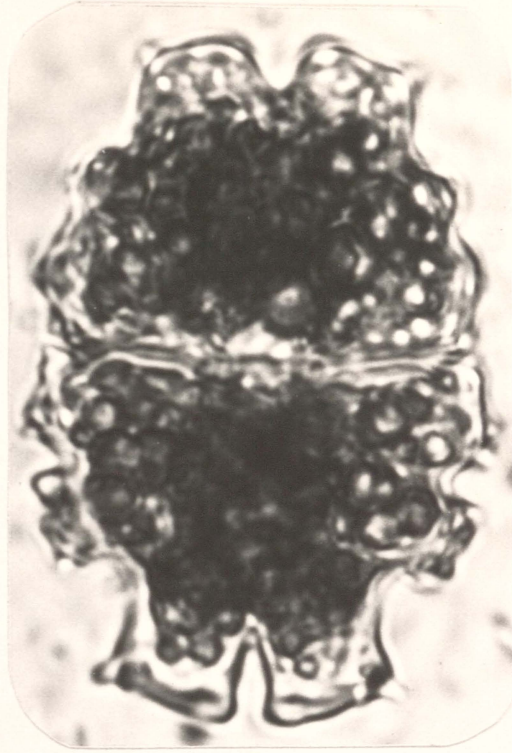


Plate 20

1. *Staurastrum gracile* forma
2. *Staurastrum gracile* var. *bulbosum*
3. *Staurastrum inflexum*
4. *Staurastrum leptocladum* var.
insigne
5. *Staurastrum muticum* var.
victoriense
6. *Staurastrum tohopekaligense* var.
minus
7. *Staurastrum* sp. B
8. *Stauroidesmus convergens* var.
laportei - showing variation in
form noted by Thomasson (1973).
9. As above

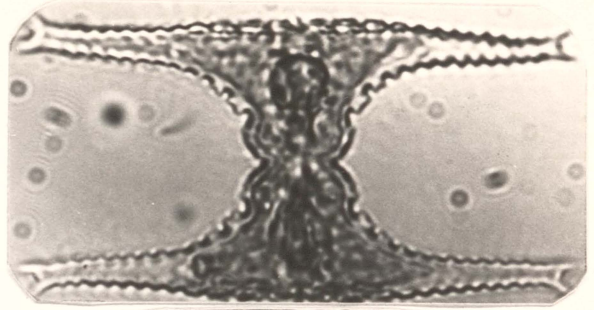
Scale:

- | | |
|--------|-------------------|
| 1, 3-9 | 1 cm = 10 μ m |
| 2 | 1 cm = 15 μ m |

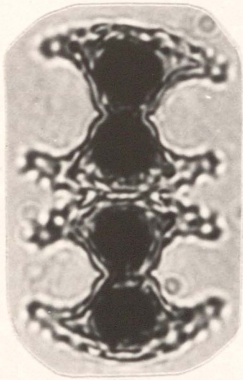
Plate 20.



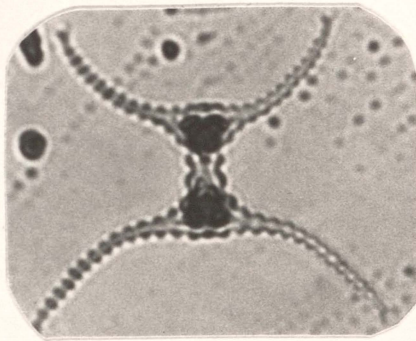
1



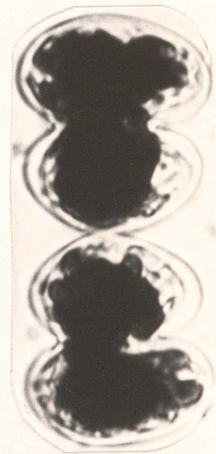
2



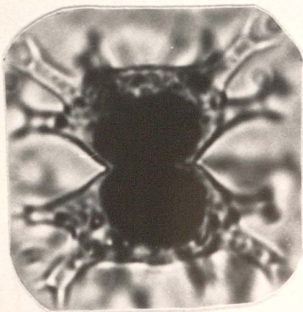
3



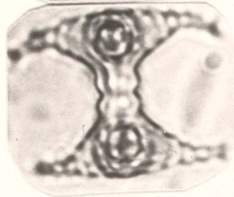
4



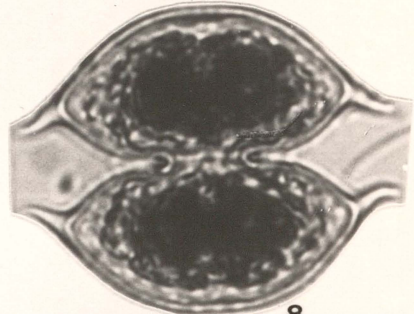
5



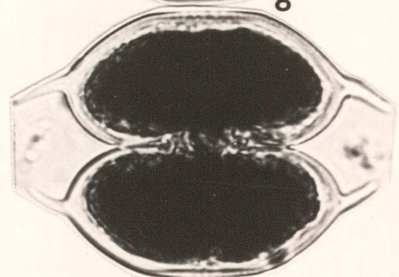
6



7



8



9

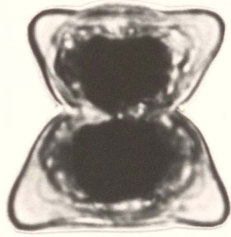
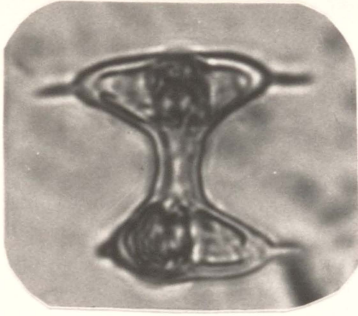
Plate 21

1. *Staurodesmus cuspidatus*
2. *Staurodesmus dejectus*
3. *Staurodesmus glaber* var.
limnophilus
4. *Staurodesmus leptodermus* var.
subcorniculatus
5. *Staurodesmus mucronatus* var.
delicatulus
- 6a. *Staurodesmus spetsbergensis*
- 6b. *Staurodesmus spetsbergensis*
7. *Bicosoeca petiolata*
8. *Dinobryon crenulatum* with statocyst
9. *Dinobryon cylindricum*

Scale:

1-4, 6a-8	1 cm = 10 μ m
5	1 cm = 5 μ m
9	1 cm = 20 μ m

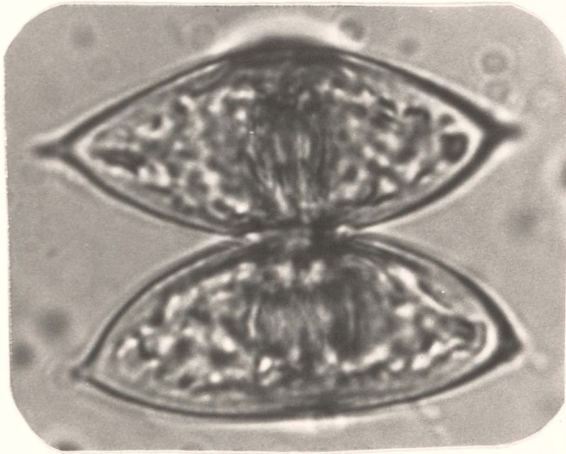
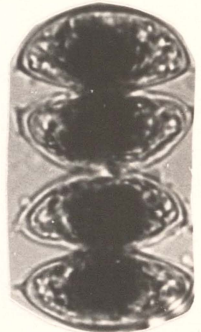
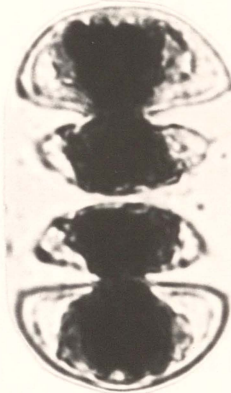
Plate 21.



2

3

4



6a

6b

5



7

8



9

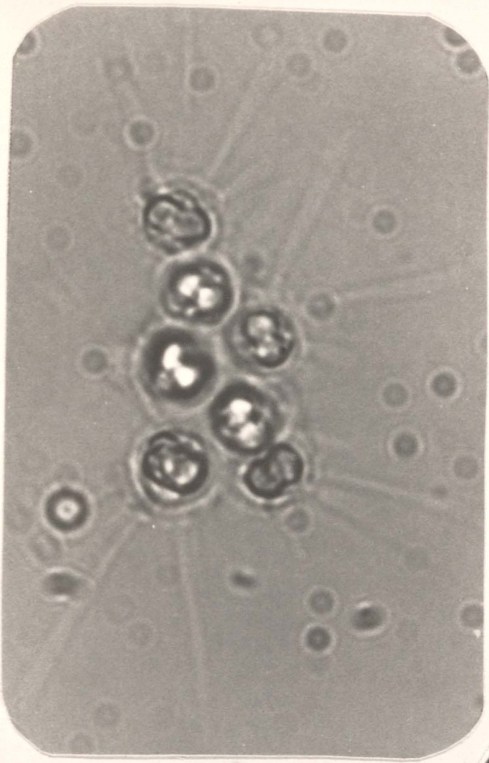
Plate 22

1. *Chrysosphaerella longispina*
2. *Synura spinosa* #
3. *Stokesiella epipyxis* ? on
Aulacosira granulata
4. *Goniochloris pseudogigas*
5. *Pseudostaurastrum hastatum*
6. *Pseudostaurastrum* sp. A
7. *Pseudostaurastrum* sp. B
8. *Pseudostaurastrum* sp. B
9. *Tetraedriella jovetii*
10. *Centrित्रactus belonophorus*
- 11-13 *Aulacosira distans*

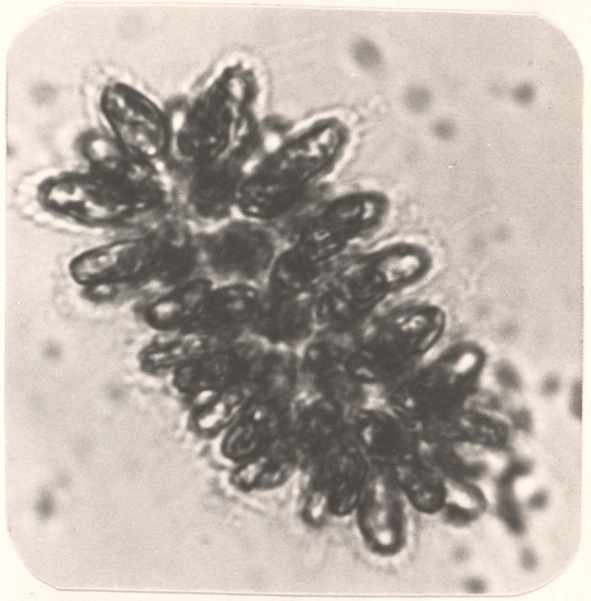
Scale:

1, 2, 5-7, 9, 11-13	1 cm = 10 μm
3	1 cm = 12 μm
4	1 cm = 8 μm
8	1 cm = 15 μm
10	1 cm = 20 μm

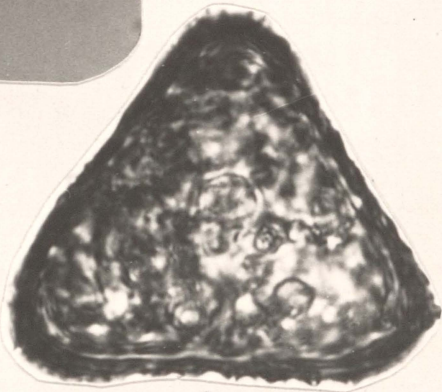
Plate 22.



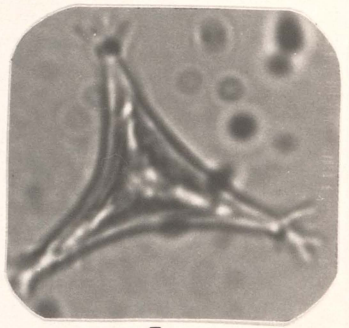
1



2



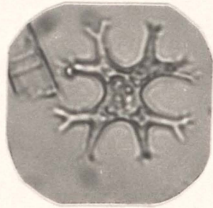
4



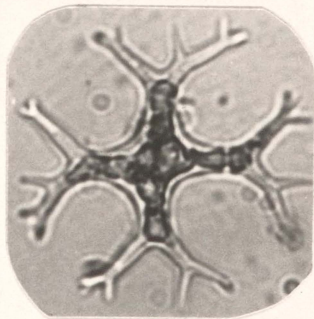
5



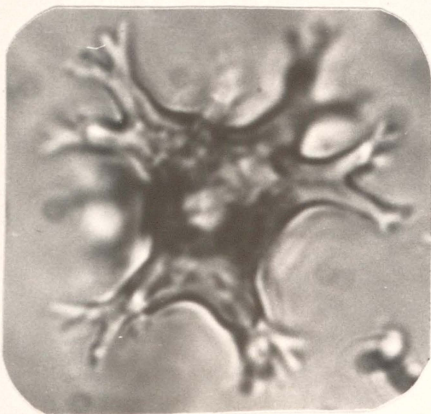
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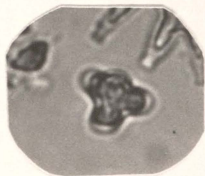
7



8



6



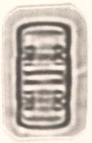
9



10



11



12



13

Plate 23

1. *Aulacosira granulata*
2. *Aulacosira granulata* var.
angustissima
3. As above
4. *Cyclotella meneghiniana*
5. As above
6. *Cyclotella stelligera* - valve view
7. As above - girdle view
8. *Rhizosolenia eriensis*
9. *Acanthoceras zachariasii*
10. As above
11. *Asterionella formosa* parasitised with
Rhizophyidium planctonicum ?

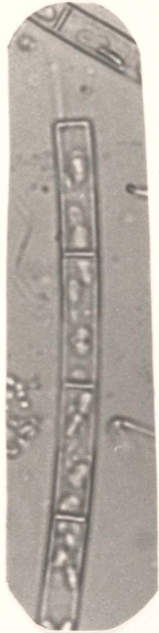
Scale:

1-3, 6-10	1 cm = 10 μ m
4-5	1 cm = 7.5 μ m
11	1 cm = 15 μ m

Plate 23.



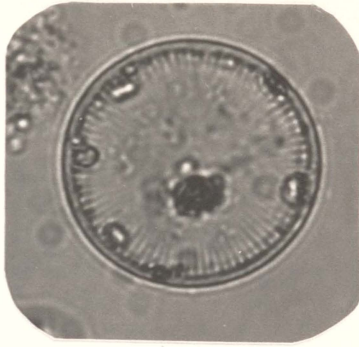
1



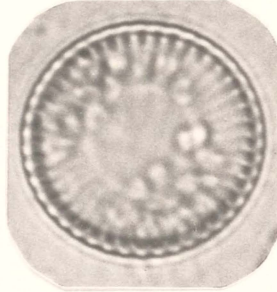
2



3



4



5



6



7



10



8



9



11

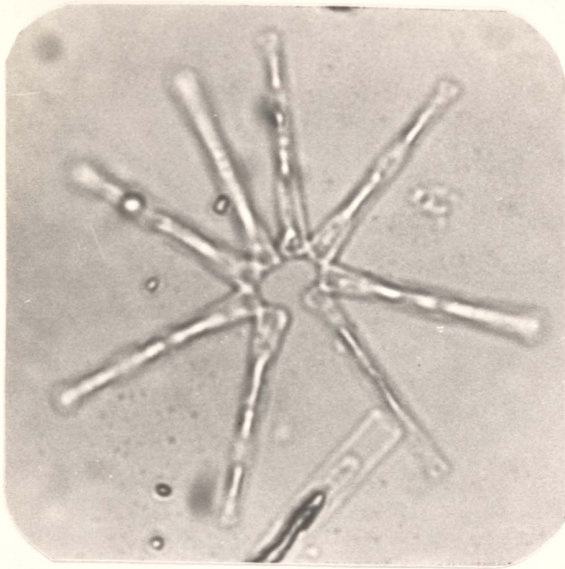
Plate 24

1. *Asterionella formosa* - colony
2. *Centronella reichelti*
3. *Meridion circulare* var.
constricta
4. *Tabellaria fenestrata* - girdle view
5. As above - valve view
6. As above - girdle view
7. *Tabellaria flocculosa* girdle view
8. As above - valve view
9. *Eunotia curvata*
10. *Eunotia diodon*
11. As above
12. *Eunotia exugia*
13. *Eunotia formica*

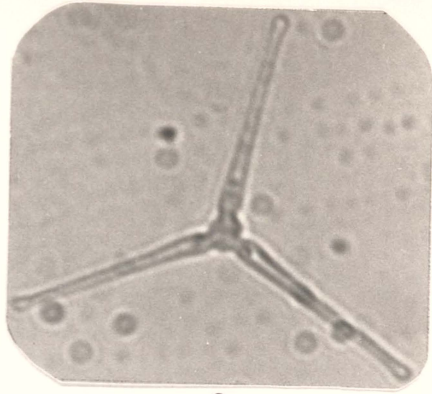
Scale:

1	1 cm = 12 μ m
2-9, 11	1 cm = 10 μ m
10	1 cm = 4 μ m
12-13	1 cm = 5 μ m

Plate 24.



1



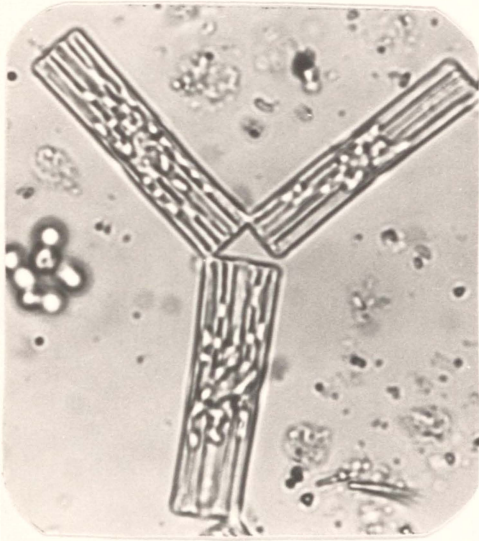
2



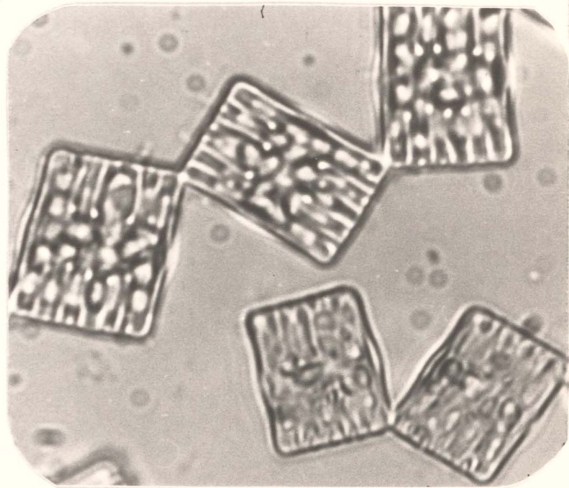
3



8



4



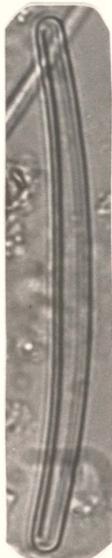
7



5



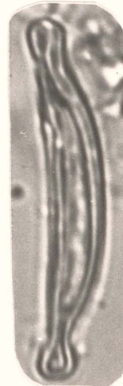
6



9



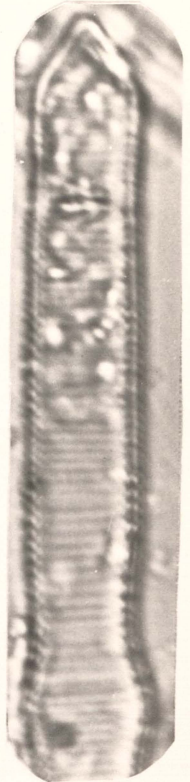
10



12



11



13

Plate 25

1. *Eunotia pectinalis*
2. *Eunotia pectinalis* var. *undulata*
3. As above
4. *Cocconeis placentula* var.
euglypta
5. *Frustulia rhomboides* var.
capitatum
6. *Frustulia rhomboides* var. *saxonica*
7. As above
8. *Gomphonema acuminatum*
9. *Gomphonema truncatum*
10. As above
11. As above
12. As above
13. *Gyrosigma acuminatum*
14. *Navicula cuspidata*
15. *Navicula radiosa*
16. *Pinnularia flexuosa*
17. *Epithemia argus*
18. *Epithemia sorex*

Scale:

1	1 cm = 5 μm
2	1 cm = 7.5 μm
3-7, 9-13, 15, 17	1 cm = 10 μm
8, 18	1 cm = 8 μm
14, 16	1 cm = 20 μm

Plate 25.

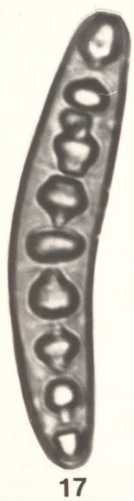
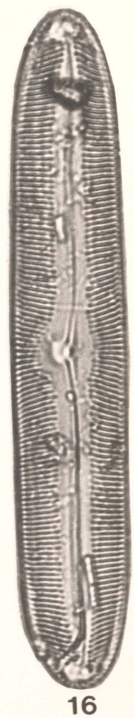
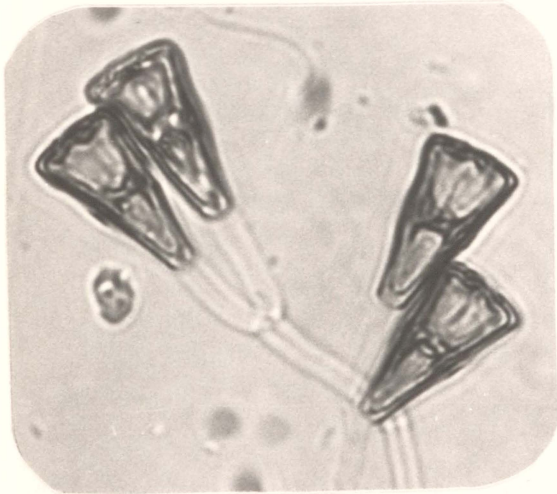
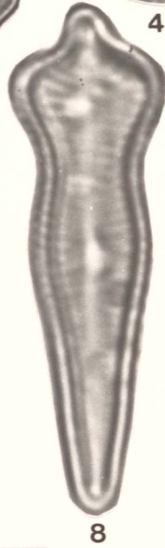
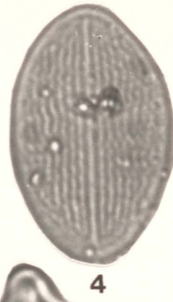


Plate 26

1. *Nitzschia acicularis*
2. *Nitzschia sigmoidea*
3. *Rhopalodia* sp.
4. As above
5. *Aphanocapsa elachista*
6. *Chroococcus limneticus*
7. *Chroococcus minor*
8. *Merismopedia elegans*
9. *Merismopedia glauca*
10. *Merismopedia tenuissima*
11. *Merismopedia minima*
12. *Merismopedia tenuissima*
13. *Microcystis aeruginosa*

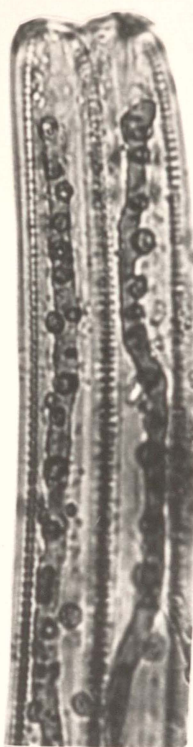
Scale:

1-2, 5, 12	1 cm = 10 μ m
3-4	1 cm = 12 μ m
6, 13	1 cm = 20 μ m
7, 9-11	1 cm = 5 μ m
8	1 cm = 8 μ m

Plate 26.



1



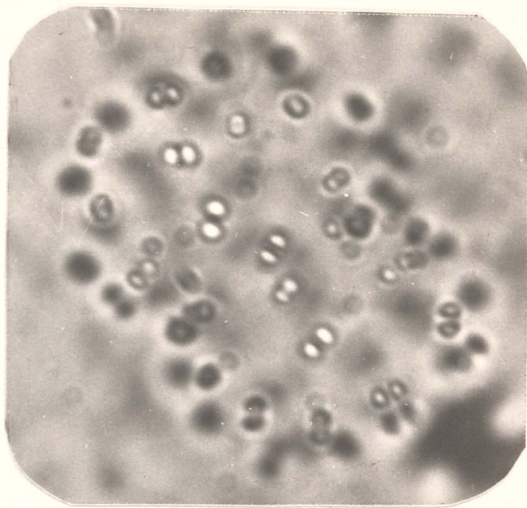
2



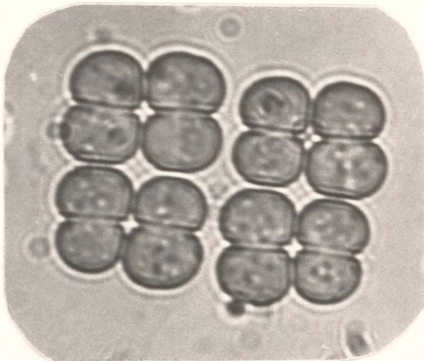
3



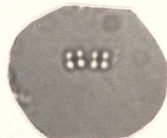
4



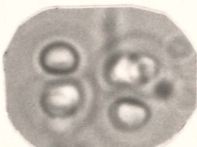
5



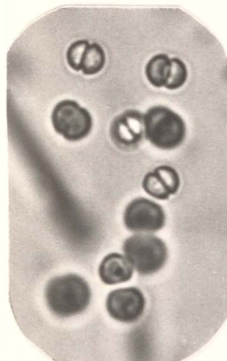
8



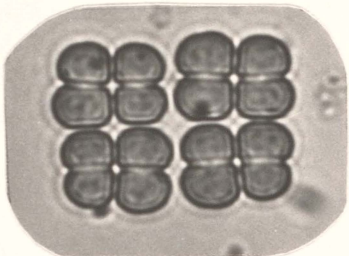
11



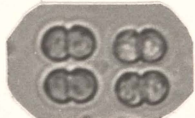
7



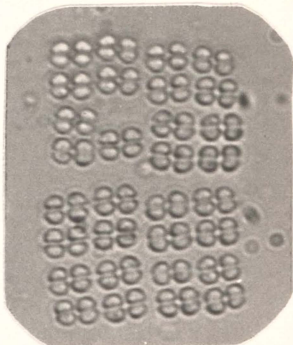
6



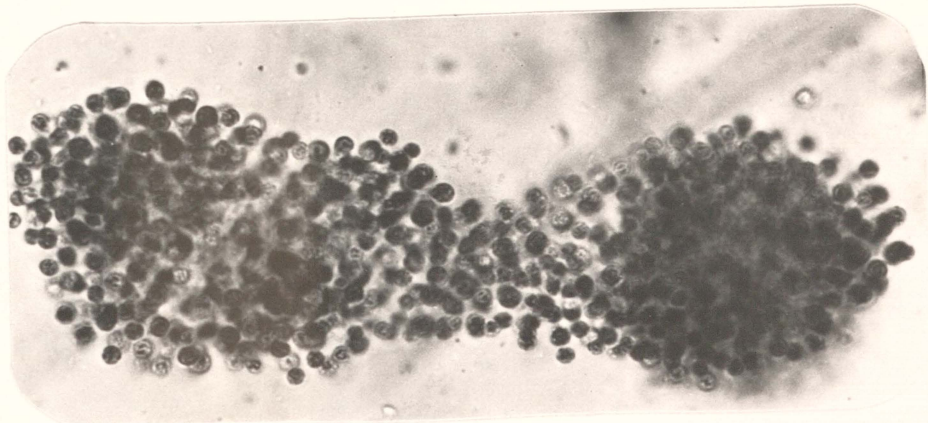
9



10



12



13

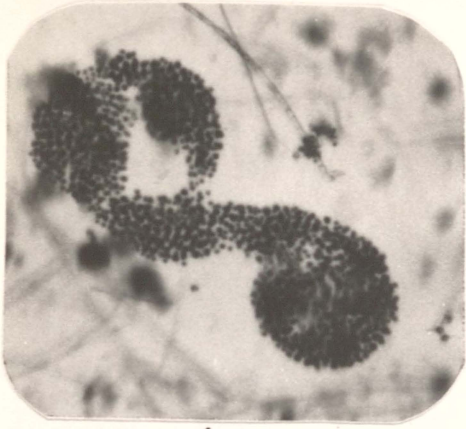
Plate 27

1. *Microcystis aeruginosa* Status 2
(see Reynolds *et al.*, [1981])
2. As above - Status 2
3. As above - Status 5
4. As above - Status 6
5. As above - Status 6
6. *Anabaena circinalis*
7. As above
8. *Anabaena flos-aquae*
9. As above

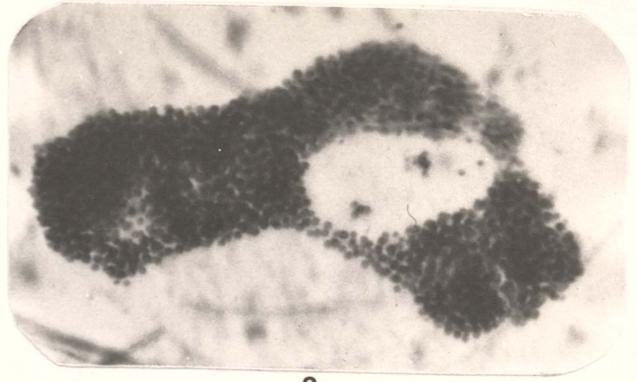
Scale:

1-4	1 cm = 40 μ m
5	1 cm = 45 μ m
6, 9	1 cm = 20 μ m
7	1 cm = 30 μ m
8	1 cm = 10 μ m

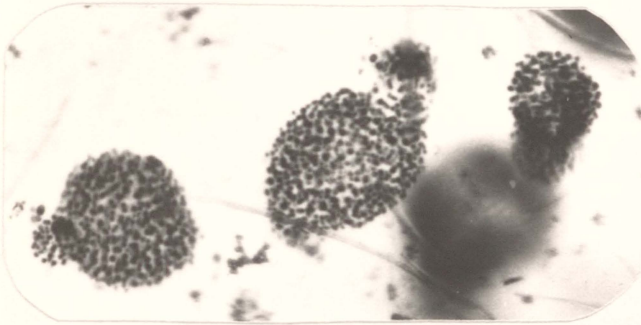
Plate 27.



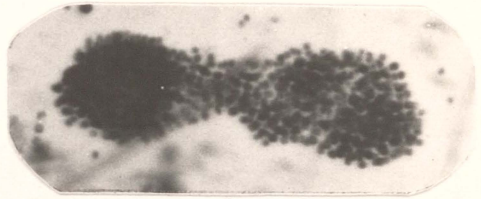
1



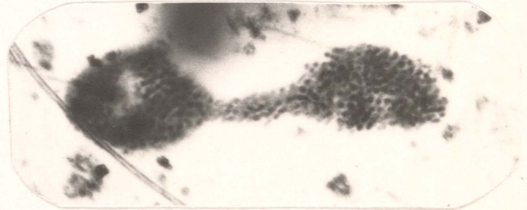
2



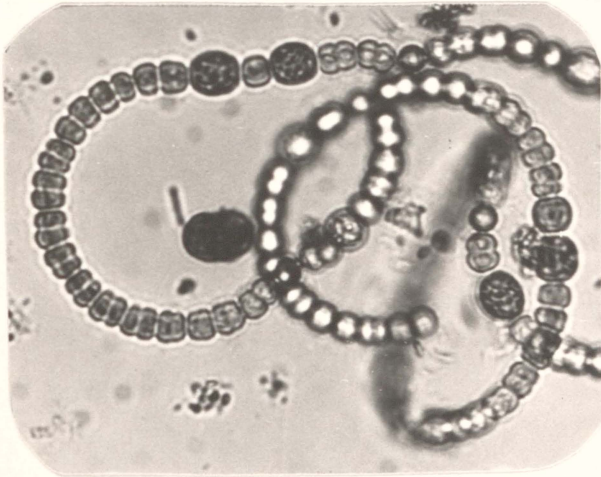
3



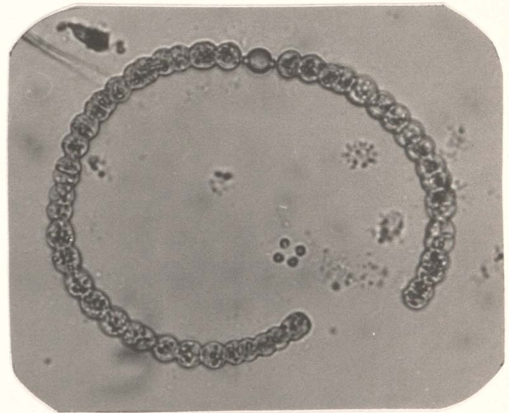
4



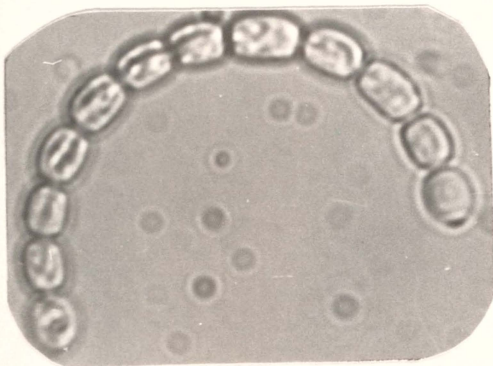
5



6



7



8



9

Plate 28

1. *Anabaena solitaria*
2. As above
3. *Anabaena spiroides* var.
tumida
4. As above
5. *Cylindrospermum minutissimum* (akinete
immature)
6. *Oscillatoria curviceps*
7. *Oscillatoria geminata*
8. *Oscillatoria limnetica*
9. *Oscillatoria limosa*
10. *Oscillatoria splendida*
11. As above
12. *Oscillatoria subbrevis*
13. *Oscillatoria tenuis*
14. *Spirulina major*
15. *Astasia harrisii*
16. *Cyclidiopsis acus*
17. *Euglena acus*
18. As above
19. *Euglena ehrenbergii*
20. *Euglena limnophila*
21. *Euglena oxyuris*
22. As above

Scale:

1, 13	1 cm = 15 μ m
2-4, 11, 17, 21	1 cm = 20 μ m
5-10, 14-16, 18, 20	1 cm = 10 μ m
12	1 cm = 5 μ m
19	1 cm = 40 μ m
22	1 cm = 22 μ m

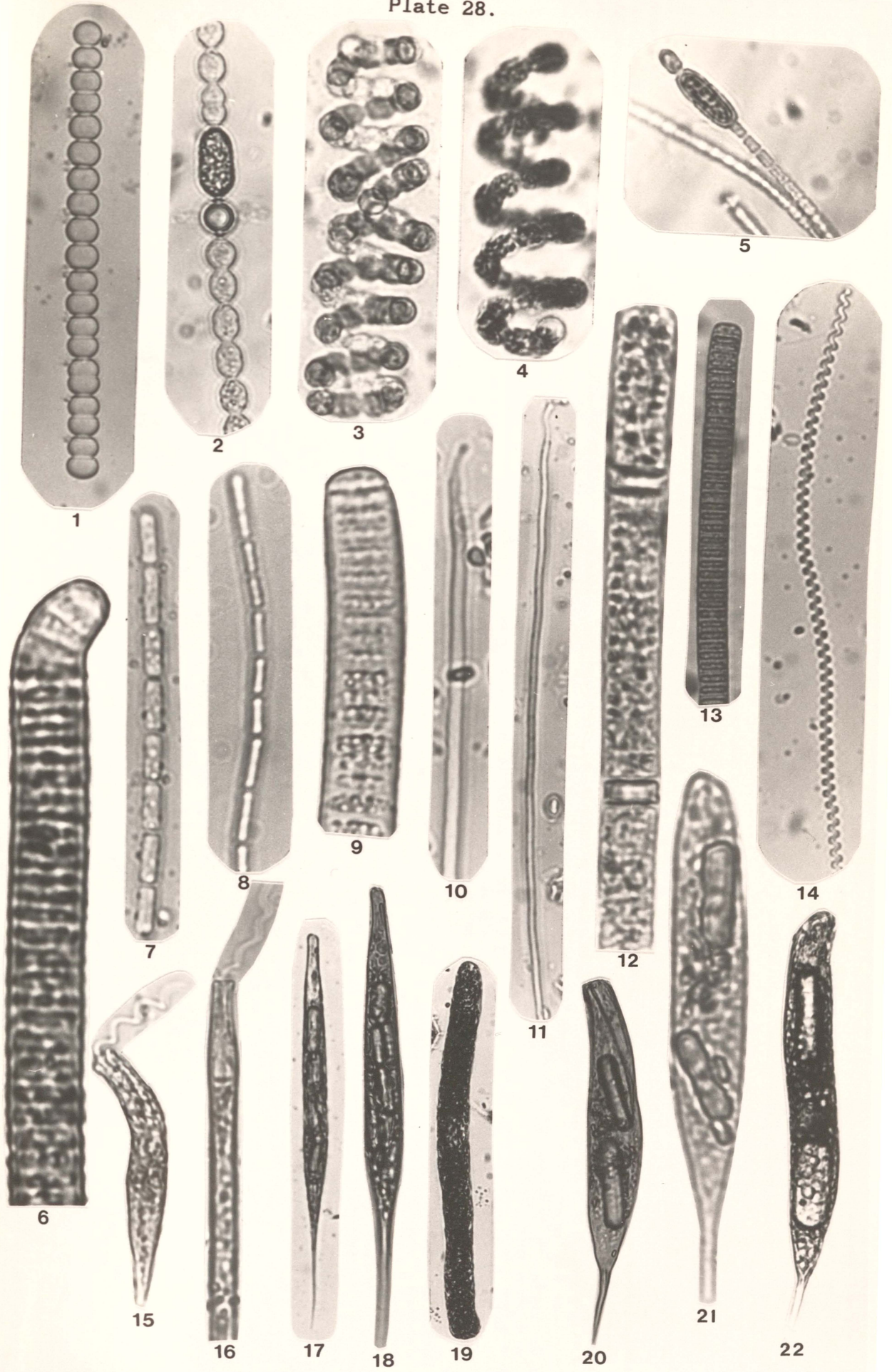


Plate 29

1. *Euglena spirogyra* var. *suprema*
2. *Euglena tripteris*
3. *Lepocinclis marssonii*
4. *Lepocinclis ovum*
5. *Menoidium gracile*
6. *Menoidium pellucidum*
7. *Phacus curvicauda*
8. As above
9. *Phacus glaber*
10. *Phacus helicoides*
11. As above
12. *Phacus inflexus*
13. *Phacus longicauda*
14. *Phacus pleuronectes*
15. *Phacus raciborski*
16. *Phacus rudicula*
17. *Phacus sesquitortus*
18. As above
19. *Phacus suecicus*
20. *Phacus suecicus* var. *oidon*
21. *Trachelomonas armata* var.
inevoluta

Scale:

- | | |
|-----------------|--------------------------|
| 1, 11 | 1 cm = 20 μm |
| 2-10, 12-19, 21 | 1 cm = 10 μm |
| 20 | 1 cm = 7.5 μm |

Plate 29.

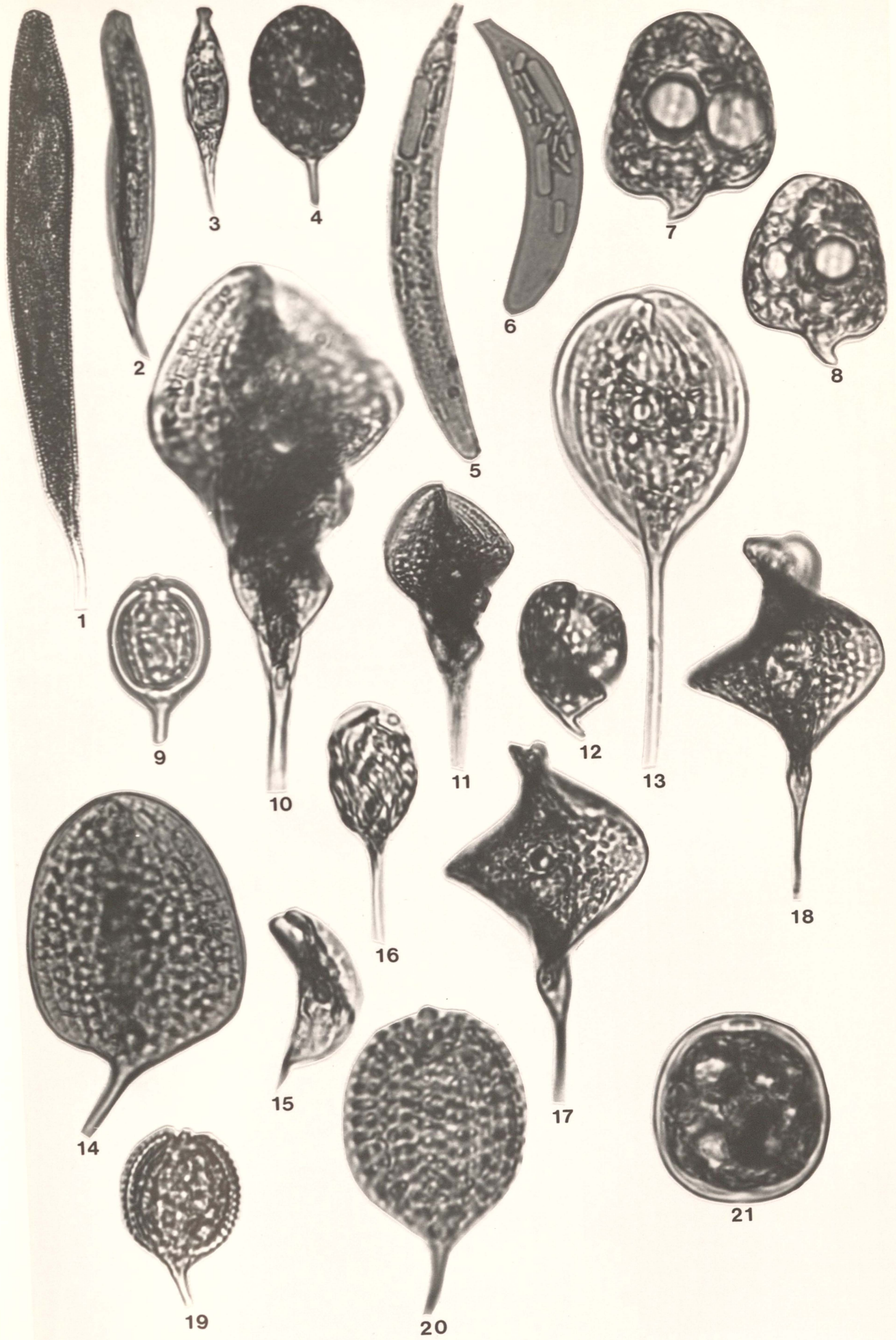


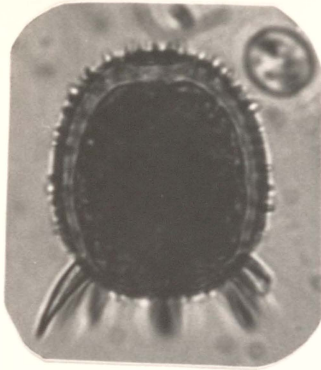
Plate 30

1. *Trachelomonas armata* var.
longispina
2. As above
3. *Trachelomonas cylindrica*
4. *Trachelomonas dybowski*
5. As above
6. *Trachelomonas furcata* (see Appendix VIII)
7. As above
8. *Trachelomonas globularis*
9. *Trachelomonas hexangulata*
10. *Trachelomonas hispida* var.
coronata
11. *Trachelomonas lemmermannii*
12. *Trachelomonas mirabilis* var.
obesa
13. *Trachelomonas planctonica*
14. As above
15. *Trachelomonas playfairi*
16. *Trachelomonas pulcherrima*
17. *Trachelomoas pulcherrima* var.
ovalis
18. *Trachelomonas volvocina*
19. As above
20. *Strombomonas urceolata* (after Etheredge [1983])
21. *Urceolus* sp. (after Etheredge [1983])
22. *Cryptomonas erosa*
23. As above
24. *Peridinium aciculiferum*
25. *Peridinium cinctum*
26. As above (after Etheredge [1983])

Scale:

1	1 cm = 12.5 μm
2, 12, 17	1 cm = 15 μm
3-10, 13-16, 18-25	1 cm = 10 μm
11	1 cm = 7.5 μm
26	SEM x 1300

Plate 30.



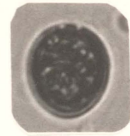
1



2



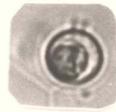
3



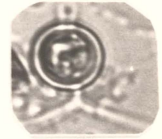
4



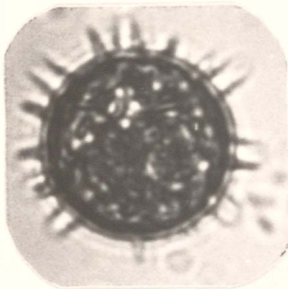
5



6



7



8



9



10



11



12



13



14



15



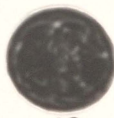
16



17



18



19



20



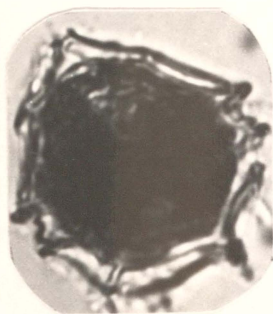
21



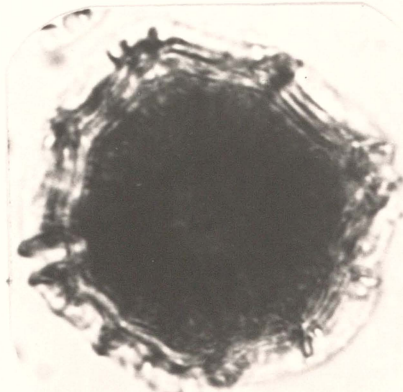
22



23



24



25



26

Plate 31

1. *Peridinium inconspicuum*
2. As above
3. *Peridinium pusillum* tab.
conjunctum
4. *Peridinium umbonatum* tab.
conjunctum var. *inaequale*
5. *Peridinium* sp. A
6. *Ceratium hirundinella* (after Etheredge [1983])
7. *Ceratium hirundinella* var.
furcoides
8. *Cystodinium cornifax*
9. *Tetradinium intermedium*

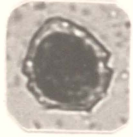
Scale:

1-2, 4, 9	1 cm = 10 μ m
3	1 cm = 7.5 μ m
5	1 cm = 15 μ m
6	SEM x 430
7	1 cm = 20 μ m
8	1 cm = 8 μ m

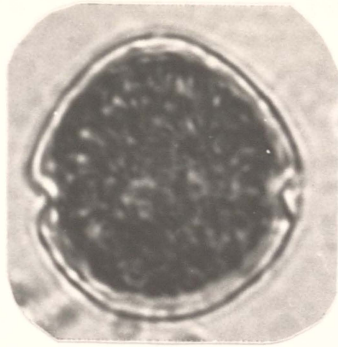
Plate 31.



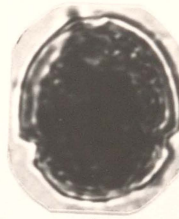
1



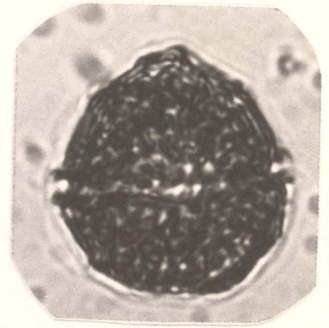
2



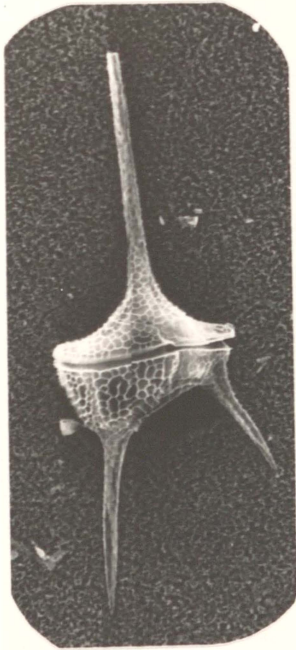
3



4



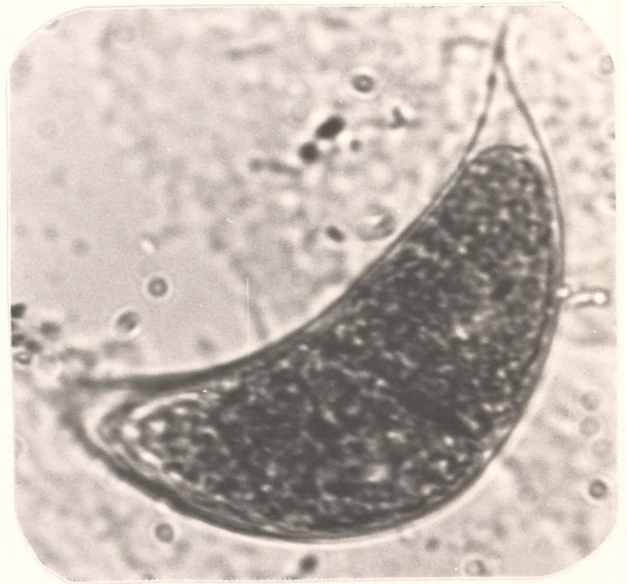
5



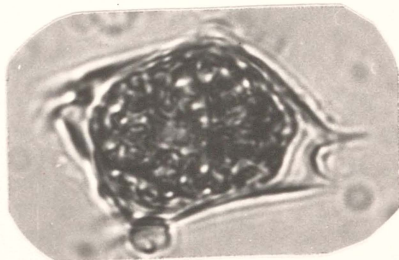
6



7



8



9

Plate 32

1. *Pediastrum angulosum* x 250

2. *P. boryanum* x 350 - considered by some phycologists (e.g., see Huber-Pestalozzi *et al.*, 1983) to warrant varietal status (*P. b.* var. *longicorne* Reinsch).

Plate 32

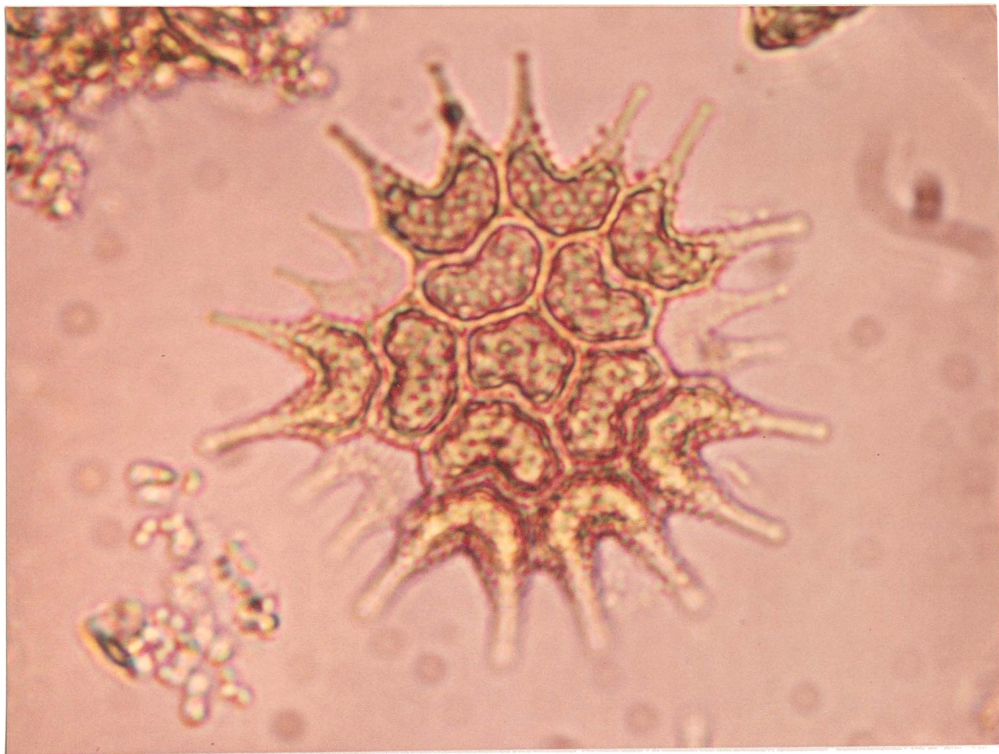
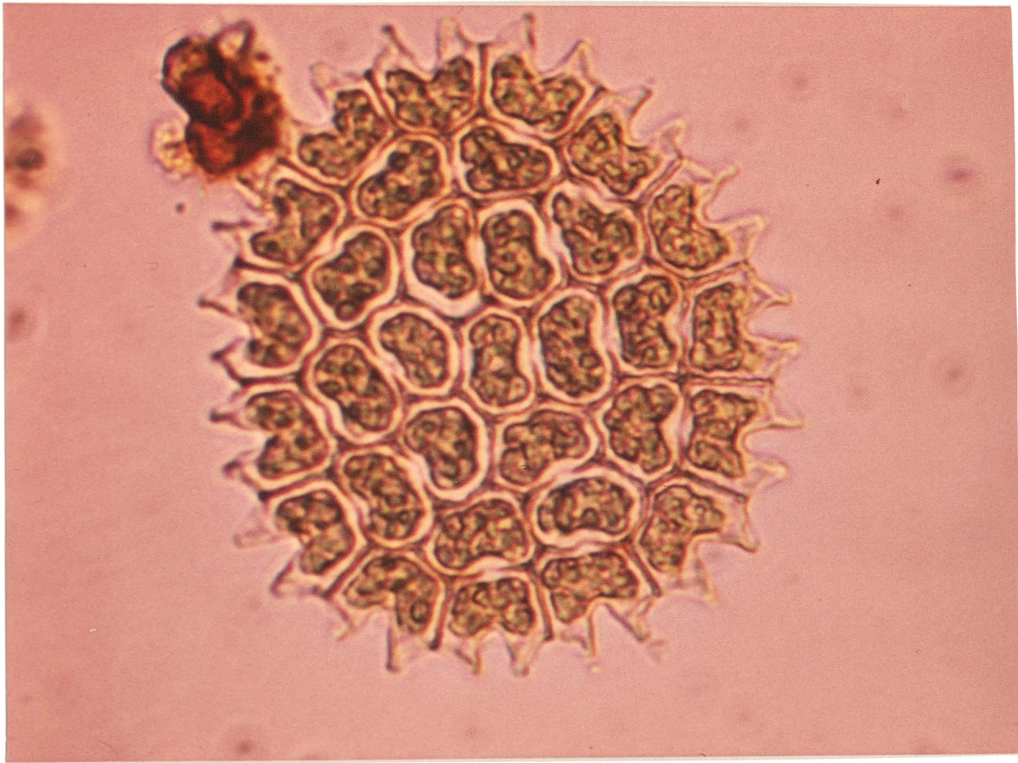


Plate 33

1. *Pediastrum duplex* x 500

2. *Pediastrum duplex* x 1000 - considered by some phycologists (e.g., Huber-Pestalozzi *et al.*, 1983) to warrant varietal status (*P. d.* var. *gracillimum* W. & G.S. West).

Plate 33

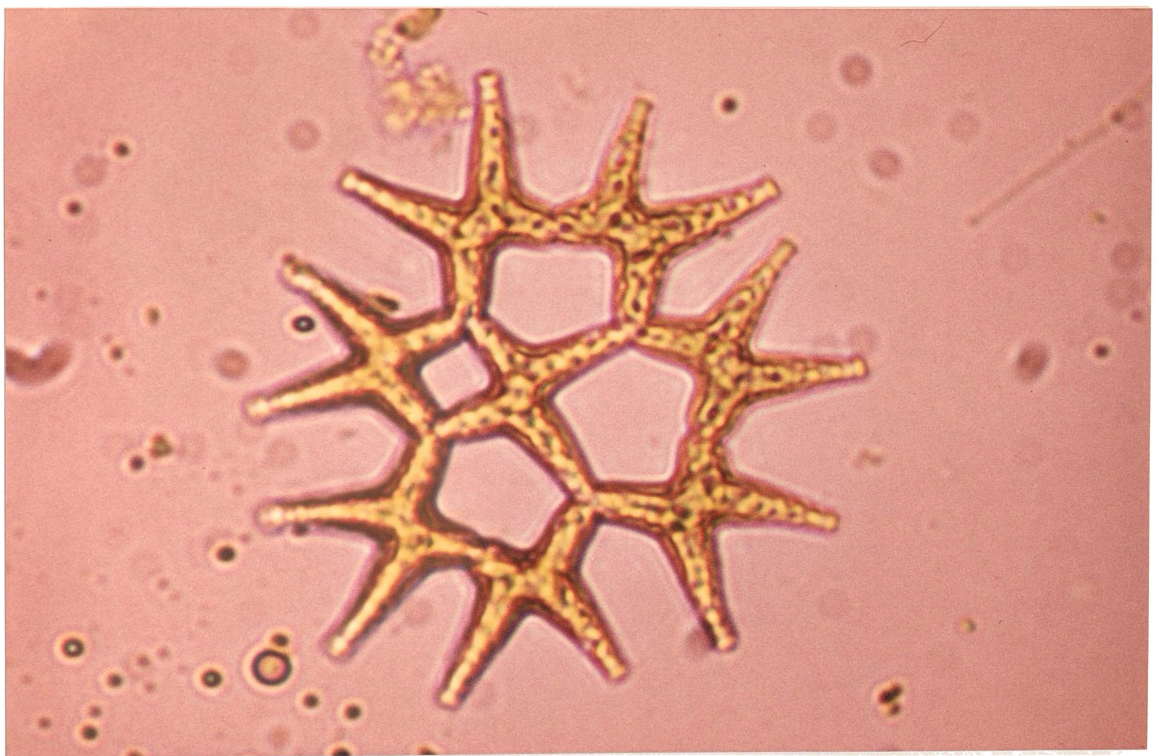
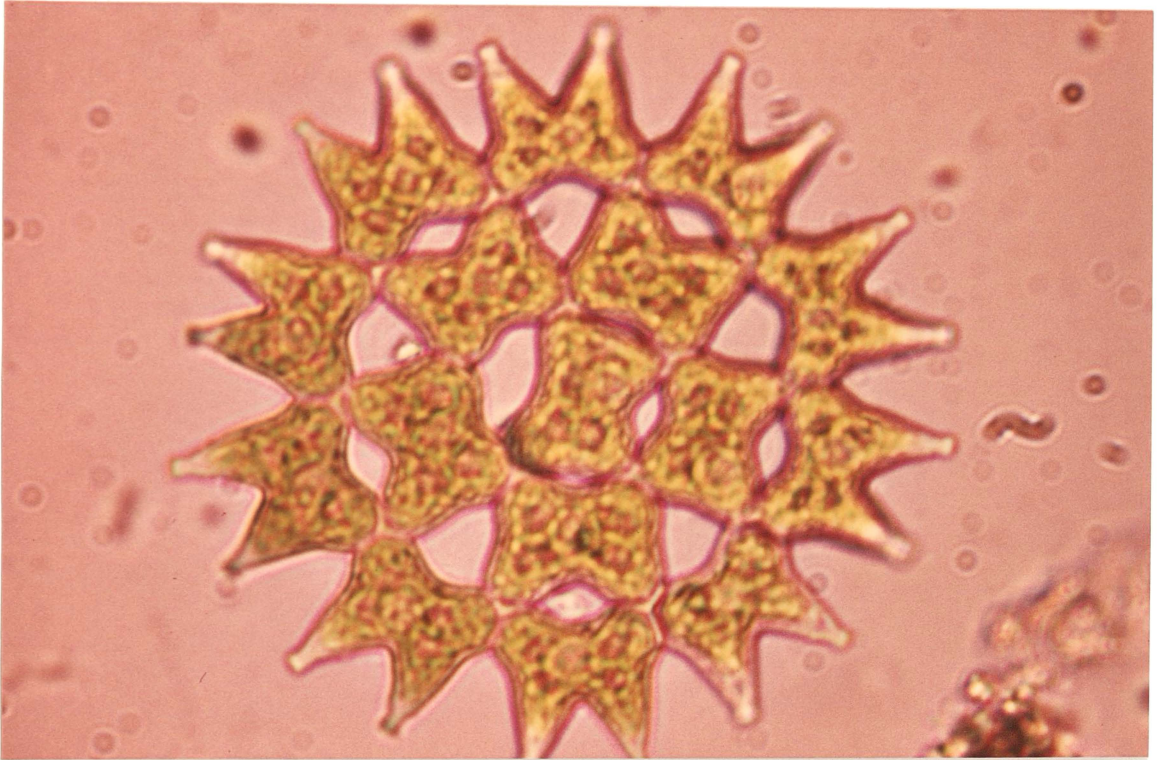


Plate 34

1. *Pediastrum duplex* x 1000 - see Plate 33 No. 2.

2. *Pediastrum tetras* x 1000 - considered by some phycologists to warrant varietal status [*P. t.* var. *tetraodon* (Corda) Hansgirg]. However, the critical diagnostic features remain unclear (Parra, 1979; Huber-Pestalozzi *et al.*, 1983), and thus this distinction has not been used in the present study.

Plate 34

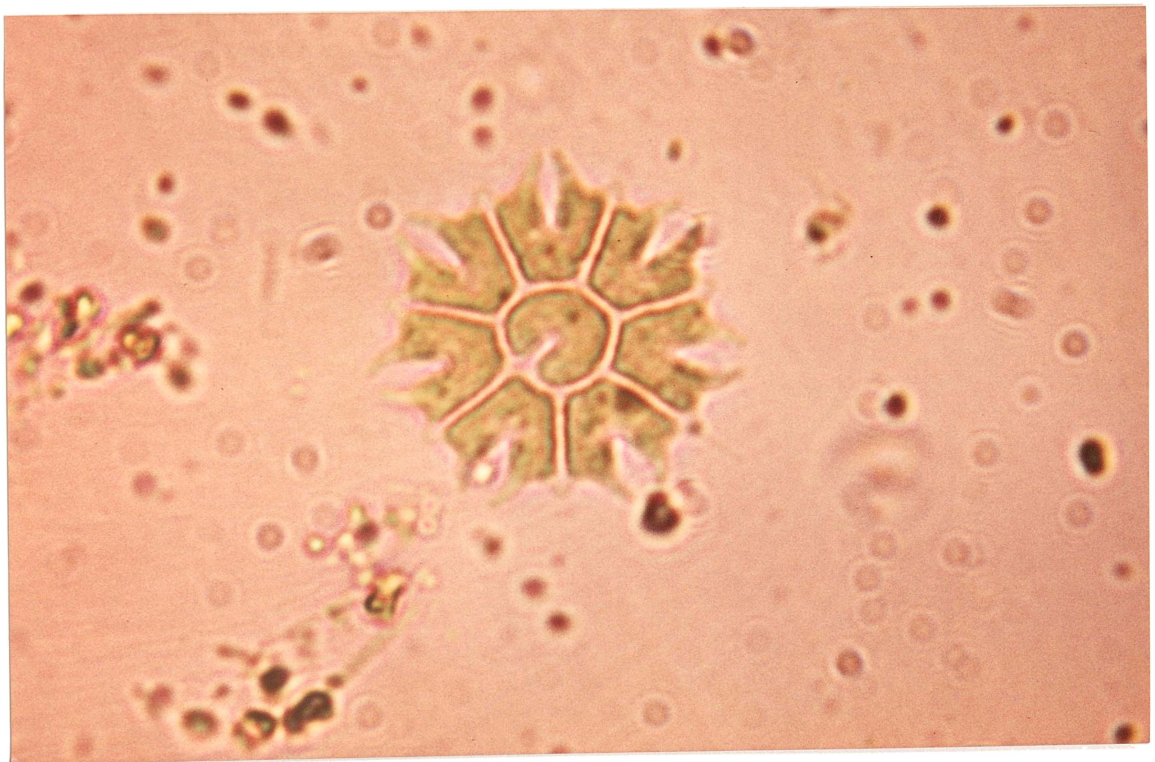


Plate 35

1. *Micrasterias decemdentata* x 1000

2. *Staurodesmus convergens* var.
laportei x 1250

Plate 35



Plate 36

1. *Melosira varians* x 1400

2. *Rhopalodia* sp. x 1100

Plate 36

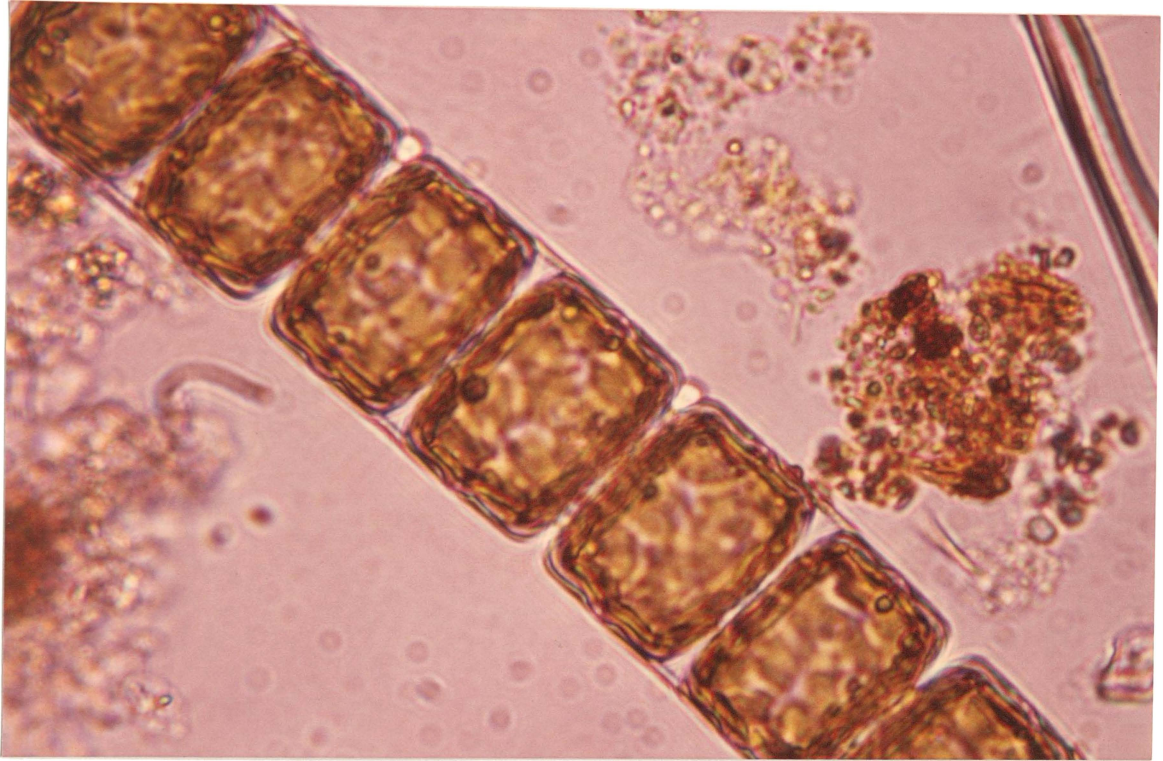


Plate 37

1. *Euglena oxyuris* x 250

2. *Menoidium pellucidum* x 1300

Plate 37



Plate 38

1. *Phacus tortus* x 1000

2. *Strombomonas urceolata* x 1000

Plate 38



APPENDIX VIILIST OF PHYTOPLANKTON SPECIES AND THE STUDY LAKES IN WHICH THEY
WERE FOUND, JULY 1983 TO JULY 1984

The taxonomic arrangement to the familial level follows Bourrelly (1966, 1968, 1970); species are arranged alphabetically within genera. Each species is coded for use in Appendix IV. The first digit defines the phylum: 1 = CHLOROPHYTA; 2 = CHROMOPHYTA; 3 = CYANOPHYTA; 4 = EUGLENOPHYTA; 5 = PYRRHOPHYTA; 6 = RAPIDOPHYTA. The second, third and fourth digits define the genus, species and variety, respectively.

Plates are included in Appendix VI.

* New New Zealand record.

Tentative identification due to lack of electron microscopical observations.

CHLOROPHYTA 1

Euchlorophyceae

Volvocales

Chlamydomonadaceae

Chlamydomonas Ehrenberg 1-1

Chlamydomonas sp. A 1-1-1

Lakes: Mangakaware, Ngaroto, Rotomanuka North, Rotomanuka South.

Chlamydomonas sp. B 1-1-2

Lakes: Rotomanuka North, Rotomanuka South.

Chlamydomonas sp. C 1-1-3

Lake: Maratoto.

Volvocaceae

Eudorina Ehrenberg 1-2

Eudorina elegans Ehrenberg 1-2-1

Plate 12 No. 1

Lakes: Mangahia, Mangakaware, Rotokauri, Rotomanuka North, Rotomanuka South.

Gonium O. F. Müller 1-3

Gonium pectorale Müller 1-3-1

Plate 12 No. 2

Lakes: Kainui, Mangakaware, Rotokauri, Rotomanuka North, Rotomanuka South.

Pandorina Bory de Saint-Vincent 1-4

Pandorina morum (Müller) Bory de Saint-Vincent 1-4-1

Plate 12 Nos. 3a, b

Lakes: Kainui, Mangahia, Mangakaware, Rotokauri, Rotoroa.

Volvox Linnaeus 1-5

Volvox aureus Ehrenberg 1-5-1
Lake: Mangakaware.

Spondylomoraceae

Spondylomorum Ehrenberg 1-6

Spondylomorum quarternarium Ehrenberg 1-6-1
Lake: Kainui.

Chlorococcales

Chlorococcaceae

Ankyra Fott 1-7

Ankyra judayi (G.M. Smith) Fott * 1-7-1
Plate 12 No. 4
Lake: Rotomanuka North

Characium A. Braun 1-8

Characium ornithocephalum A. Braun * 1-8-1
Plate 12 No. 5
Lake: Ngaroto.

Schroederia Lemmermann 1-9

Schroederia setigera (Schröder) Lemmermann 1-9-1
Lake: Mangakaware.

Tetraedron Kützing

ex Koršikov 1-10

Tetraedron minimum (A. Braun) Hansgirg 1-10-1
Plate 12 Nos. 6a, b
Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka
North, Rotomanuka South, Rotoroa.

Palmellaceae

Sphaerocystis Chodat 1-11

Sphaerocystis schroeteri Chodat 1-11-1
Lakes: Mangakaware, Maratoto, Rotokauri, Rotoroa.

Hormotilaceae

Palmodictyon Kützing 1-12

Palmodictyon viride Kützing 1-12-1
Lake: Mangakaware.

Oocystaceae

Ankistrodesmus Corda 1-13

Ankistrodesmus bernardii Komárek * 1-13-1
Plate 12 No. 7

Lake: Rotomanuka North

Ankistrodesmus bibraianus (Reinsch) Koršikov 1-13-2

Plate 12 No. 8

Lakes: Kainui, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Ankistrodesmus falcatus (Corda) Ralfs 1-13-3

Plate 13 No. 1

Lakes: Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Ankistrodesmus fasciculatus (Lundberg) Komárková-Legnerová * 1-13-4

Plate 13 No. 2

Lake: Rotomanuka North.

Ankistrodesmus fusiformis Corda sensu Koršikov 1-13-5

Lakes: Kainui, Mangahia, Ngaroto, Rotokauri, Rotomanuka North.

Ankistrodesmus gracilis (Reinsch) Koršikov 1-13-6

Plate 13 Nos. 3a, b

Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Ankistrodesmus spiralis (Turner) Lemmermann 1-13-7

Plate 13 No. 4

Lakes: Mangakaware, Ngaroto, Rotokauri, Rotomanuka North.

Chlorella Beijerinck 1-14

Chlorella sp. 1-14-1

Lakes: Mangahia, Rotokauri.

Kirchneriella Schmidle 1-15

Kirchneriella lunaris (Kirchner) Moebius 1-15-1

Plate 13 Nos. 5a, b

Lakes: Mangakaware, Rotokauri, Rotomanuka North.

Kirchneriella obesa var. *aperta* (Teiling) Brunthaler 1-15-2

Plate 14 No. 1

Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Lagerheimia Chodat 1-16

Lagerheimia ciliata (Lagerheim) Chodat * 1-16-1

Plate 14 Nos. 2a, b

Lakes: Ngaroto, Rotomanuka North.

Lagerheimia citriformis (Snow) G.M. Smith 1-16-2

Plate 14 No. 3

Lake: Rotomanuka North.

Monoraphidium Komárková-Legnerová 1-17

Monoraphidium contortum (Thuret) Komárková-Legnerová 1-17-1

Plate 14 No. 4

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Monoraphidium griffithii (Berkeley) Komárková-Legnerová 1-17-2
Plate 14 No. 5

Lakes: Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Monoraphidium irregulare (G.M. Smith) Komárková-Legnerová 1-17-3
Plate 14 No. 6

Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Monoraphidium komarkovae Ngyaard * 1-17-4
Plate 14 No. 7

Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Monoraphidium minutum (Nägeli) Komárková-Legnerová 1-17-5

Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Monoraphidium tortile (W. & G.S. West) Komárková-Legnerová * 1-17-6

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Nephrocytium Nägeli 1-18

Nephrocytium agardhianum Nägeli 1-18-1

Plate 14 Nos. 8, 9

Lakes: Kainui, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Nephrocytium limneticum (G.M. Smith) G.M. Smith 1-18-2

Lakes: Kainui, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Oocystis A. Braun 1-19

Oocystis borgei Snow 1-19-1

Lake: Rotomanuka North.

Oocystis lacustris Chodat 1-19-2

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Oocystis solitaria Wittrock 1-19-3

Plate 14 No. 10

Lakes: Kainui, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Pachycladella Silva * 1-20

Pachycladella umbrina (G.M. Smith) Silva * 1-20-1

Lake: Mangahia.

Quadrigula Printz 1-21

Quadrigula lacustris (Chodat) G.M. Smith 1-21-1
Lake: Rotomanuka North.

Raphidocelis Hindák 1-22

Raphidocelis contorta (Schimdle) Marvan *et al.*, 1-22-1
Plate 14 No. 11
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotoroa.

Rhombocystis Komárek 1-23 *

Rhombocystis complanata Komárek 1-23-1 *
Lake: Mangakaware.

Treubaria Bernard 1-24

Treubaria planctonica (G.M. Smith) Koršikov * 1-24-1
Lake: Mangahia.

Treubaria setigera (Archer) G.M. Smith * 1-24-2
Lakes: Mangahia, Rotokauri.

Trochiscia Kützing 1-25

Trochiscia aciculifera (Lagerheim) Hansgirg * 1-25-1
Lake: Rotomanuka North.

Micractiniaceae

Golenkinia Chodat 1-26

Golenkinia radiata Chodat 1-26-1
Lakes: Mangahia, Ngaroto, Rotomanuka North, Rotoroa.

Micractinium Fresenius 1-27

Micractinium bornhemiense (Conrad) Koršikov * 1-27-1
Lake: Ngaroto.

Micractinium pusillum Fresenius 1-27-2
Plate 14 No. 12
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotoroa.

Dictyosphaeriaceae

Botryococcus Kützing 1-28

Botryococcus braunii Kützing 1-28-1
Plate 15 No. 1
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotomanuka South, Rotoroa.

Dictyosphaerium Nägeli 1-29*Dictyosphaerium ehrenbergianum* Nägeli 1-29-1

Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Dictyosphaerium pulchellum Wood 1-29-2

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka South, Rotoroa.

Dictyosphaerium subsolitarium van Goor ? 1-29-3

Lakes: Mangakaware, Maratoto.

Dimorphococcus A. Braun 1-30*Dimorphococcus lunatus* A. Braun 1-30-1

Plate 15 No. 2

Lakes: Kainui, Mangahia, Mangakaware, Rotokauri.

Westella de Wildeman 1-31*Westella botryoides* (W. West) de Wildeman 1-31-1

Lake: Rotomanuka North.

Scenedesmaceae

Actinastrum Lagerheim 1-32*Actinastrum aciculare* Playfair * 1-32-1

Lake: Ngaroto.

Actinastrum fluviatile (Schröder) Fott 1-32-2

Lakes: Ngaroto, Rotomanuka North.

Actinastrum gracillimum G.M. Smith 1-32-3

Lake: Rotomanuka North.

Actinastrum hantzschii Lagerheim 1-32-4

Plate 15 Nos. 3a, b

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Coelastrum Nägeli 1-33*Coelastrum astroideum* de Notaris * 1-33-1

Lake: Rotomanuka North.

Coelastrum cambricum Archer 1-33-2

Lakes: Kainui, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Coelastrum indicum Turner * 1-33-3

Lakes: Mangakaware, Maratoto, Ngaroto, Rotomanuka North, Rotomanuka South.

Coelastrum microporum Nägeli 1-33-4

Plate 15 No. 4

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Coelastrum reticulatum (Dangeard) Senn 1-33-5
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Crucigenia Morren 1-34

Crucigenia fenestrata (Schmidle) Schmidle 1-34-1
Lakes: Mangahia, Mangakaware, Rotomanuka North.

Crucigenia quadrata Morren 1-34-2
Lakes: Rotokauri, Rotomanuka North.

Crucigeniella Lemmermann 1-35

Crucigeniella apiculata (Lemmermann) Komárek * 1-35-1
Lakes: Mangahia, Ngaroto, Rotokauri.

Crucigeniella rectangularis (Nägeli) Komárek 1-35-2
Lakes: Mangahia, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Crucigeniella truncata (G.M. Smith) Komárek 1-35-3
Lake: Ngaroto.

Scenedesmus Meyen 1-36

Scenedesmus acuminatus (Lagerheim) Chodat 1-36-1
Plate 15 Nos. 5a, b
Lakes: Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Scenedesmus acuminatus var. *minor* G.M. Smith * 1-36-1-1
Plate 15 No. 6
Lake: Rotomanuka North.

Scenedesmus acutiformis Schröder 1-36-2
Lakes: Kainui, Mangahia, Ngaroto, Rotokauri.

Scenedesmus acutus Meyen * 1-36-3
Plate 15 No. 7
Lakes: Maratoto, Rotomanuka North.

Scenedesmus armatus Chodat 1-36-4
Lake: Rotoroa.

Scenedesmus denticulatus Lagerheim 1-36-5
Lakes: Mangakaware, Ngaroto, Rotomanuka North, Rotomanuka South, Rotoroa.

Scenedesmus dimorphus (Turpin) Kützing 1-36-6
Lake: Ngaroto.

Scenedesmus ecornis (Ehrenberg) Chodat 1-36-7
Lakes: Mangakaware, Maratoto, Rotomanuka North, Rotoroa.

Scenedesmus intermedius Chodat 1-36-8
Plate 15 No. 8
Lakes: Kainui, Mangahia, Ngaroto, Rotomanuka South, Rotoroa.

Scenedesmus longispina Chodat 1-36-9
Lakes: Ngaroto, Rotoroa.

Scenedesmus magnus Meyen * 1-36-10
Lake: Rotoroa.

Scenedesmus obtusus Meyen 1-36-11
Plate 15 No. 9
Lakes: Rotokauri, Rotomanuka North, Rotomanuka South.

Scenedesmus opoliensis Richter 1-36-12
Plate 15 Nos. 10, 11
Lakes: Mangahia, Mangakaware, Ngaroto, Rotokauri.

Scenedesmus protuberans Fritsch * 1-36-13
Plate 16 No. 1
Lake: Ngaroto.

Scenedesmus quadricauda (Turpin) de Brébisson sensu Chodat 1-36-14
Plate 16 No. 2
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Scenedesmus sempervirens Chodat 1-36-15
Plate 16 No. 3
Lakes: Mangahia, Ngaroto, Rotokauri, Rotoroa.

Tetrastrum Chodat 1-37

Tetrastrum heteracanthum (Norstedt) Chodat * 1-37-1
Plate 16 No. 4
Lakes: Mangahia, Mangakaware, Rotoroa.

Tetrastrum staurogeniaforme (Schröder) Lemmermann * 1-37-2
Plate 16 No. 5
Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotomanuka North, Rotomanuka South, Rotoroa.

Tetrastrum triangulare (Chodat) Komárek * 1-37-3
Plate 16 No. 6
This taxon was recorded as *Crucigenia minima* Brunthaler by Etheredge (1983).
Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Hydrodictyaceae

Pediastrum Meyen 1-38

Pediastrum angulosum (Ehrenberg) ex Meneghini 1-38-1
Plate 16 No. 7; Plate 32 No. 1
Lakes: Rotokauri, Rotomanuka South, Rotoroa.

Pediastrum boryanum (Turpin) Meneghini 1-38-2
Plate 16 No. 8; Plate 32 No. 2
Lakes: Rotomanuka North, Rotoroa.

Pediastrum duplex Meyen 1-38-3

Plate 16 Nos. 9, 10; Plate 17 No. 1; Plate 33 Nos. 1,2; Plate 34 No. 1

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka South, Rotoroa.

Pediastrum tetras (Ehrenberg) Ralfs 1-38-4

Plate 17 Nos. 2a, b, c; Plate 34 No. 2

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Sorastrum Kützing 1-39

Sorastrum spinulosum Nägeli 1-39-1

Plate 17 No. 3

Lakes: Mangahia, Rotokauri, Rotomanuka North.

Coccomyxaceae

Elakatothrix Wille 1-40

Elakatothrix gelatinosa Wille 1-40-1

Plate 17 No. 4

Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotomanuka North, Rotomanuka South, Rotoroa.

Ulothricophyceae

Ulothricales

Ulothricaceae

Ulothrix Kützing 1-41

Ulothrix sp. 1-41-1

Lakes: Mangakaware, Rotokauri.

Oedogoniales

Oedogoniaceae

Bulbochaete Agardh 1-50

Bulbochaete sp. ster. 1-50-1

Lakes: Mangahia, Rotomanuka North.

Oedogonium Link ex Hirn 1-51

Oedogonium undulatum (de Brébisson) A. Braun 1-51-1

Plate 17 No. 5

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri.

Oedogonium sp. ster. 1-51-2

Lakes: Kainui, Mangakaware, Rotoroa.

Zygophyceae

Zygnematales

Zygnemataceae

Spirogyra Link 1-53

Spirogyra sp. A ster. 1-53-1

Lakes: Kainui, Mangahia, Mangakaware, Rotokauri, Rotoroa.

Spirogyra sp. B ster. 1-53-2
Lake: Rotokauri.

Mougeotia C. Agardh 1-54

Mougeotia sp. A ster. 1-54-1
Plate 17 No. 6
Lakes: Rotomanuka North, Rotoroa.

Mougeotia sp. B ster. 1-54-2
Plate 17 No. 7
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Mougeotia sp. C ster. 1-54-3
Plate 17 No. 8
Lake: Rotokauri.

Mougeotia sp. D ster. 1-54-4
Lakes: Mangahia, Rotoroa.

Zygnema C. Agardh 1-55

Zygnema sp. ster. 1-55-1
Plate 17 No. 10
Lake: Rotoroa.

Mesotaeniaceae

Gonatozygon De Bary 1-56

Gonatozygon brebissonii De Bary 1-56-1
Plate 17 No. 9
Lakes: Mangakaware, Rotokauri, Rotomanuka North, Rotomanuka South.

Gonatozygon kinahanii (Archer) Rabenhorst 1-56-2
Lakes: Mangakaware, Rotokauri, Rotoroa.

Netrium (Nägeli) Itzigsohn & Rothe 1-57

Netrium digitus (Ehrenberg) Itzigsohn & Rothe 1-57-1
Plate 17 No. 11
Lake: Rotomanuka North.

Desmidiaceae

Actinotaenium (Nägeli) Teiling 1-58

Actinotaenium globosum (Bulnheim) Förster ex Compère 1-58-1
Lake: Rotokauri.

Actinotaenium wollei (W. & G.S. West) Teiling ex Ružička & Pouzar *
1-58-2
Lakes: Maratoto, Rotokauri.

Closterium Nitzsch ex Ralfs 1-59

Closterium aciculare T. West 1-59-1
Lakes: Mangahia, Mangakaware, Ngaroto, Rotomanuka South.

Closterium acutum de Brébisson in Ralfs var. *acutum* 1-59-2
Lakes: Kainui, Rotokauri.

Closterium acutum var. *linea* (Perty) W. & G.S. West 1-59-2-1
Plate 18 No. 1
Lake: Rotomanuka North.

Closterium acutum var. *variabile* (Lemmermann) Krieger 1-59-2-2
Plate 18 No. 2
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotomanuka South, Rotoroa,

Closterium diana var. *pseudodiana* (Roy) Krieger 1-59-3
Plate 18 No. 3
Lake: Mangahia.

Closterium gracile de Brébisson ex Ralfs 1-59-4
Plate 18 No. 4
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotomanuka South, Rotoroa.

Closterium kuetzingii de Brébisson 1-59-5
Lake: Rotokauri.

Closterium leibleinii Kützing ex Ralfs 1-59-6
Plate 18 No. 5
Lake: Rotokauri.

Closterium moniliferum (Bory) Ehrenberg ex Ralfs 1-59-7
Plate 18 No. 6
Lakes: Mangahia, Rotokauri.

Closterium parvulum Nägeli 1-59-8
Plate 18 No. 7
Lakes: Kainui, Mangahia, Maratoto, Ngaroto, Rotokauri, Rotomanuka
North.

Closterium pronum de Brébisson 1-59-9
Lakes: Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North,
Rotomanuka South, Rotoroa.

Closterium setaceum Ehrenberg ex Ralfs 1-59-10
Plate 18 No. 8
Lakes: Kainui, Rotokauri.

Closterium venus var. *westii* Krieger 1-59-11
Lake: Rotokauri.

Cosmarium Corda ex Ralfs 1-60

Cosmarium amplum Norstedt 1-60-1
Plate 18 No. 9
Lake: Rotomanuka North.

Cosmarium bioculatum (de Brébisson) ex Ralfs 1-60-2
Lake: Rotokauri.

Cosmarium botrytis Meneghini ex Ralfs 1-60-3
Lake: Rotomanuka North

Cosmarium contractum Kirchner 1-60-4
Lakes: Kainui, Maratoto, Rotokauri, Rotomanuka South.

Cosmarium laeve Rabenhorst 1-60-5
Plate 18 No. 10
Lakes: Ngaroto, Rotokauri, Rotomanuka North.

Cosmarium lapponicum Borge 1-60-6
Lake: Rotokauri.

Cosmarium lundelli Delponte 1-60-7
Lake: Rotokauri.

Cosmarium lundelli var. *ellipticum* W. & G.S. West 1-60-7-1
Lake: Mangahia.

Cosmarium reniforme (Ralfs) Archer 1-60-8
Lake: Rotokauri.

Desmidium Agardh 1-61

Desmidium baileyi (Ralfs) Norstedt 1-61-1
Plate 19 No. 1
Lake: Rotokauri.

Euastrum Ehrenberg ex Ralfs 1-62

Euastrum denticulatum (Kirchner) Gay 1-62-1
Lake: Rotokauri.

Euastrum praemorsum (Norstedt) Schmidle 1-62-2
Plate 19 No. 2
Lake: Rotokauri.

Euastrum verrucosum Ehrenberg ex Ralfs 1-62-3 *
Plate 19 No. 3
Lake: Rotomanuka North.

Hyalotheca Ehrenberg ex Ralfs 1-63

Hyalotheca dissiliens (J.E. Smith) de Brébisson 1-63-1
Plate 19 No. 4
Lake: Rotokauri.

Micrasterias Agardh ex Ralfs 1-64

Micrasterias decemdentata (Nägeli) Archer 1-64-1
Plate 19 No. 5; Plate 35 No. 1
Lakes: Rotokauri, Rotomanuka North.

Penium de Brébisson ex Ralfs 1-65

Penium margaritaceum (Ehrenberg) ex de Brébisson in Ralfs 1-65-1
Lake: Rotoroa.

Phymatodocis Nordstedt 1-66

Phymatodocis nordstedtiana Wolle 1-66-1
Lakes: Mangakaware, Rotokauri.

Pleurotaenium Nägeli 1-67

Pleurotaenium minutum (Ralfs) Delponte 1-67-1
Plate 19 No. 6
Lake: Mangahia.

Pleurotaenium trabecula Ehrenberg ex Nägeli 1-67-2
Plate 19 No. 7
Lakes: Mangahia, Maratoto, Rotokauri.

Pleurotaenium trabecula var. *elongatum* Cedergrén 1-67-2-1
Lake: Rotokauri, Rotoroa.

Sphaerosozma Corda ex Ralfs 1-68

Sphaerosozma aubertianum W. West 1-68-1
Lake: Rotokauri.

Spondylosium de Brébisson ex Kützing 1-69

Spondylosium planum (Wolle) W. & G.S. West 1-69-1
Plate 19 No. 8
Lake: Rotokauri.

Spondylosium pulchellum Archer 1-69-2
Lake: Maratoto.

Staurastrum Meyen ex Ralfs 1-70

Staurastrum arcuatum Nordstedt 1-70-1
Lakes: Kainui, Mangakaware, Rotokauri, Rotomanuka North, Rotoroa.

Staurastrum avicula de Brébisson 1-70-2
Plate 19 No. 9
Lakes: Kainui, Ngaroto, Rotomanuka North, Rotomanuka South.

Staurastrum brachiatum Ralfs 1-70-3
Lakes: Kainui, Rotoroa.

Staurastrum chaetopus Hinoke ? 1-70-4
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotomanuka South.

Staurastrum cingulum var. *obesum* G.M. Smith 1-70-5
Plate 19 No. 10
Lake: Mangakaware.

Staurastrum gracile Ralfs forma 1-70-6
This phytoplankter is similar to that discussed by Thomasson (1972, p. 262).
Plate 20 No. 1
Lakes: Maratoto, Rotomanuka South.

Staurastrum gracile var. *bulbosum* West 1-70-6-1

Plate 20 No. 2

Lakes: Rotokauri, Rotomanuka North, Rotoroa.

Staurastrum grande var. *parvum* W. West 1-70-7

Lake: Rotokauri.

Staurastrum inflexum de Brébisson 1-70-8

This phytoplankter was tentatively identified as *S. seabaldi* Reinsch forma by Etheredge (1983).

Plate 20 No. 3

Lake: Maratoto.

Staurastrum leptocladum var. *insigne* W. & G.S. West 1-70-9

Plate 20 No. 4

Lakes: Kainui, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Staurastrum muticum var. *victoriense* G.S. West 1-70-10

Plate 20 No. 5

Lakes: Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Staurastrum pinque Teiling 1-70-11

Lake: Mangakaware.

Staurastrum tohopekaligense var. *minus* (Turner) Scott & Prescott-
1-70-12

Plate 20 No. 6

Lakes: Kainui, Rotokauri, Rotomanuka North, Rotoroa.

Staurastrum subradians Fritsch & Rich forma ? 1-70-13

This phytoplankter is similar to that discussed by Thomasson (1972, p. 271).

Lakes: Kainui, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Staurastrum sp. A 1-70-14

Lakes: Mangakaware, Maratoto, Rotomanuka North, Rotomanuka South, Rotoroa.

Staurastrum sp. B 1-70-15

Plate 20 No. 7

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotomanuka North, Rotoroa.

Staurastrum sp. C 1-70-16

Lakes: Kainui, Maratoto, Ngaroto, Rotokauri, Rotoroa.

Staurodesmus Teiling 1-71

Staurodesmus convergens var. *laportei* Teiling 1-71-1

Plate 20 No. 8; Plate 35 No. 2

Lake: Rotokauri.

Staurodesmus cuspidatus (de Brébisson) Teiling 1-71-2

Plate 21 No. 1

Lakes: Kainui, Mangakaware, Ngaroto, Rotomanuka South, Rotoroa.

Staurodesmus dejectus (de Brébisson) Teiling 1-71-3
Plate 21 No. 2

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotomanuka South, Rotoroa.

Staurodesmus glaber var. *limnophilus* Teiling 1-71-4
Plate 21 No. 3

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka
North, Rotomanuka South, Rotoroa.

Staurodesmus leptodermus var. *subcorniculatus* (Rich) Teiling 1-71-5
Plate 21 No. 4

Lake: Mangakaware, Rotokauri.

Staurodesmus mammillatus (Norstedt) Teiling 1-71-6

Lake: Kainui.

Staurodesmus mucronatus var. *delicatulus* (G.S. West) Teiling 1-71-7-1
Plate 21 No. 5

Lake: Rotomanuka North.

Staurodesmus mucronatus var. *subtriangularis* (W. West?) Croasdale
1-71-7-2

Lakes: Kainui, Mangakaware, Rotokauri.

Staurodesmus spetsbergensis (Nordstedt) Teiling 1-71-8

Plate 21 Nos. 6a, b

Lakes: Mangakaware, Rotokauri.

CHROMOPHYTA 2

Chrysophyceae

Chromulinales

Chrysococcaceae

Chrysococcus Klebs 2-1

Chrysococcus rufescens Klebs 2-1-1

Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka
North, Rotomanuka South, Rotoroa.

Bicosoeca Clarke 2-2

Bicosoeca petiolata (Stein) Pringsheim * 2-2-1

Plate 21 No. 7

Lake: Mangahia.

Chrysamoebaceae

Chrysamoeba Klebs 2-3

Chrysamoeba radians Klebs 2-3-1

Lakes: Mangahia, Rotomanuka North.

Dinobryaceae

Dinobryon Ehrenberg 2-4

Dinobryon bavaricum Imhof 2-4-1

Lakes: Rotomanuka North, Rotoroa.

Dinobryon crenulatum W. & G.S. West 2-4-2
 Plate 21 No. 8
 Lakes: Rotomanuka North, Rotoroa.

Dinobryon cylindricum Imhof 2-4-3
 Plate 21 No. 9
 Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
 Rotomanuka North, Rotomanuka South, Rotoroa.

Dinobryon divergens Imhof 2-4-4
 Lakes: Ngaroto, Rotomanuka North, Rotoroa.

Dinobryon elegantissimum f. *gallica* Bourrelly * 2-4-5-1
 Lakes: Rotomanuka North, Rotoroa.

Dinobryon sociale Ehrenberg 2-4-6
 Lake: Mangakaware.

Synuraceae

Chrysosphaerella Lauterborn
 emend. Nicholls 2-5

Chrysosphaerella longispina Lauterborn emend. Nicholls # 2-5-1
 Plate 22 No. 1
 Lakes: Mangakaware, Rotomanuka North.

Mallomonas Perty 2-6

Mallomonas acaroides Perty # 2-6-1
 Lakes: Mangahia, Maratoto, Ngaroto, Rotokauri, Rotomanuka South.

Mallomonas akrokomos Ruttner 2-6-2
 Lakes: Mangahia, Mangakaware, Maratoto, Rotokauri, Rotomanuka North,
 Rotomanuka South, Rotoroa.

Mallomonas tonsurata Teiling # 2-6-3
 Lakes: Kainui, Mangahia, Maratoto, Ngaroto, Rotokauri, Rotomanuka
 North, Rotoroa.

Stokesiella Lemmermann 2-7

Stokesiella epipyxis Pascher ? 2-7-1
 Plate 22 No. 3
 Lake: Rotomanuka North.

Synura Ehrenberg 2-8

Synura spinosa Koršikov # 2-8-1
 Plate 22 No. 2
 Lakes: Ngaroto, Rotomanuka North.

Synura uvella Ehrenberg # 2-8-2
 Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka
 North, Rotomanuka South, Rotoroa.

Xanthophyceae

Mischococcales

Pleurichloridaceae

Goniochloris Geitler 2-9

Goniochloris pseudogigas (Bourrelly) Bourrelly 2-9-1

Plate 22 No. 4

Lake: Rotoroa.

Goniochloris smithii (Bourrelly) Fott 2-9-2

Lake: Mangakaware.

Pseudostaurastrum Chodat 2-10

Pseudostaurastrum hastatum (Reinsch) Chodat 2-10-1

Plate 22 No. 5

Lake: Kainui.

Pseudostaurastrum sp. A 2-10-2

Plate 22 No. 6

This taxon is synonymous with *Tetraedron planctonicum* G.M. Smith (Kováčik, 1975). In his revision of the genus *Tetraedron*, Kováčik lists it as an 'unclear and unrevised species' belonging to *Pseudostaurastrum* Chodat.

Lakes: Mangakaware, Maratoto, Rotokauri.

Pseudostaurastrum sp. B 2-10-3

Plate 22 Nos. 7, 8

This taxon is synonymous with *Tetraedron gracile* (Reinsch) Hansgirg (Kováčik, 1975). In his revision of the genus *Tetraedron*, Kováčik lists it as an 'unclear and unrevised species' belonging to *Pseudostaurastrum* Chodat.

Lake: Rotomanuka North.

Tetraedriella Pascher 2-11

Tetraedriella jovetii (Bourrelly) Bourrelly * 2-11-1

Plate 22 No. 9

Lake: Mangahia.

Tetraedriella regularis (Kützing) Fott 2-11-2

Lake: Rotomanuka North.

Characiopsidiaceae

Peroniella Gobi 2-12

Peroniella planctonica G.M. Smith 2-12-1

Lakes: Maratoto, Ngaroto.

Sciadiaceae

Centrtractus Lemmermann 2-13

Centrtractus belonophorus Lemmermann 2-13-1

(= *belanophorus*, *belenophorus*; see Krienitz & Heynig [1983]).

Plate 22 No. 10

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotomanuka South, Rotoroa.

Centritractus africanus Fritsch & Rich 2-13-2
Lakes: Mangahia, Mangakaware, Rotoroa.

Diatomophyceae

Coscinodiscales

Coscinodiscaceae

Aulacosira Thwaites 2-14

Aulacosira distans (Ehrenberg) Simonsen 2-14-1
Plate 22 Nos. 11-13

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotomanuka South, Rotoroa.

Aulacosira granulata (Ehrenberg) Simonsen 2-14-2
Plate 23 No. 1

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotomanuka South, Rotoroa.

Aulacosira granulata var. *angustissima* (O.F. Müller) Simonsen
2-14-2-1

Plate 23 Nos. 2, 3

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotomanuka South, Rotoroa.

Cyclotella Kützing 2-15

Cyclotella meneghiniana Kützing 2-15-1

Plate 23 Nos. 4, 5

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka
North, Rotomanuka South.

Cyclotella stelligera Cleve & Grunow 2-15-2

Plate 23 Nos. 6, 7

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,
Rotomanuka North, Rotomanuka South, Rotoroa.

Melosira C.A. Agardh 2-16

Melosira varians C.A. Agardh 2-16-1

Plate 36 No. 1

Lakes: Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka South,
Rotoroa.

Rhizosoleniales

Rhizosoleniaceae

Rhizosolenia Brightwell

nom. cons., non Ehrenberg 2-17

Rhizosolenia eriensis H.L. Smith 2-17-1

Plate 23 No. 8

Lakes: Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka South.

Biddulphiales

Chaetocerales

Acanthoceras Honigmann 2-18*Acanthoceras zachariasii* (Brun) Simonsen 2-18-1

Plate 23 Nos. 9, 10

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Diatomales

Diatomaceae

Asterionella Hassall 2-19*Asterionella formosa* Hassall 2-19-1

Plate 23 No. 11; Plate 24 No. 1

Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Centronella Voigt 2-20*Centronella reichelti* Voigt 2-20-1

Plate 24 No. 2

Lake: Rotomanuka North.

Fragilaria Lyngbye 2-21*Fragilaria brevistriata* Grunow 2-21-1

Lake: Rotoroa.

Fragilaria capucina Demazières 2-21-2

Lakes: Mangakaware, Rotokauri, Rotomanuka North.

Fragilaria delicatissima (W. Smith) Lange-Bertalot 2-21-3

Lakes: Mangakaware, Rotomanuka North.

Fragilaria ulna (Nitzsch) Lange-Bertalot 2-21-4

Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Fragilaria ulna var. *acus* (Kützing) Lange-Bertalot 2-21-4-1

Lakes: Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotoroa.

Meridion Agardh 2-22*Meridion circulare* var. *constricta* (Ralfs) Van Heurck 2-22-1

Plate 24 No. 3

Lake: Ngaroto.

Tabellaria Ehrenberg 2-23*Tabellaria fenestrata* (Lyngbye) Kützing 2-23-1

Plate 24 Nos. 4-6

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotomanuka South, Rotoroa.

Tabellaria flocculosa (Roth) Kützing 2-23-2

Plate 24 Nos. 7, 8

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Eunotiales

Eunotiaceae

Eunotia Ehrenberg 2-24

Eunotia camelus Ehrenberg 2-24-1

Lakes: Mangakaware, Maratoto.

Eunotia curvata (Kützing) Lagerstedt 2-24-2

Plate 24 No. 9

Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka South.

Eunotia diodon Ehrenberg 2-24-3

Plate 24 Nos. 10, 11

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotomanuka North.

Eunotia exugia (de Brébisson ex Kützing) Rabenhorst 2-24-4

Plate 24 No. 12

Lakes: Rotokauri, Rotomanuka North.

Eunotia flexuosa de Brébisson ex Kützing 2-24-5

Lakes: Maratoto, Rotoroa.

Eunotia formica Ehrenberg 2-24-6

Plate 24 No. 13

Lakes: Mangakaware, Ngaroto.

Eunotia nägeli Migula 2-24-7

Lakes: Mangahia, Mangakaware, Ngaroto.

Eunotia pectinalis (O.F. Müller?) Rabenhorst 2-24-8

Plate 25 No. 1

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Eunotia pectinalis var. *minor* (Kützing) Rabenhorst 2-24-8-1

Lakes: Kainui, Mangahia, Maratoto.

Eunotia pectinalis var. *undulata* (Ralfs) Rabenhorst 2-24-8-2

Plate 25 Nos. 2, 3

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotomanuka North, Rotomanuka South, Rotoroa.

Eunotia pectinalis var. *ventricosa* Grunow 2-24-8-3

Lake: Ngaroto.

Eunotia serpentina Ehrenberg 2-24-9

Lakes: Mangahia, Ngaroto, Rotomanuka South.

Eunotia tenella (Grunow) Cleve 2-24-10

Lake: Kainui.

Achnanthes

Achnanthaceae

Achnanthes Bory de Saint-Vincent 2-25*Achnanthes linearis* (W. Smith) Grunow 2-25-1

Lakes: Mangakaware, Maratoto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Cocconeis Ehrenberg 2-26*Cocconeis placentula* Ehrenberg 2-26-1

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Cocconeis placentula var. *euglypta* (Ehrenberg) Cleve 2-26-1-1

Plate 25 No. 4

Lake: Rotomanuka North.

Rhoicosphenia Grunow 2-27*Rhoicosphenia curvata* (Kützing) Grunow 2-27-1

Lakes: Ngaroto, Rotokauri.

Naviculales

Naviculaceae

Amphora Ehrenberg ex Kützing 2-28*Amphora* sp. 2-28-1

Lakes: Mangahia, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Anomoeoneis Pfitzer 2-29*Anomoeoneis serians* (de Brébisson) Cleve 2-29-1

Lakes: Mangahia, Maratoto, Ngaroto, Rotokauri, Rotomanuka South, Rotoroa.

Cymbella Agardh 2-30*Cymbella aspersa* (Ehrenberg) Cleve 2-30-1

Lakes: Ngaroto, Rotomanuka North.

Cymbella minuta Hilse ex Rabenhorst 2-30-2

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka South, Rotoroa.

Cymbella palustris Hustedt 2-30-3

Lakes: Maratoto.

Diploneis Ehrenberg 2-31*Diploneis oblongella* (Nägeli ex Kützing) Ross 2-31-1

Lakes: Mangakaware, Ngaroto.

Frustulia Rabenhorst
nom. cons., non C. Agardh 2-32

Frustulia rhomboides var. **capitata** (A. Mayer) Patrick 2-32-1-1
Plate 25 No. 5
Lakes: Mangakaware, Rotomanuka North.

Frustulia rhomboides var. **saxonica** (Rabenhorst) de Toni 2-32-1-2
Plate 25 Nos. 6, 7
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotomanuka North, Rotoroa.

Gomphonema Ehrenberg
nom. cons., non C. Agardh 2-33

Gomphonema acuminatum Ehrenberg 2-33-1
Plate 25 No. 8
Lakes: Maratoto, Rotomanuka North, Rotoroa.

Gomphonema berggrenii Cleve 2-33-2
Lake: Ngaroto.

Gomphonema truncatum Ehrenberg 2-33-3
Plate 25 Nos. 9-12
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Gyrosigma Hassall
nom. cons., (syn. prius *Scalptrum* Corda) 2-34

Gyrosigma acuminatum (Kützing) Rabenhorst 2-34-1
Plate 25 No. 13
Lakes: Mangakaware, Rotomanuka South.

Navicula Bory de Saint-Vincent 2-35

Navicula bacillum Ehrenberg 2-35-1
Lakes: Ngaroto, Rotoroa.

Navicula cuspidata Kützing 2-35-2
Plate 25 No. 14
Lake: Rotokauri.

Navicula pupula Kützing 2-35-3
Lakes: Maratoto, Ngaroto, Rotokauri.

Navicula radiosa Kützing 2-35-4
Plate 25 No. 15
Lakes: Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Navicula subtilissima Cleve 2-35-5
Lakes: Maratoto, Rotomanuka North, Rotomanuka South, Rotoroa.

Pinnularia (Ehrenberg) Ehrenberg
nom. cons., non Lindley & Hutton 2-36

Pinnularia abaujensis (Pantocksek) Ross 2-36-1
 Lakes: Mangakaware, Maratoto.

Pinnularia abaujensis var. *linearis* (Hustedt) Patrick 2-36-1-1
 Lake: Maratoto

Pinnularia borealis Ehrenberg 2-36-2
 Lakes: Ngaroto, Rotomanuka North.

Pinnularia braunii (Grunow) Cleve 2-36-3
 Lake: Mangakaware, Maratoto.

Pinnularia brevicostata Cleve 2-36-4
 Lake: Mangakaware, Maratoto.

Pinnularia divergens W. Smith 2-36-5
 Lakes: Maratoto, Ngaroto.

Pinnularia flexuosa Cleve * 2-36-6
 Plate 25 No. 16
 Lake: Rotokauri.

Pinnularia gentilis (Donkin) Cleve 2-36-7
 Lakes: Kainui, Mangahia, Maratoto, Rotokauri, Rotoroa.

Pinnularia gibba Ehrenberg 2-36-8
 Lakes: Mangahia, Maratoto, Ngaroto, Rotoroa.

Pinnularia microstauron (Ehrenberg) Cleve 2-36-9
 Lake: Mangakaware, Maratoto.

Pinnularia stomatophora (Grunow) Cleve 2-36-10
 Lake: Ngaroto.

Pinnularia viridis (Nitzsch) Ehrenberg 2-36-11
 Lakes: Mangakaware, Ngaroto.

Stauroneis Ehrenberg 2-37

Stauroneis agrestis Petersen 2-37-1
 Lake: Rotomanuka North.

Stauroneis anceps Ehrenberg 2-37-2
 Lake: Rotoroa.

Stauroneis phoenicenteron (Nitzsch) Ehrenberg 2-37-3
 Lakes: Mangakaware, Ngaroto, Rotoroa.

Epithemiaceae

Epithemia de Brébisson 2-38

Epithemia argus Kützing 2-38-1
 Plate 25 No. 17
 Lake: Kainui.

Epithemia sorex Kützing 2-38-2
 Plate 25 No. 18
 Lakes: Mangakaware, Maratoto, Ngaroto, Rotokauri.

Rhopalodia O.F. Müller 2-39

Rhopalodia sp. 2-39-1
 Plate 26 Nos. 3, 4; Plate 36 No. 2
 Lakes: Mangakaware, Rotoroa.

Nitzschiaceae

Hantzschia Grunow
nom. cons., non Auerswald 2-40

Hantzschia amphioxys (Ehrenberg) Grunow 2-40-1
 Lake: Kainui, Mangakaware, Ngaroto, Rotomanuka North, Rotoroa.

Nitzschia Hassall
nom. cons., (syn. prius *Sigmatella* Kützing) 2-41

Nitzschia acicularis (Kützing) Smith 2-41-1
 Plate 26 No. 1
 Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Nitzschia gracilis Hantzsch 2-41-2
 Lake: Rotokauri, Rotomanuka North.

Nitzschia palea (Kützing) W. Smith 2-41-3
 Lake: Ngaroto.

Nitzschia sigmoidea (Ehrenberg) W. Smith 2-41-4
 Plate 26 No. 2
 Lake: Ngaroto.

Surirellaceae

Stenopterobia de Brébisson 2-42

Stenopterobia intermedia (Lewis) Van Heurck 2-42-1
 Lakes: Mangakaware, Maratoto, Rotomanuka North, Rotomanuka South.

Surirella Turpin 2-43

Surirella angustata Kützing 2-43-1
 Lake: Rotomanuka North.

Surirella linearis W. Smith 2-43-2
 Lakes: Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotoroa.

Surirella linearis var. *constricta* Grunow 2-43-2-1
 Lakes: Rotomanuka North, Rotomanuka South.

CYANOPHYTA 3

Cyanophyceae

Chroococcales

Chroococcaceae

Aphanocapsa Nägeli 3-1

Aphanocapsa delicatissima W. & G.S. West *(Etheredge & Pridmore, 1984). 3-1-1

Lakes: Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Aphanocapsa elachista W. & G.S. West 3-1-2

Plate 26 No. 5

Lakes: Kainui, Mangahia, Maratoto, Ngaroto.

Aphanocapsa elachista var. *conferta* W. & G.S. West 3-1-2-1

Lakes: Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Aphanothece Nägeli

nom. cons., (syn prius *Coccochloris* C. Sprengel) 3-2

Aphanothece nidulans Richter 3-2-1

Lake: Kainui.

Chroococcus Nägeli 3-3

Chroococcus dispersus (Keissler) Lemmermann 3-3-1

Lakes: Kainui, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Chroococcus dispersus var. *minor* G.M. Smith 3-3-1-1

Lakes: Kainui, Mangahia, Maratoto, Ngaroto, Rotokauri, Rotomanuka South.

Chroococcus limneticus Lemmermann 3-3-2

Plate 26 No. 6

Lakes: Kainui, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Chroococcus minor (Kützing) Nägeli 3-3-3

Plate 26 No. 7

Lakes: Maratoto, Rotokauri, Rotomanuka North.

Chroococcus minutus (Kützing) Nägeli 3-3-4

Lakes: Mangakaware, Ngaroto, Rotokauri, Rotoroa.

Chroococcus turgidus (Kützing) Nägeli 3-3-5

Lakes: Maratoto, Ngaroto, Rotokauri, Rotoroa.

Coelosphaerium Nägeli 3-4

Coelosphaerium kuetzingianum Nägeli 3-4-1

Lakes: Maratoto, Rotokauri.

Gomphosphaeria Kützing 3-5

Gomphosphaeria lacustris Chodat 3-5-1

Lakes: Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka South.

Gomphosphaeria lacustris var. compacta Lemmermann 3-5-1-1

Lake: Rotokauri.

Merismopedia Meyen 3-6

Merismopedia elegans A. Braun 3-6-1

Plate 26 No. 8

Lakes: Kainui, Rotomanuka North.

Merismopedia glauca (Ehrenberg) Nägeli 3-6-2

Plate 26 No. 9

Lakes: Rotokauri, Rotomanuka North.

Merismopedia minima Beck 3-6-3

Plate 26 No. 12

Lakes: Kainui, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Merismopedia punctata Meyen 3-6-4

Lake: Ngaroto.

Merismopedia tenuissima Lemmermann 3-6-5

Plate 26 Nos. 10, 11

Lakes: Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Microcystis Lemmermann
nom. cons., non Kützing 3-7

Microcystis aeruginosa Kützing 3-7-1

Plate 26 No. 13; Plate 27 Nos. 1-5

Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Microcystis pulverea (Wood) Forti 3-7-2

Lakes: Rotomanuka South, Rotoroa.

Rhabdoderma Schmidle & Lauterborn 3-8

Rhabdoderma lineare Schmidle & Lauterborn 3-8-1

Lakes: Rotokauri, Rotomanuka North.

Nostocales

Nostocaceae

Anabaena Bory de Saint-Vincent
ex Bornet & Flahault 3-9

Anabaena circinalis Rabenhorst ex Bornet & Flahault 3-9-1

Plate 27 Nos. 6, 7

Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North.

Anabaena flos-aquae (Lyngbye) de Brébisson ex Bornet & Flahault 3-9-2
Plate 27 Nos. 8, 9

Lake: Kainui, Mangakaware, Ngaroto, Rotomanuka North, Rotomanuka South.

Anabaena minutissima Lemmermann ? 3-9-3

Lakes: Kainui, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Anabaena solitaria Klebahn 3-9-4

Plate 28 Nos. 1, 2

Lake: Ngaroto.

Anabaena spiroides var. *tumida* Nygaard 3-9-5

Plate 28 Nos. 3, 4

Lakes: Mangahia, Ngaroto.

Anabaena tenericaulis Nygaard 3-9-6

Lakes: Ngaroto, Rotokauri, Rotomanuka South.

Cylindrospermum Kützing
ex Bornet & Flahault 3-10

Cylindrospermum minutissimum Collins *(Etheredge & Pridmore, 1984).
3-10-1

Plate 28 No. 5

Lake: Mangahia.

Oscillatoriaceae

Lyngbya C.A. Agardh ex Gomont

nom. cons., non *Lyngbyea* Sommerfelt 3-11

Lyngbya limnetica Lemmermann 3-11-1

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Oscillatoria Vaucher ex Gomont 3-12

Oscillatoria agardhii Gomont *(Etheredge & Pridmore, 1984). 3-12-1

Lakes: Mangahia, Mangakaware, Rotokauri.

Oscillatoria articulata Gardner 3-12-2

Lakes: Ngaroto, Rotomanuka North.

Oscillatoria curviceps Agardh ex Gomont *(Etheredge & Pridmore, 1984). 3-12-3

Plate 28 No. 6

Lake: Kainui.

Oscillatoria geminata Meneghini ex Gomont 3-12-4

Plate 28 No. 7

Lake: Kainui, Rotomanuka North.

Oscillatoria guttulata Van Goor 3-12-5

Lake: Ngaroto.

Oscillatoria jasarvensis Vouk 3-12-6
Lake: Rotokauri.

Oscillatoria limnetica Lemmermann 3-12-7
Plate 28 No. 8
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Rotokauri, Rotomanuka North, Rotomanuka South.

Oscillatoria limosa C.A. Agardh ex Gomont 3-12-8
Plate 28 No. 9
Lakes: Mangahia, Mangakaware, Maratoto, Rotokauri, Rotoroa.

Oscillatoria mougeotii Kützing ex Forti 3-12-9
Lake: Ngaroto.

Oscillatoria planctonica Woloszyńska *(Etheredge & Pridmore, 1984).
3-12-10
Lakes: Kainui, Maratoto, Ngaroto, Rotokauri, Rotomanuka North.

Oscillatoria splendida Greville ex Gomont 3-12-11
Plate 28 Nos. 10, 11
Lakes: Kainui, Mangahia, Maratoto, Ngaroto, Rotokauri, Rotomanuka North.

Oscillatoria subbrevis Schmidle 3-12-12
Plate 28 No. 12
Lakes: Kainui, Mangahia, Mangakaware, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Oscillatoria tenuis C.A. Agardh ex Gomont 3-12-13
Plate 28 No. 13
Lakes: Mangakaware, Rotokauri, Rotomanuka North, Rotoroa.

Phormidium Kützing ex Gomont 3-13

Phormidium mucicola Naumann & Huber-Pestalozzi 3-13-1
Lake: Rotomanuka South

Spirulina Turpin ex Gomont 3-14

Spirulina laxa G.M. Smith *(Etheredge & Pridmore, 1984). 3-14-1
Lakes: Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Spirulina major Kützing ex Gomont 3-14-2
Plate 28 No. 14
Lake: Ngaroto.

EUGLENOPHYTA 4

Euglenophyceae

Euglenales

Euglenaceae

Astasia Dujardin*nom. cons.*, non Ehrenberg 4-1*Astasia harrisii* Pringsheim * 4-1-1

Plate 28 No. 15

Lakes: Mangahia, Rotomanuka North.

Cyclidiopsis Korschikov 4-2*Cyclidiopsis acus* Korschikov 4-2-1

Plate 28 No. 16

Lakes: Ngaroto, Rotokauri, Rotomanuka North.

Euglena Ehrenberg 4-3*Euglena acus* Ehrenberg 4-3-1

Plate 28 Nos. 17, 18

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka South, Rotoroa.

Euglena ehrenbergii Klebs 4-3-2

Plate 28 No. 19

Lake: Rotokauri.

Euglena limnophila Lemmermann * 4-3-3

Plate 28 No. 20

Lake: Rotokauri.

Euglena oxyuris Schmarda 4-3-4

Plate 28 Nos. 21, 22; Plate 37 No. 1

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Euglena proxima Dangeard 4-3-5

Lakes: Mangahia, Maratoto, Rotokauri, Rotoroa.

Euglena sanguinea Ehrenberg 4-3-6

Lake: Mangahia.

Euglena spirogyra var. *suprema* Skuja * 4-3-7

Plate 29 No. 1

Lake: Rotokauri.

Euglena tripteris (Dujardin) Klebs 4-3-8

Plate 29 No. 2

Lake: Mangahia.

Lepocinclis Perty*nom. cons.*, (syn. prius *Crumenula* Dujardin) 4-4*Lepocinclis marssonii* Lemmermann emend. Conrad 4-4-1

Plate 29 No. 3

Lakes: Mangakaware, Rotokauri, Rotomanuka North, Rotoroa.

Lepocinclis ovum (Ehrenberg) Lemmermann 4-4-2

Plate 29 No. 4

Lakes: Mangahia, Mangakaware, Rotokauri, Rotomanuka North, Rotomanuka South.

Menoidium Perty 4-5

Menoidium gracile Playfair 4-5-1

Plate 29 No. 5

Lake: Rotokauri, Rotomanuka North.

Menoidium pellucidum Perty * 4-5-2

Plate 29 No. 6; Plate 37 No. 2

Lakes: Maratoto, Rotokauri.

Phacus Dujardin

nom. cons., non Nitzsch in Ersch & Gruber 4-6

Phacus acuminatus Stokes 4-6-1

Lake: Ngaroto.

Phacus agilis Skuja 4-6-2

Lakes: Rotokauri, Rotomanuka North.

Phacus chloroplastes Prescott * 4-6-3

Lake: Ngaroto.

Phacus curvicauda Swirenko 4-6-4

Plate 29 Nos. 7, 8

Lake: Rotokauri.

Phacus glaber (Deflandre) Pochmann 4-6-5

Plate 29 No. 9

Lakes: Kainui, Mangakaware, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Phacus hamatus Pochmann * 4-6-6

Lake: Maratoto.

Phacus helicoides Pochmann 4-6-7

Plate 29 Nos. 10, 11

Lakes: Mangahia, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Phacus inflexus (Kisselew) Pochmann 4-6-8

Plate 29 No. 12

Lakes: Rotokauri, Rotoroa.

Phacus latus (Roll) Pochmann * 4-6-9

Lake: Rotomanuka South.

Phacus longicauda (Ehrenberg) Dujardin 4-6-10

Plate 29 No. 13

Lakes: Mangahia, Rotokauri.

Phacus pleuronectes (O.F. Müller) Dujardin 4-6-11
 Plate 29 No. 14
 Lakes: Mangahia, Mangakaware, Maratoto, Rotokauri, Rotomanuka South,
 Rotoroa.

Phacus polytrophos Pochmann * 4-6-12
 Lake: Ngaroto.

Phacus pyrum (Ehrenberg) Stein 4-6-13
 Lakes: Mangahia, Mangakaware, Ngaroto, Rotokauri.

Phacus raciborski Drezepolski 4-6-14
 Plate 29 No. 15
 Lakes: Mangakaware, Rotokauri, Rotomanuka North.

Phacus rudicola (Playfair) Pochmann 4-6-15
 Plate 29 No. 16
 Lakes: Kainui, Ngaroto, Rotokauri.

Phacus suecicus Lemmermann 4-6-16
 Plate 29 No. 19
 Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Rotokauri, Rotomanuka
 North, Rotoroa.

Phacus suecicus var. *oidon* Pochmann 4-6-16-1
 Plate 29 No. 20
 Lakes: Mangakaware, Rotomanuka North.

Phacus sesquitortus Pochmann * 4-6-17
 Plate 29 Nos. 17, 18
 Lake: Rotomanuka North.

Phacus tortus (Lemmermann) Skvortzov 4-6-18
 Plate 38 No. 1
 Lake: Mangahia, Ngaroto, Rotokauri, Rotomanuka North.

Trachelomonas Ehrenberg 4-7

Trachelomonas aculeata Dolgoff * 4-7-1
 Lake: Rotomanuka North.

Trachelomonas armata (Ehrenberg) Stein 4-7-2
 Lakes: Maratoto, Rotokauri, Rotomanuka North.

Trachelomonas armata var. *inevoluta* Deflandre 4-7-2-1
 Plate 29 No. 21
 Lakes: Mangakaware, Rotokauri.

Trachelomonas armata var. *longispina* Playfair emend. Deflandre
 4-7-2-2
 Plate 30 Nos. 1, 2
 Lakes: Maratoto, Rotokauri, Rotomanuka North, Rotomanuka South.

Trachelomonas bacillifera var. *minima* Playfair * 4-7-3
 Lake: Rotoroa.

- Trachelomonas cylindrica* Ehrenberg 4-7-4
Plate 30 No. 3
Lakes: Mangahia, Rotokauri, Rotomanuka North, Rotoroa.
- Trachelomonas dangeardiana* Deflandre * 4-7-5
Lakes: Kainui, Mangakaware, Rotokauri.
- Trachelomonas dubia* Swirenko emend. Deflandre * 4-7-6
Lake: Rotomanuka South.
- Trachelomonas dybowskii* Drezepolski * 4-7-7
Plate 30 Nos. 4, 5
Lake: Mangakaware.
- Trachelomonas furcata* Dolgoff 4-7-8 +
+ Described by Rybak (1986) as a chrysophycean cyst, *Cysta furcata*.
Plate 30 Nos. 6, 7
Lakes: Ngaroto, Rotokauri, Rotomanuka North.
- Trachelomonas globularis* var. *punctata* Skvortzov * 4-7-9-1
Plate 30 No. 8
Lake: Mangakaware.
- Trachelomonas hexangulata* (Swirenko) Playfair 4-7-10
Plate 30 No. 9
Lakes: Mangahia, Mangakaware, Rotomanuka North, Rotomanuka South, Rotoroa.
- Trachelomonas hispida* (Perty) Stein emend. Deflandre 4-7-11
Lakes: Kainui, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.
- Trachelomonas hispida* var. *coronata* Lemmermann 4-7-11-1
Plate 30 No. 10
Lakes: Mangahia, Mangakaware, Rotomanuka North, Rotoroa.
- Trachelomonas hispida* var. *punctata* Lemmermann 4-7-11-2
Lake: Ngaroto.
- Trachelomonas lacustris* Drezepolski * 4-7-12
Lakes: Rotokauri, Rotomanuka North.
- Trachelomonas lemmermannii* Woloszyńska emend. Deflandre * 4-7-13
Plate 30 No. 11
Lake: Rotomanuka North.
- Trachelomonas mirabilis* var. *helvetica* Huber-Pestalozzi * 4-7-14-1
Lake: Rotokauri.
- Trachelomonas mirabilis* var. *obesa* (Messikommer) Conrad 4-7-14-2
Plate 30 No. 12
Lake: Mangakaware.
- Trachelomonas planctonica* Swirenko 4-7-15
Plate 30 Nos. 13, 14
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Trachelomonas planctonica var. *oblonga* Drezepolski * 4-7-15-1
Lake: Ngaroto.

Trachelomonas playfairi Deflandre 4-7-16
Plate 30 No. 15
Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Trachelomonas pulcherrima var. *minor* Playfair * 4-7-17-1
Plate 30 No. 16
Lake: Rotomanuka North.

Trachelomonas pulcherrima var. *ovalis* Playfair * 4-7-17-2
Plate 30 No. 17
Lakes: Rotomanuka North, Rotoroa.

Trachelomonas stokesi Drezepolski emend. Deflandre * 4-7-18
Lake: Rotokauri.

Trachelomonas sydneyensis Playfair 4-7-19
Lakes: Rotomanuka North, Rotoroa.

Trachelomonas volvocina Ehrenberg 4-7-20
Plate 30 Nos. 18, 19
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Trachelomonas volzii var. *cylindracea* Playfair 4-7-21
Lake: Rotomanuka South.

Strombomonas Deflandre 4-8

Strombomonas urceolata (Stokes) Deflandre 4-8-1
Plate 30 No. 20; Plate 38 No. 2
Lake: Ngaroto.

Urceolus Mereschowsky 4-9

Urceolus sp. 4-9-1
Plate 30 No. 21
Lake: Rotomanuka North.

PYRRHOPHYTA 5

Cryptophyceae

Cryptomonadales

Cryptomonadaceae

+ *Cryptomonas* Ehrenberg 5-1

* Recent scanning electron microscopical studies by Kugrens *et al.*, (1986) indicate that, as presently constituted, this genus is not a single, natural group; they consider there is evidence to warrant its separation into at least 3 genera. This contrasts markedly with the views of Santore (1985).

Cryptomonas erosa Ehrenberg 5-1-1
Plate 30 Nos. 22, 23
Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri,

Rotomanuka North, Rotomanuka South, Rotoroa.

Cryptomonas marssonii Skuja 5-1-2

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotoroa.

Cryptomonas ovata Ehrenberg 5-1-3

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Dinophyceae

Peridinales

Gymnodiniaceae

Gymnodinium Stein 5-2

Gymnodinium fuscum (Ehrenberg) Stein 5-2-1

Lakes: Mangakaware, Rotokauri, Rotomanuka North.

Peridiniaceae

Peridinium Ehrenberg 5-3

Peridinium aciculiferum (Lemmermann) Lemmermann 5-3-1

Plate 30 No. 24

Lakes: Ngaroto, Rotomanuka North.

Peridinium centennale (Playfair) Lefèvre * 5-3-2

Lake: Mangakaware.

Peridinium cinctum (Müller) Ehrenberg 5-3-3

Plate 30 Nos. 25, 26

Lakes: Kainui, Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South, Rotoroa.

Peridinium inconspicuum Lemmermann 5-3-4

Plate 31 Nos. 1, 2

Lakes: Kainui, Mangakaware, Maratoto, Rotokauri, Rotomanuka North, Rotoroa.

Peridinium polonicum Woloszyńska * 5-3-5

Lake: Maratoto.

Peridinium pusillum tab. *conjunctum* Lefèvre * 5-3-6

Plate 31 No. 3

Lakes: Mangahia, Mangakaware, Maratoto, Ngaroto, Rotokauri, Rotomanuka North, Rotomanuka South.

Peridinium umbonatum tab. *conjunctum* var. *inaequale* (Lemmermann) Lefèvre 5-3-7

Plate 31 No. 4

Lakes: Mangakaware, Rotokauri, Rotomanuka North.

Peridinium willei Huitfeldt-Kass 5-3-8

Lakes: Mangakaware, Maratoto.

Peridinium sp. A. 5-3-9

Plate 31 No. 5

Lake: Rotoroa.

Peridinium sp. B 5-3-10
Lake: Maratoto

Ceratiaceae

Ceratium Schrank 5-4

Ceratium hirundinella (O.F. Müller) Schrank 5-4-1
Plate 31 No. 6

Lakes: Kainui, Mangahia, Ngaroto, Rotokauri, Rotomanuka North,
Rotomanuka South, Rotoroa.

Ceratium hirundinella fa. *furcoides* Schröder 5-4-1-1

Plate 31 No. 7

Lake: Rotoroa.

Dinococcales

Phytodiniaceae

Cystodinium Klebs 5-5

Cystodinium cornifax (Schilling) Klebs 5-5-1

Plate 31 No. 8

Lakes: Mangahia, Rotokauri, Rotomanuka North.

Tetradinium Klebs 5-6

Tetradinium intermedium Geitler * 5-6-1

Plate 31 No. 9

Lake: Kainui.

RAPHIDOPHYTA 6

Raphidophyceae

Raphidomonadales

Vacuolariaceae

Vacuolaria Cienkowski 6-1

Vacuolaria sp. 6-1-1

This taxon was recorded as *Dylakosoma pelophilum* Skuja by Etheredge
(1983).

Lakes: Kainui, Mangakaware, Maratoto, Rotokauri, Rotomanuka North.

APPENDIX VIII

LIST OF NEW PHYTOPLANKTON SPECIES RECORDS FOR NEW ZEALANDFROM THE STUDY LAKES, JULY 1983 TO JULY 1984

CHLOROPHYTA

Euchlorophyceae

Chlorococcales

Chlorococcaceae

Ankyra judayi (G.M. Smith) Fott

Characium ornithocephalum A Braun

Oocystaceae

Ankistrodesmus bernardii Komárek

A. fasciculatus (Lundberg) Komárková-Legnerová

Lagerheimia ciliata (Lagerheim) Chodat

Monoraphidium komarkovae Nygaard

Pachycladella umbrina (G.M. Smith) Silva

Rhombocystis complanata Komárek

Treubaria planctonica (G.M. Smith) Koršikov

T. setigera (Archer) G.M. Smith

Trochiscia aciculifera (Lagerheim) Hansgirg

Micractiniaceae

Micractinium bornhemiense (Conrad) Koršikov

Scenedesmaceae

Actinastrum aciculare Playfair

Coelastrum indicum Turner

Crucigeniella apiculata (Lemmermann) Komárek

Scenedesmus acuminatus var. *minor* G.M.

Smith

S. acutus Meyen

S. intermedius Chodat

S. protuberans Fritsch

Tetrastrum heteracanthum (Norstedt) Chodat

T. staurogeniaforme (Schröder) Lemmermann

T. triangulare (Chodat) Komárek

Zygophyceae

Zygnematales

Desmidiaceae

Actinotaenium wollei (W. & G.S. West) Teiling ex
Ružička & Pouzar

Pleurotaenium minutum. The variety *P. m.*

elongatum (West & West) Cedergren has been recorded in New Zealand.

Euastrum verrucosum Ehrenberg ex Ralfs

CHROMOPHYTA

Chrysophyceae

Chromulinales

Chrysococcaceae

Bicoseca petiolata (Stein) Pringsheim

Dinobryaceae

Dinobryon elegantissimum f. *gallica*

Bourrelly

Xanthophyceae

Mischococcales

Pleurichloridaceae

Tetraedriella jovetii (Bourrelly) Bourrelly

Diatomophyceae

Naviculales

Naviculaceae

Pinnularia flexuosa Cleve

CYANOPHYTA

Cyanophyceae

Chroococcales

Chroococcaceae

Aphanocapsa delicatissima W. & G.S. West (Etheredge & Pridmore, 1984).

Nostocales

Nostocaceae

Cylindrospermum minutissimum Collins (Etheredge & Pridmore, 1984).

Oscillatoriaceae

Oscillatoria agardhii Gomont (Etheredge & Pridmore, 1984).

Oscillatoria planctonica Woloszyńska (Etheredge & Pridmore, 1984).

Spirulina major G.M. Smith (Etheredge & Pridmore, 1984).

EUGLENOPHYTA

Euglenophyceae

Euglenales

Euglenaceae

Astasia harrisii Pringsheim

Euglena limnophila Lemmermann

E. spirogyra var. *suprema* Skuja

Menoidium gracile Playfair

Phacus chloroplastes Prescott

P. hamatus Pochmann
P. latus (Roll) Pochmann
P. polytrophos Pochmann
P. sesquitortus Pochmann
Trachelomonas aculeata Dolgoff
T. dangeardiana Deflandre
T. dubia Swirenko emend. Deflandre
T. dybowskii Drezepolski
T. globularis var. *punctata* Skvortzov
T. lacustris Drezepolski
T. lemmermannii Woloszyńska emend. Deflandre
T. mirabilis var. *helvetica* Huber-
 Pestalozzi
T. planctonica var. *oblonga* Drezepolski
T. pulcherrima var. *minor* Playfair
T. p. var. *ovalis* Playfair
T. stokesi Drezepolski emend. Deflandre

PYRRHOPHYTA

Dinophyceae

Peridinales

Peridiniaceae

Peridinium centenniale (Playfair) Lefèvre

P. polonicum Woloszyńska

P. pusillum tab. *conjunctum* Lefèvre

Dinococcales

Phytodiniaceae

Tetradinium intermedium Geitler

APPENDIX IX

LIST OF OF IMPORTANT SPECIES INDICES (ISIs) FOR THE MAJOR
PHYTOPLANKTON SPECIES FOUND IN THE NINE STUDY LAKES,
JULY 1983 TO JULY 1984

The taxonomic arrangement follows Appendix VII.

LAKE KAINUI

Taxon	ISI
CHLOROPHYTA	
Euchlorophyceae	
<i>Ankistrodesmus bibraianus</i>	31.5
<i>A. gracilis</i>	25.0
<i>Monoraphidium tortile</i>	3.0
<i>Botryococcus braunii</i>	18.0
<i>Coelastrum reticulatum</i>	8.0
<i>Scenedesmus quadricauda</i>	357.0
Zygophyceae	
<i>Closterium acutum</i>	
var. <i>variabile</i>	680.0
<i>C. gracile</i>	13.0
<i>Staurastrum arcuatum</i>	90.0
<i>S. brachiatum</i>	316.0
<i>S. chaetopus?</i>	152.0
<i>S. sp. C</i>	2091.0
<i>Staurodesmus spp. *</i>	4460.0
CHROMOPHYTA	
Diatomophyceae	
<i>Tabellaria flocculosa</i>	9.0
CYANOPHYTA	
Cyanophyceae	
<i>Merismopedia minima</i>	1.0
EUGLENOPHYTA	
Euglenophyceae	
<i>Trachelomonas volvocina</i>	45.0
PYRRHOPHYTA	
Cryptophyceae	
<i>Cryptomonas spp. **</i>	51.0

* Includes *S. cuspidatus*, *S. dejectus* and *S. mammillatus*.

** Includes *C. marssonii* and *C. ovata*.

LAKE MANGAHIA

Taxon	ISI
CHLOROPHYTA	
Euchlorophyceae	
<i>Chlorella</i> sp.	372.3
<i>Monoraphidium tortile</i>	59.0
<i>Raphidocelis contorta</i>	50.0
<i>Scenedesmus opoliensus</i>	8.2
<i>Coelastrum microporum</i>	2.0
<i>S. quadricauda</i>	154.5
<i>Tetrastrum heteracanthum</i>	27.2
<i>T. staurogeniaforme</i>	5.4
<i>T. triangulare</i>	15.9
Zygophyceae	
<i>Closterium aciculare</i>	0.7
<i>C. acutum</i> var.	
<i>variable</i>	2390.0
<i>C. gracile</i>	224.2
<i>Staurastrum chaetopus?</i>	3.6
<i>S. glaber</i> var.	
<i>limnophilus</i>	1.8
CHROMOPHYTA	
Chrysophyceae	
<i>Chrysococcus rufescens</i>	18.2
<i>Mallomonas tonsurata</i>	20.0
Xanthophyceae	
<i>Centritractus</i> spp. *	0.4
Diatomophyceae	
<i>Aulacosira distans</i>	3610.0
<i>A. granulata</i>	0.5
<i>A. g.</i> var.	
<i>angustissima</i>	524.7
<i>Cyclotella stelligera</i>	3.2
<i>Tabellaria fenestrata</i>	1.1
<i>T. flocculosa</i>	36.3

CYANOPHYTA

Cyanophyceae

<i>Gomphosphaeria lacustris</i>	2.4
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EUGLENOPHYTA

Euglenophyceae

<i>Euglena acus</i>	0.4
<i>E. oxyuris</i>	0.6
<i>Trachelomonas volvocina</i>	530.0

PYRRHOPHYTA

Cryptophyceae

<i>Cryptomonas</i> spp. **	127.3
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* Includes *Centritractus belonophorus* and *C. africanus*.

** Includes *Cryptomonas marssonii* and *C. ovata*.

LAKE MANGAKAWARE

Taxon	ISI
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CHLOROPHYTA

Euchlorophyceae

<i>Palmodictyon viride</i>	14.4
<i>Kirchneriella obesa</i> var. <i>aperta</i>	7.1
<i>Monoraphidium contortum</i>	2288.2
<i>M. komarkovae</i>	95.2
<i>M. minutum</i>	3.8
<i>M. tortile</i>	214.5
<i>Oocystis lacustris</i>	0.7
<i>Raphidocelis contorta</i>	14.3
<i>Rhombocystis complanata</i>	40.0
<i>Dictyosphaerium subsolitarium?</i>	100.1
<i>Actinastrum hantzschii</i>	20.0
<i>Tetrastrum triangulare</i>	164.2

Zygophyceae

<i>Closterium acutum</i> var. <i>variabile</i>	570.0
<i>C. gracile</i>	7.1

<i>Staurastrum arcuatum</i>	0.9
<i>S. sp. B</i>	15.2
<i>Staurodesmus glaber</i> var. <i>limnophilus</i>	8.6
CHROMOPHYTA	
Chrysophyceae	
<i>Chrysococcus rufescens</i>	8.6
<i>Dinobryon cylindricum</i>	342.9
<i>Chrysosphaerella longispina</i>	0.9
<i>Synura uvella</i>	133.3
Diatomophyceae	
<i>Aulacosira distans</i>	38.1
<i>Cyclotella stelligera</i>	171.4
<i>Rhizosolenia eriensis</i>	5.7
<i>Acanthoceras zachariasii</i>	560.7
<i>Asterionella formosa</i>	398.2
<i>Tabellaria flocculosa</i>	12.4
<i>Achnanthes linearis</i>	23.8
EUGLENOPHYTA	
Euglenophyceae	
<i>Trachelomonas</i> spp. *	790.0
PYRRHOPHYTA	
Cryptophyceae	
<i>Cryptomonas erosa</i>	40.0
<i>C. spp. **</i>	113.4
Dinophyceae	
<i>Peridinium cinctum</i> ***	19.0
<i>P. pusillum</i> tab. <i>conjunctum</i>	7.1
RAPHIDOPHYTA	
Raphidophyceae	
<i>Vacuolaria</i> sp.	17.1

* Includes *Trachelomonas planctonica*, *T. playfairi* and *T. volvocina*.

** Includes *Cryptomonas marssonii* and *C. ovata*.

*** Includes *Peridinium willei*.

LAKE MARATOTO

Taxon	ISI
CHLOROPHYTA	
Euchlorophyceae	
<i>Chlamydomonas</i> sp. C	377.0
<i>Monoraphidium tortile</i>	72.0
<i>Botryococcus braunii</i>	4113.0
Zygophyceae	
<i>Closterium acutum</i> var.	
<i>varibile</i>	693.0
<i>C. gracile</i>	33.0
<i>Staurastrum inflexum</i>	25.5
<i>S. sp. B</i>	38.0
<i>Staurodesmus glaber</i> var.	
<i>limnophilus</i>	2.5
CHROMOPHYTA	
Diatomophyceae	
<i>Aulacosira granulata</i>	13.0
<i>A. g.</i> var.	
<i>angustissima</i>	4.0
<i>Tabellaria flocculosa</i>	117.0
CYANOPHYTA	
Cyanophyceae	
<i>Chroococcus dispersus</i>	
var. <i>minor</i>	2.0
EUGLENOPHYTA	
Euglenophyceae	
<i>Trachelomonas</i> spp. *	54.0
PYRRHOPHYTA	
Cryptophyceae	
<i>Cryptomonas</i> spp. **	123.5

* Includes *Trachelomonas planctonica*, *T. playfairi*, and *T. volvocina*.

** Includes *Cryptomonas marssonii* and *C. ovata*.

LAKE NGAROTO

Taxon	ISI
CHLOROPHYTA	
Euchlorophyceae	
<i>Ankistrodesmus bibraianus</i>	2.3
<i>A. falcatus</i>	1.0
<i>A. fusiformis</i>	10.0
<i>A. gracilis</i>	7.1
<i>Monoraphidium contortum</i>	300.0
<i>M. minutum</i>	4.3
<i>Oocystis lacustris</i>	14.3
<i>Raphidocelis contorta</i>	121.9
<i>Botryococcus braunii</i>	43.3
<i>Actinastrum hantzschii</i>	61.0
<i>Coelastrum microporum</i>	8.5
<i>C. reticulatum</i>	9.5
<i>Crucigeniella apiculata</i>	7.1
<i>C. rectangularis</i>	7.1
<i>Scenedesmus acuminatus</i>	32.4
<i>S. quadricauda</i>	1080.0
<i>Tetrastrum staurogeniaforme</i>	48.5
<i>T. triangulare</i>	38.1
<i>Pediastrum duplex</i>	7.1
<i>P. tetras</i>	24.3
Zygophyceae	
<i>Mougeotia</i> sp. B	2.9
<i>Closterium acutum</i>	
var. <i>variable</i>	210.0
<i>C. gracile</i>	7.6
<i>Staurastrum</i> sp. C	81.4
CHROMOPHYTA	
Chrysophyceae	
<i>Chrysococcus rufescens</i>	12.8
Diatomophyceae	
<i>Aulacosira distans</i>	114.2
<i>A. granulata</i> var.	
<i>angustissima</i>	4410.0
<i>Asterionella formosa</i>	121.4
<i>Tabellaria flocculosa</i>	5.2

CYANOPHYTA

Cyanophyceae

<i>Chroococcus dispersus</i>	
var. <i>minor</i>	7.6
<i>C. limneticus</i>	95.2
<i>Merismopedia minima</i>	34.3
<i>M. tenuissima</i>	1.9
<i>Microcystis aeruginosa</i>	730.1
<i>Anabaena circinalis</i>	131.1
<i>A. flos-aquae</i>	7.6
<i>A. solitaria</i>	1.9
<i>A. tenericaulis</i>	428.4

EUGLENOPHYTA

Euglenophyceae

<i>Trachelomonas volvocina</i>	291.4
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PYRRHOPHYTA

Cryptophyceae

<i>Cryptomonas</i> spp. *	90.5
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Dinophyceae

<i>Peridinium cinctum</i>	32.4
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* Includes *Cryptomonas marssonii* and *C. ovata*.

LAKE ROTOKAURI

Taxon	ISI
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CHLOROPHYTA

Euchlorophyceae

<i>Eudorina elegans</i>	4.1
<i>Ankistrodesmus bibraianus</i>	610.6
<i>A. falcatus</i>	332.4
<i>A. fusiformis</i>	2.7
<i>A. gracilis</i>	180.0
<i>Kirchneriella lunaris</i>	20.4
<i>K. obesa</i> var.	
<i>aperta</i>	40.0
<i>Monoraphidium contortum</i>	354.2
<i>M. griffithii</i>	2.7
<i>M. komarkovae</i>	9.1
<i>M. minutum</i>	1.8

<i>M. tortile</i>	4.5
<i>Raphidocelis contorta</i>	0.4
<i>Botryococcus braunii</i>	11.8
<i>Dictyosphaerium pulchellum</i>	65.0
<i>Dimorphococcus lunatus</i>	46.4
<i>Actinastrum hantzschii</i>	3.6
<i>Coelastrum microporum</i>	40.9
<i>C. reticulatum</i>	15.0
<i>Crucigeniella apiculata</i>	1.3
<i>C. rectangularis</i>	2.7
<i>Scenedesmus acutiformis</i>	310.8
<i>S. obtusus</i>	34.0
<i>S. quadricauda</i>	5.5
<i>Pediastrum tetras</i>	4.5
Zygophyceae	
<i>Mougeotia</i> sp. B	9.9
<i>Closterium acutum</i>	
var. <i>variabile</i>	19.1
<i>Cosmarium bioculatum</i>	9.1
<i>Staurastrum muticum</i>	
var. <i>victoriense</i>	20.0
<i>S. subradians</i>	1.8
<i>S.</i> sp. C	18.2
<i>Staurodesmus dejectus</i>	50.0
CHROMOPHYTA	
Chrysophyceae	
<i>Chrysococcus rufescens</i>	90.0
<i>Dinobryon cylindricum</i>	2.7
<i>Mallomonas acaroides</i>	3.6
<i>M. akrokomos</i>	205.7
<i>M. tonsurata</i>	0.9
<i>Synura uvella</i>	151.3
Diatomophyceae	
<i>Aulacosira distans</i>	94.1
<i>A. granulata</i> var.	
<i>angustissima</i>	13.6
<i>Cyclotella stelligera</i>	3.2
<i>Rhizosolenia eriensis</i>	0.9
<i>Acanthoceras zachariasii</i>	108.1
<i>Fragilaria ulna</i>	130.9
<i>F. u.</i> var.	
<i>acus</i>	23.7
<i>Tabellaria flocculosa</i>	15.0
<i>Eunotia pectinalis</i>	8.2
<i>Achnanthes linearis</i>	81.7
<i>Amphora</i> sp.	5.5
<i>Gomphonema truncatum</i>	153.4
<i>Nitzschia acicularis</i>	77.2

CYANOPHYTA

Cyanophyceae

<i>Chroococcus dispersus</i>	
var. <i>minor</i>	13.6
<i>C. minutus</i>	0.4
<i>Gomphosphaeria lacustris</i>	8.2
<i>Merismopedia minima</i>	0.9
<i>M. tenuissima</i>	0.9
<i>Rhabdoderma lineare</i>	0.9
<i>Anabaena minutissima?</i>	27.2
<i>Oscillatoria subbrevis</i>	1.4
<i>O. tenuis</i>	3.6

EUGLENOPHYTA

Euglenophyceae

<i>Euglena acus</i>	22.3
<i>E. limnophilus</i>	9.1
<i>Lepocinclis ovum</i>	10.9
<i>Phacus helicoides</i>	4.5
<i>P. pleuronectes</i>	5.0
<i>Trachelomonas armata</i>	
var. <i>inevoluta</i>	14.6
<i>T. a.</i> var.	
<i>longispina</i>	0.9
<i>T. spp. *</i>	440.6

PYRRHOPHYTA

Cryptophyceae

<i>Cryptomonas erosa</i>	4.5
<i>C. spp. **</i>	572.7

Dinophyceae

<i>Gymnodinium fuscum</i>	4.5
<i>Peridinium pusillum</i>	
tab. <i>conjunctum</i>	13.6

RAPHIDOPHYTA

Raphidophyceae

<i>Vacuolaria</i> sp.	6.8
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* Includes *Trachelomonas planctonica*,
T. playfairi and *T. volvocina*

** Includes *Cryptomonas marssonii*
and *C. ovata*.

LAKE ROTOMANUKA NORTH.

Taxon	ISI
CHLOROPHYTA	
Euchlorophyceae	
<i>Ankistrodesmus bernardii</i>	0.5
<i>A. bibraianus</i>	4.8
<i>Kirchneriella obesa</i>	
var. <i>aperta</i>	0.5
<i>Monoraphidium contortum</i>	73.4
<i>M. griffithii</i>	4.7
<i>M. irregulare</i>	49.9
<i>M. minutum</i>	5.7
<i>M. tortile</i>	23.8
<i>Oocystis lacustris</i>	3.3
<i>O. solitaria</i>	5.7
<i>Raphidocelis contorta</i>	1.9
<i>Botryococcus braunii</i>	490.0
<i>Coelastrum microporum</i>	10.5
<i>C. reticulatum</i>	11.4
<i>Scenedesmus ecornis</i>	3.8
<i>S. obtusus</i>	4.3
<i>Tetrastrum triangulare</i>	33.3
<i>Pediastrum tetras</i>	3.3
Zygophyceae	
<i>Mougeotia</i> sp. B	3.3
<i>Closterium acutum</i>	
var. <i>variabile</i>	280.0
<i>Staurastrum</i> sp. A	1.9
CHROMOPHYTA	
Chrysophyceae	
<i>Chrysococcus rufescens</i>	34.3
<i>Dinobryon bavaricum</i>	15.2
<i>D. cylindricum</i>	2290.3
<i>Chrysophaerella longispina</i>	28.5
<i>Synura uvella</i>	54.7
Diatomophyceae	
<i>Cyclotella stelligera</i>	450.0
<i>Fragilaria delicatissima</i>	57.1
<i>Tabellaria flocculosa</i>	15.7
<i>Eunotia pectinalis</i>	5.7
<i>Achnanthes linearis</i>	9.5

CYANOPHYTA

Cyanophyceae

<i>Chroococcus limneticus</i>	0.9
<i>Merismopedia elegans</i>	1.9
<i>M. glauca</i>	1.9
<i>M. tenuissima</i>	0.9
<i>Microcystis aeruginosa</i>	30.5
<i>Anabaena minutissima?</i>	1.0

EUGLENOPHYTA

Euglenophyceae

<i>Lepocinclis marssonii</i>	15.2
<i>L. ovum</i>	2.4
<i>Menoidium gracile</i>	2.4
<i>Phacus agilis</i>	11.4
<i>P. raciborski</i>	1.9
<i>P. suecicus</i>	2.9
<i>Trachelomonas armata</i> var.	
<i>longispina</i>	6.7
<i>T. longispina</i>	1.4
<i>T. volvocina</i>	470.0

PYRRHOPHYTA

Cryptophyceae

<i>Cryptomonas</i> spp. *	1171.0
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Dinophyceae

<i>Peridinium cinctum</i>	700.0
<i>P. inconspicuum</i>	34.5
<i>P. pusillum</i> tab.	
<i>conjunctum</i>	4.4
<i>Ceratium hirundinella</i>	57.1

RAPHIDOPHYTA

Raphidophyceae

<i>Vacuolaria</i> sp.	178.0
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* Includes *Cryptomonas marssonii* and *C. ovata*

LAKE ROTOMANUKA SOUTH

Taxon	ISI
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CHLOROPHYTA

Euchlorophyceae

<i>Chlamydomonas</i> sp. A	2.7
<i>Ankistrodesmus bibraianus</i>	4.0
<i>Monoraphidium komarkovae</i>	4.0
<i>M. tortile</i>	16.0
<i>Oocystis lacustris</i>	8.0
<i>Actinastrum hantzschii</i>	9.3
<i>Coelastrum reticulatum</i>	26.7
<i>Scenedesmus quadricauda</i>	18.0
<i>Tetrastrum triangulare</i>	4.0
<i>Elakatothrix gelatinosa</i>	4.0

Zygophyceae

<i>Closterium acutum</i>	
var. <i>variabile</i>	4720.5
<i>C. gracile</i>	16.0
<i>Cosmarium contractum</i>	1.3
<i>Staurostrum</i> sp. A	46.7
<i>Staurodesmus glaber</i>	
var. <i>limnophilus</i>	16.0

CHROMOPHYTA

Chrysophyceae

<i>Chrysococcus rufescens</i>	37.3
<i>Dinobryon cylindricum</i>	20.0
<i>Mallomonas acaroides</i>	5.3
<i>M. akrokomos</i>	3.3
<i>Synura uvella</i>	42.7

Diatomophyceae

<i>Aulacosira granulata</i>	13.3
<i>Cyclotella stelligera</i>	51.3
<i>Acanthoceras zachariasii</i>	40.0
<i>Tabellaria flocculosa</i>	29.3
<i>Nitzschia acicularis</i>	5.3

CYANOPHYTA

Cyanophyceae

<i>Aphanocapsa delicatissima</i>	0.7
<i>Chroococcus dispersus</i>	
var. <i>minor</i>	4.0
<i>Merismopedia minima</i>	8.0
<i>Microcystis aeruginosa</i>	1150.0
<i>Anabaena tenericaulis</i>	336.0
<i>Phormidium mucicola</i>	1.3

EUGLENOPHYTA

Euglenophyceae

<i>Trachelomonas</i> spp. *	303.4
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PYRRHOPHYTA

Cryptophyceae

<i>Cryptomonas erosa</i>	4.0
<i>C. ovata</i>	146.6

Dinophyceae

<i>Peridinium pusillum</i> <i>tab. conjunctum</i>	2.7
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* Includes *Trachelomonas planctonicum* and *T. volvocina*.

LAKE ROTOROA

Taxon	ISI
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CHLOROPHYTA

Euchlorophyceae

<i>Monoraphidium contortum</i>	0.4
<i>Oocystis lacustris</i>	61.8
<i>Botryococcus braunii</i>	11.8
<i>Dictyosphaerium ehrenbergii</i>	18.2
<i>Coelastrum microporum</i>	22.7
<i>Scenedesmus quadricauda</i>	3.6
<i>Tetrastrum triangulare</i>	4700.2
<i>Elakatothrix gelatinosa</i>	5.0

Zygophyceae

<i>Closterium acutum</i> var. <i>variabile</i>	360.0
<i>Staurastrum</i> sp. A	57.3

CHROMOPHYTA

Chrysophyceae

<i>Chrysococcus rufescens</i>	3.6
<i>Dinobryon bavaricum</i>	74.9
<i>D. cylindricum</i>	1700.0
<i>D. elegantissimum</i> f. <i>gallica</i>	1.8
<i>Synura uvella</i>	7.2

Xanthophyceae

<i>Centritractus</i> spp. *	3.6
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Diatomophyceae

<i>Aulacosira distans</i>	5.0
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<i>Cyclotella stelligera</i>	650.0
<i>Fragilaria ulna</i> var. <i>acus</i>	0.9
<i>Tabellaria flocculosa</i>	6.4
<i>Achnanthes linearis</i>	2.7
<i>Nitzschia acicularis</i>	9.1
CYANOPHYTA	
Cyanophyceae	
<i>Chroococcus dispersus</i>	1.8
<i>C. limneticus</i>	25.4
EUGLENOPHYTA	
Euglenophyceae	
<i>Trachelomonas</i> spp. *	143.1
PYRRHOPHYTA	
Cryptophyceae	
<i>Cryptomonas</i> spp. *	276.7
Dinophyceae	
<i>Peridinium</i> spp. *	162.2
<i>Ceratium hirundinella</i>	11.8
* Includes <i>Trachelomonas planctonica</i> , <i>T. playfairi</i> and <i>T. volvocina</i> .	
** Includes <i>Cryptomonas marssonii</i> and <i>C. ovata</i> .	
*** Includes <i>Peridinium cinctum</i> and <i>P. sp. A</i> .	

APPENDIX XLIST OF PHYTOPLANKTON FOUND IN LAKE GAULT, 17 MAY 1984

CHLOROPHYTA

Euchlorophyceae

Chlamydomonas sp.
Dictyosphaerium sp.
Oocystis lacustris
Scenedesmus quadricauda

Zygophyceae

Closterium acutum var. *variabile*
C. gracile
Gymnozyga moniliferum
Mougeotia sp.
Pleurotaenium trabecula
Staurodesmus dejectus

CHROMOPHYTA

Chrysophyceae

Dinobryon sp.
Synura sp.

Diatomophyceae

Achnanthes linearis
Anomoeneis serians var. *brachysira*
Amphora sp.
Aulacosira distans
Cyclotella stelligera
Eunotia lunaris
E. pectinalis
Fragilaria ulna
Frustulia rhomboides
F. r. var. *saxonica*
Rhopalodia gibba
Surirella linearis var. *constricta*
Tabellaria flocculosa

Xanthophyceae

Tribonema sp.

CYANOPHYTA

Cyanophyceae

Anabaena sp.
Chroococcus dispersus

C. turgidus
Lyngbya sp.
Merismopedia tenuissima
Oscillatoria limnetica

EUGLENOPHYTA

Euglenophyceae

Euglena acus
Trachelomonas volvocina

PYRRHOPHYTA

Dinophyceae

Peridinium inconspicuum
P. sp.

APPENDIX XI

PLANKTONIC CYANOBACTERIA IN NEW ZEALAND INLAND WATERS:

DISTRIBUTION AND POPULATION DYNAMICS

Pridmore & Etheredge (in press)

Planktonic cyanobacteria in New Zealand inland waters: distribution and population dynamics

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Abstract One hundred and four taxa of planktonic cyanobacteria (blue-green algae) have been recorded from New Zealand lakes: 32 belong to the Chroococcales, 72 to the Nostocales. None of the taxa is endemic to New Zealand; most (if not all) are cosmopolitan. On average, more taxa have been reported from North Island (7.8 ± 6.7 , $N = 69$) than South Island lakes (3.3 ± 3.9 , $N = 59$). This difference is attributable, in part, to the large proportion of glacial lakes in the South Island, which are commonly poor in plant nutrients and possess sparse phytoplankton populations. Many of the taxa show a strong preference for eutrophic conditions. Notable exceptions are *Anabaena affinis* and *Gomphosphaeria lacustris*, which occur in a large proportion of mesotrophic (48%) and oligotrophic lakes (43%), respectively. Taxa which are often abundant and frequently responsible for conspicuous water-blooms are *Microcystis aeruginosa*, *Anabaena circinalis*, *A. flos-aquae* and *A. spiroides*. The limited population data available indicate a high level of interannual variability in the timing, magnitude, and duration of cyanobacterial blooms in New Zealand lakes.

Keywords blue-green algae; cyanobacteria; lakes; distribution; phytoplankton; population dynamics; water-blooms; New Zealand

INTRODUCTION

Planktonic cyanobacteria (blue-green algae) are found in many New Zealand lakes, but too few lakes have been studied to know their exact distribution. Usually their presence is noted only when populations become large enough for lake users to complain of discoloured water, thick scums, or pungent odours. However, cyanobacteria are often present when none of these displeasing effects are exhibited.

The earliest reports of planktonic cyanobacteria in New Zealand were by Swedish and German phycologists. Nordstedt (1888) published an illustrated account of phytoplankton specimens collected by Berggren in 1874/75. Included in this account were descriptions of four species of planktonic cyanobacteria found in Lakes Lyndon, Pearson, Tarawera, and Taupo. Eleven years later, Lemmermann (1899) noted the presence of seven planktonic cyanobacterial taxa in Lake Wakatipu.

Unfortunately, after this brief input from overseas workers, little was published on New Zealand planktonic cyanobacteria for more than 60 years — only two papers in the 1930s, one in the 1950s, and nine in the 1960s. Flint (1966, 1969, 1970, 1975, 1977, 1979), Cassie (1969, 1974, 1975, 1978, 1979), and Thomasson (1960, 1974, 1980) went some way towards rectifying this deficiency, but sufficient information was still not available in the early 1980s to allow New Zealanders to move successfully out of the “inventory” phase of planktonic cyanobacterial research.

In 1983 we undertook a two-year survey of planktonic cyanobacteria in 78 New Zealand lakes. The aim of the survey was to view as many specimens as possible so that a taxonomic guide could be written. During this survey, 77 taxa (70 species, 7 varieties) of planktonic cyanobacteria were observed. Of these, one genus and 14 species had not been recorded previously in New Zealand (Etheredge & Pridmore 1984).

In this text, we combine our survey data with other published work to identify patterns of cyanobacterial distribution and seasonal abundance in New Zealand lakes. We also comment on the planktonic species which produce nuisance growths in New Zealand and on the times of year when these growths appear. Experimental studies on planktonic cyanobacteria in New Zealand inland waters are reviewed by Viner (1987).

REPORTED TAXA

To date, 104 taxa of planktonic cyanobacteria have been reported from New Zealand lakes (Appendix 1). Thirty-two of these belong to the order Chroococcales, which includes unicellular and non-coenobial colonial forms. The remaining 72 are filamentous and belong to the order Nostocales.

Genera which are represented by five or more taxa are *Chroococcus* (6), *Merismopedia* (6), *Microcystis* (6), *Lyngbya* (10), *Anabaena* (15), and *Oscillatoria* (28). The latter three genera contain 51% of the reported taxa. In all, 26 genera have been recorded.

Four of the reported species are considered doubtful taxa. *Nodularia implexa* (Bornet & Flahault) Bourrelly, described originally as *Aulosira implexa* by Bornet & Flahault (1888), has been excluded from *Nodularia* Mertens by Nordin & Stein (1980). Drouet (1973) has placed this taxon in *Scytonema hofmannii* Agardh. *Dactylococcopsis acicularis* Lemmermann and *D. irregularis* G. M. Smith are considered by Komárek (1969) not to be cyanobacteria, and are listed by Komárková-Legnerová (1969) as synonyms of the chlorophycean algae *Monoraphidium griffithii* (Berkeley) Komárková-Legnerová and *M. irregulare* (G. M. Smith) Komárková-Legnerová, respectively. *Microcystis flos-aquae* (Wittrock) Kirchner is thought by some to be a growth or age form of *Microcystis aeruginosa* Kuetzing (Huber-Pestalozzi 1938; Prescott 1962; Reynolds et al. 1981).

None of the reported taxa are endemic to New Zealand; most (if not all) are cosmopolitan.

OCCURRENCE

Planktonic cyanobacteria have been recorded from 127 New Zealand lakes. These lakes have been formed in a variety of ways (e.g., glaciation, volcanic activity, wind-blown sand, river activity) and cover a diverse range of physical and chemical conditions (Table 1).

Species which are represented commonly include *Microcystis aeruginosa*, *Anabaena flos-aquae*, *A. circinalis*, *Gomphosphaeria lacustris*, and *Oscillatoria limnetica* (Table 2). The first three frequently dominate New Zealand phytoplankton communities (e.g., Burns & Mitchell 1974; Flint 1975; White et al. 1978; Vincent et al. 1984; Dryden & Vincent 1986); the latter two usually do not. For example, during a one-year study of nine Waikato lakes (sampled fortnightly), neither *G. lacustris* nor *O. limnetica* was found to exceed 32 plankton units per ml (Etheredge 1987). Flint (1975) recorded *G. lacustris* from 25 New Zealand lakes; in only four

of these was it considered "dominant". Other common, but rarely abundant, taxa include *Chroococcus limneticus*, *Lyngbya limnetica*, *Oscillatoria subbrevis*, and *O. tenuis* (e.g., Thomasson 1960, 1974; Cassie 1974, 1975; Flint 1979; Etheredge 1987) (Table 2).

Species which are found frequently in Northern Hemisphere temperate lakes (e.g., see Prescott 1962; Hutchinson 1967; Whitford & Schumacher 1973; Palmer 1977; Carr & Whitton 1982), but have not been reported here, include *Aphanocapsa pulchra* (Kuetzing) Rabenhorst, *Coelosphaerium naegelianum* Unger, *Gomphosphaeria aponina* Kuetzing, *Anabaena planctonica* Brunenthaler, *Oscillatoria prolifica* (Greville) Gomont, and *O. redekei* van Goor. *Aphanizomenon flos-aquae*, *Gloetrichia echinulata*, *G. natans*, *Oscillatoria agardhii*, *O. bornetii*, and *O. rubescens* have been observed in New Zealand (Table 3), but are not as common or abundant as in Northern Hemisphere temperate lakes (e.g., see Prescott 1962; Rheinheimer 1980; Fay 1983; Skulberg & Skulberg 1985).

DISTRIBUTION

Geographical patterns

Although the evidence is limited, a few differences appear to exist between the cyanobacterial communities of North and South Island lakes. More cyanobacterial taxa have been reported on average from North Island (mean \pm s.d. 7.8 ± 6.7 , $N = 69$) than South Island lakes (3.3 ± 3.9 , $N = 58$) (t-test, $P < 0.001$). This difference is attributable, in part, to the large proportion of glacial lakes in the South Island. These lakes are commonly poor in plant nutrients and possess sparse phytoplankton

Table 1 Some characteristics of New Zealand lakes which contain planktonic cyanobacteria. Data from Green (1975), Jolly & Irwin (1975), Lineham (1983), White (1983), and Livingston et al. (1986a, 1986b).

Characteristic	Range of recorded values
Altitude	0–841 m a.s.l.
Maximum depth	0.5–444 m
Surface temperature	3.3–27.5 °C
Annual average secchi disc depth	0.1–15 m
Salinity (whole lake average)	<1–8500 g m ⁻³
Annual median pH	4.6–7.5
Annual average concentration of:	
Chl. <i>a</i>	0.5–94 mg m ⁻³
total N	55–3340 mg m ⁻³
total P	5–732 mg m ⁻³

populations (Flint 1975). Apart from *Gomphosphaeria lacustris*, cyanobacteria appear to be rare or absent. In the North Island, however, there are no glacial lakes (Irwin 1975); most of the lakes are formed by river activity, wind-blown sand or volcanic activity, and are located in lowland catchments of intensive agricultural use. These lakes are commonly rich in nutrients, phytoplankton, and cyanobacterial species. When South Island glacial lakes are excluded from the comparison, North and South Island lakes contain a similar number of reported cyanobacterial taxa (t-test, $P > 0.05$).

Species which are common in the North Island, but have not been observed in the South Island, are *Anabaena circinalis*, *Chroococcus turgidus*, and *Nodularia harveyana*. No planktonic cyanobacterial taxa appear to be restricted to the South Island.

Nutrient-related patterns

In New Zealand, most planktonic cyanobacterial taxa occur in eutrophic, mesotrophic, as well as oligotrophic waters (Table 2). Only a few (*Merismopedia minima*, *M. tenuissima*, *Microcystis pulvere*).

Table 2 Percentage of eutrophic, mesotrophic, and oligotrophic lakes studied in New Zealand in which a given cyanobacterial taxon has been found. Only taxa recorded from six or more lakes are listed. *, species found in at least 20 lakes. Data from Etheredge & Pridmore (in press).

Taxon	Percentage occurrence		
	Eutrophic (N=56)	Mesotrophic (N=25)	Oligotrophic (N=42)
<i>Anabaena affinis</i> *	4	48	21
<i>A. aphanizomenoides</i>	11	4	19
<i>A. circinalis</i> *	43	40	12
<i>A. flos-aquae</i> *	50	40	17
<i>A. solitaria</i>	4	8	5
<i>A. spiroides</i> *	21	20	5
<i>A. spiroides</i>			
var. <i>tumida</i>	9	4	5
<i>A. tenericaulis</i>	16	4	2
<i>Aphanizomenon flos-aquae</i>	5	12	17
<i>Aphanocapsa elachista</i>	11	24	12
<i>A. elachista</i>			
var. <i>conferta</i>	20	8	7
<i>Chroococcus dispersus</i>	14	12	10
<i>C. dispersus</i>			
var. <i>minor</i>	14	4	2
<i>C. limneticus</i> *	29	20	7
<i>C. minutus</i>	7	8	5
<i>C. turgidus</i>	9	0	7
<i>Coelosphaerium kuetzingianum</i>	14	8	5
<i>Dactylococcopsis smithii</i>	5	8	2
<i>Gomphosphaeria lacustris</i> *	20	24	43
<i>Lyngbya limnetica</i> *	27	16	12
<i>Merismopedia glauca</i>	9	8	10
<i>M. minima</i>	21	8	0
<i>M. tenuissima</i>	25	0	0
<i>Microcystis aeruginosa</i> *	55	32	19
<i>M. pulvere</i>	12	4	0
<i>Nodularia harveyana</i>	7	8	2
<i>N. spumigena</i>	7	12	5
<i>Oscillatoria limnetica</i> *	43	28	14
<i>O. limosa</i>	16	12	7
<i>O. planctonica</i>	9	8	0
<i>O. splendida</i>	12	4	7
<i>O. subbrevis</i> *	29	12	7
<i>O. tenuis</i> *	20	28	10
<i>Spirulina laxa</i>	14	8	0

Oscillatoria planctonica, *Spirulina laxa*) appear to be restricted to nutrient-rich waters, and none is found exclusively in oligotrophic lakes.

Many of the commonly reported species (e.g., *Microcystis aeruginosa*, *Oscillatoria limnetica*, *O. subbrevis*) show a strong preference for eutrophic conditions (as indicated by the high values of percentage occurrence in Table 2). Notable exceptions are *Anabaena affinis* and *Gomphosphaeria lacustris*, which occur in a large proportion of mesotrophic (48%) and oligotrophic lakes (43%), respectively. Interestingly, Hutchinson (1967) has noted *G. lacustris* in some large deep lakes of Central Europe which are otherwise not characterised by planktonic cyanobacteria.

The effects of specific in-lake nutrient concentrations (e.g., nitrogen, phosphorus) on New Zealand planktonic species are not well understood. Work is limited to a few lakes, and only occasionally have biomass and nutrient data been accompanied by physiological tests (e.g., Viner 1984b).

Burns & Mitchell (1974) found statistically significant negative correlations between heterocyst frequency (% of total number of vegetative cells) and the levels of nitrate and total inorganic nitrogen in Lake Hayes during a one-year study of *Anabaena flos-aquae*. The number of heterocysts per ml. however, was not significantly related to inorganic nitrogen concentration. Viner (1984b) found that ambient inorganic nitrogen had little influence on the N₂-fixation rates of *Anabaena oscillarioides*

in Lake Rotongaio; once heterocysts had developed, N₂-fixation rates were primarily dependent upon available light, although heterocyst numbers were also important.

A comparison of species lists from eight nitrogen-deficient lakes in the Rotorua district with those of seven nitrogen-sufficient lakes in the Waikato, suggests that nitrogen deficiency may have an effect on the proportion of cyanobacterial taxa which fix atmospheric nitrogen (Table 4). However, too few other New Zealand lakes have been studied sufficiently to carry this comparison further.

Humic-stained waters

Lakes in the Westland beech-podocarp forests between Greymouth and Hokitika appear to have few cyanobacteria. These lakes have amber-coloured waters, low phytoplankton productivity, high allochthonous inputs, and a neutral to slightly alkaline pH (Paerl et al. 1979). The near-neutral pH suggests that the lakes are not dystrophic (Wetzel 1975: 648-650), but Paerl et al. (1979) note that the pH measurements may be incorrect because the analyses were not conducted in the field. The only cyanobacteria recorded from these lakes are *Anabaena* sp. and *Anacystis* (*Microcystis*) sp. in Lake Brunner (Flint 1975), which is the largest and least-stained lake of the group. Paerl et al. (1979) found no cyanobacteria during their survey of eight of the lakes in March 1979.

Table 3 Some planktonic cyanobacterial species which have been observed in New Zealand, but are not as common or abundant as in Northern Hemisphere temperate lakes. *, lake where the given taxon was found to be abundant.

Taxon	Where observed	Reference
<i>Aphanizomenon flos-aquae</i>	L. Heron, Pounui	Etheredge & Pridmore (in press)
	L. Horowhenua	Cassie (1974)
	L. Kanono	Cassie & Freeman (1980)
	L. Manapouri, Middleton	Thomasson (1980)
	L. Matheson, Tarawera	Flint (1966)
	L. Okareka, Okataina.	
	Rotoiti, Taupo, Tikitapu	Thomasson (1974)
<i>Gloeotrichia echinulata</i>	L. Rotoehu*	Cassie (1978)
	L. Pounui	Etheredge & Pridmore (in press)
<i>G. natans</i>	L. Okareka	Kloos (1976)
	L. Okareka, Rotoma	Thomasson (1974)
<i>Oscillatoria agardhii</i>	L. Mangahia, Rotokauri	Etheredge & Pridmore (in press)
<i>O. bornetii</i>	L. Manapouri	Thomasson (1980)
	L. Mapourika	Flint (1979)
<i>O. rubescens</i>	L. Forsyth, Kimihia;	Etheredge & Pridmore
	Cooper's Lagoon	(in press)
	L. Okataina.	Thomasson (1974)
	L. Rotoiti	Cassie (1974)

Table 4 Percentage of planktonic cyanobacterial taxa which are capable of fixing atmospheric nitrogen in eight nitrogen-deficient Rotorua district lakes and seven nitrogen-sufficient Waikato lakes. Data from Etheredge & Pridmore (in press).

	Cyanobacterial taxa	
	Total number	% N ₂ fixers
Rotorua district lakes		
Okareka	17	41
Okaro	6	50
Rotoehu	9	44
Rotoiti	23	35
Rotomahana	9	33
Rotorua	27	27
Tarawera	11	63
Tikitapu	10	40
Mean (\pm s.e.)	14 \pm 3	42 \pm 4
Waikato district lakes		
Kainui	16	12
Mangakaware	14	14
Ngaroto	26	19
Rotomanuka North	22	9
Rotoroa	14	0
Whangape	13	15
Te Koutu	9	11
Mean (\pm s.e.)	16 \pm 2	11 \pm 2

Thirty-two taxa of planktonic cyanobacteria have been recorded, however, from four Waikato humic-stained lakes of near neutral pH (Etheredge 1987). Planktonic species of this group are also present in Lakes Gault, Mangahia, Maratoto, and Matheson (Table 5), all of which fit the classic definition of dystrophy. Interestingly, Etheredge (1987) has noted

an increase in the number of planktonic cyanobacterial taxa in Lake Maratoto from 3 to 10 since its pH has become less acidic (4.5–5.5 in 1979 to 5.1–6.4 in 1983/84).

POPULATION DYNAMICS

The population dynamics of the most abundant New Zealand cyanobacteria are not well known. This is a result of the use of semi-quantitative counting techniques and/or inappropriate sampling intervals in many of the earlier New Zealand studies. Recently, however, several long-term sets of quantitative data have become available (e.g., Forsyth et al. 1983; Vincent et al. 1984; Dryden & Vincent 1986; Etheredge 1987) and thus it is now possible to make some initial generalisations.

Whilst the traditional seasonal periodicity of the cyanobacteria is apparent in many temperate lakes, the pattern is by no means universal (Gibson & Smith 1982). In New Zealand, there is evidence to suggest that whilst a number of taxa exhibit some degree of seasonal wax and wane, in some instances they also contribute a major proportion of the phytoplankton standing crop throughout an entire year. For example, in Lake Rotomanuka South and Lake Ngaroto (two shallow, eutrophic Waikato lakes), the results of a regular sampling programme (July 1983–July 1984) show that *Microcystis aeruginosa* was present on 100 and 96% of sampling occasions, respectively (Etheredge 1987). Furthermore, with one exception, this species contributed significantly throughout the entire period to the total phytoplankton biomass (Fig. 1, 2). Although no biomass data are available, *M. aeruginosa* was also present

Table 5 Planktonic cyanobacteria recorded from four New Zealand dystrophic lakes. Observations are those of the authors unless otherwise stated. †Flint (1975); ‡Flint (1979).

Lake	Taxa observed
Gault (169° 59' E, 43° 26' S)	<i>Anabaena</i> sp [†] ; <i>Anacystis</i> sp [†] ; <i>Chroococcus dispersus</i> , <i>Merismopedia tenuissima</i> , <i>Oscillatoria limnetica</i>
Mangahia (175° 14' E, 37° 53' S)	<i>Anabaena circinalis</i> , <i>A. spiroides</i> var. <i>tumida</i> , <i>Aphanocapsa elachista</i> , <i>Chroococcus dispersus</i> var. <i>minor</i> , <i>Cylindrospermum minutissimum</i> , <i>Gomphosphaeria lacustris</i> , <i>Lyngbya limnetica</i> , <i>Oscillatoria agardhii</i> , <i>O. limnetica</i> , <i>O. limosa</i> , <i>O. splendida</i> , <i>O. subbrevis</i> .
Maratoto (175° 18' E, 37° 53' S)	<i>Anabaena</i> sp., <i>Aphanocapsa elachista</i> var. <i>conferta</i> , <i>Aphanothece</i> sp., <i>Chroococcus dispersus</i> var. <i>minor</i> , <i>C. limneticus</i> , <i>C. minor</i> , <i>Lyngbya limnetica</i> , <i>Microcystis aeruginosa</i> , <i>Oscillatoria limnetica</i> , <i>O. splendida</i> .
Matheson (169° 58' E, 43° 26' S)	<i>Aphanizomenon flos-aquae</i> †, <i>Oscillatoria tenuis</i> var. <i>tergestina</i> †.

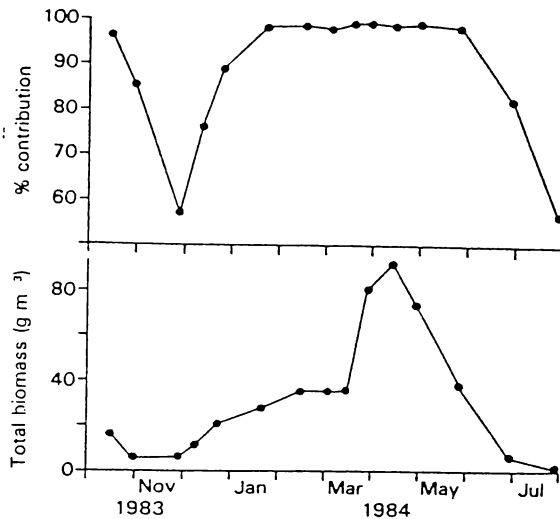


Fig. 1 Fluctuations in total biomass of phytoplankton in Lake Rotomanuka South, October 1983 to July 1984, and in percentage contribution of *Microcystis aeruginosa* to total biomass. From Etheredge (1987).

on 100% of sampling occasions throughout a one-year sampling programme (two-weekly sampling interval) in Lake Hakanoa (Pridmore, unpubl. data). Also, in eutrophic Lake Pupuke, Cassie (1979) reported the presence of this species on 80% of visits (monthly sampling interval).

In several Waikato lakes, the seasonal dynamics of *M. aeruginosa* are characterised by autumnal maxima; this contrasts with the summer peaks recorded in temperate lakes elsewhere (Reynolds et al. 1981). For example, in Lake Ngaroto, the maximum biomass (70.6 g m^{-3}) for the period July 1983–July 1984 occurred in mid March, but high levels (54.9 g m^{-3}) were still recorded in late May. Similarly, in Lake Rotomanuka South, the peak biomass (91.9 g m^{-3}) for the period October 1983–July 1986, occurred in late April with relatively high levels (36.9 g m^{-3}) still recorded in late May (Etheredge 1987). In Lake Okaro, this species achieved maximum abundance from mid-summer stratification (December) to winter mixing (June) (Dryden & Vincent 1986).

Several *Anabaena* species also may be found throughout most of the year, including the winter months, in many New Zealand lakes. This differs from their typical association with stable, stratified summer conditions (Reynolds 1984). *Anabaena flos-aquae*, although usually reaching its maximum abundance during summer (Burns & Mitchell 1974; Forsyth & McColl 1975; Vincent et al. 1984), does occur in appreciable numbers at other times. Burns

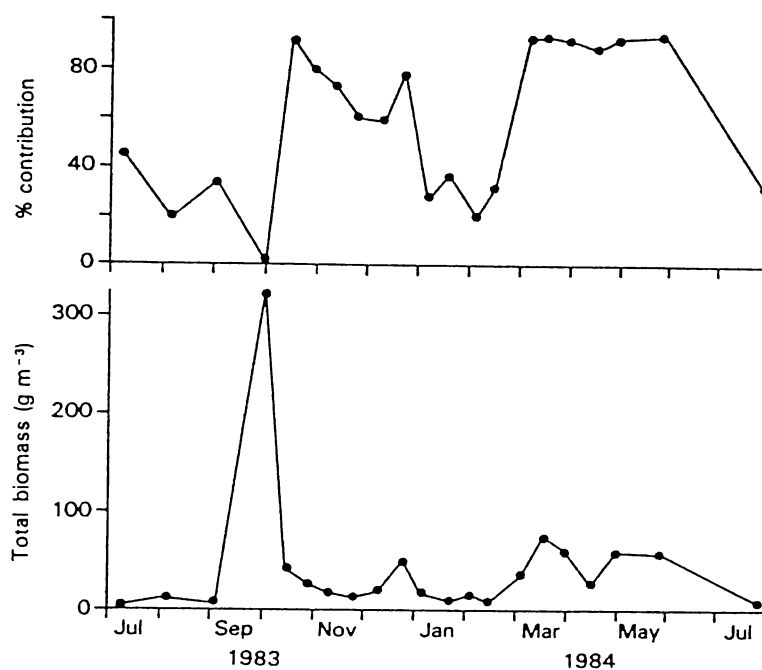
& Mitchell (1974) reported that this species showed a slight but progressive increase in abundance throughout autumn in Lake Hayes; in June, when the lake was isothermal (8.2°C), the concentration was c. $560 \text{ cells ml}^{-1}$ in the upper 10 m. Furthermore, the results of a one-year sampling programme (October 1983–September 1984) in Lake Tarawera indicated that the maximum biomass (334.8 mg m^{-3} ; mean value of upper 30 m) and bloom of *A. flos-aquae* occurred in winter (August); this coincided with the highest mean number of cells per filament (130; $N=15$) for the year (Etheredge, unpubl. data). Also, a secondary abundance peak of this species has been reported in Lake Okaro, during early-winter mixing (May–June) (Dryden & Vincent 1986).

Anabaena oscillarioides also is known to be present continuously in Lake Rotongaio, North Island. This species was numerically dominant from October 1974 to September 1975; throughout the coldest months (April–September 1975) it comprised at least 90% of the total phytoplankton community (Forsyth et al. 1983). However, in a further study (September 1978–January 1981) *A. oscillarioides*, although present throughout the entire sampling period, was the numerical dominant only during the warmer, stratified periods (Viner & Kemp 1983).

In comparison, *Anabaena spiroides* appears less suited to fluctuating physico-chemical regimes; in general it is scarce or absent throughout winter and spring, and reaches its peak abundance during the summer and autumn months (Cassie 1969, 1978; McColl 1972; Forsyth & McColl 1975; Flint 1977).

Sommer et al. (1986), in their model of planktonic succession, stressed the existence of seasonal sequences, which, although prone to disturbance by irregular physical events, are both predictable and directional. However, in New Zealand it is becoming increasingly evident that unpredictability, which is undoubtedly related to our oceanic climate, is the overriding characteristic of planktonic cyanobacterial community dynamics. Also, analyses of data from long-term studies indicate that there is a marked absence of repeatability. For example, during a one-year study (July 1983–July 1984) of Lake Kainui (a small darkly-stained Waikato lake), *Microcystis aeruginosa* was found in only 10% of samples and its contribution to the mean total density of phytoplankton was minimal ($3.8 \text{ colonies ml}^{-1}$); *Anabaena spiroides* var. *tumida* was not recorded during this period (Etheredge, unpubl. data). However, during January 1985 a mixed bloom of these two species occurred; their maximum biomass values were 2017 and 143 mg m^{-3} , respectively (Etheredge 1987). In Lake Mangakaware, another humic-stained lake, *Anabaena circinalis* was present during the period July 1983–

Fig. 2 Fluctuations in total biomass of phytoplankton in Lake Ngaroto, July 1983 to July 1984, and in percentage contribution of *Microcystis aeruginosa* to total biomass. From Etheredge (1987).



July 1984 in only 10% of samples (maximum biomass 16.0 mg m^{-3}), but during the period February 1985–April 1986 the maximum biomass recorded for this species was 563 mg m^{-3} and occurred during a bloom in March 1986 (Etheredge 1987). This lack of repeatability has also been noted in Lake Johnson, where *Anabaena flos-aquae* bloomed in two successive summers (January 1970, c. $26\,000 \text{ cells ml}^{-1}$ and December 1970, c. $96\,000 \text{ cells ml}^{-1}$ respectively), but was either very rare or absent during the 1971 summer (Burns & Mitchell 1974).

WATER BLOOMS AND SCUMS

To date, conspicuous blooms and scums of planktonic cyanobacteria have been reported from 33 New Zealand lakes (Table 6). Twenty-nine of the lakes are eutrophic, three are mesotrophic: Alexandrina, Rotoaira, Rotoiti (North Island); one is oligotrophic (Tarawera) (Livingston et al. 1986a, 1986b). Most of the lakes are shallow; only Lakes Alexandrina, Hayes, Johnson, Ngapouri, Okaro, Pupuke, Rotoiti (North Island), Rotongaio, Tarawera, and Tutira have mean depths greater than 10 m.

At least eight taxa are responsible for the conspicuous growths. These are *Anabaena circinalis*,

A. flos-aquae, *A. oscillarioides*, *A. spiroides*, *A. tenericaulis*, *Aphanizomenon flos-aquae*, *Nodularia spumigena*, and *Microcystis aeruginosa*. All are filamentous and capable of fixing atmospheric nitrogen (N_2), except for *M. aeruginosa*. All can form gas vesicles. A species tentatively identified as *Anacystis incerta* Drouet & Daily has bloomed in Tomahawk Lagoon (Mitchell 1971). The identity of this species under the Geitlerian system of taxonomy is unknown.

Of the eight taxa, only *Anabaena flos-aquae* and *A. spiroides* appear to form scums or blooms in both the North and South Islands. Conspicuous growths of *Nodularia spumigena* are restricted to two South Island coastal lakes with brackish waters (Lakes Ellesmere, Forsyth). Reports involving the remaining five species are limited to North Island lakes.

Most of the reported scums and blooms are caused by *Anabaena flos-aquae* (15 lakes), *Microcystis aeruginosa* (11 lakes), and *Anabaena spiroides* (8 lakes). These species typically produce water blooms during summer and autumn (e.g., Mitchell 1971; Burns & Mitchell 1974; Flint 1977; Cassie 1978, 1979; Vincent et al. 1984; Dryden & Vincent 1986), although conspicuous growths of *Anabaena flos-aquae* have been recorded from Lakes Hayes, Okaro, and Tarawera in winter (Burns & Mitchell 1974; Dryden & Vincent 1986).

Table 6 New Zealand lakes in which planktonic cyanobacteria have produced water-blooms or scums.

Lake	Species responsible for bloom or scum	Reference
Alexandrina	<i>Anabaena flos-aquae</i>	Stout (1981)
Butcher's Dam	<i>Anabaena flos-aquae</i>	Burns & Mitchell (1974)
Ellesmere	<i>Nodularia spumigena</i>	Dodgshun (1981)
Forsyth	<i>Nodularia spumigena</i>	Flint (1975)
Hakanoa	<i>Anabaena spiroides</i>	Pridmore (unpubl. data)
	<i>Microcystis aeruginosa</i>	Flint (1975); Pridmore (unpubl. data)
Hayes	<i>Anabaena flos-aquae</i>	Burns & Mitchell (1974); Burns (1975)
Horowhenua	<i>Anabaena</i> sp.	Flint (1975)
	<i>Microcystis aeruginosa</i>	Flint (1975); Pridmore (unpubl. data)
Horseshoe	<i>Anabaena flos-aquae</i>	Parsons (1985)
Johnson	<i>Anabaena flos-aquae</i>	Burns & Mitchell (1974); Burns (1975)
Kainui	<i>Microcystis aeruginosa</i>	Etheredge (1987)
Mangakaware	<i>Anabaena circinalis</i>	Etheredge (1987)
Ngahewa	<i>Anabaena flos-aquae</i>	Kellar & Goldman (1979); Pridmore (unpubl. data)
	<i>Anabaena spiroides</i>	Kellar & Goldman (1979); Paerl (1979); Dryden & Vincent (1986)
	<i>Anabaena circinalis</i>	Paerl (1979)
	<i>Anabaena</i> sp.	Fish (1968)
Ngapouri	<i>Anabaena flos-aquae</i>	Dryden & Vincent (1986)
	<i>Microcystis</i> sp.	Fish (1968)
Ngaroto	<i>Anabaena circinalis</i>	Etheredge (1987)
	<i>Microcystis aeruginosa</i>	Pridmore (unpubl. data); Etheredge (1987)
Okaro	<i>Anabaena flos-aquae</i>	Dryden & Vincent (1986)
	<i>Anabaena spiroides</i>	Flint (1975, 1977); McCull (1972); Paerl (1979)
	<i>Anabaena</i> sp.	Fish (1968)
	<i>Microcystis aeruginosa</i>	Dryden & Vincent (1986)
Omapere	<i>Anabaena flos-aquae</i>	Pridmore (unpubl. data)
Orakai	<i>Anabaena tenericaulis</i>	Flint (1975)
Pupuke	<i>Microcystis aeruginosa</i>	Cassie (1979)
Rotoaira	<i>Anabaena flos-aquae</i>	Pridmore (unpubl. data)
Rotoehu	<i>Aphanizomenon flos-aquae</i>	Cassie (1978)
Rotoiti (North Island)	<i>Anabaena flos-aquae</i>	Dryden & Vincent (1986)
	<i>Anabaena spiroides</i>	Cassie (1978)
	<i>Anabaena spiroides</i>	Flint (1975, 1977)
Rotoiti (by Kaikoura)	<i>Anabaena spiroides</i>	Etheredge (1987)
Rotomanuka South	<i>Anabaena tenericaulis</i>	Etheredge (1987)
	<i>Microcystis aeruginosa</i>	Etheredge (1987)
Rotongaio	<i>Anabaena oscillarioides</i>	Paerl (1979); Vincent (1980); Forsyth et al. (1983); Viner & Kemp (1983)
	<i>Anabaena circinalis</i>	Paerl (1979)
	<i>Anabaena</i> sp.	Jolly & Chapman (1977)
Rotorua (North Island)	<i>Anabaena circinalis</i>	White et al. (1978)
	<i>Anabaena spiroides</i>	Cassie (1978)
	<i>Microcystis aeruginosa</i>	Pridmore (unpubl. data)
	<i>Anabaena spiroides</i>	Flint (1975, 1977)
Rotorua (by Kaikoura)	<i>Anabaena spiroides</i>	Flint (1975)
Roundabout	<i>Anabaena flos-aquae</i>	Dryden & Vincent (1986); Etheredge (unpubl. data)
Tarawera	<i>Anabaena flos-aquae</i>	Etheredge (1987)
Te Koutu	<i>Anabaena tenericaulis</i>	Etheredge (1987)
	<i>Microcystis aeruginosa</i>	Etheredge (1987)
Tomahawk Lagoon	<i>Anabaena flos-aquae</i>	Mitchell (1971)
	<i>Anacystis incerta?</i>	Mitchell (1971)
Tutira	<i>Anabaena</i> sp.	McCull (1978)
	<i>Microcystis aeruginosa</i>	McCull (1978)
Waahi	<i>Anabaena spiroides</i>	Chapman (1980)
Waitawa	<i>Microcystis aeruginosa</i>	Flint (1975)

Warm temperatures and calm surface conditions are known to encourage the growth of planktonic cyanobacteria possessing gas vesicles (Reynolds & Walsby 1975; Fay 1983; Viner 1984a). These organisms can move in stratified waters to an optimal depth for photosynthesis and growth by altering their buoyancy and thus outcompete other algae. The occurrence of high winter densities therefore is unusual. However, N_2 -fixing cyanobacteria such as *Anabaena flos-aquae* are also favoured by low ratios of dissolved inorganic nitrogen (DIN) to phosphorus (DRP), since they can supplement their nitrogen requirements with molecular nitrogen (Schindler 1977; Flett et al. 1980; Smith 1982). Ratios of DIN:DRP in Lakes Okaro and Tara-wera are often low ($<10 \mu\text{g } \mu\text{g}^{-1}$) during winter mixing (McCull 1972; White et al. 1985). This does not explain, however, the winter bloom of *A. flos-aquae* in Lake Hayes in August 1973; the concentration of DIN during the bloom was 208 mg m^{-3} , and few heterocysts were present (Burns & Mitchell 1974).

Water-blooms of *Gloeotrichia* and *Oscillatoria* have not been recorded in New Zealand. Only one bloom of *Aphanizomenon flos-aquae* has been observed, in Lake Rotoehu (Cassie 1978).

CONCLUDING REMARKS

Planktonic cyanobacterial research in New Zealand is still very much in the "inventory" phase. Many lakes have either not been sampled or sampled insufficiently to produce comprehensive species lists. Quantitative information (physical, chemical, biological) at regular sampling intervals (preferably less than two weeks) is needed. Only with such data can we better understand the factors influencing cyanobacterial growth, and thus move towards their effective management. We hope that future studies of planktonic cyanobacteria in New Zealand will adopt this approach and dispense with simple qualitative and semi-quantitative techniques.

ADDENDUM

Work conducted during the Cyanobacterial Forum by R. D. Pridmore and C. S. Reynolds (Freshwater Biological Association, United Kingdom) has indicated that the *Anabaena* species currently in Lake Rotongaio is not *A. oscillarioides* Bory de Saint-Vincent. The identity of this species and of the strains earlier reported in Lake Rotongaio as *A. oscillarioides* is currently under investigation.

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Appendix 1 Classification of planktonic cyanobacteria (blue-green algae) reported from New Zealand lakes. Taxonomic arrangement is based on Desikachary (1959). *, doubtful taxon (see text).

Order CHROOCOCCALES

Family Chroococcaceae

Aphanocapsa delicatissima W. & G.S. West
A. elachista W. & G.S. West
A. elachista var. *conferta* W. & G.S. West
Aphanothece nidulans Richter
A. stagnina (Sprengel) Braun
Chroococcus dispersus (Keissler) Lemmermann
C. dispersus var. *minor* G.M. Smith
C. limneticus Lemmermann
C. minor (Kuetzing) Naegeli
C. minutus (Kuetzing) Naegeli
C. turgidus (Kuetzing) Naegeli
Coelosphaerium kuetzingianum Naegeli
Dactylococcopsis acicularis Lemmermann*
D. irregularis G.M. Smith*
D. smithii R. & F. Chodat
Gloeocapsa stegophila (Itzigsohn) Rabenhorst
Gloeothece linearis var. *composita* G.M. Smith
Gomphosphaeria lacustris Chodat
G. lacustris var. *compacta* Lemmermann
Merismopedia elegans Braun
M. elegans var. *major* G.M. Smith
M. glauca (Ehrenberg) Naegeli
M. minima Beck
M. punctata Meyen
M. tenuissima Lemmermann
Microcystis aeruginosa Kuetzing
M. elabens (de Brébisson) Kuetzing
M. elabens var. *minor* Nygaard
M. flos-aquae (Wittrock) Kirchner*
M. minutissima W. West
M. pulverea (Wood) Forti
Rhabdoderma lineare Schmidle & Lauterborn

Order NOSTOCALES

Family Oscillatoriaceae

Arthrospira platensis (Nordstedt) Gomont
A. tenuis Bruehl & Biswas
Lyngbya bipunctata Lemmermann
L. birgei G.M. Smith
L. cryptovaginata Schkorbatow
L. epiphytica Hieronymus
L. hieronymusii Lemmermann
L. lacustris Lemmermann
L. limnetica Lemmermann
L. limnetica f. *minor* Geitler
L. martensiana Meneghini
L. putealis Montagne
Oscillatoria agardhii Gomont
O. angustissima W. & G.S. West
O. annae van Goor
O. articulata Gardner
O. bornetii Zukal
O. chlorina Kuetzing
O. cortiana Meneghini
O. curviceps C.A. Agardh

O. formosa Bory de Saint-Vincent
O. geminata Meneghini
O. gutulata van Goor
O. iwanoffiana (Nygaard) Geitler
O. jasorvensis Vouk
O. lacustris (Klebahn) Geitler
O. limnetica Lemmermann
O. limosa C.A. Agardh
O. mougeotii Kuetzing
O. okeni var. *gracilis* (Kuetzing) Forti
O. ornata Kuetzing
O. planctonica Woloszynska
O. princeps Vaucher
O. rubescens de Candolle
O. sancta Kuetzing
O. splendida Greville
O. subbrevis Schmidle
O. subtilissima Kuetzing
O. tenuis C.A. Agardh
O. tenuis var. *tergestina* (Kuetzing) Rabenhorst
Phormidium mucicola Naumann & Huber-Pestalozzi
P. rotheanum var. *capitatum* Desikachary
Spirulina laxa G.M. Smith
S. major Kuetzing

Family Nostocaceae

Anabaena aequalis Borge
A. affinis Lemmermann
A. aphanizomenoides Forti
A. circinalis Rabenhorst
A. flos-aquae (Lyngbye) de Brébisson
A. macrospora Kleblahn
A. miniata Skuja
A. oscillarioides Bory de Saint-Vincent
A. solitaria Klebahn
A. sphaerica var. *tenuis* G.S. West
A. spiroides Klebahn
A. spiroides var. *crassa* Lemmermann
A. spiroides var. *tumida* Nygaard
A. tenericaulis Nygaard
A. verrucosa Boye-Peterson
Anabaenopsis arnoldii Aptekarj
Aphanizomenon flos-aquae (Linnaeus) Ralfs
Cylindrospermum minutissimum Collins
Nodularia harveyana (Thwaites) Thuret
N. implexa (Bornet & Flahault) Bourrelly*
N. spumigena Mertens
Nostoc commune Vaucher
Raphidiopsis mediterranea Skuja

Family Rivulariaceae

Dichothrix gypsophila (Kuetzing) Bornet & Flahault
Gloeotrichia echinulata (J.E. Smith) Richter
G. natans (Hedwig) Rabenhorst

Family Scytonemataceae

Tolypothrix penicillata (Agardh) Thuret
T. tenuis Kuetzing

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