10 Identification guide to common periphyton in New Zealand streams and rivers

10.1 Introduction

This identification guide covers many of the simple photosynthetic organisms (algae) that occur in the periphyton of streams and rivers in New Zealand. It is intended to provide rapid and practical assistance for non-specialist biologists and stream ecologists wishing to identify the most common taxa in samples of periphyton. For completeness we also include some less common taxa because they can be abundant regionally.

The guide is organised into broad groups based on easily distinguishable features. These groups do not necessarily correspond to those used in taxonomic classification.

10.2 Nomenclature and classification

The term "algae" has traditionally been used to encompass all simple organisms that are capable of photosynthesis and that are not included in the bryophytes (mosses and liverworts) or vascular plants. Therefore algae do not form a single evolutionary group. For example, the prokaryotic "blue-green algae" (see page 124) are only distantly related to the rest of the algae, which are eukaryotic organisms (see page 122) and it is now usual to refer to the blue-green algae as cyanobacteria. Nevertheless, the term "algae" remains a useful ecological grouping of chlorophyll *a*-containing organisms that occur in mixed communities in aquatic habitats.

The classification of algae is based on a wide range of characteristics, the more obvious of which are listed in Table 9. Using various combinations of these features it is possible to distinguish the main groups, as shown in the key (Table 10). The groups normally encountered in stream and river periphyton are shown highlighted in colours, with their common names in **BOLD CAPITALS**. Sections 10.2.1 to 10.2.6 give more information about each of the groups.

Each description in this manual is based on a genus and includes basic taxonomic information (e.g., Division, Order, Genus). The colours highlighting each group in Table 10 are repeated throughout the guide as a quick indication of the algal group to which each genus belongs. Note that, at the level of Order, you will find a slightly different classification scheme in almost every phycology guide. For the eukaryotic algae we follow the orders used by Prescott (1978) and Round *at al.* (1990) (for the diatoms). For cyanobacteria, the groups used are those proposed by Anagnostidis and Komàrek (1985) (see Section 10.2.1). For an up-to-date account of algal classification see Graham and Wilcox 2000.

Table 9: Characteristics of algae used in classification and identification

Cellular organisation:	The simple photosynthetic organisms found in periphyton are either: • "prokaryotes", in which the cell inclusions are not bound by membranes and pigments are distributed throughout the cell, giving a diffuse appearance (these are the "blue-greens" (Cyanobacteria)); or • "eukaryotes", in which cell inclusions such as nucleus, mitochondria and chloroplasts are distinguishable and are enclosed by membranes.
Cell pigments	All possess the photosynthetic pigment chlorophyll *a*, but chlorophylls *b* and *c*, and phycobilins also occur in certain groups.
Flagella	Flagella (singular: flagellum) are long, thin flexible appendages that allow many algal cells to move around. Some algae have no flagella; sometimes they occur only at the reproductive stages; in some cases they are always present and there may be one, two or four. Where there are two or more flagella they may be the same or different lengths. Flagellated species are mainly planktonic and are rarely encountered in stream periphyton.
Colour	Cell colour ranges from red to brown through yellow and green to blue-green and even blue. The major taxonomic groups are named on the basis of colour but, because many taxa contain a mixture of pigments, colour is not always a reliable guide to the groups. Colour may vary with environmental conditions and may also vary according to the type and duration of preservation.
Food reserves	Some of these organisms have food reserves of starch and therefore a positive reaction to the iodine starch test. Others store food as leucosin or oil and do not react to the starch test.
Cell wall type	Cyanobacteria often possess a muco-polysaccharide sheath; green algae have cellulose cell walls laid down in a criss-cross pattern; diatoms have rigid walls made of silica.
Reproduction	Some algae and cyanobacteria reproduce by cell division, each new cell being independent of all others. Most algae also produce specialised reproductive bodies, or spores, and in some groups the form of these is the main character that distinguishes species. Sexual reproduction is also common.
Gross structure	This is the group of characteristics that is of most practical use in *identifying* algae. For example, is the alga single-celled, filamentous, colonial or sheet-like? Does the alga have different types of cells – e.g., heterocysts? Many of the same structural characteristics occur in different groups, and thus do not reflect natural relationships.
Ecology	Aquatic algae including cyanobacteria are capable of inhabiting almost all damp to wet habitats in existence, from sea water through to hot springs. However, many types occur only within a certain range of conditions.

Table 10: Key to the major groups of common freshwater periphyton

1a	Cells without chloroplasts (though granules in the cells could be mistaken for chloroplasts), diffuse blue-green, olive or red-brown. Cells often very small.	
	Division: **Cyanobacteria (BLUE-GREENS) [see page 124]**	
1b	Cells with chloroplasts (discrete structure in which the cell pigment is concentrated).	**2**
2a	Chloroplasts pale to deep grass green.	**3**
2b	Chloroplasts some other colour.	**4**
3a	Single-celled, filamentous or colonial form, normally with one or two chloroplasts arranged as sheets inside the cell wall or along the length of the cell. Sometimes with many chloroplasts. Where flagella are present there are two or four and their lengths are equal. Positive reaction to starch test.	
	Division: **Chlorophyta**; Class: Chlorophyceae **(GREEN ALGAE) [see page 124]**	
3b	Large, erect plants, typically 4-50 cm long, with regular branches. Rooted by rhizoids in soft sediment. Cells large with numerous chloroplasts.	
	Division: **Chlorophyta**; Class: Charophyceae	
3c	Single-celled, colonial or filamentous, normally with two or more small, discoid chloroplasts per cell. Where flagella are present there are two, of unequal length. Negative reaction to starch test.	
	Division: **Xanthophyta (YELLOW-GREEN ALGAE) [see page 125]**	
3d	Single cells with one long, thick flagellum emerging from a depression at the end of the cell. Two-to-many discoid chloroplasts. Cell wall can be elastic and striated.	
	Division: **Euglenophyta**	
4a	Cells with a rigid, ornamented silica wall composed of two halves, sometimes forming filaments. Often motile, but no flagella. One to many brownish chloroplasts.	
	Division: **Bacillariophyta (DIATOMS) [see page 126]**	
4b	Cells not as above.	**5**
5a	Cells with two flagella, partly within two furrows on the cell surface, one around the cell, the other at right angles. Cell walls of smooth or angular plates, flat or with projecting horns. Positive reaction to starch test.	
	Division: **Dinophyta (= Pyrrophyta {dinoflagellates})**	
5b	Cells without two deep furrows	**6**
6a	Chloroplasts pale yellow to brown, usually 1 or 2 per cell. Cells single, colonial or (rarely) filamentous. If flagella are present they are either one long one, or one long and one short.	
	Division: **Chrysophyta (GOLDEN-BROWN ALGAE) [see page 128]**	
6b	Chloroplasts some other colour, no cysts, flagella (if present) not strongly unequal.	**7**
7a	Single-celled, bean-shaped with two slightly unequal flagella arising from a small depression of furrow. One or two chloroplasts, coloured olive, red or blue.	
	Division: **Cryptophyta**	
7b	Plants filamentous and frequently with complex structure, or flattened and encrusting, or (rarely) single-celled. One or more chloroplasts per cell, coloured olive, red or blue. Usually attached to rocks and mosses in streams. No flagella.	
	Division: **Rhodophyta (RED ALGAE) [see page 128]**	

Throughout the idenification guide, the above colours are used to indicate the major algal group to which each genus belongs.

10.2.1 Cyanobacteria

Cyanobacteria are easily distinguished from other algae by the absence of chloroplasts – the discrete organelles that contain the photosynthetic pigments in eukaryotes. Instead, these pigments are diffused throughout the cell protoplasm. Additional pigments found in this group are responsible for the range of colours they exhibit, most notably the blue-green appearance. The orders of cyanobacteria represented in this guide are listed below. These groups are those used by Anagnostidis and Komàrek (1985), with details in Anagnostidis and Komàrek (1988a, b) and Komàrek and Anagnostidis (1986, 1989). This classification system follows the traditional botanical approach, being based on "Geitler's" system (see Geitler 1925, 1932, 1942) but now incorporating morphological, cytological and ecophysiological characters. Note that several other classification schemes have been proposed based on the bacteriological approach (Stanier 1977 and Rippka *et al.* 1979) or on "Drouet's" system (Drouet and Daily 1956 and Drouet 1981), where the number of taxa was reduced considerably.

Chroococcales: Unicells, colonies, pseudoparenchymatous colonies or pseudofilamentous colonies. Trichomes, heterocysts and akinetes are lacking. Cell division in one, two or more perpendicular planes. Examples include *Gloeothece* and *Chamaesiphon*.

Oscillatoriales: Cells forming trichomes (a single row of cells connected by cross walls); false branching, gas vesicles and sheaths lacking or facultatively present. Heterocysts, akinetes and true branching absent. Reproduction occurs by "hormogonia" formation through trichome fragmentation. Examples are *Phormidium*, *Oscillatoria* and *Lyngbya*.

Nostocales: Cells forming trichomes with a wide or narrow mucilaginous sheath. Trichomes unbranched or falsely branched (initiated at a heterocyst or between two vegetative cells). Specialised nitrogen-fixing cells (heterocysts) and spore cells (akinetes) may be present. Reproduction mainly by hormogonia or hormocysts. Examples are *Nostoc*, *Tolypothrix*, *Calothrix* and *Rivularia*.

Stigonematales: Cells forming true trichomes, sometimes combined with pseudotrichomes. True branching always present while false branching may occur. Akinetes rarely present while heterocysts occur facultatively in several genera. Reproduction mainly by hormogonia and hormocysts. Best known example is *Stigonema*.

10.2.2 The green algae (Division: Chlorophyta)

The orders listed below belong to the class Chlorophyceae and are represented in the periphyton of New Zealand streams and rivers. These are traditional orders (largely as used in Prescott 1973). See Graham and Wilcox (2000) for recent classification schemes.

Tetrasporales: These occur in a non-motile vegetative form, usually in colonies held together by mucilage (e.g., *Gloeocystis*, *Palmella*). The cells can reproduce by simple cell division. The chloroplasts are usually described as cup-like – that is, they are curved so that they line part of the inside of the cell.

Chlorococcales: These can look similar to the Tetrasporales (e.g., *Oocystis*). The main difference is that the cells do not reproduce by simple cell division in the vegetative state, though they do divide to form spores. Single-

celled or colonial. Examples found in periphyton are *Pediastrum*, *Ankistrodesmus*, *Scenedesmus*.

Ulotrichales: Unbranched simple filaments with mostly cylindrical cells containing a single band-like chloroplast similar to that in the Chlorococcales. Most species are attached when young, but become free-floating later. The best known filamentous alga in this order is *Ulothrix*. Others include *Geminella.*

Ulvales Many cells in a sheet-like arrangement, e.g., *Enteromorpha,* in which the sheets form hollow filaments.

Microsporales: Unbranched filaments of cylindrical cells with walls in sections with a cell wall at the centre – so that broken-up filaments comprise H-shaped pieces. The chloroplast covers the whole wall of the cell and may be thin or dense. The only genus in this order is *Microspora.*

Cylindrocapsales: Another order with only one genus – *Cylindrocapsa*. Usually filamentous with dense, large chloroplasts.

Chaetophorales: Branched filaments that arise from a holdfast. Cells forming branches often smaller than those nearer the base. Chloroplasts are parietal, sometimes completely covering the cell wall. Examples are *Chaetophora, Draparnaldia* and *Stigeoclonium*.

Cladophorales: (also known as Siphoncladales) Repeatedly branched filaments, cylindrical cells, thick walls. Chloroplast parietal and net-like in young, healthy specimens, but sometimes appearing as many small disks. Often the cell walls are very thick and the filaments frequently carry many diatom epiphytes, e.g., *Cladophora, Rhizoclonium*.

Oedogoniales: There are both unbranched and branched forms in this order, which is characterised by occasional ring-like scars at the front end of cells, caused by cell division. Genera described in this guide are *Oedogonium* (unbranched) and *Bulbochaete* (branched).

Zygnematales: Unbranched filaments of long or short cylindrical cells with a cellulose cell wall; end walls are separated by a middle lamella. The chloroplasts are large, with 1–2 per cell usually. Species in this order have no motile reproductive cells. Instead, cells transform into amoeboid gametes, two of which fuse to form the zygospore (via "conjugation" of cells). Genera represented in this guide are *Mougeotia, Spirogyra* and *Zygnema.*

Desmidiales: The desmids are single-celled forms (occasionally in filaments) related to the Zygnematales through having a similar mode of reproduction. Most desmids are divided into two equal halves. The chloroplasts are variable and can be complex. Examples found in periphyton are *Cosmarium*, *Closterium* and *Staurastrum*.

10.2.3 The yellow-green algae (Division: Xanthophyta)

The yellow-green algae can be difficult to distinguish from the green algae. The main features that separate the two divisions are a predominance of yellowish pigments (e.g., carotenoids) in the yellow-greens, and leucosin or oils as food reserves, rather than starch. Just two orders are included in this manual.

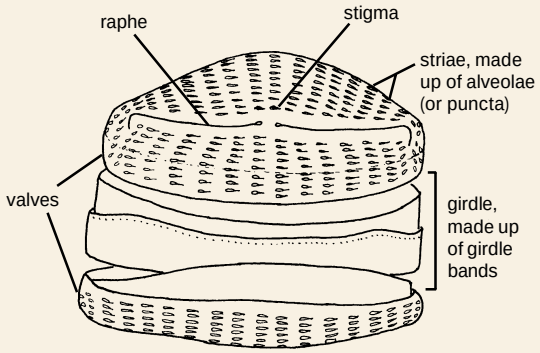
Tribonematales	Branched or unbranched filaments, e.g., *Tribonema.*
Vaucheriales	Branched, cylindrical filaments, no cross walls, e.g., *Vaucheria.*

10.2.4 The diatoms (Division: Bacillariophyta)

The structure of diatoms means that it is relatively easy to identify many of them to species or even variety. In this guide, we include descriptions of many *common* species – particularly those that are useful indicators of environmental conditions. This should enable you to distinguish them from other species that are similar in appearance, but that you won't necessarily be able to identify beyond genus level. Some identifications should be possible using fresh or frozen material.

For detailed studies on diatoms it is necessary to examine acid-cleaned specimens at magnifications of up to x1000, using an oil-immersion objective on a light microscope in order to see the ornamentation of the cell walls. In addition, you need an understanding of their structure and a comprehensive collection of specialised diatom taxonomy texts because, as yet, there is no complete guide to diatoms in New Zealand.

Structure of a generalised diatom frustule



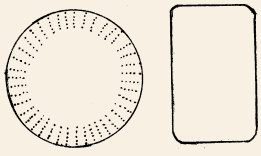
(drawing: Liz Bergey)

Briefly, the diatom cell wall is made of silica and the basic construction is of two halves (valves) that fit together with one half overlapping the other so that the whole structure resembles a chocolate box. The two valves together are called the frustule. Classification is based on the arrangement of various surface features and etchings on the frustule. A major feature is the raphe, a pair of slits in the valve face. When present, the raphe may be on both valves or on one valve only. The two valves may be connected by a girdle or a series of girdle bands. The valve faces may carry rows (called striae) of openings or depressions (known as puncta or areolae). Larger holes are called "stigmata" (singular: stigma). Most descriptions of diatoms are based on the view from the top ("valve view"). The view from the side ("girdle view") can look quite different.

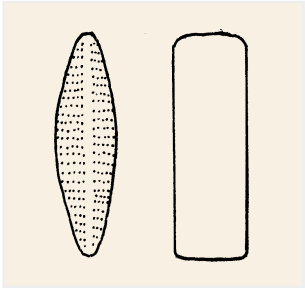
The structure of the chloroplasts and other cell inclusions may also be considered in descriptions. For more details about the fine structure of diatoms refer to Barber and Haworth (1981), Round, Crawford and Mann (1990) and Cox (1996).

As for the algae in general, various classification systems have been proposed for diatoms (see Bourelly 1981, Krammer and Lange-Bertalot 1987–1997, Round *et al.* 1990) and we follow the system of orders of Round *et al.* 1990. For descriptive purposes, these orders can be placed in seven groups (as used by E. Stoermer, pers. comm.) that are convenient though not necessarily natural (i.e., made up of related organisms). The illustrations below show representative valve and girdle views in each group.

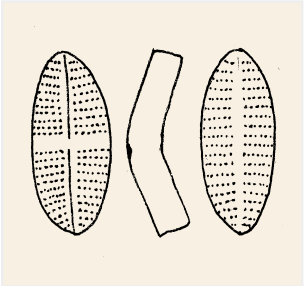
Centrics: Radially symmetric valves. No raphe system.
Thalassiosirales: *Cyclotella;*
Melosirales: *Melosira;* Aulacosirales: *Aulacoseira.*



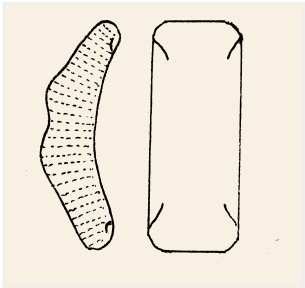
Araphid pennates: Usually symmetrical along the all axes of the valve (exceptions: *Meridion, Asterionella*). No raphe system on either valve, but usually a "pseudoraphe" present (i.e., a break in the striae, as if a raphe were present).
Fragilariales: *Fragilaria, Fragilariaforma, Staurosira, Diatoma, Meridion, Synedra;*
Tabellariales: *Tabellaria.*



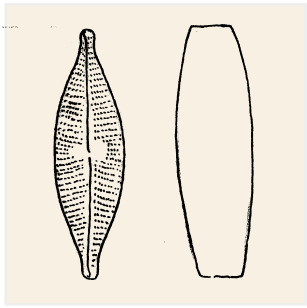
Monoraphid pennates: Usually symmetrical along at least two axes. A raphe system present on one valve only. The second valve may or many not have a pseudoraphe. The ornamentation on the two valves can be quite different. (Illustration shows raphe valve, girdle view and pseudoraphe valve.)
Achnanthales: *Achnanthes, Achnanthidium, Cocconeis.*



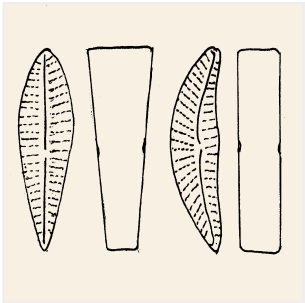
Eunotioids: A rudimentary raphe system on both valves, with the two valves usually similar. There may be asymmetry along all three axes.
Eunotiales: *Eunotia, Eunophora, Actinella.*



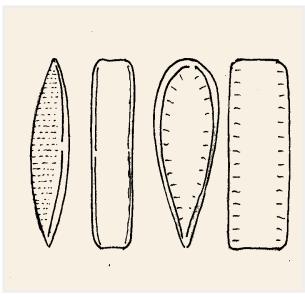
Biraphid pennates: Symmetric naviculoids: These are usually more or less symmetric along both the long and cross-valve axes (exception: some *Pinnularia* species). A fully developed raphe system present on both valves. The two valves are usually identical.
Mastogloiales: *Mastogloia;*
Naviculales: *Brachysira, Frustulia, Navicula, Neidium, Pinnularia, Stauroneis.*



Biraphid pennates: Asymmetric: Lacking symmetry along at least one axis. A raphe system present on both valves. The two valves are usually identical (an exception is *Rhoicosphenia*).
Cymbellales: *Cymbella, Rhoicosphenia, Encyonema, Gomphonema, Gomphoneis, Reimeria;*
Thalassiophysales: *Amphora.*



Biraphid pennates: "External" raphe: The raphe lies partly or wholly along the edge of the valve, sometimes within a raised canal. The structure can be quite complex. Some diatoms in this group are nitrogen-fixing because of a symbiotic relationship with cyanophytes, and can therefore tolerate nitrogen-limited situations. Bacillariales: *Nitzschia;*
Rhopalodales: *Epithemia, Rhopalodia;*
Surirellales: *Surirella, Stenopterobia.*



10.2.5 The golden-brown algae (Division: Chrysophyta)

Mostly motile cells, though the division includes some filamentous and sheet-like forms. This Division is more commonly found in lake habitats than in flowing waters. Chrysophytes are characterised by possessing a very large chloroplast, and by their particular combination of pigments. The one example described is *Dinobryon* (Order: Chrysomonadales).

10.2.6 The red algae (Division: Rhodophyta)

The red algae are distinguished from the other algal divisions by their methods of reproduction and life histories. The "red" comes from the predominance of the red pigment phycoerythrin in many species. Most red algae are marine. The examples in this manual represent the two subclasses of the Rhodophyta. See Bourelly (1985) for a version of classification finer than this. See Entwistle and Kraft (1984) for an account of freshwater red algae in south-east Australia, including notes on the New Zealand flora.

Bangiophycidae	Freshwater forms have a branched, unbranched or plate-like thallus, with thick cell walls. Asexual reproduction is by non-motile spores. Sexual reproduction rare. Represented by *Chroodactylon, Compsopogon*.
Florideophycidae	The more "advanced" group, with a wide range of morphologiesfrom slightly branched filaments to more complex growths. The female sex organs (carpogonia) are characteristic. Representatives are: *Audouinella, Batrachospermum, Bostrychia.*

10.3 How to use this guide

To aid identification, each taxon described in this guide is assigned to a group on the basis of cell type and growth form. These groups do not necessarily correspond to the traditional classification outlined above.

Photosynthetic periphyton may be subdivided into two **cell types**:

- Containing "organelles" (distinguishable structures like chloroplasts and a nucleus), but may not have cell walls. These are the green, yellow-green and red algae, and the diatoms.
- Cell contents diffuse, granular, with no distinguishable organelles (but take care not to interpret granules as chloroplasts). These are the cyanobacteria.

These groups can then each be divided into four broad **growth forms** that are easily distinguished:

- flamentous, unbranched;
- filamentous, branched;
- single-celled;
- colonial or multi-celled (e.g., sheets).

Since diatoms are readily recognised from their silica frustules they are placed in groups on their own.

A further obvious feature of algae is colour. In periphyton this can be:

- green (various shades);
- brown – golden-brown;
- pale bluish green, olive-green or pinkish.

However, even though colour is used to name the major taxonomic groups, the colour of a particular algal genus or species can vary quite a lot depending on, for example, the environmental conditions of the habitat, the health of the cells, preservatives used, and the light source and filters on your microscope. Therefore, you should be cautious in using colour as a diagnostic feature. Just remember that it is often helpful, but sometimes can be misleading.

The groups used in this guide are as follows.

(a) Group C: cells containing chloroplasts (eukaryotic algae)

1. **C: unbranched filaments**. All of these are green algae, except one representative from the yellow-greens. 11 genera
2. **C: branched filaments**. This is a more diverse group, including genera from the green, yellow-green and red algae. 10 genera
3. **C: unbranched filaments, or as single cells (diatoms)**. This group includes diatoms that grow in filaments. They are grouped separately from the unbranched filaments above because all of them are also frequently seen in periphyton as single cells. 7 genera, some with individual species described.
4. **C: single cells (diatoms)**. Because diatoms are relatively easy to recognise from their solid "skeletons", and because many species are found in periphyton, they are all grouped together. 35 genera, with individual species described for most.
5. **C: single cells (non-diatom)**. This much smaller group includes single-celled green algae. 3 genera.
6. **C: colonial**. Included here are cells that are always found growing in colonies of 4 cells or more. 6 genera (5 green, 1 golden-brown).
7. **C: colonial (sheet-like)**. This includes just one distinctive green alga.

(b) Group BG: cells with diffuse cell contents (prokaryotic algae: Cyanobacteria)

8. **BG: unbranched filaments**. Filaments growing in masses or singly. mixed with other algae. 7 genera.
9. **BG: filaments in gelatinous masses**. These are filamentous forms that always grow in cohesive gelatinous clumps. 2 genera.
10. **BG: branched filaments**. Filaments growing in masses or singly, mixed with other algae. 5 genera.
11. **BG: single cells**. One example of a single-celled blue-green alga in periphyton.
12. **BG: colonies**. Two examples of colonial cyanobacteria occasionally found in periphyton.

To use the guide, decide on the category to which your specimen belongs, then look for possible matches in the relevant section. All genera included are listed on page 131.

The coloured bars alongside the descriptions refer to the algal group (e.g., Division) to which the genus belongs (see Table 11 on page 123 for a key to the groups).

As noted above, each description refers initially to a *genus*. In each section the genera are usually in alphabetical order. Most green, yellow-green and red algae require detailed studies – including examination of the reproductive bodies – in order to get past genus level. Many diatoms, on the other hand, can be identified to *species* relatively easily. Common species within many of the genera are described (in words and/or photographs), with the more

frequently encountered species first – though these may not be the most common in all samples. In environmental studies species identification can be important because some diatom species are known to have particular environmental preferences that are not shared by other species in the same genus. Their identification can add considerable value to the interpretation of taxonomic data.

Notes on *macroscopic appearance* and *microscopic details* are included. The former is included only where a taxon has some recognisable feature, rather than being part of a mixed periphyton community. For microscopic examination we assume the use of a good quality light microscope capable of magnifications of at least 400×. An oil-immersion objective allowing magnifications of >1000↔ is also desirable for examining the smaller algal taxa. Ideally you will have an eyepiece micrometer on your microscope so that you can measure the dimensions of your specimens. This should be calibrated using a stage micrometer.

A typical *size range* is given for most taxa.

For a few genera we include notes on the *appearance of algae following freezing*, with illustrations where the changes are particularly noticeable. Many types of algae – particularly diatoms – are not greatly altered by freezing other than some shrinkage of the chloroplasts.

Although examination of frozen material is not ideal, it is often impractical to examine fresh material in routine environmental monitoring programmes. Normally part of the sample needs to be analysed for chlorophyll *a* (a measure of total live biomass). Unless this can be done immediately, the samples must be temporarily preserved. Freezing is the most effective way of doing this. Preservatives such as glutaraldeyde retain the cellular structure of algae, but interfere with the chlorophyll content (see Section 8).

For each taxon there are notes on typical habitat and environmental preferences (if known), as well as observations on abundance and distribution. These comments are based on published notes on algal distributions in New Zealand (Cassie 1984a,b, Biggs and Price 1987), on information in the literature on habitat preferences (Cassie 1989, Cox 1996, Winter and Duthie 2000), and on personal observations.

We also note taxa that might be confused with the one being described. In addition, for some of the diatoms we include notes on recent name changes.

All the photographs in this guide are of periphyton from New Zealand rivers and streams. Magnifications are approximate.

Following the illustrated guide, Sections 10.5 to 10.8 comprise:

- A glossary explaining the technical terms used in the descriptions.
- A table summarising recent new diatom genera that are becoming generally accepted. These genera do not appear in older identification texts, though many of the species can be found under their traditional genus name.
- A list of general references used for identification of algae. (See Section 11 for a full list of literature cited.)
- A list of the diatom species described, with authorities, and reference(s) to one or more source(s) from which the identification may be made.

Definitions

Conductivity: high, >200 µS/cm
medium, 80–200
low < 80

LM = light microscope
SEM = scanning electron microscope
µm = micrometre (1 mm = 1000 µm)
cf. = “compare with” (i.e., looks like)

10.4 Guide to periphyton genera

Contents (names in parentheses indicate a partial description only)

Cylindrocapsa

C: unbranched filaments

Division: Chlorophyta, Order: Cylindrocapsales

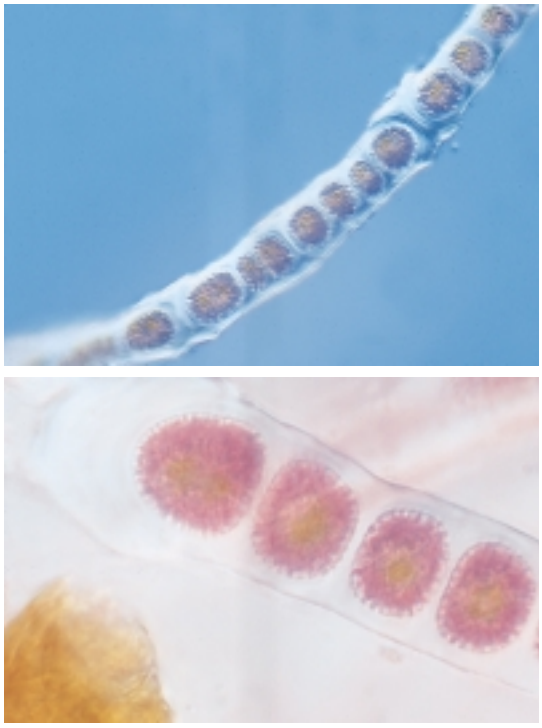
How to recognise the genus:

Macroscopic: Cylindrocapsa grows as dark green-brown masses.

Microscopic: Thick cell wall with a many-layered clear gelatinous sheath between cells. Each cell contains a single large dense chloroplast. In the example illustrated the cells have a distinctive purple colouration, which occurs during reproduction. Normally cells are green. The filaments are about 25 µm across

Habitat and distribution: The genus *Cylindrocapsa* is found mostly in boggy areas but also in slow-flowing shallow streams downstream of wetlands. It has been reported rarely in New Zealand and we have found it only in high altitude, pristine areas. The specimen photographed was collected in the Arthur's Pass region, South Island.

Possible confusion: Distinctive, therefore unlikely to be confused.



Cylindrocapsa *filaments. top, x 200, bottom, x 800.*

Geminella

C: unbranched filaments

Division: Chlorophyta, **Order:** Ulotrichales

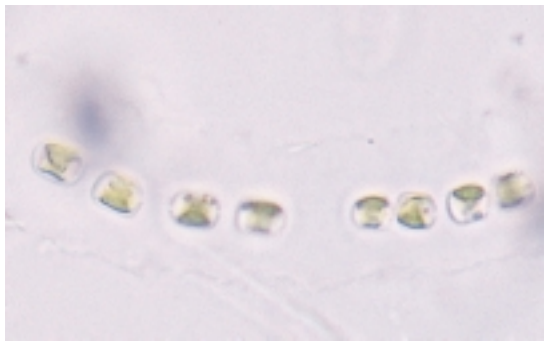
How to recognise the genus:

Macroscopic: Geminella has no distinctive macroscopic features.

Microscopic: Small, separate cells, each with a single folded chloroplast, embedded in a thick mucilaginous sheath to form filaments. Individual cells are about 8 µm across and 10 µm long. The entire sheath is around 30 µm in diameter.

Habitat and distribution: *Geminella* is typically a lake-dwelling genus but has been found in the periphyton of lake-fed rivers, usually close to the lake outlet.

Possible confusion: Distinctive, therefore unlikely to be confused.



Geminella. *Note the sheath, just visible. x 800*

Klebsormidium

C: unbranched filaments

Division: Chlorophyta **Class:** Charophyceae

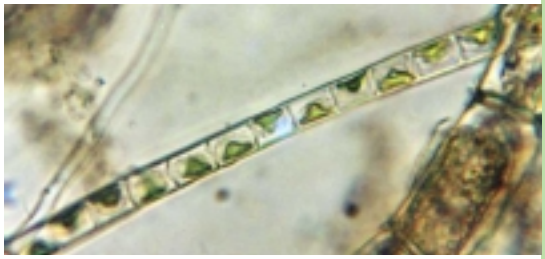
How to recognise the genus:

Microscopic: Narrow filaments (less than 10 µm across). The curved chloroplast covers a relatively small proportion of the cell wall.

Habitat and distribution: Not certain.

Possible confusion: The chloroplasts in *Ulothrix* (page 138) are similarly curved but occupy much more of the cell wall.

Note: *Klebsormidium* was recently placed in the Charophyceae (see Margulis *et al.* 1990)



Klebsormidium. *x 550 (photo: Stephen Moore, Otago Regional Council)*

Microspora

C: unbranched filaments

Division: Chlorophyta **Order:** Microsporales

How to recognise the genus:

Macroscopic: Microspora forms long, deep-green filaments, often trailing in water and entangled around other algae or vascular water plants.

Microscopic: Unbranched filaments of regular, oblong or, usually, squarish cells; the chloroplast is reticulate (net-like) and parietal (arranged against the cell walls). Through the microscope the chloroplast appears as a dense layer around the inside of the cell wall.

The clearest distinguishing feature of this genus is the H-shaped join between cells, although this is not always obvious. Try to find the end of a filament; the cells normally break at the end of the H rather than at the dividing wall. Under high power (1000x) it should be possible to see the where successive sections of cell wall overlap. Filaments range from about 10 to 40 µm across.

Habitat and distribution: *Microspora* is found in a range of conditions, but often in clean, gently flowing streams. The genus is common and widespread. It may proliferate in enriched cold streams.

Possible confusion: *Tribonema* (see page 137). This also has H-joins. However, the two genera are easy to distinguish as *Tribonema* has several discoid chloroplasts rather than a dense net.

from top:

Microspora *growing amongst macrophytes in a spring-fed stream.*

Microspora *filaments (with diatoms). x 150*

Fragment of Microspora *in which the cells are dividing. Note the new H-shapes alternating with the older (outer) pieces. x 350*

Microspora *sp. x 680*

Mougeotia

C: unbranched filaments

Division: Chlorophyta, **Order:** Zygnematales

How to recognise the genus:

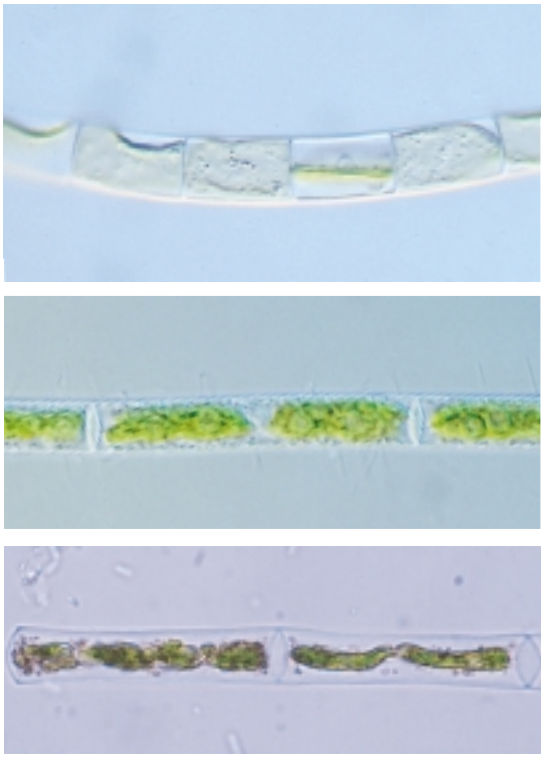
Macroscopic: Mougeotia grows in light green cottony-looking masses that feel slimy and are often mixed with other types of algae.

Microscopic: Unbranched filaments of oblong cells, usually much longer than they are wide. The chloroplast is a ribbon-like and runs along the cell. It may be twisted in places. Pyrenoids often visible at regular intervals along the chloroplast. In many cases, between each cell is a well-defined lens-shaped (or "rice-grain" shaped) area.

Typically filaments are 25–40 µm across, with cells up to 150 µm long.

Habitat and distribution: *Mougeotia* is typically found in moderately enriched to highly enriched slow flowing streams. It has been observed as the dominant taxon during low flows in an enriched lowland river in Canterbury.

Possible confusion: After freezing, *Mougeotia* and *Spirogyra* (see page 136) can be confused, though the lens-shape between cells (if present) reamins clear. The two genera are easily distinguishable when fresh.



from top:

Mougeotia *from the Waiau River. Note the sheet-like chloroplasts, in some cases folded over. x 500*

Mougeotia *filament from the Waipara River, Canterbury. x 650*

Filament following freezing. x 650

Rhizoclonium

C: unbranched filaments

Division: Chlorophyta, **Order:** Cladophorales

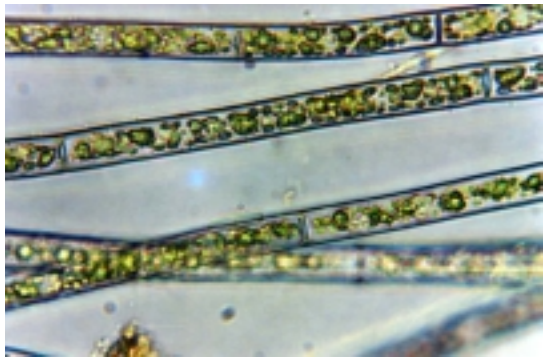
How to recognise the genus:

Macroscopic: Long, coarse, tough filaments, dull-green coloured.

Microscopic: Cells from 10 to over 50 µm wide, usually much longer than wide. Chloroplast is a dense or loose network.

Habitat and distribution: *Rhizoclonium* is found only in high conductivity, warm rivers and streams, Encountered most often in Hawkes Bay (usually very large species). Also found in tidal rivers in Otago (Stephen Moore, pers. comm.)

Possible confusion: Possibly with *Cladophora*, which is branched, though sometimes *Rhizoclonium* puts out rhizoids.



Rhizoclonium *sp. x 450 (photo: Stephen Moore, Otago Regional Council)*

Oedogonium

C: unbranched filaments

Division: Chlorophyta, **Order:** Oedogoniales

How to recognise the genus:

Macroscopic: Oedogonium sp. grows in dull green masses and can form massive blooms under warm, stable, low-flow conditions.

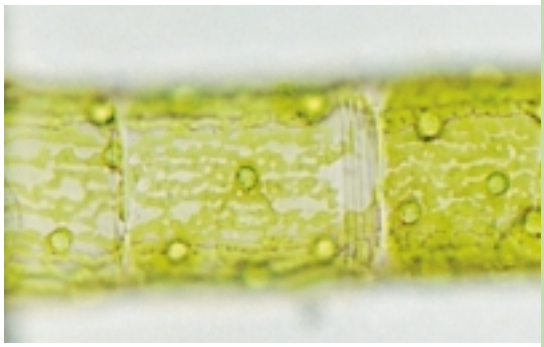
Microscopic: Unbranched filaments attached to the substrate at one end. The cells are fairly regular and square to oblong and sometimes slightly barrel-shaped. The chloroplast is a light green parietal network with a lacy appearance. Pyrenoids are scattered throughout the network.Look for the scarring that occurs as a result of cell division – one or more rings encircling the outer cell wall at the end of some cells. This, with the non-branching form, is diagnostic for the genus.

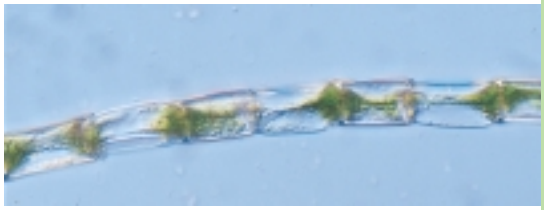
In frozen material, the chloroplast shrinks away from the cell wall but remains attached at the perimeter at each end of the cell. Although it looks quite different from the fresh cells, it is fairly distinctive.

There are many species of *Oedogonium*. To distinguish them it is necessary to consider a combination of size of the vegetative cells, and the size and form of the reproductive bodies. Filaments range from about 10 to 40 µm across.

Habitat and distribution: *Oedogonium* is normally associated with fairly enriched conditions but may also occur in streams with stable, low flows, sometimes with little apparent enrichment. It is extremely common and widespread and occasionally forms blooms.

Possible confusion: Usually there is no difficulty in identifying this genus, although the branched genus *Bulbochaete* (closely related) has similar cells (see page 142).





from top:

Oedogonium *bloom in the Hakataramea River, North Otago, 1996.*

Fresh Oedogonium *filament. Nore the scarring on the left hand cell. Specimen from clean, foothillls stream, Canterbury. x 400*

A different Oedogonium *species, from an enriched lowland river. Note the lacy chloroplasts and cell-scarring. x 600*

Filament following freezing. This is the typical appearance: cell walls collapse and the chloroplast shrinks to the middle of the cell. x 300

Spirogyra

C: unbranched filaments

Division: Chlorophyta, **Order:** Zygnematales

How to recognise the genus:

Macroscopic: Clouds of fine, bright green filaments often with a foamy look (bubbles at the water surface). Very slimy to touch.

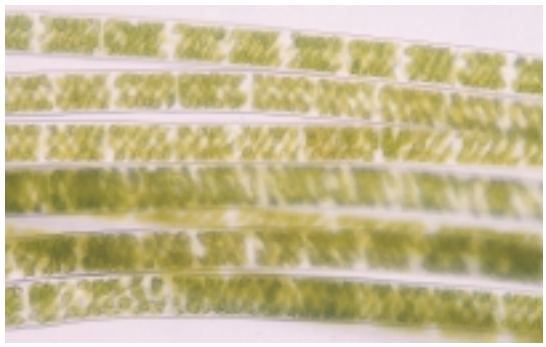
Microscopic: Smooth-sided filaments with cells varying from almost square to very much longer than they are wide. Cells up to 70 µm wide and 100 µm long, or more. Within the cells, one or more long ribbon-like chloroplasts are arranged in a spiral or series of overlapping spirals. Pyrenoids are dotted along the chloroplasts.

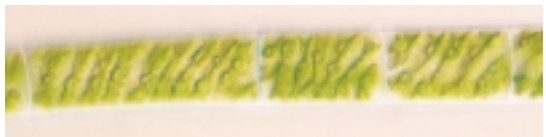
The walls between successive cells are usually more or less flat; sometimes somewhat convex (into the cell). Some species have "replicate" end walls that are evident under the microscope as an H-shape on the dividing wall.

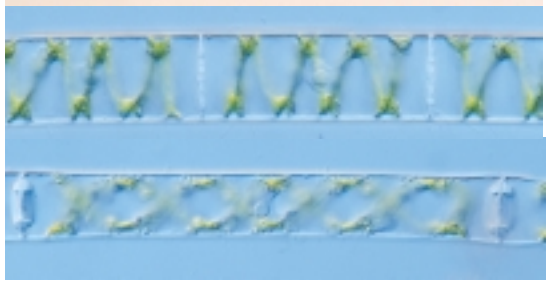
In frozen material the spiral chloroplasts shrink together to form a dense mass at the centre of each cell.

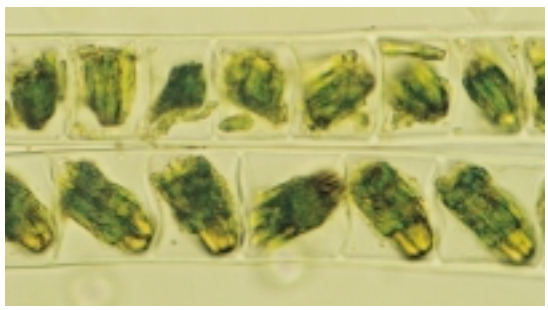
Habitat and distribution: *Spirogyra* is found most often in slow-flowing backwaters in open (unshaded) situations in a range of environments from pristine mountain rivers to lowland streams and often appears in response to point sources of nutrients such as from groundwater inputs. The genus is extremely common and widespread. Species with replicate ends seem to occur mostly in lakes.

Possible confusion: With *Mougeotia* (when frozen) (see page 134). In both cases the chloroplast shrinks to the centre of the cell.









from top:

Spirogyra *growing along the margins of the Ashley River, Canterbury.*

Dense Spirogyra *from Siverstream, Canterbury. x135*

Three species with different spiral patterns. Note the pyrenoids (first specimen). nuclei (second and third specimens) and replicate ends (third specimen) x 270

Spirogyra *filaments following freezing.*

Tribonema

C: unbranched filaments

Division: Xanthophyta, **Order:** Tribonematales

How to recognise the genus:

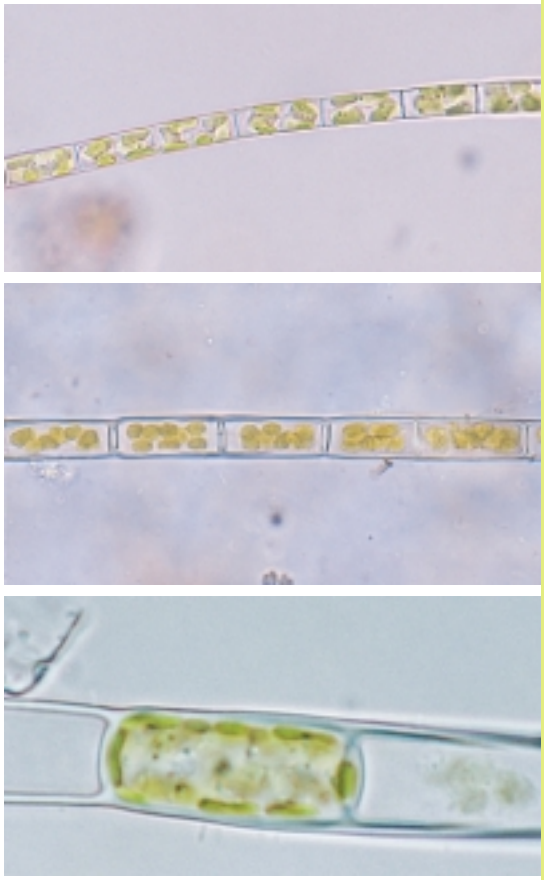
Macroscopic: Light green masses of filaments.

Microscopic: Cells longer than wide, usually slightly inflated at the central part of the cell (barrel-shaped). The cell walls are thin and successive cells are joined at the central area (rather than at the cell dividing walls) where cell walls overlap. Thus when the cells dissociate, they break into H-shaped pieces – halves of adjacent cells. There are several disc-shaped pale green chloroplasts dotted through each cell.

Tribonema filaments are usually quite fine, ranging in size from 3 to 10 µm in diameter and 15 to 50 µm long.

Habitat and distribution: This genus occurs in open situations in a range of conditions, from clean headwater streams (mixed with filamentous diatoms, during low-flow conditions), to lowland high-conductivity streams.

Possible confusion: *Microspora* also has H-shaped cell walls. However, in *Microspora* the chloroplasts are much denser and are single sheets rather than several separate bodies (see page 133).



from top:

A fine filament of Tribonema*, showing the disc-like chloroplasts. Cell joins not obvious. x 500.*

Tribonema *filament clearly showing H-joins between calls, and also the yellow-green colour of the disk-like chloroplasts. x 500.*

Higher power photo of a Tribonema *cell separating at the H-join. x 1400*

Ulothrix

C: unbranched filaments

Division: Chlorophyta, **Order:** Ulotricales

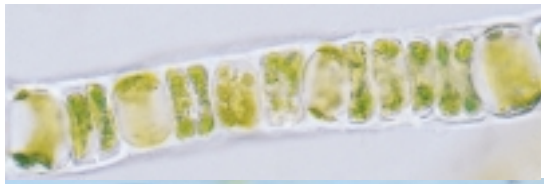
How to recognise the genus:

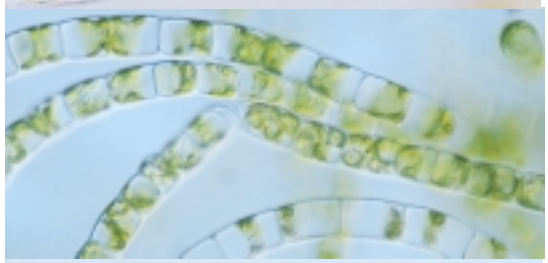
Macroscopic: Vivid green skeins of fine filaments.

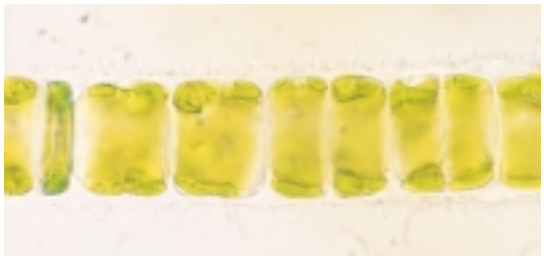
Microscopic: Unbranched filaments of cells ranging in length from noticeably shorter than they are wide to (occasionally) longer. Each cell has a single chloroplast that forms either a complete or partial ring around the inside of the cell wall. The width of the ring varies from almost as long as the cell to very narrow. The filaments may be attached to the stream substrate with a holdfast. Cells of *Ulothrix zonata* – a very common species in New Zealand – may be up to 45 µm in diameter. Other species are smaller – up to 20 µm in diameter.

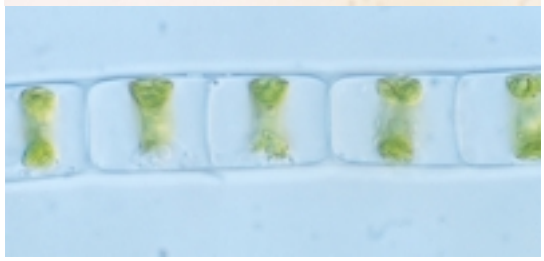
Habitat and distribution: *Ulothrix* sp. (especially *U. zonata*) is very widespread. Much growth occurs in spring and, under suitable flow conditions (i.e., low, stable flows) blooms of *Ulothrix* are common in many lowland rivers. It also dominates the periphyton communities of many mountain streams in spring and late summer.

Possible confusion: Perhaps could be confused with sparsely branched types of *Stigeoclonium* (see page 145), in which the chloroplasts are similar.









from top:

Spring growth of Ulothrix *sp. in a steep headwater stream (Avoca catchment, Canterbury).*

Three examples of Ulothrix *(probably* U. zonata*). Note the air bubbles in the cells in the top two photographs. x 270*

Two examples of Ulothrix *at high power showing the different extent of the chloroplast. x 680*

Zygnema

C: unbranched filaments

Division: Chlorophyta, **Order:** Zygnematales

How to recognise the genus:

Macroscopic: Light green slimy filaments.

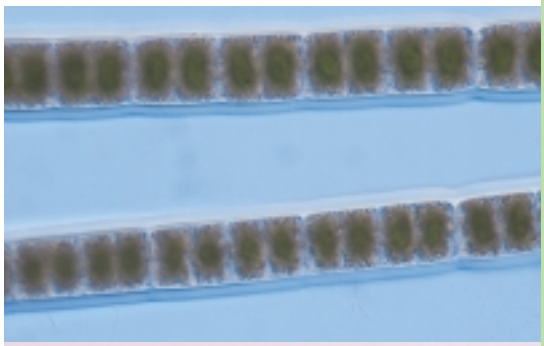
Microscopic: Unbranched filaments of cylindrical cells with straight or rounded end walls. The cells vary in length from almost square to oblong. There are two star-shaped chloroplasts per cell, arranged side-by side. Sometimes this arrangement is extremely clear. Where the chloroplasts more or less fill the cell, the arrangement is not quite as obvious. In fresh material, often the cell nucleus can be seen between the chloroplasts, as a greyish, more-or-less circular body.

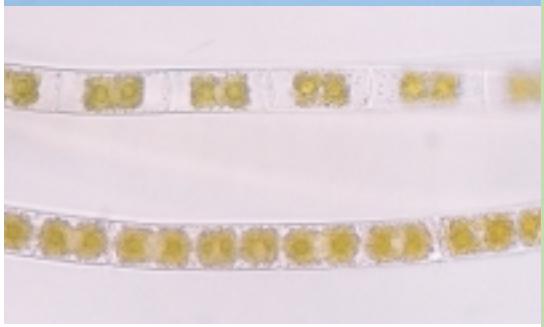
In frozen material the chloroplasts shrink and lose their star-like appearance but it is usually still possible to discern the double side-by-side arrangement.

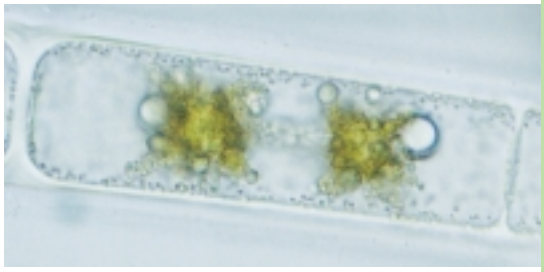
Filaments vary from about 20 to 50 µm wide.

Habitat and distribution: *Zygnema* is usually found in relatively still waters in lakes, rather than rivers. However it has been collected from slow-moving backwater areas in rivers in a range of environmental conditions: pristine to lowland. This genus is widespread but is not commonly found in periphyton.

Possible confusion: *Zygnema* is usually easy to recognise though there may be confusion with *Spirogyra* in frozen material (see page 136) as the chloroplasts clump together in both genera.







from top:

Zygnema *growing in the Waipawa River, Hawkes Bay*

Filaments with various densities of cell contents: note the muclaginous covering to the filaments in the top two filaments. x 270

Lower photo: x 600.

Audouinella

C: branched filaments

Division: Rhodophyta, **Subclass:** Florideophycidae

How to recognise the genus:

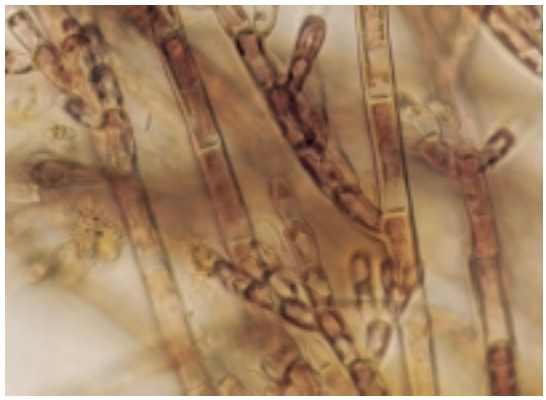
Macroscopic: Pink–brown patches, like felt, sometimes forming a continuous, firmly attached mat, on rocky substrates.

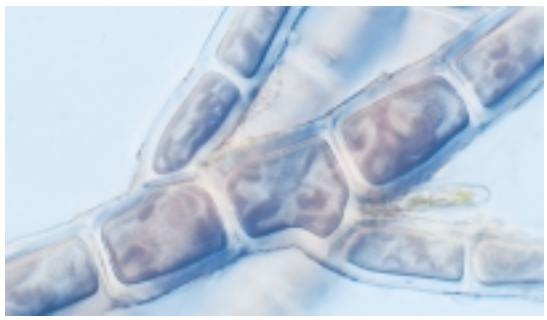
Microscopic: Tufts of branched filaments growing from a basal holdfast. Thick cell walls and square to oblong cells, sometimes with constrictions at the cell walls. The filaments branch repeatedly with often no clear "main" filament; tips usually rounded or slightly tapering. The chloroplasts are a dull greyish green sometimes with a pink or purple tinge. There are no pyrenoids.

The most common species in New Zealand is *Audouinella hermanii.* Cells are 10–25 µm in diameter.

Habitat and distribution: *Audouinella* can be very common in clean foothills and lowland rivers, where the reddish brown mats may be visible particularly on very stable substrates like bedrock and large stones. Also found in shady forest streams. Widespread.

Possible confusion: Usually none, though note that *Batrachospermum* (page 141) goes through a young stage that resembles *Audouinella.*





from top:

Audouinella *growing amongst moss and green algae, recently dried out.*

Audouinella *from the Cass River, Canterbury. x 220 (photo: Nelson Boustead)*

Audouinella*. x 680*

Batrachospermum

C: branched filaments

Division: Rhodophyta, **Subclass:** Florideophycidae

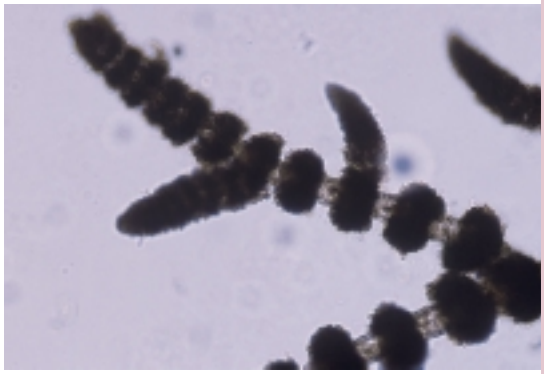
How to recognise the genus:

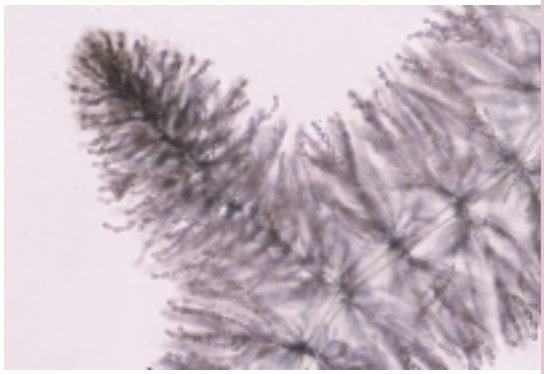
Macroscopic: Red–brown to green–grey fronds growing in streaming brown jelly-like masses up to about 15 cm long. The main branches are clearly visible to the naked eye and have a beaded appearance.

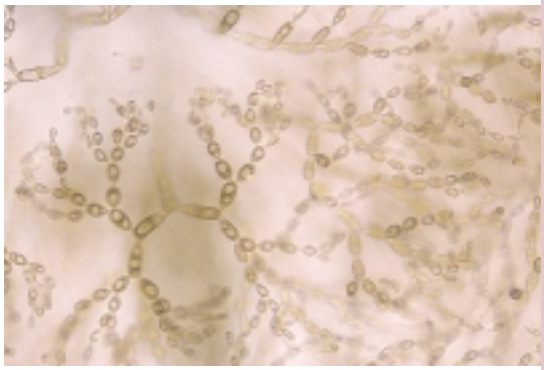
Microscopic: Batrachospermum comprises a thick central filament bearing closely spaced whorls of much branched filaments. Individual cells are bulbous with rounded cells at the branch tips. The central filament is also branched.

Habitat and distribution: Clean, cool streams, often spring fed, or shady forest streams.

Possible confusion: Unlikely, though note that *Batrachospermum* goes through a young stage that resembles *Audouinella* (page 140). If you see both genera in a sample, there is a good chance that it is all *Batrachospermum*. However, without culturing the sample you cannot be certain.







from top:

Batrachospermum *sp. from a spring-fed creek, Canterbury. x 70*

A different species of Batrachospermum *sp. from the same spring-fed creek. x 135*

As above. x 270

Bulbochaete

C: branched filaments

Division: Chlorophyta, **Order:** Oedogoniales

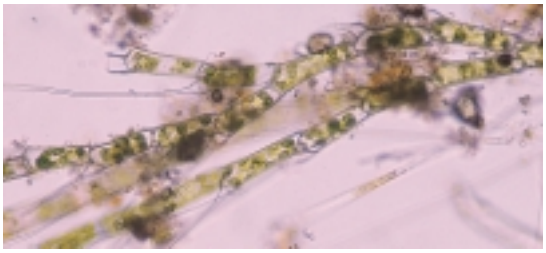
How to recognise the genus:

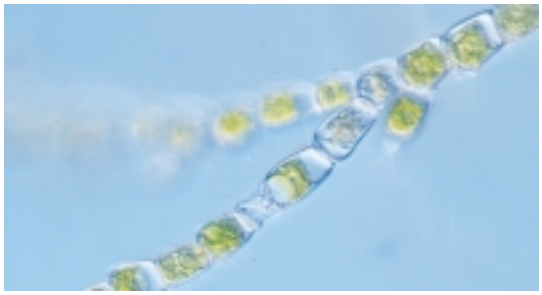
Macroscopic: Green filaments with no particular distinguishing features.

Microscopic: Bulbochaete has branched filaments of somewhat bulbous cells, most bearing a long hair – a "seta" (though these can detach). Cells are 20–30 µm across. *Bulbochaete* is closely related to *Oedogonium* (see page 135) and has a similar chloroplast – a lacy network lining the cell.

Habitat and distribution: *Bulbochaete* is encountered most often in lakes and pools, however it does occur in the periphyton of outlet streams and rivers.

Possible confusion: Usually none; a very distinctive genus.





from top:

Bulbochaete*, from a lake outlet, Canterbury. x 135*

Bulbochaete *with setae missing Note the resemblance of the cells to* Oedogonium*. x 270.*

Chaetophora

C: branched filaments

Division: Chlorophyta, **Order:** Chaetophorales

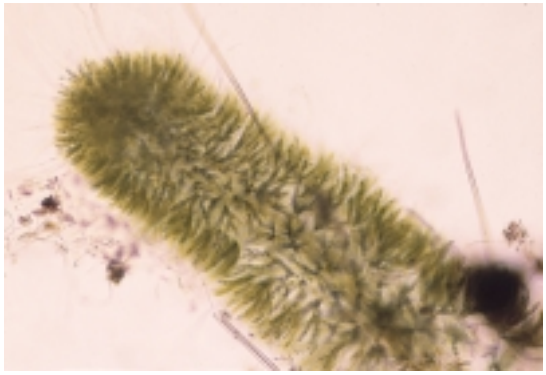
How to recognise the genus:

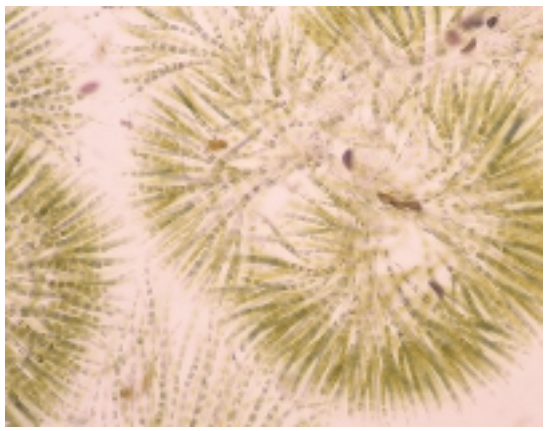
Macroscopic: Bright green firm jelly-like blobs up to 10 mm across, or elongated branching fronds in mucilage.

Microscopic: Chaetophora is closely related to *Stigeoclonium* and is distinguished by being enclosed in firm mucilage (hence its macroscopic appearance) and by its much denser branching. Each tuft arises from a flattened mass of cells. The chloroplast is a parietal band covering most of the cell wall.

Habitat and distribution: *Chaetophora* seems to prefer cool, clean and moderate- to fast-flowing streams. It is not often found in periphyton but may possibly be more common than recorded because of confusion with *Stigeoclonium* (see below).

Possible confusion: Maybe with *Stigeoclonium*, though growth form differs: *Chaetophora* grows in compact masses, *Stigeoclonium* in streaming tufts. The growth form of *Chaetophora* can be preserved quite well even after samples have been blended and frozen.





from top:

Chaetophora *cf.* incrassata *(branching fronds). x 70*

Chaetophora*, a type that forms firm globules. x 80*

Chroodactylon

C: branched filaments

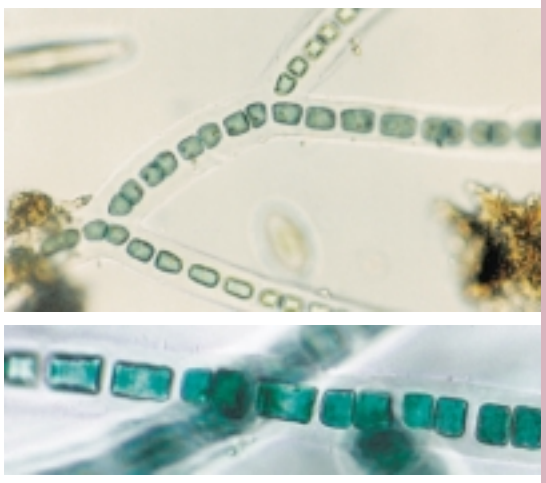
Division: Rhodophyta; **Subclass:** Bangiophycidae

How to recognise the genus:

Microscopic: Single rows of vivid blue-green, oval cells, usually isolated from each other, within a thick, clear sheath. Branching is irregular. The chloroplast is star-shaped, though this is not always evident. .

Habitat and distribution: *Chroodactylon* is found occasionally in periphyton, and can be common within individual samples. Distribution not known.

Possible confusion: Distinctive. The genus could be mistaken for a cyanobacteria because of its colour. However, discrete chloroplasts are usually obvious.



Chroodactylon, *showing branching (top, x250) and the striking blue-green colour (bottom, x 450). (Photos: Nelson Boustead)*

Compsopogon

C: branched filaments

Division: Rhodophyta; **Subclass:** Bangiophycidae

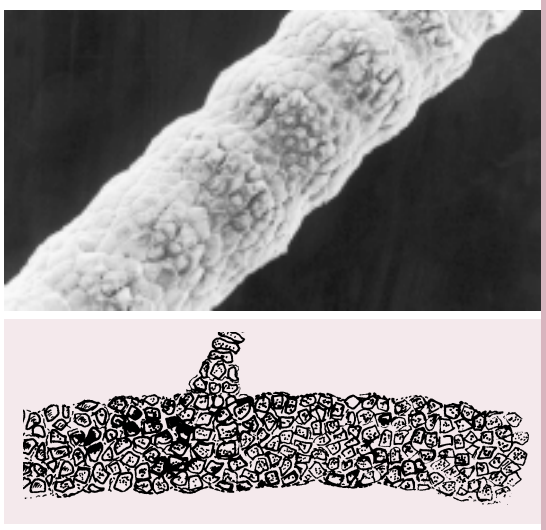
How to recognise the genus:

Macroscopic: Forms coarse, stringy red–brown or bleached filaments, sometimes very long ("like fishing line").

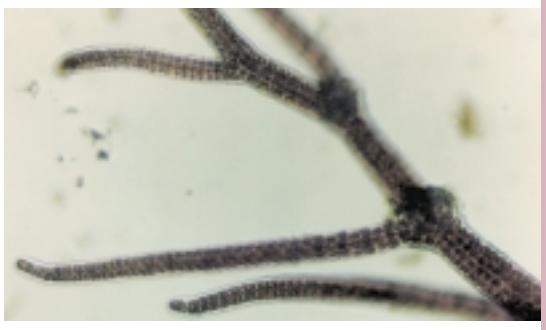
Microscopic: Main filaments can be 400 µm wide or more and comprise a "cortex" (layer) of angular cells overlying a central axis of large, clear cells. Branches reduce to a single row of disc-like cells at the tips.

Habitat and distribution: Usually reported from tropical areas. In New Zealand, most records of *Compsopogon* have been from lowland rivers in the North Island.

Possible confusion: Distinctive, though it could possibly be confused with another red alga, *Bostrychia* (Subclass: Florideophycidae) which also has multi-cellular branched filaments (see photo). In *Bostrychia* the cells are arranged in longitudinal lines (i.e., a bundle of several filaments with the outer layer forming a cortex of flattened cells), clearest in young filaments. The branch tips tend to curl. In *Compsopogon*, the cells are not clearly in rows. *Bostrychia* is mainly a marine genus but one species occurs in fresh water.



Compsopogon. *Top: SEM of main stem showing the cortex of flattened, angular cells overlying rounded axial cells. x 120. Bottom: drawing showing main stem and branch.*



Bostrychia. *x 70 (photo: Nelson Boustead)*

Cladophora

C: branched filaments

Division: Chlorophyta, **Order:** Cladophorales

How to recognise the genus:

Macroscopic: Deep or dull green to brown, tough filaments in mats or masses; individual filaments sometimes thick, stringy and khaki brown because of epiphytes.

Microscopic: Large branched filaments with very long cells. Branches originate from cell cross walls and are usually smaller than the main stem. Filaments taper slightly towards rounded ends. The cell contents appear granular – a combination of the lace-like chloroplast lining the inside of the cell walls (often appearing as many small chloroplasts) and numerous pyrenoids.

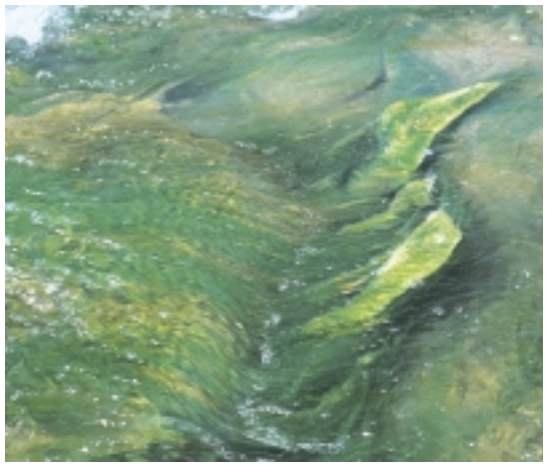
There is no mucilaginous layer on the outside of the cell walls, accounting for the coarse feel and appearance of *Cladophora*, and the ease of colonisation of the filaments by epiphytes – mainly diatoms.

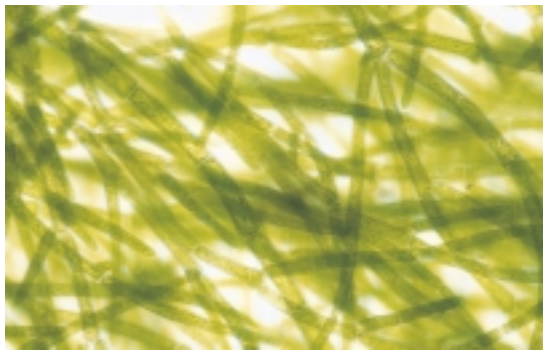
In frozen material the cell walls may collapse and become distorted.

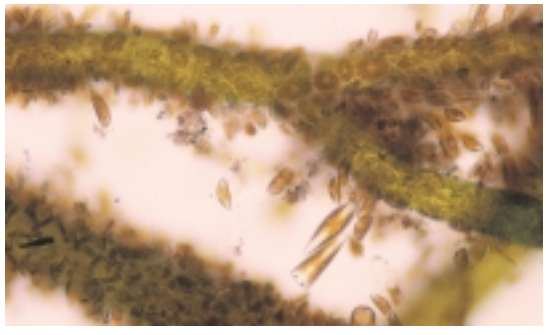
In New Zealand, *Cladophora glomerata* has been identified as the most common species. Cells on the main axes may be up to 75 – 100 µm across, on branches they are about half that size and also shorter.

Habitat and distribution: *Cladophora* is often found in high-conductivity streams and rivers and can form large blooms in summer and autumn under stable flow conditions. The taxon is widespread in soft-rock areas of North Island (naturally high conductivity) and occurs elsewhere in response to other sources of enrichment.

Possible confusion: *Rhizoclonium* (see page 134). *Rhizoclonium* has large, long, cylindrical cells, very occasionally branched, but not with the tree-like pattern in *Cladophora*. There is a slight chance that *Cladophora* filaments could be confused with *Vaucheria*, which lacks cross walls (see page 147).







from top:

Cladophora, *Wairoa River, Hawkes Bay.*

Cladophora *sp.: top: x 70; bottom: x 270. Note the pattern of branching.*

Cladophora glomerata*, with epiphytes (diatoms). x 270*

Draparnaldia

C: branched filaments

Division: Chlorophyta, **Order:** Chaetophorales

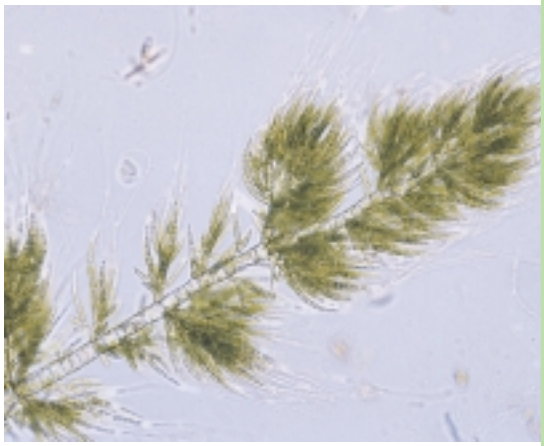
How to recognise the genus:

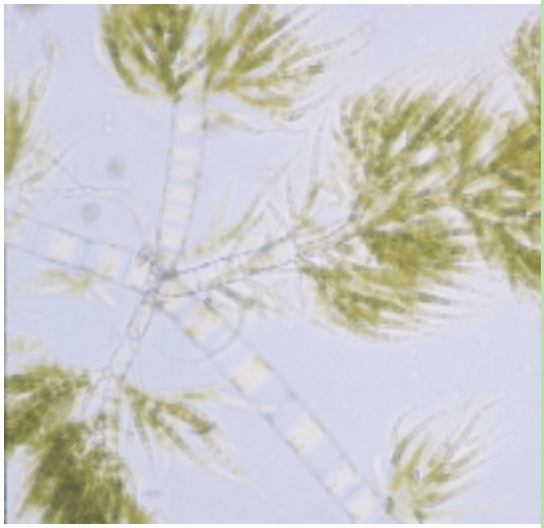
Macroscopic: Light green, soft masses, up to about 5 mm across, slimy because of copious mucilage.

Microscopic: Draparnaldia is closely related to *Stigeoclonium* and *Chaetophora*. It is distinguished by the thick central filament that carries densely branching tufts of filaments whose ends taper to fine hairs. The large central cells have a single parietal chloroplast that extends part way around the cell and is much narrower than the cell. The central stem is up to 100 µm across. Branch cells are up to 10 µm across, and longer than they are wide.

Habitat and distribution: *Draparnaldia* occurs mostly in clean, cool streams, often spring-fed. Distribution is uncertain.

Possible confusion: Usually no problem identifying this genus.





from top:

Draparnaldia *from a spring-fed stream, Canterbury. x 80*

Note the very wide main branches. x 200

Stigeoclonium

C: branched filaments

Class: Chlorophyceae, **Order:** Chaetophorales

How to recognise the genus:

Macroscopic: Bright green tufts growing on stony substrates, often dotted amongst growths of brown algae (diatoms).

Microscopic: Branched alga with small, squarish to elongated cells, sometimes inflated at the centre and constricted at the cross walls. The cross-walls are straight. Within the cells, the chloroplast partly lines the inside of the cell wall. Each tuft is attached to the stream substrate by a holdfast structure of similar cells in a sheet-like arrangement. Branching varies among species and can be quite sparse. The filaments taper either to a point or to a more blunt end. Cell diameter is typically up to about 15 µm for main axes and less for the branches.

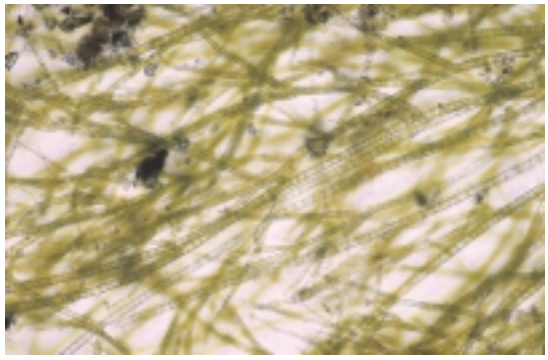
Stigeoclonium does not change greatly in overall appearance following freezing. The branching habit and tapering filaments of this genus make it easy to recognise, fresh or frozen.

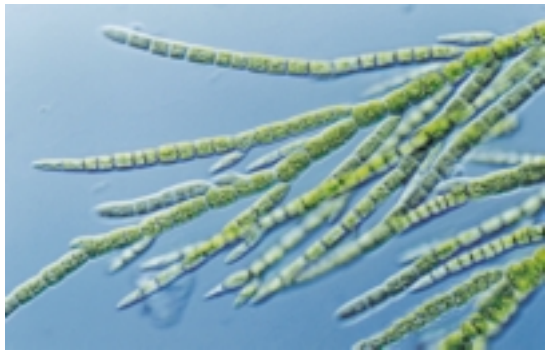
Habitat and distribution:

Stigeocloneum seems to prefer moderate- to fast-flowing streams in a range of environments, from clean to enriched waters. The genus is common and widespread and may dominate the periphyton.

Possible confusion:

In very sparsely branched specimens the filaments may be mistaken for *Ulothrix*, because of the similar arrangement of the chloroplast. If you identify a doubtful *Ulothrix*, check along the filaments to see if there is any branching. Also watch out for confusion with *Chaetophora*, which forms firm mucilaginous clumps (see page 143).





from top:

Tuft of Stigeoclonium *with diatoms.*

Stigeoclonium *from the Hokitika River, West Coast. x 70.*

Stigeoclonium *from the Cust River, Canterbury. x 270*

Vaucheria

C: branched filaments

Division: Xanthophyta, **Order:** Vaucheriales

How to recognise the genus:

Macroscopic: Dark green round or oval "cushions" – up to about 20 cm across – attached to stones or other stable substrate. When squeezed free of water the cushion has a tough "woolly" feel.

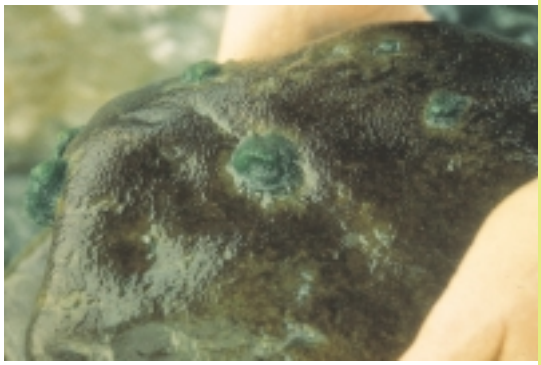
Microscopic: Large branched filaments with rounded tips and no cell cross walls. Multiple small, disc-like chloroplasts line the cell wall. Diatom epiphytes are often present.

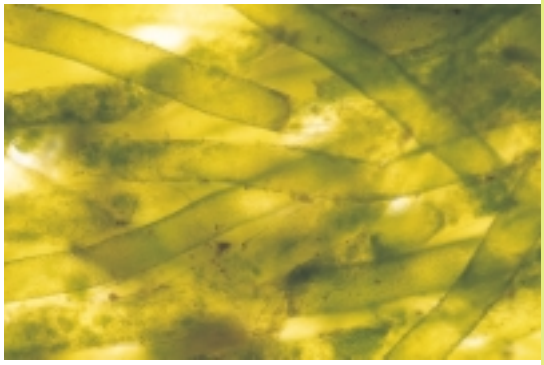
In frozen material, the cell walls collapse and become distorted and the chloroplasts clump together.

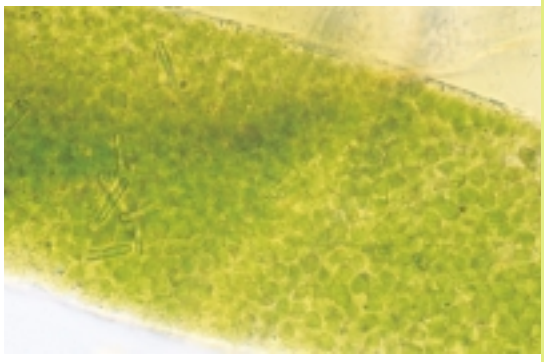
The filaments are up to 150 µm in diameter and decrease in size with branching. Note that branching can be infrequent and the clearest diagnostic feature is the lack of cross walls.

Habitat and distribution: Found in a wide range of conditions, from clean, cool headwater and spring-fed streams, to more enriched lowland locations.

Possible confusion: The macroscopic appearance of *Vaucheria* is very characteristic. It is possible that isolated filaments under the microscope could be mistaken for *Cladophora*. Therefore in cells with apparently multiple small chloroplasts, you should always check for the presence of cross walls.







from top:

Vaucheria *growing in tufts.*

Vaucheria *from the Avon River, Christchurch. x 70*

Showing branching, x 135

Showing many small chloroplasts. x 270

Aulacoseira

C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta **Order:** Centrales

How to recognise the genus:

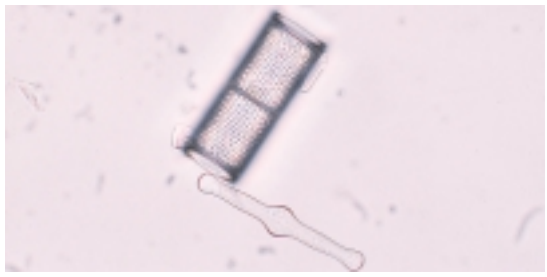
Microscopic: Aulacoseira forms distinctive short filaments in which the ornamentation of the valves is often visible even under relatively low power (e.g., x 400). Several irregular chloroplasts.

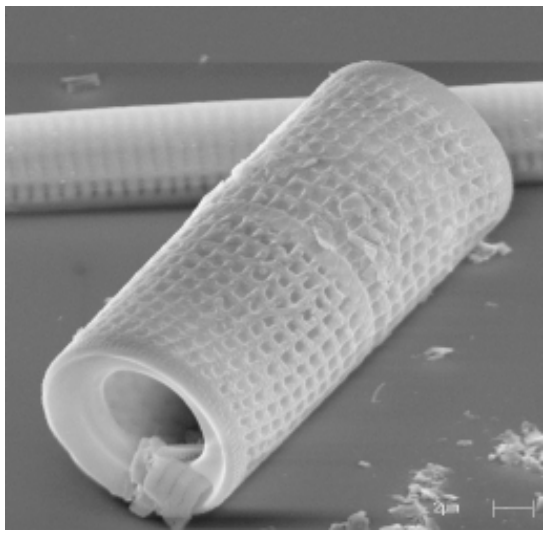
Possible confusion: Usually none.

Aulacoseira species

The most common species of *Aulacoseira* in New Zealand is probably *A. granulata* (and its varieties). The species is is characterised by widely spaced long spines linking successive valves. These cannot be seen easily in live material. The valves range from 5 to 25 µm wide and can be short and fat or very elongated (*A. granulata* var. *angustissima*). The specimens illustrated are tentatively identified as this species.

Habitat and distribution: *Aulacoseira* species are most often found in lakes as part of the phytoplankton. However they may appear occasionally in the periphyton of lake-fed streams and rivers.





Note: The old genus name *Aulacoseira* has recently been resurrected to include several species previously placed in *Melosira*, but separated because of their very different cell wall structure (see Round *et al.* 1990).

from top:

Aulacoseira *filament, Tarawera River. x 270*

Cleaned specimen, Waiau River. x 680

Aulacoseira *sp. SEM. Cells separated at the girdle.*

Diatoma

C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta, **Order:** Fragilariales

How to recognise the genus:

Macroscopic: Brown shiny, slimy covering on rocks, though often *Diatoma* species are mixed with other algae – both diatoms and green algae.

Microscopic: Diatoma species form ribbon-like filaments or zig-zag or star-like colonies. They are also seen as solitary cells. Each cell contains several chloroplasts. In cleaned material *Diatoma* cells lie in either valve or girdle view. Thick ribs of silica across the valve face ("costae") are visible as dark lines (valve view) or knobs at the sides (girdle view).

Possible confusion: The two *Diatoma* species described below are fairly distinctive.

Diatoma hiemale var. *mesodon*

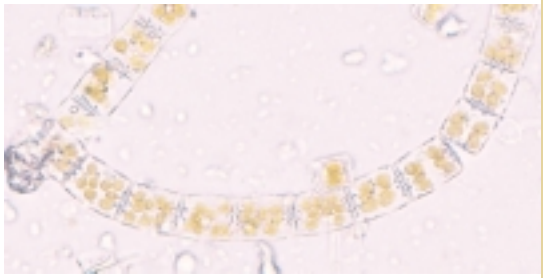
Short ribbon-like filaments of square cells each containing several irregular, brown-coloured chloroplasts; sometimes seen from the top. Often seen as single cells. Two or 3 ribs across the valve face. Cells 15–20 µm long and 5–12 µm across (valve view).

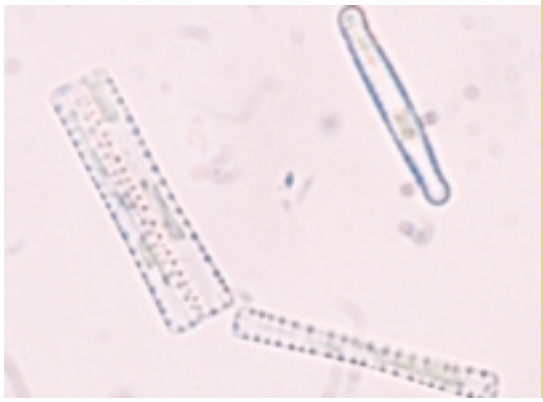
Habitat and distribution: Common and widespread; "occasional" or less in many periphyton samples. This species often dominates the periphyton in cold, clean headwater streams.

Diatoma tenuis

Solitary or in zig-zag colonies; cells elongated. In valve view, the two ends may bulge out slightly (sometimes in different directions). In girdle view you see a rectangle with dark dots down each long edge. Cells are typically 15–30 µm long and up to 4 µm wide.

Habitat and distribution: *D. tenuis* has been identified mainly from the periphyton of southern South Island rivers, from the lowlands to the headwaters. This species has been recorded as dominant in the periphyton, e.g., in some locations on the Waiau River, Southland, in summer 2000.





from top:

Filaments of D. hiemale *growing in a backwater of a pristine mountain stream. (The green is* Spirogyra*.)*

Live Diatoma hiemale *chains. x 450*

Diatoma hiemale *valve and girdle views. x 1000*

Joined cells of Diatoma tenuis*, girdle view, plus valve view (right). x 1200*

Eunotia

C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta, **Order:** Eunotiales

How to recognise the genus:

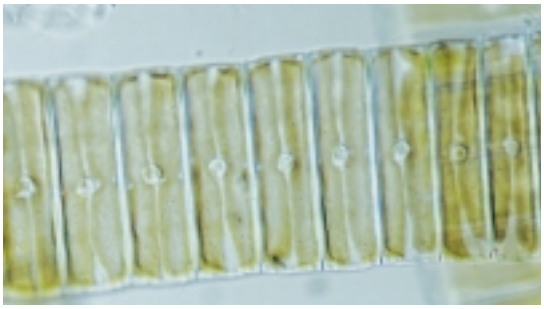
Microscopic: In valve view *Eunotia* species are mostly variations on a crescent shape; the girdle view is rectangular, sometimes rhomboidal. Each part of the raphe system is very short. Often all four raphe ends may be seen in girdle view. Some species of *Eunotia* form ribbon-like filaments in which they lie in girdle view. There are two sheet-like chloroplasts in each cell. Species range in size from 10 µm up to 150 µm long.

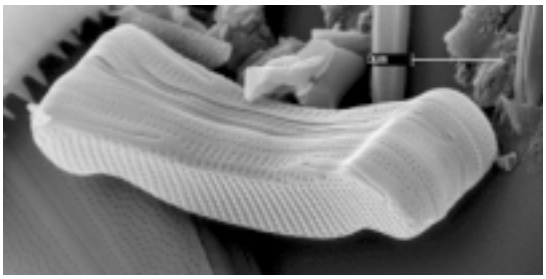
Possible confusion: Single cells of *Eunotia* are usually recognisable, especially if lying in valve view. In filaments, there could be confusion with *Fragilaria*. Look for single cells in valve view that are likely to be the same species as the filaments (from their size, etc). In wet samples you can agitate the sample to get cells to turn over. Check the chloroplasts: *Fragilaria* has irregular plates; *Eunotia* usually has two larger sheets per cell. Under high power LM, focus through to find the raphe system in *Eunotia*.

Eunotia species

Identification of many *Eunotia* species is difficult without access to a good microscope and to cleaning and mounting facilities. Therefore we do not provide any individual descriptions. For characterising periphyton it is more important to be able to distinguish between filaments of *Fragilaria* and *Eunotia*.

Habitat and distribution: *Eunotia* species tend to be very common in low-conductivity, acid still waters, e.g., in lakes and upland bogs and tarns. The genus can also be an important part of stream periphyton, especially as filaments in relatively clean, spring-fed lowland streams, or mountain-fed streams, e.g. *Eunotia* cf. *serpentina* (illustrated).





from top:

Eunotia *filaments from a spring-fed stream, Canterbury. Note the chloroplasts. This is probably* Eunotia serpentina*, which has undulating valve margins when seen in valve view, discernible here as faint shadows running along the filament. x 375*

Girdle view of a single valve of Eunotia *cf.* serpentina*. x 800*

Valve view, Eunotia serpentina*. x 800*

Valve view of Eunotia cf. incisa *(from a small stream, Stewart Island). x 2000*

SEM showing structure of valve of Eunotia*. Note short raphes extending over the edge of the valve face.*

Fragilaria

C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta, **Order:** Fragilariales

How to recognise the genus:

Microscopic: Fragilaria species form ribbon-like colonies in which cells lie in girdle view. Some species are commonly seen as single cells. An elongated chloroplasts lies against the face of each valve. Currently, the genus *Fragilaria* is reserved for species that have certain structural features that cannot usually be seen under LM (including, in many species, spines around the margins of the valve face, which allow them to form chains).

Possible confusion: Single cells of some *Fragilaria* species cannot be distinguished from *Synedra* under LM. Some *Synedra* species also have spines around the valve edge and form chains (page 187). *Fragilaria* filaments could be confused with *Eunotia* (see page 150).

Fragilaria vaucheriae

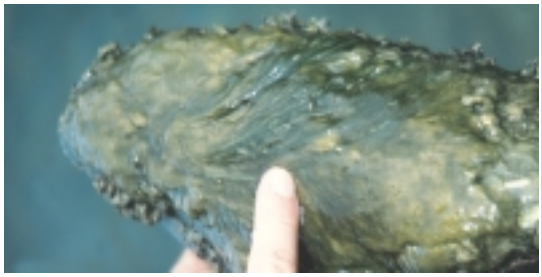
Small spindle-shaped cells, sometimes with capitate ends, rectangular in girdle view. Often seen as single cells but also in filaments. The species is distinguished by the presence of a slightly swollen area, without striae, to one side of the valve centre. There are two narrow chloroplasts. Up to 30 µm long and 6 µm wide.

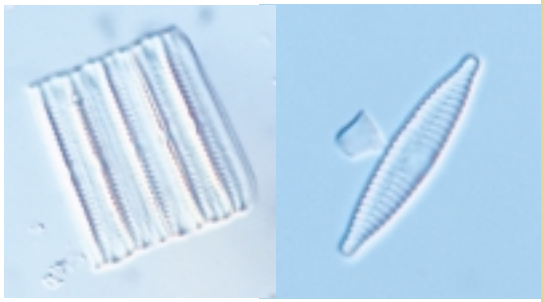
Habitat and distribution: Very common; seems to occur in a wide range of conditions.

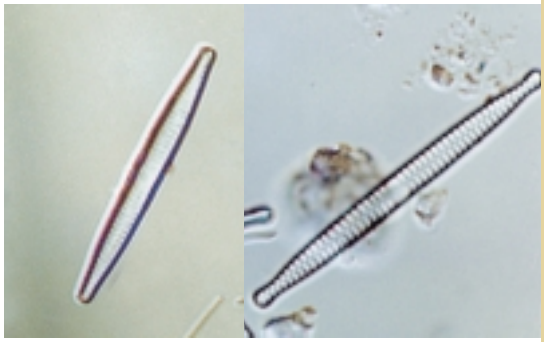
Fragilaria capucina

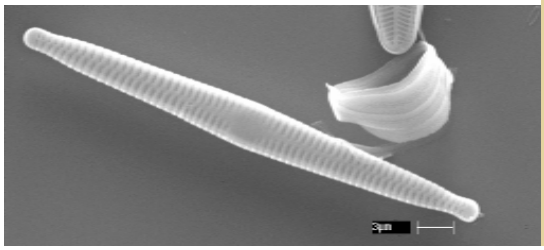
Pencil-shaped cells generally longer than *F. vaucheriae* (up to over 100 µm long, but often only 25 µm). Central area spans the whole width of the valve, clear axial area. Fine striae usually, though some varieties have a coarser arrangement with striae clearly alternating on either side of the valve (see photo).

Habitat and distribution: Probably wide-spread. When not in chains, some varieties of this species may be identified as *Synedra rumpens* (see page 188).









from top:

Fragilaria filaments growing over a thick diatom mat.

Filament of Fragilaria vaucheriae*. Fresh material. x 500.*

Fragilaria vaucheriae*, cleaned frustules, valve view (left), girdle view (right). x 2000*

Fragilaria capucina (left); Fragilaria capucina *var.* distans (right – *note the widely-spaced striae). x 2000*

SEM , Fragilaria capucina*. Note the small spines at the valve margin.*

Fragilariforma

C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta, **Order:** Fragilariales

How to recognise the genus:

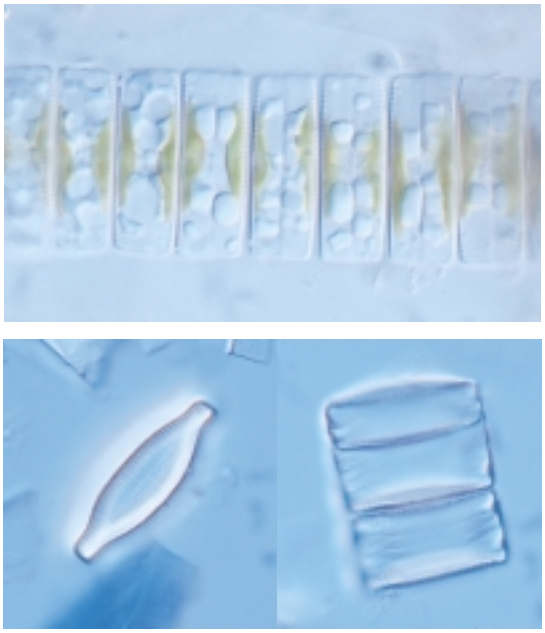
Microscopic: Fragilariforma is a new genus based on *Fragilaria viriscens*. It is distinguished from *Fragilaria* by the type of puncta and its very narrow pseudoraphe, i.e., striae almost span the whole valve width. Other diagnostic features are visible only under SEM. *Fragilariforma* species form ribbon-like colonies in which they lie in girdle view.

Possible confusion: With other *Fragilaria* species and also with *Eunotia* species in chains (see page 150). Always try to find a valve view in the sample.

Fragilariforma viriscens

Small elongated cells (10–20 µm long by about 10 µm wide) usually seen as filaments. The cells have fine striae, a very narrow axial area and no central area.

Habitat and distribution: Occasionally found in South Island periphyton samples. Reported to prefer low-conductivity spring and stream waters (Cox 1996).



from top:

Fragilariforma cf. viriscens*: live filament. x 1000*

Cleaned material, valve and girdle views; from a South Island West Coast stream. x 850.

Note on the re-classification of *Fragilaria*

The genus *Fragilaria* has recently been downsized by splitting off newly established genera including *Fragilariforma*. The other new genera represented in this guide include species that are most often seen as single cells, though they may also form short filaments. They are covered on pages 184 (*Staurosira*, based on *Fragilaria construens*) and 185 (*Staurosirella*, based on *Fragilaria lapponica*).

Pseudostaurosira (based on *Fragilaria brevistriata*) is also seen occasionally (see photo, right)

See Williams and Round (1987, 1988) for a full account of the new genera.

Pseudostaurosira brevistriata *valve view and short chain, Okuku River, Canterbury. x 1300*

Melosira

C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta, **Order:** Centrales

How to recognise the genus:

Macroscopic: Medium brown fluffy masses, though often *Melosira* is mixed with other algae – both diatoms and green algae. Can sometimes form whitish to iridescent green mats as a monoculture.

Microscopic: Cylindrical filaments with cells approximately as long as they are wide. There is no ornamentation on the cell walls either in valve or girdle view. Several to many irregular, brown-coloured, chloroplasts line the cell walls. Sometimes the chloroplasts fit together in a neat jigsaw pattern. Cells are loosely joined and the filaments break up easily into single cells, especially following blending. It is common to see *Melosira* only as single cells unless the sample is dominated by the genus.

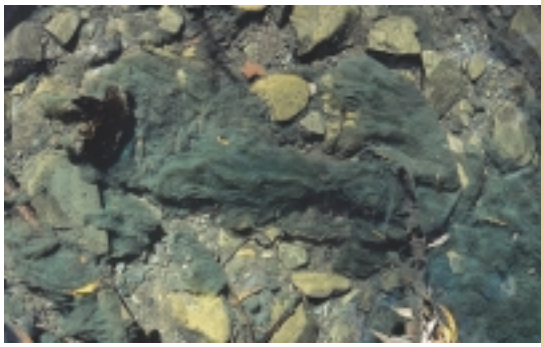
Possible confusion: *Aulacoseira* (page 148) forms similar chains but the valves have noticeable ornamentation. If Melosira is not recognised as a diatom filament, the species may be confused with a range of non-diatom filaments.

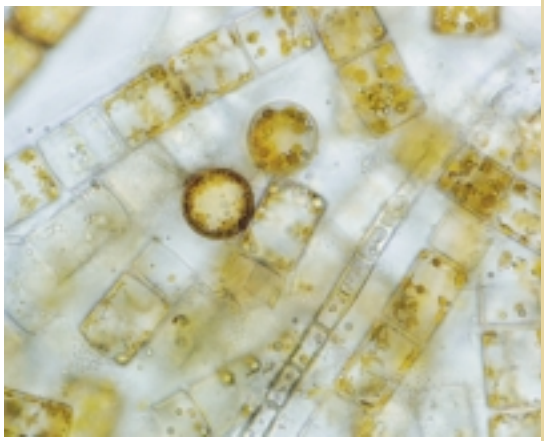
Melosira varians

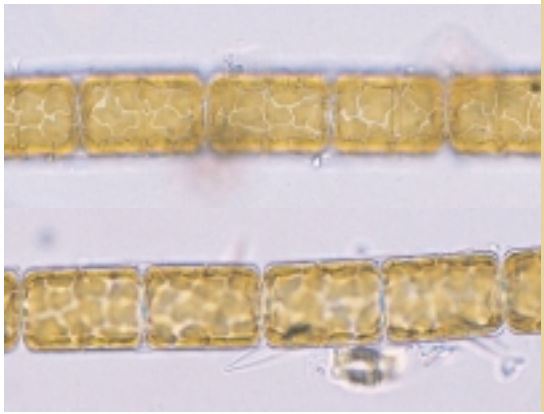
This is the only *Melosira* species known in New Zealand. Cleaned material viewed under high power shows barrel-shaped frustules with little ornamentation. Easy to identify. *M. varians* ranges from 10 to 40 µm in diameter.

Habitat and distribution: *Melosira varians* is found throughout the country in slow to medium flowing open lowland streams. It can dominate the periphyton community in moderately enriched situations. It is reported as both a "cleanwater species" and "moderately polluted water species" in Cassie (1989).

Note: Other species of *Melosira* listed in some texts have been transferred to the genus *Aulacoseira*, notably *A. granulata* (see page 148).







from top:

Masses of Melosira varians *growing on a stream bed.*

Melosira varians*-dominated periphyton community, photographed following storage (freezing). x 400*

Healthy Melosira varians *filament showing chloroplasts in two planes of focus. x 480*

Tabellaria

C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta, **Order:** Tabellariales

How to recognise the genus:

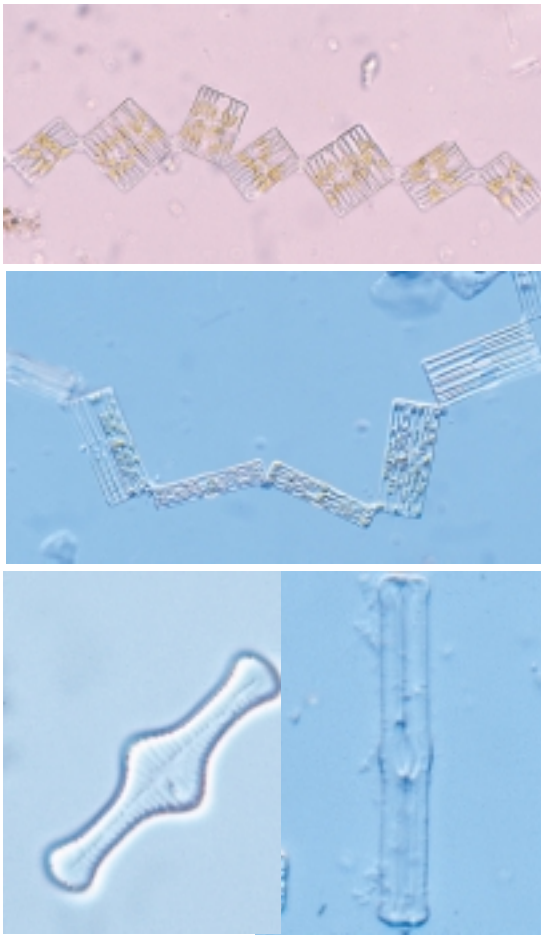
Microscopic: *Tabellaria* species form zig-zag or straight filaments and are also often seen as single cells. The cells usually fall in girdle view – oblong to square with prominent dark projections running towards the centre of the cell ("septa" – sheets of silica partly filling in the girdle bands). Valve views – narrow with swollen ends and centre – are usually seen in cleaned preparations where frustules have broken apart into the two valves and several girdle bands. This is an araphid genus. There are several small chloroplasts throughout the cell.

Possible confusion: Unlikely.

Tabellaria flocculosa

Tabellaria flocculosa forms zig-zag chains of valves in girdle view. Each valve is square to oblong in girdle view and usually about 10–40 µm wide by 30–100 µm long. There are several (up to 7 or 8) irregular looking septa at each side, usually with short rudimentary septa opposite. In valve view there is a prominent central bulge and expanded ends.

Habitat and distribution: This is the only *Tabellaria* species found widely in New Zealand periphyton. Although widespread, it is not often common in stream periphyton communities. It seems to do best in low-conductivity, clean waters. (see Cassie (1989), p. 18). We have found the elongated form illustrated mostly in clean, high-altitude outlets from tarns.



from top:

Chains of Tabellaria flocculosa*, typical cells, more or less square (top), and elongated oblong cells (bottom). x 350*

Tabellaria flocculosa*, valve views. Left: typical form. x 1500. Right: elongated form. x 700.*

Note: The elongated *Tabellaria* species illustrated is most likely a form of *Tabellaria flocculosa*. A widespread species that has the same shape in girdle view is *Tabellaria fenestrata*. However, in *T. fenestrata* there are usually four septa only and no rudimentary septa. Some the the cells shown here appear to have both rudimentary septa and sometimes more than four full-sized septa.

The following two genera form "filaments" in mucilage tubes in which the cells are not joined into true filaments. Both genera are frequently seen in single-celled form, and are described in more detail under C: single cells (diatoms)

Encyonema

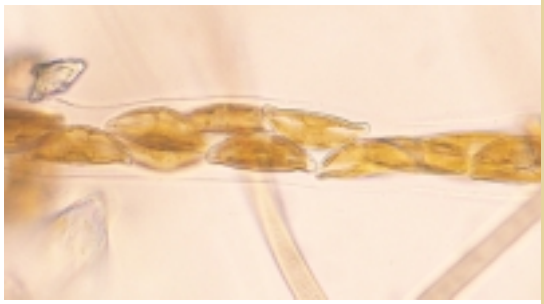
C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta, **Order:** Cymbellales

How to recognise the genus:

Microscopic: See page 166 for a full description. Some species of *Encyonema* typically form long "filaments" of somewhat irregularly arranged frustules in mucilage tubes.

Possible confusion: Single cells of *Encyonema* are easily confused with *Cymbella*, though the latter tend to grow on stalks (like *Gomphonema* or *Gomphoneis*) and do not occur in mucilage tubes.



Encyonema caespitosa *packed into a mucilage tube, forming a filament. x 400*

Frustulia

C: unbranched filaments/single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

Microscopic: See page 169 for a full description. *Frustulia* may occur scattered in long mucilage tubes, but is normally encountered as single cells.

Possible confusion: Single cells of *Frustulia* may be confused with other naviculoid diatoms but this is the only naviculoid genus you will find in mucilage tubes.

Frustulia *cells in a mucilage tube. x400*

Achnanthes

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Achnanthales

How to recognise the genus:

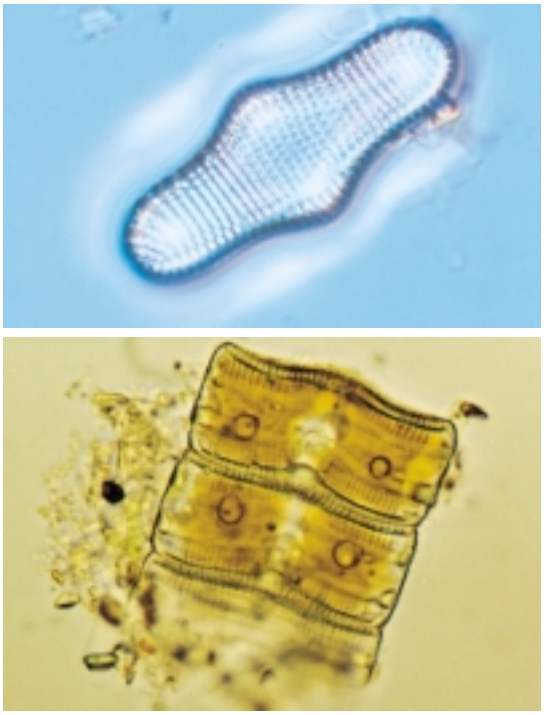
Microscopic: This is a monoraphid genus. In girdle view the valve is slightly bent into a V-shape with the raphe valve on the inside of the V (i.e., concave). The raphe and pseudoraphe are somewhat off-centre and the areolae are large and clearly seen at 1000 x.

Possible confusion: Unlikely. Most representatives of this genus are marine, and the freshwater species are large and distinctive.

Achnanthes inflata

Microscopic: The only common representative of *Achnanthes* in periphyton in New Zealand is *A. inflata*, which is recognised from its large size (up to 80 µm long) and distinctive shape.

Habitat and distribution: Normally found mainly in clean, cool, shaded streams and never in great numbers. This species seems to be able to withstand some salt-water intrusion (Patrick and Reimer 1966) and has been reported as common in an Otago estuary (Steven Moore, Otago Regional Council, pers. comm.)



from top:

Achnanthes *cf.* inflata*, valve view (raphless valve). x 1000*

Achnanthes *cf.* inflata*, live cells in girdle view. x 1000*

A note on the re-classification of *Achnanthes*

Until recently many monraphid diatom species with a "bent" valve were included in *Achnanthes*, but many freshwater species have now been transferred to the genus *Achnanthidium* [and subsequently to other genera, see Ross *et al.* 1990] (see page 157). The genus *Achnanthes* is currently reserved for species with a particular type of areola and raphe structure. The chloroplast is also different.

Achnanthidium

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Achnanthales

How to recognise the genus:

Macroscopic: Achnanthidium is usually part of a mixed community of periphyton. When dominant these diatoms form a dense, dark brown slimy layer.

Microscopic: A monoraphid genus. Most *Achnanthidium* species are very small and live attached by mucilage to substrates or aquatic plants. The valve is bent so that in girdle view they are slightly V-shaped. In valve view they are oval, elongated or captitate (i.e., with a "head" at the ends). In many species the raphe and pseudoraphe valves differ in their ornamentation. There is one chloroplast.

Possible confusion: Other small diatoms. Look for the V-shape in girdle view.

Achnanthidium minutissimum

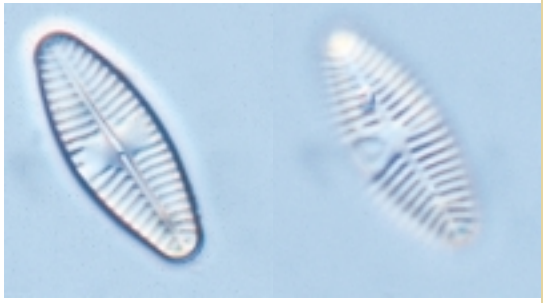
A very small species (5–25 µm long), narrow with slightly pinched ends. In girdle view the V is flattened out a little at each end.

Habitat and distribution: Common and widespread in a range of ecological conditions but does best in clean, low-conductivity streams. The species often dominates the periphyton following flooding, growing in dense masses attached to substrates. In more stable conditions other species take over.

Achnanthidium lanceolatum (now transferred to *Planothidium lanceolatum*, see note page 158)

Planothidium lanceolatum has an obvious "empty area" on the pseudoraphe valve on one side of the central area, formed by a flap of silica. The cells can be relatively large (up to 35 µm long) compared with other species in this genus. Each stria is made up of more than one row of puncta (visible only under SEM).

Habitat and distribution: *P. lanceolatum* is widespread and occasionally abundant. It occurs in the periphyton of a wide range of river and stream types, is tolerant of moderate levels of organic pollution and is reported to favour alkaline waters (e.g., see Round and Bukhtiyarova 1996).



from top:

Dense brown coating of diatoms on a river stone. Achnanthidium minutissimum *dominated this community from the Selwyn River, Canterbury.*

Achnanthidium minutissimum, *valve and girdle views (g.v. in centre). x 1400*

Planothidium lanceolatum, *showing the raphe valve (left) and rapheless valve (right). Note the silica "flap". x 1100*

Achnanthidium linearis (now transferred to *Rossithidium linearis*, see note below)

A very small diatom (10–20 µm long), elongated oval in shape and often seen in girdle view as a straight-sided shallow "V". Striae are quite close together and usually parallel, with no break at the centre except sometimes a slight gap on the raphe valve.

Habitat and distribution: Common, widespread and seems to tolerate a wide range of conditions.

The following related species have yet to be formally transferred to an appropriate genus.

Achnanthes oblongella (= *A. saxonica* in Foged 1979)

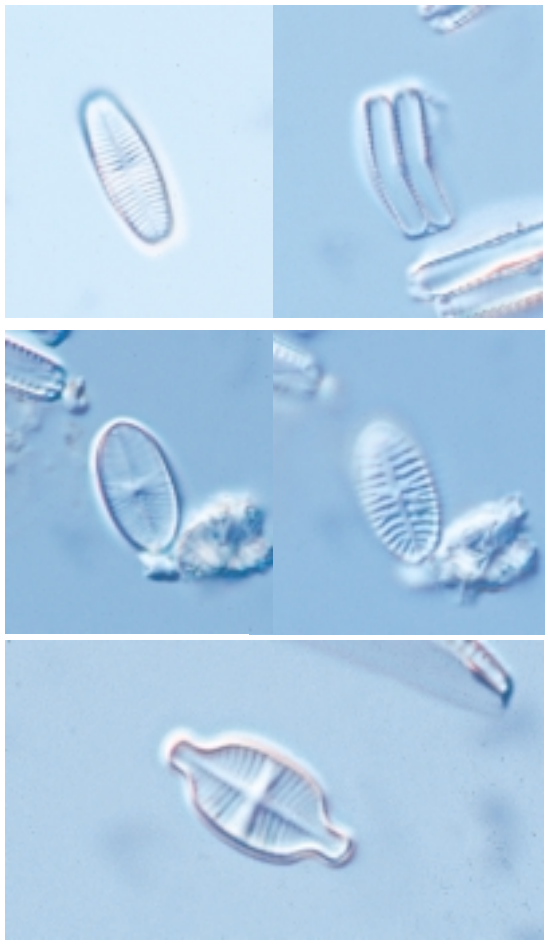
Another small species, 10–20 µm long. The raphless valve has quite prominent and slightly irregular striae.

Habitat and distribution: Widespread but not usually common.

Achnanthes exigua

Small, 10–20 µm long, with noticeably pinched ends.

Habitat and distribution: Not very common. Habitat unknown.



from top:

Rossithidium linearis*, valve view (left) and girdle view (right). x 1400*

Achnanthes oblongella*, raphe valve (left) and raphless valve (right). x 1400*

Achnanthes exigua*, rapheless valve. x 1400*

A note on the re-classification of *Achnanthidium*

Some species included in *Achnanthidium* have been re-assigned to new genera, proposed by Round and Bukhtiyarova (1996) on the basis that the original genus lacked any unifying diagnostic characters except for the "bent" frustule and for being monoraphid. The genera commonly found in the New Zealand periphyton are represented by the first three species described above:

Achnanthidium (e.g., *A. minutissima*)

Planothidium (e.g., *A. lanceolata*)

Rossithidium (e.g., *A. linearis*)

Actinella

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Eunotiales

How to recognise the genus

Microscopic: Elongated cells expanded at one end, and living attached to plants or substrate by the other (narrow) end. Some species are wedge-shaped in girdle view (like *Gomphonema).* Closely related to *Eunotia, Actinella* species also usually have an inconspicuous raphe system that lies to one side of the valve.

Possible confusion: *Actinella* species are often very distinctive, however small forms that are wedge-shaped in girdle view could easily be mistaken for *Gomphonema* under low power LM. Check for raphe endings at the centre of the valve in *Gomphonema* (visible as a slightly thickened area in the middle of each long side in girdle view, see page 171).

Actinella species

Until recently *Actinella* had been rarely reported in New Zealand. The genus has now been found in several locations and these finds include new species that are still being described.

Habitat and distribution: *Actinella* seems to be confined to clean, acid habitats. It can be extremely common locally. Distribution not certain. Most recent findings have been in the South Island and Stewart Island.

Actinella *sp. valve and girdle views. From the outlet stream of a high altitude tarn, South Island. x 1400*

Asterionella

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Eunotiales

How to recognise the genus

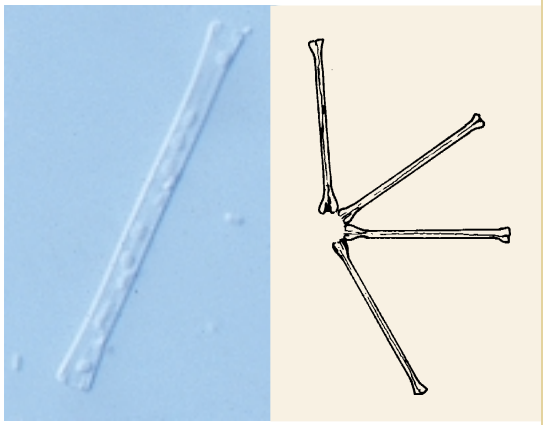
Microscopic: An araphid genus with long thin cells inflated at one or both ends, often forming star-shaped colonies.

Possible confusion: Should be no problem recognising this genus.

Asterionella formosa

Long cells, inflated at both ends, more at one end than the other. Often seen joined at one end to make a star-shape.

Habitat and distribution: *Asterionella formosa* is most common in lake plankton, but can be common in lake-fed rivers and streams.



Asterionella formosa*. Left: single cell from periphyton (Waiau River). x 600. Right: drawing of part of star-shaped colony.*

Amphora

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Thalassiophysales

How to recognise the genus:

Microscopic: An asymmetrical biraphid diatom. *Amphora* species in valve view are roughly crescent-moon-shaped, like *Cymbella.* However, because the girdle band is much wider on the convex side of the valve than on the concave side, the two valves are usually visible side-by-side, i.e., the girdle and valve views are the same. Single valves are seen when the frustule has broken apart. There is an H-shaped chloroplast. In many *Amphora* species, the ornamentations on the valve are too fine to be seen except under very high power.

Possible confusion: The valve views of *Amphora* and *Cymbella* / *Encyonema* are similar in shape: *Amphora* tends to be finer. In *Cymbella* and *Encyonema* the girdle may be also wider at the top (curved) side of the valve than at the bottom so that in girdle view, both valve faces are visible obliquely. You'll need to look for cells in valve view to be sure of your identification. Also note that *Eunophora* (see photo below) looks superficially like *Amphora*, but is actually closely related to *Eunotia*. *Eunophora* (a recently described genus, see Vyverman *et al.* 1998) is common in pristine, high-altitude lakes but is rarely found in streams and therefore is not described separately in this manual.

Amphora veneta var. *capitata*

A very small, fine diatom in which the valve markings are difficult to see. Size: 20–40 µm long and up to 15 µm wide (whole valve).

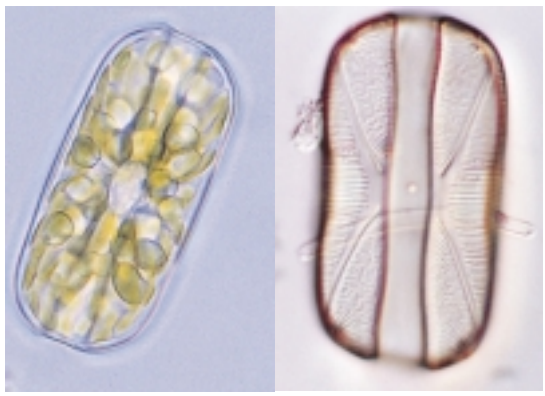
Habitat and distribution: *A. veneta* has been reported as common in a moderately enriched North Island stream and has occurred occasionally elsewhere. It is reported (Cox 1996) to occur in enriched waters and to be pollution tolerant.

Amphora ovalis

Much larger, 30–100 µm long and up to 50 µm wide.

Habitat and distribution: Not seen very often to date. We have found some in the Waiau River. This species is reported to be widespread in medium conductivity waters overseas.

Compare with *Eunophora*:



from top:

Amphora veneta *var.* capitata, *single valve (left) and whole frustule. Cleaned material, from the Waitekauri River, Coromandel. x 1000*

Amphora ovalis, *from the Waiau River, Southland. x 1000*

Eunophora *sp. (Order: Eunotiales). As in* Amphora *the valves lie side by side; however the genus has four to many chloroplasts and features in common with* Eunotia. *Left: live cell , x 700 ; right: cleaned frustule x 1000*

Brachysira

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

Microscopic: A symmetrical biraphid diatom. *Brachysira* species are naviculoid in valve view and more or less rectangular in girdle view. Instead of the regular radial striae seen in *Navicula* species, the valve decorations are more irregular, generally appearing as dashes that line up to form wavy lines down the valve face. There is single, lobed chloroplast.

Possible confusion: The shape is similar to that of *Navicula* (see page 174). However, in the latter, the paired chloroplasts should be distinctive. Under medium to high power (over 400x) it should be possible to see clearly the irregular markings on cleaned frustules of *Brachysira*.

Brachysira vitrea *(= Anomoeoneis vitrea)*

Slender naviculoid shape with pinched ends, 15-40 µm long and about 5 µm wide. Striations not clear on the valve face, even at high power.

Habitat and distribution: Widespread mostly in low to medium conductivity waters. Most commonly found in lakes and tarns, but has has been found in periphyton samples from lake-fed streams and rivers, e.g., it is quite common in the Waiau River in Southland.

Brachysira serians *(= Anomoeoneis serians)*

Cells larger: 50–100 µm long and 10–20 µm wide. Pronounced naviculoid shape. Variety *acuta* is smaller and has drawn out ends. Identification not certain.

Habitat and distribution: Less often seen in periphyton. More likely to occur in the bottom sediments of clean, acid-water lakes and tarns.

Note: Until recently, *Brachysira* species were included in the genus *Anomoeoneis*. Species remaining in the latter genus are typically found in high conductivity waters. *A. sphaerophora* has been recorded in New Zealand but has not been noted in any of our periphyton samples.

from top:

Brachysira vitrea*, from the Waiau River. x 1400*

Brachysira *cf* serians *var. acuta, live specimen showing the form of the chloroplast (compare with* Navicula*); also note the large oil droplets (food storage). x 1000*

Brachysira *sp. (unknown), Waiau River. x 1400*

*SEM (*Brachysira *sp.) showing markings on the valve face.*

Cocconeis

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Achnanthales

How to recognise the genus:

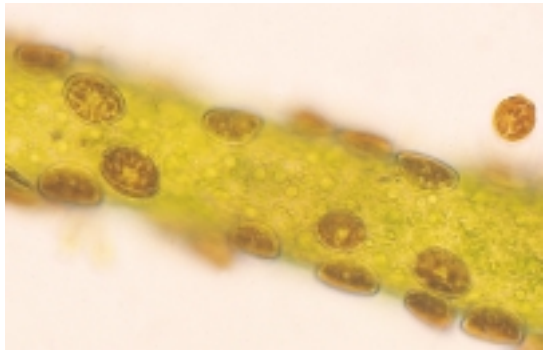
Microscopic: A monoraphid diatom. *Cocconeis* species are oval in shape and virtually always seen in valve view. Commonly epiphytic. There is a single flattened or lobed chloroplast, and the puncta – especially around the edge of the frustule – are often clearly visible. Examining cleaned material under high power (x 1000) should allow you to see both the raphe and rapheless valves, which can be quite different.

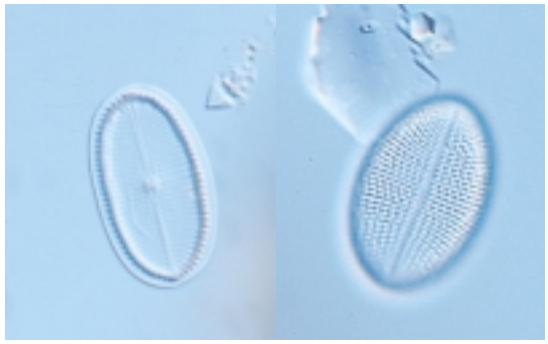
Possible confusion: Usually none

Cocconeis placentula

A oval-shaped diatom that varies considerably in size – from 10 to 90 µm long and 8 to 40 µm wide. Look for the distinctive ridge around the perimeter of the raphe valve. The ornamentation of the raphless valve varies in different varieties.

Habitat and distribution: *C. placentula* is common and widespread, occurring in a range of conditions from clean to moderately enriched to very enriched waters. This species sometimes dominates the periphyton following high flows because its flattened shape allows it to withstand turbulent conditions. Found on stones or growing as an epiphyte on wood, filamentous algae or vascular plants.

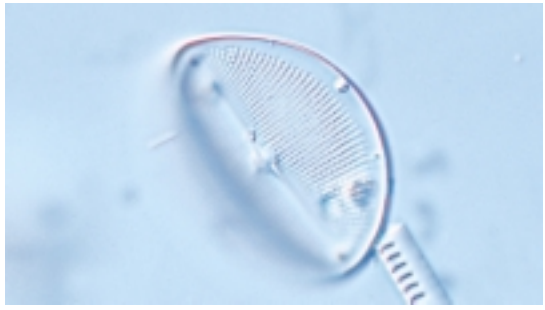




Cocconeis pediculus

C. pediculus differs from *C. placentula* in that it is distinctly curved (so that it is like a bowl) and lacks an extra ring around the outer edge of the raphe valve. Its size range is smaller: 10 to about 30 µm long and up to 20 µm wide.

Habitat and distribution: Grows as an epiphyte on filamentous algae (e.g., *Cladophora*) or on vascular plants. Tends to occur in high conductivity waters. Not as widespread or as common as *C. placentula.* All of our examples have come from periphyton from North Island rivers.



from top:

A filament of the green alga Cladophora *colonised by* Cocconeis *as an epiphyte. x 300*

Cocconeis placentula*, raphe valve (left), rapheless valve (right). x 1200*

Cocconeis *cf.* pediculus*. x 1200*

Cyclotella

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Thalassiosirales

How to recognise the genus:

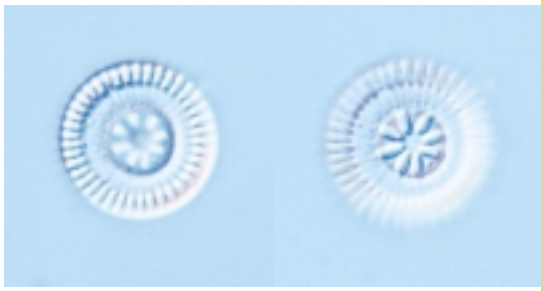
Microscopic: This is a centric diatom. In valve view it is round with radial striae around the edge that differ from the pattern in the middle. The girdle view is rectangular (with rounded corners). There are numerous small chloroplasts.

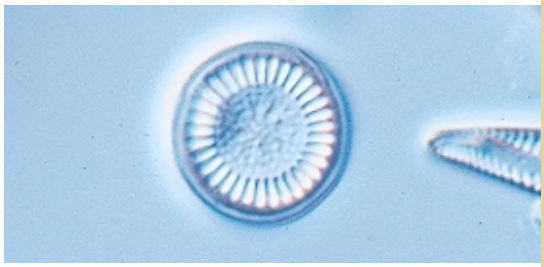
Possible confusion: Many small centric diatoms are difficult to identify. However, the common *Cyclotella* species (below) is one of just a few that turn up regularly in periphyton samples, and it is fairly easy to recognise.

Cyclotella cf. *stelligera*

Microscopic: Cyclotella stelligera is typically 5–40 µm in diameter and circular in valve view, with radial striae around the margin and a few raised bumps in the centre – the overall effect a bit like a daisy. In girdle view the cells are rectangular with rounded edges.

Habitat and distribution: *Cyclotella* is normally planktonic, in lakes. *C. stelligera* is seen occasionally in the periphyton of lake-fed streams and rivers.





from top:

Cyclotella stelligera *in two planes of focus. x 1200*

Cyclotella *cf.* meneghiniana*, another species found in habitats similar to those of* C. stelligera*. x 1400*

Cyclostephanos

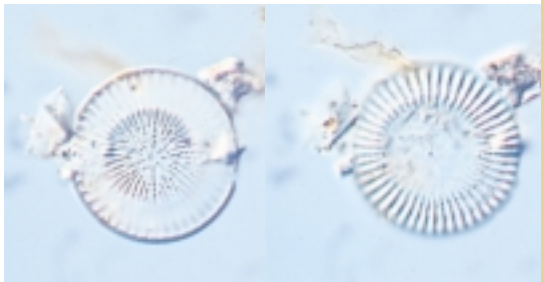
C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Thalassiosirales

How to recognise the genus:

Microscopic: Another centric diatom. It differs from *Cyclotella* (above) in having a pattern of radiating markings on the valve face that is continuous between the edge and centre, though you'll need to view cleaned specimens in different planes of focus. Other ultra-structural details separate the two genera including the presence of spines in *Cyclostephanos*.

Possible confusion: Other centric diatoms (see above); however this genus is clearly distinguishable from *Cyclotella* (above).



Cyclostephanos *sp. in two planes of focus; note that the striae are continuous from the edge to the centre of the valve but the valve is not flat. Common in the Moawhango River, North Island. x 1200*

Cymbella

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Cymbellales

How to recognise the genus:

Macroscopic: Cymbella kappii can accumulate as mats of light brown-green streaky slime.

Microscopic: An biraphid diatom that is asymmetric across the valve. Most species are more or less half-moon shaped in valve view. Some grow on mucilage stalks.

Possible confusion: *Cymbella* resembles *Encyonema* (page 166), and the differences are obvious only under high power (1000 x). In *Cymbella* the raphe ends turn upwards at their outer ends and are deflected downwards in the middle of the valve. In *Encyonema*, it is the other way around. Features of the chloroplast are also reversed in the two genera.
Other half-moon shaped genera include *Epithemia* (page 168) and *Amphora* (page 160). These are fairly easy to separate from *Cymbella*.

Cymbella kappii

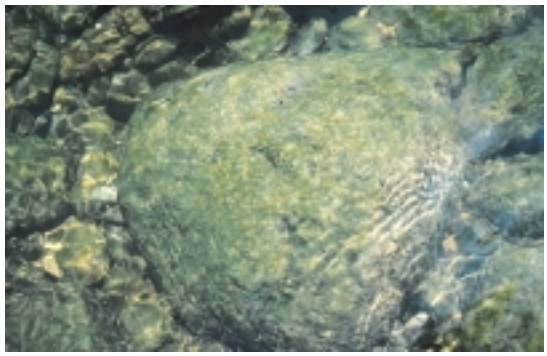
Cymbella kappii is typically 25–35 µm long and about 10 µm wide. Because this species is so common in New Zealand periphyton, you can be reasonably confident from the shape alone that the identification is correct. If in doubt, check that there are two stigmata (isolated holes) in the central area, below the raphe endings (see photo).

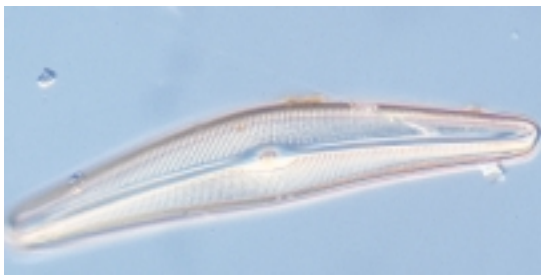
Habitat and distribution: Very widespread in New Zealand and has been recorded as dominant or abundant in several lowland streams and rivers.

Cymbella aspera

C. aspera is a large, easily recognised diatom, typically 70 to 150 µm long and 20 to 45 µm wide. The striae and puncta are large enough to distinguish and count easily. There are no stigmata in the central area of the valve.

Habitat and distribution: This species is seen in the periphyton fairly often, and can be abundant in low-conductivity streams. Widespread.





from top:

Cymbella *slime in the Wangapeka River, near Nelson*

left: Cymbella kappii*. x 1000; right:* Cymbella *sp., showing girdle view. x 800*

Cymbella aspera: *live specimen showing chloroplast.Note the "fold" at the dorsal (top) side of the cell. In* Encyonema*, this is at the bottom. x 350*

Cymbella aspera, *cleaned specimen. Note lack of stigmata. x 350*

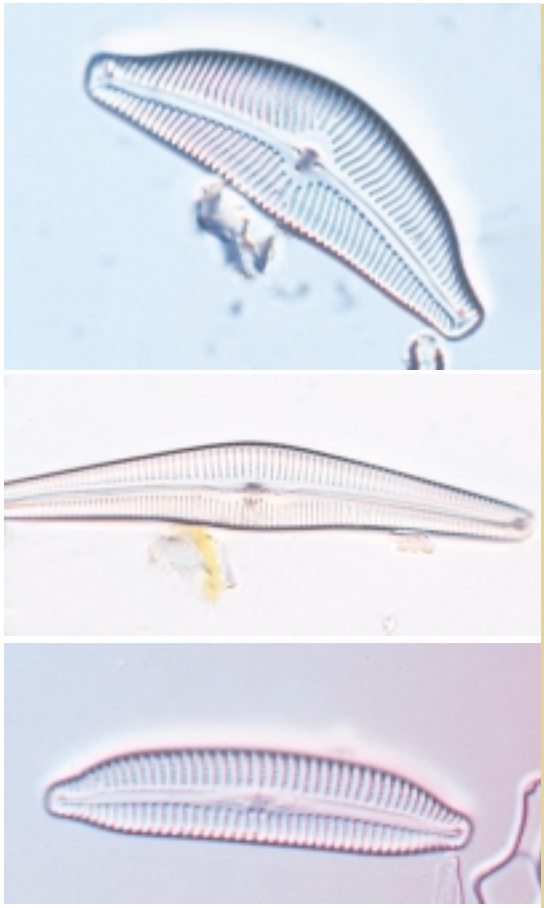
Cymbella tumida

A larger, chunkier diatom than *C. kappii*, typically 40–80 µm long and 15–20 µm wide. Slightly bulbous ends; striae radiating from a round central area with a single stigma.

Habitat and distribution: *Cymbella tumida* seems to occur in rivers with moderate to high conductivity. It has been noted as common in some North Island samples.

Other *Cymbella* species

Stream periphyton may contain various other species of *Cymbella*. To distinguish these from the three common species described, examine cleaned material under high power and look for: overall shape and size, density and direction of the striae, shape and size of the central area and number of stigmata present.



from top:

Cymbella tumida*, from the Maowhango River, North Island. x 1200*

Cymbella cistula *var* gracilis*. Note 4 stigmata. x 700*

Cymbella *sp. (unknown). x 1000*

Diatomella

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

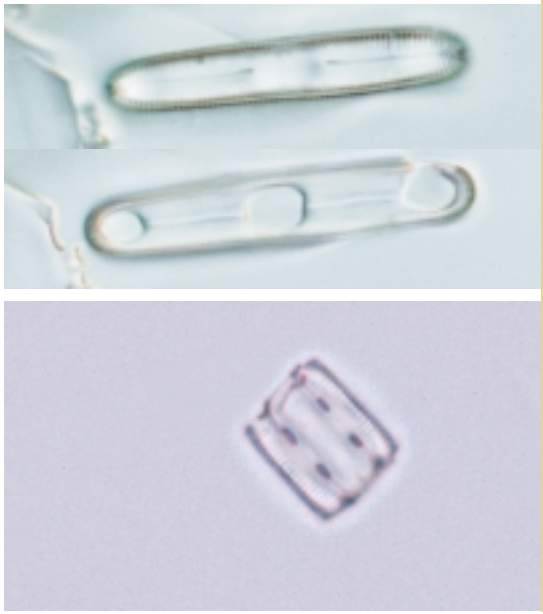
Microscopic: A symmetric biraphid genus with noticeable "septa" present, each a plate with three large holes. In girdle view the solid sept show up as short thick lines.

Possible confusion: A distinctive genus.

Diatomella balfouriana
Diatomella parva

Diatomella balfouriana is up to 30 µm long; *D. parva* around 10 µm.

Habitat and distribution: Possibly confined to clean mountain-fed streams. Distribution not certain. Specimens found in a stream in Abel Tasman National Park (*D. balfouriana*) and in the Waiau River, Southland (*D. parva*).



Diatomella balfouriana*, valve view focussed to show the raphe (lop) and the septum (bottom). x 1400*

Diatomella parva*, girdle view. x 1400*

Diploneis

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

Microscopic: A symmetric biraphid diatom. Usually oval in shape, but sometimes with a constriction in the middle of the valve. The raphe lies in a thick rib of silica. Obvious rows of spots (holes) run parallel to the outer edges of this rib. The striae are easy to see even under low power. Two chloroplasts.

Possible confusion: A fairly distinctive diatom genus.

Diploneis elliptica

Diploneis elliptica is basically oval, usually between 20 and 80 µm long. It is distinguished from other species by its shape, rounded central area and the coarse striae and puncta. *Diploneis ovalis* is similar in shape but has finer striae and puncta.

Habitat and distribution: Usually inhabits lakes, though we have found this diatom in the periphyton of lake-fed rivers; can be occasional to common.

Diploneis *cf.* elliptica. *x 1800*

Encyonema

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Cymbellales

How to recognise the genus:

Macroscopic: Some species of *Encyonema* grow in mucilage tubes (see page 155) and can accumulate as extensive mats of light brown slime.

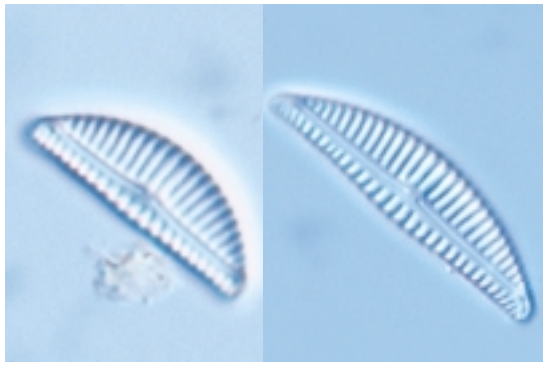
Microscopic: A biraphid diatom, asymmetric across the valve with most species roughly half-moon shaped. Look for upward-pointing central raphe endings and downward-pointing terminal endings. The chloroplast in valve view is more or less H-shaped.

Possible confusion: *Cymbella* (see page 164).

Encyonema minutum (= *Cymbella minuta* = *Cymbella ventricosa*)

Small (15–30 µm long, 5–7 µm wide) with a more or less flat ventral (bottom) side and a strongly rounded dorsal side. The striae can be seen clearly at 400↔ and the raphe runs close to the ventral (bottom) margin. There are no stigmata.

Habitat and distribution: *E. minutum* is common and widespread throughout New Zealand. It has been recorded as dominant or abundant in periphyton from streams draining moderately developed catchments.



Encyonema minutum, *cleaned specimens showing range of size. x 1500*

Encyonema gracile *(= Cymbella gracilis = Cymbella lunata)*

Narrow cells, slightly rounded on the dorsal (upper) side and more or less flat beneath, from 30 to 50 µm long and 5 to 7 µm wide. The rounded ends sometimes seem to point slightly downwards. Fine striae.

Habitat and distribution: This species seems to occur mostly in the periphyton of clean-water lake-fed rivers. It has also been recorded in the periphyton of high altitude lakes and tarns (acid conditions?). Most examples seen in South Island samples.

Encyonema prostratum *(= Cymbella prostrata)*

Chunky cells with prominent markings, often seen as filaments in mucilage tubes. Cells are 40–80 µm long and 20–30 µm wide. The striae contine right around the ends of the valve.

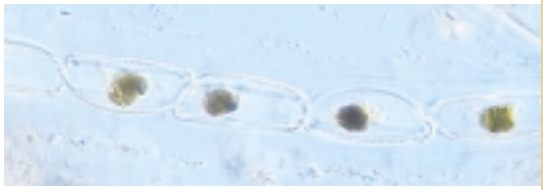
Habitat and distribution: Seems to occur usually in relatively high conductivity streams. This species does not appear to be widespread but it has been reported in abundance in the Shotover River (S. Moore, pers. comm.) and in a stream near Murchison.

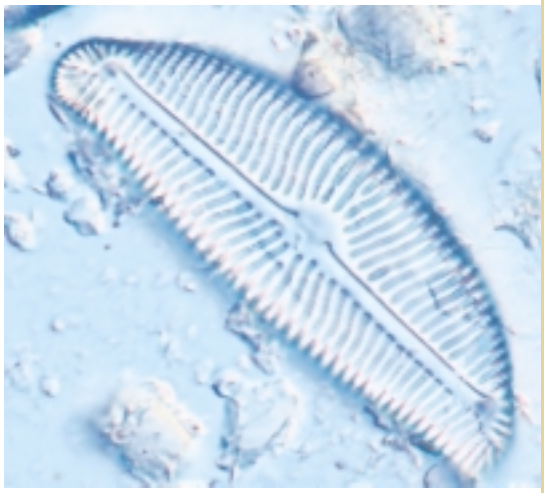
Encyonema caespitosum *(= Cymbella caespitosa)*

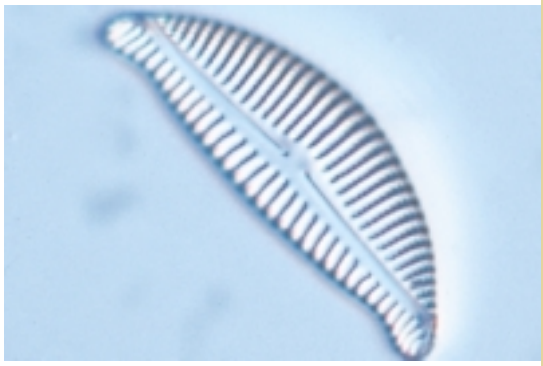
Microscopic: Smaller than *E. prostratum*, with more pointed ends; 20–40 µm long and 10–15 µm wide. The cells often have a somewhat asymmetrical appearance. Again the striae are quite prominent. Occurs as filaments in mucilage tubes (see illustration page 155).

Habitat and distribution: Found in the periphyton of large rivers. Distribution unknown.

Note: The old genus *Encyonema* has now been expanded to include many species placed in *Cymbella*, including the examples above. (See Round *et al.* 1990.)







from top:

Encyonema gracile. *x 1400*

Encyonema prostratum *cells in a mucilage tube. x 350*

Encyonema prostratum. *x 1400*

Encyonema caespitosum. *x 1400.*

Epithemia

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Rhopalodiales

How to recognise the genus:

Microscopic: Epithemia has an "external" raphe. In valve view the cells are typically shaped like an orange segment (side view) or half-moon; the girdle view is roughly rectangular. Thickened areas (costae) on the valve wall show up as obvious dark lines under LM. The raphe runs in a "canal" along the ventral (i.e., the bottom, concave) edge of the valve, curving up at the centre. A single deeply lobed sheet-like chloroplast lies at the ventral side of the valve. All cells contain symbiotic cyanobacteria (visible as small spheres mainly in the girdle view of live specimens).

Possible confusion: Possibly *Cymbella* and *Encyonema* (see pages 164, 167). However, the structure of *Epithemia* is quite different from either of these genera.

Epithemia sorex

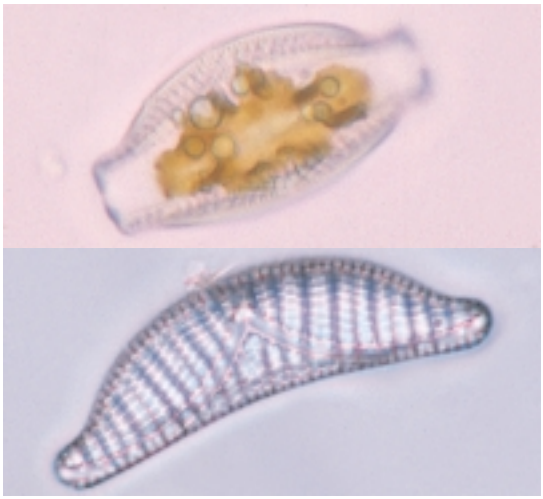
Epithemia sorex is 20–60 µm long and 6–16 µm wide. In valve view it looks like a "Napolean's Hat". In girdle view it is oval with squared-off ends (because of the way the valve bulges out at the sides). In valve view the entire raphe canal is visible.

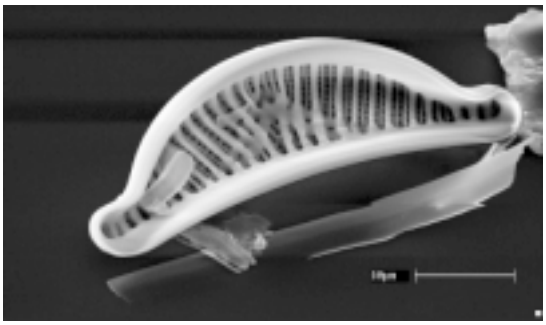
Habitat and distribution: Common, found in lowland (enriched) streams and rivers throughout New Zealand, often growing attached to plants and other algae. It occasionally dominates periphyton, usually in moderately enriched streams after prolonged low flows.

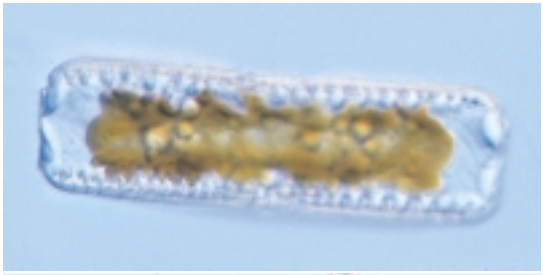
Epithemia cf. *adnata* *(= Epithemia zebra)*

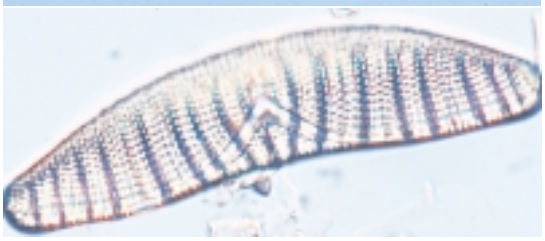
Larger than *Epithemia sorex*, up to 150 µm, with rounded ends, coarser markings and costae usually more widely and less regularly spaced. Rectangular in girdle view.

Habitat and distribution: Seems to be widespread, though not usually common in periphyton. Often occurs with *Epithemia sorex*. Reported to prefer moderate to high conductivity streams, possibly extending to brackish water (Cox 1996).









from top:

Epithemia sorex*, girdle view (live cell). x 850, valve view (cleaned specimen). x 1400*

SEM showing internal "costae" and raphe canal.

Epithemia *cf.* adnata*, girdle view (live). x 500; valve view (cleaned specimen). x 1000*

Frustulia

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

Microscopic: Frustulia is a symmetrical biraphid naviculoid genus, rectangular in girdle view. The raphe is distinctive: instead of a simple slit (or line), there is a ridge at either side (actually on the inside of the valve) so that the raphe appears to lie in a channel. The striae are very fine, barely visible under LM. Two chloroplasts, as in *Navicula*, but usually extending futher across the valve face.

Possible confusion: Other naviculoid genera. Look for the form of the raphe, especially the outer ends, and the extent of the chloroplasts. In *Navicula* (see page 174) the two lateral chloroplasts do not extend the width of the valve.

Frustulia rhomboides

A fairly large species, somewhat angular in shape, from 70 to 150 µm long and to 30 µm wide (at the widest point).

Habitat and distribution: Usually occurs only occasionally in stream periphyton, but this species can be abundant. It can also be very common in clean-water lake sediments. Widespread.

Frustulia rhomboides var. *crassinerva*

Smaller than *Frustulia rhomboides*, 30–50 µm long. This variety has capitate (pinched) ends and very slightly undulating margins.

Habitat and distribution: Not certain. Again may be abundant in streams in some areas (e.g., West Coast). May be more common in cleaner (acid) waters.

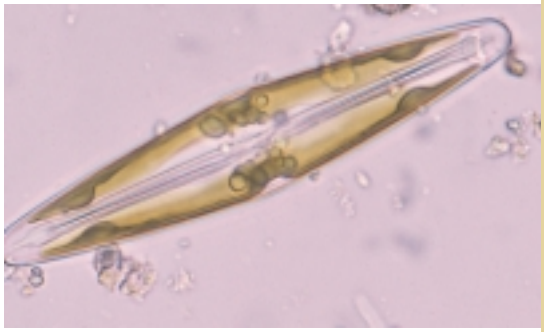
Note: Other varieties of *Frustulia rhomboides* have more rounded sides, or are longer and more slender.

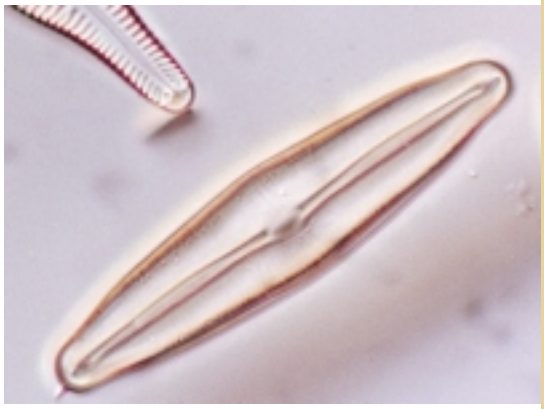
Frustulia vulgaris

Up to 60 µm long, 12 µm wide. The cell has barely capitate ends and slightly rounded sides. The valve face sometimes looks slightly asymmetrical, with the raphe tending to one side.

Habitat and distribution: This species occurs quite often in periphyton samples over a range of conditions; can be common.

Note: Some species of *Frustulia* form "filaments" of cells in mucilage tubes. See page 155.





from top:

Frustulia rhomboides, *live specimen. x 450*

Frustulia *cf.* rhomboides *var.* crassinerva*. x 1300*

Frustulia *cf.* vulgaris. x 1300

Gomphoneis

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Cymbellales

How to recognise the genus:

Macroscopic: Gomphoneis can form thick, glistening, light-brownish mats on river substrates.

Microscopic: An asymmetric biraphid diatom, *Gomphoneis* is club-shaped in valve view, with the raphe lying along the centre of the long axis. Under high power (in cleaned specimens) there seems to be a discontinuity in the density of the striae about half way between the valve margin and the raphe. This occurs where the puncta go right through to the inside (see SEM below). Double rows of striae may just be visible. In girdle view the genus is wedge-shaped. *Gomphoneis* grows attached to the substrate by long branching mucilage stalks. The chloroplast seems to be H-shaped, with sheets flattened against each valve face and joined at the centre.

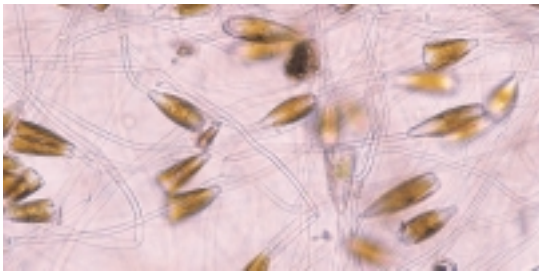
Possible confusion: *Gomphonema* spp. (page 171). Look for the larger size, double striae (barely visible under LM) and long stalks in *Gomphoneis.*

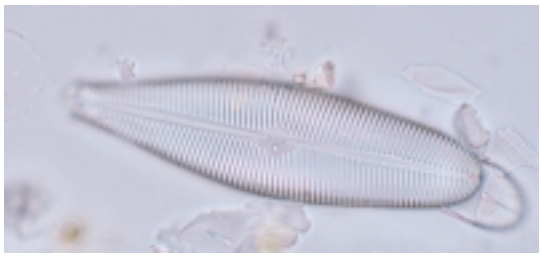
Gomphoneis minuta var. cassieae

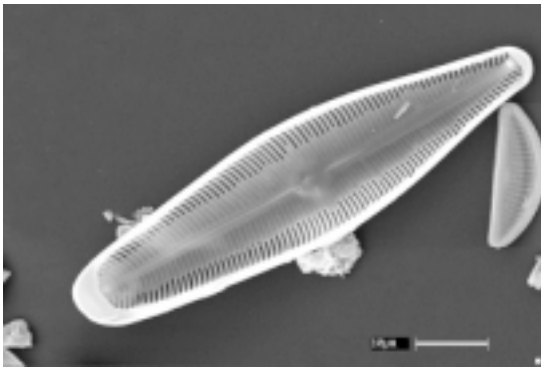
Gomphoneis minuta var. *cassieae* ranges in size from 60 to 100 µm long and about 20 µm wide (at the widest point).

Habitat and distribution: This species occurs all over New Zealand and often dominates periphyton communities in moderately enriched to enriched waters.

Note: This species has formerly been identified as *Gomphoneis herculeana* and was re-assigned by Kociolek and Stoermer 1988. We assume here that the New Zealand form of *Gomphoneis* is *G. minuta* var. *cassieae*. However, the difference between the two species is subtle.







from top:

Thick Gomphoneis *growth on a stone, with* Fragilaria *(the darker strands in the middle).*

Mass of live Gomphoneis*, showing stalks. x 125*

Gomphoneis minuta *var.* cassieae*, cleaned specimen, x 820*

The interior structure of Gomphoneis*. SEM.*

Gomphonema

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Cymbellales

How to recognise the genus:

Microscopic: There are many species of *Gomphonema* in New Zealand, some of which still await description. Obvious features of this asymmetric biraphid genus are longitudinal asymmetry and a wedge shape in girdle view. Many live attached to the substrate – either rocks or water plants, for example, and sometimes growing in masses – by long or short mucilage stalks that enable them to withstand water currents.

Possible confusion: *Gomphoneis* (see page 170).

Gomphonema parvulum

Distinguished mainly by size and shape: 10–25 µm long; narrow leaf-like with pinched ends (slightly pinched or markedly so). Under high power, cleaned specimens are identified by the more-or-less parallel and relatively densely spaced striae (though the latter is very variable), a space on one side of the central area, and a single "stigma" opposite the space.

Habitat and distribution: *G. parvulum* is generally considered to be pollution tolerant, and if common to dominant in a sample, this often indicates that there is some enrichment (particularly organic) to the water.

Note: Most *Gomphonem*a specimens of the shape and size illustrated are likely to be *G. parvulum*. However, another species, *Gomphonema angustatum* , is similar and it can be difficult to decide which one you have, even under high power. Many specimens seem to have spaced out central striae characteristic of *G. angustatum*, but also have striae that are close to parallel rather than radiate. The former is characteristic of *G. parvulum*). *G. parvulum* and *G. angustatum* are clearly distinguished in, for example, Foged (1979, p. 57/59, pl 38). However, illustrations in other publications (e.g., Krammer and Lange-Bertalot 1997) are not as clear cut.

Note: Don't confuse the similarly named species *Gomphonema angustatum* and *G. angustum* (see page 172)

from top:

Small Gomphonema *sp., growing massed together attached to substrate, mostly in girdle view.*

Two specimens of G. *cf.* parvulum. x 1600

Left: Uncertain species, possibly a variety of G. *cf.* parvulum*, wider, with more densely spaced striae than we see normally. Right:* G. parvulum *tending towards* G. angustatum? *x 1600*

Gomphonema *sp., girdle view. Note the thickened areas on each side, indicating the raphe endings.*

Gomphonema truncatum *(= G. constrictum)*

"Jelly-baby"-shaped with a rounded end. 20–70 µm long, striae radiate at the centre with a space at centre on both sides of valve and a single stigma.

Habitat and distribution: A fairly common epiphyte, usually in moderate to high conductivity streams.

Gomphonema acuminatum

A very distinctive shape, like *Gomphonema truncatum* but with an extra projection at the end. 30–100 µm long.

Habitat and distribution: Sensitive to moderate levels of pollution (Cox 1996). Widespread and can be common.

Gomphonema cf. *minutum* *(= G.tenellum)*

Small, narrow species, up to 25 µm long and about 5 µm wide, with quite widely spaced striae.

Habitat and distribution: This small species seems to be widespread and can be very common. Often in fairly clean streams. Identification is uncertain.

Gomphonema cf. *angustum* *(= G.intricatum)*

Narrow, elongated cell, up to 50 µm long and 8 µm wide, with a wide axial area.

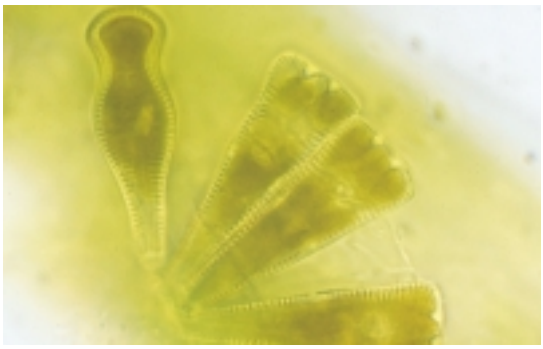
Habitat and distribution: Reported to prefer clean streams.Seems to be widespread and can be common.

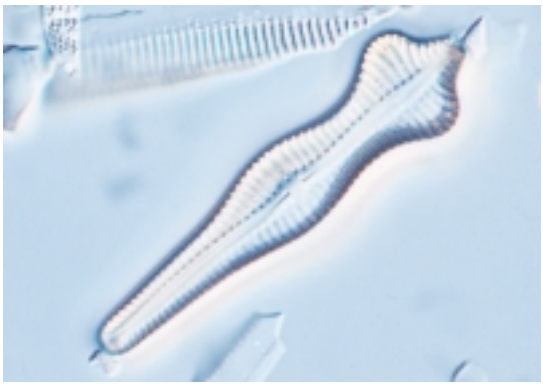
Gomphonema clavatum *(= G. longiceps)*

Club-shaped, blunt ends, 25–100 µm long. narrow axial area with central stria shorter, wider spaced, one stigma.

Habitat and distribution: Encountered occasionally. Distribution not certain.

Note: The above are some of the more obvious species of *Gomphonema* found in stream periphyton. There are many others. In processing periphyton samples, the best way to deal with them is to note the different forms in a sample, assign any to the above species, then simply assign numbers to the others (see Section 8.1).





from top:

Gomphonema truncatum, *live cells. x 1000*

Gomphonema acuminatum. *x 1250*

Gomphonema *cf.* minutum. *x 1250*

Gomphonema *cf.* angustum. *x 1250*

Gomphonema clavatum. *x 1250*

Gyrosigma

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

Microscopic: Gyrosigma has a sigmoid shape, with fine striae. It is biraphid, like *Navicula*. There are two chloroplasts, one along each side of the girdle bands.

Possible confusion: Another genus, *Pleurosigma*, has a similar shape, but is rarely seen in fresh water in New Zealand. In *Pleurosigma* the puncta often appear to lie in diagonal rows, while in *Gyrosigma*, if visible, they lie parallel to the raphe.

Gyrosigma cf. *scalproides*

Parallel sides, with the ends turning in opposite directions to form an S-shape. 60–100 µm long and about 15 µm wide. Central raphe endings are T-shaped (but this can be difficult to make out).

Habitat and distribution: This species has been recorded as abundant in lowland streams in North Island, but does not seem to be widespread.

Note: *Gyrosigma spencerii* (not illustrated) is similar in size but tapers more gradually towards the ends. It seems to be quite widespread, but not common. Reported to occur in high-conductivity streams.

Gyrosima *cf.* scalproides *from the lower Waitekauri River, Coromandel. live specimen, x 700; cleaned valve, x 700*

Mastogloia

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Mastogloiales

How to recognise the genus:

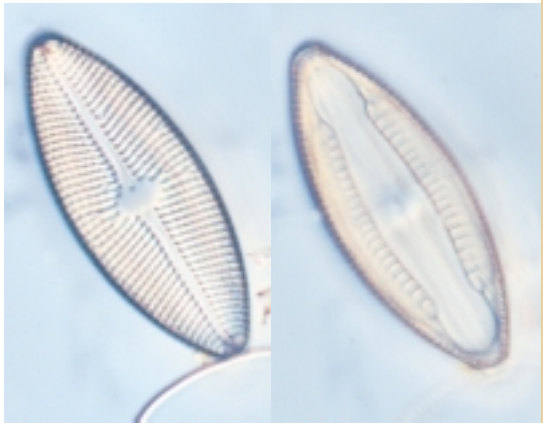
Microscopic: Mastogloia is biraphid and fairly "chunky" (i.e., heavily silicified). Naviculoid in valve view with a distinctive wavy raphe. Focussing through the specimen reveals a series of chambers on each side of the valve, which is part of the girdle. In valve view the frustule is rectangular, with the chambers visible. Two chloroplasts, one at each end.

Possible confusion: Normally very distinctive, but when separate from the girdle, the valve faces could be mistaken for *Navicula* (see page 174). Look for the wavy raphe.

Mastogloia elliptica

Microscopic: Roughly oval, with slightly pinched ends, 30–70 µm long and 10–20 µm wide.

Habitat and distribution: *M. elliptica* can be common in the periphyton of lake-fed rivers in both North and South Islands.



Mastogloia elliptica, *focussing on the valve face (left) and the internal chambers (locules) (right). x 1200*

Meridion

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Fragilariales

How to recognise the genus:

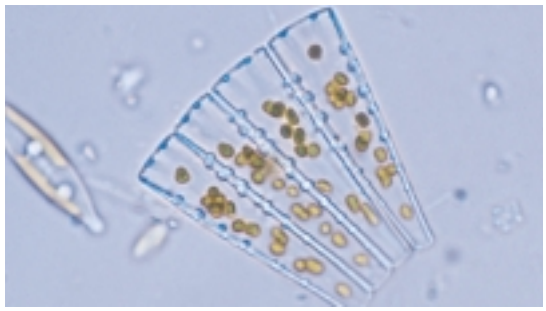
Microscopic: An araphid genus, *Meridion* forms semi-circular or radial colonies of valves joined face to face. In girdle view, the valves are wedge shaped. Like *Diatoma*, thick ribs ("costae") cross the valve face and these are visible in girdle view as small knobs down each long edge. There are several small chloroplasts dotted around the cell. This is a small genus with only one main species.

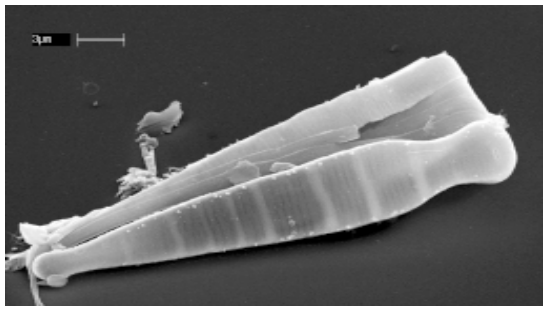
Possible confusion: Unlikely.

Meridion circulare

From 20 to about 80 µm long.

Habitat and distribution: *Meridion circulare* seems to prefer clean, cool streams, in which cells attach themselves to the substrate with a mucilage pad. It is usually not very common. A "cleanwater species" in Cassie (1989).





from top:

Meridion circulare *colony. x 900*

SEM of a single frustule of M. circulare*.*

Navicula

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

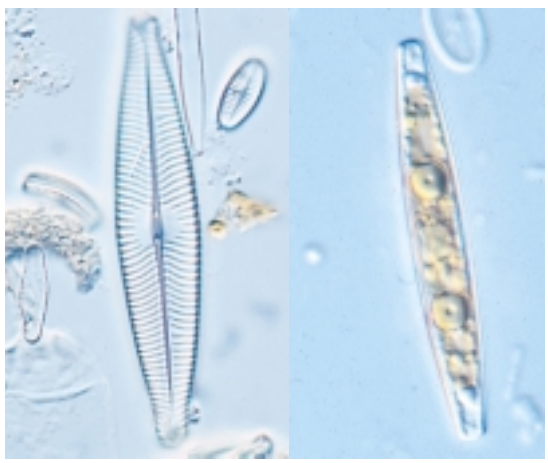
Microscopic: Navicula occurs in almost all periphyton samples containing diatoms. The genus is biraphid, with basically lens-shaped ("naviculoid") frustules. Two narrow chloroplasts are located laterally in valve view. Striae usually radiate from the centre. In fresh samples *Navicula* species tend to be noticeably motile.

Possible confusion: Other naviculoid diatoms include *Frustulia, Mastogloia, Neidium, Brachysira, Stauroneis*. Look for the narrow paired chloroplasts in healthy *Navicula.*

Navicula lanceolata (= N. avenacea)

Up to about 70 µm long, with noticeable striae radiating from a round central area, becoming convergent at the ends. which are blunt and barely capitate.

Habitat and distribution: *N. lanceolata* is widespread, common and can dominate the periphyton in streams of low to moderate conductivity. Often called *N. avenacea.*



left. Navicula lanceolata *x 900. right, Girdle view of a live specimen. x 900*

Navicula cryptocephala

Small, slender, with capitate ends; 20–40 µm long and 5–7 µm, wide. Narrow axial area expanding to a rounded area at the centre of the valve. In live material look for fine striae, and the arrangement of the two narrow chloroplasts exactly opposite each other.

Habitat and distribution: Widespread and common; occasionally dominates the periphyton in relatively clean streams.

Navicula capitoradiata

Similar in size to *N. cryptocephala*, but a little fatter with a smaller central area. The chloroplasts are slightly offset from each other (see Cox 1996).

Habitat and distribution: Cox (1996) reports that *N. capitoradiata* prefers high-conductivity streams and is pollution tolerant. Thus it may be important to separate it from *N. cryptocephala.* Distribution in NZ uncertain.

Navicula rhynchocephala

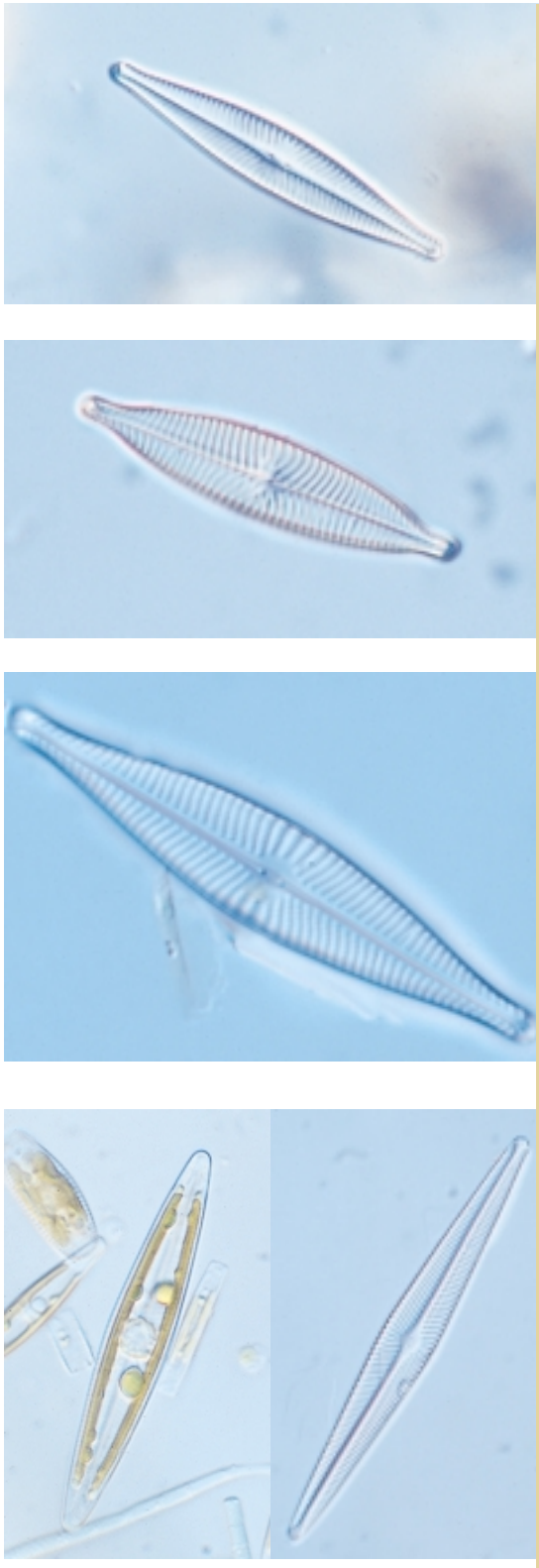
Resembles a bigger (35–80 µm long) version of *N. cryptocephala.* The striae are coarser and the central area rounded (like *N. avenacea*). The chloroplasts are wider and rather ragged looking.

Habitat and distribution: Widespread in low to moderately enriched streams draining foothills, but not usually common. Reported as a "grossly polluted water species" (Cassie 1989).

Navicula radiosa

Microscopic: Longer and narrower than either *N. avenacea* or *N. rhynchocephala*, up to 100 µm long. Ends definitely not capitate. Striae radiate out from the centre. Central area smaller than *N. avenacea.* Long thin chloroplasts lie opposite each other.

Habitat and distribution: Found in cool, clean streams. Widespread but not usually common. Reported to be sensitive to moderate pollution (Cox 1996).



from top:

Navicula cryptocephala, *x 1500*

Navicula capitoradiata, *x 1500*

Navicula rhynchocephala, *x 1500*

Navicula radiosa*; (left) live specimen x 600; (right) cleaned specimen, x 600*

Navicula cf. *margalithi*

Blunt cigar-shaped typically 40–50 µm long and 10 µm wide. Distinctive in its almost parallel striae.

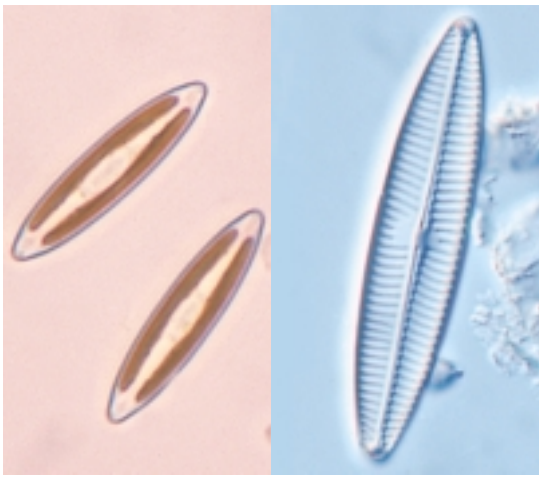
Habitat and distribution: This species has been recorded as common in some North Island locations. Not yet found in South Island yet. (Tentative identification.)

Note: Many other species of *Navicula* occur in stream periphyton usually as "occasional" or less, e.g., :

N. gregaria: about 15 µm long, pinched ends, striae parallel, chloroplasts markedly offset.

N. cincta: 15–25 µm long, smooth-sided (like a rugby ball), chloroplasts opposite.

(Both species reported to occur in high-conductivity streams. *N. cincta* may be pollution-tolerant.)



Navicula *cf.* margalithi*, Moawhango River, North Island. left, live cells x 700; right, cleaned specimen x 1400.*

NB. Navicula *cf.* gregaria *appears on the photo of* Meridion*, page 174.*

Neidium

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

Microscopic: Biraphid, symmetric naviculoid cells, rectangular in girdle view. Very fine striae that lie more or less parallel across the valve. In most species, at the centre of the valve the raphe endings curve in opposite directions. There are four chloroplasts per cell.

Possible confusion: Usually easy to recognise by its size and shape, the distinctive central raphe endings (if present) and the four chloroplasts.

Neidium affine

Usually 40–80 µm long and about 20 µm wide, with rounded capitate ends and slightly curved margins, not quite parallel.

Habitat and distribution: Fairly widespread but not very common. Usually found in clean streams.

Neidium iridis

A larger species, 50–90 µm long. Slightly rounded sides curving smoothly to the ends.

Habitat and distribution: Reported usually from very slow moving streams or ponds. Widespread but not common.

left: Neidium affine*, from the Waiau River, Southland. x 1100*

right: Neidium iridis*: live specimen from a pond, Wairau Valley, Canterbury. x 700*

Nitzschia

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Bacillariales

How to recognise the genus:

Microscopic: A large genus with an "external" raphe system. Most *Nitzschia* species are narrow needle-like cells. Some are slightly sigmoid (S-shaped). The raphe lies on a ridge (the "keel") near or at one edge of each valve. A series of internal ribs across the keel appear as a row of dots (the "keel puncta") under the microscope. This is very obvious in some species. There are two chloroplasts, arranged along the valve – a good indicator of this genus.

Possible confusion: Small *Nitzschia* species may be confused with some small *Synedra* species, especially where the chloroplasts are not clearly visible (see page 187). Look for the more delicate structure (less silicon) of many *Nitzschia*. If possible, examine specimens at 1000x and look for the keel puncta. The genus *Hantzschia* (not in this manual) is closely related; the main *visible* difference from *Nitzschia* is strong asymmetry across the valve. *Nitzschia* has many species that are difficult to identify. All identifications below are tentative.

Nitzschia cf. *palea*

Usually 15–60 µm long and up to 5 µm wide. Delicate-looking sometimes with a slightly asymmetric appearance. The keel edge is rounded and the opposite edge is slightly rounded, flattened or even slightly concave. The striae are very fine – virtually invisible except at very high power. The keel puncta can also be difficult to make out under low power (400 x and less).

Habitat and distribution: Widespread, common and well-known as a pollution tolerant species.

Nitzschia cf. *amphibia*

From about 10 to 40 µm and 4–6 µm wide. The striae and keel puncta are conspicuous compared with those of *N. palea*.

Habitat and distribution: Widespread and common in a wide range of conditions; may not as pollution-tolerant as *N. palea*, but possibly does best in high-conductivity streams.

Nitzschia cf. *inconspicua*

A minute diatom, 3–15 µm long, with rounded ends. Valve markings not visible except under high power.

Habitat and distribution: Common in high-conductivity streams. Tolerates moderate pollution levels.

from top:

Nitzschia *cf.* palea*, x 1800*

Nitzschia *cf.* amphibia, *x 1800.*

Nitszchia *cf.* inconspicua, *several specimens. x 1800*

Scanning electron micrograph of Nizschia *sp. to illustrate structure. (NB. valve broken at centre.)*

Nitzschia cf. *dissipata*

Usually small but can be up to 70 µm long and 3 to 6 µm wide, with tapering ends. The elongated keel puncta are set in from the valve edge. Very fine striae (not visible under LM).

Habitat and distribution: Seems to be widespread, but not common in stream periphyton samples. Usually in higher conductivity waters.

Nitzschia cf. *linearis*

Typically large (over 90 µm long), with obvious, elongated keel puncta and fine striae.There is a notch at the centre of the valve where the two raphe ends meet (see photo). Long chloroplasts. In fresh samples usually lies in girdle view.

Habitat and distribution: Reported overseas as being tolerant of polluted conditions (Cox 1996). Seems to be widespread in New Zealand. In fresh or frozen material could be confused with *N. intermedia* (below).

Nitzschia cf. *intermedia*

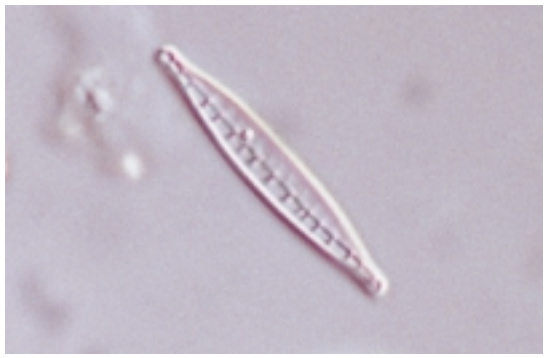
Another large species, up to 150 µm long. The keel puncta are dot-like, more widely spaced than in *N. linearis*, and there is no obvious central notch. Long chloroplasts.

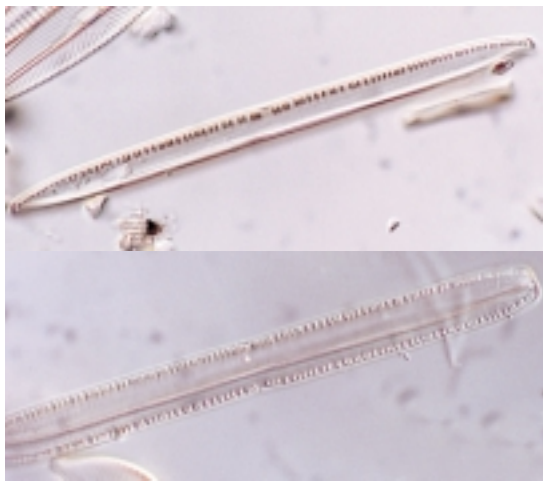
Habitat and distribution: Found widely in periphyton from lowland rivers, and can be common. This species is reported to prefer moderate to high conductivity, but is not particularly tolerant of organic pollution (Cox 1996).

Nitzschia cf. *acicularis*

A delicate species, 20–60 µm long, including fine, drawn-out ends. The keel puncta and striae not visible under the light microscope.

Habitat and distribution: Encountered widely in stream periphyton, but usually not very abundant. This species is reported overseas as being tolerant of moderately polluted conditions (Cox 1996).





from top:

Nitzschia *cf.* dissipata*. Small specimen from the Avon River, Christchurch. x 1400*

Nitzschia *cf.* linearis*, cleaned material. Top: valve view – note notch; lower: girdle view. x 800*

Nitzschia *cf.* intermedia*, x 350, live specimen (girdle view) from the Ashley River, Canterbury, showing chloroplasts and continuous keel puncta.*

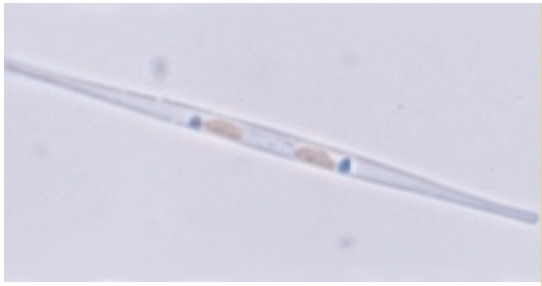
Nitzschia *cf.* acicularis*. Live specimen. x 900.*

Nitzschia cf. *gracilis*

Fine, elongated, up to 100 µm long. Ends drawn out and rounded at the tips. Keel puncta and striae visible only under high power.

Habitat and distribution: Not known.

Note: *Nitzschia sigmoidea* (not illustrated) is a large species (150 –500 µm long and up to 15 µm wide) which is S-shaped in girdle view. In other smaller species the valve is have a sigmoid shape in valve view, e.g., *Nitzschia nana* (= *N. ignorata*, about 50 µm long and 4 µm wide). None of these are common in stream periphyton.



Nitzschia *cf.* gracilis*. live specimen x 1100. Note the two small chloroplasts.*

Pinnularia

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

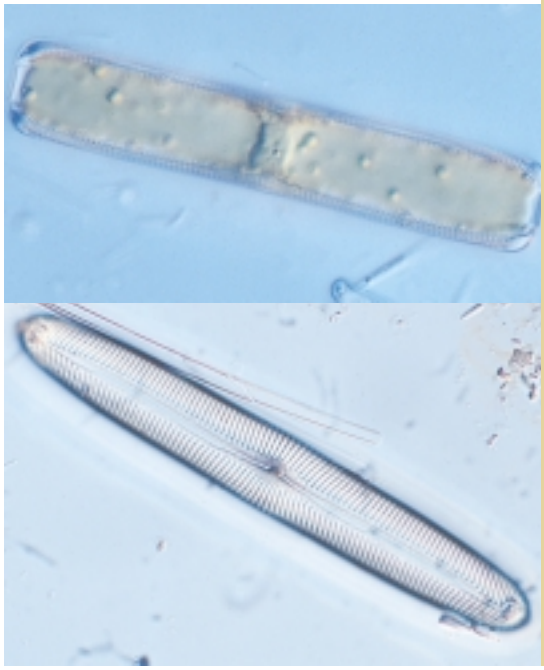
Microscopic: A biraphid symmetric naviculoid genus. Each stria is made up of many tiny holes opening into a chamber, so that the striae appear wide and continuous rather than made up of a series of puncta. This is especially visible in large species. The raphe endings curve strongly in the same direction and some species seem almost asymmetrical across the valve (like *Cymbella*). The two chloroplasts lie one each side of the frustule. In valve view you see both; in girdle view you see a single sheet. *Pinnularia* species are fairly motile.

Possible confusion: Can sometimes look like *Navicula* sp. (see page 74). Note that there are many species of *Pinnularia*, species can be variable and identification can be difficult. Most of the following identifications are tentative.

Pinnularia viridis

A large diatom (up to 150 µm long and 25 µm wide), cigar-shaped with prominent striae that are slightly radiate in the middle of the valve changing to parallel and then convergent at the ends.

Habitat and distribution: Occurs occasionally in stream and river periphyton. Along with many other *Pinnularia* species, the preferred habitat is clean, acid lakes and ponds. Widespread.



from top:

Live Pinnularia. *cf.* viridis *in girdle view, showing the large sheet-like chloroplast. x 500*

Pinnularia viridis*, cleaned specimen. x 700*

Pinnularia cf. *gibba*

Large (80–120 µm long and about 15 µm wide), with very slightly capitate ends. Quite short striae, sometimes with a gap at the centre of the valve; wide axial and central areas.

Habitat and distribution: Habitat uncertain. Not usually common in stream periphyton. Widespread.

Pinnularia cf. *microstauron*

Smaller – up to 70 µm long and 15 µm wide with slightly undulating margins and blunt rounded ends. A gap in the striae at the central area, but much less empty space in the central and axial areas than *P. gibba*.

Habitat and distribution: Probably widespread, usually in low conductivity.

Pinnularia cf. *mesolepta*

Margins definitely undulating, with rounded ends, from 25 to 80 µm long and 15 µm wide.

Habitat and distribution: Probably widespread and found in a range of stream types.

Pinnularia cf. *subcapitata*

Usually small (25 to 60 µm long and are 6–7 µm wide); slightly undulating sides, and rounded slightly capitate. There is a gap in the striae each side of the central area. The axial area can be quite wide.

Habitat and distribution: Occasionally found in stream and river periphyton. Most findings from South Island samples, especially high country streams.

Note: *Pinnularia* species are typically abundant in acid wetland areas. Note also that there are many small species of *Pinnularia*. To distinguish between species look at the cell shape and arrangment of the striae. Is there a gap at the central area? Do the striae radiate from this area? Do they change direction part way along the valve (as in the specimen in the bottom photograph)?

from top:

Pinnularia *cf.* gibba, *Waiau River. x 1200*

Pinnularia *cf.* microstauron*. Tentative identification. x 1200*

Pinnularia *cf.* interrupta*, live cell from a lowland stream, Banks Peninsula, Canterbury. x 1200*

Pinnularia *cf.* subcapitata *variety?. This example has a very wide axial area so the identification is tentative only. x 1200*

Pinnularia *sp. found in a stream on Stewart Island. x 1200*

Placoneis

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Mastogloiales

How to recognise the genus:

Microscopic: Placoneis species are biraphid symmetric naviculoids, usually with fat, rounded sides and capitate ends. The main diagnostic feature is the single lobed chloroplast. Cleaned specimens show strongly radiating striae; individual puncta may be visible under high power.

Possible confusion: *Navicula*: check the chloroplast structure if possible. There are other differences but these are clearly visible only under SEM. *P. placentula* is distinctive.

Placoneis placentula (= *Navicula placentula*)

Usually quite large, up to 60 µm long and noticeably wider than most naviculoid diatoms (up to 25 µm wide).

Habitat and distribution:

Reported to be a clean-water species, but usually in moderate to high conductivity streams (Cox 1996). Widespread but usually not common.

Placoneis placentula *from the Moawhanga River, central North Island. x 1300*

Note: *Placoneis* was formerly included in *Navicula*, but is now reinstated as a genus in its own right (see Cox 1987).

Reimeria

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Cymbellales

How to recognise the genus:

Microscopic: Reimeria is a biraphid asymmetric genus. Features are a small, slightly curved valve view (like *Cymbella*) with a bulge on the concave side, widely spaced striae and small size. Rectangular in girdle view and quite motile.

Possible confusion: With other small diatoms such as *Fragilaria* especially in girdle view.

Reimeria sinuata (= *Cymbella sinuata*)

This is the only species known in New Zealand. *R. sinuata* varies in size from 10 to 25 µm long.

Habitat and distribution: Quite common and widespread in New Zealand stream periphyton. It has been recorded as abundant in lowland rivers, e.g., in Westland, during summer low flows.

Reimeria sinuata*, with girdle view above. x 1900.*

Note: The genus *Reimeria* was established in 1987, based on *Cymbella sinuata* (see Kociolek and Stoermer 1987).

Rhoicosphenia

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Cymbellales

How to recognise the genus:

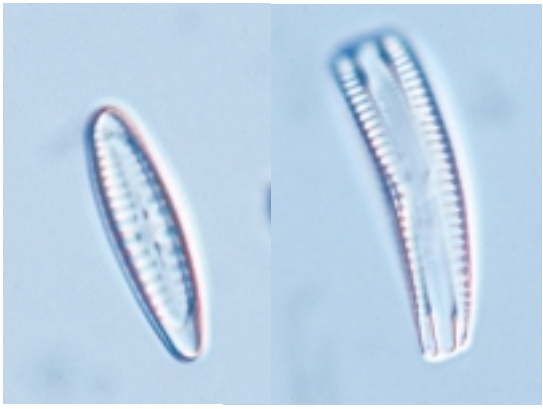
Microscopic: Rhoicosphenia is a small biraphid genus, asymmetric in three planes. In valve view it is club-shaped (like *Gomphonema*); in girdle view it is bent (like *Achnanthidium*) and also wider at one end. Under high power (x 1000) the valve view shows a "thickening" at each pole where an internal layer of silica extends into the cell. The concave valve face has a more highly developed raphe than the convex face. *Rhoicosphehia* grows on short stalks often as an epiphyte on other algae.

Possible confusion: *Gomphonema* (see page 171) – though the girdle view is distinctive.

Rhoicosphenia abbreviata *(= R. curvata)*

Only one species of *Rhoicosphenia* is found commonly in streams. *R. abbreviata* varies in size from 20 to 60 µm long and up to 8 µm wide.

Habitat and distribution: Very common and widespread in New Zealand periphyton. It has been recorded as dominant (growing massed together on substrates) in small lowland streams with moderate to high water velocities. It seems to be pollution tolerant.



Rhoicosphenia curvata *from the Tarawera River; left: valve view; right: girdle view. x 1800*

Rhopalodia

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Rhopalodiales

How to recognise the genus:

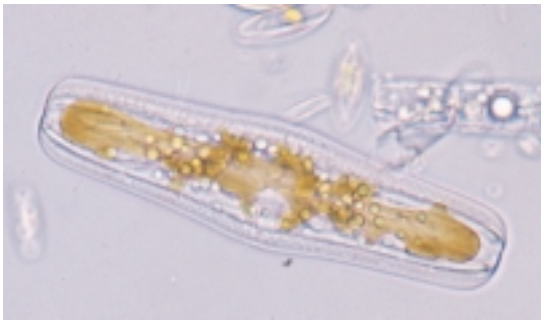
Microscopic: In this genus the raphe system lies close to the valve edges, and the valve faces are rotated so that they lie roughly in the same plane (as in *Amphora*, for example). so you normally see both valve faces at the same time. Thick ribs of silica (costae) may run across the inside of the valves, visible as heavy lines or stripes under LM. There is a single large chloroplast. Some *Rhopalodia* species contain symbiotic bacteria which enable them to fix inorganic nitrogen.

Possible confusion: Unlikely.

Rhopalodia novae-zealandiae

A large diatom up to 200 µm long and 25 µm wide (both valves). Cells have rounded ends and a bulge at the middle of each side, with a slight notch where the raphe ends meet. Striae should be visible at 400x in fresh material,There are no thicker ribs (costae).

Habitat and distribution: Very abundant in lakes but can also be common in clean lake-fed rivers and streams.



Rhopalodia novae-zealandiae, *live specimen showing chloroplast. x 500*

Rhopalodia operculata

Smaller than *R. novae-zealandiae* (20–40 µm long and about 20 µm wide). Valves are rounded on their outer margins and have thick costae running across them.

Habitat and distribution: This species is encountered occasionally in river periphyton. Distribution and habitat preferences uncertain.

Note: May be the same as *R. musculus* in Foged 1979.

Rhopalodia operculata*. x 1200*

Sellaphora

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

Microscopic: A biraphid genus with rounded ends (valve view). The raphe lies in a sort of raised plate running along the centre of the valve. There is often a clear area at each end of the valve. A single chloroplast, with lobes lying against each side of the valve and joined in the middle to form an "H" shape.

Possible confusion: With other naviculoids, though the shape is fairly distinctive, and the chloroplast different.

Sellaphora pupula

S. pupula is 30–70 µm long and 5–20 µm wide. Elongated shape with rounded, slightly capitate ends.

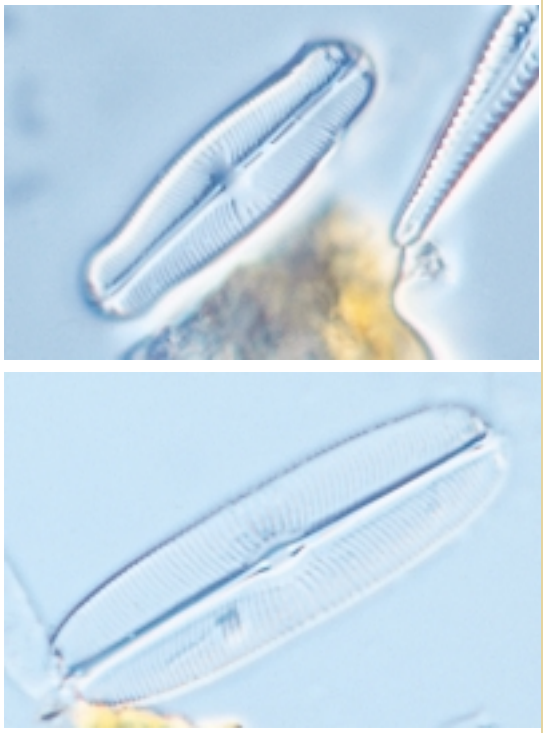
Habitat and distribution: *Sellaphora pupula* seems to be quite widespread in stream periphyton in New Zealand, though never abundant. Overseas, it is reported as being tolerant of a wide range of ecological conditions (Cox 1996).

Sellaphora bacillum

*S*imilar in size to *S. pupula* but has parallel sides.

Habitat and distribution: *Sellaphora bacillum* has been recorded throughout New Zealand (Cassie 1984). It is reported overseas as being tolerant of some pollution.

Note: Species in *Sellaphora* were formerly placed in *Navicula* but have now been transferred back to their original genus (see Mann 1989).



from top:

Sellaphora pupula*, cleaned specimen from the Tarawera River. x 2000*

Sellaphora bacillum*, cleaned specimen from a stream, West Coast, South Island . x 2000*

Stauroneis

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Naviculales

How to recognise the genus:

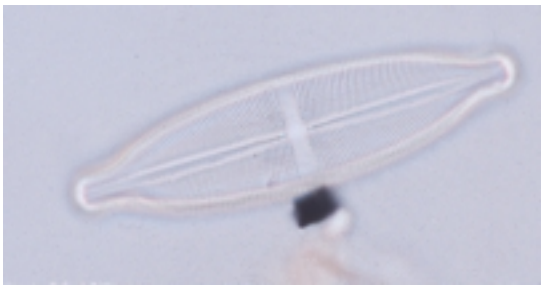
Microscopic: A symmetric biraphid naviculoid. Some species can be quite large (over 100 µm long). The main diagnostic feature is the thickened band of silica across the middle of the valve (this may be difficult to see). There may also be internal flaps of silica at the ends of the valve (cf. *Rhoicosphenia*). Fine striae in which the puncta may be visible. Two chloroplasts lie against the girdle (one each side) and extend under the valve face.

Possible confusion: *Navicula (see page 174)*, other naviculoids.

Stauroneis cf. anceps

Up to 75 µm long and 15 µm wide. Rouded margins terminating in rounded captitate ends. Striae radiate throughout the valve.

Habitat and distribution: Widespread, mostly in ponds and lakes or slow-moving stream outlets. Reported to occur over a wide ecological range (Cox 1996).



from top:

Stauroneis *sp., live specimen showing chloroplasts. x 450*

Stauroneis anceps*, cleaned specimen from the Waiau River. x 1100*

Staurosira

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Fragilariales

How to recognise the genus:

Microscopic: A small araphid genus formerly included in *Fragilaria*. Small cells often cruciform (shaped like a cross), with a prominent striae and a pseudoraphe that usually widens at the centre of the cell. Rectangular in girdle view.

Possible confusion: Other small araphid genera formerly placed in *Fragilaria*, especially *Staurosirella*, which has a very different stria structure (see page 185). In *Staurosira* the striae comprise single rows of small round or oval puncta.

Staurosira construens (= Fragilaria construens)

Cruciform to oval cells 8–25µm long, up to 12 µm wide, rectangular in girdle view, sometimes forming short chains.

Habitat and distribution: Has been recorded as common in clean, spring-fed streams. Widespread.

Drawing of Staur osira construens *showing features visible under LM. x 2000.*

Staurosirella

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Fragilariales

How to recognise the genus:

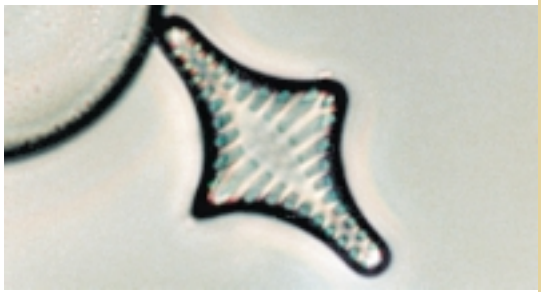
Microscopic: An small araphid genus formerly included in *Fragilaria*. Small cells cruciform or oval with wide striae; pseudoraphe may be wider at the centre. Rectangular in girdle view.

Possible confusion: Cruciform cells of *Staurosira* (page 184). Difficult to distinguish except under high-power LM, although *Staurosira* is usually smaller. In *Staurosirella* the coarse striae are spaced farther apart than the finer striae of *Staurosira*.

Staurosirella leptostauron *(= Fragilaria leptostauron)*

Cruciform cells 15–35µm long and up to 20 µm across, s ometimes forming short chains. Coarse striae widely spaced (less than 9 in 10 µm). Under high power fine lines across the striae may be visible.

Habitat and distribution: Usually occurs in clean rivers and streams, and can be locally common. Distribution not certain.



Staurosirella leptostauron *from the Okuku River, Canterbury. x 2000*

Stenopterobia

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Surirellales

How to recognise the genus:

Microscopic: Elongated cells, sometimes S-shaped, with an “external” raphe system. As in *Surirella* (page 196), the raphe runs around the entire margin of the valve so that the two”distal” raphe ends are adjacent to each other, and the central join is at the opposite end of the cell. There are small ribs around the whole cell margin. A single chloroplast has a large lobe lying against each valve face.

Possible confusion: The S-shaped species could be confused with some *Nitzschia* species that have a similar shape and also *Gyrosigma*. Check the chloroplast.

Stenopterobia species

Stenopterobia delicatissima is spindle shaped with noticeable ribs around the margin. Size: from 30 to 100 µm long.

Stenopterobia curvula is longer, slender, sigmoid with somewhat angular ends (rather than rounded). Marginal ribs faint. Size: up to about 250 µm long.

Habitat and distribution: Both these species have been found in pristine streams draining small lakes and wetlands. Distribution uncertain.

left: Stenopterobia delicatissima*. x 1100*

right: Stenopterobia curvula *with chloroplast partly intact. x 350*

Surirella

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Surirellales

How to recognise the genus:

Microscopic: Surirella species have an "external" raphe. They can be oval to rounded, sometimes with a "waist" at the middle. The "keel" (containing the raphe) encircles the entire valve. Prominent ribs lead onto it. Valves are generally rectangular in girdle view with the ribs visible at each side. There is a single large lobed chloroplast arranged as a plate against each valve face, joined by a narrow "bridge".

Possible confusion: The valve views of *Surirella* and *Epithemia* (page 168) species are occasionally confused.

Surirella linearis

Elongated oval, more or less symmetrical, sometimes with a slight "waist" in the middle. From 40 to 100 µm long and 10 to 20 µm wide. Ribs round the edge quite large and widely spaced.

Habitat and distribution: Seems to occur in a range of conditions, from low-conductivity to enriched. Widespread, can be quite common.

Surirella angusta

Smaller with parallel (or slightly rounded) sides, conical ends and closely spaced ribs. Typical size 20-30 µm long and about 10 µm wide.

Habitat and distribution: Widely found in nutrient-rich lowland rivers and streams.

Surirella brebissonii var. *kuetzingii*

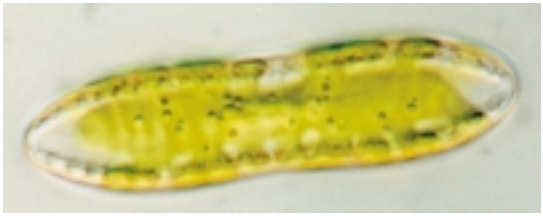
Small and rounded, slightly pointed at one end. Usually 10-20 µm wide.

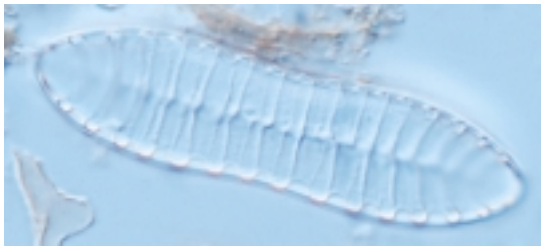
Habitat and distribution: Not certain, but has been recorded as common in a stream in farmland in the Catlins region.

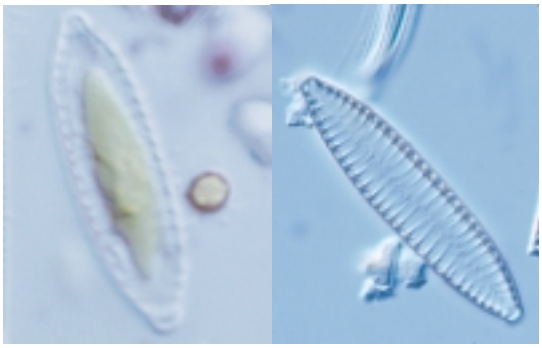
Note: *S. minuta* (not illustrated) also occurs in enriched streams. It is elongated egg-shaped with parallel ribs, 10-45 long and 10 µm wide.

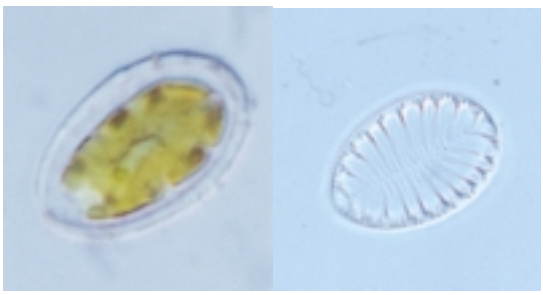
S. tenera (not illustrated) occurs occasionally in stream periphyton. This species is much larger (up to 200 µm long), an elongated oval shape, rounded at one end and much sharper at the other. The ribs are noticeably closer together at the ends of the valve than in the middle. (See Foged 1979 for illustrations.)

Many species of *Surirella* are extremely abundant in freshwater wetland areas.









from top:

Surirella linearis, *live cell showing large chloroplast. x 900*

Surirella *cf.* linearis, *showing ribs. x 900*

Surirella angusta, *live cell and cleaned frustule. x 1200*

Surirella cf. brebissonii var. kuetzingii, *live cell and cleaned frustule. x 1200*

Synedra

C: single cells (diatoms)

Division: Bacillariophyta, **Order:** Fragilariales

How to recognise the genus:

Macroscopic: Sometimes *Synedra* species can dominate the periphyton and may have the appearance of masses of short, thick, brown "filaments".

Microscopic: An araphid genus. *Synedra* are thin pencil-like cells, solitary or occasionally in fan-shaped colonies where the frustules attach to the substrate by one end. A couple of species form filaments like *Fragilaria*. A "pseudoraphe" runs the length of the cell on both valves often with a clear central area in the middle. In the larger species under high power LM, a single "rimoportula" (a small hole) is visible at each end of the valve. This is diagnostic for the genus. Two long chloroplasts, one lying against each valve face.

Possible confusion: The small species of *Synedra* can sometimes be confused with *Nitzschia* (page 177): check the chloroplasts, or examine under higher power. Also some types of *Synedra* and *Fragilaria* (page 151) may be impossible to distinguish without the use of an SEM.

Note: A range of different schemes has been published for classifying *Synedra* species. The following are suggested to cover the common forms found in New Zealand periphyton.

Synedra ulna

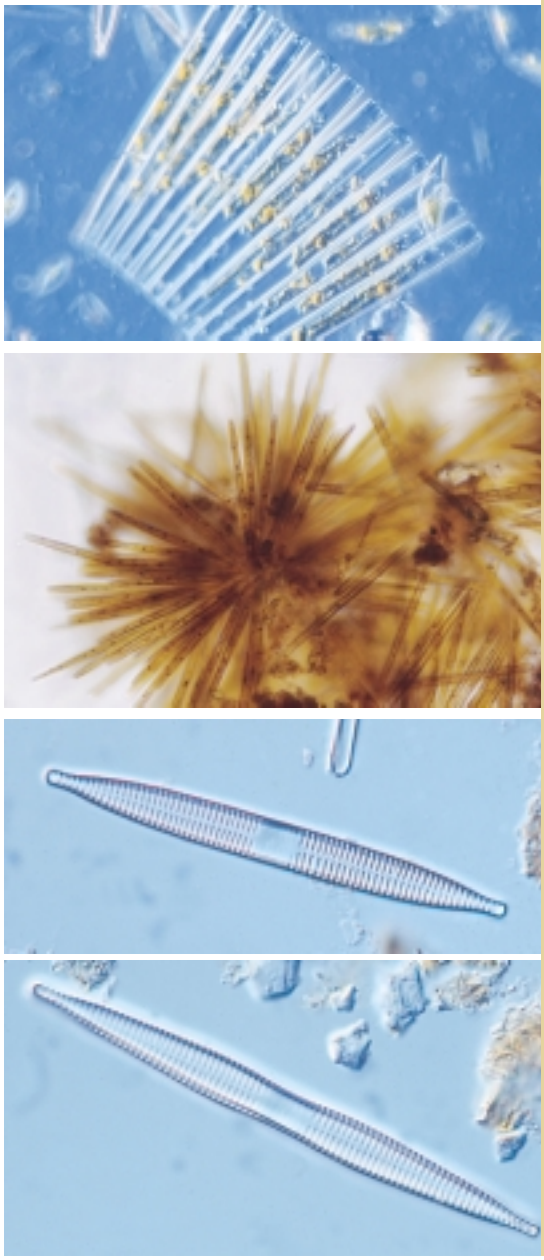
Very variable length, up to 200 µm long. Regular parallel striae and parallel margins tapering or rounded at the apices. (Some varieties differ in shape.) There is usually a clear central area (absent in some varieties).

Habitat and distribution: *Synedra ulna* seems to grow well in response to nutrients. It can dominate the periphyton in enriched lowland streams. The species is widespread and extremely common.

Synedra ulna *var.* contracta

As for *S. ulna*, except that the centre of the valve is slightly concave. Size, up to about 120 µm long.

Habitat and distribution: Frequently found in the periphyton of large lowland rivers. Widespread.



from top:

Synedra ulna *cf. var.* biceps, *growing in a colony joined face-to-face. x 270*

Synedra *cf.* acus, *from the Avon River, Christchurch, growing in star-shaped colonies, each cell attached at one end. x 270*

Synedra ulna, *x 900*

Synedra ulna *var.* contracta. *x 900*

Synedra ulna var. *biceps*

Very long cells (up to as much as 500 µm). No central area. Small spines along the valve margins allow the formation of colonies joined face-to-face (cf. *Fragilaria*).

Habitat and distribution: Found dominating enriched streams in summer. Probably widespread.

Synedra cf. *ulna* var. *ramesi*

Short, stubby with pinched ends and a narrowing at the centre of the valve. Striae fine and slightly irregular-looking. Size: up to 60 µm long.

Habitat and distribution: Seems to occur mostly in clean-water streams and rivers. It is can be quite common.

Synedra acus

The valve definitely tapers from the central area to the ends and there is no narrowing at the centre. 90–180 µm long.

Habitat and distribution: Common. Seems to be mostly in moderate conductivity streams.

Synedra rumpens

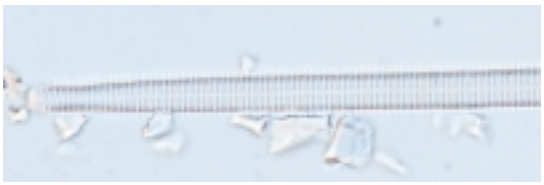
Small fine cells, 25–50 µm long and 2–4 µm wide. Central area apears to be very slightly swollen.

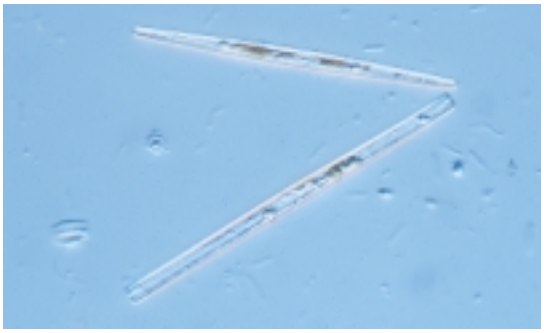
Habitat and distribution: Can be very abundant locally, but its small size and lack of detail make it difficult to discern. There may be confusion with *Fragilaria capucina* (see page 151). Indeed Williams and Round (1987) consider *S. rumpens* and *F. capucina* to be synonomous.

Synedra delicatissima

Very fine, needle-like cells tapering to the apices; up to about 200 µm long and 3–5 µm wide

Habitat and distribution: Not certain.





from top:

Synedra ulna *var.* biceps*. Half of valve. Note spines around the valve margin. Also note the rimoportula (islolated hole) near the tip of the valve. One at each end is characteristic of* Synedra *species. x 700*

Synedra ulna *var* ramesi*. x 1000*

Synedra acus, *live specimen. x 800*

Synedra rumpens*. x 1400*

Synedra delicatissima. *x 400*

Cosmarium

C: single cells (non-diatom)

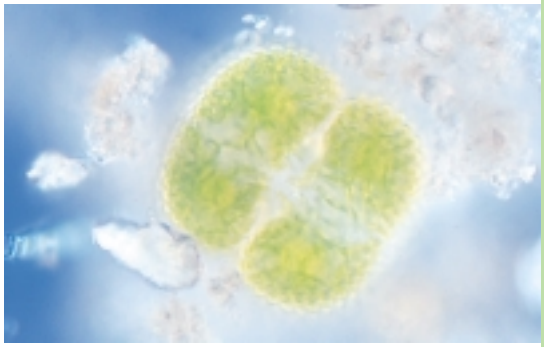
Division: Chlorophyta, **Order:** Desmidales

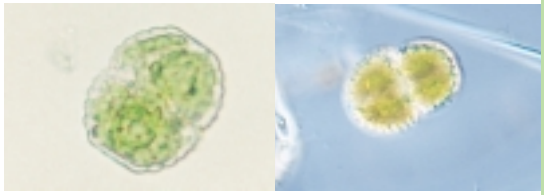
How to recognise the genus:

Microscopic: Like other desmids, *Cosmarium* is clearly divided into two parts, visible in "face view" (see photographs). From the top, the shape is usually rounded or oval. There are many species. Those encountered in periphyton range from relatively small (around 25 µm across) to larger species such as *C. margaritatum* (illustrated).

Habitat and distribution: *Cosmarium* is most abundant in lakes and wetland areas. However some species regularly occur in the periphyton of streams and rivers and can be common.

Possible confusion: Potential confusion with some species of *Staurastrum* (see page 190) which have a triangular top view but may resemble *Cosmarium* in face view.





from top:

Cosmarium *cf.* margaritatum *from the Waitekauri River , Coromandel. x 400*

left: Cosmarium *cf.* impressulum *from the Waitekauri River , Coromandel. x 400; right: Cosmarium sp. x*

Closterium

C: single cells (non-diatom)

Class: Chlorophyta, **Order:** Desmidales

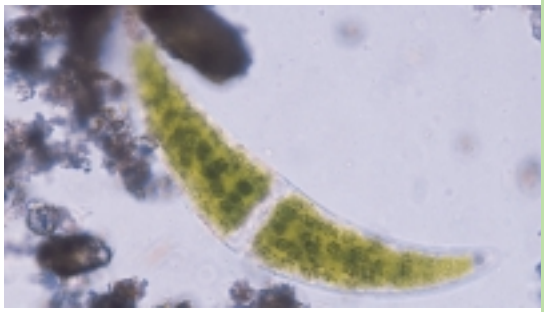
How to recognise the genus:

Microscopic: Crescent-shaped cells with an obvious division of chloroplasts at the centre (but no constriction to the outside of the cell). In live material you should be able to make out vacuoles at each end containing moving granules. Usually large – up to 500 µm long and 40 µm wide.

Habitat and distribution: The genus as a whole is more typical of lake than river habitats, but a large form often occurs in the periphyton. It can be quite common in moderately enriched (e.g., lowland agricultural) streams, in a mixed periphyton community.

Possible confusion: Unlikely.

Note: For a full account of Desmids in New Zealand, see Croasdale and Flint (1986, 1988) and Croasdale, Flint and Raine (1994).



from top:

Closterium *sp. from the Wairau River, North Canterbury. x 270*

A smaller species of Closterium. *x 270*

Staurastrum

C: single cells (non-diatom)

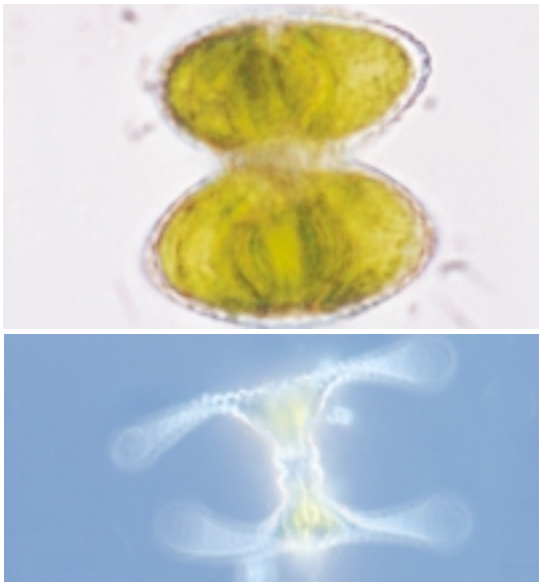
Division: Chlorophyta, **Order:** Desmidales

How to recognise the genus:

Microscopic: Similar to *Cosmarium*, but the top view is three-sided rather than rounded. The form found most often in periphyton resembles a solid triangle rather than the more delicate three-pronged planktonic form. Up to about 40 µm across.

Habitat and distribution: Very common planktonic genus in enriched ponds and lakes. The solid triangular forms can be common in the periphyton of lowland sreams and rivers.

Possible confusion: Possibly with *Cosmarium* (see page 189).



from top:

Side view of Staurastrum *sp., a "solid" type often encountered in periphyton. The top view is triangular. x 400*

The more delicate type of Staurastrum *normally seen as part of the plankton communitiy in ponds and lakes. x 400*

Ankistrodesmus

C: colonial

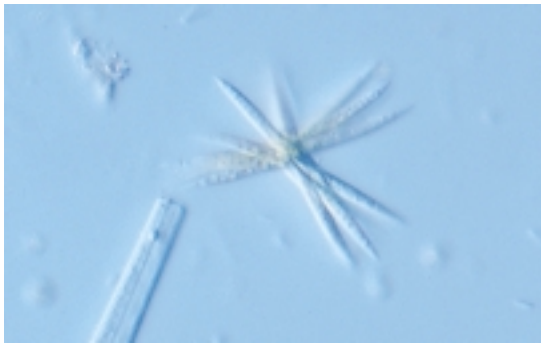
Division: Chlorophyta, **Order:** Chlorococcales

How to recognise the genus:

Microscopic: Small colonies that look like loose bundles of spindle-shaped cells, though the bundles seem to break apart easily and you often seen individual cells scattered among other taxa. Cells may be up to 100 µm long but are often much smaller. The chloroplast covers most of the cell wall and there is usually a pyrenoid.

Habitat and distribution: *Ankistrodesmus* can be common in the periphyton of low- to moderately enriched streams.

Possible confusion: There are other fine, spindle-shaped green algae, but these generally are not a common component of periptyon communities.



Ankistrodesmus *sp. x 650*

Dinobryon

C: colonial

Division: Chrysophyta, **Order:** Chrysomonadales

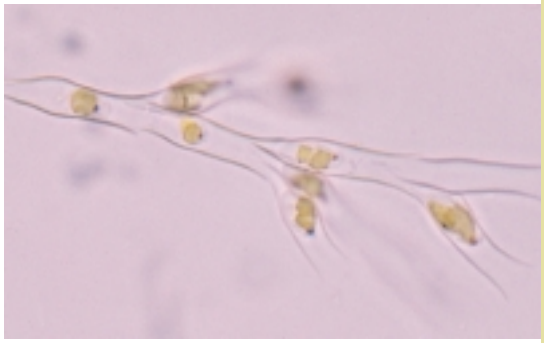
How to recognise the genus:

Microscopic: colonies of cup-like individuals, each containing an oval cell with a light yellow-green chloroplast. This is one of the golden-brown algae.

Habitat and distribution: Usually part of lake phytoplankon, but has occurred in periphyton of lake outflows.

Possible confusion: Unlikely.

Note: Another representative of the golden-brown algae sometimes found in periphyton is *Chrysocapsa* (Order Chrysocapsales), which forms colonies of round cells embedded in mucilage.



from top:

Dinobryon *sp. x 500*

A brown gelatinous coating of a colonial alga identified as Chrysocapsa*, found as dominant in summer/autumn low flows in a foothills Canterbury river with moderate conductivity.*

Gloeocystis

C: colonial

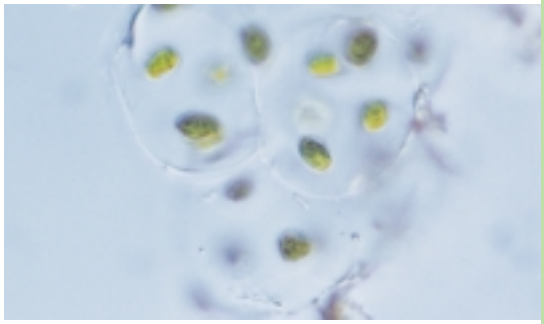
Division: Chlorophyta, **Order:** Tetrasporales

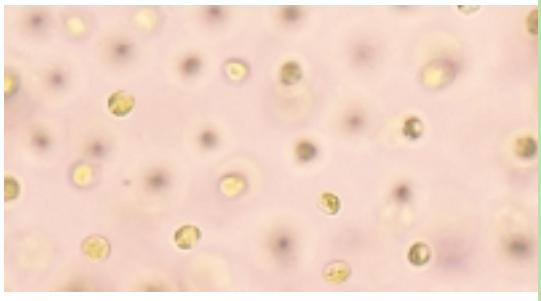
How to recognise the genus:

Microscopic: Small colonies of 4 or 8 green, spherical cells around 10 µm in diameter, each enclosed in a mucilage "envelope". The cells may separate during blending. The single chloroplast can cover the entire cell wall.

Habitat and distribution: Not certain. Has been found in abundance in a stream on the Coromandel Peninsula.

Possible confusion: There are many kinds of green colonial cells similar to *Gloeocystis* and all are difficult to identify. For example, the lower photograph is possibly *Palmella* (Order: Tetrasporales) in which many spherical cells (up to 10 µm across) are arranged in an amorphous mass with cell sheaths not always visible. It is often only possible to identify such green cells as "unknown colonial greens" or "unknown green unicells".





from top:

Gloeocystis*. Note the definite sheaths around groups of 4 cells. x 500*

Possibly Palmella*: smaller cells scattered in a mass of mucilage. x 500*

Pediastrum

C: colonial

Division: Chlorophyta, **Order:** Chlorococcales

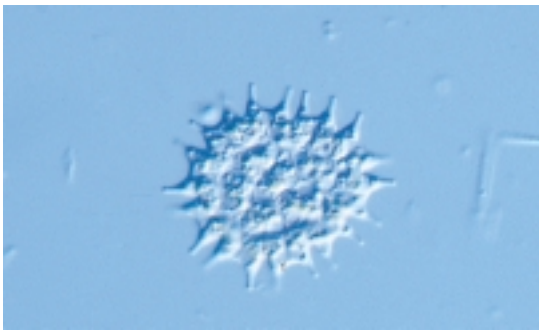
How to recognise the genus:

Microscopic: More or less circular colonies of lobed cells, up to about 100 µm across.

Habitat and distribution:

Mostly found in slow-moving streams. Not usually common.

Possible confusion: Unlikely.



Pediastrum*: a relatively small colony (about 40 µm across). x 600*

Scenedesmus

C: colonial

Division: Chlorophyta, **Order:** Chlorococcales

How to recognise the genus:

Microscopic: This genus grows as small colonies that look like stacks of oblong cells. Sometimes there are two stacks side-by-side and there are usually 4, 8 or 16 cells. The many species in this genus are distinguished on the basis of size and shape of the cells and the presence and form of spines. Cells may be up to 35 µm long. The chloroplast covers most of the cell wall and each cell has one pyrenoid.

Habitat and distribution: *Scenedesmus* can be extremely common in the periphyton of low- to moderately enriched streams, especially in the absence of other green algae. It occurs as "rare" or "occasional" in many periphyton samples.

Possible confusion: Unlikely.

Two different species of Scenedesmus*. The upper one is often common in periphyton. x 700*

Tetrastrum

C: colonial

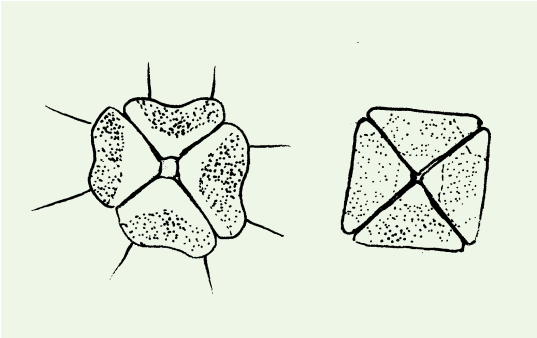
Division: Chlorophyta, **Order:** Chlorococcales

How to recognise the genus:

Microscopic: Colonies of four cells arranged in the shape of a cross. About 30 µm across.

Habitat and distribution: Not often found in periphyton, but has been recorded as common in a moderately enriched stream (Waitekauri River)

Possible confusion: Similar to *Crucigenia*. *Tetrastrum* has "spines" protruding from the cells, *Crucigenia* does not. Also *Tetrastrum* does not tend to form multiple colonies. In blended material it may be difficult to decide between them.



Diagrams of Tetrastrum *(left) and* Crucigenia *(right). Note that* Crucigenia *is often found growing in multiple groups.*

Enteromorpha

C: colonial (sheet-like)

Division: Chlorophyta, **Order:** Ulvales

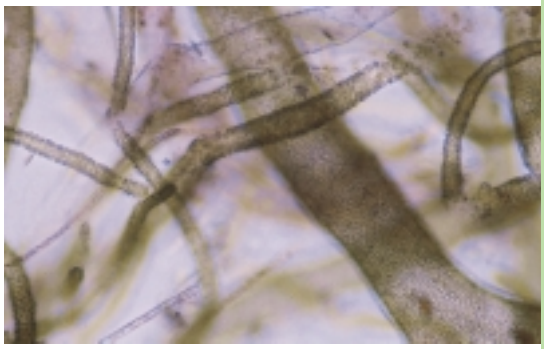
How to recognise the genus:

Macroscopic: Thin, bright-green fronds, like a tiny seaweed.

Microscopic: Sheets of cells organised into hollow tubes a single cell thick, often with branches.

Habitat and distribution: Most species of *Enteromorpha* inhabit brackish or marine habitats. We have found the genus in high conductivity streams, for example in the Waipara River, Canterbury during summer low flows (measured conductivity about 180 µS/cm).

Possible confusion: Unlikely.



from top:

Enteromorpha*, from the Waipara River, Canterbury.*

Enteromorpha*. x 90*

Enteromorpha*. x 300*

Anabaena

BG: unbranched filaments

Division: Cyanobacteria, **Order:** Nostocales

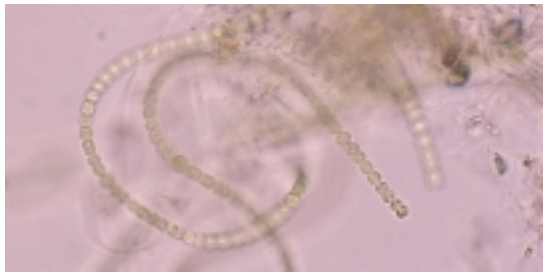
How to recognise the genus:

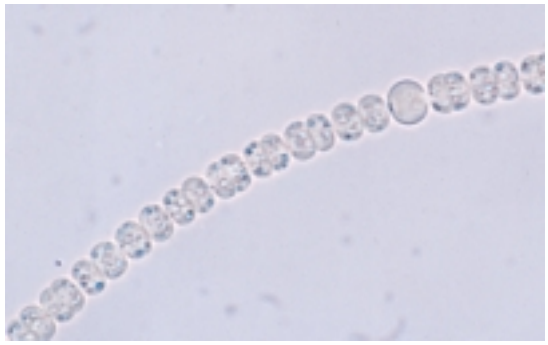
Macroscopic: Usually no distinguishing macroscopic features but in lakes, some species of *Anabaena* can form severe toxic blooms.

Microscopic: Unbranched trichomes (filaments) may be straight or curved to spiral. Individual cells are rounded or barrel-shaped, and there are frequent intercalary heterocysts (appearing between vegetative cells), approximately the same size as the vegetative cells. Akinetes (reproductive cells), where present, are often much larger ellipsoidal to cylindrical, highly granular cells.

Habitat and distribution: We have found *Anabaena* species in slow-flowing high-country streams, mixed with green filamentous algae, diatoms and other cyanobacteria.

Possible confusion: *Anabaena* looks very similar to *Aphanizomenon* (not in this manual). However, the end cells of *Aphanizemenon* are elongated and sometimes narrowed.





from top:

Anabaena *sp., from an inland Canterbury stream, curved species. x 270*

Anabaena *sp. x 680*

Calothrix

BG: unbranched filaments

Divison: Cyanobacteria, **Order:** Nostocales

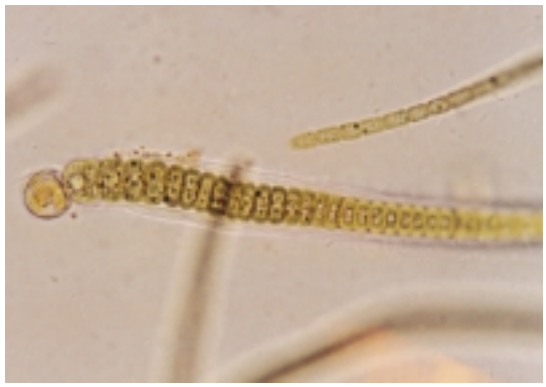
How to recognise the genus:

Microscopic: Relatively short trichomes growing from a heterocyst at the base of the filament and usually tapering to a fine point. The trichome is enclosed in a firm sheath. *Calothrix* may grow in star-like tufts or as solitary trichomes.

Habitat and distribution: *Calothrix* often grows amongst other algae and can be epiphytic. It is not seen often in periphyton.

Possible confusion: *Rivularia* (page 200) also has trichomes tapering from a basal heterocyst, though these are smaller than *Calothrix*, and always arranged side-by-side in a macroscopic colony.

Note: *Calothrix* can have limited false branching, and merges into *Dichothrix* (see page 200).



Calothrix. *x 700 (photo: Donna Sutherland)*

Cylindrospermum

BG: unbranched filaments

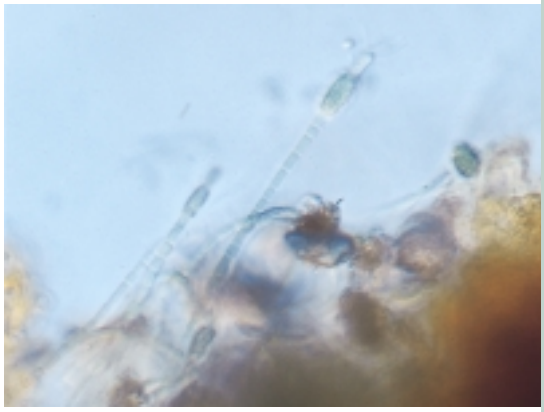
Division: Cyanobacteria, **Order:** Nostocales

How to recognise the genus:

Microscopic: Light blue-green symmetrical trichomes with terminal heterocysts. Akinetes develop just beside the terminal heterocyst at both ends of the trichome in most species.

Habitat and distribution: Mostly in still waters but has been found in slow-flowing pool outlets.

Possible confusion: Could be confused with *Cylindrospermopsis*. However, the position of akinetes in *Cylindrospermum* is adjacent to the terminal heterocyst while in *Cylindrospermopsis* they are always slightly distant from the heterocyst.



Cylindrospermum. *x 400*

Leptolyngbya

BG: unbranched filaments

Division: Cyanobacteria, **Order:** Oscillatoriales

How to recognise the genus:

Microscopic: This genus includes most of the very narrow species (0.5–3 µm wide) previously included in *Phormidium* or *Lyngbya*. Little detail will be visible except under very high magnification. The filaments do not taper and are enclosed within a fine but distinct sheath The colour varies from pale blue-green to brown. The cylindrical cells are often shorter than they are wide, but can be longer. There are no specialised cells. The thallus comprises a free cluster of tangled trichomes.

Habitat and distribution: Clean-water upland streams and rivers. Probably widespread in New Zealand.

Possible confusion: *Leptolyngbya*, *Leibleinia*, and *Jaaginema* are all very similar in appearance. However, *Leibleinia* differs by its special epiphytic mode of life (see photo) and *Jaaginema* (not in this manual) has no sheath.

from top:

Masses of Leptolyngbya. *Outlet from tarn, Richmond Range, Nelson/Marlborough. x270*

Leibleinia *growing as an epiphyte on* Tolypothrix. *x 700 (photo: Donna Sutherland)*

Lyngbya

BG: unbranched filaments

Division: Cyanobacteria, **Order:** Oscillatoriales

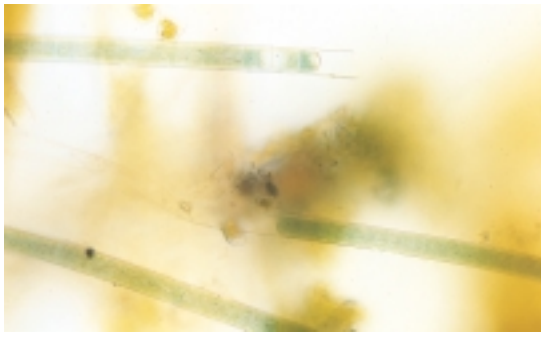
How to recognise the genus:

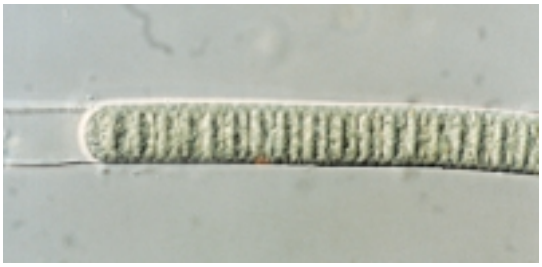
Microscopic: Straight filaments that do not taper, usually blue-green, and with a definite sheath which is often evident beyond the tip of the trichome. The cells are usually disc-like, i.e., wider than they are long, and there are no heterocysts. Cell division is rapid, and often new cell walls can be seen forming even before the walls in the previous division are completed. Size varies from 5 µm to 25 µm across.

Habitat and distribution: Clean-water upland streams and rivers. *Lyngbya* is widespread in New Zealand.

Possible confusion: Some *Lyngbya* species resemble *Oscillatoria* (see page 197) and *Phormidium* (see page 198). *Oscillatoria* seldom has a sheath and the cells are disc-like; *Phormidium* usually has a sheath and the cells appear square.

Note also the appearance of *Heteroleibleinia* (formerly included in *Lyngbya*).

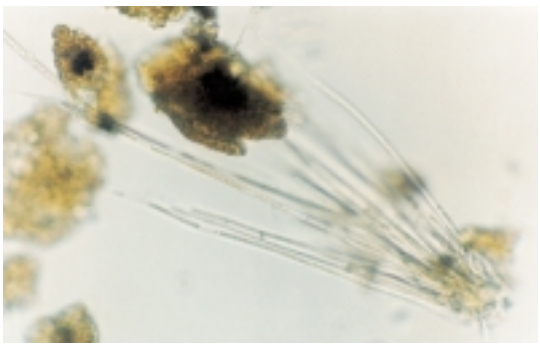




from top:

Lyngbya *from a clean mountain stream (Arthurs's Pass). x 270.*

Lyngbya*. x 600 (photo: Donna Sutherland)*



Possibly Heteroleibleinia*, previously included in* Lyngbya*. This can be quite common in clean streams. x 250 (photo: Nelson Boustead)*

Oscillatoria

BG: unbranched filaments

Division: Cyanobacteria, **Order:** Oscillatoriales

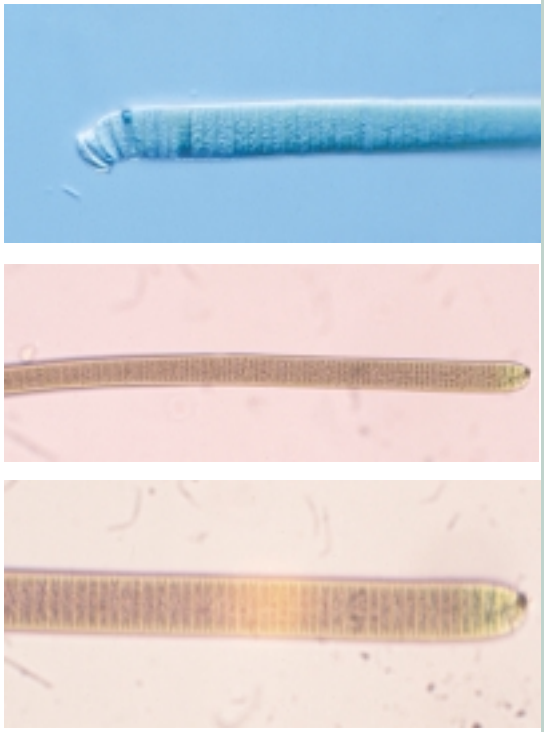
How to recognise the genus:

Macroscopic: Slimy, dark-coloured layers, or undistinguishable, mixed with other periphytic algae.

Microscopic: The trichomes are cylindrical, straight or slightly wavy. Akinetes and heterocysts are always absent. Sheath absent for most part, but some species will rarely produce sheaths under sub-optimal conditions. Trichomes can move by a waving (oscillation) action. The cells are characteristically discoid (i.e., cells wider than long) and are between 6–23 µm wide. A thickened cap (calyptra) sometimes forms on the end of older trichomes (this feature is age-related). Cell division occurs rapidly and often new cell walls can be seen forming before the walls in the previous division are completed.

Habitat and distribution: Widespread in New Zealand, and found in a wide range of conditions.

Possible confusion: *Lyngbya* (see page 196), *Phormidium* (see page 198) and *Oscillatoria* all look somewhat similar. *Phormidium* and *Lyngbya* typically have sheath (most easily seen extending beyond the end of the trichome).



from top:

Oscillatoria*, showing the thickened cap (calyptra) at the end (found in older trichomes). x 500*

Note the new cell walls forming within each narrow cell. x 270 (photo: Donna Sutherland)

As above. x 540 (photo: Donna Sutherland)

Phormidium

BG: unbranched filaments

Division: Cyanobacteria, **Order:** Oscillatoriales

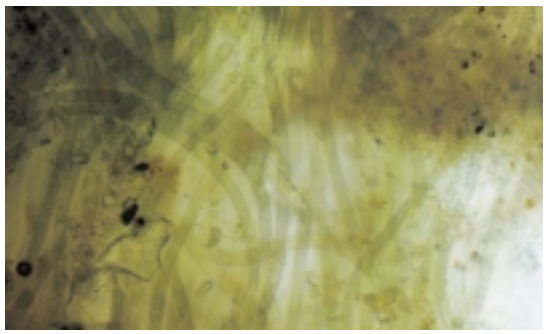
How to recognise the genus:

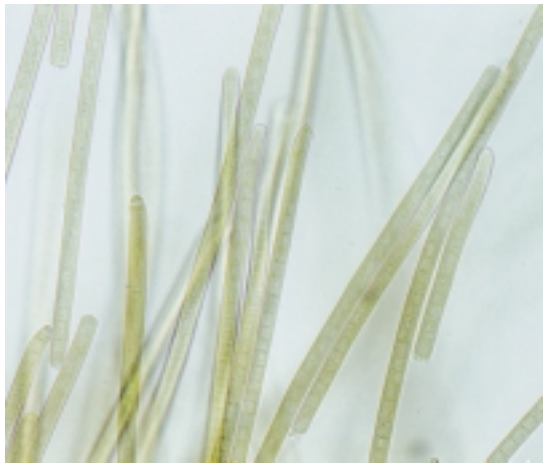
Macroscopic: Forms expanded, gelatinous, dark green to black mats growing on stable substrates – stones, other alga, plants. These mats can be fine and thin to compact and leather like. Very rarely, single trichomes are scattered throughout a mixed periphyton community.

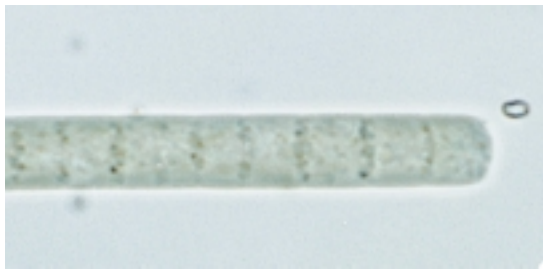
Microscopic: The cylindrical trichomes are slightly to intensely waved, and unconstricted or slightly constricted at the cross-walls. The sheaths when present, are firm and adherent to the trichome, never lamellated. Trichomes move with a gliding, trembling or waving action. Cells are typically box-like, that is as long as they are wide. Ther are no heterocysts.

Habitat and distribution: The genus is widespread in New Zealand, often very abundant in high-conductivity streams and rivers.

Possible confusion: *Phormidium*, *Lyngbya* (see page 196) and *Oscillatoria* (see page 197) all look somewhat similar. *Phormidium* has square, box-like cells, rather than the disk-like cells seen in the other two genera. Specimens that can not be distinguished between these three genera are typically provisionally placed in *Phormidium*.







from top:

Phormidium *mat. Waipapa River, Hawkes Bay.*

Phormidium *filaments (from the Waipara River, Canterbury). x 270*

Phormidium. *x 400*

Phormidium. *x 1400*

Nostoc

BG: filaments in gelatinous masses

Division: Cyanobacteria, **Order:** Nostocales

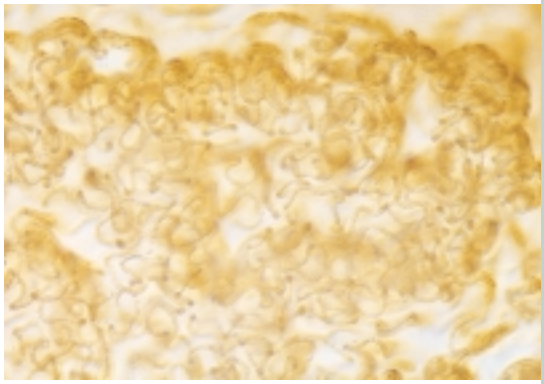
How to recognise the genus:

Macroscopic: Tough, irregularly shaped or rounded, gelatinous nodules, clear to yellow-brown to dark brown in colour; usually growing on stone substrates.

Microscopic: Under low power (up to 200x) *Nostoc* appears as a compact, cohesive mass in which numerous looped and twisted filaments are embedded. These may be denser around the outsides of the colony. Under higher power (up to 1000x) you can see that individual filaments are unbranched and comprise chains of bead-like rounded cells. (Don't mistake overlapping trichomes for branches.) The cells can be up to 8 µm in diameter, while the heterocycts are often slightly larger. Akinetes, where present, develop between adjacent heterocysts.

Habitat and distribution: *Nostoc* is usually found in fast-flowing relatively clean-water upland streams and rivers, growing attached to rocky substrates. Some species also grow on damp soil. The alga can become abundant and quite noticeable. It is widespread in New Zealand.

Possible confusion: Macroscopically, *Nostoc* is quite characteristic, though some types of green algae grow as tough nodules in similar environmental conditions. These are usually much darker than typical *Nostoc*. Under the microscope *Anabaena* (see page 194) and *Wollea* (not in this manual) look very similar to *Notsoc*. These three genera are distinguished on the basis of growth form – *Anabaena* never forms gelatinous colonies while the colonies of *Wollea* are long and tube-like with parallel trichomes.



from top:

Nostoc *growing on a stone taken from a fast-flowing hill-country stream in Otago.*

Nostoc colonies on Cladophora.

Nostoc *sp., showing edge of nodule. x 135*

Nostoc *trichomes. x 270.*

Rivularia

BG: filaments in gelatinous masses

Division: Cyanobacteria, **Order:** Nostocales

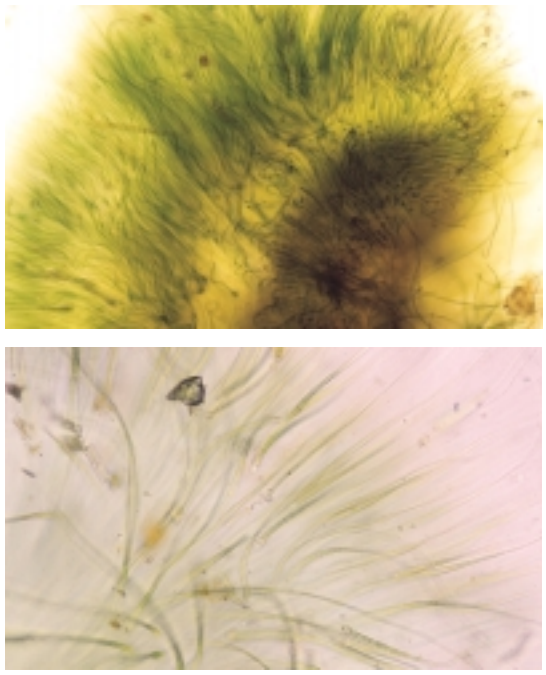
How to recognise the genus:

Macroscopic: Small dark raised hemispherical colonies attached firmly to substrates, up to 3 mm across.

Microscopic: Masses (colonies) of short tapering trichomes arranged parallel to each other, sometimes with false branching. Each trichome is enclosed within a sheath and a heterocyst is located at the base of each.

Habitat and distribution: *Rivularia* is usually found in fast-flowing relatively clean-water upland streams and rivers, growing attached to rocky substrates. Some species also grow on damp soil.

Possible confusion: *Gloeotrichia* (not included in this manual) is similar to *Rivularia* except that it has an akinete next to each heterocyst. *Gloeotrichia* colonies tend to be less firm than *Rivularia* and are usually found floating in lakes rather than in streams.



Rivularia, *Waiau River. x 70 (top) and x 135 (bottom). Note tapering filaments with a heterocyst at the base.*

Dichothrix

BG: branched filaments

Class: Cyanobacteria, **Order:** Nostocales

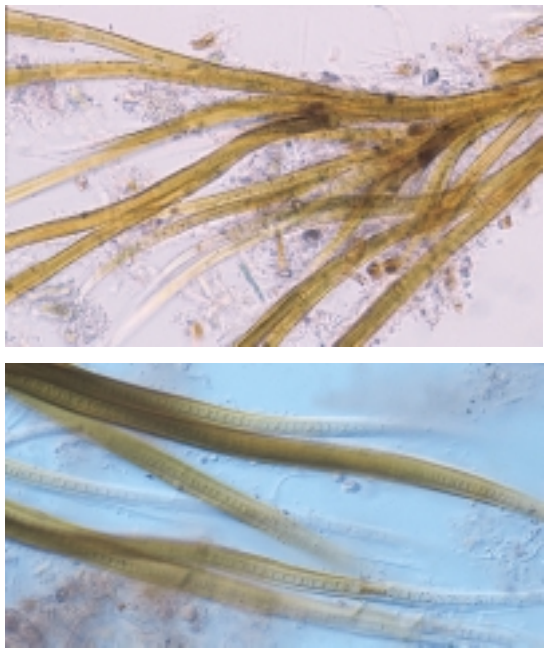
How to recognise the genus:

Macroscopic: Brown gelatinous layer.

Microscopic: Brown to blue-green branching trichomes. The heavily pigmented sheaths are either thin and firm or lamellated and several times wider than the trichome. Each trichome originates with a heterocyst and gradually tapers towards the end forming a hair-like structure. False branching always originates at a heterocyst (compare with *Scytonema*).

Habitat and distribution: Found mostly in lakes but also in clean-water streams. Probably widespread.

Possible confusion: *Tolypothrix* (see page 203) has a similar type of false branching, but the new branches part immediately from the original trichome. The hair-like tapered ends are absent in *Tolypothrix*.



from top:

Dichothrix. *Note false branching with trichomes running parallel before branching off. x 135*

Note thick sheath and tapering ends. x 270

Coleodesmium

BG: branched filaments

Division: Cyanobacteria, **Order:** Nostocales

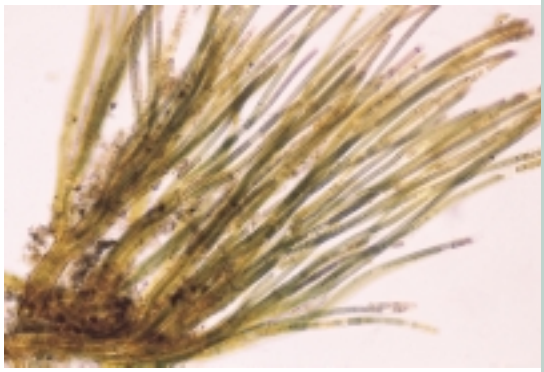
How to recognise the genus:

Macroscopic: Tiny blue-green tufts up to 3 mm across, atttached to substrates in streams.

Microscopic: Bundles of trichomes that lie side by side and entwined around each other within a common sheath, then gradually branch off (with additional false branching) to form an expanded fan-like thallus. At the ends of the branches, each trichome lies within an individual, finer sheath and often can be seen breaking up to form rounded fragments. Heterocysts seem to be both intercalary and at the origins of false branches. The cells are slightly constricted at the cross walls. Trichomes typically 10 to 15 µm in diameter.

Habitat and distribution: *Coleodesmium* was first found in New Zealand in 1996 by Steven Moore of Otago Regional Council, and identified by Dr Paul Broady (University of Canterbury). It is apparently common in Otago, and has been found in Taranaki. We have recently (May 2000) found the genus in clean foothills streams in both Canterbury and Nelson / Marlborough. The genus may well be widespread.

Possible confusion: *Schizothrix* (not illustrated in this manual) also has multiple filaments within a sheath, with progressive branching. However, there are no heterocysts and spores do not form. (See Bourelly 1985 for a description of both genera).



from top:

Coleodesmium. *Note typical branching fan-like growth. x 70*

Note the heterocysts. x 270

Filaments showing sheath and individual cells. x 270

Scytonema

BG: branched filaments

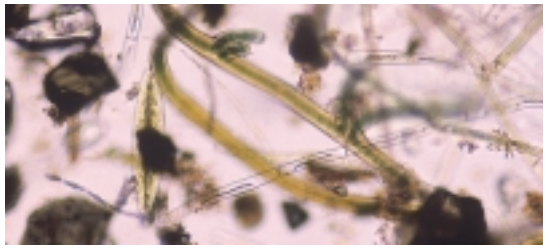
Division: Cyanobacteria, **Order:** Nostocales

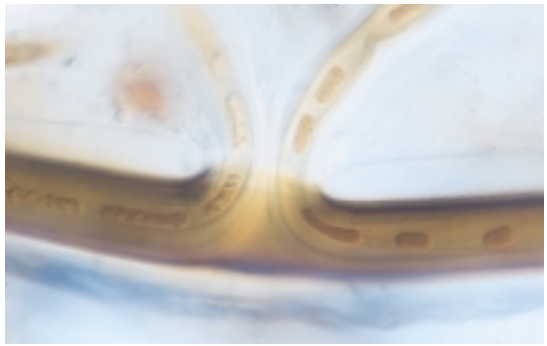
How to recognise the genus:

Microscopic: Long trichomes with a definite base and tip, always enclosed in a usually heavily pigmented sheath. False branches always arise between two vegetative cells. Usually two branches arise beside one another, rarely only one. Heterocysts are always intercalary.

Habitat and distribution: Most often found in still waters, but can occur in outlet streams and rivers.

Possible confusion: *Tolypothrix* and *Scytonema* are habitually very similar. However, the false branches of *Tolypothrix* arise from heterocysts.





from top:

Scytonema *amongst other periphyton, Waiau River, Southland. x 90*

Branching in Scytonema*. Note wide sheath. x 680*

Stigonema

BG: branched filaments

Division: Cyanobacteria, **Order:** Stigonematales

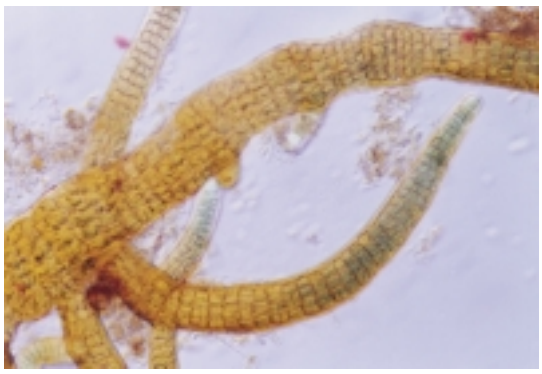
How to recognise the genus:

Macroscopic: Tough, irregularly shaped, gelatinous nodules, yellow-brown to dark brown; usually on stone substrates.

Microscopic: Trichomes divided into main filament and branches, with the rounded cells generally in multiple rows. Heterocysts are either intercalary or absent. True branching occurs, i.e., a new branch grows directly from cells in the main stem (compare with false branching in *Dichothrix* and *Tolypothrix*).

Habitat and distribution: *Stigonema* is often found in damp habitats rather than in flowing water. The specimen photographed was from a shallow, clean, upland stream near Motueka, South Island, growing with other cyanobacteria on marble bedrock. Distribution not known.

Possible confusion: *Stigonema* is unlikely to be confused with any other taxon in this manual. A similar taxon, *Fischerella* (see photo) has cells in single rows.



from top:

Stigonema: *note the true branching, and multiple rows of cells. x 250*

Probably Fisherella, from a spring-fed stream, Canterbury. *There is true branching but the cells are mainly in single rows. x 70*

Tolypothrix

BG: branched filaments

Class: Cyanobacteria, **Order:** Nostocales

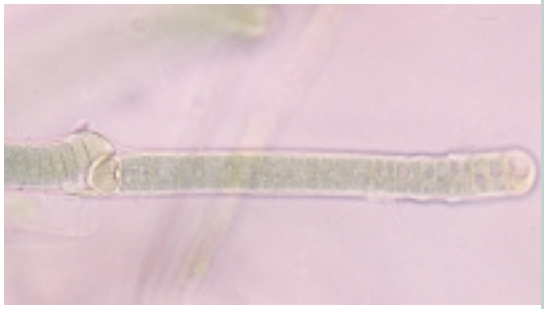
How to recognise the genus:

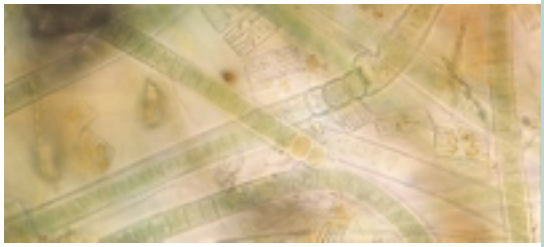
Macroscopic: Forms tangled, brown to yellow-brown clumps / tufts often mixed with other periphyton, or attached to rocks or aquatic plants.

Microscopic: Long, straight (not tapered) blue-green trichomes in a thin, firm sheath. Cells typically barrel-shaped and rounded at the edges forming a slight constriction between successive cells. *Tolypothrix* has false branches that always arise just below a heterocyst.

Habitat and distribution: *Tolypothrix* is more often encountered in lakes than rivers but we have found it in a range of rivers and streams. The genus seems to be associated with clean conditions and can be very abundant in hard-water streams.

Possible confusion: A distinctive genus. Possible confusion with *Dichothrix* (page 200). However, the latter has a thick brown sheath and tapering trichomes.





from top:

Tolypothrix *in a mixed periphyton community, Waiau River. x 270*

Tolypothrix, *the beginnings of a new "branch". x 400*

Chamaesiphon

BG: single cells

Division: Cyanobacteria, **Order:** Chamaesiphonales

How to recognise the genus:

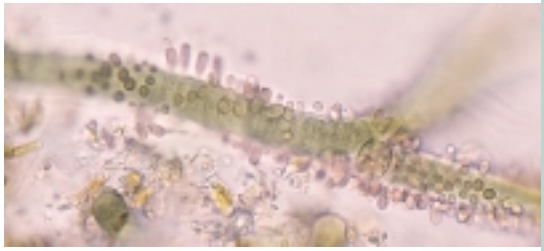
Microscopic: Single cells forming polarized "pseudofilaments". The cells, encased in an open-ended sheath, are attached to the substrate at the narrow end. Division of cells occurs rapidly at the terminal end. Often you will see the new young cells separating off from the mother cell as round "exospores".

Habitat and distribution:

Chamaesiphon grows as an epiphyte on other periphyton, attached to larger substrates, e.g., wood. It is fairly widespread in fast-flowing waters throughout New Zealand, but not common. It seems more likely to occur in cleaner waters.

Possible confusion:

A distinctive genus, unlikely to be confused with any others.



from top:

Chamaesiphon *colonising* Tolypothrix, *from a foothills stream, Canterbury. x 350*

Long Chamaesiphon *cells on* Cladophora, *Moawhango River, central North Island. x 600*

Aphanocapsa

BG: colonial

Division: Cyanobacteria, **Order:** Chroococcales

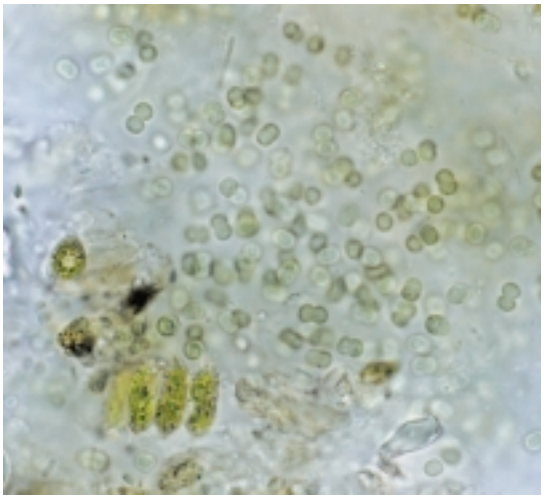
How to recognise the genus:

Macroscopic: Gelatinous masses.

Microscopic: Usually pale blue-green globular cells, around 2 to 4 µm across, loosely distributed through a gelatinous mass.

Habitat and distribution: Most often in tarns and lakes, but does occur in outflow streams.

Possible confusion: *Aphanothece* and *Gloeothece* (not in this manual) also form colonies of cells embedded in mucilage. In both of these the cells are more oval or elongated than round and in *Gloeothece* there are sheaths around individual cells.



Aphanocapsa. *x 1400*

Merismopedia

BG: colonial

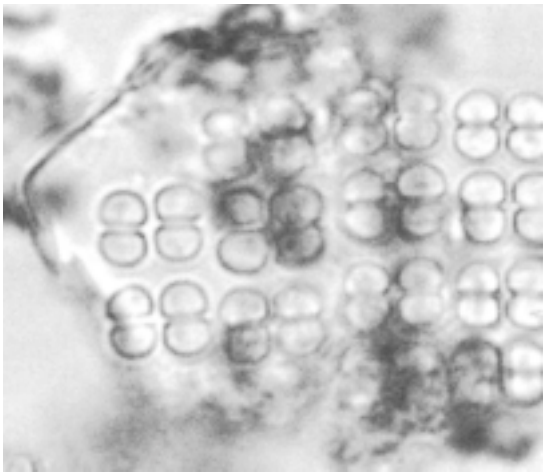
Division: Cyanobacteria, **Order:** Chroococcales

How to recognise the genus:

Microscopic: Flat colonies of round or oval blue-green cells arranged in mucilage (not always visible) in a regular right-angled criss-cross pattern. Species are determined from the number of cells in each colony (from 4 to hundreds) and the shape and size of individual cells. Cells are typically 3 to 6 µm across.

Habitat and distribution: Although usually found in lakes, *Merismopedia* occasionally appears in periphyton samples from a range of river types. The genus is normally rare.

Possible confusion: None. A distinctive genus.



Merismopedia. *x 700 (photo: Phillippe Gerbeaux)*

10.5 Glossary of terms used in taxonomic descriptions

akinete in cyanobacteria, specialised reproductive cell within the trichome.

araphid term for diatoms that have no raphe.

areolae in diatoms, holes or depressions on the valve surface that make up the striae (see puncta, which often means small holes).

axial area in diatoms, a break in the striae that runs along the middle of the valve; may contain the raphe system.

biraphid term for diatoms that have a raphe system on both valves.

capitate ending in a knob or head.

central area in diatoms, the part of the axial area at the centre of the valve.

chloroplast structure within a cell which holds the photosynthetic pigments.

convergent in diatoms, striae that are inclined from the valve margin towards the valve ends (plural: costae).

costa in diatoms, ribs of silica that run across the valve and appear under LM as heavy lines.

dorsal top or upper.

eukaryote refers to organisms in which cell inclusions are enclosed within membranes (includes all the algae except for cyanobacteria).

false in cyanobacteria, branches that form when a new trichome grows within the

branching same sheath as an existing trichome, rather than branches that form when cells divide in a different direction.

frustule the entire silica cell wall of a diatom.

genus the unit of classification next most detailed after species. Subsequent units are family, order, class, division.

girdle (also called the cingulum) bands of silica that join together the two parts (valves) of a diatom frustule.

girdle view diatoms seen from the side (i.e., you see the side of each valve, plus the girdle in between).

heterocsyt in cyanobacteria, cells within the trichome that are different from the normal vegetative cells; the site of nitrogen fixation.

hormogonium in cyanobacteria, part of the trichome that detaches as a reproductive body (plural hormogonia).

intercalary in cyanobacteria, in amongst the vegetative cells.

keel in diatom species whose valve is sharply angled at the raphe, the edge of the ridge where the raphe is situated.

keel puncta openings through the keel that look like a series of dots or lines under the light microscope

lamellated in layers.

monoraphid term for diatoms that have a raphe system on one valve only.

motile capable of moving.

naviculoid in diatoms, shaped like *Navicula*: symmetrical, lens-shaped.

parietal referring to chloroplasts: lying against the inside of the cell wall.

prokaryote refers to organisms that do not have cell inclusions (such as chloroplasts) contained in membranes, e.g., cyanobacteria.

pseudoraphe in araphid diatoms, a break in the striae as if a raphe was present.

puncta in diatoms, small openings or depressions that make up the striae.

pyrenoid structure within a cell where starch is stored.

radiate	in diatoms, striae that are inclined from the valve margin towards the centre of the valve.
raphe	in diatoms, a pair of slits in the valve face which appears as lines under the light microscope.
reticulate	referring to chloroplasts, with holes, like lace or netting.
rimoportula	in diatoms, an isolated hole lying at the edge of the valve face.
septum	in diatoms, plates of silica within the girdle bands, lying parallel to the valve face (plural: septa) .
setae	hair-like extensions from cells.
species	usually the most detailed unit of biological classification (though some species are further split into varieties).
stigma	in diatoms, isolated hole(s) on the valve face (plural stigmata).
stria	in diatoms, a row of areolae, under low power LM appearing like a line (plural: striae).
taxon	any taxonomic unit (species, genus, family, etc.)
thallus	the overall form of an alga.
trichome	in cyanobacteria, a multi-celled filament.
true branching	branches that form by cells dividing in a different direction (compare with false branching in cyanobacteria).
valve	in diatoms, one of the pair of silica structures that fit together to form the frustule.
valve view	diatoms seen from the top (i.e., the face of the valve).
vegetative cells	the ordinary cells of a filament (or a trichome in cyanobacteria), i.e., not reproductive cells, holdfast cells, etc.
ventral	bottom or lower.

10.6 Recently re-named diatom genera, with their equivalent traditional names

The following table lists diatom genera mentioned in this manual which have new names as a result of re-classification of exisiting genera, or new descriptions. These changes are just a small proportion of the many revisions currently being applied in diatom taxonomy.

Revised classification	**Traditional classification**
Achnanthidium	*Achnanthes minutissima* group
Aulacoseira	some freshwater *Melosira* species
Brachysira	*Anomoeoneis vitrea* group
Cyclostephnos	*Stephanodiscus dubius* group
Encyonema	*Cymbella cesatii* group
Eunophora	newly described
Fragilariforma	*Fragilaria viriscens* group
Placoneis	*Navicula gastrum* group
Planothidium	*Achnanthes lanceolata* group
Pseudostaurosira	*Fragilaria brevistriata* group
Reimeria	*Cymbella sinuata*
Rossithidium	*Achnanthes linearis group*
Sellaphora	*Navicula pupula* group
Staurosira	*Fragilaria construens* group
Staurosirella	*Fragilaria leptostauron* group

10.7 Selection of texts that may be useful in stream periphyton identifications

Bourelly, P. 1981: Les Algues d'eau douce: Initiation à la systématique. Tome II: Les Algues jaunes at brunes. Boubee, Paris.

Bourelly, P. 1985: Les Algues d'eau douce: Initiation à la systématique. Tome III: Les Algues bleues et rouge. Boubee, Paris.

Bourelly, P. 1988: Les Algues d'eau douce: Initiation à a systématique. Compléments Tome I: Algues vertes. Boubee, Paris.

Bourelly, P. 1990: Les Algues d'eau douce: Initiation à la systématique. Tome I: Les Algues vertes. Boubee, Paris.

Cox, E.J. 1996. Identification of freshwater diatoms from live material. Chapman & Hall.

Croasdale, H. and Flint, E.A. 1986. Flora of New Zealand: freshwater algae, chlorophyta, desmids. Volume I. Christchurch: DSIR Botany Division.

Croasdale, H. and Flint, E.A. 1988. Flora of New Zealand: freshwater algae, chlorophyta, desmids. Volume II. Christchurch: DSIR Botany Division.

Croasdale, H., Flint, E.A. and Racine, M.M. 1994. Flora of New Zealand: freshwater algae, chlorophyta, desmids. Volume III. Christchurch: DSIR Botany Division.

Drouet, F. 1981: Revision of the Stigonemataceae with a summary of the classification of the blue-green algae. Nova Hedwigia 66: 1–221.

Entwistle, T.J.; Kraft, G.T. 1984. Survey of freshwater red algae (Rhodophyta) of south-eastern Australia. *Australian Journal of Marine and Freshwater Research 35*: 213–259.

Entwistle, T.J., Sonneman, J.A.; Lewis, S.H. 1998: Freshwater algae of Australia. a guide to the conspicuous genera. Sainty and Associates, NSW, Australia.

Etheredge, M.K.; Pridmore, R.D. 1987. The Freshwater Planktonic Blue-greens (Cyanophyta/Cyanobacteria) of New Zealand. A taxonomic guide. Water & Soil Miscellaneous Publication No. 111. Ministry of Works and Development, Wellington.

Foged, N. 1979: Diatoms in New Zealand. The North Island. *Bibliotheca Phycologica. Band 47*. J. Cramer, Vaduz.

Krammer, K.; Lange-Bertalot, H. 1991–1997. Bacillariophyceae. Vols 1–4. (Susswasserflora von Mitteleuropa; Bd. 2). Fischer, Stuttgart.

Patrick, R.; Reimer, C. W. 1966: The diatoms of the United States. Vol 1. Academy of Natural Sciences, Philadelphia.

Patrick, R.; Reimer, C. W. 1975: The diatoms of the United States. Vol. 2. Academy of Natural Sciences, Philadelphia.

Prescott, G. W. 1973: Algae of the Western Great Lakes area. Wm C. Brown, Iowa.

Prescott, G. W. 1954: How to know the freshwater algae. Wm C. Brown, Iowa.

Whitford, L. A.; Schumacher, G. J. 1973: A manual of freshwater algae. Spars Press, Raleigh, North Carolina.

10.8 List of diatom species with authorities and selected references for identification

Abbreviations used for references:

P&R Patrick and Reimer

KLB Krammer and Lange-Bertalot

page

Achnanthes exigua Grunow 158
P&R 1966. p. 257. pl 16, f. 21-22.

Achnanthes inflata (Kutzing) Grunow 156
P&R 1966. p. 279, pl. 19, figs 15-16

Achnanthes oblongella Oestrup 158
KLB 1991-1997. vol. 2 / 4, p. 29, pl 16 / 1-14

Achnanthidium lanceolatum Brebisson 157
P&R 1966. p. 269, Pl 18, f 1-10 (as *Achnanthes lanceolata*; now *Planothidium lanceolatum* (see Round and Bukhityarova 1996)

Achanthidium linearis W. Smith 158
P&R 1966. p. 251, pl.16, f3-4 (as *Achnanthes linearis*; now *Rossithidium linearis* (see Round and Bukhityarova 1996).

Achnanthidium minutissimum (Kutzing) Czarnecki 157
P&R 1966. p. 253, pl. 16 figs 9-10 (as *Achnanthes minutissima*).

Amphora ovalis (Kutzing) Kutzing 160
KLB 1991-1997. vol. 2 / 1, p. 345, pl.149.

Amphora veneta var *capitata* (Haworth)
KLB 1991-1997. vol. 2 / 1, p. 349, pl.151 / 8. 160

Asterionella formosa Hassall
KLB 1991-1997. vol. 2 / 3, p. 103, pl. 103-104

Aulacoseira granulata (Ehrenberg) Simonsen 1979 148
KLB 1991-1997. vol. 2 / 3, p.22, pl 16 / 10); Foged 1979, pl. I (as *Melosira granulata*).

Brachysira serians (Brebisson in Kutzing) Round & Mann 161
Cox 1996. p. 84, fig. 27b, P&R 1966, p. 378, pl 33 / 1,2 (var acuta) (as *Anomoeoneis*).

Brachysira vitrea (Grunow) Ross 161
KLB 1991-1997. vol. 2 / 1, p. 256, pl 94 / 21-28 (as *Anomoeoneis*). (also listed in Foged 1979 as *Anomoeoneis exilis* var. *lanceolata*).

Cocconeis pediculus Ehrenberg 162
P&R 1966. p. 240, pl 15, figs 3-4.

Cocconeis placentula Ehrenberg 162
P&R 1966. p. 240, pl 15, fig 7

Cyclotella meneghiniana Kutzing1 163
KLB 1991-1997. vol. 2 / 3, p. 44, pl 44 / 1-10; Foged 1979, pl. III, fig. 6.

Cyclotella stelligera Cleve & Grunow 163
KLB 1991-1997. vol. 2 / 3 p. 50, pl 49 / 1-4; Foged 1979, p. 36, pl III, figs 8,9,11

Cymbella aspera (Ehrenberg) Peragallo 164
KLB 1991-1997. vol. 2 / 1, p. 319, pl 131 / 1; Foged, pl. 35, fig. 14

Cymbella cistula (Hempr.) Grunow var *gracilis* Hustedt 165
Foged 1979, p. 37, pl 35, fig. 12

Cymbella kappii Cholnoky 164
Foged 1979. p. 39, pl. 34, figs 8-10

Cymbella tumida (Brebisson) Van Heurck 165
KLB 1991-1997. vol. 2 / 1 p. 318, pl. 130 / 4-6; P&R 1975. p. 58, pl 10, f. 8

Diatoma heimale var. *mesodon* (Ehrenberg) Grunow 149
P&R 1966. p. 108

Diatoma tenuis Agardh 149
KLB 1991-1997. vol. 2 / 3. p. 97, pl 96, figs 8-10

Diatomella balfouriana Greville 165
P&R 1966. p. 297, pl. 20, figs 6-7

Diatomella parva Manguin 165
Foged 1979. p 43, pl XVI, figs 8,9

page

Diploneis elliptica (Kutzing) Cleve 166
P&R 1966. p. 414. pl 38, fig 10;
KLB 1991-1997. vol 2 / 1, p. 285, pl. 16 / 4

Encyonema caespitosum Kutzing 167
P&R 1975, p. 41, pl 6, f 5-6 (as *Cymbella prostrata* v. *auerswaldii*); Cox 1996 p. 57, fig 18c; KLB 1991-1997. vol. 2 / 1 p. 310, pl. 121 / 12-16, 122 / 1-2 (as *Cymbella caespitosa*)

Encyonema gracile Rabenhorst 167
KLB 1991-1997. vol. 2 / 1, p. 308, pl. 120 / 1-16 (as *Cymbella gracilis*). Also in P&R 1966. p. 46, pl 7, figs 11-14 as *Cymbella lunata.*

Encyonema minutum (Hilse in Rabenhorst) D.G. Mann 166
P&R 1975, p. 47, pl 8, figs 3, 4 (as *Cymbella minuta*)

Encyonema prostratum (Berkeley) Kutzing 167
P&R 1975, p. 40, pl 6 f 4. (as *Cymbella prostrata*)

Epithemia adnata (Kutzing) Brebisson 168
KLB 1991-1997. vol. 2 / 2, p. 152, pl 107 / 9-11, P&R 1975. pl 24 figs 3-4
(also in Foged 1979, pl XXXVIII as *E. zebra*)

Epithemia sorex Kutzing 168
P&R 1975. p. 188, pl 27, f. 4
Foged 1975. pl XXXVIII, f 2,6,10,11.
KLB 1991-1997. vol. 2 / 2, p. 154, pl. 106 / 1-14.

Eunotia serpentina Ehrenberg 150
KLB 1991-1997, vol. 2 / 3, p. 195, pl. 166 / 5.

Fragilaria vaucheriae (Kutzing) Petersen 151
Foged 1979. p. 143, pl. 7
P&R 1966. p. 120, pl 3, fig, 14

Fragilaria capucina Desmazieres 151
Foged 1975. p. 143, pl VII.

Fragilaria capucina var *distans* (Grunow) Lange-Bertalot 151
KLB 1991-1997. vol. 2 / 3, p. 124, pl 109 / 113)

Fragilariforma viriscens (Ralfs) Williams & Round 152
KLB 1991-1997. vol. 2 / 3, p. 135, pl 126 / 7
P&R 1966 p. 119, pl 3, fig. 9 as *Fragilaria*
(genus initially named *Neofragilaria*, renamed *Fragilariforma* (Williams and Round 1988)).

Frustulia rhomboides (Ehrenberg) De Toni 169
KLB 1991-1997. vol. 2 / 1, p. 258, pl. 95 / 1
P&R 1966. p. 306, pl 21, f. 5

Frustulia rhomboides var. *crassinerva* 169
KLB 1991-1997. vol. 2 / 1, p. 259, pl. 95 / 6-7, P&R 1966, p. 307, pl. 22, f. 1

Frustulia vulgaris (Thwaites) De Toni 169
KLB 1991-1997 2 / 1, p. 260, pl. 97 / 4-5
P&R 1966, p. 307, pl 22 f3

Gomphoneis minuta var. *cassieae* Kociolek & Stoermer 170
see Kociolek & Stoermer 1987 (NZ form formerly identified as *Gomphoneis herculeana*)

Gomphonema acuminatum Ehrenberg 172
KLB 1991-1997. vol. 2 / 1, p. 365. pl 160 / 1-12

Gomphonema angustatum (Kutzing) Rahenhorst 171
KLB 1991-1997. vol. 2 / 1. p. 360, pl 155 / 1-21
(see note, page 171 of this guide)

Gomphonema angustum Agardh 172
KLB 1991-1997. vol. 2 / 1. p. 370, pl 164 / 1-6
P&R 1975, p. 134, pl. 18, fig. 1

Gomphonema clavatum Ehrenberg 172
KLB 1991-1997. vol. 2 / 1, p. 367, pl 173 / 1-12

Gomphonema minutum (C. Agardh) C. Agardh 172
KLB 1991-1997. vol. 2 / 1, p. 370, pl. 159, f. 5-8

Gomphonema parvulum Kutzing 171
P&R 1975. p. 123. pl 17 fig. 8
see also KLB 1991-1997. vol. 2 / 1 p. 358, pl. 154 / 1-25; Foged 1979, pl. XXXVII / 8-9