4

A Key to the More Frequently Occurring Freshwater Algae

4.1 Introduction to the key

This key allows the user to identify the more frequently-encountered algae to genus level, with some mention of the more common species within that genus, and is constructed on the basis of features that can be observed using a reasonable light microscope. It is not a taxonomic key, but one in which algae are separated on the basis of readily-observable morphological features such as shape, motility, cell wall structure and colonial form. Only occasional and very simple laboratory preparations might be required as it is generally assumed that observations will be made on fresh specimens. The main exception to this is with some diatoms, where cleaning may be required to remove organic cell material and reveal surface markings on their silica walls (Section 2.5.4).

Before using the key the reader should familiarise themself with the main characteristics of each of the major groups (phyla) of algae as described in Chapter 1. The characteristics described there will help understand the points of identification in the specimen being observed.

4.1.1 Using the key

Using the key to identify a particular alga involves a number of stages.

1. Initial observations with a light microscope. Before using the key the investigator should carefully observe the specimen noting size, shape, morphological features both external and internal and anything else of interest. It is important to observe a number of examples of the alga to be identified to get a good overall picture of its characteristics. This is especially true of cleaned diatoms when views of different aspects of a cell are often needed. Note that it is always best to observe fresh live material as well as preserved, and that (in the case of diatoms) cleaned and mounted material may also be needed to see certain features such as markings on the silica wall surface.

2. Using the key. As with all binary keys, two sets of alternative features are presented at each stage and the user must consider which best fits the specimen being observed. Each alternative leads on to a further (numbered) binary choice, with the sequence of choices ultimately reaching the name of the genus to which the specimen is provisionally assigned.

3. Confirmation of genus can be made with reference to the fuller description given and the photographs plus line drawings provided. In some cases, details and illustrations of individual species are also given. Algal photographs are invariably of fresh specimens unless stated otherwise. In many

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cases the photographs are taken under bright field microscopy, but other techniques such as phase contrast, differential interference contrast (DIC) microscopy and negative staining are also used to enhance contrast. Photographs of acid-digested diatoms are derived from lake sediment samples (Capstick, 2004).

By working through the key many of the important features of the specimen will have been used so the user will already have in their mind the main features of that organism. Until the user is familiar with the key there may be occasions when it is difficult to decide which set of alternatives is best and this could lead to incorrect identification. It is always best to note progress through the key by writing down the sequence of numbers, so that if a mistake occurs steps can easily be retraced and an alternative route followed. After each key number is a number in brackets, referring back to the number you were last at.

4.1.2 Morphological groupings

Because this is a morphological rather than a taxonomic key algae from different phyla may be juxtaposed in the text. The user will find that most specimens with the following features are found in the following key groups:

- Key nos 5 to23: branched filamentous forms (non-diatom).
- Key nos 27 to 29: diatom filaments, strands or ribbons.
- Key nos 30 to 42: unbranched filaments but not blue-greens.
- Key nos 43 to 55: filamentous blue-greens.
- Key nos 57 to 67: colonial blue-greens.
- Key nos 72 to 75: motile colonies.
- Key nos 77 to 80: colonial diatoms.
- Key nos 81 to 105: other colonial forms (mainly greens).
- Key nos 107 to 125: unicellular flagellates
- Key nos 128 to 143: centric diatoms
- Key nos 144 to 203: pennate diatoms
- Key nos 207 to 212: single-celled green algae
- Key nos 214 to 217: some desmids (also 223)
- Key nos 218 to 222: remaining single-celled green algae.

4.2 Key to the main genera and species

1 (a) Plants macroscopic, often growing to >20 cm in length. Thallus differentiated into nodes bearing whorls of branches and internodes. Erect in habit and growing anchored to the substrate. Chloroplasts discoid and numerous . . . . **Charophyta 2**

(b) Plants microscopic or if visible to the naked eye it is normally because they are present as a mass - but still requiring microscopic observation to determine the more detailed morphology **3**

2 (1) (a) Plants coarse to touch, frequently encrusted with lime. (Common name Stonewort). . . . . **Chara**

(b) Plants not coarse to touch, usually deep green in colour, not encrusted with lime. . . . . **Nitella**

Members of the Charophyta are essentially branched filaments with a main axis of large elongate cells (one per internode) and a whorl of smaller cells forming the branches at each node. The large internodal cells may be several centimetres in length. Both **Chara** and **Nitella** live anchored to the bottom in still, clear freshwaters by means of colourless rhizoids. A few species may occur in brackish waters. They are probably the only true members of the rhizobenthos in freshwaters. **Chara** particularly favours hard waters with a pH >7.0 but the pH range of the whole group is between 5.0 and 10.0. They are not present in polluted waters especially where sewage is being discharged. Some species of the Charophyta impart a garlic like odour to the water. Chlorophyta (Plate I).

3 (1) (a) Cells grouped together to form a filament, strand or ribbon (see glossary for definition of these terms). Sometimes filaments can grow in such profusion to be visible en masse, or are visible as multiseriate rows encrusting stones.. . . . . **4**

(b) Cells individual or in groups that may be regular or irregular in shape but not forming a filament, strand or ribbon **56**

4 (3) (a) Cell pigments localized in chloroplasts*. Colour when fresh may be grass green, pale green, golden to brown, olive green or (rarely) blueish or reddish **5**

(b) Cell pigments not localized in chloroplasts. Colour when fresh is frequently blue-green but may be olive green **43**

It can sometimes be difficult to decide whether chloroplasts are present or not as with some species they may be large enough to appear to fill the whole cell leaving no visible clear areas. It is important in such cases to use other features as well such as pigment colour but this is best done with live, fresh material. It is also useful to look for the range of features indicated in Table 1.2. The only group of algae not having chloroplasts are the Cyanophyta and they, for example, do not have flagella so if the specimen is a flagellate it cannot be a cyanophyte and hence must have chloroplasts. Cross-referencing to other features in the table can also help arrive at the correct answer.

5 (4) (a) Filaments branched, sometimes rarely. False or true branching. Filaments may branch only occasionally (in some cases to generate reproductive structures) so it is important to examine a reasonable length to determine whether they branch or not. **6**

(b) Filaments or ribbons unbranched 24

6 (5) (a) Branches of filament rejoin to form a net . . . . **Hydrodictyon**

Hydrodictyon (commonly known as the 'water net') forms macroscopic nets that are free floating (occasionally attached) of many centimetres in length. Populations may be large enough to partially block small streams, especially nutrient-rich nutrient rich waters. The cells are cylindrical and joined at the ends to form a net. Individual adult cells can be several millimetres in length. There is a single parietal, net-like chloroplast with several pyrenoids within the cell. Widespread in ponds and slow moving ditches. It can produce very large masses in the summer which may be a nuisance blocking the watercourse. Chlorophyta (Fig. 4.1).

(b) Branches of filaments do not rejoin to form a net **7**

7 (6) (a) Each cell is enclosed in a flask-shaped lorica which is narrow at one end and with a wide opening at the other. One or two loricas may arise from the mouth of the one beneath forming a forked or dendroid series. The algal cells within each lorica are biflagellate with brownish chloroplasts . . . . .**Dinobryon**

Dinobryon is a mainly colonial alga, the characteristic feature of which is that the cells are surrounded by a flask-shaped lorica.

Plate I **1.** *Nitella*. **2.** *Chara.*

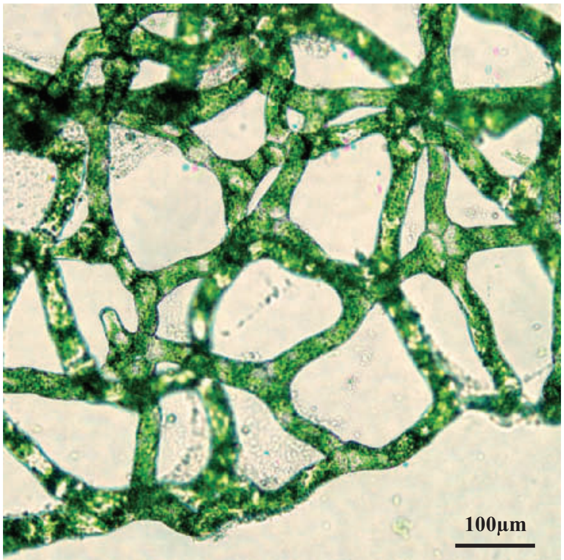


Figure 4.1 *Hydrodictyon*. Detail from edge of tubular net showing 3D intercellular network.

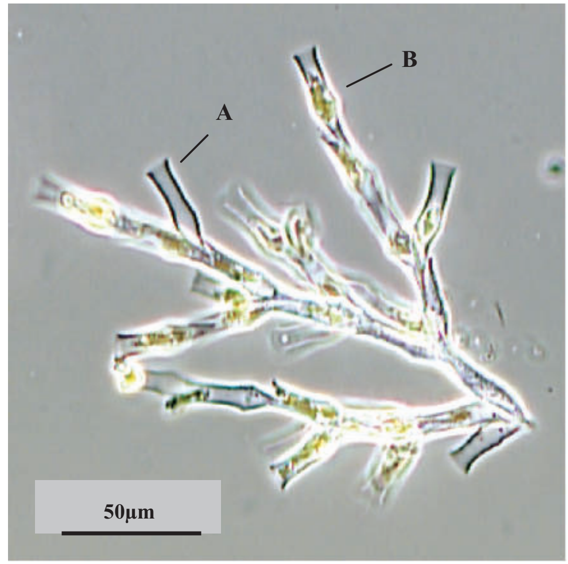


Figure 4.2 *Dinobryon.* Phase-contrast image of free-floating dendroid colony. A, Empty lorica; B, lorica containing biflagellate cell.

It can be solitary but more frequently occurs in colonies. These colonies are branched or dendroid with each new lorica emerging from the open neck of, and attached by means of a stalk to, the old. Each lorica contains one biflagellate cell attached to the base of the lorica by a fine cytoplasmic thread. The flagella are of unequal lengths (heterokont). There are typically two chloroplasts per cell with chrysolaminarin granules at the base. An eyespot is also present. The lorica may be clear or coloured brown, smooth or ornamented and vary in overall shape depending upon species. The lorica may be up to 100+ µm in length.

Dinobryon is widely recognized as a bacteria-consuming mixotroph (capable of both autotrophic and heterotrophic nutrition). Very widely distributed in the plankton of ponds and lakes from nutrient-enriched to nutrient-poor. It may be present in hard or soft waters. Common in the plankton of cool waters and in mountain regions. Has been associated with odour probems in drinking water (Palmer, 1962). Chrysophyta. Plate II and Fig. 4.2.

(b) Cells not in flask-shaped loricas **8**

8 (7) (a) Filaments without cross walls dividing them into separate cells (siphonaceous or coenocytic), cross walls only appearing when reproductive structures produced. Irregularly branched . . . . **Vaucheria**

Filaments are cylindrical, multinucleate and lack cross walls. There are numerous disc-shaped to oval chloroplasts with or without pyrenoids. The usual storage products are oil and fat, very rarely starch. Branching does occur but is irregular. Filament 20–140 µm wide. The various species are identified mainly by their reproductive structures. Widespread and may form green mats of tangled filaments in shallow freshwaters, on stones and damp soil. It may also occur in

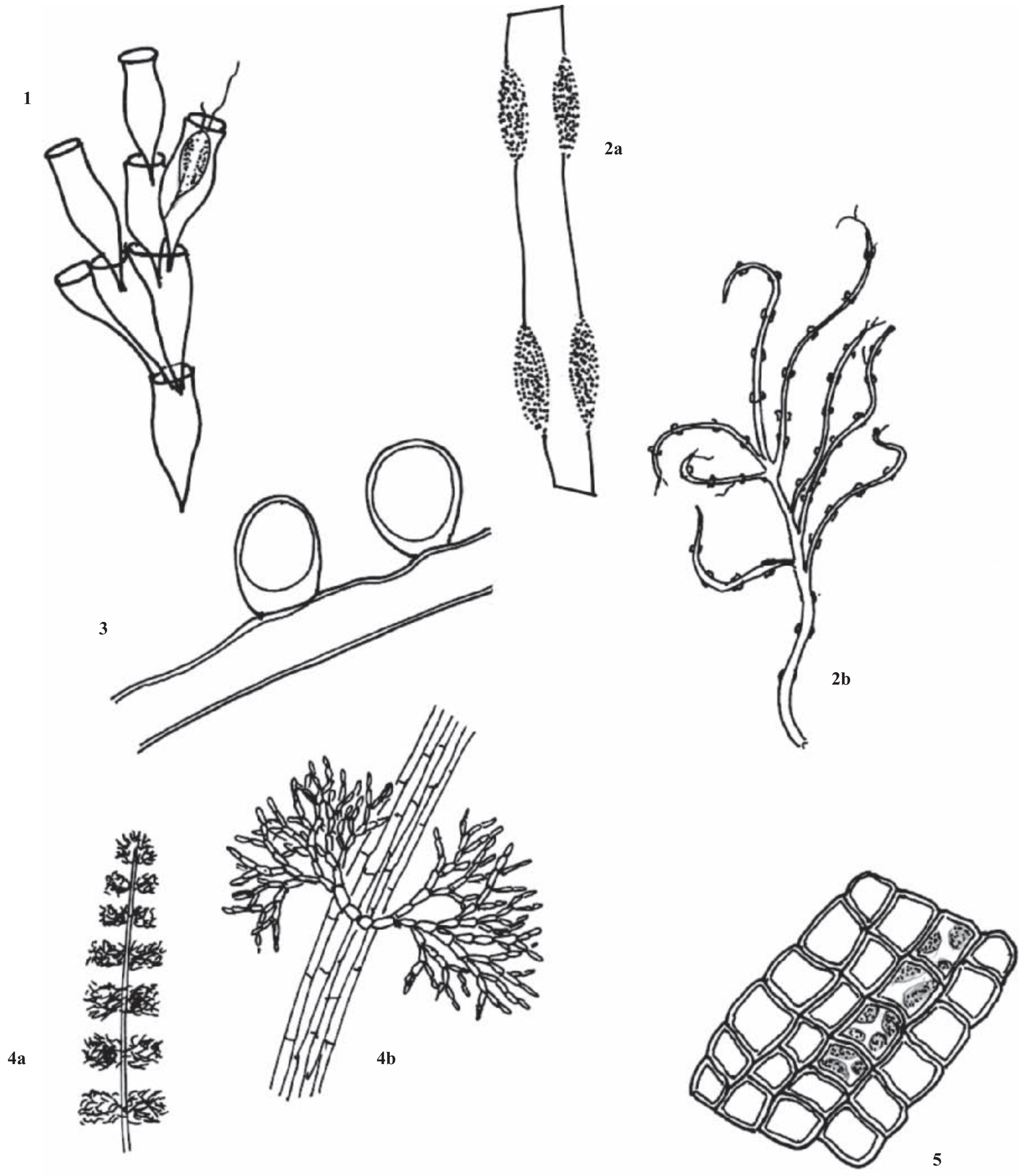
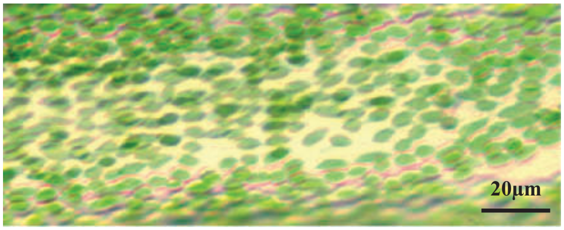


Plate II **1.** *Dinobryon*. **2.** *Lemanea* (a) growths on higher plant stem, (b) whole alga. **3.** V*aucheria*. **4.** *Batrachospermum,* (a) whole alga, (b) details of branching. **5.** *Hildenbrandia.*



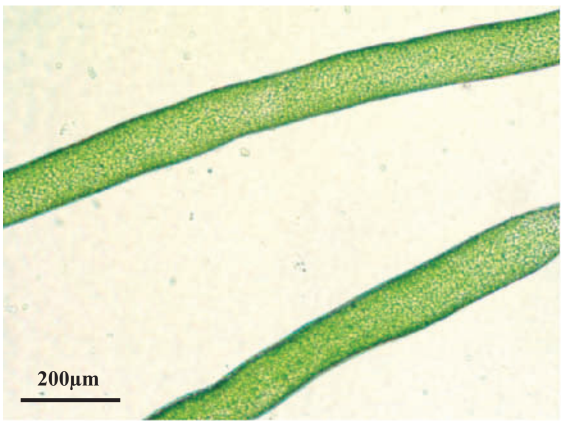


Figure 4.3 *Vaucheria*. Top: Detail from surface of filament (DIC image) showing numerous discoid chloroplasts Bottom: Low power view of filaments showing absence of cell walls.

salt marshes and brackish water muds. Xanthophyta. Plate II and Fig. 4.3.

(b) Filaments with normal cross walls, not siphonaceous **9**

9 (8) (a) Filaments multiseriate, i.e. columns of cells in many parallel or radiating rows. Branches may or may not be present **10**

(b) Filaments not multiseriate **13**

(but see also **Coleochaete** which, when older, forms a mass or disc of cells that appear multiseriate).

10 (9) (a) Filaments branched (although the branching can be scarce and difficult to find – hence the need to look along several filaments to confirm situation) with branches arising in tufts (embedded in mucilage) or as less frequent and more tapered bristles **11**

(b) Filaments encrusting on stones or macrophytes forming single or packed layers of cells, green, red or brown in colour. **12**

11 (10) (a) Filaments loosely embedded in copious mucilage. Main filament axis with tufts of branches arranged at regular intervals . . . . **Batrachospermum**

Batrachospermum produces large multibranched filaments in a mucilaginous or gelatinous mass, similar to frog spawn. The overall appearance of the filaments is that they are beaded. There is a main large axis with regular whorls of smaller branches. Chloroplasts have no pyrenoids and are ribbon-like (several per cell), olive brown to reddish or grey-blue in colour. The whorls may be more than 1 mm in diameter. Widespread and with a characteristic appearance. Found in streams and pools/bogs. Rhodophyta. Plate II. Fig. 4.4.

(b) Plants without regular tufts of branches. Thickened areas along stem. . . . . . **Lemanea**

The thallus of **Lemanea** is cartilaginous and thus has an erect posture being attached at the base. The bristle-like 'stems' can grow up to 20 cm in length and show little to frequent branching. When growing in water plants look like stiff tufts of black or brown hair, each hair having irregular thickenings along their length. Chloroplasts are numerous, parietal and disc-shaped. Widespread in moderate to fast flowing streams attached to stones. Rhodophyta. Plate II.

12 (10) (a) Cells of filaments stacked in vertical rows to form a pseudoparenchymatous mass. These filaments are found as a thin, flat rose-coloured encrustation on stones. **Hildenbrandia**

Figure 4.4 *Batrachospermum.* Top: Detail showing a whorl of uniaxial tufts (A) arising from the main axis (B). Bottom: General view of thallus.

The thalli of **Hildenbrandia** grow over stones in rivers and streams, frequently in hard waters. The thalli are crustose, reddish in colour and closely adhere to the substrate. Cells cubical in vertical rows, each cell up to 16 μm in diameter. Rhodophyta. Plate II.

(b) Filaments attached to a surface, radiating from a central point forming a flattened disc or slightly rounded cushion of cells - some of which have fine hairs or setae which are sheathed at the base .... **Coleochaete**

Coleochaete is a member of the Chlorophyta. It is uniseriate when younger or can grow as a mass where the filaments tend to merge to form a pseudoparenchymatous mass. Branches may be dichotomous or irregular. There may be an erect part of the thallus as well as the flattened disc-like cushion. The cells frequently have long bristles sheathed at their bases. There is a single parietal plate-like chloroplast with one or two pyrenoids. Widespread as an epiphyte on aquatic macrophytes and other surfaces. Chlorophyta. Plate III.

13 (9) (a) Some cells along the filament bear hairs or setae **14**

(b) No hairs or setae present........... **18**

14 (13) (a) Hairs or setae having a bulbous base . **15**

(b) No bulbous base present with the hairs or setae **16**

15 (14) (a) Filaments growing horizontally or prostrate, epiphytic. Branching irregular or may be absent. Some cells with one to several hairs .... **Aphanochaete**

Aphanochaete is a prostrate creeping epiphyte and a member of the Chlorophyta. Cells longer than broad and sometimes slightly swollen in the centre and often bearing one or more long bristles swollen at the base. Chloroplasts disc-shaped with one or more pyrenoids. Widespread distribution, often reported in nutrient-rich waters as an epiphyte on submerged macrophytes and larger filamentous green algae. Plate III.

(b) Filaments not prostrate, branched, with cells somewhat broader at the top than the base. Many cells have one or more characteristic colourless chaetae (a terminal hair with a swollen base) arising from the top of the cell. .... **Bulbochaete.**

Bulbochaete is a member of the **Oedogoniales**. It has branched filaments and is

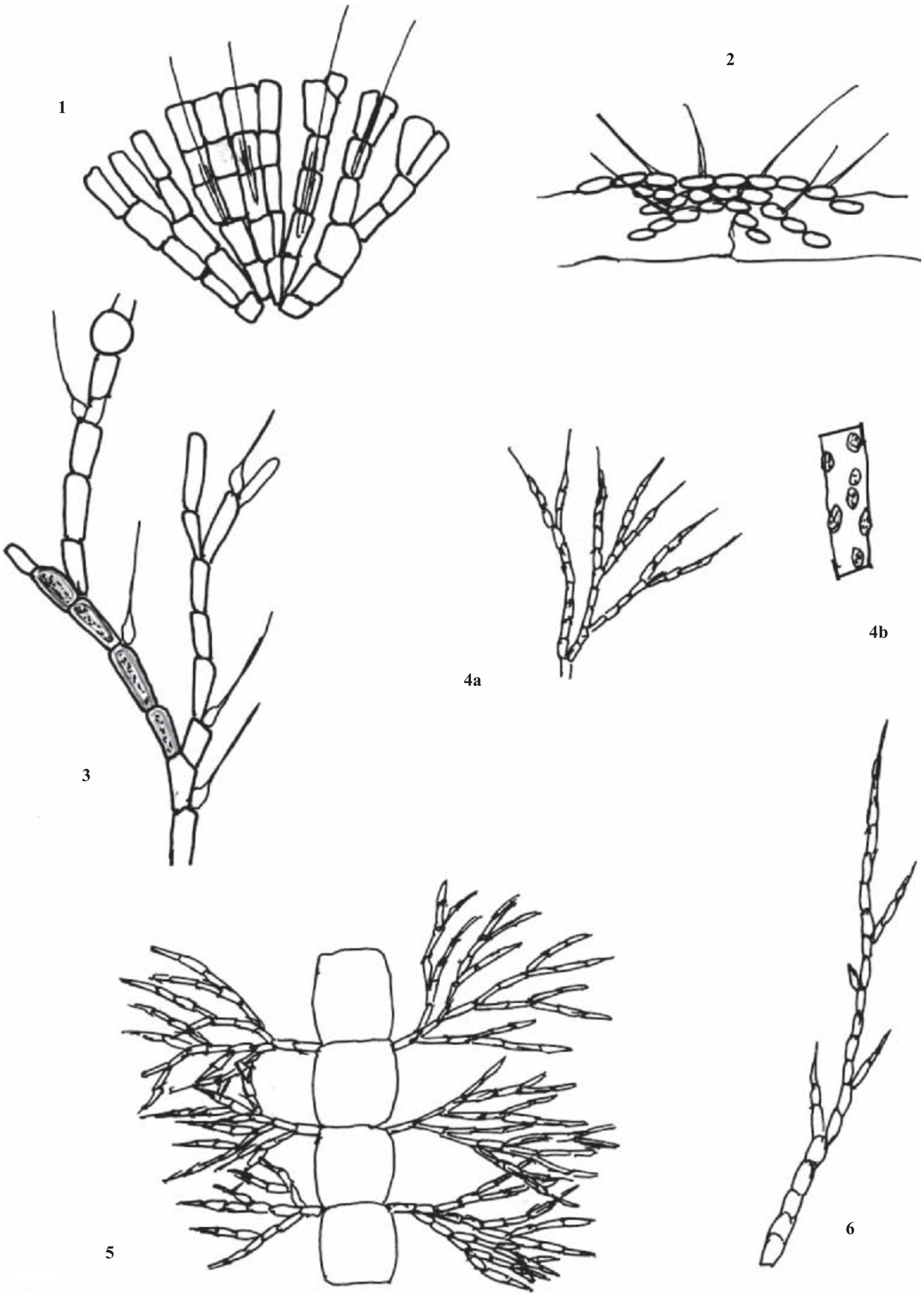


Plate III **1.** *Coleochaete.* **2.** *Aphanochaete.* **3.** *Bulbochaete.* **4.** *Chaetophora*, (a) whole alga, (b) growths on stem of higher plant. **5.** *Draparnaldia.* **6.** *Stigeoclonium.*

easily identified by the hairs which have distinctly swollen bases. Chloroplast parietal and net-like with several pyrenoids. Widespread distribution, growing attached to submerged macrophytes or stones. Wide pH and nutrient range. Chlorophyta. Plate III.

16 (14) (a) Filaments enclosed in soft watery mucilage which has no definite shape **17**

(b) Filaments with a firm mucilage surround having a definite shape. Often forming macroscopic attached masses **Chaetophora**

Chaetophora filaments are frequently attached to stones or submerged aquatic plants. Filaments can be quite long (10+ cm.). Branching more common towards filament apex. End cells of filament/branch with a pointed shape or in the form of a long multicellular hair. The erect system is well developed but the prostrate one is not. Fairly widespread distribution at the edges of shallow flowing or still waters attached to a substrate such as aquatic plants. Chlorophyta Plate III.

17 (16) (a) Main filament axis composed of a single row of larger cells from which arise tufts of branches composed of much smaller cells, the whole enclosed in soft mucilage . . . . **Draparnaldia**

Draparnaldia is a member of the Chlorophyta. The erect filaments are attached to the substratum by means of rhizoids. Filaments embedded in soft mucilage. Main filament cells barrel-shaped (40–100 µm wide) with net-like or complete band-shaped parietal chloroplast with several pyrenoids. Branches arise in whorls from main axis. Branch cells smaller with single chloroplast and up to three pyrenoids. Branches have either a blunt terminal cell or form a multicellular hair. Widely distributed often in phosphorus-poor waters. Plate III.

(b) Filament main axis cells not markedly different to branch cells (except those at the end of branches, which are thinner and hair-like). Branches not usually occurring in distinct whorls . . . . **Stigeoclonium**

Filaments of **Stigeoclonium** are usually attached by means of basal cells to a variety of surfaces. Branches can be opposite, alternate but rarely whorled and terminating in a tapering series of cells sometimes forming a terminal multicellular hair. Filaments surrounded by a thin mucilaginous layer. Chloroplasts parietal with one or more pyrenoids. Cells 5–40 µm wide and many times longer than broad. Widespread distribution usually attached to rocks or stones but may break away and be found free floating. Several species, in flowing or still waters. ***S. tenue*** is common and is often used as an indicator of enriched or organically-polluted situations (also reported as tolerant to heavy metal pollution). Chlorophyta. Plate III. Fig. 4.5.

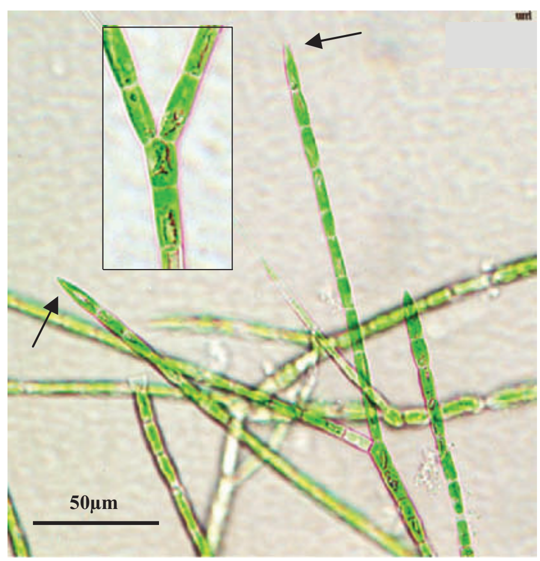


Figure 4.5 *Stigeoclonium*. General view of filaments, with branches tapering to a fine point (arrows). Inset: Mode of branching.

18 (13) (a) Branched filaments embedded in mucilage **19**

(b) Branched filaments not embedded in mucilage **21**

19 (18) (a) Plant forms a gelatinous globular cushion. Mucilage may be firm and encrusted with lime in hard water locations **20**

(b) Mucilage covering thin. Usually attached at base and forming trailing branched filaments. Not cushion-like or globular . . . . **Stigeoclonium (see 17)**

20 (19) (a) Cushions composed of filaments with branches tapering to a long multicellular hair or having a single rounded cell at apex. Mucilage firm forming cushions 1–2+ cm wide **Chaetophora (see 16)**

(b) Cushions generally smaller (>5 mm diameter). Filaments with less branches and cells rounded or with swollen ends, often lime-encrusted . . . . **Gongrosira**

Gongrosira forms cushion-like colonies that may be lime-encrusted in hard waters. Filaments arise from a basal prostrate group of cells, forming an erect as well as a prostrate system. No hairs present and terminal cells of branches bluntly rounded. Cells cylindrical or swollen. Often with thickened walls. Parietal chloroplasts with 1 to several pyrenoids. Frequent in streams, shallow lake margins or ponds, on stones, often in hard water regions. Cells 4–30 μm wide, 1 to 3 times longer than breadth. Chlorophyta. Plate IV.

21 (18) (a) Plants small erect, cells <5 μm diameter but up to ×4 as long as broad. Cell walls thin. Filaments highly branched with the first cross wall of a branch being a small distance from the main axis. Pyrenoids absent . . . . **Microthamnion**

Microthamnion consists of attached delicate branched filaments of the same width throughout. Chloroplasts parietal and pyrenoids absent. Cells 1.5–5 μm diameter and up to ×12 long as broad. Widespread distribution often in acid organically-rich waters and waters with higher iron and/or manganese compounds. Attached to substrate by means of a holdfast. Often in association with **Microspora** assemblages. Can also be found on soils. Chlorophyta. Plate IV.

(b) Plants larger. Cells greater than 7 μm in diameter. The first cross walls of each branch occurs at the origin of the branch. Pyrenoids are present **22**

22 (21) (a) Filaments and branches tapering gradually, over two or three cells, to a fine point . . . . **Stigeoclonium (see 17)**

(b) Filaments tapering abruptly, not gradually, with a rounded blunt end cell **23**

23 (22) (a) Branches, which may be sparse in occurrence, usually short, sometimes consisting of only one cell and almost rhizoidal in appearance . . . . **Rhizoclonium**

Rhizoclonium forms coarse, wiry filaments with short sometimes rhizoidal branches although these are not always present. Cells are elongate with robust walls, 10–40 μm broad and between 2 and 8 times as long as they are broad. The chloroplast is net-like with numerous pyrenoids. Common in hard, shallow, waters where it may be found in dense mats. Often found with (and confused with) **Cladophora.** Chlorophyta. Plate IV.

(b) Branches often longer and and more robust. Repeated branching may occur . . . . **Cladophora**

Cladophora is typically well branched but in gently flowing waters branching may be intermittent and difficult to find. In contrast, on a lake shoreline habitat subject to choppy wave action, the form may be tufted or bush-like with many branches. **Cladophora** may

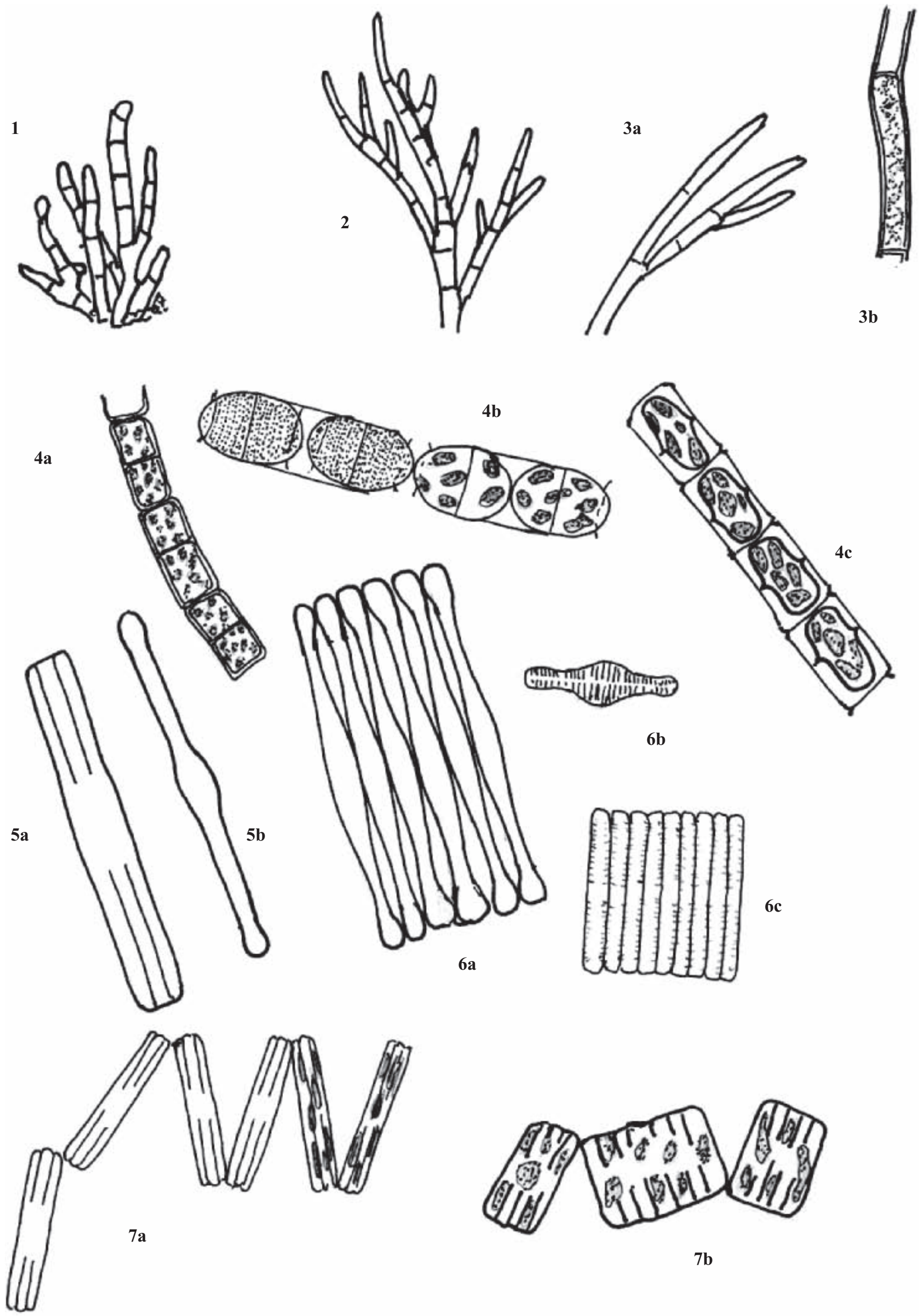


Plate IV **1.** *Gongrosira.* **2.** *Microthamnion.* **3.** *Rhizoclonium*: (a) general view; (b) cell detail. **4.** *Melosira*: (a) *M. varians*; (b) *M. nummuloides*; (c) *M. dickiei.* **5.** *Tabellaria fenestrata*: (a) colony – girdle view; (b) single cell – valve view **6.** *Fragilaria*: (a) *F. crotonensis*; (b) *F. capucina* – single cell, girdle view; (b) colony – valve view. **7.** *Tabellaria*: (a) *T. fenestrata* – zigzag colony; (b) *T. flocculosa.*

Figure 4.6 *Cladophora* General view of filaments, showing newly-formed branches.

be free living or attached to a substrate by means of a small holdfast. The branches may be alternate or opposite, dichotomous or even trichotomous. Cell walls are robust and the chloroplast net-like (reticulate) and parietal with numerous pyrenoids. Cells 50–150 µm broad and up to ×10 long as broad. Commonly known as 'blanket weed' it can form extensive, coarse to touch mats. Frequent in hard or semi-hard waters especially those enriched with sewage. May also be found in marine habitats especially those enriched with sewage. **Cladophora** can also produce large growths in water treatment filtration systems such as slow sand filters where severe problems of filter clogging may result. Chlorophyta. Figs 2.28 and 4.6.

(Not to be confused with **Pithophora**, which is common in ponds but whose filaments frequently contain dark akinetes that are swollen and barrel-shaped. Cells 20–100 µm wide and up to 400 µm long. Not illustrated.)

24 (5) (a) Cells with a siliceous wall **25**

To determine whether a silica wall is present it may be necessary to 'clean' the specimen with a suitable oxidizing or acidifying agent (see Section 2.5.4). Some indication can be obtained, however, by sharply focusing on the cell wall. If a regular pattern of markings can be made out (e.g. Fig. 1.13) then it is quite probable that the wall is made of silica. If an empty cell can be found then it may be easier to see any markings. With some pennate diatoms a distinctive gliding movement may be observed in live (fresh) material

(b) Cell wall not made of silica **30**

25 (24) (a) Cells embedded in a gelatinous tube but separate from each other within the tube

Frustulia in part see 199

Cymbella and Encyonema in part see 160

(b) Cells not as above **26**

26 (25) (a) Cells joined together to form a continuous filament not surrounded by extensive mucilage. Filaments and cells circular in cross section **27**

(b) Cells forming a ribbon or chain. Cells elongate and not circular in transverse section **28**

27 (26) The former genus **Melosira**, consisting of filaments of centric cells, has now been subdivided into **Melosira** and **Aulacoseira** (see below)

(a) Cell walls with no obvious markings. Cells linked in pairs (paired arrangement may be difficult to see) . . . . **Melosira**

Cells of **Melosira** do not have distinctive markings on their surface. They are rectangular (**M. varians**) or ovoid (**M. nummuloides**) in shape (girdle view) with relatively thin walls or rectangular with quite thick walls (**M. dickiei**). Cells of the filament are linked together in pairs although this can require careful observation to see. Chloroplasts are small discs or plates and may be golden-brown to dark-brown. **M. varians** (cells 8–35 μm in diameter, 4–14 μm deep) is common and sometimes abundant in shallow, frequently smaller, eutrophic waters. **M. dickiei** (10–2 μm in diameter, 7–10 μm deep) is found on damp rocks and river banks and **M. nummuloides** (9–42 μm in diameter, 10–14 μm deep) is found in brackish or marine environments, often attached to the substratum. **M. varians** can grow in water treatment filters open to sunlight and cause clogging problems. Bacillariophyta. Plate IV and Fig. 4.7.

(b) Cell walls with granulated markings and often with spines at end (often best seen at end of a filament). Forming a continuous filament and not in pairs . . . . **Aulacoseira**

In **Aulacoseira** the cells are rectangular in shape (girdle view) and are linked together to form long filaments. The surface of the silica cell wall has characteristic markings of rows of dots (punctae) and the ends of the cells bear a ring of spines (one or two of which may be quite long) that link the cells together. A sulcus can usually be observed between the mantle and girdle band. Chloroplasts disc-shaped and usually golden-brown. Several species are found in freshwaters. Some are more common in eutrophic lakes, e.g. **A. ambigua** (cells 4–17 × 5–13 μm in size), **A. granulata** (cells 4–30 × 5–24 μm in size), **A. granulate var angustissima** (has narrow, long cells with a obvious long spine protruding from the end cell) and **A italica** (cells 6–23 × 8–20 μm in size) and others in less enriched waters, e.g. **A. islandica** (cells 3–28 ×4–21 μm in size) and **A. subarctica** (cells 3–15 × 2.5–18 μm in size)**. A. granulata** can cause filter clogging problems in water works (see also **Melosira**). Bacillariophyta. Figs 1.3, 4.8, 4.9.

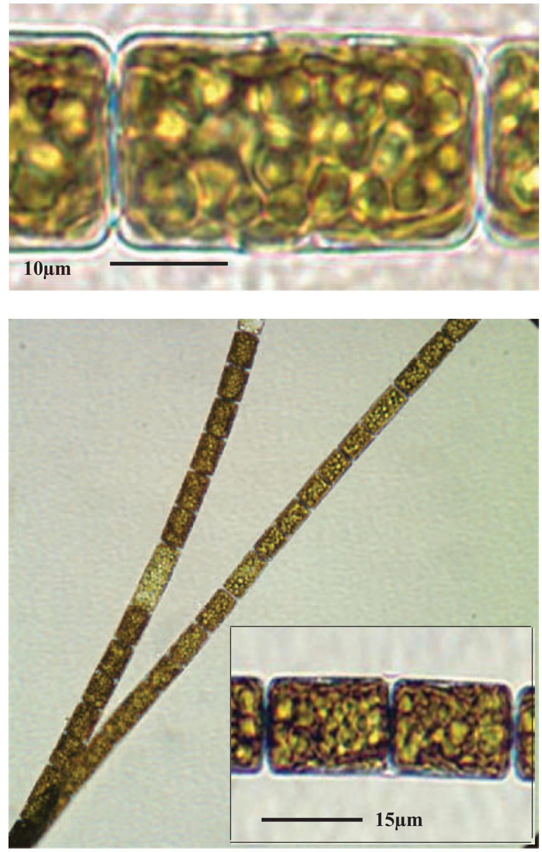


Figure 4.7 *Melosira* Top: Single cell showing numerous yellow-brown discoid chloroplasts. Bottom: Straight, unbranched filaments typical of this colonial diatom. Inset: Characteristic paired arrangement of cells along filament.

28 (26) (a) Cells with internal septa or costae (see below) **29**

Costae are silica thickenings on the inside of the valve, orientated at right angles to the apical (long) axis. Septa are silica plates that run across the inside of the cell from the girdle bands. The septa may protrude for different lengths into the cell.

(b) Cells without internal septa . . . . **Fragilaria**

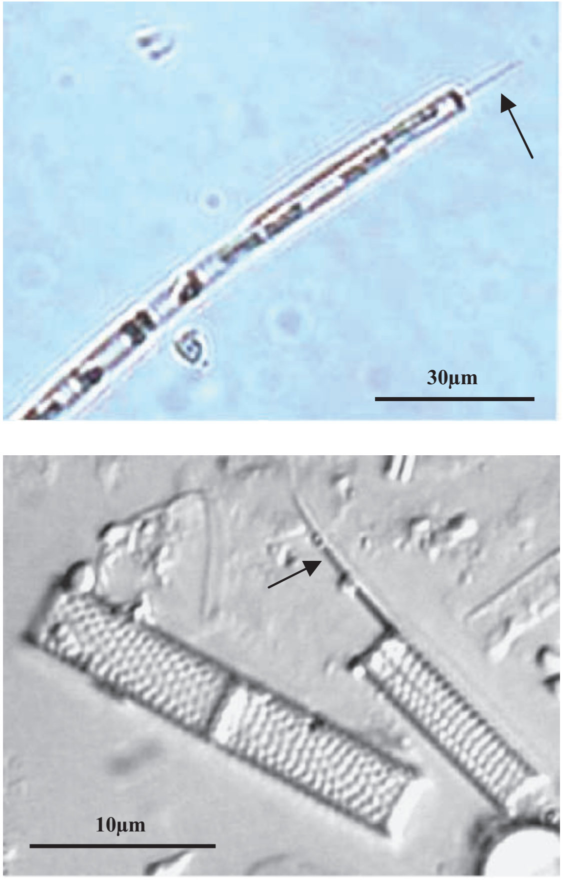


Figure 4.8 *Aulacoseira* Top: Planktonic filament (*A. granulata* var. *angustissima*). Bottom: Fragmented filament (*A. granulata*) – acid digest, lake sediment sample. A terminal spine (arrow) is visible in both cases.

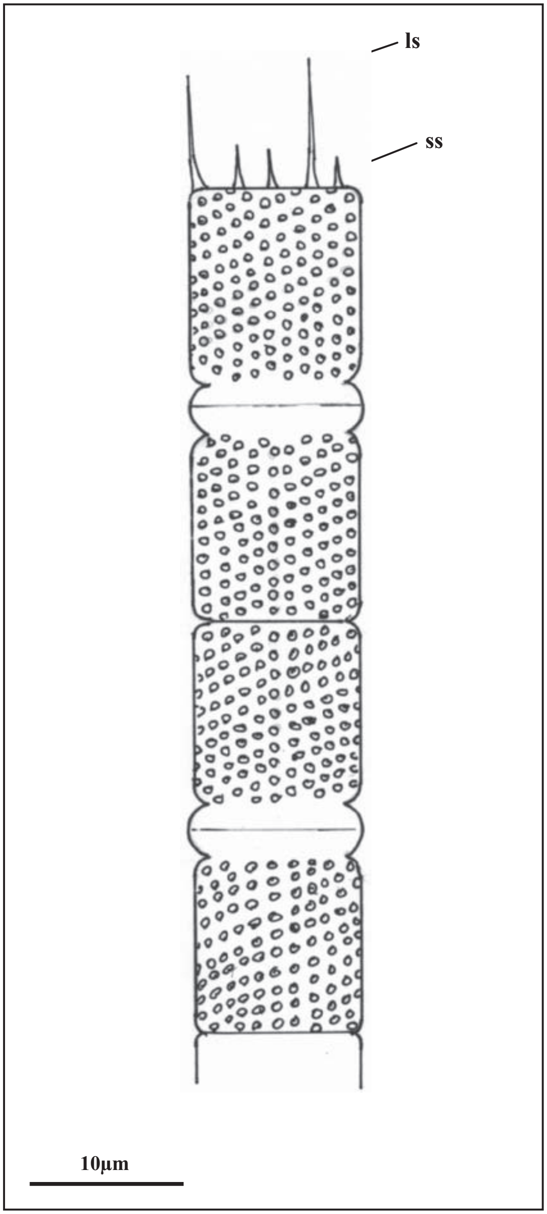


Figure 4.9 *Aulacoseira granulata*. Cells have terminal long (ls) and short (ss) spines.

In **Fragilaria** the pennate or elongate frustules are joined by their valve faces to form a ribbon-like chain. Valves fusiform in shape, sometimes slightly swollen at the centre (gibbous) or with swollen (capitate) ends or narrow and rectangular in girdle view. Usually seen in girdle view in non acid-cleaned material. Valve surface with fine striae. Two plate-shaped chloroplasts present. **Fragilaria crotonensis** can be found in meso- to eutrophic waters, sometimes forming blooms. Size, 40–170 µm long, 2–4 µm wide. **F. capucina** is also widespread occurring in lakes and rivers, 10–100 µm long, 3.5–4.5 µm wide. Can impart unwanted odour to drinking waters (Palmer, 1962). Large numbers can cause

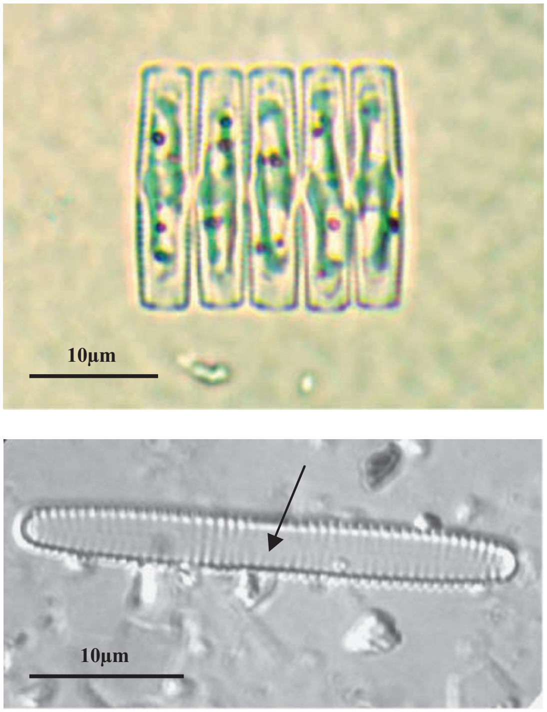


Figure 4.10 *Fragilaria.* Top: Ribbon arrangement of diatom colony. Fixed sample. Bottom: Single cell showing fine transverse striae, with central clear area (arrow). Acid digest, lake sediment sample.

filter clogging problems in water treatment works. Bacillariophyta. Plate IV. Fig. 4.10.

29 (28) (a) Cells rectangular or tabular in normal view, sometimes united to form zig-zag colonies. When seen individually and not as part of a chain the valves often show a strongly swollen middle region. Cells without costae but have internal septa which can be clearly seen . . . . **Tabellaria**

Tabellaria cells are rectangular in girdle view and form colonies that may be stellate or zig-zag. The stellate colonies can be confused with **Asterionella** but can be distinguished by: (1) internal septa in **Tabellaria**, and (2) more squared-off ends to the cells in **Tabellaria** when compared with the more rounded ends in **Asterionella**. **T. fenestrata** (33–116 μm long, 4–10 μm wide) and **T. flocculosa** (6–130 μm long and <5 μm wide) are the most frequent species.

Common in the plankton of less nutrient-rich lakes although they can be seen in mildly eutrophic conditions. Large numbers can clog water treatment filters. Bacillariophyta. Plates IV and V, Figs 2.28, 4.11.

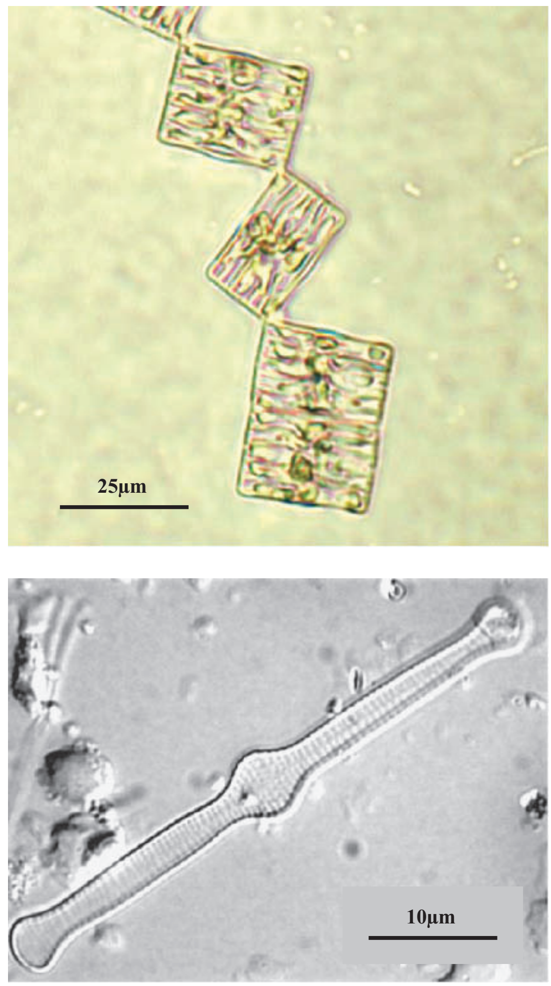


Figure 4.11 *Tabellaria.* Top: Zig-zag colony from river biofilm. Fixed preparation. Bottom: Different species – valve view of single cell. Acid digest, lake sediments.

(b) Cells rectangular, may unite to form zig-zag colonies. Cells rod-shaped when seen individually with (at the most) slightly swollen centres. Transverse costae present within the cells. . . . . **Diatoma**

Diatoma forms zig-zag or ribbon-like colonies or ribbon-like chains. Internal costae are present and may be seen as ridges or points at the cell margin. Chloroplasts discoid to plate-like >10 per cell. Cells may be capitate. Several species occur - the more common of which are **D. vulgaris** with cells (8–75 µm long and 7–18 µm wide) having bluntly rounded ends, common in the plankton of moderately eutrophic lakes and rivers, and **D. tenuis** (22–120 µm long and >10 m wide) with capitate apices broader than the rest of the cell. Planktonic and epiphytic. Large numbers of planktonic species can cause filter clogging problems in water treatment works. Bacillariophyta. Fig. 4.12.

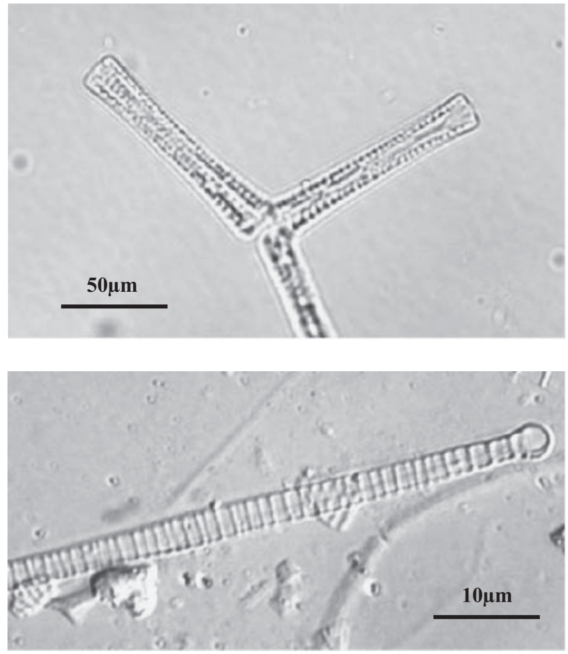


Figure 4.12 *Diatoma*. Top: Star-shaped pattern of cells at edge of planktonic colony. Bottom: Single cell, showing transverse costae. Acid digest, lake sediment sample.

30 (24) (a) Chloroplasts form a distinct spiral band within the cell . . . . **Spirogyra**

Spirogyra has cylindrical cells that are joined end to end to form an unbranched filament. The cell walls are firm and have a thin film of mucilage on the outside, giving them a slimy feel. Chloroplasts have a helical shape and there can be up to 15 per cell. Numerous pyrenoids are present. The nucleus, often visible in live material, is in the centre of the cell. Cells may be between 10 and 160 µm in diameter and up to 590 µm long. Filaments fragment easily at the cross walls, each fragment growing into a new filament. Sexual reproduction in **Spirogyra** involves conjugation between cells of different filaments and results in the production of a resistant zygote. It is widely distributed in shallow ponds and ditches where it can form dense green masses. Can grow in large enough amounts in shallow open-water treatment filters to cause blockage of those filters. Chlorophyta. Plate V. Fig. 4.13.

(b) Chloroplasts not in the form of a spiral band **31**

31 (30) (a) Filaments are unbranched with the cells embedded in a prominent broad mucilaginous hyaline cylindrical envelope or sheath. Cells are short cylinders with broadly rounded ends. . . . . **Geminella**

Cells are between 5–25 µm broad and up to twice as long as they are wide and are surrounded by a thick sheath of mucilage. Cells often occur in pairs along the filament. The chloroplast is a parietal plate, roughly saddle-shaped and located near the central region of the cell. A pyrenoid is usually present. Reproduction is by fragmentation of

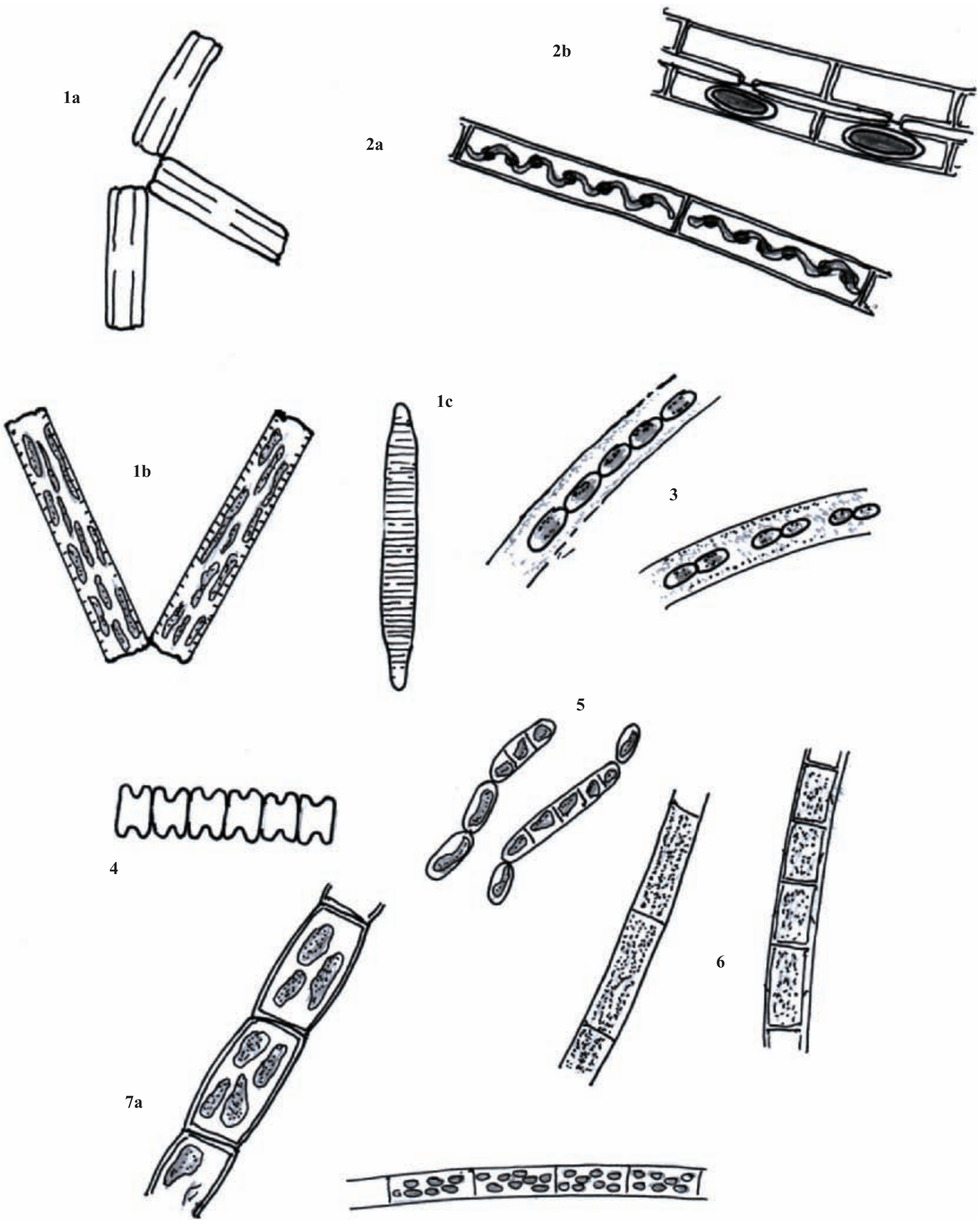


Plate V **1.** *Tabellaria flocculosa*: (a) colony; (b) girdle view of cells; (c) single cell – valve view. **2.** *Spirogyra*: (a) vegetative filament; (b) oospores. **3.** *Geminella.* **4.** *Spondylosium.* **5.** *Stichococcus.* **6.** *Microspora.* **7.** *Tribonema*: (a) *T. viride*; (b) *T. vulgare.*

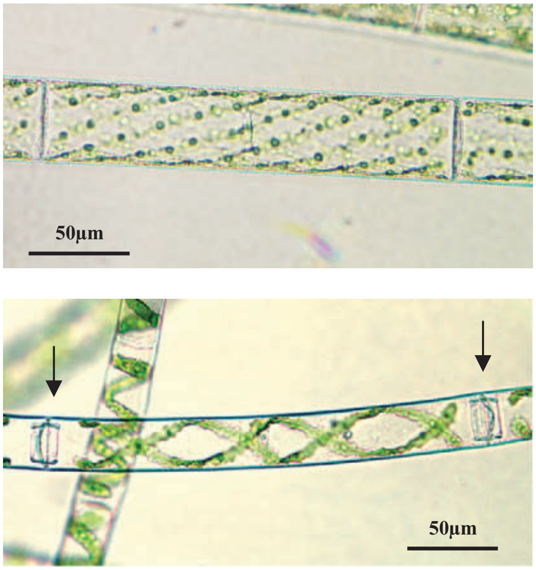


Figure 4.13 *Spirogyra*. Top: Species with multiple (about 6) spiral chloroplasts and simple cross walls. The chloroplasts have numerous pyrenoids (small dots). Bottom: Species with two chloroplasts and complex (replicate) cross walls (arrows).

the filament. Occurs in shallow, often slightly acidic, waters. Chlorophyta. Plate V.

(b) Cells not embedded in a prominent mucilaginous envelope **32**

32 (31) (a) Filament outline with constrictions giving it a toothed appearance **33**

(b) Filament outline without constrictions and does not have toothed appearance . . . **34**

33 (32) (a) Cells elliptical in shape in one view but show a deep narrow constriction when seen from the other view giving a toothed appearance with the teeth being smoothly rounded. No gap between adjoining cells. **Spondylosium**

Spondylosium is a filamentous desmid. Each cell resembles an angular or rounded (depending upon the species of **Spondylosum**) **Cosmarium** cell with a deep constriction - giving the characteristic toothed appearance to the filament as a whole. Cell walls fairly smooth. There is one chloroplast with pyrenoid in each semicell. Frequent around lake margins in upland areas. Chlorophyta. Plate V.

(b) Cells angular, rarely elliptical, in one view with a small lens-shaped gap between the cells usually visible. Cells only have a small constriction so the toothed margin not so pronounced and the 'teeth' are more angular . . . . **Desmidium**

Desmidium is a filamentous desmid. The cells can form long twisted filaments enclosed in a gelatinous envelope. When viewed in transverse section the filaments may be triangular. There is one chloroplast with pyrenoid in each semicell. Cells 26–50 µm broad. Sometimes the space between the cells can be difficult to see. Common in the vegetation and along the margins of oligotrophic lakes. Chlorophyta. Fig. 4.14.

34 (32) (a) Filaments very short, often only 2 or 3 cells long (more like a short chain than a

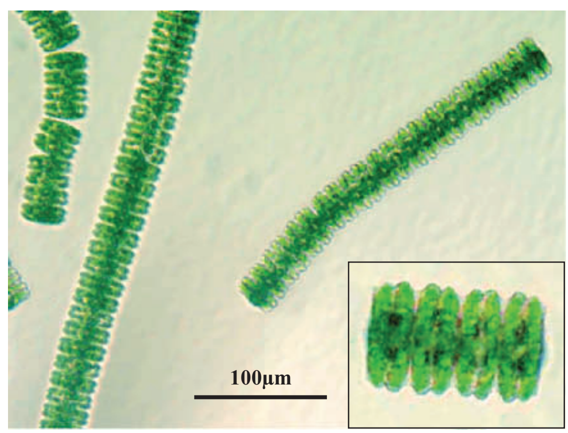


Figure 4.14 *Desmidium.* Elongate filaments of this colonial desmid. Inset: Details of four cells, each composed of two semicells.

filament). Cells cylindrical with free ends rounded . . . . **Stichococcus**

Stichococcus can occur singly or form very reduced filaments, just short chains. Cells 1–16 μm broad and 4–32 μm long. There is a single lobed chloroplast but no pyrenoid. Occurs on damp earth, tree trunks etc. as well as in freshwaters. Chlorophyta. Plate V.

(b) Filaments many cells in length, not typically short **35**

35 (34) (a) Large alga with tubular thallus many cells broad and long, macroscopic in size . . . . **Enteromorpha**

Enteromorpha has a tube-like thallus that may or may not branch. The plant can grow to many centimetres in length. The tube itself consists of a layer one cell thick. The tubes are attached to a substrate by means of rhizoidal branches and an attachment disc. **Enteromorpha** has a worldwide distribution mainly in marine and brackish water habitats but it can stray into freshwater. The two most common species are **E. intestinalis** and **E. compressa.** Chlorophyta. (Not illustrated.)

(b) Alga not a large tubular thallus **36**

36 (35) (a) Two star-shaped chloroplasts per cell . . . . **Zygnema**

Cells of **Zygnema** are cylindrical and have two, characteristic, star-shaped chloroplasts separated by a clear area. Each chloroplast has a pyrenoid. The filaments usually have a soft mucilage sheath, are unbranched and not very long. They may be attached to a substrate by means of rhizoids. Cells 16–50 μm in diameter and 2 to 3 times long as broad. As members of the Chlorophyta they store starch. Common in shallow waters where it can form luxuriant growths. Chlorophyta. Fig. 4.15.

(b) Chloroplast either single or more than two per cell **37**

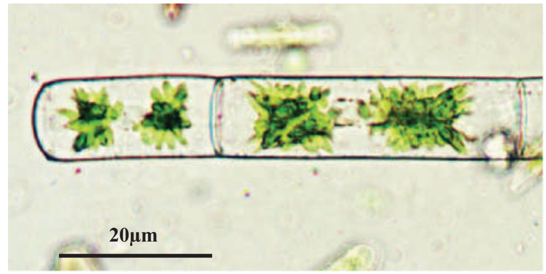


Figure 4.15 *Zygnema*. End of filament showing cells with two typical stellate chloroplasts.

37 (36) (a) One chloroplast per cell in the form of a flat plate arranged along the long axis of the cell. When viewed from one direction the chloroplast fills most of the cell but when viewed from the other it is a thin line down the middle . . . . **Mougeotia**

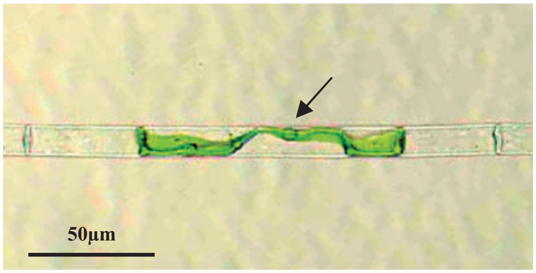
The chloroplast of **Mougeotia** is suspended on cytoplasmic strands and can move within the cell depending upon the light. Hence sometimes it may be seen face-on, sometimes edge-on and sometimes twisted. The cells form long unbranched free floating filaments. Cells 3.5–35 μm in diameter and between 5 and 12 times as long as broad. There are several pyrenoids per cell and when the chloroplast is viewed edge-on the pyrenoids give it a lumpy appearance. Storage product starch. Common in many habitats. Chlorophyta. Fig. 4.16.

(b) Chloroplast not as above **38**

38 (37) (a) Chloroplast reticulate (see glossary) **39**

(b) Chloroplast not reticulate **41**

39 (38) (a) Cell walls thick, often lamellate, made up of two overlapping halves which can break into H-pieces. End cells usually have H-shaped ends. Pyrenoids absent . . . . **Microspora**



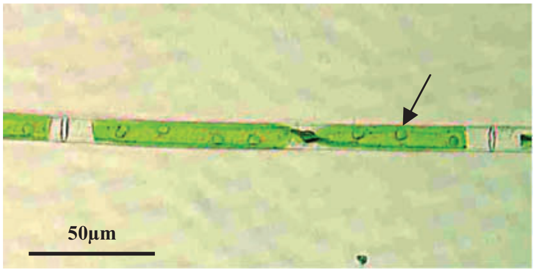


Figure 4.16 *Mougeotia.* Detail of separate cells showing plate-like chloroplast in edge (top) and face (bottom) view. Small refractive pyrenoids can be seen in the chloroplast (arrows).

Microspora forms unbranched filaments with a holdfast for substratum attachment. The cell walls are characteristically lamellate and shaped like an 'H' so that each cell is composed of two H-pieces joined together. Chloroplast reticulate not very well defined and pyrenoids absent. Storage product starch. Cells 5–30 μm in diameter and 1 to 3 times as long as broad. Common but not usually abundant in small freshwater bodies. More frequent at cooler times of the year. Chlorophyta. Plate V.

(b) Cell wall not thick and lamellate and not composed of H-pieces. Pyrenoids present **40**

40 (39) (a) Cells cylindrical or slightly swollen, cell walls robust. Cells 20–80 μm broad and between 5 and 15 times as long as broad . . . . **Cladophora**

(in part see 23)

(b) Cells cylindrical, sometimes slightly swollen at one end. Cell wall firm but not very robust. Filaments unbranched. Some cells along the filament will have ring-like transverse lines at the swollen end (cap cells). Cells 10–40 μm wide and 2–5 times as long as broad . . . . **Oedogonium**

Oedogonium cells form long, unbranched, filaments. The chloroplast is parietal and net-like. Cells are rectangular and longer than broad. The chloroplast is parietal and net-like with several pyrenoids. Over 200 species have been described and further identification is impossible without the reproductive structures being present. Abundant in still or gently moving waters where they may form dense mats Chlorophyta. Fig. 4.17.

41 (38) (a) Chloroplast a ring or is plate-shaped extending 1/3 to most of the way round the cell (at right angles to the long axis). One or more pyrenoids. Starch test positive **42**

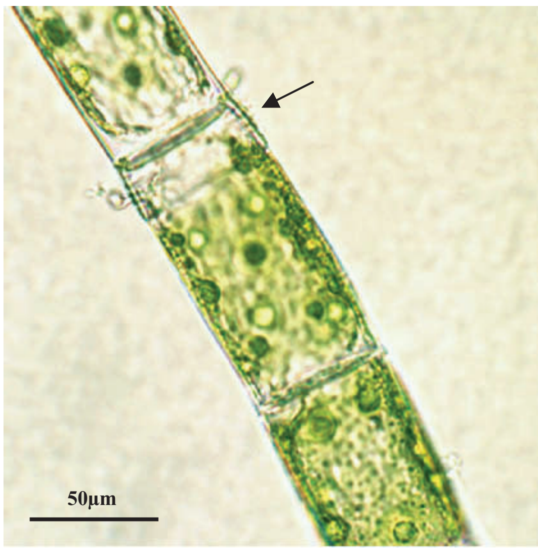


Figure 4.17 *Oedogonium.* The central cell (cap cell) has residual cell wall material, seen as transverse lines (arrow).

(b) Cells cylindrical or slightly barrel-shaped, between 2 and 6 times as long as broad. Chloroplasts one to many, curved discs or plate-shaped. Cell walls may fragment into H-pieces. Starch test negative . . . . **Tribonema**

Tribonema forms unbranched filaments. The cell walls are composed of H-pieces (compare with **Microspora**, which it can be distinguished from as it does not store starch). The presence of these H-pieces is best seen at the broken end of a filament. Common in the phytoplankton of lakes and reservoirs especially those rich in organic and humic materials. Xanthophyta. Plate V. Fig. 4.18.

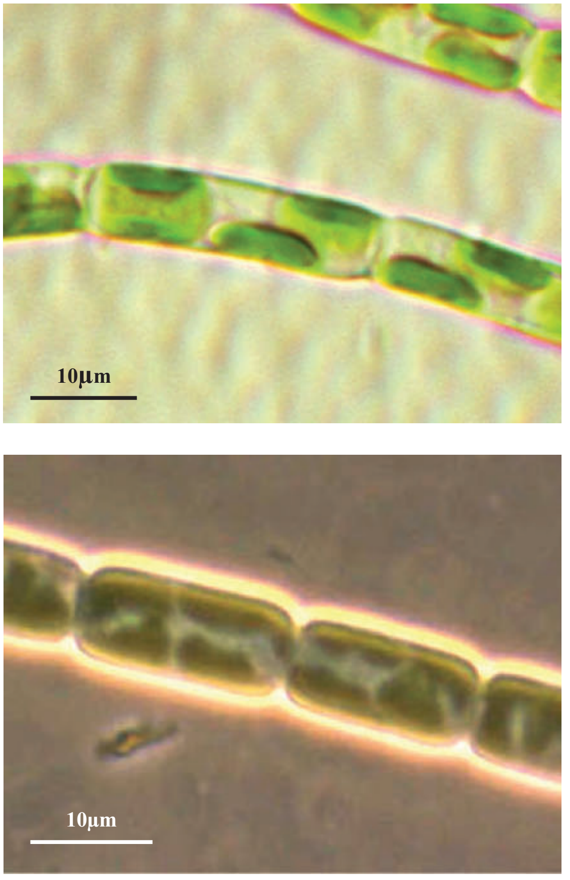


Figure 4.18 *Tribonema.* Top: Detail from filament, showing peripheral discoid chloroplasts. Bottom: Phase-contrast image showing narrowing at cross walls, giving cells a 'barrel shape'.

42 (41) (a) Chloroplast saddle-shaped extending more than half way around the circumference of the cell . . . . **Ulothrix**

Ulothrix species are composed of unbranched filaments. The cells are cylindrical either longer or shorter than broad, depending upon the species. There is a single annular or saddle-shaped chloroplast with one or more pyrenoids. Commonly forms bright green floating masses in shallow waters particularly at cooler times of the year. It can also be attached to submerged stones or wood. Common species include **U. zonata** (cells 11–37 µm wide and usually shorter than broad with fairly thick walls) and **U. aequalis** (cells 13–15 µm wide and 18–30 µm long). Can cause filter blocking in water treatment works. Chlorophyta. Plate VI. Fig. 4.19.

(b) Chloroplast extending less than half way round the cell . . . . **Klebsormidium**

Cylindrical (may be slightly barrel-shaped) cells 5–15 µm broad and 1–3 times long as broad. H-shaped pieces sometimes present at cross walls. The chloroplast consists of a parietal band or plate extending part way round the cell. A pyrenoid is usually present. Common on damp soil and in streams. The filaments fragment easily. Chlorophyta. Plate VI.

43 (4) **NB.** In the following section the terms *trichome* and *filament* are both used when speaking about blue-green algae. The difference between the two terms is defined as follows (John *et al.*, 2002).

A filament is a number of cells united in one or more rows to form a chain or thread. In the

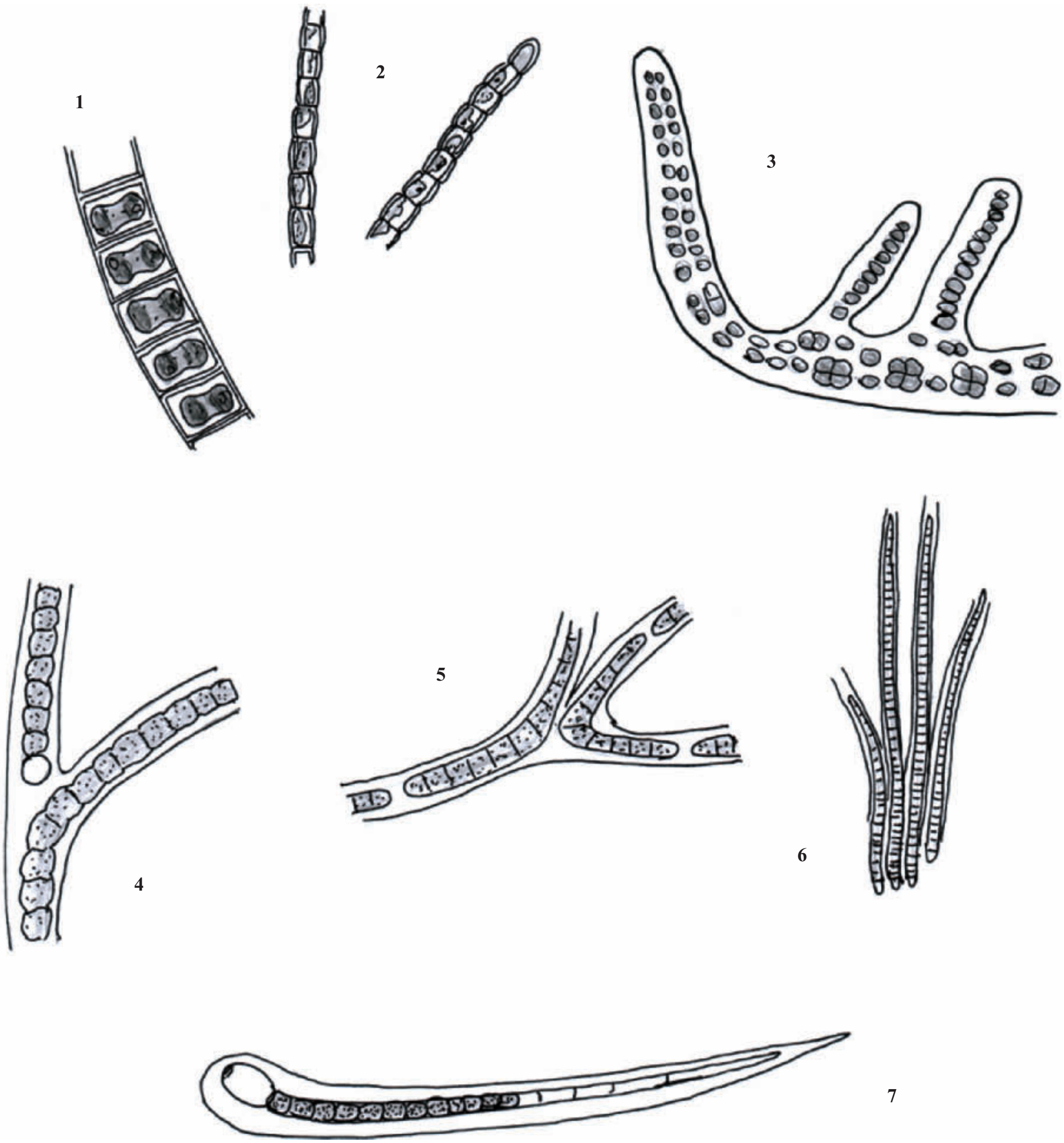


Plate VI **1.** *Ulothrix.* **2.** *Klebsormidium.* **3.** *Stigonema.* **4.** *Tolypothrix.* **5.** *Scytonema.* **6.** *Homoeothrix* **7.** *Calothrix.*

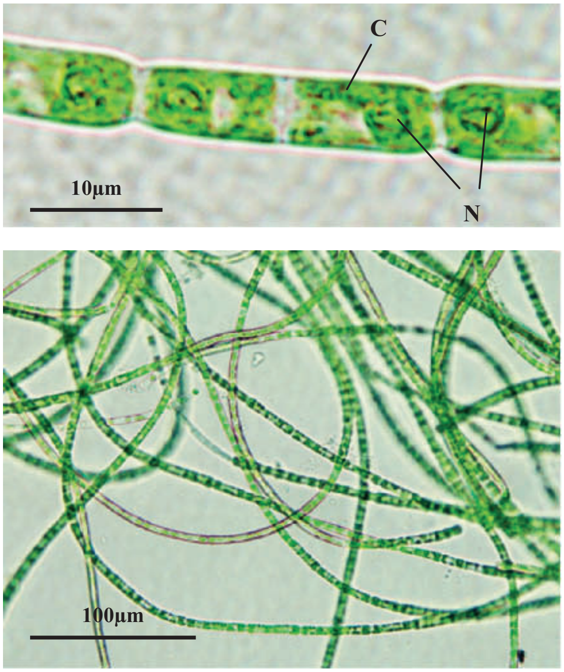


Figure 4.19 *Ulothrix.* Top: Detail from filament showing chloroplast (C) wrapping around the inside of the cell and prominent nuclei (N). Bottom: General view of floating mass of filaments.

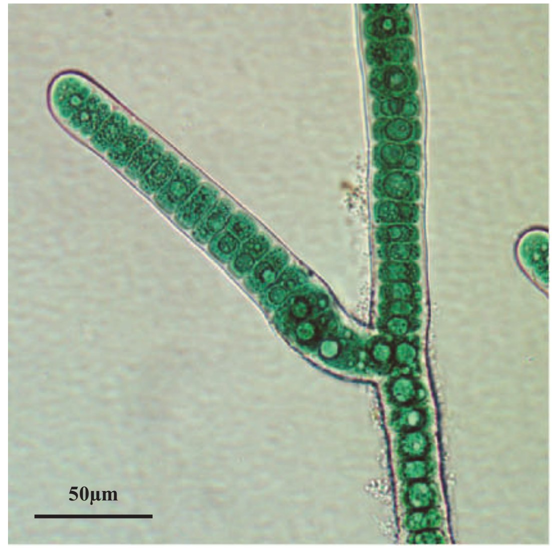


Figure 4.20 *Stigonema.* Blue-green alga, showing uniseriate main axis and side branch (true branching).

case of blue-green algae it refers to species which have a sheath surrounding the cells. A trichome is a linear arrangement of cells arranged without a surrounding sheath.

(a) Filaments or trichomes without true branching. False branching may be present **44**

(b) True branching present . . . . . **Stigonema**

Stigonema grows with branched trichomes up to 50 µm wide, the main axis of which may be multiseriate with the side branches uniseriate. The branched mass is structured enough to be called a colony (John *et al.*, 2002). Young cells at the branch tips can be transformed into hormogonia. Occasional heterocysts may be present. A firm mucilaginous sheath is present which is often stained yellow brown in colour. Cells may be quadrate or cylindrical (depending upon species). It grows as a thin mat over stones, rocks, damp soil or damp trees but can break away and become free floating. Cyanophyta. Plate VI. Fig. 4.20.

44 (43) (a) False branching present **45**

(b) False branching mostly absent (may rarely be present in **Rivularia** but this genus is easy to distinguish because of its tapering trichomes) **46**

45 (44) (a) False branches arise singly . . . . **Tolypothrix**

In **Tolypothrix** the trichomes show false branching where the branches are single and are often with a basal heterocyst. A brownish (sometimes colourless) sheath is present. Hormogonia may be produced at the ends. Filaments 6–18 µm in diameter. Usually attached or tangled amongst submerged

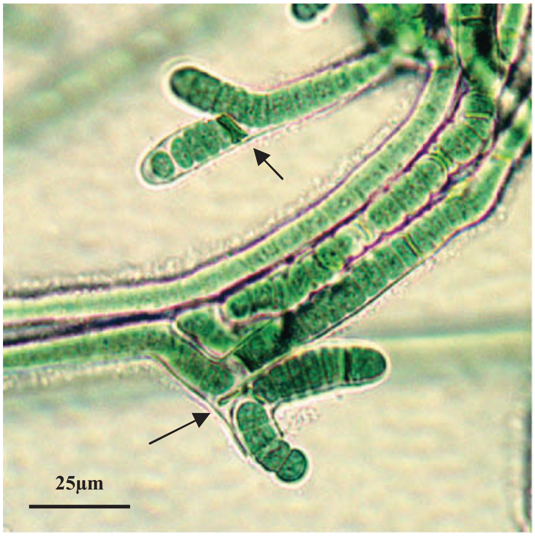


Figure 4.21 *Tolypothrix.* Detail from a web of filaments showing the false branching in this alga. Cells at the base of branches (arrows) have a distinctive flattened appearance

vegetation but occasionally free floating, often in more calcareous waters. Can occur on damp rocks. Cyanophyta. Plate VI. Fig. 4.21.

NB. In some genera false branching is rare but may occur occasionally. This can be true in **Homoeothrix, Calothrix, Gloeotrichia and Rivularia.** In this key these are separated out on the basis that false branching will not normally be seen.

(b) False branches arise in pairs . . . . **Scytonema**

Scytonema has false branches that appear to arise in pairs. This is distinctive for the genus. The branches usually occur between heterocysts. Trichomes sheathed. Cells 5–30 µm wide. Hormogonia may form at the apex of the trichome. Akinetes may be present. It occurs on damp rocks and soil and forms dark tufted mats in lakes or in damp terrestrial habitats such as rocks and walls. Cyanophyta. Plate VI.

46 (44) (a) Heterocysts present (although sometimes infrequent) **47**

(b) Heterocysts absent **53**

47 (46) (a) Trichomes tapering to a fine point . . . **48**

(b) Trichomes not tapering to a fine point but possibly showing some slight narrowing towards the end **50**

48 (47) (a) Tapered trichomes solitary or in small tufts . . . . **Calothrix**

Individual trichomes are tapered and have a solitary basal heterocyst. It grows as mats or tufts of trichomes over a surface. The sheath is firm and often dark straw coloured. Trichomes 5–10 µm wide at their base. False branching may rarely occur. Hormogonia may form towards the end of the filament. Most frequent in hard water streams attached to a substratum. Cyanophyta. Plate VI.

(b) Tapered trichomes always in a colony which may be globular or spherical **49**

49 (48) (a) Basal heterocysts usually with an akinete immediately above. Usually planktonic in spherical colonies of radiating trichomes . . . . **Gloeotrichia**

Colonies of **Gloeotrichia** are usually free floating and spherical. The radiating sheathed trichomes are embedded in soft mucilage. They taper towards the end and have a basal heterocyst. An akinete is frequently present immediately above the heterocyst and is cylindrical in shape. Trichomes 4–10 µm in diameter, colonies up to 5mm in diameter. Although usually free floating the colonies may be attached when young before breaking free. Hormogonia may be fomed at the trichome ends. Can occur in both brackish and fresh waters. Cyanophyta. Plate VII. Fig. 4.22.

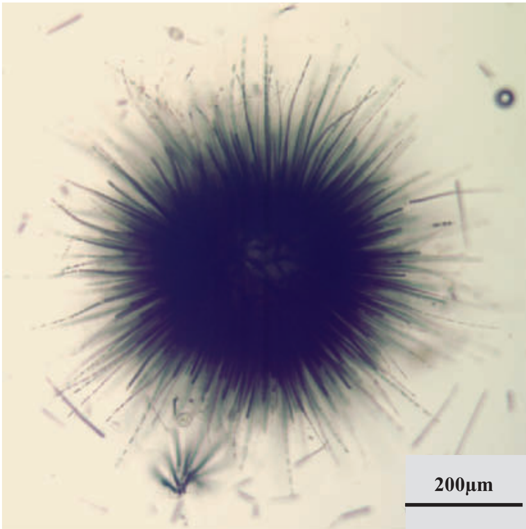


Figure 4.22 *Gloeotrichia.* Single colony showing radiating filaments. Fixed, iodine stained.

(b) Basal heterocysts present on trichome but no akinetes present. Usually grows as attached globular colonies embedded in firm mucilage . . . . **Rivularia**

Rivularia colonies are subspherical to globular and contain numerous filaments that are attached to a substratum. The colony consists of tapering filaments each of which has a basal heterocyst. The tapering trichome often ends in a long hair. False branching, although uncommon, may occur. The trichomes are often radially arranged in firm mucilage. Hormogonia may be produced at the end of the trichome. Most frequently found in hard waters and colonies may exhibit some calcification.

Cyanophyta. Plate VII.

50 (47) (a) Heterocysts terminal, gonidia ellipsoidal to ovate adjoining the heterocyst . . . . **Cylindrospermum**

Cylindrospermum is characterized by its terminal heterocyst which may be at one or both ends of a trichome. A large akinete may be present, often next to the heterocyst. The trichomes are usually loosely tangled in soft mucilage and grow on damp soil, stones, rocks, etc. Occurs in waters or muds forming dark green patches and on damp soils. Cells 3.5–6 µm in diameter, 4–13 µm long. Cyanophyta. Plate VII.

(b) Heterocysts not terminal but intercalary **51**

51 (50) (a) Each end of the trichome tapers slightly and is somewhat elongated. Gonidia, when present, solitary . . . . **Aphanizomenon**

Trichomes of **Aphanizomenon** may be grouped together like sheaths of wheat and form ‘rafts’ visible to the naked eye (**A. flos-aquae**) or be solitary (**A. gracile**, **A. issatschenkoi** and **A. aphanizomenoides**). The trichomes are relatively short and show a slight taper at each end. No sheath is present. Cells are rectangular, 5–6 µm in diameter and 8–12 µm long with slight constrictions at the cross walls. Heterocysts cylindrical, 7 µm in diameter and 12–29 µm long and located in the middle region of the trichome. Gonidia are also cylindrical and in the mid region but not adjacent to the heterocysts. They are about 8µm in diameter and 60–70 µm long. Common in the plankton especially in nutrient-rich lakes where it can form dense blooms. **Aphanizomenon** is one of the genera of blue-green algae that has been reported to produce toxins in water. Four such toxins have been associated with this genus - saxitoxin, cylindrospermopsin, anatoxin-a and lypopolysaccharides. (Chorus and Bartrum, 1999). Cyanophyta. Plate VII. Fig. 4.23.

(b) End cells of trichome not narrower than the rest so trichome does not taper **52**

52 (51) (a) Trichomes solitary or in a tangled, sometimes coiled, mass . . . . **Anabaena**

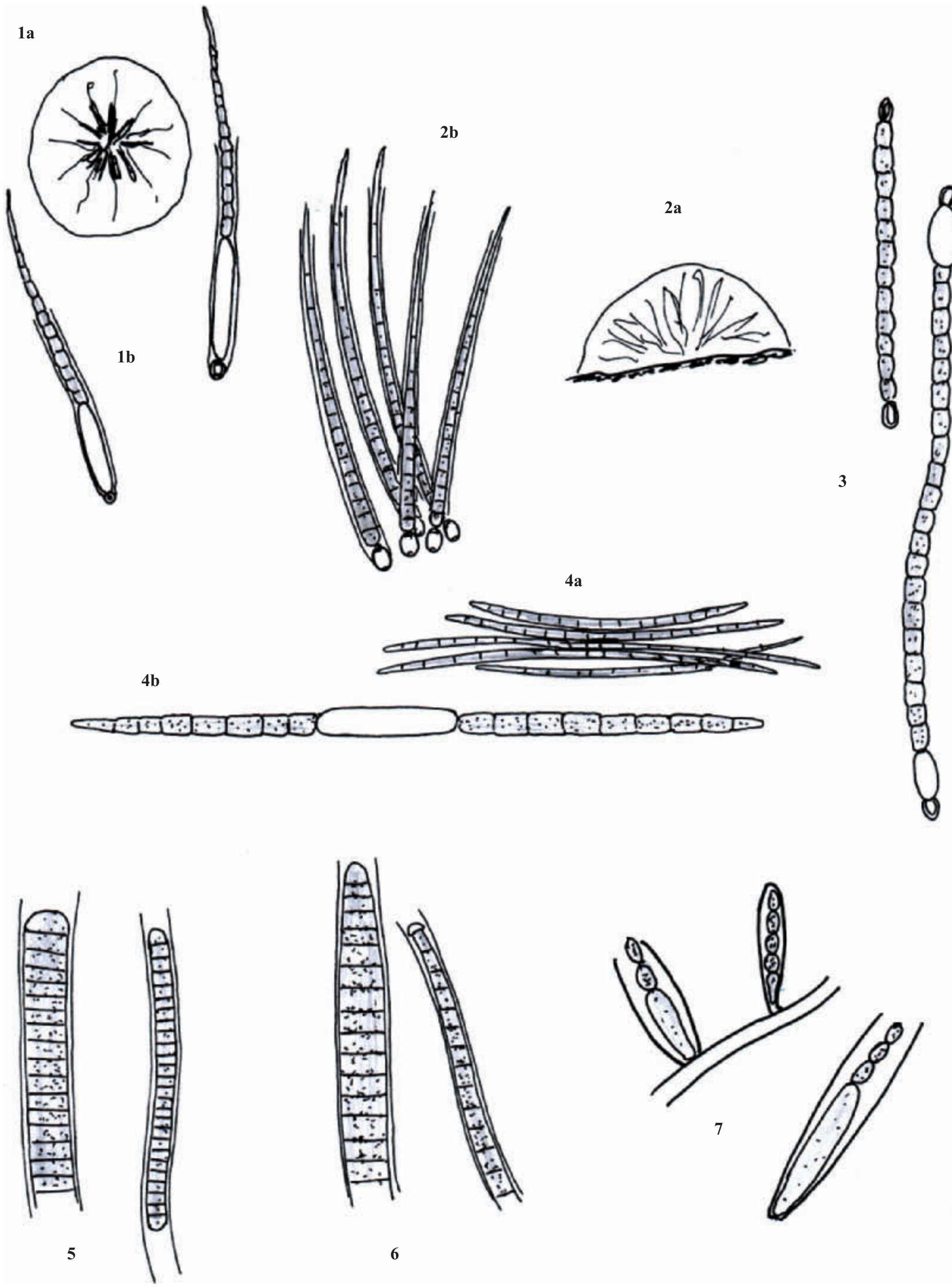


Plate VII **1.** *Gloeotrichia*: (a) colony; (b) filaments. **2.** *Rivularia*: (a) colony; (b) filaments. **3.** *Cylindrospermum.* **4.** *Aphanizomenon*: (a) raft of filaments; (b) single filament. **5.** *Lyngbya.* **6.** *Phormidium.* **7.** *Chamaesiphon.*

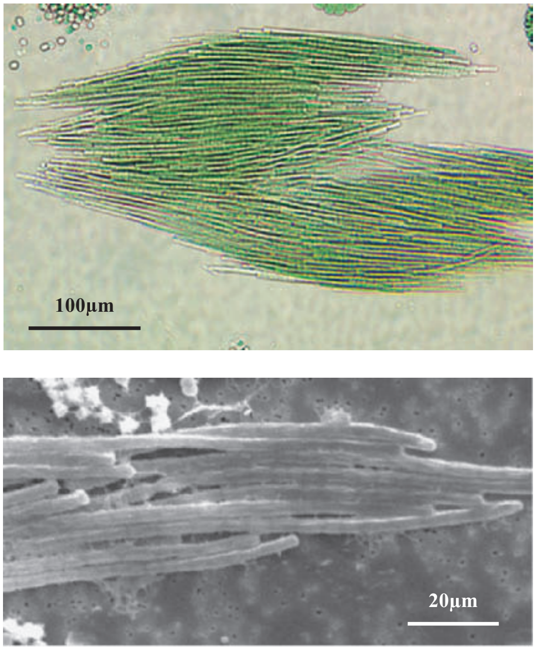


Figure 4.23 *Aphanizomenon.* Top: Typical view of planktonic raft in lake phytoplankton. Bottom: SEM detail of individual filaments.

There are many species of **Anabaena.** The trichomes are fairly easy to recognise and are of uniform width throughout with a layer of amorphous and frequently inconspicuous mucilage on their surface. The filaments may be straight, curved or coiled depending upon the species. Some species produce gas vacuoles and can form blooms. Cells bead-like to barrel-shaped, 3.5–14 μm wide. Heterocysts are spherical and the akinetes are rounded or cylindrical, produced adjacent to the heterocysts, and are frequent in natural populations Many species can only be identified if the akinetes are present. Cells are rounded or barrel-shaped giving the filament the appearance of a string of pearls. An extremely common species in the plankton where it frequently forms blooms. Heterocysts may not be frequent in nitrogen-rich waters. **Anabaena** can occur in lakes, ponds and ditches. It has been reported (Palmer, 1962) as potentially producing taste and odour in water used for drinking purposes. When present in large numbers in the plankton problems of filter clogging can arise when the water passes through a treatment works. **Anabaena** species are also able to produce a range of toxins in water. These include microcystins, anatoxin-a, saxitoxins and lipopolysaccharides (Chorus and Bartrum, 1999). Cyanophyta. Figs 1.3, 1.4, 1.5, 2.7, 4.24a, b, c.

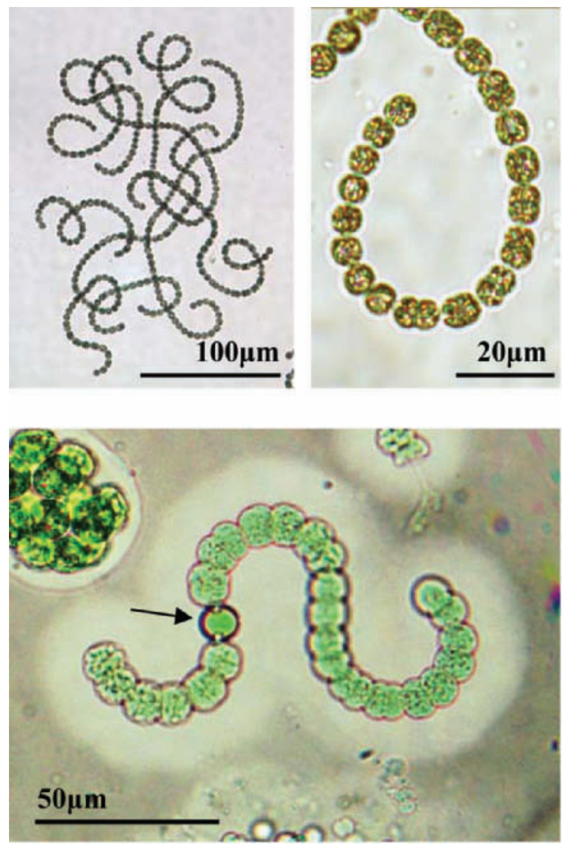


Figure 4.24a *Anabaena.* Top left: Large planktonic colony. Top right: Detail of olive-brown cells in colony. Bottom: Small planktonic colony showing filament embedded in mucilage, and having a single heterocyst (arrow). Indian ink preparation. Comparison of the two colonies shows the colour variation that can occur in this alga.

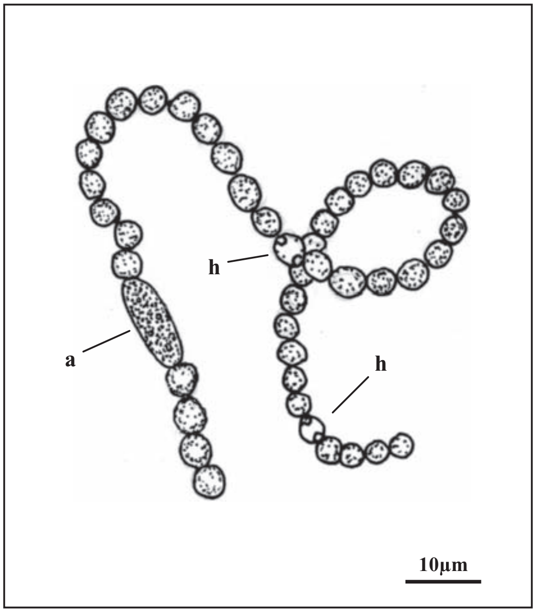


Figure 4.24b *Anabaena circinalis.* Filament with spherical vegetative cells and akinetes (a) not adjacent to heterocysts (h).

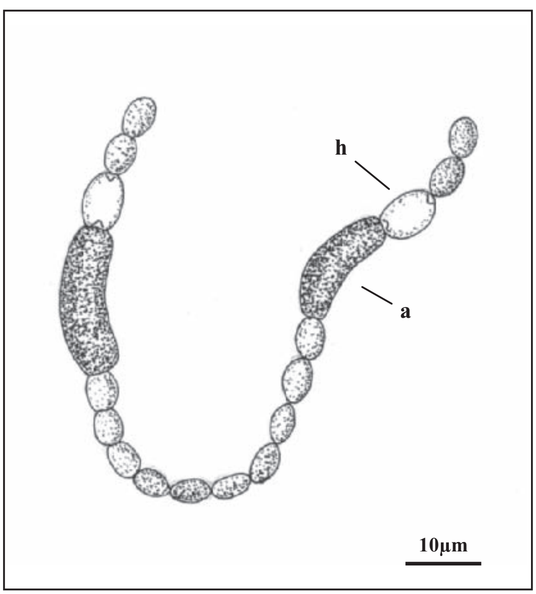


Figure 4.24c *Anabaena flos-aquae*. Single filament with sausage-shaped akinetes (a) adjacent to heterocysts (h).

(b) Trichomes embedded in obvious and extensive firm mucilage . . . . **Nostoc**

Cells of **Nostoc** are similar to **Anabaena** but they are embedded in firm, extensive, mucilage which may be leathery in texture and coloured straw or brown. In older colonies the trichomes tend to be situated towards the edge. Akinetes may occur in older parts of the colony and are produced between heterocysts (unlike in **Anabaena**). Hormogonia may be occasionally produced. The cells are approximately spherical to barrel-shaped 3–6 μm wide. Grows on damp or wet surfaces, shallow waters. Can be free floating or attached. It occurs in rice paddies where it is used to contribute nitrogen to the rice crop. **Nostoc** can produce toxins in freshwaters, e.g. microcystins and lipopolysaccharides (Chorus and Bartrum, 1999). Cyanophyta. Fig. 4.25.

53 (46) (a) Trichomes form a regularly spirally-coiled cylinder in which the individual cells may be difficult to distinguish . . . **Spirulina**

Here the cylindrical trichomes are twisted into a very regular spiral or helix, where the cell cross walls are frequently obscure. Gas vacuoles may be present. Trichomes 1–8 μm in diameter depending upon species. **Spirulina** is widespread in both freshwaters and brackish environments. Cyanophyta. Fig. 4.26.

(b) Trichomes not forming a regular and definite spiral. The individual cells of the trichome usually more easy to distinguish **54**

54 (53) (a) Trichomes without a sheath . . . . **Oscillatoria**

Trichomes may be straight or bent, single or in groups, free floating or attached. They may be short or quite long. The trichomes may be capable of a gliding movement and a

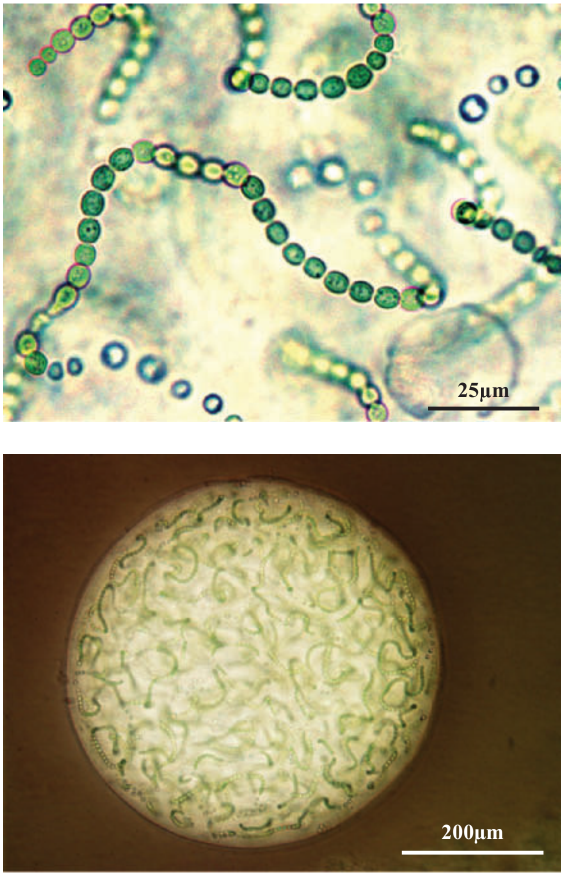


Figure 4.25 *Nostoc*. Top: Detail from colony, with filaments embedded in a mucilaginous matrix. Bottom: Low power view of large globular colony. Indian ink preparation.

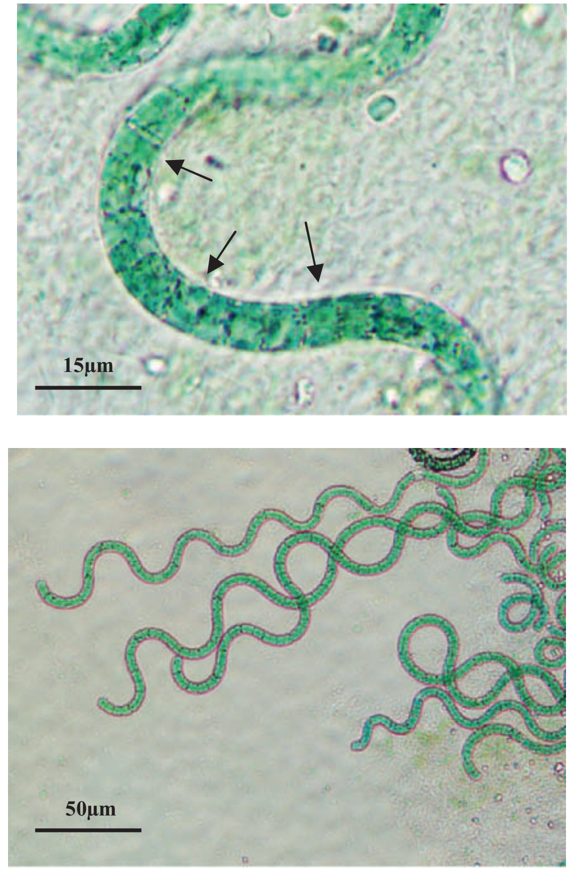


Figure 4.26 *Spirulina*. Top: Detail from spiral filament showing short disc-shaped cells (arrows). Bottom: Low power view of filaments showing typical spiral morphology.

gentle waving (oscillatory movement). The trichomes may be blue-green, olive green, reddish or brownish in colour. Free floating forms commonly have gas vacuoles. Cells 1–60 µm wide, either longer or shorter than wide. The cell cross walls may or may not be narrowed depending upon species as may the presence or absence of a calyptra on the end cell of the trichome. The end cell may be rounded or have a characteristic shape.

Anagnostidis and Komarek (1988) separate several genera from **Oscillatoria.** The most notable of these (major species) are **Tychonema bornetii** and **T. bourrellyi** (formerly **Oscillatoria bornetii** and **O. bourrellyi**), which are separated mainly on the basis of the cells containing numerous liquid filled vacuoles; **Planktothrix agardhii, P. rubescens** and **P. prolifica** (formerly **Oscillatoria agardhii, O. rubescens** and **O. prolifica**) are all narrow-celled species. **Limnothrix redekei, (Oscillatoria redekei)** has gas vacuoles localized either side of the cross walls Several species are reported to produce taste and odour in water used for drinking

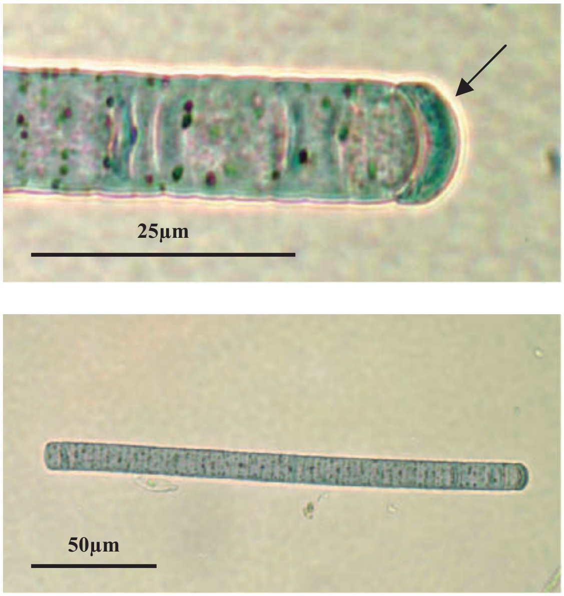


Figure 4.27 *Oscillatoria.* Top: Detail showing cap cell (arrow) at end of filament. Bottom: Single, free floating filament. This species has a distinctive purple coloration.

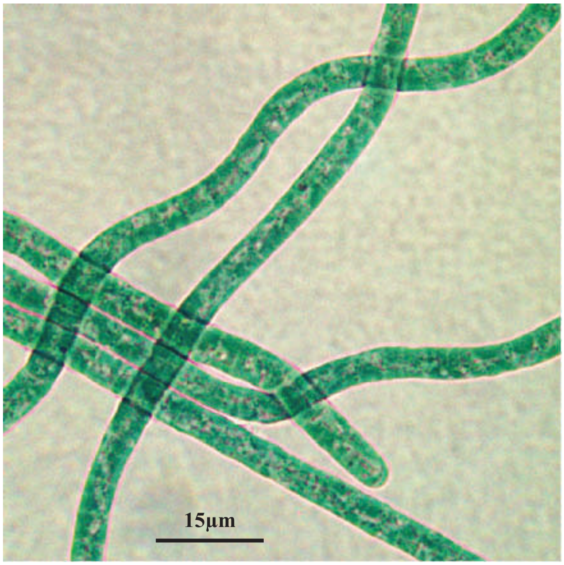


Figure 4.28 *Lyngbya.* General view of tangled filaments. N.B. Cultured specimen does not show an obvious sheath.

purposes (Palmer, 1962). When present in large numbers it can clog filters used in water treatment processes. Some members of the **Oscillatoria** group are known to produce toxins such as microcystins, anatoxin-a, lipopolysaccharides and aplysiatoxins (Chorus and Bartrum, 1999). Cyanophyta. Plate VIII. Fig. 4.27.

(b)Trichomes surrounded by a sheath . . . **55**

55 (54) (a) Trichomes single or free living. Sheath delicate but firm (rarely thick) . . . . **Lyngbya**

Trichomes of **Lyngbya** are a single row of cells enclosed in a fairly firm sheath. Trichomes may be solitary or form a coiled or tangled mass. Free floating or growing on a substrate. The sheaths may become yellowish-brown through staining with chemicals in the water. Cells 1–24 µm in diameter. Hormogonia may be formed. Larger species of **Lyngbya** may be confused with **Oscillatoria,** especially if the former has migrated out of its sheath. **Lyngbya** can produce a range of toxins in water such as aplysiatoxin, lyngbyatoxin-a, saxitoxin and lypopolysaccharides (Chorus and Bartrum, 1999). Cyanophyta. Plate VII. Fig. 4.28.

(b) Filaments interwoven in a sticky gelatinous matrix. Sheaths of filaments become indistinct and sticky . . . . **Phormidium**

Phormidium is extremely common on damp soil, stones, rocks, etc. The trichomes are cylindrical and may taper slightly towards the ends. Cells shorter than wide. May trichomes are present within the gelatinous mass. Trichomes capable of movement.The end cell of the filament is often characteristic of the species. Cells 0.6–12 µm wide and 1.0–10 µm long. Because of the difficulty in seeing the sheath when preserved it can often be confused with **Oscillatoria.** Cyanophyta. Plate VII. Figs 2.23, 2.29, 4.29.

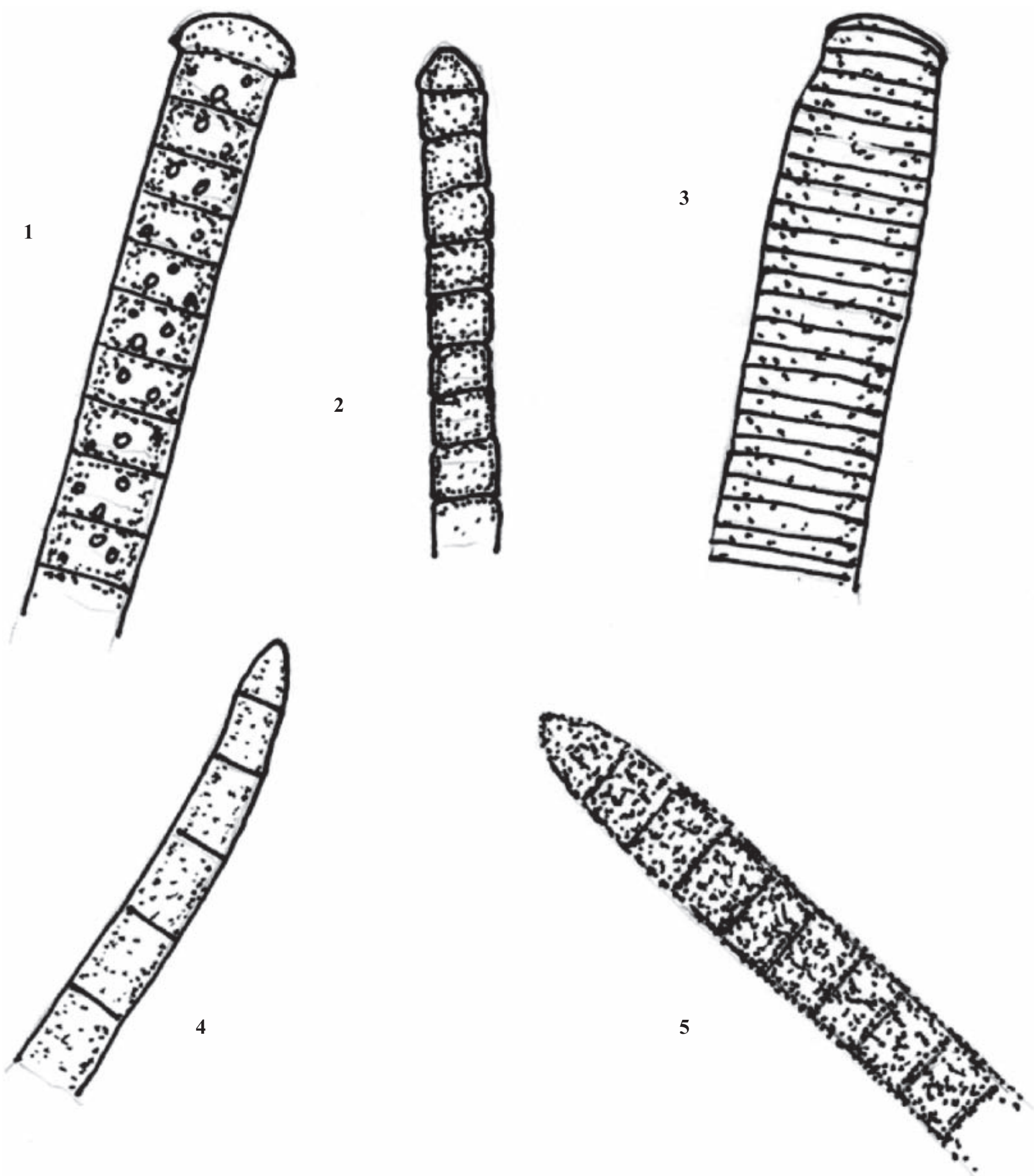


Plate VIII **1.** *Oscillatoria rubescens.* **2.** *Oscillatoria tenuis.* **3.** *Oscillatoria princeps.* **4.** *Oscillatoria brevis.* **5.** *Oscillatoria agardhii.*

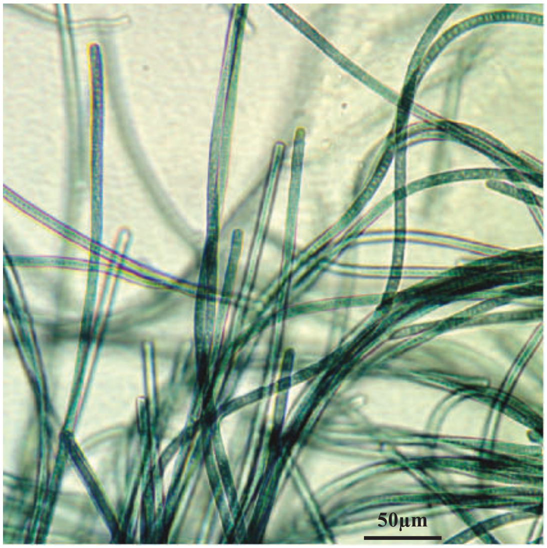


Figure 4.29 *Phormidium.* Mass of tangled filaments forming a dense algal mat.

56 (3) (a) Cell pigments not localized in chloroplasts **57**

(b) Cell pigments localized in chloroplasts **68**

NB some genera, e.g. **Botryococcus**, have colonies that are stained densely brown making it difficult to see cell contents, especially chloroplasts. This can be made easier by gently squashing the colony under a coverslip to spread the cells out thus making the contents of individual cells more visible.

57 (56) (a) Epiphytic, unicellular or at the most a few-celled colony in which exospores are produced at the apical end . . . . **Chamaesiphon**

Chamaesiphon is epiphytic on other aquatic plants sometimes forming dense aggregates. Cells normally sausage or club-shaped, sometimes curved, 10–50 μm long and 2–7 μm wide. Cells usually surrounded by a sheath which may be brownish in colour. Exospores are produced at the apex of the mother cell and are spherical 2–9 μm in diameter, 5–70 μm long, and are produced in single or multiple rows. Cyanophyta. Plate VII.

(b) Cells occur as isolated individuals or form colonies which are not epiphytic . . . **58**

58 (57) (a) Cells arranged in a rectilinear series, often in groups of four, forming a plate one cell thick, often of many cells . . **Merismopedia**

Merismopedia cells are spherical to oval forming a colony of a single layer, shaped as a plate or rectangle, within thin structureless mucilage. Cells are arranged in rows, sometimes in groups of four. The cells, often a pale blue in colour, are 0.5–5 μm in diameter and 1–16 μm long. Free floating or resting on bottom sediments. Cyanophyta. Plate IX.

(b) Cells not as above but individual or in spherical, ovate or irregular colonies but 3-dimensional and not a flat plate **59**

59 (58) (a) Cells in distinct colonies which form hollow spheres with cells arranged regularly around the periphery **60**

(b) Cells individual or in colonies that are not hollow (at most clathrate (see glossary) with cells distributed throughout **63**

60 (59) (a) Cells pear-shaped to subspherical, sometimes with a mucilaginous sheath. Cells arranged at the ends of branching mucilaginous strands separate from one another and radiating from the colony centre . . . . **Gomphosphaeria**

Gomphosphaeria is common in lakes and ponds and and ditches and may become the dominant planktonic alga. Cells 1.5–12 μm wide and 2–16 μm long. Cells have distinct gelatinized envelopes and are often arranged in clusters within the colony. Reported as

Figure 4.30 *Gomphosphaeria.* Top: Detail from edge of colony showing pear-shaped, granular cells in side view (arrow). Bottom: Typical lobed colonies, which have been slightly compressed to accentuate surface mucilage and see peripheral cells. Indian ink preparation.

producing taste and odour in waters used for drinking (Palmer, 1962). Cyanophyta. Plate IX. Figs 1.3, 4.30.

(b) Cells spherical, not pear-shaped in globular to spherical colonies.. . . . . **61**

61 (60) (a) Cells not on the end of mucilaginous stalks within the colony . . . . **Coelosphaerium**

Cells of **Coelosphaerium** are spherical to subspherical or even oval. The cells are not attached to stalks within the colony, are closely packed, and form a more or less single layer towards the outside of the colony. Colonies are common in the plankton and may reach bloom proportions. Cells 2–5 µm broad and 2–7 µm long. Gas vacuoles may be present. This genus can potentially produce taste and odours in drinking waters. Colonies 20–180 µm in diameter. Cyanophyta. Plate IX.

(b) Cells with stalks (sometimes not very distinct) radiating from the centre of the colony **62**

62 (61) (a) Cells spherical to slightly elongated. Arranged at the ends of branched stalks which are thin and quite easily seen . . . . **Snowella**

Cells forming a globular colony embedded in mucilage. The cells are located towards the outside of the colony but do not form a single distinct layer and are located at the ends of distinct branched stalks. Cells 1.5–3.0 µm in diameter, 2–4 µm long. Gas vacuoles uncommon. Colonies up to 80 µm in size. Widespread in the plankton of eutrophic standing waters. Cyanophyta. Plate IX.

(b) Cells spherical to obovoid, stalks indistinct but quite thick near colony centre. Stalks branched with cell at the end of the sometimes numerous branches . . . . **Woronichinia**

Woronichinia cells are arranged in the outer region of the colony which may contain several hundred cells. Colonies are free floating and up to 180 µm in diameter. Cells 3.5–5.0 µm in diameter and 5–7 µm long. Common in the plankton. Cyanophyta. Plate IX.

63 (59) (a) Cells solitary or forming small colonies of 2–4–8 or rarely 16–32 cells sometimes but not always embedded in mucilage **64**

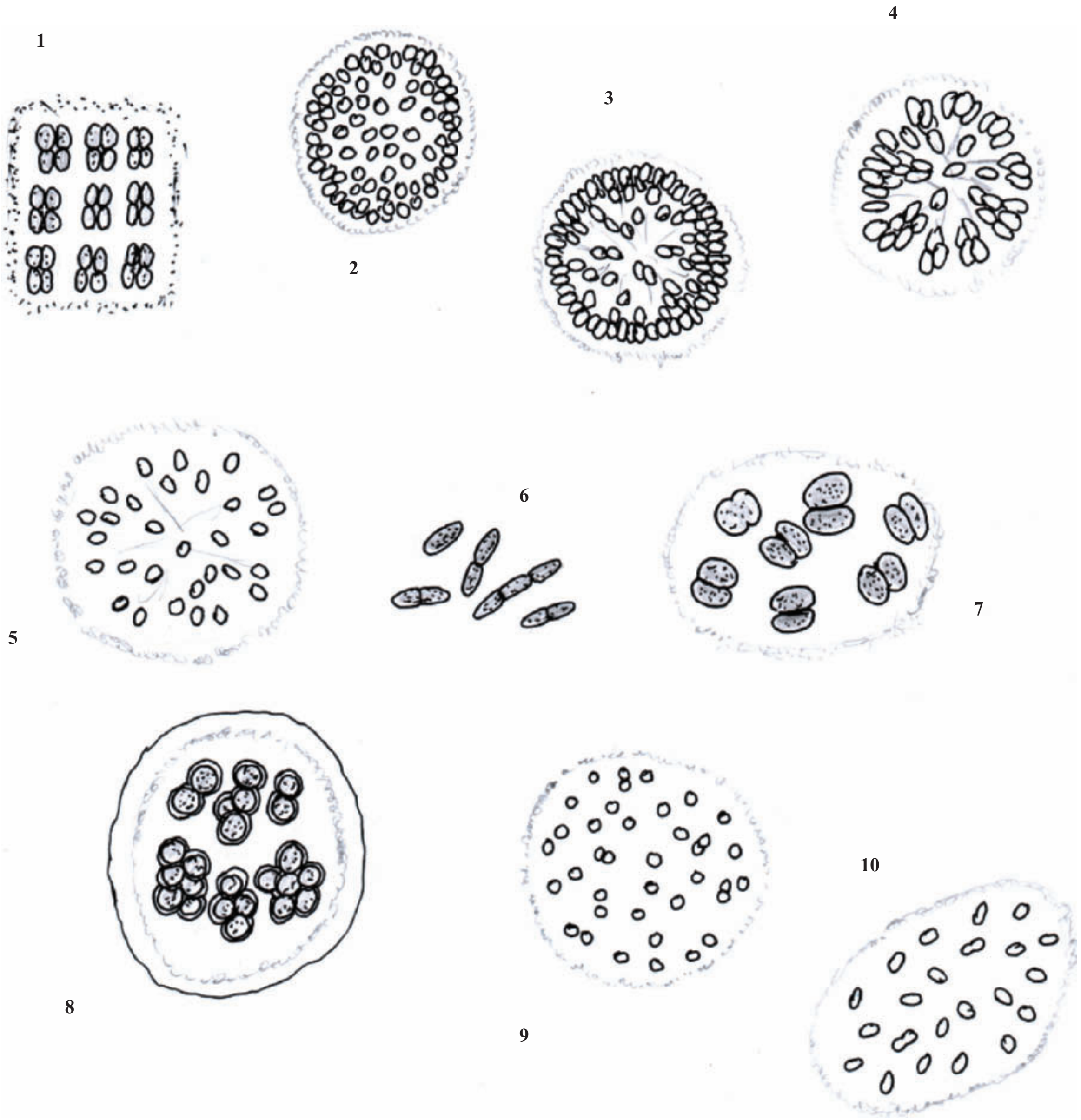


Plate IX **1.** *Merismopedia.* **2.** *Coelosphaerium.* **3.** *Woronichinia.* **4.** *Gomphosphaeria.* **5.** *Snowella.* **6.** *Synechococcus.* **7.** *Chroococcus.* **8.** *Gloeocapsa.* **9.** *Aphanocapsa.* **10.** *Aphanothece.*

(b) Mucilaginous colonies composed of many cells often in the hundreds **66**

64 (63) (a) Cells spherical or slightly oval **65**

(b) Cells elongate, i.e. longer than broad sometimes cylindrical . . . . . **Synechococcus**

Synechococcus cells are ovoid to cylindrical, 1–12 μm broad and 2–10 times as long as broad. Cells either solitary, in twos or rarely fours, sometimes in short chains. Mucilage envelope either thin or absent. Frequent in the plankton and on damp surfaces. Cyanophyta. Plate IX. Fig. 4.31.

65 (64) (a) Cells with a distinct envelope of mucilage which is lamellate and usually thick . . . . **Gloeocapsa**

Gloeocapsa cells are spherical, between 1 and 17 μm in diameter and are surrounded by a sheath which is usually laminate. The sheath can be up to 10 μm thick and can vary in colour. Colonies may grow large enough to see with the naked eye. Abundant especially on wet rocks although sometimes epiphytic. Can produce taste and odour in drinking waters (Palmer, 1962). Cyanophyta. Plate IX. Fig. 4.32.

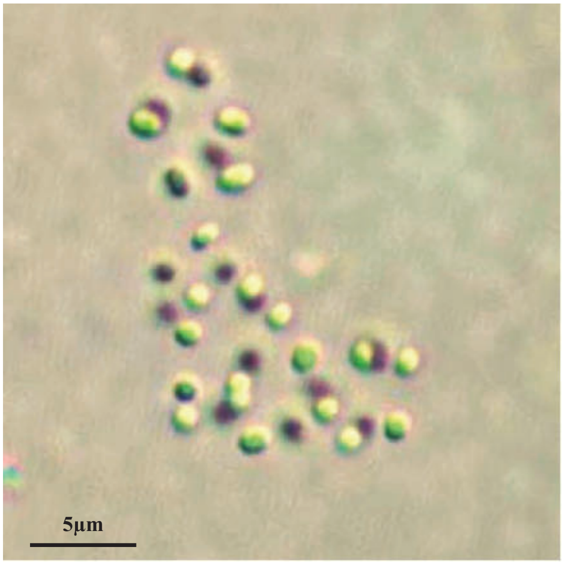


Figure 4.31 *Synechococcus.* Cultured isolate from a hyposaline, alkaline lake in Hungary (Somyogi strain ACT 0616).

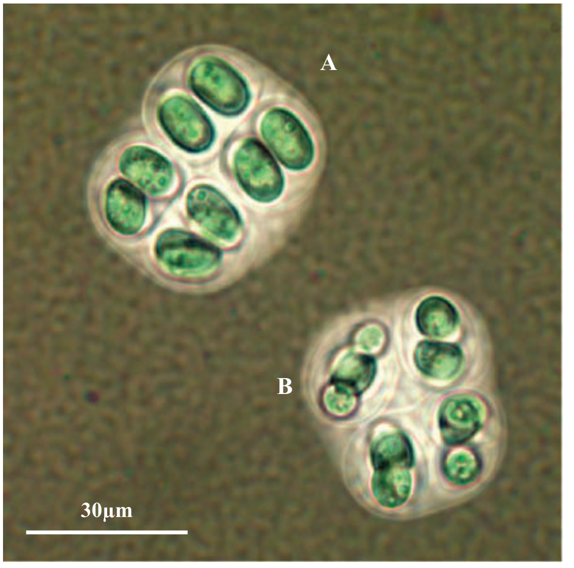
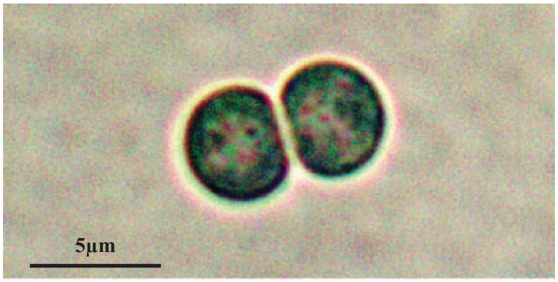


Figure 4.32 *Gloeocapsa.* Two colonies with thick mucilaginous sheaths. The plates of cells can be seen in both face (A) and side (B) view. Indian ink preparation.

(b) Cells nearly spherical. After division daughter cells occur in groups of 2–4–8–16 in a gelatinous sheath which is often homogenous with the surrounding mucilage but may be lamellate in some species **Chroococcus**

Chroococcus usually forms small groups of cells which can either be free floating or attached. Cells have distinct sheaths which may be reformed after each cell division resulting in a multilayered sheath. Only planktonic species have gas vacuoles. Planktonic species do not tend to have distinct sheaths since surface layers are often confluent with the surrounding mucilage. Cells 2–58 μm in



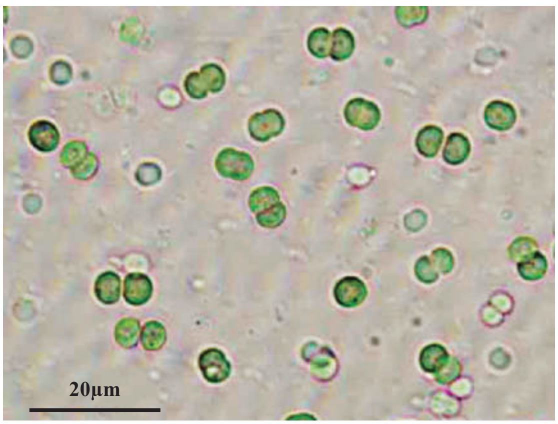


Figure 4.33 *Chroococcus.* Top: High contrast image of pair of cells, with granular contents and central pale nucleoid. Bottom: Actively growing culture with cells at various stages of division and separation.

diameter. Easily confused with **Gloeocapsa.** Cyanophyta. Plate IX. Fig. 4.33.

66 (63) (a) Large mucilaginous colonies. Cells approximately spherical to globular in shape **67**

(b) Large mucilaginous colonies. Cells cylindrical to elongate in shape . . . **Aphanothece**

Aphanothece cells are spherical to ovate or cylindrical and loosely embedded in copious mucilage. Free floating or sedentary colonies which may be tens of millimetres in size. Cells 1–4 µm broad and 2–8 µm long. Cells have a typical blue-green colour and the smaller species are easily confused with bacteria. Common in the plankton or along the margins of lakes and ponds. Cyanophyta. Plate IX. Fig. 1.3.

67 (66) (a) Cells of colony densely crowded within the mucilage . . . . **Microcystis**

Cells of **Microcystis** are spherical to subspherical (very slightly elongate) and are usually gas vacolate. They form large globular to irregular mucilaginous colonies (often containing hundreds of cells) a millimetre or more in size that are planktonic and are often responsible for nuisance water blooms. Colonies may be globular, more elongate or irregular and with holes and the mucilage is distinct and fairly firm. During periods of non-active growth the colonies may rest on the bottom and in that state may loose their gas vacuoles. Colonies increase by fragmentation. Cells 2.5–6 µm in diameter. Frequently reported as producing taste and odours in drinking water (Palmer, 1962). Because they can grow in large numbers (producing blooms) they can clog filtration systems in water treatment works. **Microcystis** is well known for producing toxins such as microcystins and lipopolysaccharides in water (Chorus and Bartrum, 1999). Cyanophyta. Figs 1.3, 2.18, 2.21, 4.34.

(b) Cells more spaced out within the mucilage so that the colonies appear less dense . . . . **Aphanocapsa**

Aphanocapsa forms globular amorphous gelatinous colonies that are usually free floating but can be terrestrial. Cells are much more spaced out than in a **Microcystis** colony and also sometimes occur as pairs within the colony as a result of cell division. The mucilage at the outer margin of the colony is not as distinct as in **Microcystis.** Cells approximately spherical 1–5.5 µm in diameter depending upon species. Common in the plankton. Cyanophyta. Plate IX. Fig. 4.35.

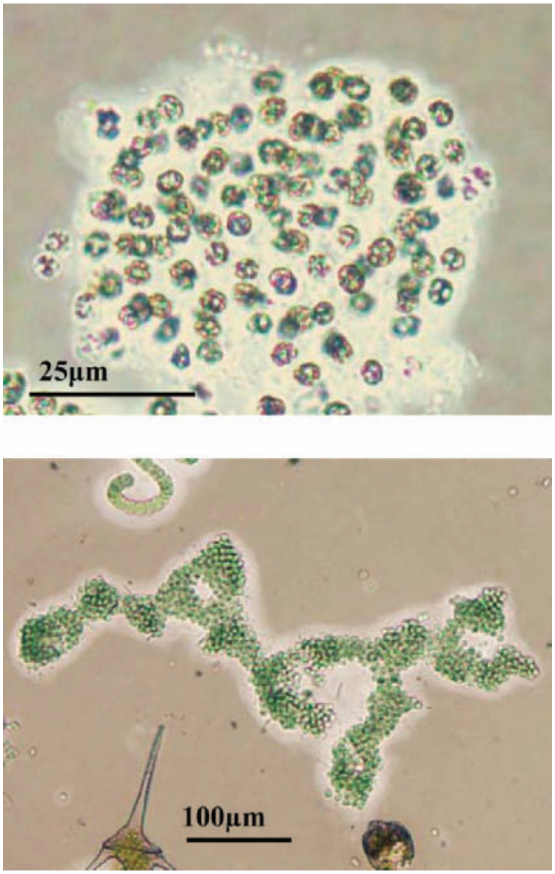


Figure 4.34 *Microcystis*. Indian ink preparations. Top: Detail from edge of colony showing granular algal cells within copious mucilage Bottom: Typical appearance of entire colony, loosely extending in all directions. The colour of this alga varies from olive brown (top) to fresh blue-green (bottom).

68 (56) (a) Cells arranged in colonies of definite shape **69**

(b) Cells either individual, in pairs or in aggregations with no definite shape **106**

69 (68) (a) Cells of the colony with flagella, colony motile **70**

NB it is important to look at fresh specimens to determine to presence or absence

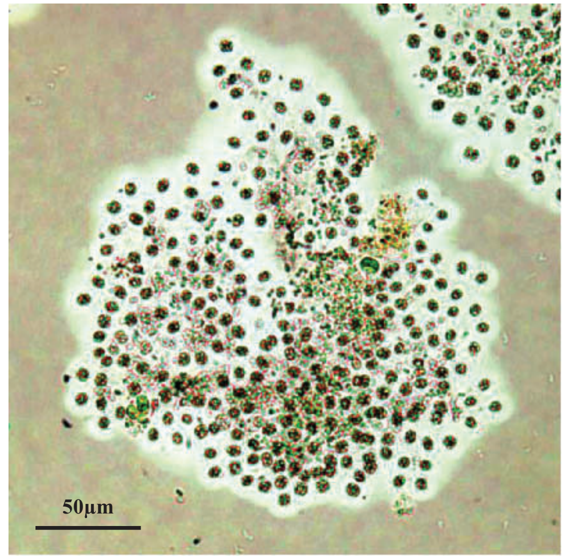


Figure 4.35 *Aphanocapsa*. Low power view of colony. Olive-brown cells of this alga are widely dispersed within the copious mucilage. A range of other algae and bacteria are also present. Indian ink preparation.

of flagella as they may be difficult to see in preserved samples.

(b) Cells of colony without flagella, colony non-motile **76**

70 (69) (a) Each cell is enclosed in a flask-shaped lorica, narrow and pointed at one end and wide at the other . . . . **Dinobryon**

(in part see 7)

(b) Cells not located in a lorica **71**

71 (70) (a) Adjacent cells touching in densely packed colonies **72**

(b) Cells spaced apart within a colourless mucilage matrix. **73**

72 (71) (a) Chloroplast green and cup-shaped, storage product starch. Cells embedded in mucilage that obviously extends beyond the cells at the colony edge. Cells have two equal-length flagella. . . . . **Pandorina**

Colonies of **Pandorina** are spherical in shape with 8–32 densely-packed cells. Individual cells have flattened sides where they touch their neighbour and also slightly flattened apices. Cells 8–20 µm long On the outside of the cells is a broad band of mucilage through which the flagella protrude. The colony centre is not hollow. Individual cells may divide to form daughter colonies which are later released. Colonies swim with a tumbling motion through the water. Common in the plankton. Reported to impart a fishy odour to drinking water (Palmer, 1962). Chlorophyta. Plate X. Figs 1.3, 4.36.

(b) Chloroplasts brown to golden brown. Storage product leucosin. No obvious broad mucilaginous envelope. Each cell has two flagella of unequal length . . . . **Synura**

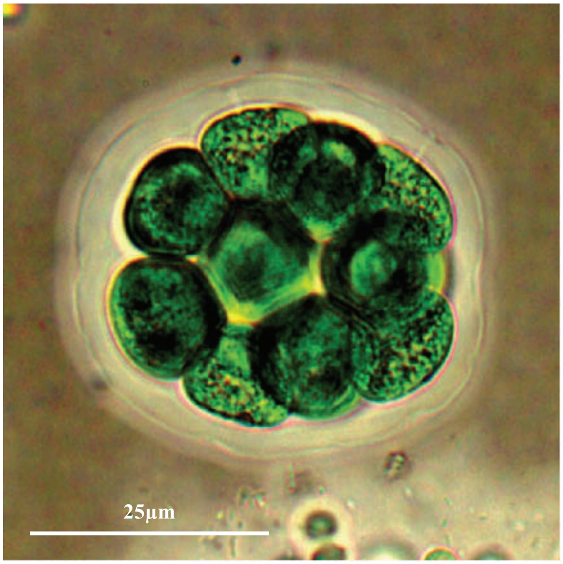


Figure 4.36 *Pandorina*. Indian ink preparation, showing surface mucilage. Cells have flattened sides where they make contact. Flagella are not visible in this bright field image.

Cells of **Synura** have two golden-brown chloroplasts and are more pear-shaped, 7–17 µm broad. Up to 40 closely packed cells per colony. The cells are covered with fine silica scales which are not always obvious. Common in the plankton. Can produce both taste and odour to drinking waters (Palmer, 1962). Chrysophyta. Plate X. Figs 1.3, 4.37.

73 (71) (a) Colonies of 64 cells or less **74**

(b) Colonies with many more cells than 64, often over 100 . . . . **75**

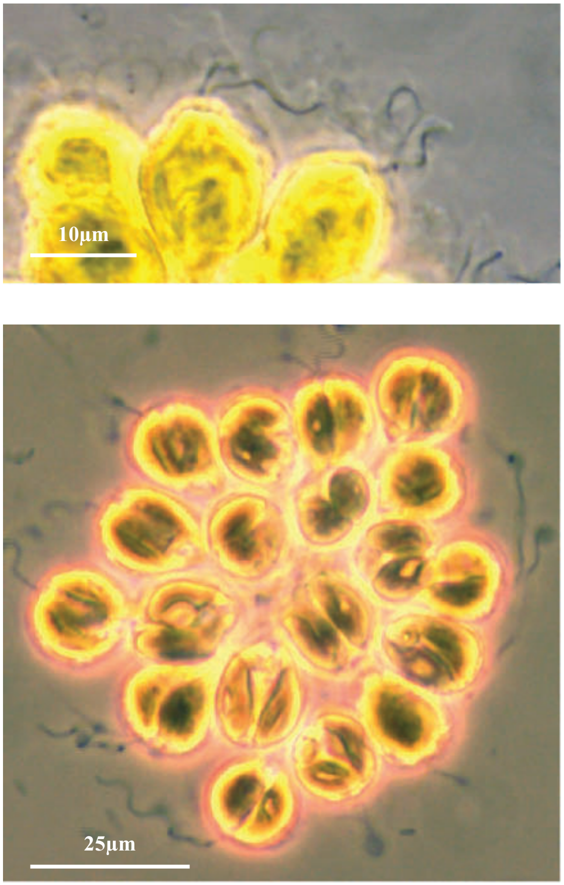


Figure 4.37 *Synura.* Top: Edge of colony (lightly fixed preparation) showing biflagellate golden cells. Bottom: Live colony, phase contrast image.

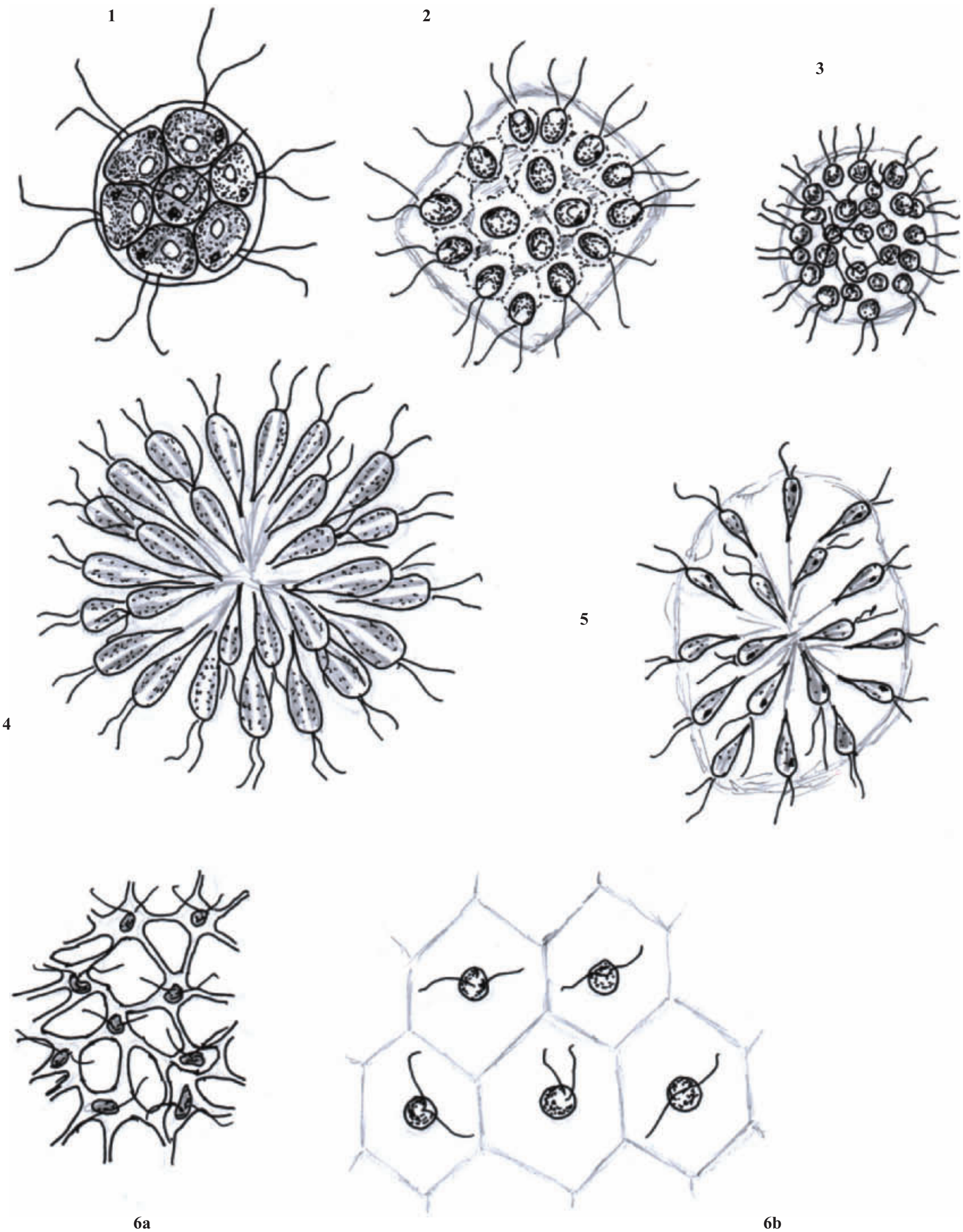


Plate X **1.** *Pandorina.* **2.** *Gonium.* **3.** *Eudorina.* **4.** *Synura.* **5.** *Uroglena.* **6.** *Volvox*, surface detail of colony: (a) *V. globator*; (b) *V. tertius.*

74 (73) (a) Colony a flat plate of 4–16 (sometimes 32) ovoid to spherical cells. Cell flagellae are all directed to the same plane (i.e. the flagella point outwards from the side which the cells occupy rather than upwards or downwards). . . . . **Gonium**

Cells within a **Gonium** colony are arranged in a flat gelatinous envelope. Each cell has two equal length flagella. The chloroplast is green and cup-shaped with one or more pyrenoids. Cells 7–20 µm broad. Common in relatively still waters. Can impart both taste and odour to drinking waters (Palmer, 1962). Chlorophyta. Plate X. Fig. 4.38.

(b) Colony globular to elliptical composed of 16–32 (sometimes 64) cells. Cells spherical in shape and arranged near to the surface of the mucilaginous matrix. Each cell has two equal length flagella which point in all directions from the colony edge . **Eudorina**

Unlike the cells of a **Pandorina** colony, those of **Eudorina** are spherical and spaced out within the mucilaginous matrix near to the edge leaving a clear zone at the centre. In immature colonies they may be more closely packed. The chloroplasts are cup-shaped and green with one or more pyrenoids. The storage product is starch. Widely distributed in the plankton and can form dense growths. Can impart both taste and odours to drinking waters (Palmer, 1962). Chlorophyta. Plate X. Fig. 4.39.

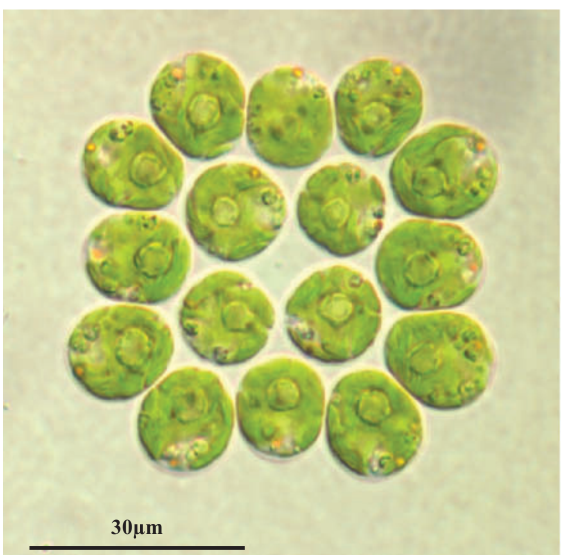


Figure 4.38 *Gonium.* Single colony (one cell deep) showing regular arrangement of cells. Internal detail (prominent nucleus, cup-shaped chloroplast, orange eyespot) but not flagella are visible in this DIC image.

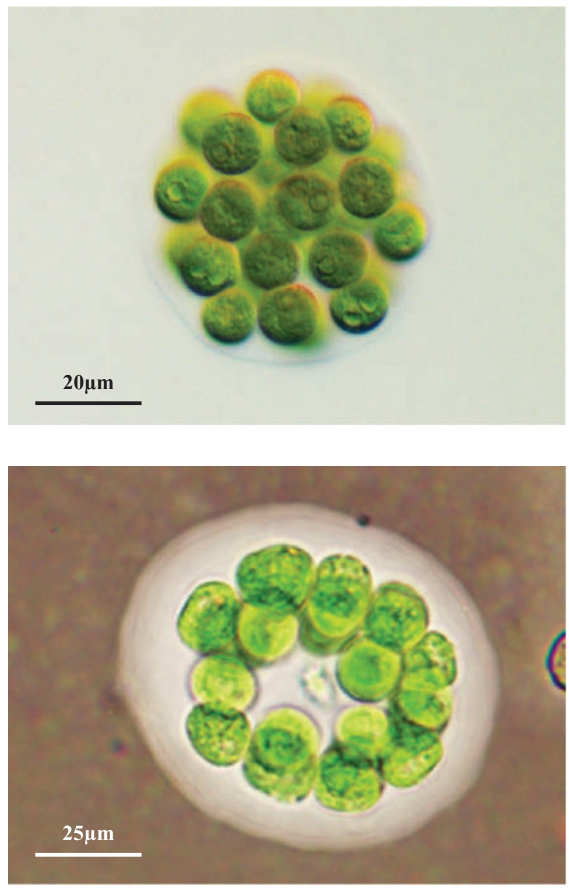


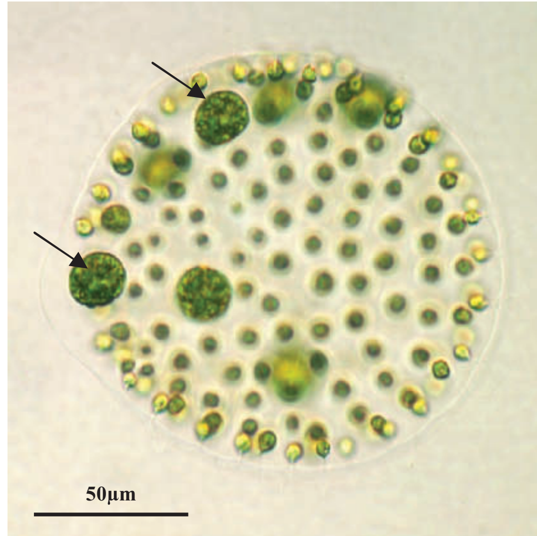
Figure 4.39 *Eudorina.* Top: Cells dispersed (not touching) within the globular colony. Bottom: Colony slightly compressed to show central cavity and mucilaginous matrix. Indian ink preparation. The flagella are not visible in either the DIC (top) or BF (bottom) images.

75 (73) (a) Chloroplasts golden brown. Cells pear-shaped with thread-like mucilage strands connecting them to the colony centre. Storage product leucosin . . . . **Uroglena**

Colonies of **Uroglena** can be quite large, up to 1mm in diameter, and are composed of many hundreds of cells. Individual cells are 10–22 μm in length and possess one or two chloroplasts. Cysts are produced which have smooth walls and may not have a collar. Each cell has two, unequal length, flagella. Although similar, **Uroglena** colonies can be distinguished from **Volvox** by their golden brown chloroplasts, pear-shaped cells and the unequal flagella. Common in the plankton. Reported to be able to impart unwanted odours to drinking waters (Palmer, 1962). Chrysophyta. Plate X.

(b) Chloroplasts green, storage product starch. Cells spherical with interconnecting mucilaginous strands and are situated around the periphery of the colony. Mucilaginous strands do not radiate from the centre of the colony. Each cell with two equal length flagella . . . . **Volvox**

Volvox colonies are large and spherical, composed of hundreds or thousands of cells. Daughter colonies develop from special cells within the hollow colony from where they are released. Mature colonies can be up to 2.5 mm in diameter. . Common in the plankton. May produce a fishy odour in drinking waters (Palmer, 1962). Chlorophyta. Plate X. Fig. 4.40.



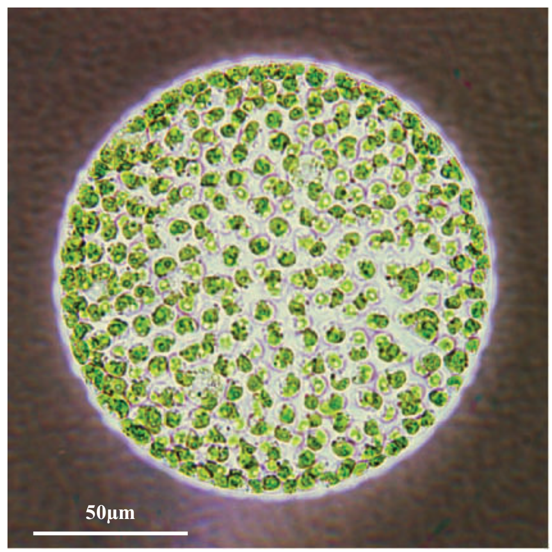


Figure 4.40 *Volvox.* Top: Image focused on the equatorial cells of the spherical colony. Numerous daughter colonies (arrows) are present in the central cavity. Bottom: Indian ink preparation, showing limits of colony. Flagella not visible in these bright field images.

76 (69) (a) Cells with silica walls which often bear distinct markings. Storage products mainly oils that can often be seen as small globules within the cell, not starch **77**

(b) Cells do not have silica walls. Main storage product starch. **81**

77 (76) (a) Cells cuneate in shape so when joined together form a fan-shaped colony **Meridion**

The cells, or frustules, of **Meridion** are heteropolar in girdle view and isobilateral in valve view. Within the frustule are thickened transparent costae and on the frustule

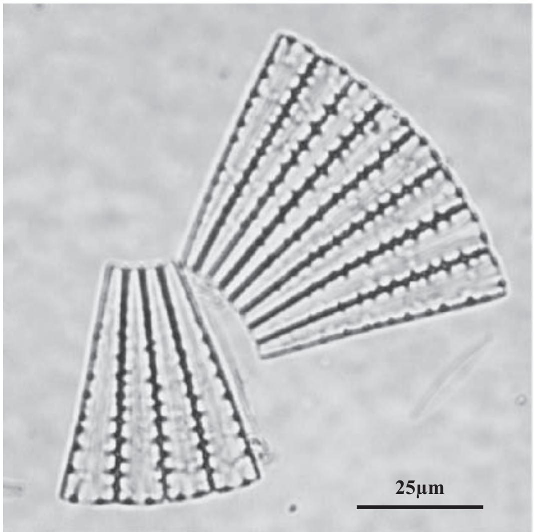


Figure 4.41 *Meridion*. Fan-shaped colonies of this colonial diatom. Prepared slide.

surface fine parallel striae. A pseudoraphe is present on both valves. Individual cells are usually united to form fan-shaped colonies. If growth of the colony is vigorous then a flat spiral-shaped colony develops. Cells 24–45 µm long. Grows attached to surfaces in shallow waters. Bacillariophyta. Plate XI. Fig. 4.41.

(b) Cells form stellate or zig-zag colonies **78**

78 (77) (a) Frustules swollen at each end to form a knob, the inner one at the hub of the star-shaped colony being slightly larger than the outer one . . . . **Asterionella**

Asterionella frustules are long, straight and narrow. The narrow central part of the frustule does have fine transverse striae but these are difficult to see. There are usually two or more chloroplasts per cell. Frustules 40–130 µm long and up to 20 times as long as broad. **Asterionella** can be abundant in the plankton of lakes especially in the spring and to a lesser extent in the autumn. Can impart a geranium or spicy odour to drinking waters (Palmer, 1962). Large growths of **Asterionella** can cause problems of filter clogging in water treatment works supplied by lakes or reservoirs. Bacillariophyta. Plate XI. Figs 1.16, 4.42.

(b) Frustules not swollen at each end, colonies either stellate or zig-zag **79**

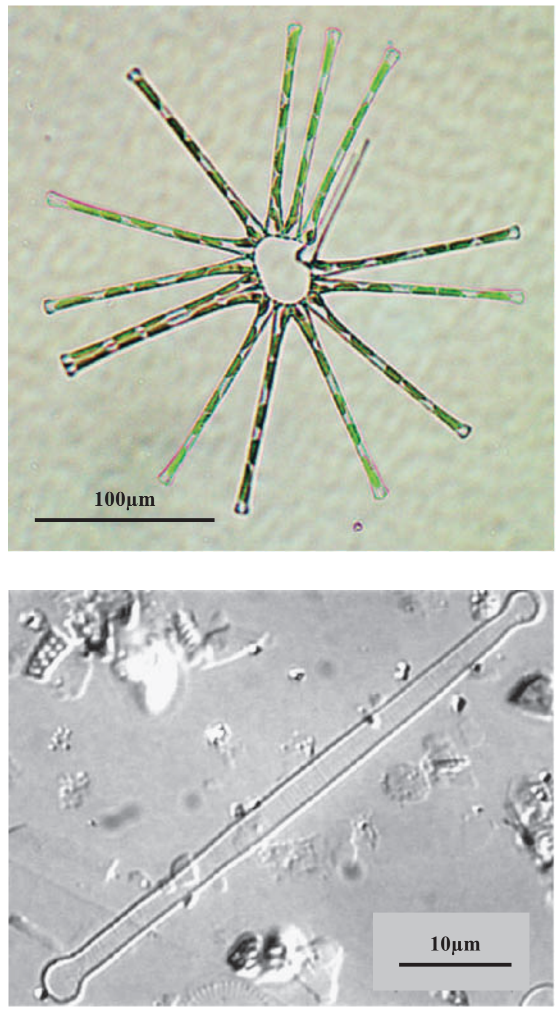


Figure 4.42 *Asterionella*. Top: Stellate planktonic colony, single spiral. Most cells have five chloroplasts. Bottom: Acid digest, lake sediment sample. Single cell showing frustule with rounded ends.

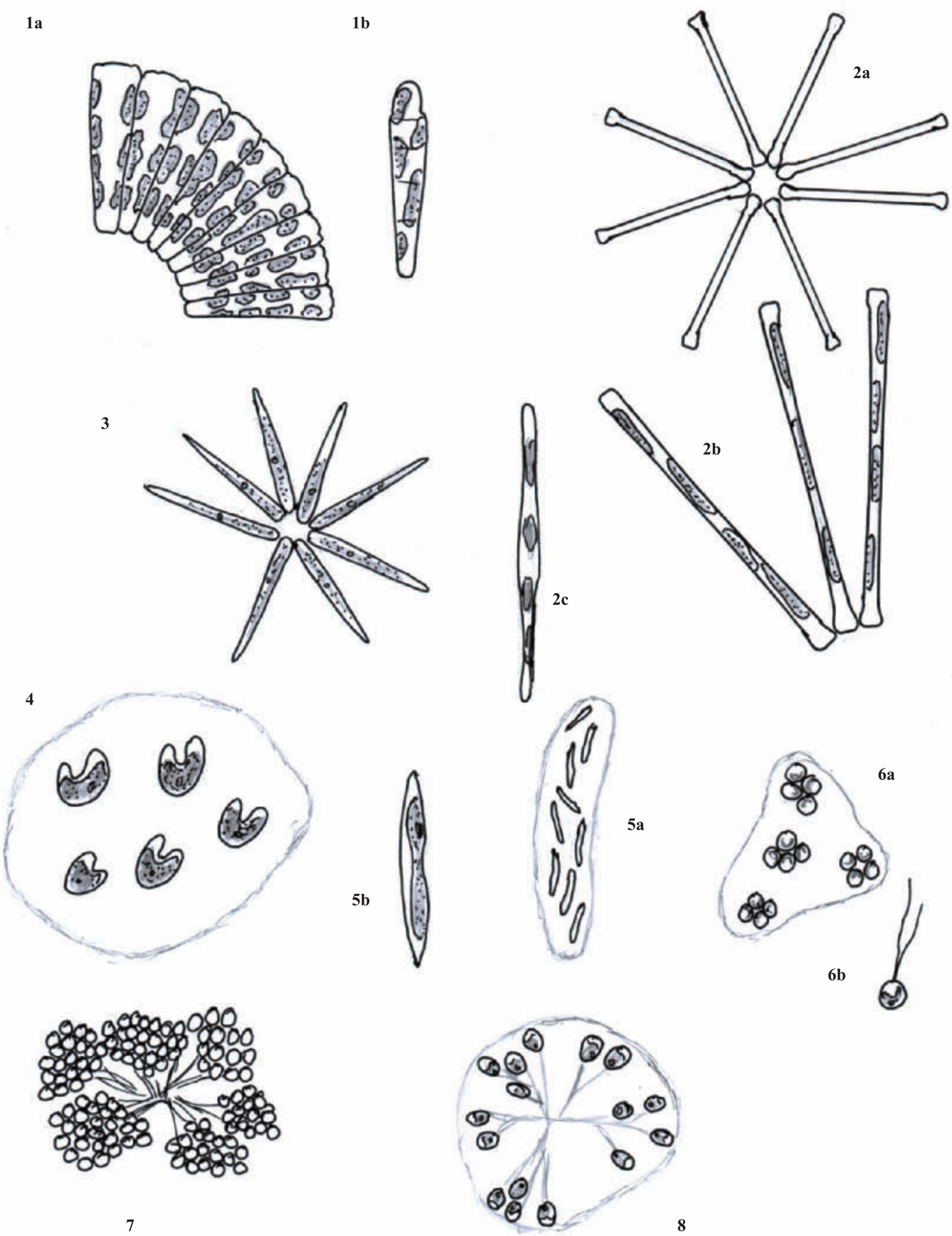


Plate XI **1.** *Meridion*, showing plastids: (a) colony, girdle view; (b) single cells, valve view. **2.** *Asterionella*: (a) colony; (b) detail, girdle view; (c) single cell, valve view. **3.** *Actinastrum.* **4.** *Kirchneriella.* **5.** *Elakatothrix*: (a) colony; (b) single cell. **6.** *Tetraspora*: (a) colony; (b) zoospore. **7.** *Botryococcus.* **8.** *Dictyosphaerium.*

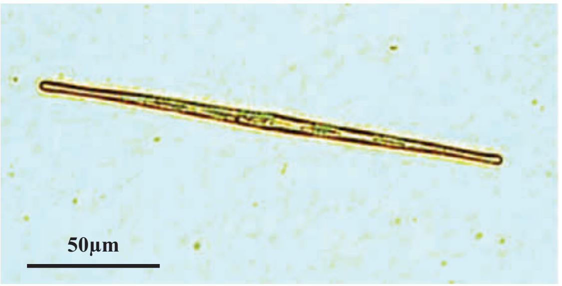


Figure 4.43 *Synedra*. Pennate diatom. Elongate fusiform cell of a common planktonic species.

79 (78) (a) Frustules with neither internal septa nor costae . . . . **Synedra**

(in part see 192)

Synedra has elongate, linear, isopolar valves. There is a narrow pseudoraphe and fine transverse striae. Colonies of **Synedra** stellate or short chains but it can also be present as single cells or as an attached epiphyte. Widespread distribution and may be abundant. Can produce both unwanted taste and odour problems in drinking waters and, when in large numbers, clog filters (Palmer, 1962). Bacillariophyta. Plate XXVI. Figs 2.23, 4.43.

(b) Frustules have either internal septa or costae **80**

80 (79) (a) Frustules with internal longitudinal septa but no costae. There are small polar and larger central swellings when seen in valve view . . . . **Tabellaria**

(in part see 28)

NB. Although the swollen centre can be clearly seen in valve view if you are observing a stellate colony you see the cells in girdle view and the swelling is not visible. **Tabellaria** cells, unlike those of **Asterionella** with whose colonies they may be confused, do not have such swollen and rounded ends to the cells. However shorter cells and colonies of **Asterionella** do appear (sometimes less than a quarter the length of normal cells) and these do not have such obvious swellings at the poles - which can give rise to confusion.

(b) Frustules without internal septa but with thick internal costae. Valve ends may be swollen but no median swelling present. Cells almost elliptical (albeit elongated in some species) in valve view Bacillariophyta. . . . . **Diatoma**

(in part see 29)

81 (76) (a) Cells elongate, cigar-shaped, without silica walls, radially arranged in a star-shaped colony with the cells attached to each other at one end only . . . . **Actinastrum**

Cells of **Actinastrum** join together to form 4–8-16-celled star-shaped colonies. Each cell is cigar-shaped with a single chloroplast with pyrenoid and are between 10 and 25 μm long and 3–6 μm wide. Common in the plankton of lakes and may occur in rivers. Chlorophyta. Plate XI. Fig. 4.44.

(b) Cells not elongate like a cigar, often more spherical, cubical, crescent-shaped or at the most short cylinders. Can form plate-like colonies. Stellate colonies are not formed **82**

82 (81) (a) Cells of colonies arranged within a definite mucilaginous envelope **83**

(b) Cells not within a definite mucilaginous envelope **91**

83 (82) (a) cells crescent-shaped or fusiform **84**

(b) Cells spherical, ovoid or other shape **85**

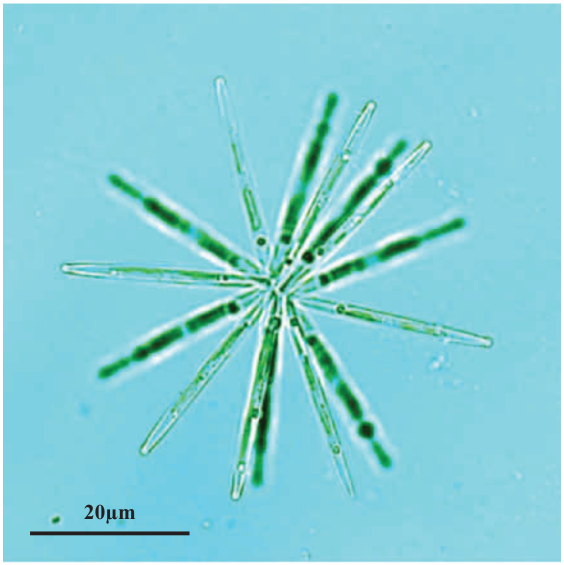


Figure 4.44 *Actinastrum.* Single colony, with cells radiating out from a central point.

84 (83) (a) Cells crescent-shaped (lunate), irregularly arranged in small mucilaginous colonies . . . . **Kirchneriella**

Kirchneriella cells have a parietal chloroplast with a pyrenoid. Lunate or crescent-shaped cells are often so curved that their ends almost touch although some may be sigmoid or slightly spiral. Cells 3–8 μm wide and 10–14 μm long, often enclosed in mucilage, and in groups of 2, 4, 8 or up to 32. Free floating and widely distributed in the plankton. Chlorophyta. Plate XI.

(b) Cells fusiform or wedge-shaped ovals . . . . **Elakatothrix**

There is a single chloroplast (sometimes two) which is parietal and may or may not have one or two pyrenoids. Cells 3–6 μm broad and 15–25 μm long. Cells of **Elakatothrix** have a characteristic spindle or fusiform shape and are arranged in pairs or somewhat irregularly within mucilaginous colonies. Usually free floating, an occasional planktonic species. Chlorophyta. Plate XI.

85 (83) (a) Cells spherical, ovoid or ellipsoidal and more or less radially arranged at the ends of strands of mucilage, and embedded in mucilage, to form a radiating globular colony . . . . **Dictyosphaerium**

Dictyosphaerium coenobia are composed of 4 to 64 cells which are spherical to subreniform and are connected by threads radiating from the colony centre. The whole is embedded in mucilage. Cells spherical to ovoid, 3–10 μm in diameter with parietal cup-shaped chloroplasts with pyrenoids. Frequent in the plankton of lakes and ponds and slow moving waters. Can be found amongst submerged macrophytes or submerged objects. May impart an odour to drinking waters (Palmer, 1962). Chlorophyta. Plate XI. Fig. 4.45.

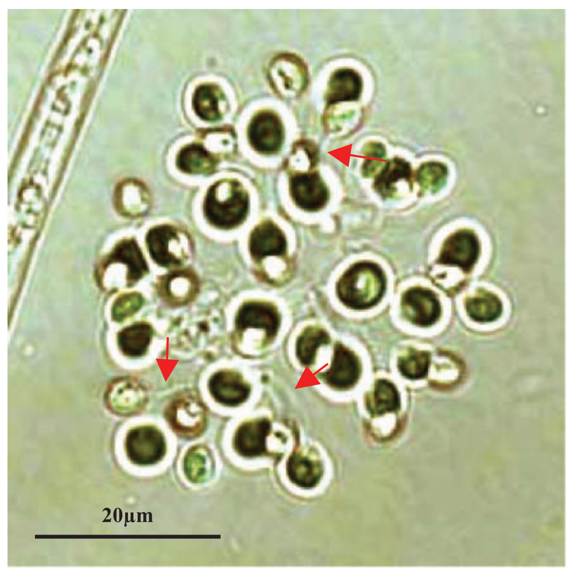


Figure 4.45 *Dictyosphaerium.* Phase contrast image of single colony. Cells are attached to fine mucilaginous threads (arrows) radiating out from the centre of the colony.

(b) Cells not attached to mucilage strands that are radially arranged **86**

86 (a) Cells of colony very densely packed and often appearing dark brown to black in colour. Individual cells can be difficult to distinguish . . . . **Botryococcus**

Cells of **Botryococcus** are difficult to see because they are so densely packed. The colonies may be pale but are often quite dark and look like a piece of organic debris. Cells may be easier to see if the colony is gently squashed under the microscope cover slip. Cells roughly spherical in shape, 3–9 µm wide and 6–10 µm long. The chloroplast is parietal with a pyrenoid. The cells are embedded in a tough oily mucilage. Widespread in the plankton. Chlorophyta. Plate XI.

(b) Cells of colony not so densely packed and colonies not brown in colour **87**

87 (86) (a) Cells with pseudocilia (see Glossary) . . . . **Tetraspora**

Tetraspora forms large irregular gelatinous colonies that can be visible to the naked eye. The cells are in groups of 2 or 4 within the mucilage. Each cell usually has two fine pseudocilia and they are arranged around the edge of the colony. The chloroplast is cup-shaped and a pyrenoid is present. Cells 6–12 µm in diameter. Common in the plankton, in shallow waters, ponds and ditches or associated with submerged macrophytes. Chlorophyta. Plate XI.

(b) Cells without pseudocilia **88**

88 (87) (a) Mucilaginous surrounds to the cells show marked stratification or layering **89**

(b) Mucilaginous surrounds to cells more or less homogenous, no marked stratification **90**

89 (88) (a) Chloroplast dense and star-shaped . . . . **Asterococcus**

Cells of **Asterococcus** are spherical or globular, up to 40 µm in diameter. Single dense star-shaped chloroplast with arms radiating from the centre is present together with a centrally located pyrenoid. Small groups of cells are surrounded by broad stratified or lamellate hyaline mucilage. Between 1 and 16 cells contained within the mucilage. Free floating, common in softer shallow waters usually amongst other algae and moss. Chlorophyta. Plate XII.

(b) Chloroplast cup-shaped, not star-shaped, and nearly fills the whole cell . . . . **Gloeocystis**

Gloeocystis cells are spherical and usually in groups of 4–8–16 surrounded by stratified or lamellate mucilage but may be solitary. There is a single cup-shaped parietal chloroplast with pyrenoid and often many starch grains. Cells 4–23 µm in diameter. Found in more stagnant ponds as part of the tychoplankton. Can, if present in large numbers, impart unwanted odour to drinking waters (Palmer, 1962). Chlorophyta. Plate XII.

90 (88) (a) Chloroplast cup-shaped with a single pyrenoid . . . . **Palmella**

Palmella cells are spherical or rounded cylinders, 3–15 µm broad. They are surrounded by an indefinite mucilaginous mass which may be coloured greenish to reddish and is found on damp surfaces. Some other species of algae have palmelloid stages in their life cycle which gives rise to confusion. The jelly-like masses can cause blockage of filters in water treatment processes. Chlorophyta. Plate XII.

(b) Chloroplast parietal with none to many pyrenoids . . . . **Sphaerocystis**

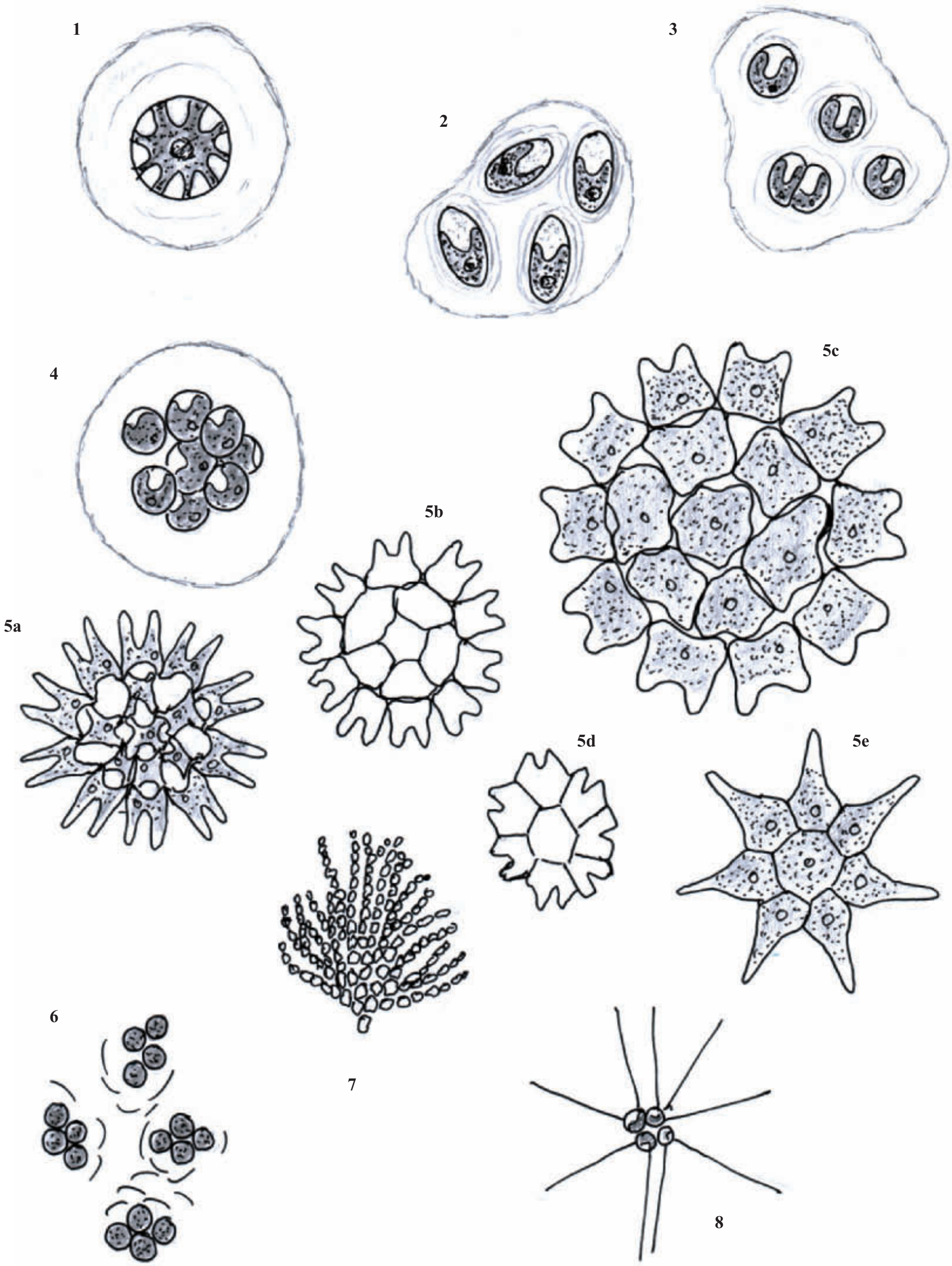


Plate XII **1.** *Asterococcus.* **2.** *Gloeocystis.* **3.** *Palmella.* **4.** *Sphaerocystis.* **5.** *Pediastrum*: (a) *P. duplex*; (b) *P. boryanum*; (c) *P. boryanum* var. *cornutum*; (d) *P. tetras*; (e) *P. simplex.* **6.** *Westella.* **7.** *Protoderma.* **8.** *Micractinium.*

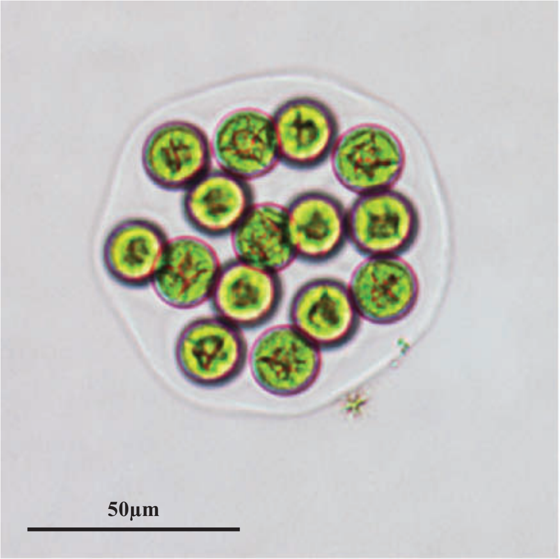


Figure 4.46 *Sphaerocystis.* Free-floating colony of cells dispersed throughout a globule of mucilage.

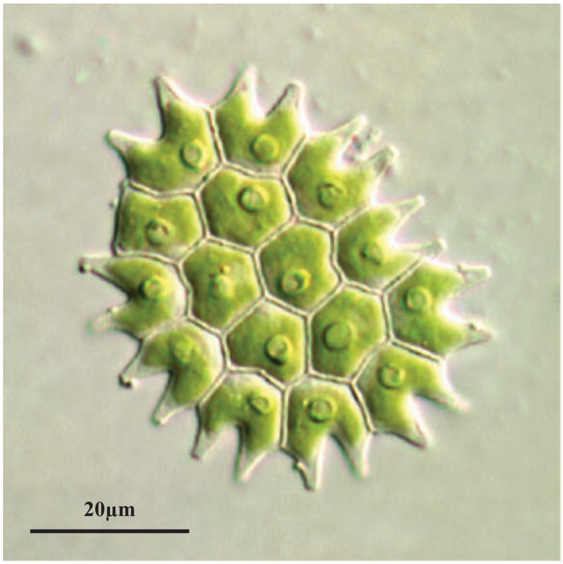


Figure 4.47 *Pediastrum.* Plate-like colony, one cell thick – with distinctive peripheral and central cells. Cell walls and nuclei are prominent in this DIC image.

Cells 7–20 μm broad, spherical. Colonies globular and free floating with cells embedded in stuctureless mucilage. Reproduction is by the mother cell dividing to form 8–16 daughter cells which form characteristic microcolonies within the parent colony. Common and sometimes abundant in the plankton of lakes. Chlorophyta. Plate XII. Fig. 4.46.

91 (82) (a) Colonies either spherical, oval or a flat disc **92**

(b) Colonies not as above **101**

92 (91) (a) Cells of colony form a flat disc **93**

(b) Cells forming a spherical or ovoid colony or globular groups of 4–16 cells **96**

93 (92) (a) Colony free floating . . . . **Pediastrum**

Pediastrum forms characteristic flat plate-like colonies which are common in lakes, ponds and slow flowing rivers that are nutrient-rich. The cell walls are often quite tough and persist for some time after the contents have disappeared. There are many species. Can, if present in large numbers, impart unwanted odour to drinking waters (Palmer, 1962). Chlorophyta. Plate XII. Figs 2.18, 4.47.

(b) Colony attached to a surface **94**

94 (93) (a) At least some of the cells bear setae (see glossary) **95**

(b) Cells without setae . . . . **Protoderma**

Protoderma forms a cushion or disc one cell thick (sometimes becomes a little thicker with age) that is actually composed of irregularly branched filaments. This is more obvious towards the edge of the disc. Cells quadrate to cylindrical up to 15 μm in length. Chloroplasts are parietal with a pyrenoid. Commonly attached to submerged aquatics. Chlorophyta. Plate XII.

95 (94) (a) Setae with sheaths, cells up to 40 µm in length . . . . **Coleochaete**

(in part see 12)

(b) Setae not sheathed, frequent. Cells up to 30 µm long . . . . **Chaetopeltis**

Colonies composed of radiating rectangular cells forming a flat disc (up to 1 mm in diameter) on submerged aquatic plants. Chloroplast cup-shaped. Chlorophyta. (Not illustrated.)

96 (92) (a) Cells bearing long spines and forming free floating colonies of 4–16 cells . . . . **Micractinium**

Cells more or less spherical, 3–7 µm in diameter, forming small colonies, 4 being the most frequent number. Each cell with 1 to 5 fine tapering spines which are 10–35 µm long. Chloroplasts parietal with a single pyrenoid. Occurs frequently in the plankton of lakes, ponds and larger rivers, especially if enriched with nutrients. Chlorophyta. Plate XII. Fig. 4.72 (Key no. 207).

(b) Cells without spines **97**

97 (96) (a) Cells globose to spherical forming a tightly packed hollow sphere of up to 100 cells **98**

(b) Cells oval or with finger-like processes extending outwards, more loosely arranged. Oval cells may have thickened poles or may be within an encasing envelope **99**

98 (97) (a) Up to 100 cells per colony, loosely held together by the mother cell walls from the previous generation . . . . **Westella**

Westella cells form a free floating colony loosely connected by the original mother cell walls. Cells 3–9 µm in diameter, chloroplast parietal with or without a pyrenoid. Planktonic.

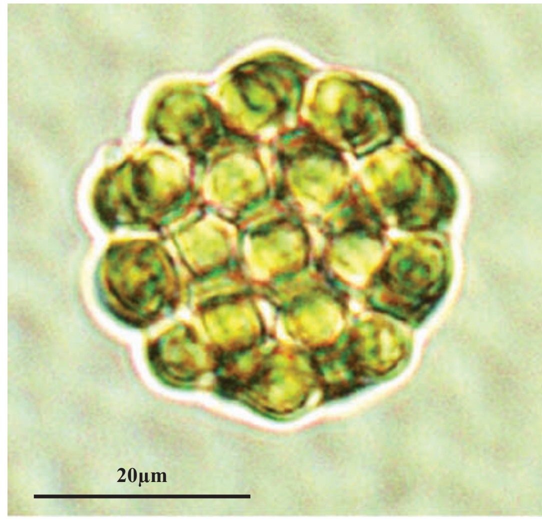


Figure 4.48 *Coelastrum.* Hollow colony of closely joined, regularly arranged cells.

NB Some authors regard **Westella** as synonymous with **Dictyosphaerium.** Chlorophyta. Plate XII.

(b) Hollow spherical colonies of up to 64 closely joined cells arranged in a regular sphere rather like a football . . . **Coelastrum**

Cells of **Coelastrum** are spherical, 8–30 µm in diameter with a parietal chloroplast and pyrenoid. Found in the plankton of lakes and slow flowing rivers. Chlorophyta. Plate XIII. Fig. 4.48.

99 (97) (a) Cells with finger-like or spike-like processes extending outwards (1 to 4 per cell). Cells kidney-shaped and joined to each other by a mucilaginous protrubance so as to form a radiating colony . . . . **Sorastrum**

Sorastrum is related to **Pediastrum** but the cells form a more spherical colony of between 8 and 64 cells. Chloroplast parietal with a pyrenoid. The outer facing surface of the cell bears 1–4 finger- or spine-like processes 4–15 µm long. Uncommon, found

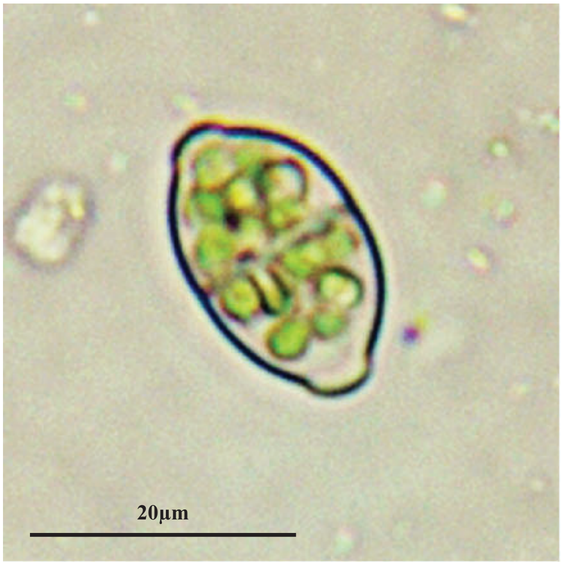


Figure 4.49 *Oocystis*. Pair of cells, showing disc-shaped chloroplasts and a polar swelling at each end of the colony.

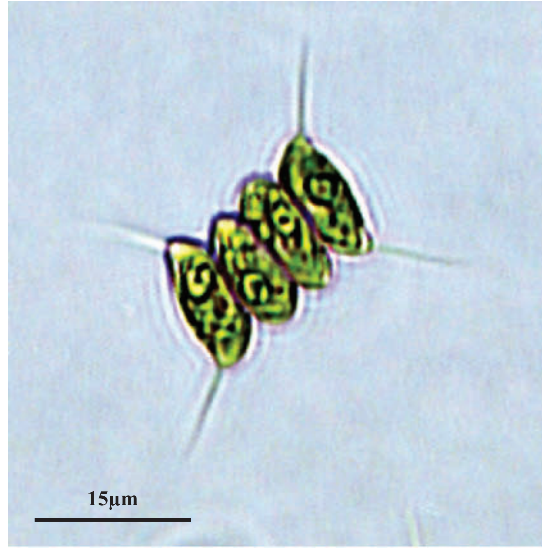


Figure 4.50 *Scenedesmus*. Four cell colony. This species (*S. quadricauda*) has two prominent spines on each outer cell.

in similar locations to **Pediastrum.** Chlorophyta. Plate XIII.

(b) Cells ovoid to spherical and without finger-like processes or spines **100**

100 (99) (a) Cells usually oval and often having a clearly observable polar swelling or nodule at each end. Mother cell wall, when present, more or less entire and surrounds 2–4–8 daughter cells. Cells 4–50 µm long . . . . **Oocystis** Plate XIII. Fig. 4.49. (in part see 210)

(b) Cells normally spherical, without polar nodules. Mother cell walls fragmented. Up to 10+ cells per colony. Cells 3–9 µm broad . . . . **Westella**

(in part see 98)

101 (91) (a) Cells roughly cylindrical (or sausage-shaped, ellipsoidal or fusiform) and usually more than 2 times long as broad. Colonies of usually single, but sometimes double rows of 4–16 cells that are joined along the long axis. . . . . **Scenedesmus**

Scenedesmus is a very common and sometimes abundant genus. It is especially found in eutrophic and hypertrophic waters. Some species bear spines, others ridges and others no ornamentation. Cell sizes vary greatly from species to species. When abundant may impart unwanted odours to drinking waters (Palmer, 1962). Chlorophyta. Plate XIV. Fig. 4.50.

(b) Cells as long as broad or spherical to very short cylinders joined end to end **102**

102 (101) (a) Cells very short cylinders (2–6 µm broad and 3–20 µm long) joined end to end in 2s, 3s, 4s, etc. . . . . **Stichococcus**

(in part see 34)

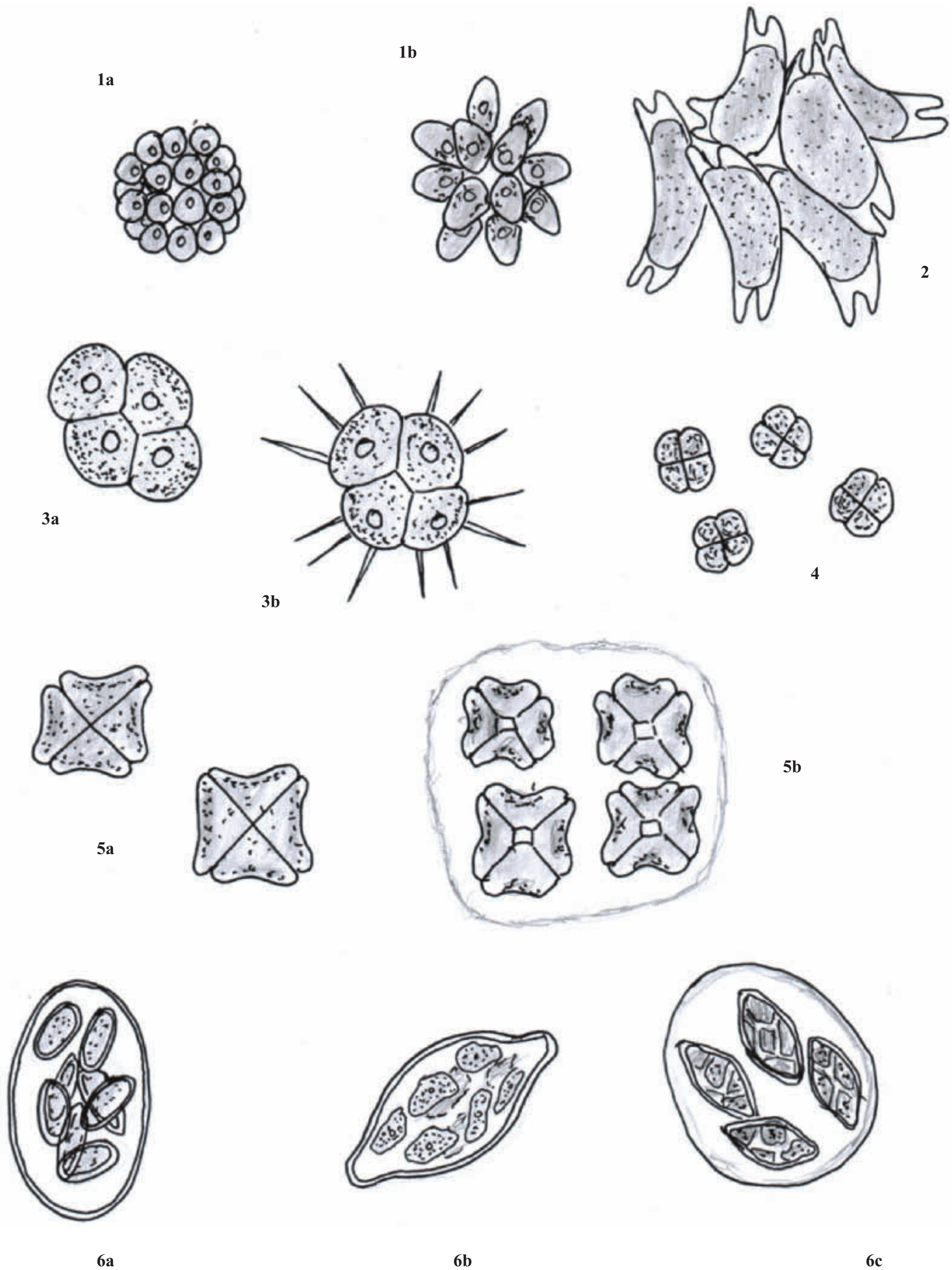


Plate XIII **1.** *Coelastrum*: (a) *C. microporum*; (b) *C. asteroideum*. **2.** *Sorastrum*. **3.** *Tetrastrum*: (a) *T. triangulare*; (b) *T. staurogeniforme*. **4.** *Pleurococcus*. **5.** *Crucigenia*: (a) *C. tetrapedia*; (b) *C. fenestrata*. **6.** *Oocystis*: (a) *O. elliptica*; (b) *O. solitaria*; (b) *O. natans*.

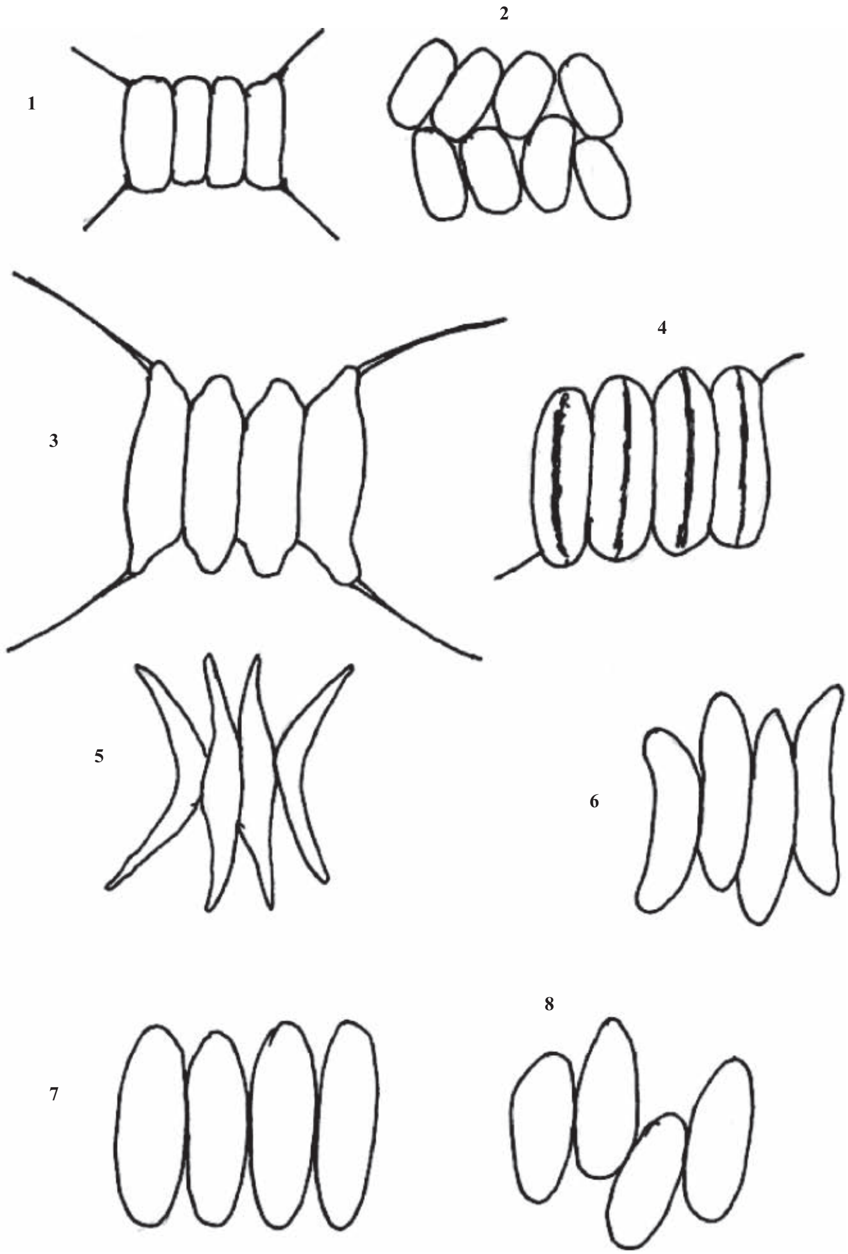


Plate XIV Species of *Scenedesmus*. **1.** *S. quadricauda.* **2.** *S. arcuatus.* **3.** *S. opaliensis.* **4.** *S. ornatus.* **5**. *S. acuminatus.* **6.** *S. dimorphus.* **7.** *S. obliquus.* **8.** *S. obtusus.*

(b) Cells as long as broad, spherical or globose in shape **103**

103 (102) (a) Cells with spines or projections **104**

(b) Cells without spines or projections **105**

104 (103) (a) Cells spherical, in groups of 4–16, each bearing long tapering spines (many times as long as the cell) . . . . **Micractinium**

(in part see 96)

(b) Cells angular and usually in groups of four but may be solitary. Spines usually very fine and short (not more than 2 times cell diameter) . . . . **Tetrastrum**

Cells of **Tetrastrum** are 3–7 µm broad (excluding the spines) with a cup-shaped chloroplast with or without a pyrenoid. Planktonic but not usually abundant. Chlorophyta. Plate XIII.

105 (103) (a) Cells growing on a damp substrate, aerial, globular or angular in shape when touching and forming definite clusters . . . . **Pleurococcus**

Pleurococcus (synonym **Apatococcus** and **Desmococcus**). Cells are globular to angular and usually in dense masses, sometimes forming short filaments. The chloroplast is large, parietal and lobed, with or without pyrenoid. Cells 5–20 µm wide. Frequently found on tree bark, fences etc..

(b) Cells aquatic, oval or triangular in shape, usually in groups of four sometimes sticking to each other by means of a thin mucilaginous surround . . . . . . **Crucigenia**

Crucigenia colonies consist of four cells arranged in a cross so that a gap may be present at the colony centre. Cells have a parietal chloroplast with a small pyrenoid, 5–10µm broad. Frequent in the plankton. Chlorophyta. Plate XIII.

106 (68) (a) Cells with flagella, motile **107**

(b) Cells without flagella, non-motile **127**

NB some groups of diatoms are able to move with a gliding action and do not have flagella.

107 (106) (a) Cells covered with delicate scales bearing long bristles or spines which, at a first glance, resemble many flagella. There is, in fact, one single flagellum at the apical end used for locomotion . . . **Mallomonas**

Mallomonas is unicellular and free swimming. Its cells are an elongated oval shape and are covered with numerous fine overlapping plates made of silica. These plates (which may not be obvious in live material) bear spines so that the whole organism is covered with these long spines. The spines may become detached from the plates, especially on preservation. There are two golden-brown parietal chloroplasts. The food reserve is leucosin. Common in the plankton. **Mallomonas** can impart unwanted odours to drinking water (Palmer, 1962). Chrysophyta. Plate XV.

(b) Cells without spine bearing scales **108**

108 (107) (a) Cells with one, two or four flagella attached at one end only **109**

(b) Cells with two flagella attached other than at anterior end **123**

NB In dinoflagellates two flagella arise at the centre of the cell. One trails backwards and is relatively easy to see and the other

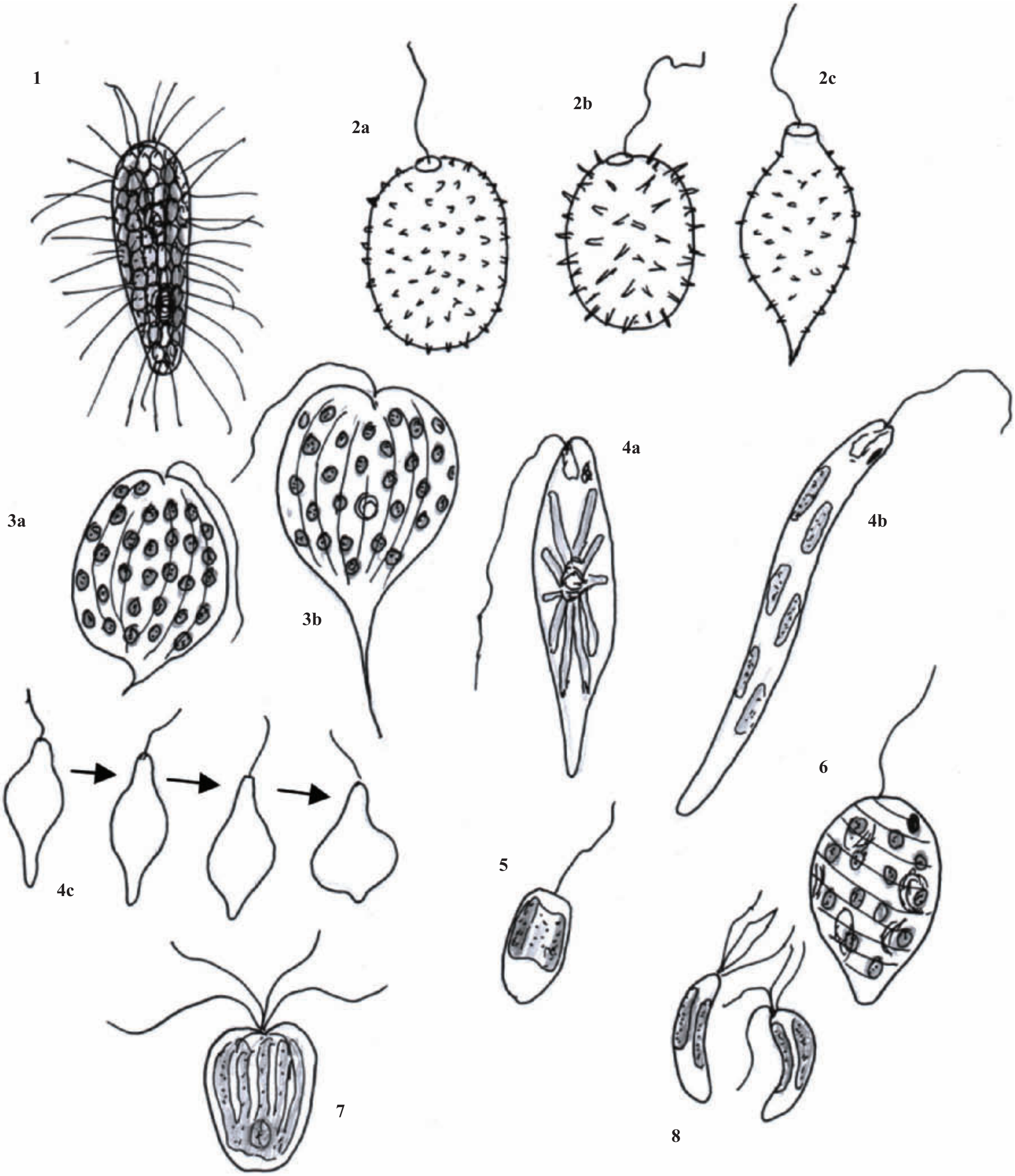


Plate XV **1.** *Mallomonas.* **2.** *Trachelomonas*: (a) *T. hispida*; (b) *T. superba*; (c) *T. caudata.* **3.** *Phacus*: (a) *P. triqueter*; (b) *P. longicauda.* **4.** *Euglena*: (a) *E. viridis*; (b) *E. mutabilis*; (c). Euglenoid movement. **5.** *Chromulina.* **6.** *Lepocinclis.* **7.** *Pyramimonas.* **8.** *Spermatozopsis.*

lies in a furrow around the center of the cell and is more difficult to see (see Fig. 4.56).

109 (108) (a) Cells with single emergent flagellum **110**

(b) Cells with two or more emergent flagella **114**

110 (109) (a) Cells enclosed in a brownish test (see glossary) of various shapes with the flagellum emerging from an anterior aperture .... **Trachelomonas**

Trachelomonas is free swimming and unicellular. The cells, which are **Euglena**-like, are enclosed in a roundish (although there are many variations on this shape) test, lorica or theca which may range from pale to dark brown in colour and is usually opaque. The surface of the test may be smooth, granulate or spiny. The single flagellum emerges from a round aperture at the anterior end. A red eyespot is present. There are two to many disc-shaped chloroplasts. Small paramylum bodies may be present Found mainly in shallow waters, ditches and ponds, often as a tychoplankter, but may be found in larger water bodies. Many species separated on the basis of the shape and ornamentation of the test. Euglenophyta. Plate XV.

(b) Cells not enclosed in a test **111**

111 (110) (a) Cells with pronounced dorsiventral flattening (flattened side to side so leaf-like in shape) often with part of the cell twisted .... **Phacus**

Phacus is solitary and free swimming. Cells are markedly flattened and may be twisted along their length. Broad at the anterior but pointed at the posterior end, the point being of variable length. There are numerous disc-shaped chloroplasts without pyrenoids and an eyespot. Disc-shaped paramylum bodies (one to many) are present. The pellicle is rigid and longitudinal striations and granules may be visible on the surface. Common in ponds and still waters, tychoplanktonic, especially where enriched with organic matter such as swamps. Numerous species. Euglenophyta. Plate XV.

(b) Cells not flattened or leaf-like ... **112**

112 (111) (a) Cells roughly cylindrical or fusiform often show metaboly (see glossary) .... **Euglena**

Euglena cells are solitary and free swimming. They are usually elongated but may be spindle-shaped or twisted. The periplast may be flexible or firm and when firm may, in some species, show spiral markings or rows of granules. Chloro\ plasts one to many and variously-shaped, disc-shaped or stellate to band-like, depending upon the species Sometimes pyrenoids are present. The emergent flagellum arises from an apical reservoir. A prominent eyespot is present. Storage product is paramylum and numerous granules of variable shape may be present. Numerous species and identification to species level difficult. Common to abundant in ponds and shallow waters. Some species found in acid waters. If present in large numbers **Euglena** can impart both taste and odour to drinking waters (Palmer, 1962). Euglenophyta. Plate XV. Figures 1.6, 4.51.

(b) cells ovoid to pyriform and do not show metaboly **113**

113 (112) (a) Cells ovoid, periplast firm with pointed tail .... **Lepocinclis**

Lepocinclis is found in ponds and small water bodies, often alongside other

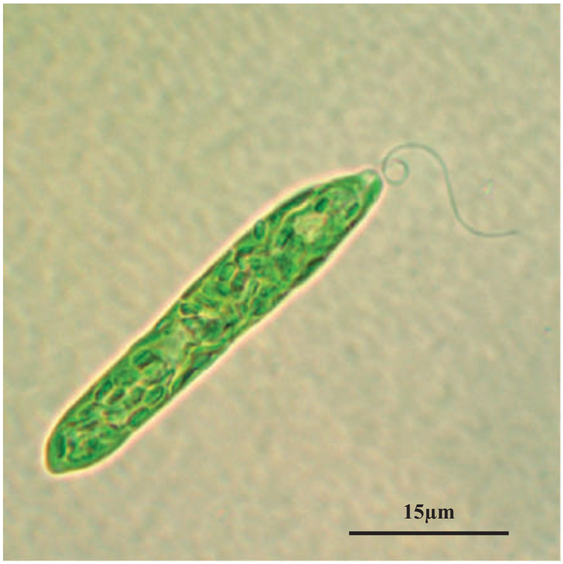


Figure 4.51 *Euglena.* Single cell with discoid chloroplasts and prominent apical flagellum.

euglenoids. The cells are circular in section and may be spherical to spindle-shaped. The pellicle is rigid with spirally arranged striations on the surface. There is sometimes a tapering tail at the base of the cell. There are numerous discoid chloroplasts and an anterior eyespot is present. A single long flagellum (up to twice the length of the cell) is present. Two annular-shaped paramylum granules are present. Cells 10–20 µm wide and 25–40 µm long. Euglenophyta. Plate XV.

(b) Cells oval, without pointed tail, show slight metaboly . . . . **Chromulina**

Widespread in cleaner waters often amongst other vegetation, often in the neuston or plankton. Cells ovoid with one or two curved plate-like chloroplasts. A single long flagellum is present. There is also a leucosin body located at the posterior end of the cell. Cells 6–7 µm wide and 9–14 µm long. Chrysophyta. Plate XV.

114 (109) (a) Cells with four flagella **115**

(b) cells with two flagella **117**

115 (114) (a) Cells with a broad crescent shape . . . . **Spermatozopsis**

Only one species found, **Spermatozopsis exsultans**. Cells are crescent-shaped or curved, sometimes S-shaped. Cells have four flagella and a parietal chloroplast. There are no pyrenoids but an eyespot is present. Cells 7–12 µm long and 3–4 µm wide. Quite widely distributed although never abundant in small ponds, nutrient-rich pools or puddles or slow flowing waters. Chlorophyta. Plate XV.

(b) Cells ovoid, sometimes with a truncated anterior end **116**

116 (115) (a) Cell strawberry-shaped, four lobes forming an indentation at the anterior end from which the flagella arise . . . . **Pyramimonas**

The shape of the cells is characteristically strawberry or subpyramidal. The chloroplast is cup-shaped and often four lobed towards the anterior end. A pyrenoid is present towards the base. Cells naked, without wall, 12–16 µm broad and 20–30 µm long. Widespread in ponds and still waters frequently at colder times of the year although it can occur all the year round. Prasinophyta. Plate XV.

(b) Cells oval or occasionally heart-shaped but not lobed . . . . **Carteria**

Carteria cells are virtually identical to those of **Chlamydomonas** except that they may be pear-shaped or ellipsoidal and have four, not two, flagella. There is cup-shaped chloroplast usually without any pyrenoids but occasionally one may be present. Frequent and occasionally abundant in still waters and similar habitats to **Chlamydomonas**. Cells 9–20 μm in diameter. Less widespread than **Chlamydomonas**. Chlorophyta. Plate XVI.

117 (114) (a) Cells fusiform in shape . . . . **Chlorogonium**

Cells of **Chlorogonium** are elongate fusiform or spindle-shaped tapering at both ends with two flagella arising from the narrow apical end. There is a rigid cell wall. The chloroplast fills most of the cell and pyrenoids are usually present There is an anterior eyespot. Cells 2–15 μm broad and up to 80 μm long. Can occur in large numbers in small bodies of water especially those rich in humic materials. Chlorophyta. Plate XVI.

(b) Cells not fusiform in shape **118**

118 (117) (a) Cells with anterior end flattened obliquely (cut off at an angle in one view as in Plate XVI). Flagella arise from the oblique face near to the front end and are of slightly unequal length, ... **119**

(b) Cells with anterior end rounded or flattened transversly. Flagella inserted at the end (apex) of the cell and of equal length **121**

119 (118) (a) Cells obovoid but strongly curved towards the rear end to form a hyaline tail . . . . **Rhodomonas**

Rhodomonas cells are small (8–13 μm long, 3–8 μm wide) and fairly delicate so are often overlooked even though it is widespread. There is a single reddish-golden chloroplast with a large pyrenoid to one side with a definite starch sheath. A hyaline tail with a basal granule is present in **R. lacustris var nannoplanctica** otherwise the end just tapers. Two slightly unequal flagella are present. Widespread in the plankton. Some reports suggest that it is able to survive under low lighting conditions but this is not a prerequisite in its ecology (Wehr and Sheath, 2003). Cryptophyta. Plate XVI. Fig. 4.52.

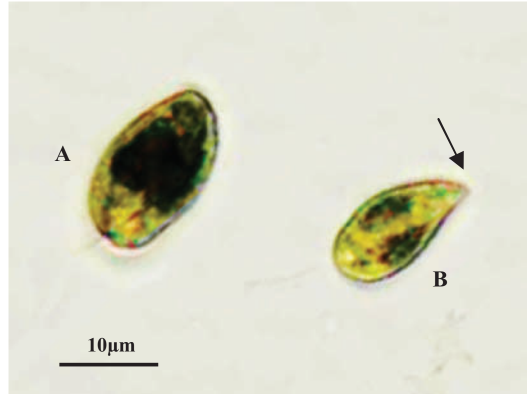


Figure 4.52 *Rhodomonas*. Cells appear oval in face view (A) and comma-shaped in side view (B), with a distinct posterior hyaline tail (arrow). Flagella not visible in this iodine-stained preparation.

(b) Cells not strongly curved. Tail, if present, not hyaline **120**

120 (119) (a) Gullet absent, chloroplast blue to blue-green or reddish . . . . **Chroomonas**

Chroomonas and **Cryptomonas** are very similar except that the colour of the chloroplast is markedly different in **Chroomonas**. There are two unequal flagella. The single chloroplast, which is blue-green in colour, contains phycocyanin. A single pyrenoid is present. Cells 7–18 μm long, 4–8 μm wide. Planktonic, occuring in ponds and shallow waters. Cryptophyta. Plate XVI.

(b) Gullet present, chloroplasts brown to olive green . . . . **Cryptomonas**

Cells of **Cryptomonas** are slipper to bean-shaped with some dorsiventral flattening.

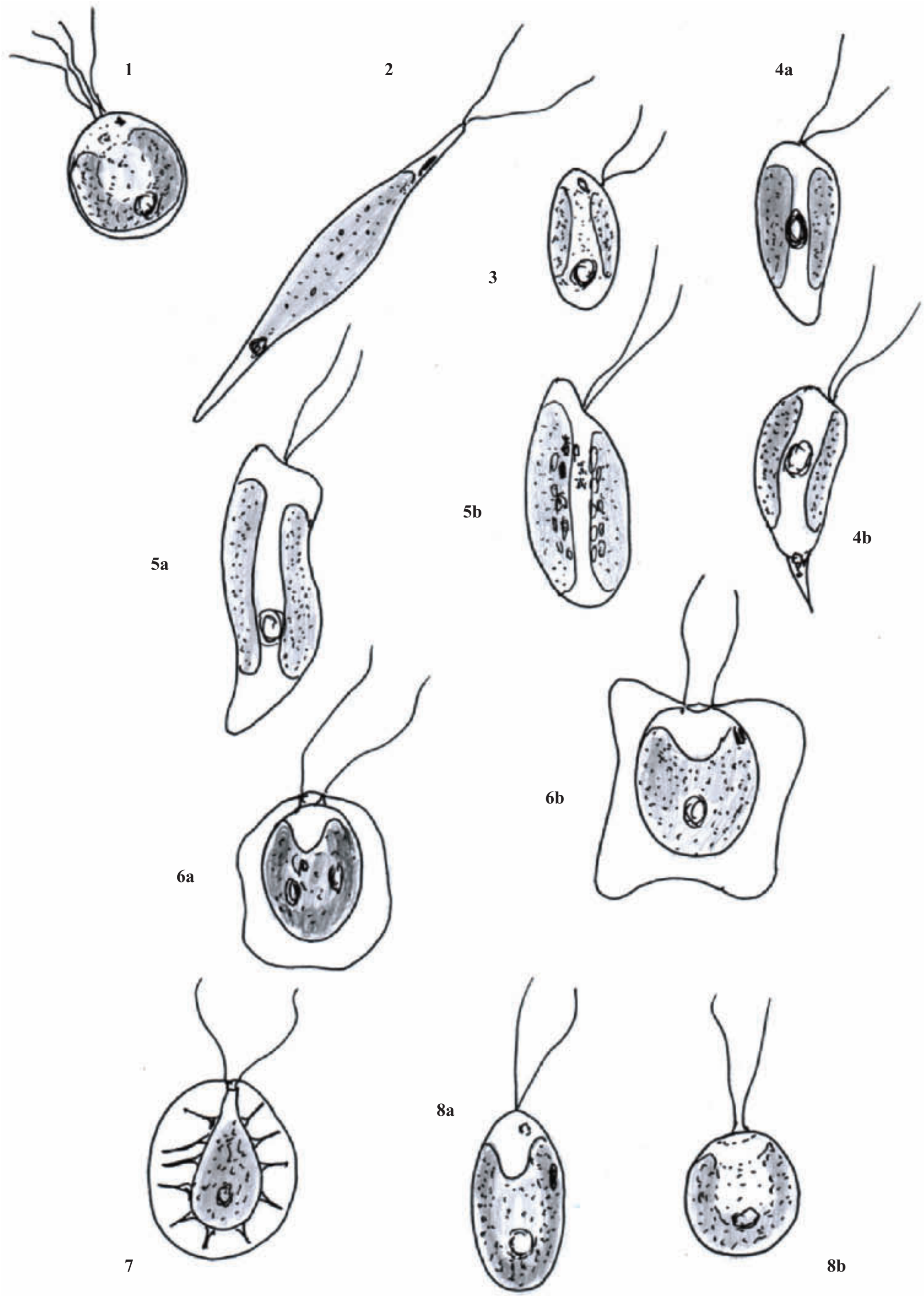


Plate XVI **1.** *Carteria.* **2.** *Chlorogonium.* **3.** *Chroomonas.* **4.** *Rhodomonas*: (a) *R. lacustris*; (b) *R. nanoplanktica.* **5.** *Cryptomonas*: (a) *C. curvata*; (b) *C. ovata.* **6.** *Pteromonas*: (a) *P. aequiciliata*; (b) *P. aculeata.* **7.** *Haematococcus.* **8.** *Chlamydomonas*: (a) *C. reinhardtii*; (b) *C. globosa.*

Two nearly equal flagella. One or two reddish brown chloroplasts per cell with up to four pyrenoids. Gullet more conspicuous as a longitudinal furrow extending from the anterior end. Cells up to 80 μm in length and 26 μm wide. Free swimming in the plankton. Widespread and sometimes in large numbers. Has been reported to impart an odour to drinking water if present in large numbers (Palmer, 1962). Cryptophyta. Plate XVI. Fig. 4.53.

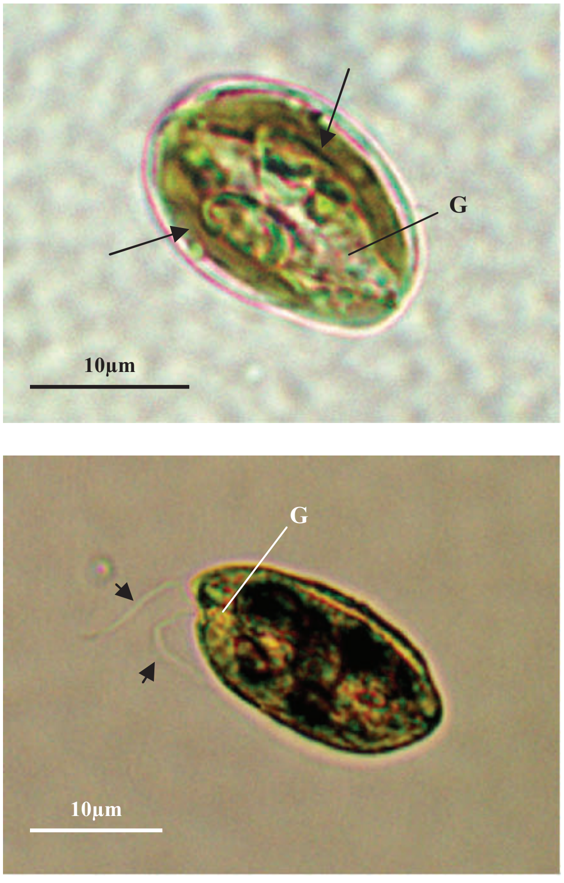


Figure 4.53 *Cryptomonas* (cryptophyte). Top: Face view of live cell (bright field image) containing a pair of olive-brown chloroplasts (arrows) and apical gullet (G). Bottom: Side view of iodine-stained cell. Two flagella (arrows) are just visible, inserted close to the gullet entrance.

121 (118) (a) Chloroplast in centre of cell and suspended there by strands of cytoplasm . . . . **Haematococcus**

Cells of **Haematococcus** (sometimes called **Sphaerella**) are oval to spherical and between 8–30 μm in diameter. There is a thick mucilaginous wall. The green pigments in the chloroplast are often masked with red haematochrome so that the cells appear red. The chloroplast is cup-shaped with one to four pyrenoids. There are often protoplasmic extensions into the wide cell wall. The cells are often noticed in an encysted state giving them a red colour. Occurs in small water bodies and snow as well as bird baths which it may colour red. Chlorophyta. Plate XVI. Fig. 4.54.

(b) Chloroplast not attached to the cell wall by means of cytoplasmic strands **122**

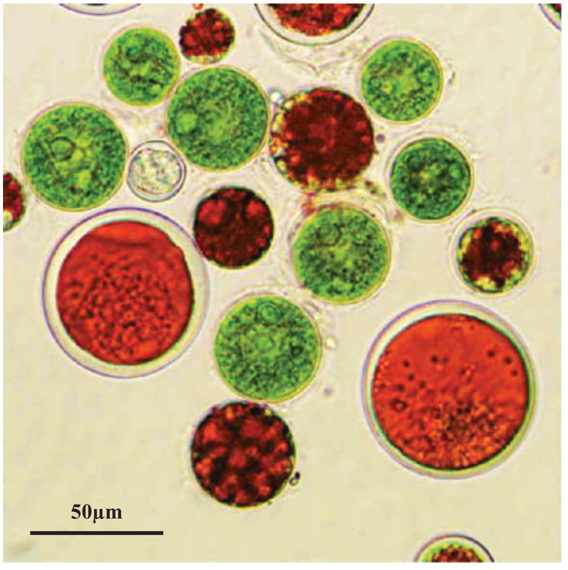


Figure 4.54 *Haematococcus.* Non-motile cells, ranging from immature (green) to fully mature cysts filled with red pigment (haematochrome).

122 (121) (a) Cells with hyaline wing around the cell but prominent on either side .... **Pteromonas**

Pteromonas cells have wing-like extensions of the cell wall with two flagella emerging from the anterior end. The cells are rounded but flattened in side view. The wings give the cells an angular appearance. A cup-shaped chloroplast is present with one to many pyrenoids. **Pteromonas** is widespread in its occurrence but generally prefers nutrient-rich waters, either ponds or slow rivers. Plate XVI.

(b) Cells without hyaline wing .... **Chlamydomonas**

Chlamydomonas is a very large genus with numerous species. Widely distributed in a range of habitats, especially small pools and ditches, often nutrient-rich. The chloroplast is large and cup-shaped,filling much of the cell, with one or more pyrenoids. Two flagella are present inserted at the anterior end. A prominent eye spot is also present at the anterior end. Non-motile palmelloid stages are known to occur. If present in large numbers it can impart odour to drinking water (Palmer, 1962). Chlorophyta. Plate XVI. Fig. 4.55.

123 (108) (a) Cells with a long anterior horn and two or three posterior horns .... **Ceratium**

Ceratium cells are quite large and brownish in colour with two or three posterior 'horns'. The shape, with the horns, is characteristic. There is a narrow but prominent transverse furrow across the middle of the cell around which contains a flagellum. A second flagellum trails backwards from the mid region. The cell surface is covered by a number of plates of specific shape and arrangement. The numerous chloroplasts are discoid and golden-brown in

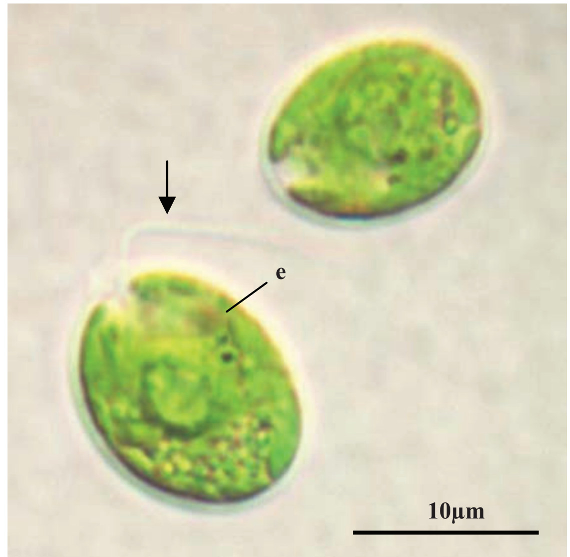


Figure 4.55 *Chlamydomonas*. DIC image showing (lower cell) central nucleus, parietal chloroplast with eye-spot (e) and one of a pair of flagella (arrow).

colour. Characteristic thick walled resistant cysts are produced towards the end of the growing season. **Ceratium** commonly imparts a fishy odour and biter taste to drinking waters (Palmer, 1962). Dinophyta. Plate XVII. Figs 1.3, 1.9, 1.10, 2.7, 4.56.

(b) Cells otherwise shaped **124**

124 (123) (a) Cell wall thin and difficult to see (except in empty cells) or completely absent **125**

(b) Cell wall thick, cellulose plates covering the cell easily seen. Transverse furrow encircling the central area of the cell .... **Peridinium**

Peridinium cells are normally ovoid in outline and free swimming. The cell is covered with angular plates arranged in a specific order. The epitheca and hypotheca are approximately equal in size.

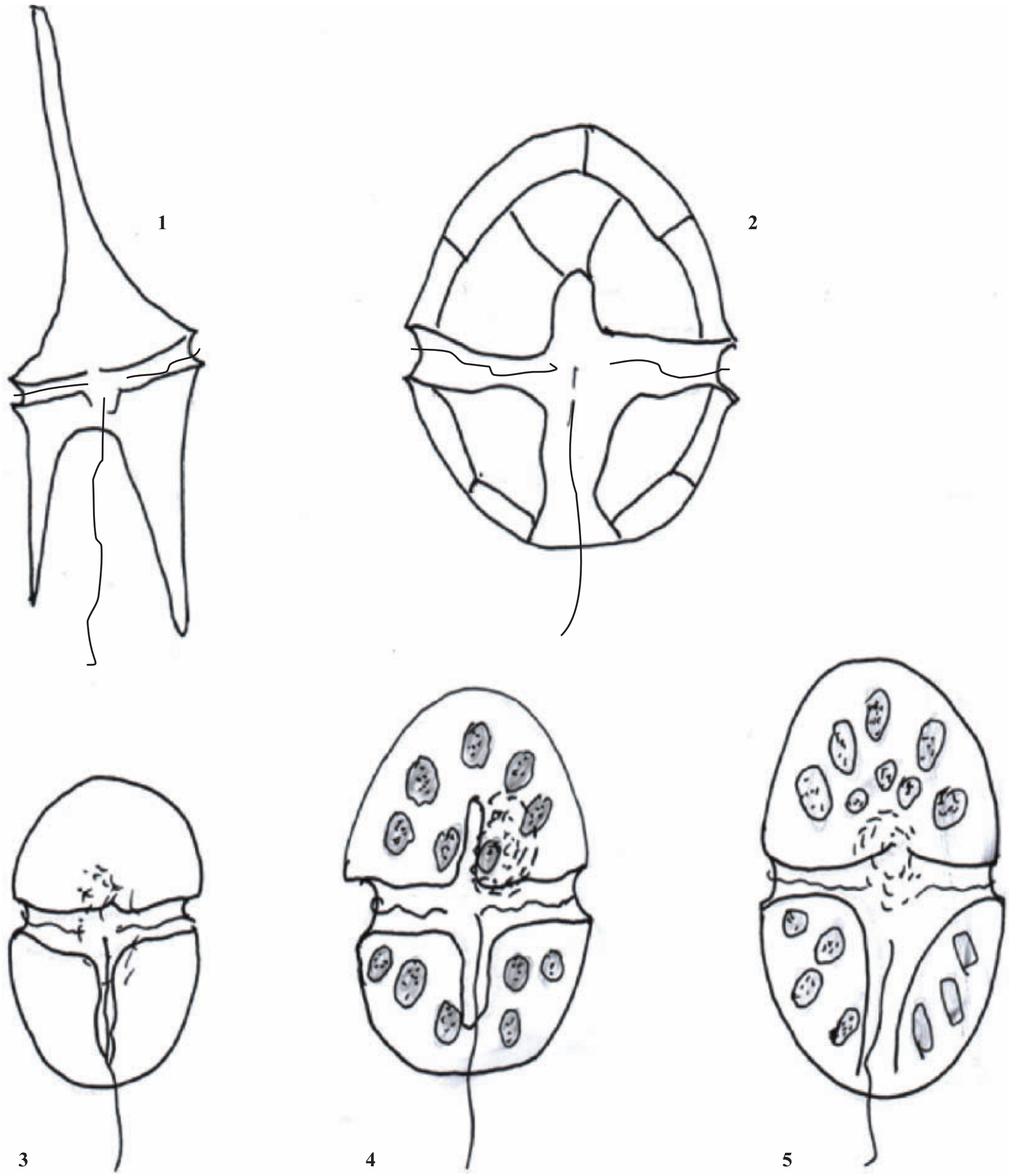


Plate XVII **1.** *Ceratium.* **2.** *Peridinium.* **3.** *Gymnodinium.* **4.** *Woloszynskia.* **5.** *Glenodinium.*

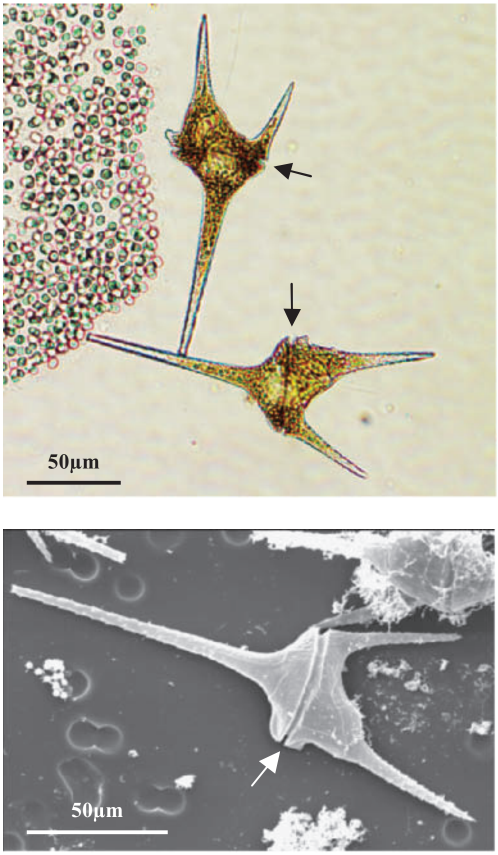


Figure 4.56 *Ceratium.* Top: Two cells in fresh phytoplankton sample. Bottom: Scanning electron microscope image showing typical dinoflagellate plated surface (more clearly visible in Fig. 4.57). Cells have a clear transverse furrow (arrow).

There are numerous brown chloroplasts. A widespread genus found in a range of freshwater habitats. Reported to impart both taste and odour to drinking waters (Palmer, 1962). Dinophyta. Plate XVII. Figs 1.8, 4.57.

125 (124) (a) Cells without walls, protoplast naked .... **Gymnodinium**

Cells approximately oval but sometimes flattened dorsiventrally. A median transverse groove is present. Epicone (above median groove) and hypocone (below median groove) about equal in size. The cell wall is thin and smooth. Cells 7–80 µm wide and 8–118 µm long. Dinophyta. Plate XVII.

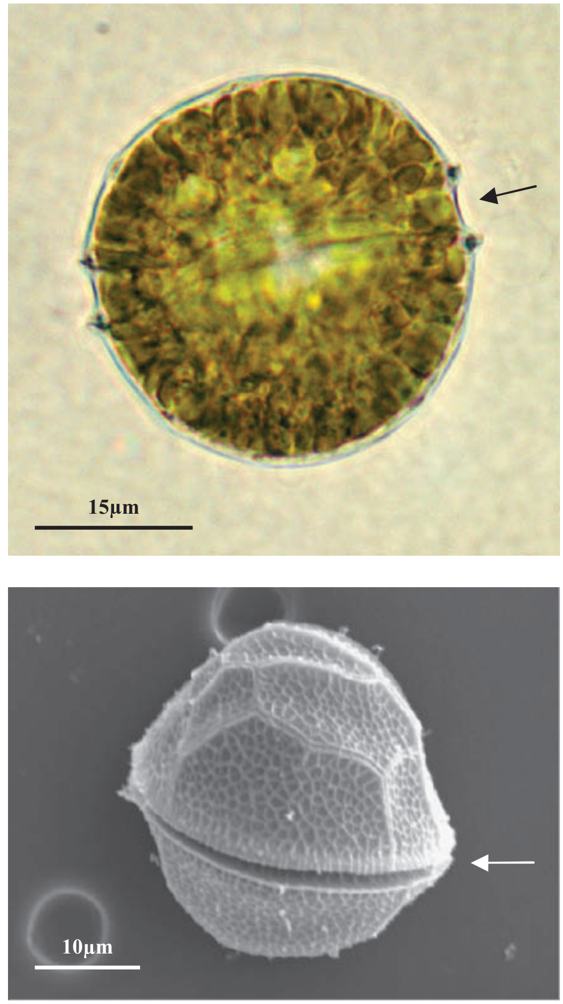


Figure 4.57 *Peridinium.* Top: Living cell containing numerous brownish chloroplasts. Bottom: SEM image showing surface outlines of thecal plates. Both images show a clear transverse furrow (arrow).

(b) Cells with thin walls with plates but these are delicate and difficult to see unless cells empty .... **Glenodinium**

Cells approximately oval in shape and sometimes dorsiventrally flattened. Groove around the mid-region bearing one of the two flagella. Cell wall thin and sometimes lightly ornamented with about 20 plates. Numerous yellow-brown chloroplasts, a prominent eyespot may be present. Cells 13–48 μm wide and 25–50 μm long. Widespread in ponds and swamps. Also found in saline situations. Epitheca (above the central groove) and hypotheca (below the central groove) of similar size. Dinophyta. Plate XVII.

Woloszynskia is a genus with epicone and hypocone of nearly equal size and with up to 100 delicate thin plates over the cell surface. An eyespot may be present. Plate XVIII.

126 (105) (a) Cells isolated or in groups, wall siliceous with grooves or dots (punctae) which form a definite pattern or other definite markings on the surface. Storage products mainly lipids and droplets may be visible within the cell. Chloroplasts one to many, yellow-green or golden to brown in colour **127**

(b) Cell wall not made of silica or decorated with patterned dots or bars. No conspicuous lipid droplets present **204**

127 (126) (a) Cells circular in outline in valve view. Decorations usually arranged in radial rows or radial segments; sometimes quite faint or in the form of large processes (ocelli, see Glossary). Cells often solitary but can occur in loose chains **128**

NB Plate XVIII shows some typical examples of the markings on the valve faces of centric diatoms to aid the reader as to the types of patterns seen. Not all types are included, see also Plates XIX and XXI.

NB Campylodiscus may appear circular in one view but is saddle-shaped in another. This is a distorted form of a pennate diatom, not a centric one, so will key out through section (b).

(b) Cells elongate, cigar-, boat-, crescent-shaped, or a distorted version of these. Decorations arranged bilaterally, although this is not always obvious in cells having a crescent or distorted shape **139**

NB The structure of the diatom wall is complex (see Chapter 1) and some features may be difficult to see using light microscopy alone. In many cases scanning electron microscopy may be required for positive identification. It is realized that this facility will not be available to many users of this text. An attempt has thus been made to limit the features used in the key to those which can be seen using a well set up light microscope. It is always best to observe both live and cleaned diatom material so that the cell contents and external mucilage can be seen together with any markings on the silica frustules. Readers are strongly recommended to consult the more detailed literature mentioned in the bibliography.

128 (127) (a) Valve with clear central area devoid of regular markings (a hyaline area) with 5–7 broad hyaline rays extending to the cell margin . . . . **Asteromphalus**

Asteromphalus is a widely distributed marine and estuarine species common in cool temperate waters. The valves have a relatively flat surface and between the hyaline rays there may be fine or coarse areolae (depending upon the species). Cell diameter 25–100 μm. Numerous discoid chloroplasts Bacillariophyta. Plate XXI.

(b) Valve without broad hyaline rays **129**

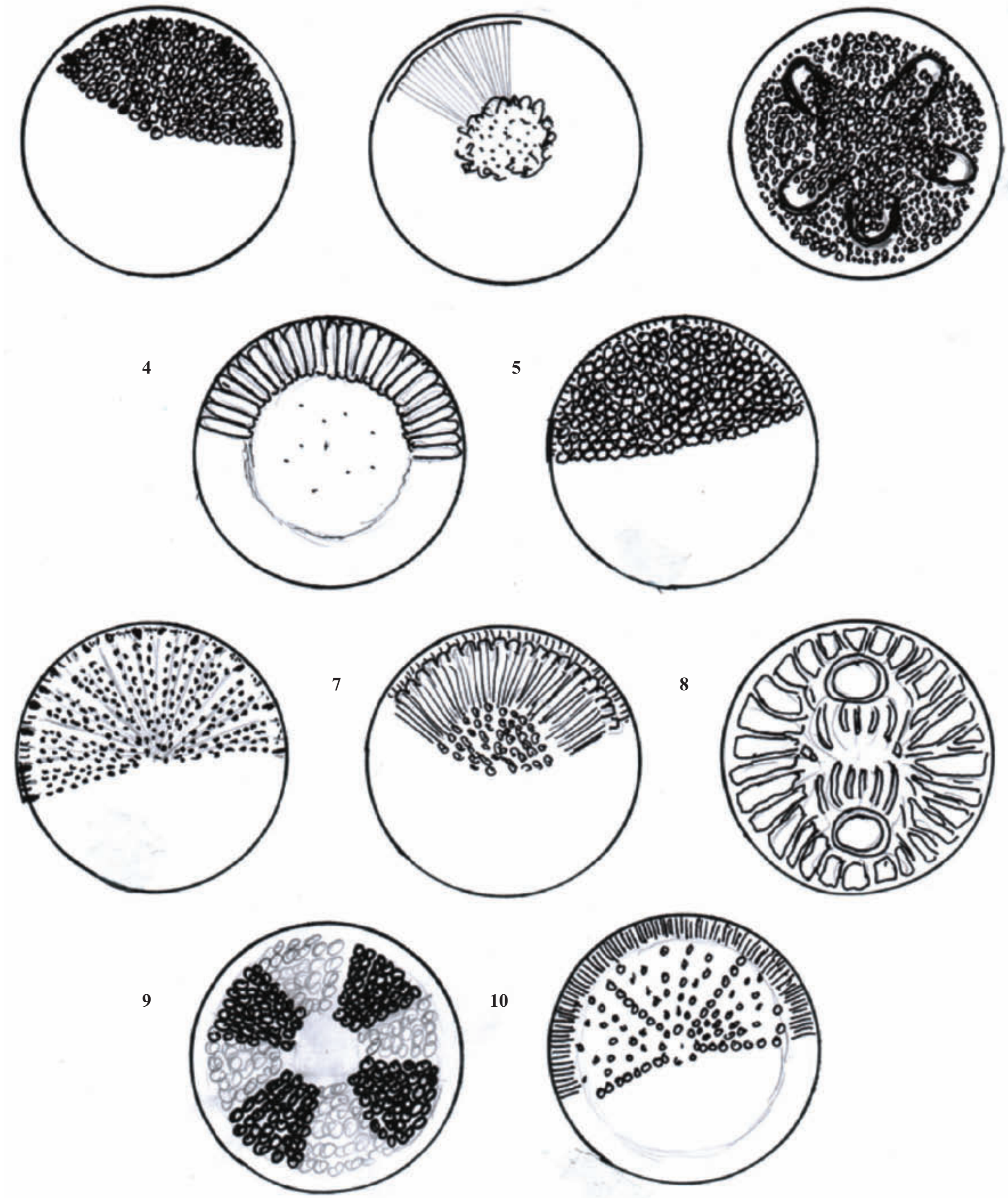


Plate XVIII **1.** *Thalassiosira.* **2.** *Hyalodiscus.* **3.** *Aulacodiscus.* **4.** *Cyclotella.* **5.** *Coscinodiscus.* **6.** *Stephanodiscus.* **7.** *Cyclostephanus.* **8.** *Auliscus.* **9.** *Actinoptychus.* **10.** *Actinocyclus.*

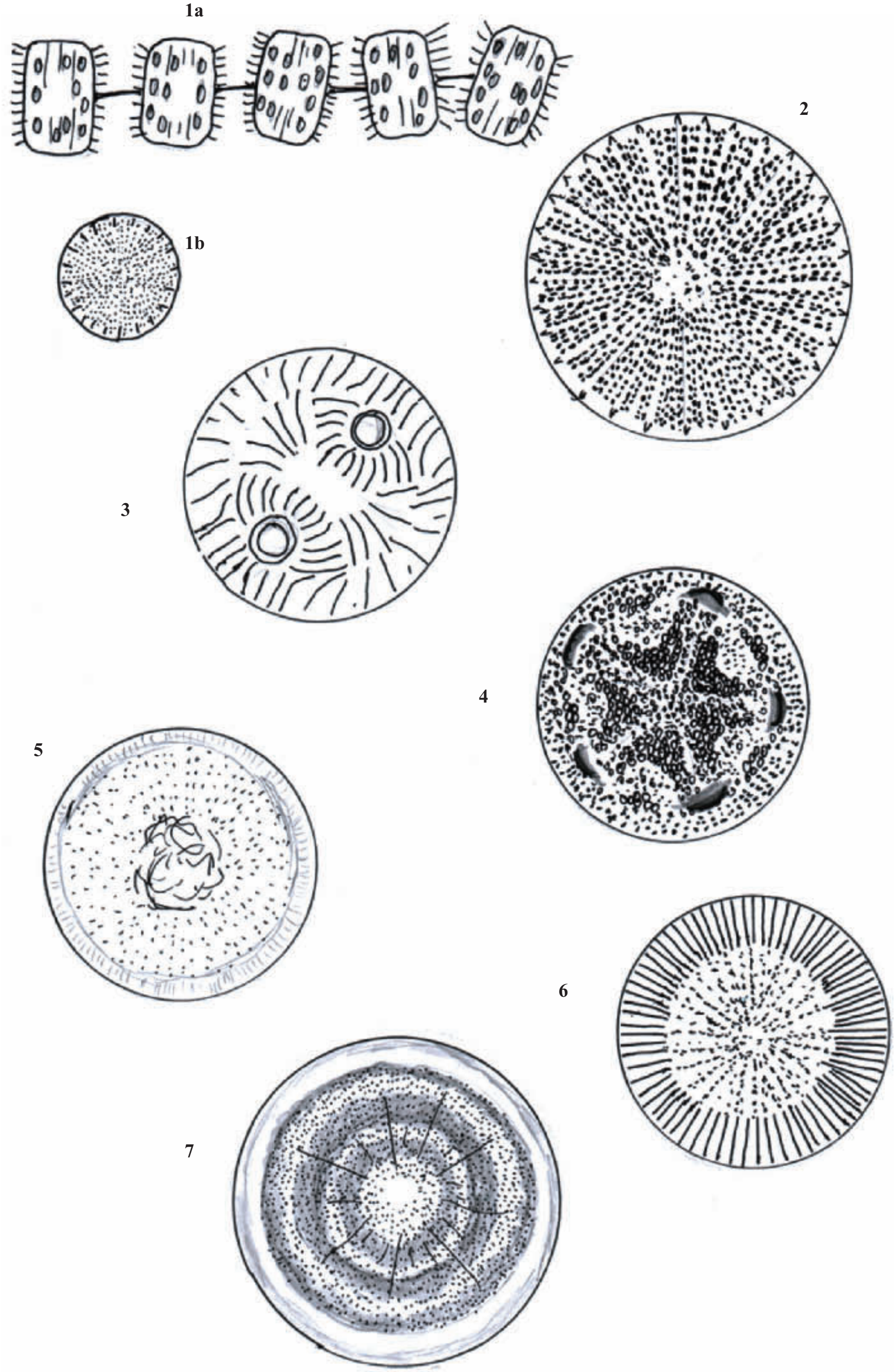


Plate XIX **1.** *Thalassiosira.* (a) Chain of cells, girdle view; (b) single cell, valve view. **2.** *Stephanodiscus.* **3.** *Auliscus.* **4.** *Aulacodiscus.* **5.** *Hyalodiscus.* **6.** *Cyclotella.* **7.** *Actinocyclus.*

129 (128) (a) Markings on valve surface divided into (usually) six segments that are alternately raised or level giving an alternating light and dark appearance . . . . . **Actinoptychus**

Actinoptychus is a cosmopolitan marine, coastal and estuarine species common at most times of the year. The markings on the valve are characteristic (Plate XXI). The segments are covered with coarse areolation. Chloroplasts plate-like or irregular. Cells 20–80 μm in diameter. Bacillariophyta. Plate XXI.

(b) Valve markings not as above **130**

130 (131) (a) Margin or rim of valve with spines **131**

NB Coscinodiscus (138) may have spines (but they may be difficult to see using a light microscope).

(b) No spines present at rim or margin of valve **134**

NB some centric diatoms secrete chitin fibres or threads that protrude from the valve margin and may superficially look like spines. These may function to bind cells together in loose chains or act as a deterrent to grazing animals.

131 (130) (a) Cells usually in chains joined together by mucilage strands originating from the valve surface centre or embedded in mucilage. Valve face gently undulating.with punctae in a radiating mesh-like pattern . . . . **Thalassiosira**

Cells of **Thalassiosira** can be solitary but are more frequently joined to form loose chains or even be embedded in mucilage. Valve face circular, fairly flat to gently undulating, and covered with quite coarse punctae which may be radial or arranged in arcs. Small spines may be visible at valve margin. Chloroplasts small discs and numerous. Very common and widely distributed in marine and estuarine habitats. Bacillariophyta. Plates XVIII and XIX.

(b) Cells solitary, or if in loose chains not embedded in mucilage or with mucilaginous strands stretching from valve face to valve face **132**

132 (131) (a) Valves with small central area bearing 2–5 pores. Distinct striae radiate out from this central area to the valve margin. Usually linked to form short chains by means of small spines. Valve faces then held close together. . . . . **Orthoseira**

Cells short cylinders with numerous discoid chloroplasts. Found on damp rocks, in wet moss or on stream banks, usually in upland areas Bacillariophyta. Plate XXI.

(b) Cells not as above **133**

133 (132) (a) Valves large (35–130 μm) and more heavily silicified. Many radially arranged ribs and grooves on valve surface originating from a clear central area. . . . . **Ellerbeckia**

Ellerbeckia cells are large diameter short cylinders sometimes joined in short chains. Numerous small disc-shaped chloroplasts. Clear differentiation between the markings on the valve face and the mantle, which has a distinctive hatched pattern. Found in damp habitats. Bacillariophyta. Plate XX.

(b) Cells usually solitary but sometimes forming loose chains. Valve surface with radiating rows of punctae (single towards the center but often double or more towards the edge). Central area punctuate but rows not as clearly defined. Valve surface concentrically undulate . . . . **Stephanodiscus**

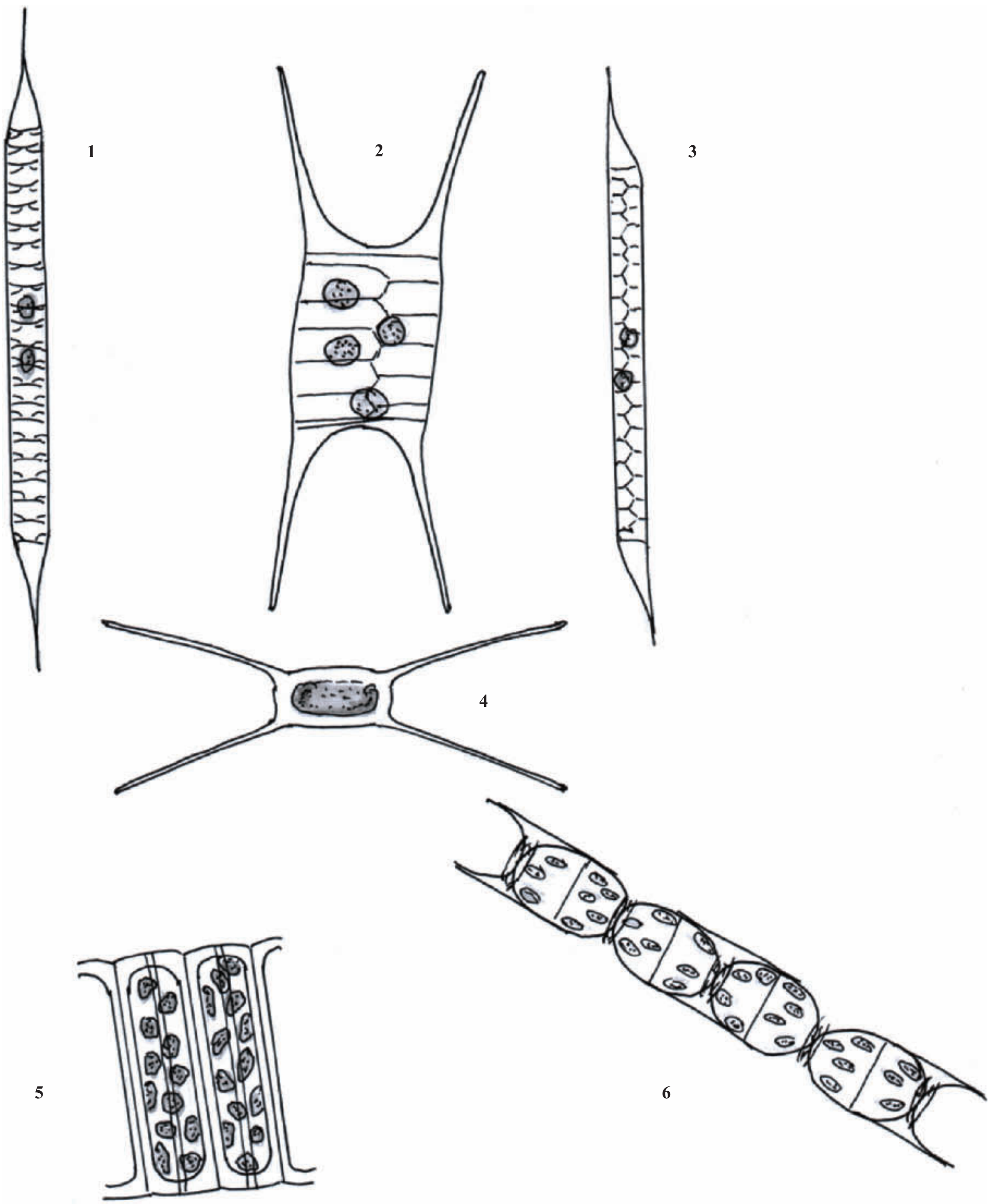


Plate XX **1.** *Rhizosolenia.* **2.** *Acanthoceras.* **3.** *Urosolenia.* **4.** *Chaetoceros.* **5.** *Ellerbeckia.* **6.** *Melosira nummuloides.*

Cells of **Stephanodiscus** are disc-shaped and slightly barrel-shaped in girdle view. The valve face is undulate with the centre either raised or lower than the margin. The valve margin has a ring of short spines and in some small species long delicate chitin threads that allow cells to link together to form loose chains. Numerous discoid chloroplasts, sometimes appearing to lie around the margin of the cell. Common in freshwaters, especially eutrophic ones, planktonic. **Stephanodiscus** has been reported (Palmer, 1962) as producing geranium and fishy odours and tastes in drinking waters and, when in large numbers, cause blockage of filters. Bacillariophyta. Plate XIX. Fig. 4.58.

Cyclostephanus shows features that are intermediate between **Stephanodiscus** and **Cyclotella**.

134 (130) (a) Valve face with two or more circular processes (ocelli) on the surface. They are clearly visible as obvious large structures compared with normal punctae **135**

(b) No obvious large circular structures on valve surface **136**

135 (134) (a) Cells broadly elliptical or subcircular in valve view. Two large ocelli on valve surface which is also decorated with lines around the margin and radiating from the central area . . . . **Auliscus**

Auliscus cells are frequently attached to sand grains, stones or rocks in inshore and estuarine habitats. Although bottom living they may be found in the plankton. Cells 40–80 μm in diameter. The shape of the cells and the large ocelli are characteristic of the species. Bacillariophyta. Plate XIX. Fig. 4.59.

(b) Cells circular in valve view. More than 2 marginal processes. Valve surface flat at centre but raised as it goes towards the marginal processes. Marginal processes may have a furrow running back towards the centre. Valve surface areolate . . . . **Aulacodiscus**

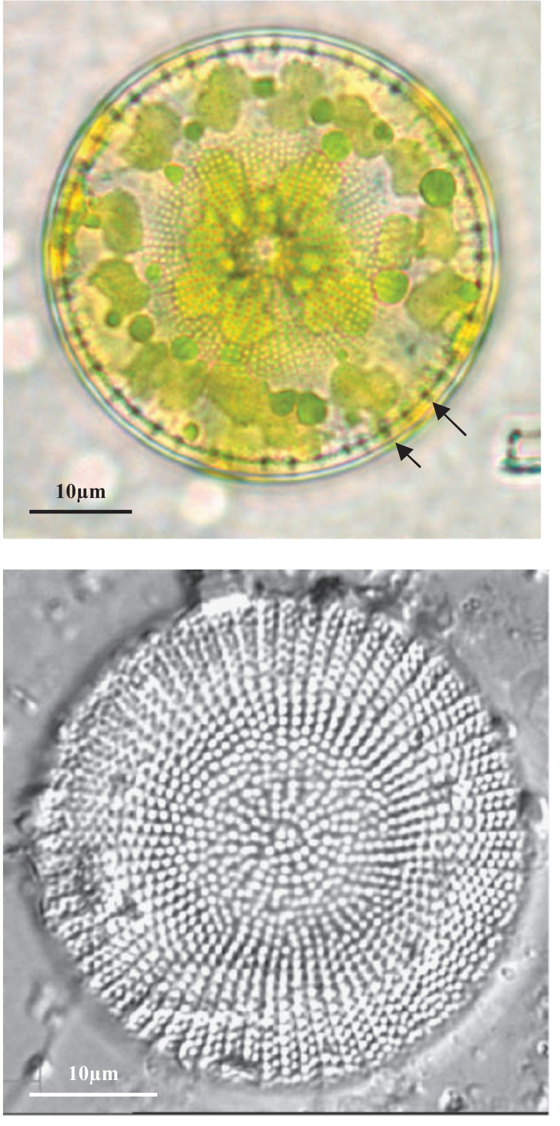


Figure 4.58 *Stephanodiscus*. Centric diatom. Top: Live planktonic cell., with numerous discoid chloroplasts and a frustule with clear marginal spines (arrows). Bottom: Acid digest, lake sediment sample – showing radiating rows of fine punctae.

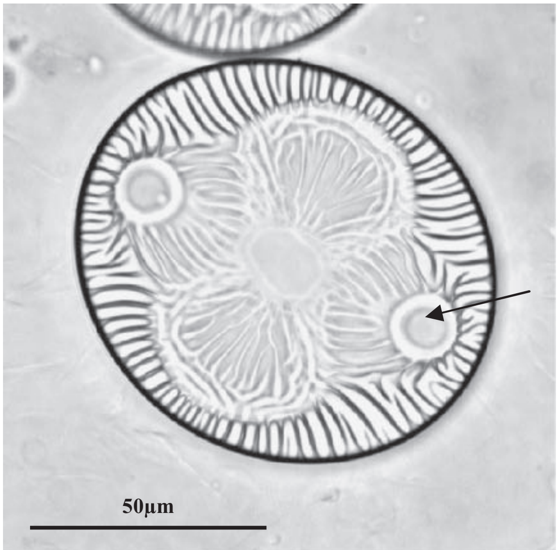


Figure 4.59 *Auliscus* Surface view of frustule, showing ocelli. (arrow). Prepared slide.

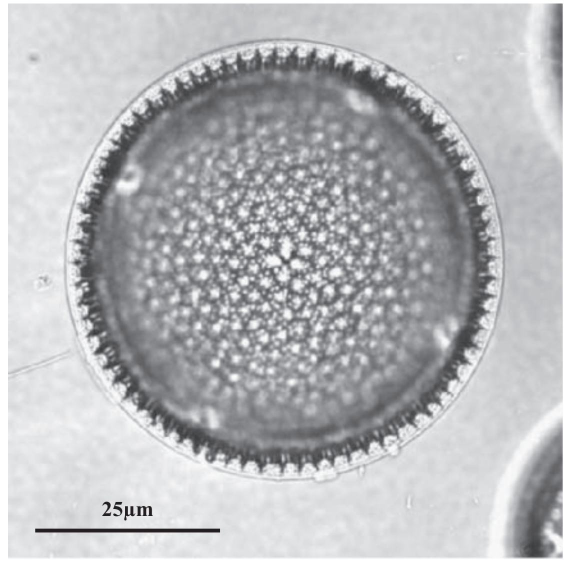


Figure 4.60 *Aulacodiscus.* Valve view showing central areolate pattern of frustule. Acid digest, lake sediment sample.

A marine and brackish water species associated with sediments where it can be very common. The processes on the valve surface are variable in number but normally range between 3 and 8. Cell diameter 60–200 µm. Bacillariophyta. Plate XIX. Fig. 4.60.

136 (134) (a) Valve surface apparently almost devoid of markings and with large concentric area around the centre . . . . **Hyalodiscus**

Hyalodiscus cells are either sessile, in short chains or as individuals in the marine plankton. Valves circular and strongly convex with the centres slightly flattened. Because of the markedly convex nature of the valve face only a small area can be in focus under a light microscope at one time, hence the apparent lack of markings. In fact the whole valve surface is covered with areolae arranged in radial rows. Chloroplasts numerous and rod-shaped. Cells 12–115 µm in diameter. Bacillariophyta. Plate XIX. Fig. 4.61.

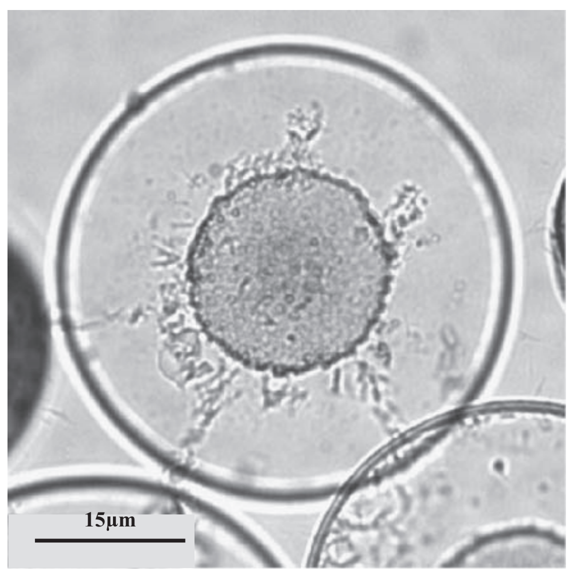


Figure 4.61 *Hyalodiscus* Diatom with peripheral clear area on valve surface. Prepared slide.

(b)Valve surface with obvious markings over whole or a large part of the area **137**

137 (136) (a) Valve surface with two distinct areas of markings. The middle area is punctuate and the outer striate or ribbed . . . . **Cyclotella**

The cells of **Cyclotella** are disc-shaped with circular-shaped **v**alves with a slightly undulate surface. Valve margins without spines but in some species small tubules are present that could be mistaken as spines. The central area is irregularly punctuate and distinct from the concentric outer area is regularly striate. Cells frequently solitary but may be attached in chains by mucilaginous threads There are several discoid chloroplasts usually arranged around the cell margin. Widespread in lakes, rivers, marine and brackish water habitats. Has been reported to produce geranium and fishy odours and tastes in drinking water (Palmer, 1962). Two of the more common species in cool temperate waters are **C. meneghiniana** with cells 10–30 µm in diameter and **C. kuetzingiana** with cells 10–40 µm in diameter. The former has 40–50 rows of radiating striae and the latter up to 90 radiating rows. Can be present in large numbers in reservoirs and lakes and cause problems of filter blocking in water treatment works using those waters. Bacillariophyta, Plate XIX. Fig. 4.62.

(b) Valve markings not in two distinct zones **138**

138 (137) (a) Valve surface flat to slightly convex. Areolae in straight parallel lines (tangential to the radius) of decreasing length giving the surface a segmented cross hatched appearance. . . . . **Actinocyclus**

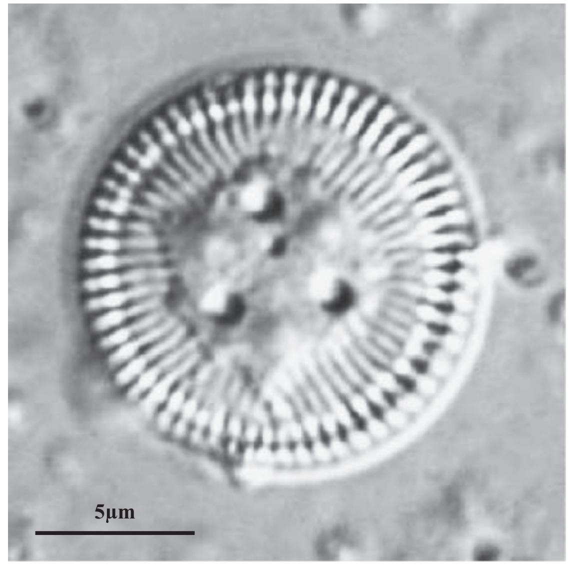


Figure 4.62 *Cyclotella*. Valve view of diatom, with clear separation of central and peripheral areas. Acid digest, lake sediment sample.

Valves of **Actinocyclus** are circular to slightly subcircular. There is a small central hyaline area with irregular punctae. The valve face is marked with areolae in regular parallel rows of decreasing length. Chloroplasts plate-like and numerous. Cells 20–170 µm in diameter. Common in coastal and estuarine plankton and as an epiphyte. Bacillariophyta. Plate XIX.

(b) Valve surface gently undulate. Coarse punctate markings over surface forming radial rows or arcs. Punctae circular or hexagonal . . . . **Coscinodiscus**

The valve markings on **Coscinodiscus** are generally coarse and often hexagonal in shape although not always so. They cover the whole valve face except for a small central hyaline area which may be present together with a rosette of larger punctae (these may be present without the hyaline area). The valve margin may have small spines although these are seldom visible under a light microscope. Choroplasts numerous and plate-like. Free living and abundant in the plankton. Mostly salt water with only one British freshwater species, **C. lacustris.** Cells up to 300 μm in diameter. Bacillariophyta. Plate XXI.

139 (127) (a) Valves with at least one long spine. The spines are as long as, or longer than, the cell **140**

(b) Valves without long spines **144**

140 (139) (a) Cells forming a typical filament. Cells many times as long as broad. One long spine visible at the end of the filament . . . . **Aulacoseira granulata v. angustissima**

For main description see key 27

(b) Cells not as above **141**

141 (140) (a) Cells with two long spines per cell, one at each end **142**

(b) Cells with four long spines per cell, two at each end **143**

142 (141) (a) Cells long and thin, up to 200 × 10 μm. Spines arise from the centre of the valve end . . . . **Rhizosolenia**

Rhizosolenia cells may be solitary or they may form chains. Numerous small plate-like/disc-shaped chloroplasts. Frustule wall only lightly silicified so can be overlooked, especially in acid-cleaned specimens when the frustule components often disintegrate. Planktonic in lakes and slow flowing rivers. Bacillariophyta. Plate XX.

(b) Cells long, but not as long as above, 150 × 20 μm. Spines arise from opposite corners . . . . **Urosolenia**

Cells are most frequently solitary with many disc-shaped chloroplasts. A planktonic species in lakes which are enriched and of a slightly alkaline nature. Bacillariophyta. Plate XX.

143 (141) (a) Cells not markedly elongate but square to rectangular. Frustules have four spines, one arising from each corner and either projecting in the direction of the long axis of the cell or at a shallow angle. Many girdle bands visible. Four discoid to plate-like chloroplasts per cell. . . . . **Acanthoceras**

Acanthoceras cells are normally solitary with one to many plate-like/disc-shaped chloroplasts. Found in the plankton of enriched lakes usually in slightly alkaline conditions. Cells up to 40 × 80 μm in size. Bacillariophyta. Plate XX.

(b) Cells square to shallow rectangular in shape. Few girdle bands visible. Spines project at 45° angle from each corner. 1 or 2 cup-shaped chloroplasts per cell. Size up to 15 × 30 μm. . . . . **Chaetoceros**

Chaetoceros cells are usually joined together into filaments by the interlocking of the spines. Found in waters with a high conductivity, especially in coastal regions, and in brackish waters. Bacillariophyta. Plate XX.

144 (139) (a) Cells cuneate, heteropolar and forming fan-shaped colonies . . . . **Meridion**

See also key no. 77

(b) Cells not as above **145**

145 (144) (a) Cells with either costae or septa present **146**

(b) Cells without either costae or septa **147**

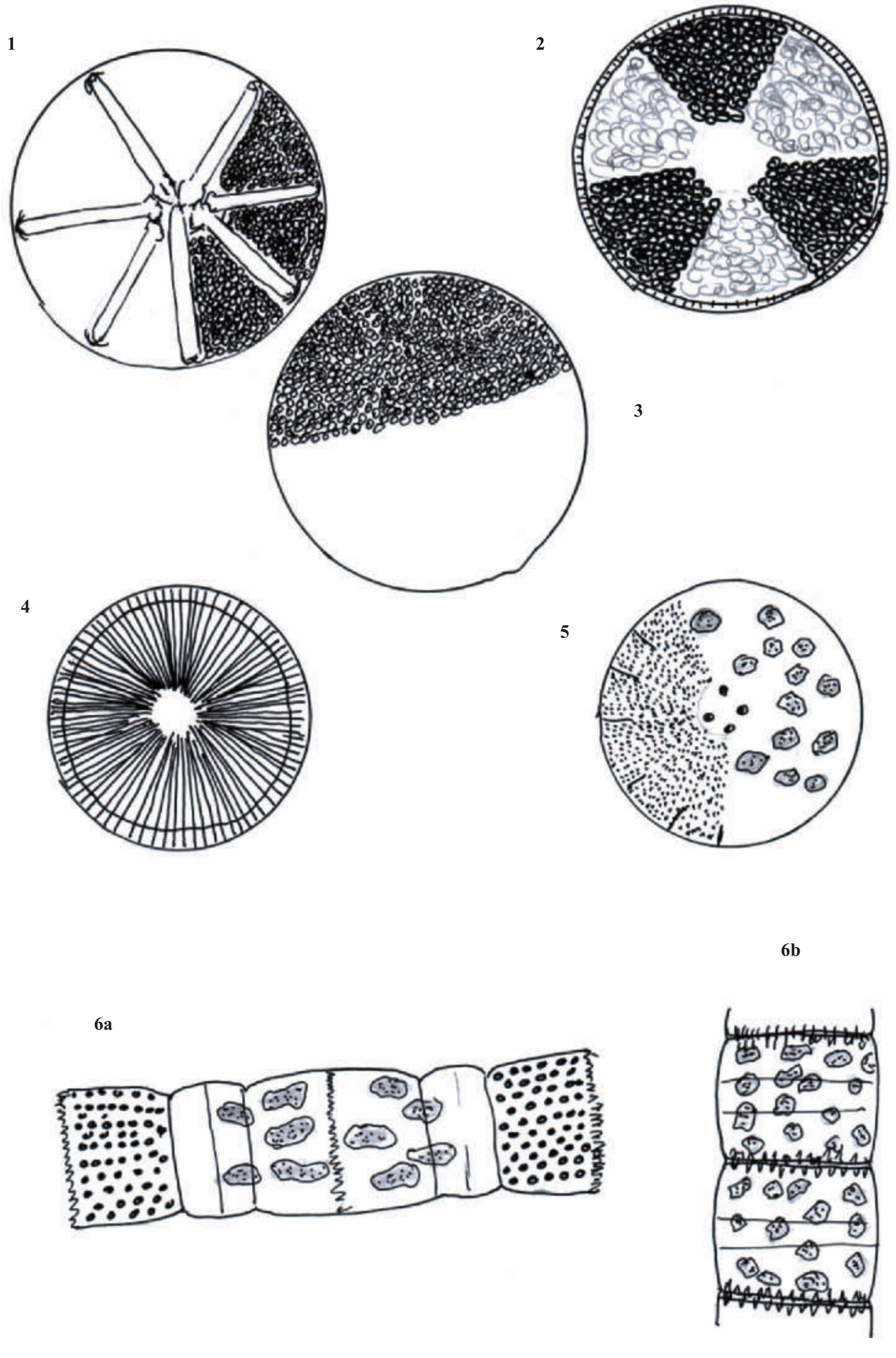


Plate XXI **1.** *Asteromphalus.* **2.** *Actinoptychus.* **3.** *Coscinodiscus.* **4.** *Ellerbeckia* (valve view). **5.** *Orthoseira.* **6.** *Aulacoseira*: (a) *A. granulate*; (b) *A. italica.*

146 (145) (a) Valves swollen in the middle and with slightly swollen poles. Isopolar . . . . **Tabellaria**

Tabellaria form zig-zag, almost linear or sometimes stellate colonies.. The cells are usually seen in girdle view making the prominent septa easy to see. Cells are rectangular to oblong in shape. In valve view they are elongate, slightly capitate with a slightly inflated mid-region. Chloroplasts elongate and lying between the septa. **T. flocculosa** has valves 10–100 μm long and **T. fenestrata** cells 30–120 μm long. Widespread oligotrophic and mesotrophic in the plankton or attached to stones or other vegetation.

Can produce fishy odours in drinking waters and block treatment filters (Palmer, 1962). Reported to produce fishy tastes in drinking water if present in large numbers (Palmer, 1962).Bacillariophyta. **See also key 29.**

(b) Valves isopolar with costae but no septa . . . . **Diatoma**

Diatoma cells often form ribbon or zig-zag shaped (occasionally stellate) colonies. In girdle view the valves are rectangular to oblong with small plate-like or discoid chloroplasts. There are distinct thickened transverse bars (costae) across the valves. Valve ends sometimes capitate, rostrate or bluntly rounded. Cells up to 100 μm long. Epiphytic or planktonic, in littoral regions of lakes or slow flowing rivers. Can impart an odour to drinking water (Palmer, 1962). Bacilariophyta. **See also key 29.**

147 (145) (a) Cells triradiate in valve view with a small chloroplast near to the base of each arm . . . . **Centronella**

Centronella has characteristically triradiate-shaped cells with a small chloroplast at the base of each arm. It occasionally occurs in the plankton of meso- and eutrophic lakes although it is quite rare. Bacillariophyta. (Not illustrated.)

(b) Cells not triradiate **148**

148 (147) (a) Cells S-shaped (sigmoid) in outline **149**

(b) Cells not S-shaped in outline.. . . . **151**

149 (148) (a) Cells sigmoid in outline, broad in the central region and narrowing towards the apices Usually quite large (>70 μm long). Two large plate-like chloroplasts, one either side of the longitudinal axis . . . . **Gyrosigma**

Gyrosigma cells are sigmoid in shape, although some species are only slightly so. The poles are rounded. The raphe is S-shaped. The striae on the valve surface are both parallel to the raphe and also transverse. They are generally fine but may be coarser in some species. Two plate-like chloroplasts are present lying either side of the girdle. Pyrenoids may be present. **G. acuminatum** and **G. attenuatum** are widespread species. Found in flowing or standing waters on sediments and rocks usually in waters with high electrolyte content. Bacillariophyta. Plate XXII. Fig. 4.63 (**Pleurosigma** illustrated).

(b) Cells narrow and sigmoid, only slightly tapering towards the ends. Longitudinal margins of frustule more or less parallel. One chloroplast or if two one either side of the centre **150**

150 (149) (a) Cells long (up to 200 μm) and narrow (6–9 μm). Single long plate-like chloroplast. Around the cell margin may be seen a line of dots . . . . **Stenopterobia**

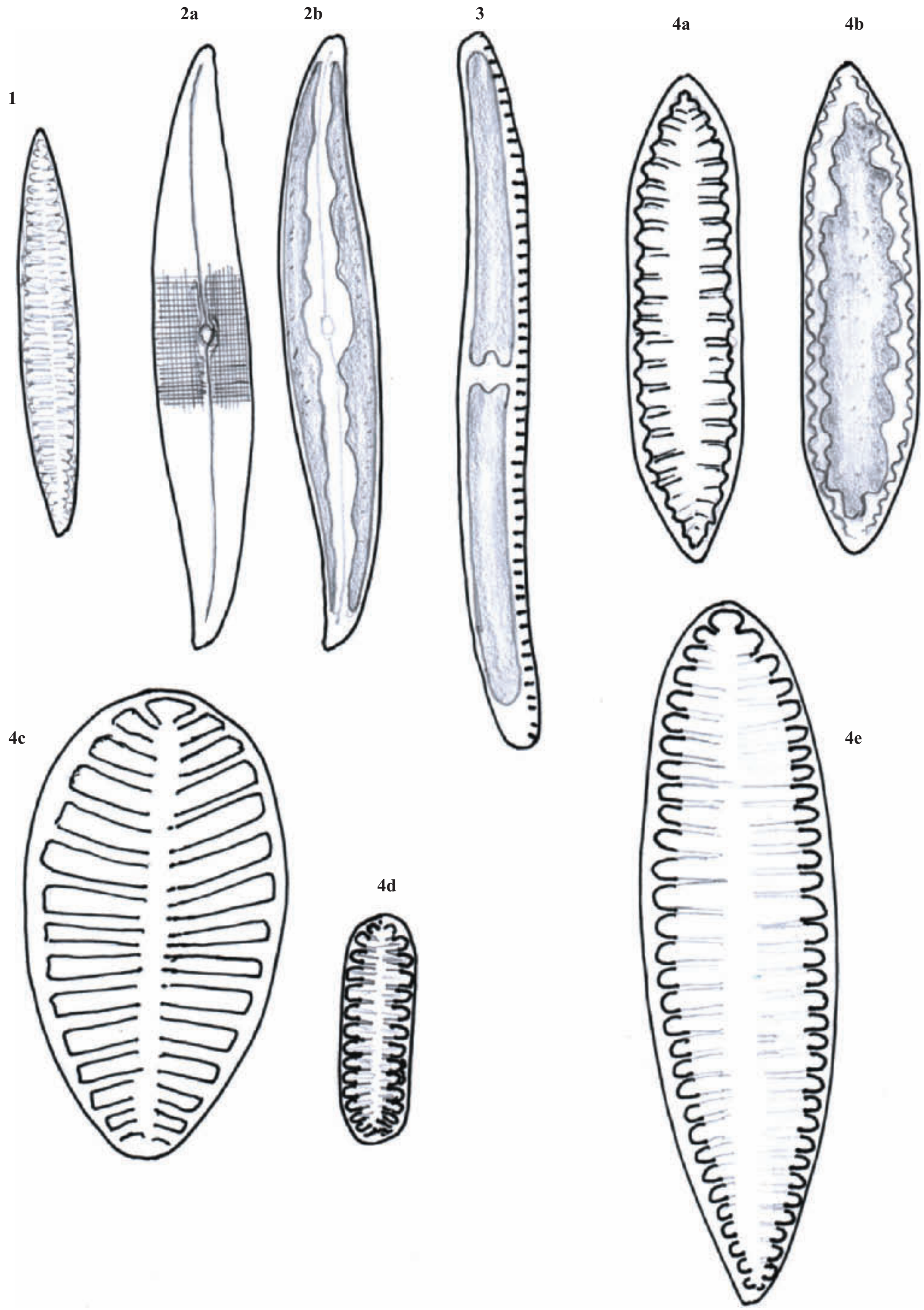


Plate XXII **1.** *Stenopterobia.* **2.** *Gyrosigma*: (a) frustule markings; (b) chloroplasts. **3.** *Nitzschia.* **4.** *Surirella*: (a) *S. linearis* – frustule markings; (b) *S. linearis* – chloroplast; (c) *S. robusta*; (d) *S. minuta*; (e) *S. elegans.*

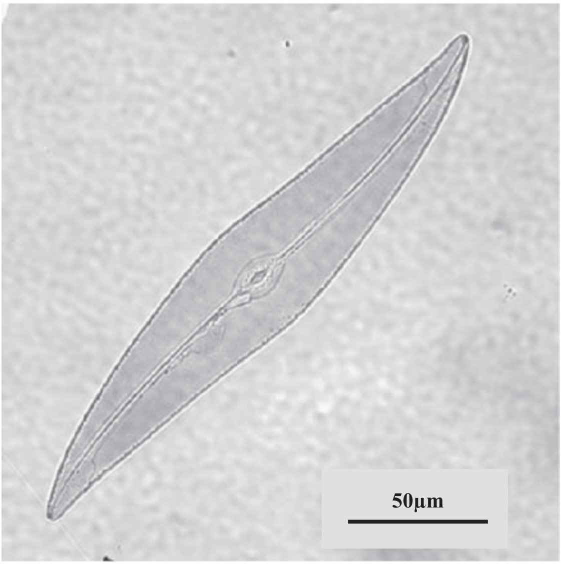


Figure 4.63 *Gyrosigma* A solitary diatom with sigmoid valves. Prepared slide.

Stenopterobia occurs in oligotrophic, often upland, pools but is rarely abundant. Its cells are *sigmoid* in some species (**S. sigmatella**) or *linear* in **S. delicatissima**). Cells have one chloroplast which is divided into two parts. As with other members of the Surirellales the raphe is supported on a raised wing around the margin of the cell. Bacillariophyta, Plate XXII (linear form illustrated).

(b) Cells long but broader (>10 µm broad). Two plate-like chloroplasts, one above and one below the central area **Nitzschia sigmoidea**

As with all members of the genus **Nitzschia**, **N. sigmoidea** has its raphe raised on a keel along one margin. The keel supports show up along that margin as a series of dots (carinal dots). **N. sigmoidea** cells are large, 90–>200 µm long and 8–14 µm broad. Two plate-like chloroplasts are present, one above and one below the central area. Common and widespread in meso- to eutrophic waters. A benthic species. Bacillariophyta. Plate XXII.

NB Although **N. sigmoidea** is the most common of the sigmoid **Nitzschia** species others do occur, e.g. **N. flexa**, **N. vermicularis**, **N. acula**, **N. filiformis** and **N. clausii**.

151 (148) (a) Cells circular in outline in one view but saddle-shaped in another. Striae radiate on valve surface........... **Campylodiscus**

NB It is important to look at a number of specimens (or turn a single specimen over) so that a number of views can be seen in order to observe the saddle shaped appearance.

Cells of **Campylodiscus** are quite large, 60–150 µm in diameter (up to 200 µm) and approximately circular in shape (valve view) or saddle-shaped (girdle view). One large lobed chloroplast is present. Widespread in oligo- to eutrophic waters and in brackish and marine habitats. Epipelic. **C. hibernicus** and **C. noricus** are the most frequent freshwater species. Bacillariophyta. Plate XXIII.

(b) Cells not saddle-shaped in one view **152**

152 (151) (a) Cells broadly elliptical/oval, one valve with true raphe, the other with a pseudoraphe. Cells isopolar. One C-shaped chloroplast .... **Cocconeis**

Cells of **Cocconeis** are isopolar and isobilateral and nearly elliptical in shape. Fine or coarse striations may be visible on the valve surface running from the raphe/pseudoraphe to the cell margin. The raphe-bearing valve slightly concave. A single C-shaped chloroplast is present.

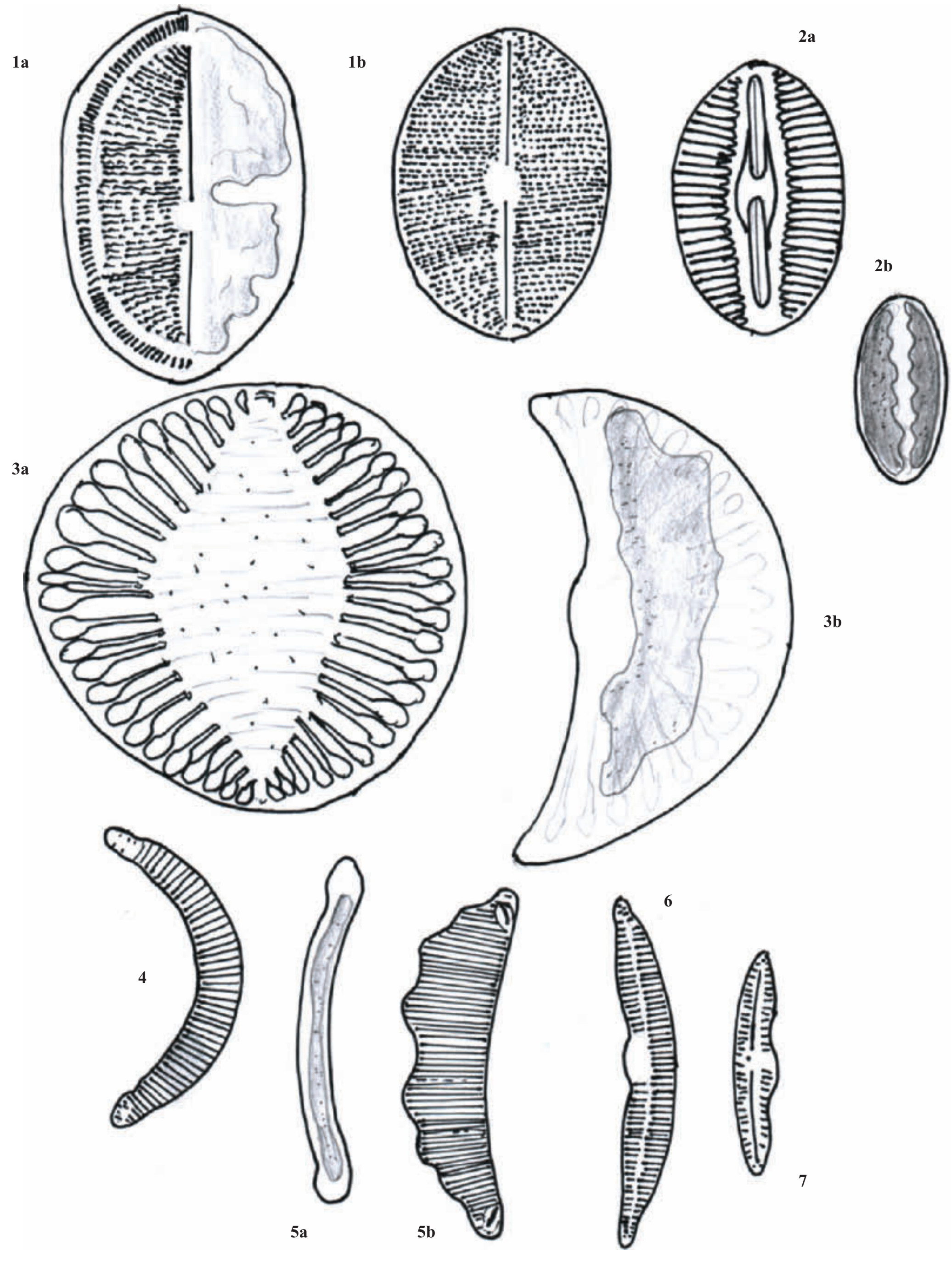


Plate XXIII **1.** *Cocconeis*: (a) *C. placentula* (showing frustule markings/chloroplast); (b) *C. pedicula*. **2.** *Diploneis*: (a) frustule markings; (b) chloroplasts. **3.** *Campylodiscus*: (a) valve view, frustule markings; (b) girdle view, chloroplast. **4.** *Semiorbis.* **5.** *Eunotia*: (a) *E. arcus* (showing chloroplast); (b) *Eunotia serra* (markings). **6.** *Hannea.* **7.** *Reimeria.*

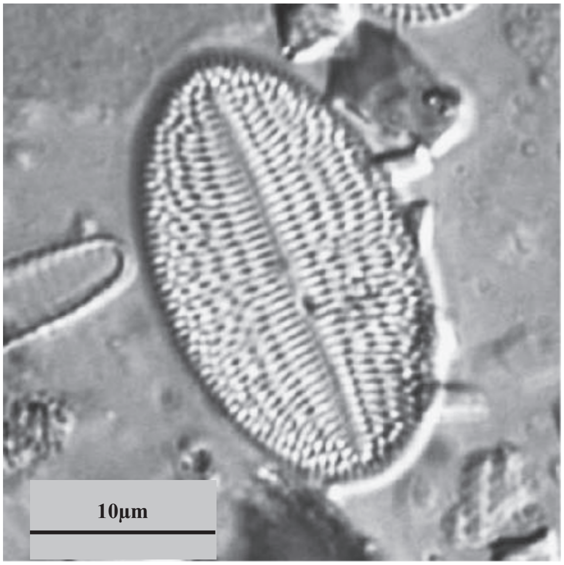


Figure 4.64 *Cocconeis*. Valve view of this sedimentary diatom. Acid digest, lake sediment sample.

Epiphytic and epilithic, found on rocks and plants attached by the concave raphe bearing valve. Very widespread and common. Two common species, **C. pediculus** (valves 11–45 µm long, 9–30 µm wide) with slightly more rhomboid cells and **C. placentula** (cells 10–70 µm long and 8–35 µm wide). Bacillariophyta. Plate XXIII. Figs 2.28, 4.64.

(b) Cells more narrowly elliptical, oval or elongate. Heteropolar or isopolar. One or more chloroplasts, not C-shaped **153**

153 (152) (a) Cells with bluntly rounded ends, both valves with a true raphe which lies within a long thickened ridge. Two chloroplasts with lobed margins, one either side of the apical axis . . . . **Diploneis**

The elliptical cells have bluntly-rounded ends. The raphe is situated between prominent silica ridges. The two chloroplasts lie either side of the long (apical) axis. Striae on the valve surface run from the raphe to the margin Cells 20–130 µm long, 10–60 µm wide. Widespread in mainly oligotrophic waters on bottom deposits. Bacillariophyta. Plate XXIII.

(b) Cells without thickened ridges along most of the length of the raphe **154**

154 (153) (a) Cells with a prominent transverse undulate surface in girdle view and banded transverse shaded areas in valve view. Isopolar . . . . **Cymatopleura**

Cells are elliptical with a central 'waist'. The valve surface is characteristically undulate giving a transverse banded appearance to the valve surface. The undulations are very visible in girdle view. The raphe is on a raised ridge running around the valve margin. A single large lobed chloroplast is present. Found on bottom sediments. Widespread and common. Cells 30–>200 µm in length, 20–60 µm broad. Bacillariophyta. Fig. 4.65.

(b) Cells without undulate surface. Lanceolate to oval in shape, sometimes egg-shaped or narrowing towards the centre (slipper-shaped). Iso- or heteropolar. . **155**

155 (154) (a) Cells with permanent rib-like markings around the margin **156**

(b) Cells not as above **157**

156 (155) (a) Cells isopolar . . . . . **Surirella group a**

(b) Cells heteropolar . . **Surirella group b**

Surirella cells have rounded to slightly pointed ends that may be iso or heteropolar. The raphe runs around the margin of the cell on a wing supported by ribs which give the characteristic markings on the frustule surface. There are two large lobed and plate-like chloroplasts but as each lies

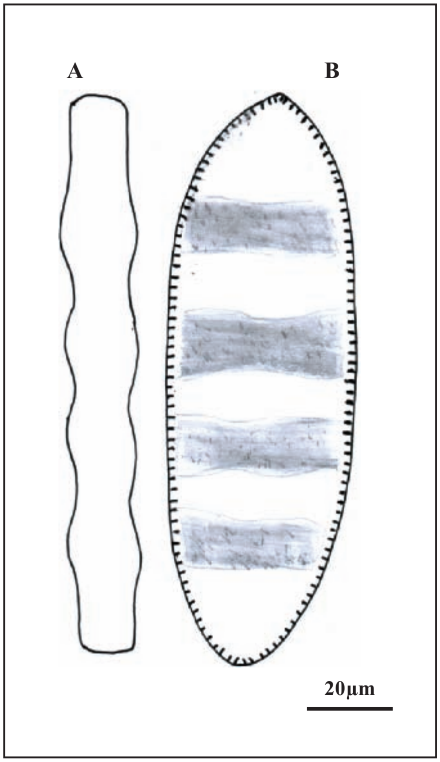


Figure 4.65 *Cymatopleura elliptica.* (A) girdle view; (B) valve view.

beneath the valve face only one is visible in valve view. Widespread on sediments and rocks. Some species found in brackish and marine habitats. 20–400 µm long and 10–150 µm broad. Some species of **Surirella**, group a above, e.g. **S. angusta**, are isopolar whilst others, group b above, are heteropolar, e.g. **S tenera** and **S robusta**, with broadly-rounded apices at one end and more narrow and slightly more pointed apices at the other. Bacillariophyta. Plate XXII.

N.B. Species of **Surirella** that are not so broadly oval but are more linear to elliptical, may be keyed out elsewhere.

157 (155) (a) Cells crescent-shaped (like the segment of an orange), with one edge strongly convex and the other either concave or nearly straight, isopolar **158**

(b) Cells not crescent-shaped or as above **165**

158 (157) (a) Cells strongly crescent-shaped or distinctly curved in valve view (the more common view) **159**

(b) Cells more mildly crescent-shaped with both margins showing more gentle convex curves **161**

159 (158) (a) Cells strongly lunate (moon-shaped) with parallel sides, raphe difficult to see other than in girdle view and then only towards the end of the valve. Valve apices strongly arcuate. Conspicuous transverse ridges extending into short spines beyond the cell margin. Two plate-like chloroplasts . . . . **Semiorbis**

Semiorbis cells are lunate (shaped like the first quarter moon) but with the sides nearly parallel. There are obvious transverse ridges on the valve face which extend into small spines at the margin. Apices rounded. Raphe reduced and not conspicuous. Two plate-like chloroplasts are present. Cells 20–40 µm long, 3.0–5.5 µm wide. Usually found in upland areas and is not particularly common. Bacillariophyta. Plate XXIII.

(b) Cells not lunate. **160**

160 (159) (a) Cells with swollen area on concave or ventral side **163**

(b) Cells not as above **161**

161 (160) (a) Cells gently curved into a crescent or nearly straight and with bluntly-rounded apices. Raphe visible towards the poles of the cell . . . . **Eunotia**

Eunotia cells are not as strongly curved as in **Semiorbis**. Sometimes with a slightly undulate convex margin but often a smooth curve. Apices bluntly-rounded or capitate/reflexed. Raphe only visible towards the cell apices where the polar nodules are obvious. Two chloroplasts lying side by side (often only visible as two in valve view). Cells 17–220 μm long, 1.5–7.0 μm wide. Attached to other surfaces, particularly plants, by means of mucilage pads. Found in slow flowing or standing waters often poor in nutrients and acidic. Bacillariophyta. Plate XXIII.

(b) Cells not as above **162**

162 (161) (a) Cells crescent-shaped with a straight ventral surface in valve view, oval in girdle view with squared-off apices. Cell apices rounded. hyaline area between markings on central dorsal surface in some species . . . . **Amphora**

Amphora cells usually lie so that they are seen in girdle view. The valves are strongly arched so that each raphe, which are themselves curved, appear on the same side. They are broadly oval in girdle view with rounded apices. There is an H-shaped chloroplast. Cells 30–90 μm long and 20–40 μm broad. **Amphora** is a benthic form which is widespread but perhaps more common in harder richer waters. Often found as an epiphyte and usually with its concave face against the substrate. Bacillariophyta. Plate XXIV.

(b) Cells not shaped as above and without hyaline area between markings on dorsal surface **164**

163 (160) (a) Cells with no true raphe. Up to 150 μm in length and 4–8 μm in breadth . . . . **Hannaea**

Cells curved (banana-shaped) with a concave ventral surface but which has a swollen area in its centre. Either solitary or in small groups on stones and rocks. Ends of cell slightly capitate or rostrate. Two lobed chloroplasts present (although only one may be visible). Only one species common, **H. arcus**. Cells 5–150 μm long, 2–50 μm wide. Found in cooler upland streams, sometimes slightly acidic. Bacillariophyta. Plate XXIII.

(b) Cells with a true raphe. 9–40 μm in length and 3–9 μm in breadth . . . . **Reimeria**

Cells of **Reimeria** are dorsiventral in shape (see Glossary) with rounded (slightly rostrate) apices. An obvious swollen area in the centre of the concave margin is present. There is a single lobed chloroplast. Cells 9–40 μm long, 3–9 μm wide. Widespread on damp rocks, in mosses and in rivers. Bacillariophyta. Plate XXIII.

164 (162) (a) Cells with strongly curved dorsal surface and a slightly convex, straight or slightly inflated ventral surface (see Plate XXIV). Central ends of raphe bent upwards (towards dorsal surface) and polar ends bent downwards (towards the ventral surface) . . . . **Encyonema**

Valves strongly arched on the dorsal margin and nearly straight on the ventral margin giving them the appearance of an orange segment (see also **Cymbella**). The raphe is closer to the ventral margin and approximately parallel to it. The outer ends of the raphe are bent downward (ventrally) whilst the central ends are bent upwards (see Plate XXIV). Frustule surface with very fine striae not easily seen with a light microscope. Chloroplast 'H'-shaped with a pyrenoid. Cells 20–58 μm long and 3–30 μm wide. Cells solitary or enclosed

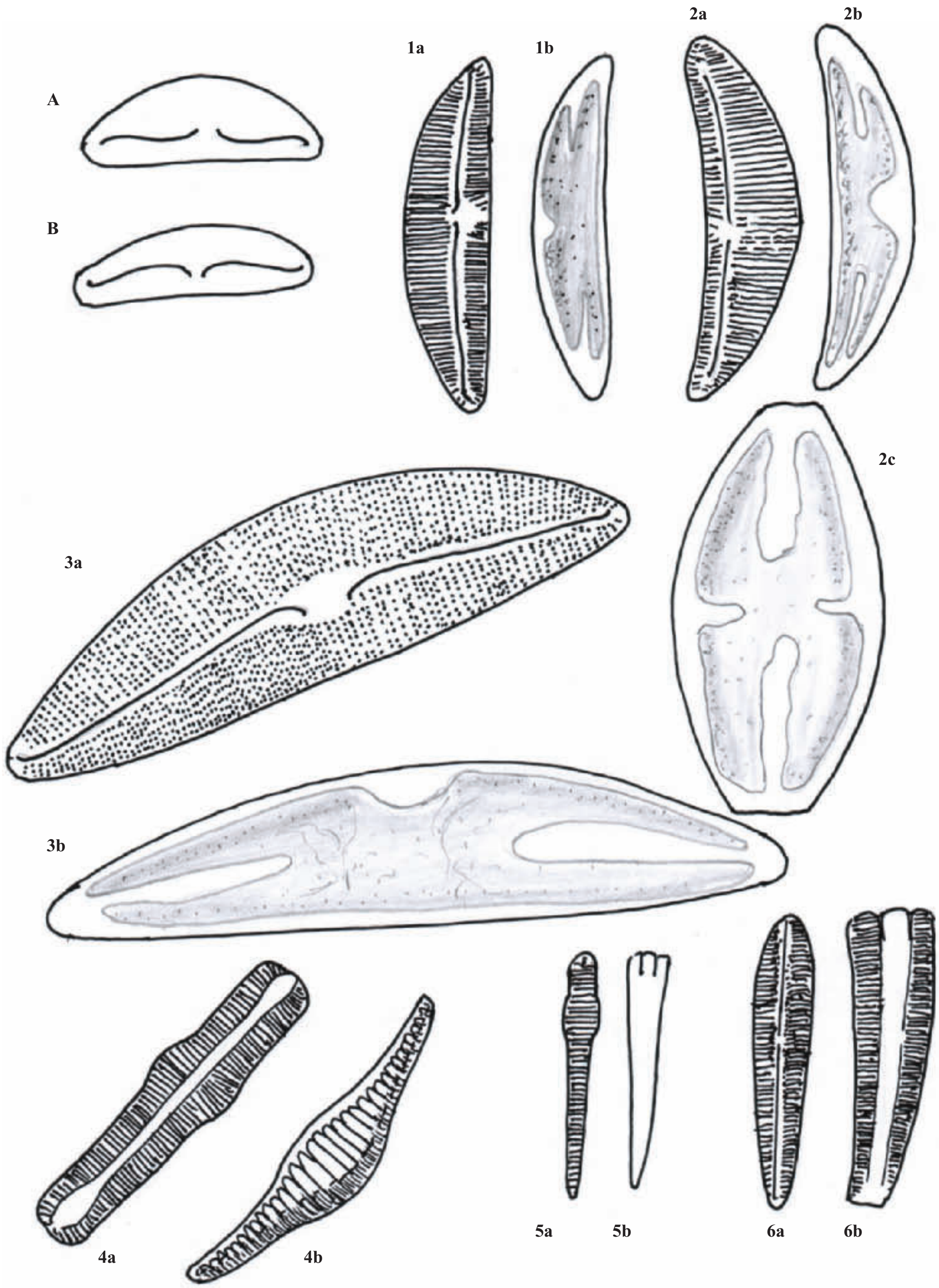


Plate XXIV A/B: general valve view - different orientations of raphe. **1.** *Encyonema*: Type A raphe. (a) frustule markings; (b) chloroplast. **2.** *Amphora*: (a) valve view – frustule markings; (b) valve view – chloroplast; (c) girdle view – chloroplast. **3.** *Cymbella*: Type B raphe (a) frustule markings; (b) chloroplast. **4.** *Rhopalodia*: (a) valve view; (b) girdle view. **5.** *Peronia*: (a) valve view; (b) girdle view. **6.** *Rhoicosphenia*: (a) valve view; (b) girdle view.

in a mucilage tube. A widespread genus in rivers on rocks and other substrata. Bacillariophyta. Plate XXIV.

(b) Cells with gently curved dorsal surface. Central raphe ends bent downwards (towards the ventral surface) and polar ends bent upwards (towards the dorsal surface) . . . . **Cymbella**

Cymbella cells have a convex dorsal magin and a straight, concave or slightly convex ventral margin. The raphe is nearly central with outer ends turned upwards towards the dorsal margin and the central ends turned downwards towards the ventral margin. A single H-shaped chloroplast is present, which has a single central pyrenoid. Valve surface with striae at right angles to the raphe. Cells 10–260 µm long and 4–50 µm wide. Cells can be free living or attached by means of a mucilage pad to a solid substratum. Can grow in open water treatment filters and reach large enough numbers to cause filter-blocking problems. Bacillariophyta. Plate XXIV. Fig. 4.66.

165 (157) (a) Cells forming star-shaped colonies . . . . **Asterionella**

See key 78

(b) Cells not forming star-shaped colonies **166**

166 (165) (a) Cells wedge-shaped and curved along its apical axis in girdle view. More club-shaped in valve view. Single H-shaped chloroplast . . . . **Rhoicosphenia**

Cells often attached by a pad of mucilage at their narrow end to plants and other substrata. Abundant and widespread in richer and even brackish waters. Heterovalvar with the lower valve having a fully developed raphe with central nodules and

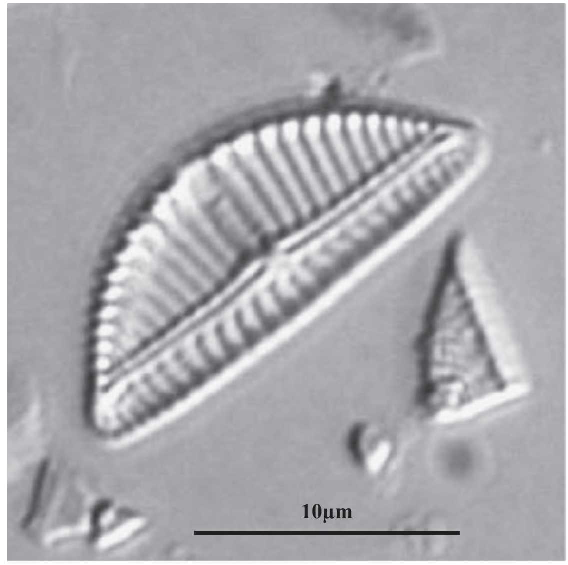


Figure 4.66 *Encyonema.* Valve view of this asymmetric diatom. Acid digest, lake sediment sample.

the upper valve with an extremely reduced raphe in the form of short slits near the poles (only visible using electron microscopy). Cells 12–75 µm long. Bacillariophyta. Plate XXIV. Figs 2.29, 4.67.

(b) Cells not as above **167**

167 (166) (a) Cells heteropolar, wedge-shaped in one view but shaped like an Egyptian mummy in other view (see Plate XXV) sometimes many times as long as broad **168**

(b) Cells not as above, isopolar and not shaped like an Egyptian mummy **170**

168 (167) (a) Cells narrow, much longer than broad, tapering slightly to an acute lower pole, bluntly-rounded and slightly capitate upper pole . . . . **Peronia**

Cells of **Peronia** are narrow and relatively straight compared with their length (15–70 µm long but only 2.5–5.0 µm

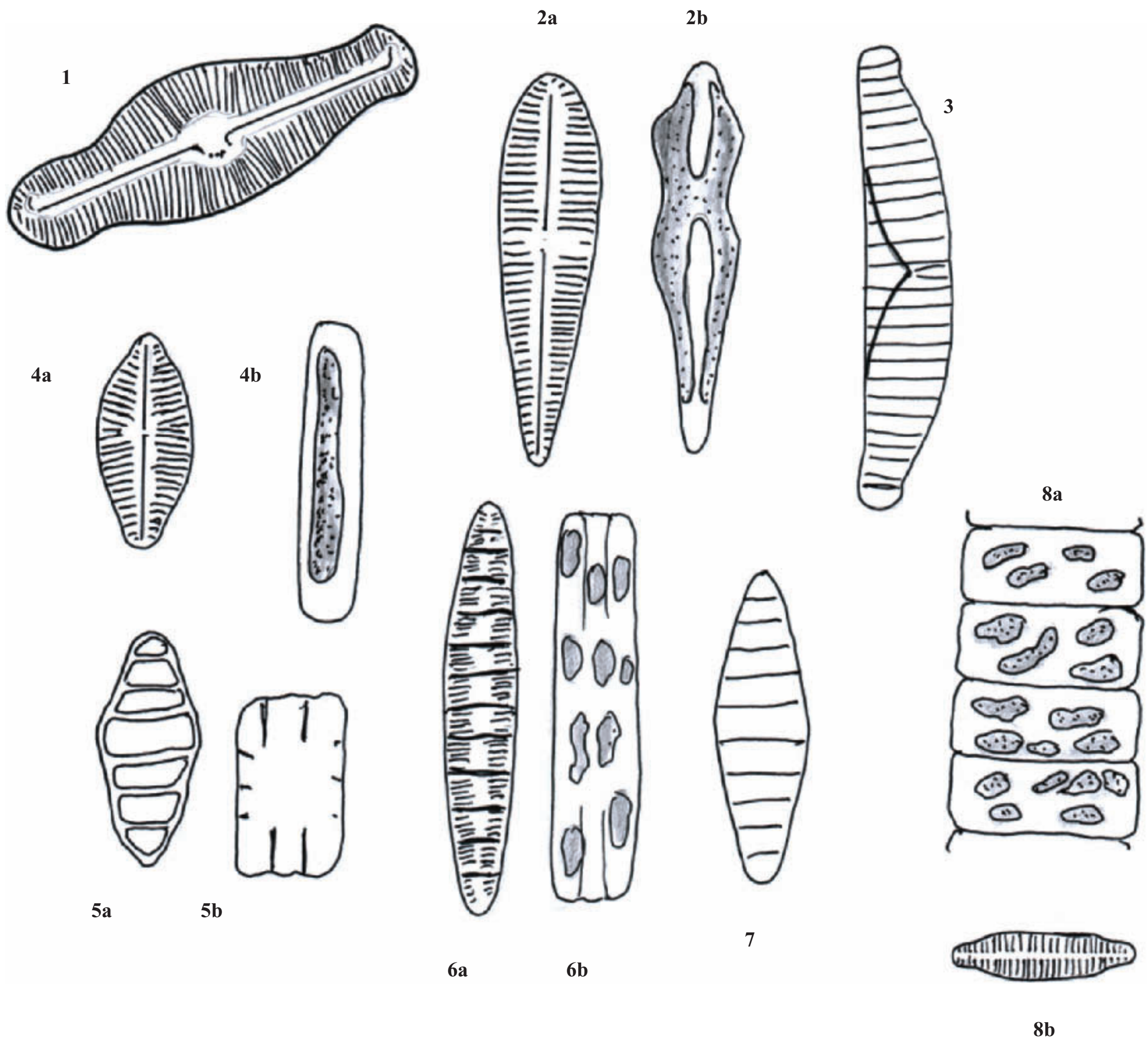


Plate XXV **1.** *Didymosphenia.* **2.** *Gomphonema*: (a) *G. augur* – valve view, frustule markings; (b) *G. acuminatum* – valve view, chloroplast. **3.** *Epithemia.* **4.** *Achnanthes*: (a) valve view, frustule markings; (b) girdle view, chloroplast. **5.** *Tetracyclus*: (a) valve view; (b) girdle view. **6.** *Diatoma hyemalis*: (a) valve view, frustule markings; (b) girdle view, chloroplasts. **7.** *Diatoma vulgaris.* **8.** *Fragilariaforma*: (a) girdle view, chloroplasts; (b) valve view, frustule markings.

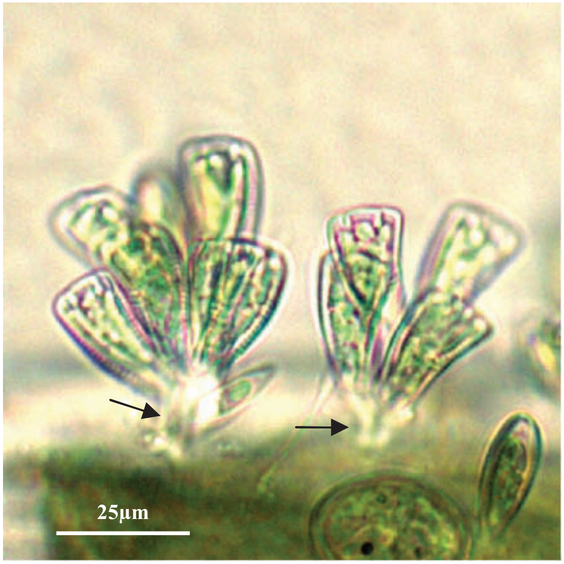


Figure 4.67 *Rhoicosphenia.* Epiphytic clusters of this sedentary diatom with cells attached by stalks (arrows). Fixed preparation.

wide). They are heteropolar with a subcapitate or bluntly-rounded apical end and a tapering, narrowly rounded, base end. One valve has an obvious raphe but the other only has a rudimentary one. The valve surface is finely striated. There are small spines around the edge of the valve. There are two chloroplasts, one either side of the centre. Grows attached to a substratum by means of a mucilage pad. Found in acidic oligotrophic waters. Bacillariophyta. Plate XXIV.

(b) Cells broader with either bluntly-rounded, capitate or rostrate upper pole **169**

169 (168) (a) Cells large (>60 µm) with markedly capitate upper and lower poles, rather like an Egyptian mummy in shape............................. **Didymosphenia**

Cells of **Didymosphenia** have a characteristic shape like an Egyptian mummy. They are quite large, 60–140 µm long and 25–43 µm wide. The cell apices are markedly capitate with the apical end being larger than the base. The central cell area is inflated. The valve face has conspicuous striae with a clear central area, in which are 2–4 prominent stigmata on one side. A single H-shaped chloroplast is present with a central pyrenoid. Occurs on damp rocks and other substrata attached by a mucilage stalk. Bacillariophyta. Plate XXV.

(b) Cells bluntly-rounded or rostrate, upper pole at most slightly capitate .... **Gomphonema**

Gomphonema cells are heteropolar in valve view but cuneate in girdle view. Some species are only slightly heteropolar (**G. angustatum**) whilst others are more strongly heteropolar, somewhat like an Egyptian mummy (**G. truncatum** and **G. acuminatum**). The valve surface has fine to obvious striae, parallel in some species or radiate in others. There is a single stigma in the clear central area. A single H-shaped chloroplast is present with a central pyrenoid. Usually attached to a surface by a single or branched mucilaginous stalk. A widespread species in a range of waters. Some species are reported as being sensitive to pollution (**G. subtile**). Bacillariophyta. Plate XXV. Figs 2.29, 4.68.

170 (167) (a) Cells isopolar, linear-lanceolate to elongate-elliptical in valve view, bent or curved in girdle view............... **171**

(b) Cells isopolar, lanceolate with rounded or protracted apices but not curved or bent in girdle view **176**

171 (170) (a) Cells with distinct costae extending from margin to margin. Single much lobed chloroplast........................ **172**

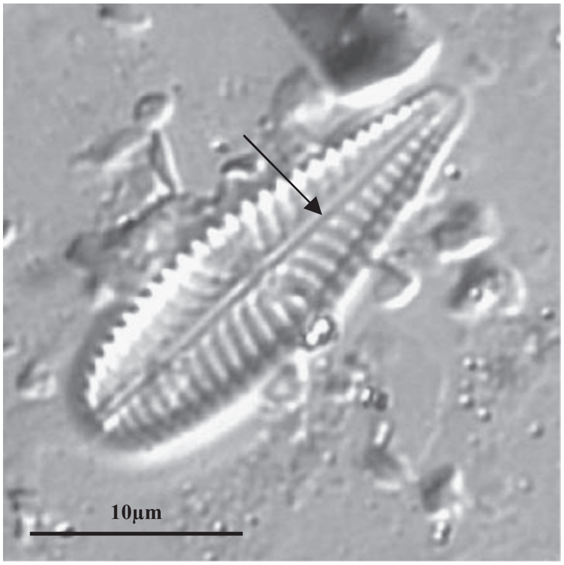


Figure 4.68 *Gomphonema.* Club-shaped diatom with prominent central raphe (arrow). Acid digest, lake sediment sample.

(b) Costae absent. Cells with single C-shaped and plate-like or two elongate/plate-like chloroplasts **173**

172 (171) (a) Cells with arched dorsal surface and concave ventral surface. Raphe characteristically V-shaped at centre of concave surface (see Plate XXV) . . . . **Epithemia**

Epithemia is a widely distributed epiphyte found in freshwater and sometimes in brackish conditions but rarely in more acid waters. The cells are solitary with a strongy dorsiventral shape. Distinct transverse striae are present. The single chloroplast has distinctly lobed margins. Cells 8–200 µm long and 4–35 µm wide. Bacillariophyta. Plate XXV.

(b) Raphe close to dorsal surface but not V-shaped . . . . **Rhopalodia**

Rhopalodia cells are solitary and either attached or free living. Freshwater or brackish water distribution. They are dorsiventral in shape often having turned down apices. Chloroplast is single and lobed. Cells 40–150 µm long and 7–12 µm wide. Coarse transverse striae are present on the valve surface. The raphe curves up from the ventral valve surface in the central ventral area. Bacillariophyta. Plate XXIV.

173 (171) (a) Cells with a strongly curved appearance but with margins/sides parallel. Bluntly rounded ends, raphe hardly visible. Transverse ridges on the frustule surface ending in short spines . . . **Semiorbis**

See also key 159

(b) No prominent transverse ridges or short spines. Cells slightly but not strongly curved **174**

174 (173) (a) Cells gently curved with a small swelling at centre of concave surface. Slightly capitate ends. Costae and septa absent . . . . **Hannaea**

See also key 163

(b) Cells gently curved or bent at centre in girdle view. Elliptical to oval or nearly rectangular in valve view **175**

175 (174) (a) Cells gently curved, no small central swelling. Dorsal or convex margin sometimes undulate. Ends of raphe visible towards poles in valve view . . . . . . **Eunotia**

See also key 161

(b) Cells with raphe clearly visible on one valve. Other valve with pseudoraphe. Cells rectangular to elliptic in valve view and bent (genuflexed) in girdle view . . . . **Achnanthes**

Cells of **Achnanthes** are heterovalvar, one valve bearing a true raphe and the

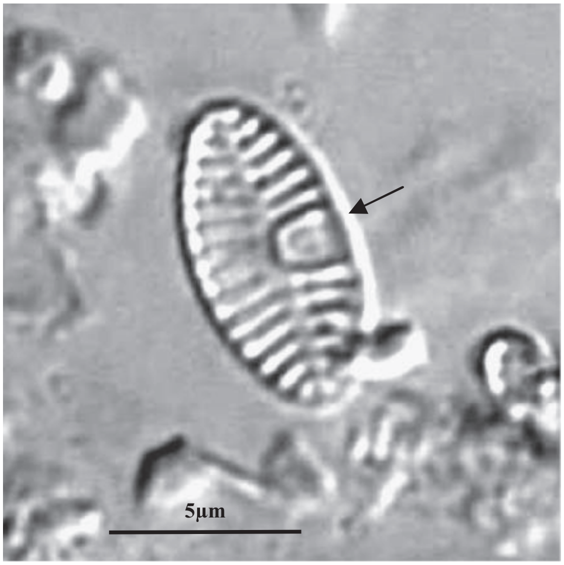


Figure 4.69 *Planothidium.* Acid digest, lake sediment sample. Face view of valve with central pseudoraphe and horse-shoe shaped marking (arrow).

other a pseudoraphe. Cell apices rounded or variable. Single plate-like chloroplast. Cells 5–35 μm long and 3–10 μm wide. A widespread and common species attached to a range of surfaces in flowing waters. Recent revisions of the old genus **Achnanthes** has resulted in a number of new genera being separated out including **Achnanthidium**, **Eucocconeis**, **Planothidium**, **Kolbesia** and **Psammothidium**. **Achnanthes minutissimum**, which is very common, has now been reclassified as **Achnanthidium minutissimum**. Bacillariophyta. Plate XXV. Fig. 4.69.

176 (170) (a) Cells linked to form colonies or chains **177**

(b) Cells mostly solitary **191**

This section of the key (177–191) contains colonial species that can be found as single cells if the colony breaks up. It is important to look at as many examples of a species in a sample to determine whether it is normally solitary or colonial.

177 (176) (a) Cells joined at corners to form star-shaped or zig-zag colonies **178**

Cells joined along valve face to form ribbons or chains rather than being joined at corners **182**

178 (177) (a) Colonies zig-zag in shape **179**

Colonies star-shaped or like the radiating spokes of a wheel **181**

179 (178) (a) Cells without transverse costae or septa. In valve view cells have a swollen central area . . . . **Tabellaria (in part)**

See key 29

Cells with strong septa and less clearly defined costae **180**

180 (179) (a) Cells with transverse costae, no septa, elongate and rectangular in girdle view. In valve view with parallel sides and bluntly to slightly curved and rounded ends . . . . **Diatoma (in part)**

See key 29

(b) Cells with both costae and septa present . . . . **Tetracyclus**

Tetracyclus cells are small and form zig-zag colonies. They are rectangular in girdle view and oval to elliptical in valve view. Short septa are present as are prominent transverse costae. There are several disc-shaped chloroplasts per cell. Cells 4–30 μm long and 3–12 μm wide. Found in both the plankton and sediments of lakes as well as amongst mosses. Bacillariophyta. Plate XXV.

181 (178) (a) Colonies star-shaped, cells many times as long as broad, rectangular in shape (sqared off ends in girdle view), septate, valves swollen in centre . . . . . . **Tabellaria**

Tabellaria can form zig-zag or star-shaped colonies which are commonly seen in girdle view. Valves 12–140 μm long and 5–16 μm broad. **T. fenestrata var. asterionelloides** can be confused with **Asterionella** but the cell ends are not swollen. There are distinct septa within the cell. There are several plate-like chloroplasts present. Widespead and common in the plankton of neutral to slightly acidic lakes. Some species can be attached to a substratum. Can produce odour in drinking waters and block filters if present in large numbers. Bacillariophyta.

See also keys 29 and 146

(b) Colonies star-shaped but valves not as above. Valve apices broader and more rounded, slightly heteropolar with the inner pole a little larger than the outer one. Non septate and cells hardly or not swollen in the centre. Several plate-like chloroplasts. . . . . **Asterionella**

See also key 78

Widespread and common in the plankton of meso- and eutrophic lakes. Bacillariophyta.

182 (177) (a) Valves with costae **184**

(b) Valves without costae **186**

183 (182) (a) Valves with costae and septa. Cells square to rectangular in girdle view . . . . **Tetracyclus**

See key 180

(b) Cells without septa **184**

184 (183) (a) Cells square to rectangular in girdle view, often linked into loose filaments by means of mucilage pads . . . . **Diatoma mesodon**

Diatoma mesodon cells are 10–40 μm long and 6–14 μm wide. They are rectangular in girdle view being wider than the cells are long. In valve view the cells are slightly elliptical or lanceolate. Costae are present within the valve. The chloroplasts are small and disc-shaped or plate-like. It occurs in upland flowing waters. Bacillariophyta. (Not illustrated.)

(b) Cells not square in shape but more elongate. Costae extend near to apices **185**

185 (184) (a) Cells linear to lanceolate with bluntly rounded apices. 30–100 μm long, 7–13 μm wide . . . . **Diatoma hyemalis**

Cell apices are rounded and somewhat blunt. Length 30–100 μm in length and 7–13 μm wide. Chloroplasts are small and plate-like or discoid, many per cell. Cells usually closely attached to one another to form a chain or ribbon. Found in lakes and ponds, frequently in the littoral zone. Bacillariophyta Plate XXV.

(b) Cells 12–85 μm long and 4–9 μm wide. Cell apices subcapitate . . **Meridion anceps**

Meridion anceps cells are more rectangular than those of **M. circulare** which are cuneate and are linear to long elliptical in girdle view. They also do not tend to form fan-shaped colonies. Cell apices capitate to subcapitate, 12–85 μm long and 4–7 μm wide. Found in more upland waters low in nutrients. Bacillariophyta. (Not illustrated.)

186 (182) (a) Cells elongate, >30 μm long **187**

(b) Cells shorter and broader **189**

187 (186) (a) Cells narrow but slightly swollen in centre. Two chloroplasts per cell **188**

(b) Cells broader, rectangular in girdle view, several disc-shaped chloroplasts . . . . **Fragilariaforma**

Cells of **Fragilariaforma** tend to be broarder in girdle view giving a more squat rectangular appearance. Cells are closely linked along their long axes to form chains or ribbons or sometimes forming zig-zag colonies. Cells more linear in valve view with sub-capitate or rostrate apices. No transverse costae are present. Chloroplasts discoid and fairly small, many. Found in oligotrophic waters, especially streams and lake margins. Bacillariophyta Plate XXV.

188 (187) (a) Cells with slightly swollen central region where adjacent cells touch . . . . **Fragilaria crotonensis**

See also key 28

(b) Cells rectangular, touching along entire length . . . . **Fragilaria capucina**

See also key 28

189 (186) (a) Cells rectangular in shape with bluntly-rounded corners and with a single chloroplast. Valve wall thickened towards the centre . . . . **Diadesmis**

Diadesmis has small valves (4–45 μm long and 2–10 μm wide) with a hyaline area along the edge of the valve and a clear area along the axis either side of the raphe. Cells can join together at their valve faces to form small ribbons or chains. Widespread in distribution on damp rocks, soils, mosses and in ponds and springs. Bacillariophyta. (Not illustrated.)

(b) Cells with two chloroplasts **190**

190 (189) (a) Cells short, round to elliptical, with blunt apices. 3–35 μm long and 2–12 μm wide . . . . **Staurosira**

Cells, which are very short and elliptical in shape, can either be attached to a substratum (e.g. sand grains) or be free living. Can form filaments, which may be zig-zag in shape. There are two plate-like chloroplasts. Cells 3–10 μm long and 3–6 μm wide. Bacillariophyta. (Not illustrated.)

(b) Cells larger, lanceolate to rhomboid, with narrowly-rounded apices . . . . **Pseudostaurosira**

Cells elliptical, lanceolate or more rhomboid in valve view. Apices narrowly-rounded to almost rostrate Valve margin may be slightly undulate. Cells usually linked to form filaments. Cells 11–30 μm long and 2–12 μm wide. Chloroplast plate-like. Found in the epipsammon in a range of waters. Bacillariophyta. (Not illustrated.)

191 (176) (a) Cells elongate and narrow, no true raphe present on either valve, may be attached to a surface by a mucilaginous pad. Two elongate chloroplasts. Isopolar with apices gently narrowing. No true raphe present . . . . **Synedra**

Cells of **Synedra** are elongate needle-shape or fusiform, sometimes with capitate ends. No raphe is present and the axial clear area is narrow. The central clear area can be from margin to margin. Fine parallel striae are present either side of the axial area. Cells from <25 μm long (**S. parasitica)** to >500 μm long (**S. ulna**). Cells are narrow, ranging from 3–10 μm wide. Two long chloroplasts are present although only one is usually visible in valve view. Some are epiphytic on other algae but other species are free living. Generally widespread in the plankton of lakes and in slow flowing rivers. Can produce odours in drinking water and block treatment filters when in large numbers (Palmer, 1962). Bacillariophyta. Plate XXVI. Figs 2.23, 4.43.

(b) Cells not attached, broader in shape. True raphe present **192**

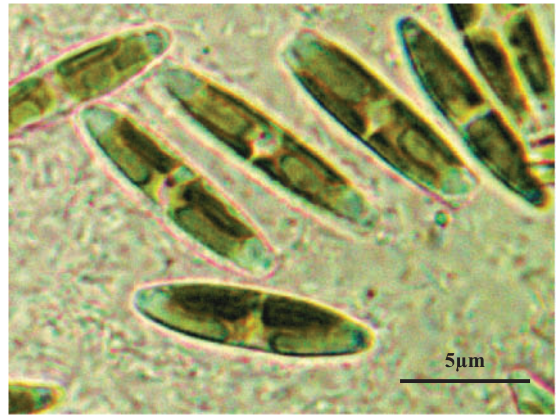
192 (191) (a) Two chloroplasts per cell, one either side of central axis. There are a series of dots (carinal dots) visible along one margin . . . . **Nitzschia**

Nitzschia is a large genus whose cells may be elliptical, narrow linear, spindle-shaped or sigmoid in valve view. In some species the valve centre may be slightly constricted. The raphe is displaced to one margin but the raphe on each valve is diagonally opposite the other. The raphe structure itself is a canal supported by bars which appear as carinal dots. There is no clear central area in the striae which may be fine or coarse in appearance. Two large chloroplasts are present, one either end of the central area. Cells 20–250 µm long and 4.5–16 µm wide. Cells are solitary and may be benthic or planktonic. A very common and widespread genus found in a variety of water types. **Nitzschia sp.** can grow in open water treatment filters in such numbers as to cause blockage of those filters. Bacillariophyta. Plate XXVI. Fig. 4.70a, b.

(b) Chloroplasts not as above. No carinal dots present **193**

193 (192) (a) One or two chloroplasts, plate-like or H–shaped, pyrenoid.may be present or obvious large droplets on the chloroplast **194**

(b) Chloroplasts not as above **195**



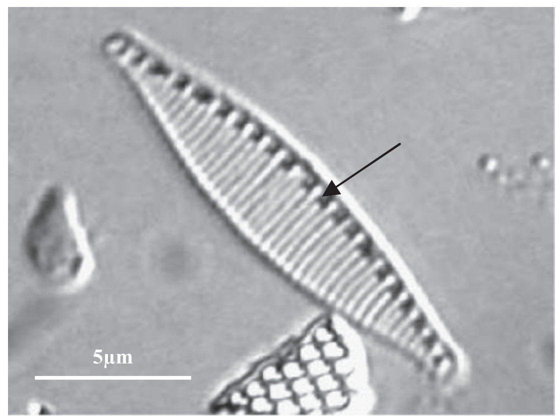


Figure 4.70a *Nitzschia*. Top: Live cells, each with two olive brown chloroplasts. Bottom: Acid digest, lake sediment sample. The raphe (arrow) with punctae is displaced to the margin (keel). See also next page.

194 (193) (a) Two plate-like chloroplasts, one above and one below the middle of the cell, often two conspicuous droplets present. Striations on valve surface interrupted by one or more marginal lines. The polar terminals of the raphe forked, central terminals hooked/bent in opposite directions . . . . **Neidium binodis**

N. binodis is a species in the genus with two H-shaped chloroplasts (the other species of **Neidium** having four). Cells linear to lanceolate with broadly rostrate ends. The valve surface has fine

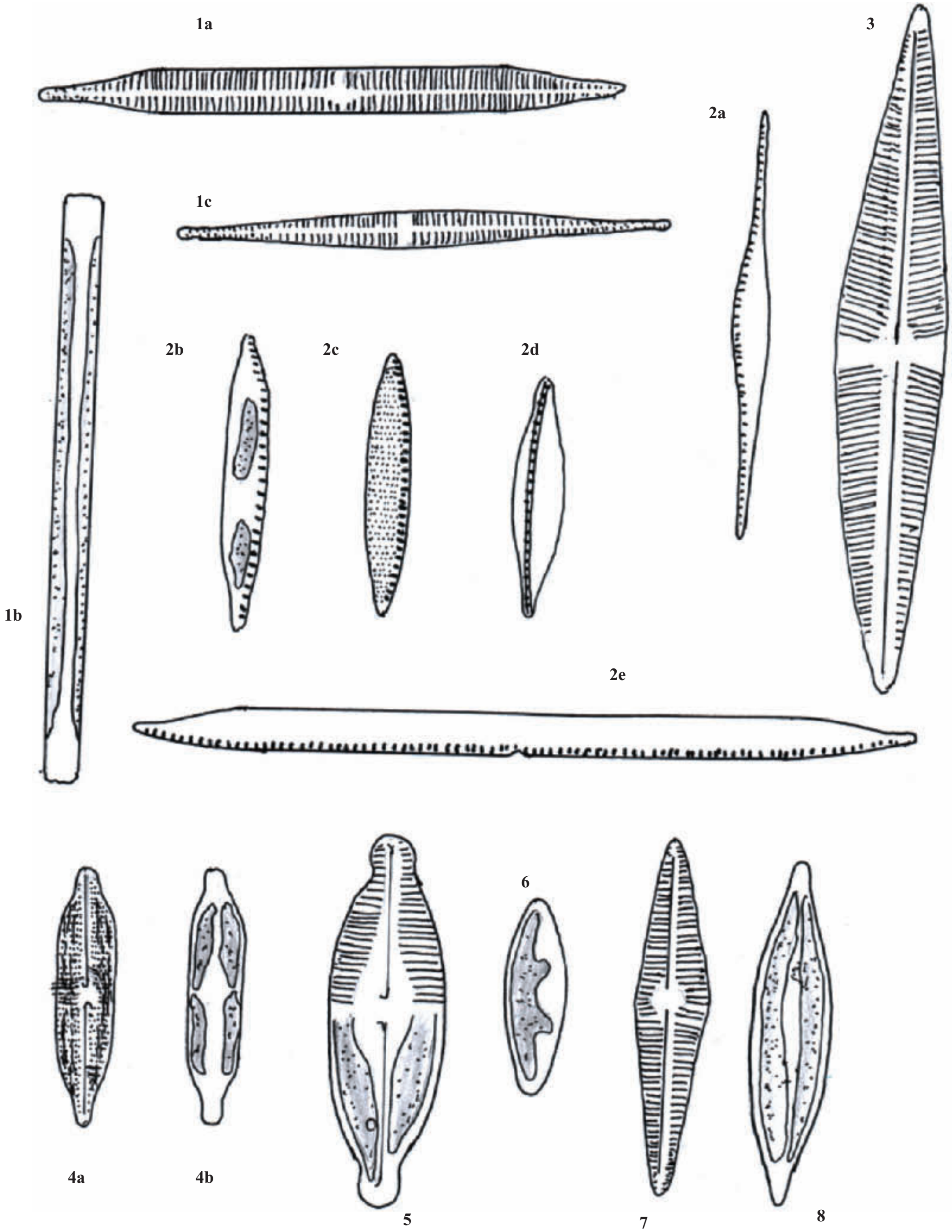


Plate XXVI **1.** *Synedra*, valve views: (a) *S. ulna* – valve view, markings; (b) *S. ulna* – girdle view, chloroplasts; (c) *S. acus.* **2.** *Nitzschia*: (a) *N. acicularis*; (b) *N. palea*; (c) *N. amphibia*; (d) *N. dissipata*; (e) *N. linearis.* **3.** *Stauroneis.* **4.** *Neidium*: (a) valve view, frustule markings; (b) chloroplasts. **5.** *Caloneis* – frustule markings/chloroplasts. **6.** *Luticola.* **7.** *Brachysira.* **8.** *Craticula.*

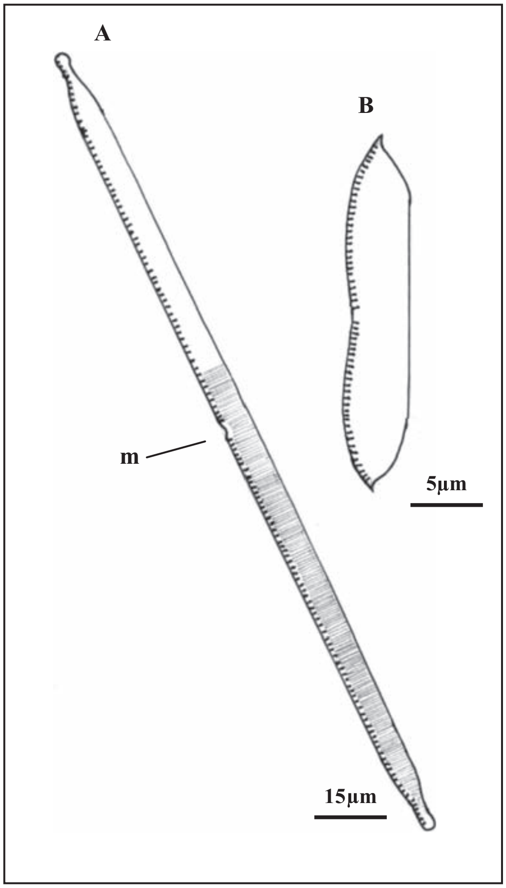


Figure 4.70b A. *Nitzschia linearis* – Straight-sided alga with small median constriction (m). B. *Nitzschia dubia.*

striae which may be interrupted near to the valve margin. Central ends of raphe bent in opposite directions. Cells usually with four chloroplasts, each containing a pyrenoid. Cells15–120 µm long, and 4–30 µm wide. A widespread genus found in oligo- to meso-trophic waters. Bacillariophyta. Plate XXVI.

(b) Two chloroplasts present, one either side of the long axis. Central raphe terminals straight or bent the same way. Clear marginal lines present. Cells with broad rostrate apices . . . . **Caloneis**

Caloneis cells are elliptical to fusiform with rounded to rostrate or capitate ends. There is either a single plate-like chloroplast or two lying either side of the axial line. The valve face bears fine striae which are interrupted by a line just inside the valve margin. The raphe ends are either straight or both bent to the same side. Cells 60–125 µm long and 25–30 µm wide. Frequent on rocks and stones in streams and amongst mosses. Bacillariophyta. Plate XXVI.

195 (193) (a) Four chloroplasts per cell . . . **Neidium**

Neidium cells have four chloroplasts with a pyrenoid each per cell although **N. binodis** (key 194) has two H-shaped chloroplasts. The valves are linear to lanceolate in shape with the cell apices broadly rostrate. The valve is ornamented with rows of punctae which are interrupted by a series of small gaps near to the margin. There is a raphe whose ends are bent in opposite directions. The cells are relatively large being 15–200 µm long and 4–30 µm wide. Widespread in nutrient-poor waters. Bacillariophyta. Plate XXVI.

(b) Less than four chloroplasts per cell **196**

196 (195) (a) Two plate-like chloroplasts, one either side of long axis, sometimes with lobed margins. Stauros (see Glossary) present **197**

(b) Cells not as above **198**

197 (196) (a) Central area of valve broader with striae missing and reaching nearly completely from side to side, forming a clear area or stauros. Cells rhomboidal to linear-lanceolate . . . . **Stauroneis**

The valves of **Stauroneis** are lanceolate to elliptical with rounded or rostrate ends. The valve surface has parallel to slightly radiate striae with a marked clear area or stauros in the central region which extends to the valve margin. There are two chloroplasts, one lying each side of the apical axis, with one to many pyrenoids. Cells 8–160 µm long and 3–20 µm wide. This is a widespread genus and is common on damp rocks, amongst mosses, with many species occurring in more oligotrophic waters. Bacillariophyta. Plate XXVI.

(b) Valves broadly lanceolate, clear central area not quite reaching the cell margins. A prominent stigma is present at one side of the central area . . . . **Luticola**

Valves linear, elliptical or lanceolate with rounded to slightly capitate apices. Valve surface with radiate, punctuate, striae. The central area is broad but does not extend to the valve edge. A single chloroplast is present with a central pyrenoid. Cells 20–50 µm long and 5–12 µm wide. A widespread species occurring on damp surfaces such as rocks, stones or soil. Bacillariophyta. Plate XXVI.

198 (196) (a) Valve surface covered with fine striae with irregular gaps. Cells lanceolate in shape, some with capitate/rostrate apices. Valve face with thickened ridge along edge . . . . **Brachysira**

Brachysira cells are solitary. The genus is widespread in may waters but especially in flowing systems. Cells have a single chloroplast and are 14–115 µm long, 4–21 µm wide. Bacillariophyta. Plate XXVI.

(b) Valves not as above **199**

199 (198) (a) Striae parallel to raphe and cross hatched. Very small clear central area which may be completely absent. Valves broadly lanceolate to slightly elliptical. Two plate-like chloroplasts . . . **Craticula**

The genus **Navicula** is a very large genus the species of which are sometimes hard to distinguish. With the use of scanning electron microscopy, several smaller genera have been divided off. These include **Craticula**, **Diadesmis** and **Luticola.**

Craticula cells have two plate-like chloroplasts and two large obvious droplets. Cells 40–150 µm long and 13–30 µm wide. Common in a range of electrolyte-rich waters. Bacillariophyta. Plate XXVI.

(b) Clear central area present, striae not cross hatched **200**

200 (199) (a) Striae rib-like in appearance . . . . **Pinnularia**

Pinnularia is a large genus. The cells are linear, lanceolate or even elliptical. The poles are usually rounded, capitate or rostrate. Striae are usually coarse (but may be finer in some species). There is a central raphe whose middle ends bend in the same direction. There are usually two plate-like chloroplasts, one either side of the midline. Some species may have other shaped chloroplasts. Cells 13–120 µm long and 4–16 µm wide. Widespread and common on sediments and other substrata and may be mixed in moss clumps. Water types range from nutrient-poor to nutrient-rich. Bacillariophyta. Plate XXVII. Figs 1.13, 4.71.

(b) Striae finer and not rib-like **201**

201 (200) (a) Raphe lying within a thickened ridge **202**

(b) Raphe not lying within a thickened ridge . . . . **Navicula**

True **Navicula** species have lanceolate valves with a narrow axial area flanked by

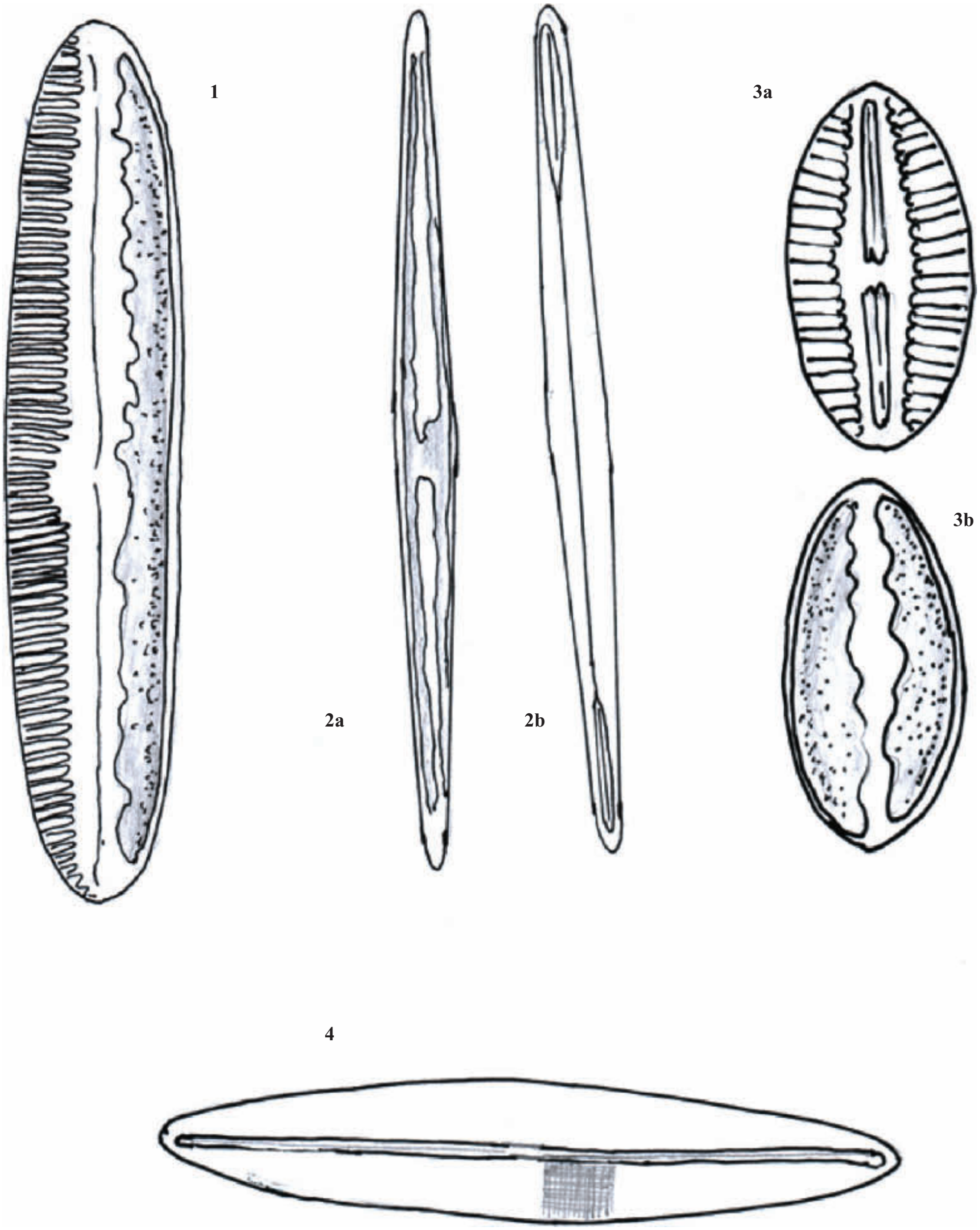


Plate XXVII **1.** *Pinnularia*, showing surface markings (left) and chloroplast (right). **2.** *Amphipleura*: (a) chloroplast; (b) surface markings. **3.** *Diploneis*: (a) surface markings; (b) chloroplasts. **4.** *Frustulia.*

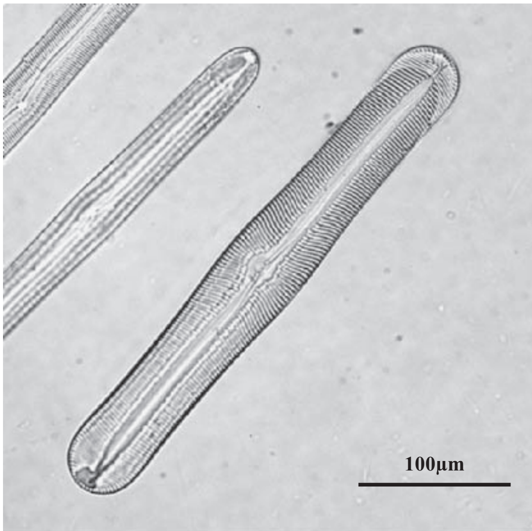


Figure 4.71 *Pinnularia*. Valve view of this large benthic diatom. Prepared slide.

fine striae which are slightly radiate at the centre but parallel towards the cell apices. The raphe is hooked at the apices with the ends both pointing the same way. Cells are often very motile (naviculoid movement). One H-shaped chloroplast. Cell apices may be narrowly rounded or subcapitate. Two plate-like chloroplasts are present lying either side of the apical axis. A very widespread and common genus. Found in a range of waters often occurring in benthic films in streams and rivers as well as in lakes. Bacillariophyta. Fig. 4.73a, b.

202 (201) (a) Raphe short with thickened ridges can be seen towards the end of valves only .... **Amphipleura**

Amphipleura can be widespread but it is not very common. The valves are lanceolate and the raphe is very short and located near to each pole edged by a definite rib. Cells 80–140 µm long and 7–9 µm wide. Found on silt and sediments, sometimes mixed with filamentous algae. More often reported from alkaline waters. Bacillariophyta. Plate XXVII.

(b) The thickened area either side of the raphe extends along the whole length of the valve **204**

203 (202) (a) Cells ovoid, two distinctly lobed chloroplasts, one either side of the long axis .... **Diploneis**

Diploneis cells are linear, rhombic or elliptical. The poles are blunt and rounded. The raphe is along the mid-line and boardered by two ridges. There are different types of striae on the valve surface. Cells 10–130 µm long and 10–60 µm wide. Found on bottom deposits and silt in a wide range of waters. Bacillariophyta. Plate XXVII.

(b) Cells more elongate. Chloroplast not lobed .... **Frustulia**

Frustulia is a benthic form living on sediments. It is a widespread genus and may be found in a range of pH waters. Two chloroplasts are present that have a plate-like appearance. Cells 50–160 µm long and 10–27 µm wide. Bacillariophyta. Plate XXVII.

204 (127) (a) Cells ovoid to spherical **205**

(b) Cells other shape (note cells with a median groove, although roughly oval in outline, are included here). **210**

205 (206) (a) Cells bearing spines **206**

(b) Cells without spines.. .... **209**

206 (205) (a) Cells spherical or only very slightly oval **207**

(b) Cells oval to elliptical **208**

207 (206) (a) Cells solitary, spherical, 5–21 μm in diameter. Numerous fairly long (relative to the cell diameter) spines . . . . **Golenkinia**

Golenkinia cells are solitary but may form false colonies because they fail to separate after division. There are several spines per cell (12+) between 24 and 45 μm long. There is a single cup-shaped chloroplast with a pyrenoid. Planktonic. Chlorophyta. Plate XXIX. Fig. 4.72.

(b) Cells sometimes solitary though usually in colonies of 8–16 cells. Cells ovoid to spherical, 3–7 μm diameter. 1–5 spines per cell each 20–35 μm long . . **Micractinium (see section 92 and Fig. 4.72)**

208 (206) (a) Cells with two spines arising at each pole . . . . **Lagerheimia**

The cells of **Lagerheimia** are ovate, 6–18 μm in diameter and up to 23 μm long. planktonic in lakes and ponds (Fig. 4.72).

(b) Cells with 3–8 spines arising from each pole . . . . **Chodatella**

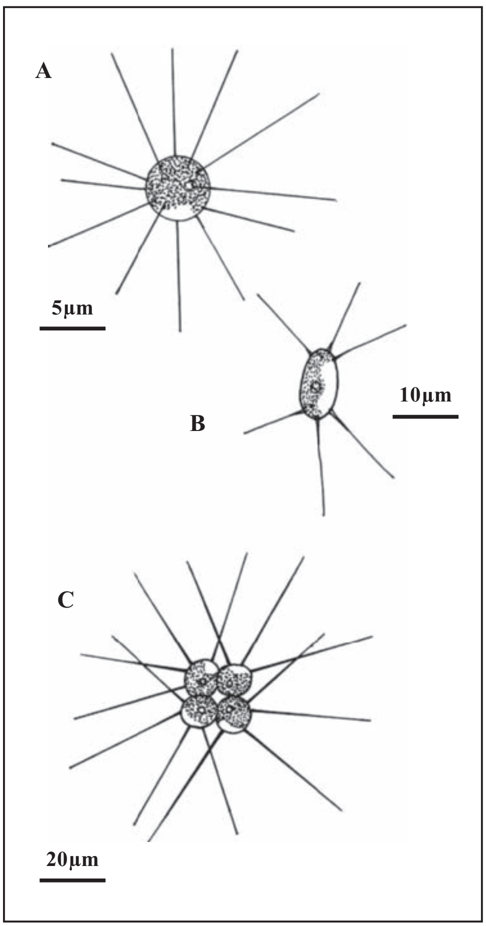


Figure 4.72 (A) *Golenkinia.* (B) *Lagerheimia.* (C) *Micractinium.*

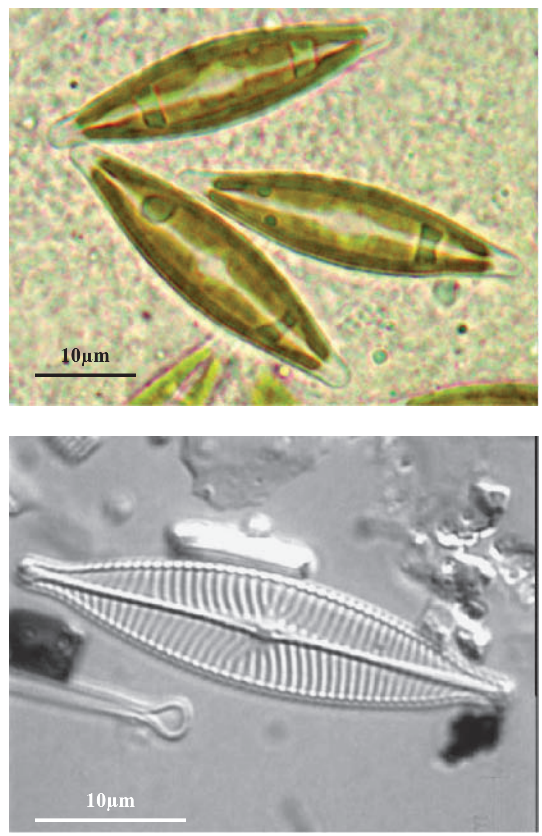


Figure 4.73a *Navicula.* Top: Group of live cells, each with two elongate olive-brown chloroplasts. Bottom: Valve view of diatom frustule, showing striae radiating out from a central area. Acid digest, lake sediment sample.

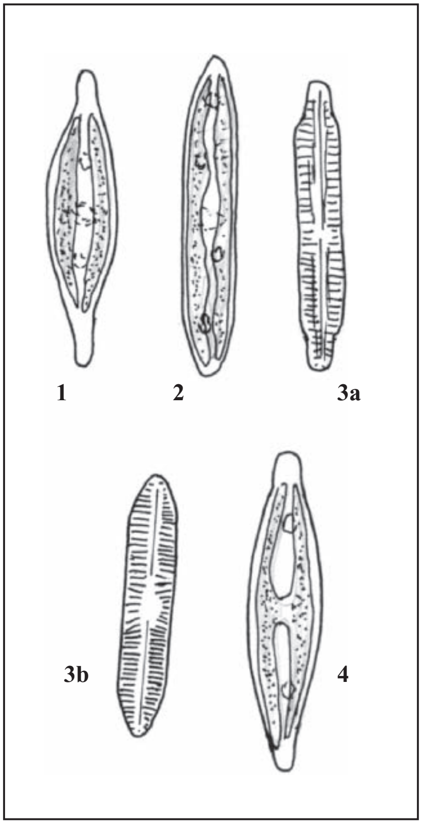


Figure 4.73b Species of *Navicula* with two plate-like chloroplasts (1–3) or an 'H'-shaped (4) chloroplast. 1. *N. rhynchocephala.* 2. *N. tripunctata.* 3a,b. *N. bryophila.* 4. *N. subtilissima.*

The cells of **Chodatella** are oblong to ovate, 6–18 μm in diameter and 10–21 μm in length. There are 1–4 chloroplasts with a pyrenoid per cell. The spines are fine and 10–24 μm long. Chlorophyta. Planktonic in lakes and ponds. Plate XXVIII.

209 (205) (a) Cells spherical in shape, small, <10 μm in diameter . . . . **Chlorella**

Chlorella cells are spherical to subspherical with a single parietal chloroplast which nearly fills the cell. A single pyrenoid is present. Cells 2–10 μm in diameter. Common in nutrient-rich waters but easily overlooked because of their small size. Its small size can also mean that it can pass through traditional water treatment sand filters giving rise to colour problems in the treated water. Chlorophyta. Plate XXVIII. Fig. 4.74.

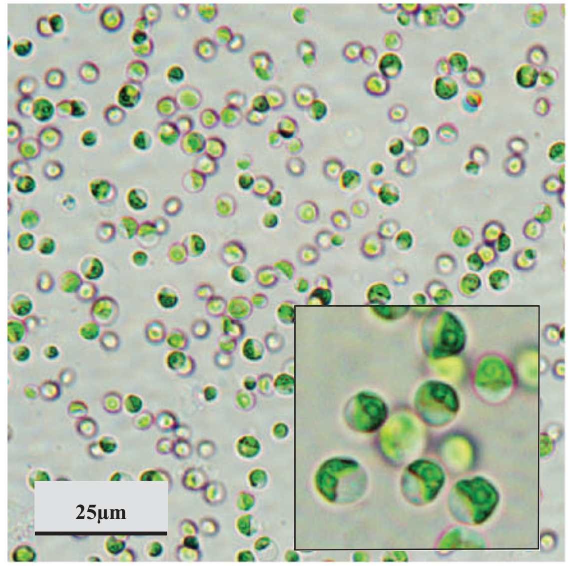


Figure 4.74 *Chlorella.* Main image: low power view of algal culture. Inset: Cell detail, showing parietal chloroplast and apical clear region.

(b) Cells ovoid and greater than 10 μm in size . . . . **Oocystis**

Oocystis has ovoid to egg-shaped cells that are either solitary or in small colonies of 2, 4, 8 or 16 cells enclosed by the mother cell wall (which is sometimes quite faint and difficult to see). The chloroplasts are discoid or plate-like with one to many per cell. Pyrenoids may or may not be present. Cells 7–50 μm long and 6–12 μm broad. Widespread in lakes and ponds. There are up to four chloroplasts per cell and pyrenoids may be present. Planktonic in harder nutrient-rich waters or sometimes softer ones. Chlorophyta. Plate XXVIII.

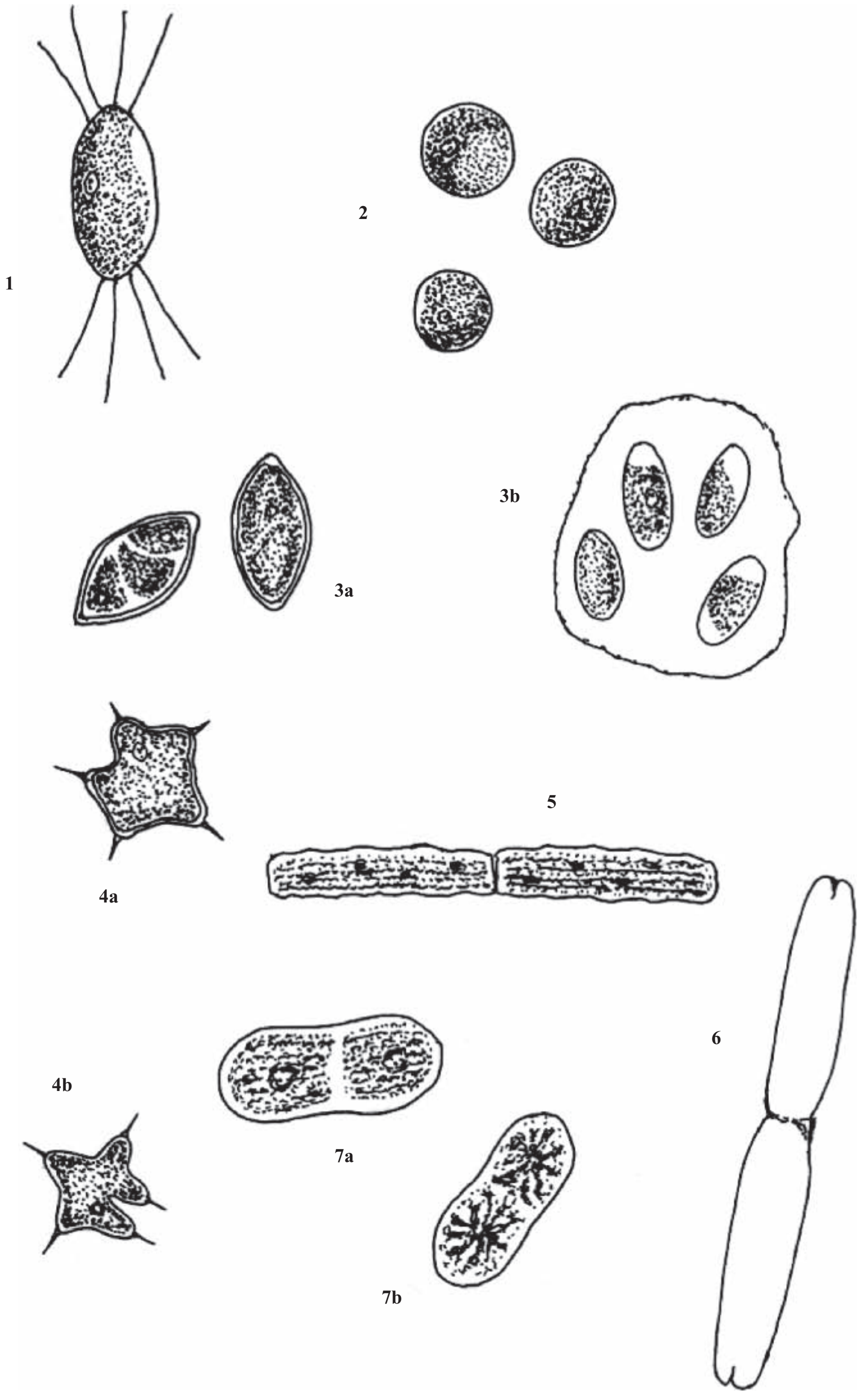


Plate XXVIII **1.** *Chodatella.* **2.** *Chlorella.* **3.** *Oocystis.* **4.** *Tetraedron.* **5.** *Pleurotaenium.* **6.** *Tetmemorus.* **7.** *Actinotaenium.*

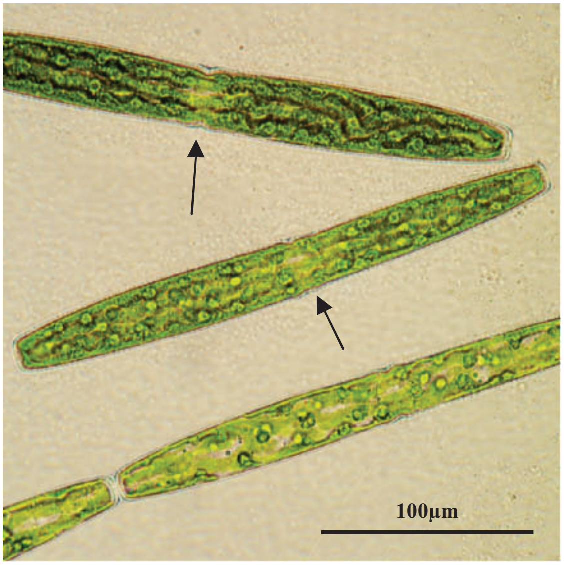


Figure 4.75 *Pleurotaenium.* These large algal cells have a median constriction (arrow). Chloroplasts are arranged in longitudinal bands (seen clearly in top cell) and have numerous pyrenoids.

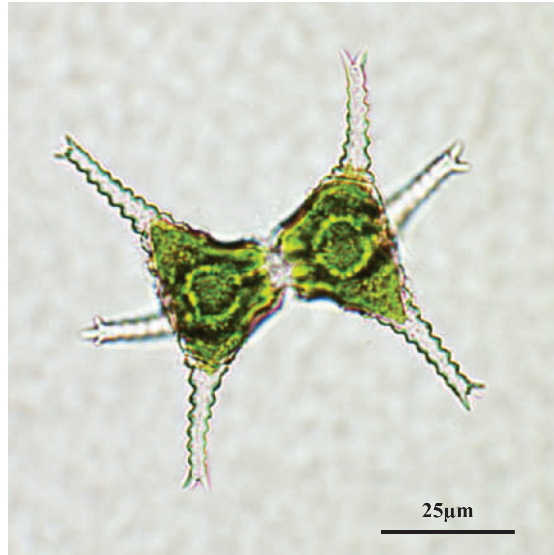


Figure 4.76 *Staurastrum*. Single cell, composed of two prominent semicells.

210 (204) (a) Cells having a distinct median groove or isthmus around the whole cell central region. Sometimes the two sides of the groove are quite close together so care must be taken with the observation (see Figs 4.75 to 4.77) **215**

(b) Cells without a median groove around the entire cell **211**

211 (210) (a) Cells angular, 4–5 sided, angles of cells rounded and tipped with a short spine. One side of the cell with a deep groove but not extending around the whole cell . . . . **Tetraedron**

Tetraedron cells are between 8 and 22 µm in diameter and are pentagonal in shape. Chloroplasts 1 to many and usually with pyrenoids. Common but rarely abundant in lowland waters. Chlorophyta. Plate XXVIII.

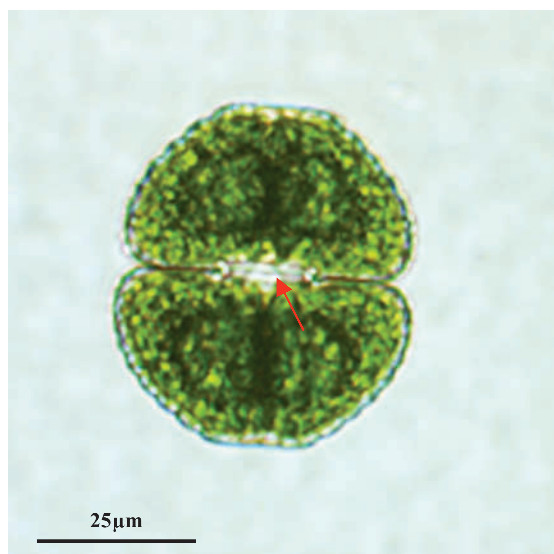


Figure 4.77 *Cosmarium.* The two semicells are joined by a narrow isthmus (arrow) at the cell equator.

(b) Cells not as above. Groove hardly or not present, if present the slight groove is equal in size on both sides of the cell or not obvious. There may be a clear area in the mid-region of the cell between two chloroplasts.. . . . . **212**

212 (211) (a) Cells with a cylindrical or near cylindrical shape **213**

(b) Cells not cylindrical in shape **217**

Desmids are almost entirely freshwater with only a few occurring in brackish waters. Taxonomically they are divided into two groups; the Saccoderm desmids which have a relatively simple shape lacking a median constriction. The second group are the Placoderm desmids that do have a definite median constriction so that the cell is divided into two semi-cells.

Most desmids are single cells although a few form filaments. Some aggregate in masses held together by a mass of mucilage. The study of desmids using a microscope has long been popular because of their beautiful shapes (e.g. **Micrasterias** Not in key. See Plate XXIX and Figure 4.81.).

213 (212) (a) Cells are an elongated straight cylinder, about ×10 long as broad. Shallow but noticeable constriction in the middle . . . . **Pleurotaenium**

In **Pleurotaenium** the median constriction is not deep and a swollen area may be present on either side of it. Cells 20–650 µm in length and up to 75 µm wide with numerous long band-shaped chloroplasts with pyrenoids. Often found in soft, more acid, waters and amongst mosses. Chlorophyta. Plate XXVIII. Fig. 4.75.

(b) Cells not as above but a shorter, more rounded cylinder **214**

214 (213) (a) Cells large, 150–240 µm in length, cylindrical to fusiform in shape with a distinctive notch at each apex . . . . **Tetmemorus**

The cells are rounded cylinders with occasionally a slight median constriction. The cell apices have a characteristic deep incision. One chloroplast in each semicell with several pyrenoids. Cells up to 250 µm in length. The cell wall may be covered with fine granules. Common in ponds and acid pools and amongst *Sphagnum*. Chlorophyta. Plate XXVIII.

(b) Cells are a short more rounded cylinder and only 60–80 µm in length . . . . **Actinotaenium**

Actinotaenium cells are relatively short with only a shallow, wide, constriction in the centre. Cell wall very finely punctuate. Chloroplast stellate with a pyrenoid. Cells 30–85 µm long. Frequent in ponds amongst other algae. Chlorophyta. Plate XXVIII.

215 (210) (a) Median groove wide, each semicell with horn-like extensions or at least a polygonal shape. Cell walls may have granulations and some planktonic species may be surrounded with mucilage . . . . **Staurastrum**

Staurastrum is a very large genus of desmids. The cells are divided into two semicells with a wide groove or isthmus between them. The outer angles of each semicell is extended into long horns or processes, which may at times be short and stumpy, giving the cells a polygonal appearance. The ends of the arms may end in short spines. The cell wall may be ornamented. In apical view, i.e. looking down on the cell so the median groove cannot be seen rather than from the side so that the medial groove is clearly visible, the cells are usually triangular but more arms may be present. Cells may be between 10 and 140 µm in length. **Staurastrum** is one of the more common desmids in the plankton. It occurs in nutrient-poor (most species) and moderately nutrient-rich lakes. Chlorophyta. Plate XXIX. Fig. 4.76.

(b) Median groove more narrow, or if wide cell walls smooth and with a single spine at cell apices. **216**

216 (215) (a) Median groove marked, acute to obtuse in angle. Semicells approximately triangular, each apex with a single spine . . . . **Staurodesmus**

Staurodesmus cells are triradiate (usually) with a spine at the end of each angle. The cells are divided into two semicels with a wide groove or isthmus in the centre. A common genus in the plankton in acid, nutrient-poor waters, although sometimes reported from nutrient-rich waters, and amongst aquatic macrophytes. Chlorophyta. Plate XXIX.

(b) Median groove very narrow, overall cell shape is ovoid to rounded. Sometimes with slightly flattened sides or ends. No spines or extended processes present but cell wall may have markings. . . . . **Cosmarium**

This is the largest desmid genus and is very widespread. The cells are normally rounded (overall shape), divided into semicells with a narrow groove or isthmus in the centre between the two halves. The semicells in some species have an angular, polygonal appearance. The cell walls may be ornamented with granules either scattered over the surface or in regular rows. Pyrenoids are present in the chloroplasts. A very widespread and common genus, especially in upland areas although some species do occur in more alkaline or nutrient-rich areas. Chlorophyta. Fig. 4.77.

217 (212) (a) Cells usually in groups of 2–4–8 or more, united along some, if not all, of the lateral walls. Spines sometimes present, especially on the end cells . . . . **Scenedesmus**

(See section 97)

(b) Cells not united as above **218**

218 (217) (a) Cells polygonal or tetragonal sometimes with spines at the angles. . . . . **Tetraedron**

(See also key 211)

Tetraedron has angular cells which may or may not have spines at the apices. There is a single chloroplast (sometimes more) with one to many pyrenoids. Common but not abundant in the plankton. Chlorophyta. Plate XXVIII.

(b) Cells elongate, crescent- or cigar-shaped. **219**

219 (218) (a) Cells with a single chloroplast almost filling the whole cell, with or without a pyrenoid. Cells needle-like or fusiform in shape **220**

(b) Cells with two axial chloroplasts, one in each half of the cell and each one having several pyrenoids in a row along its length **223**

220 (219) (a) Cells lunate to arcuate often in aggregates of 4–8–16. . . . . **Selenastrum**

Selenastrum cells are strongly curved and frequently occur in aggregations but

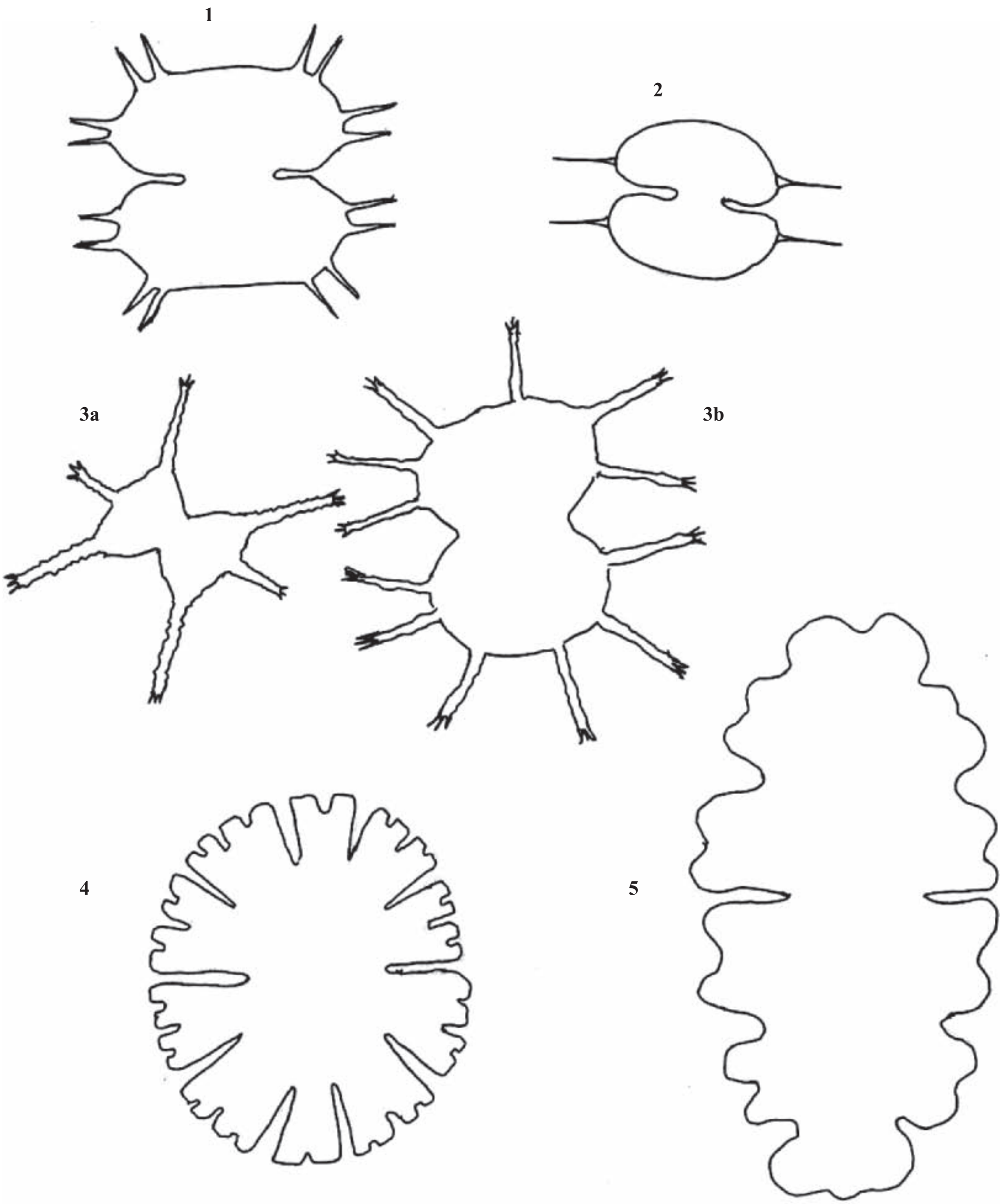


Plate XXIX **1.** *Xanthidium.* **2.** *Staurodesmus.* **3.** *Staurastrum*: (a) *S. anatinum*; (b) *S. arctison.* **4.** *Micrasterias.* **5.** *Euastrum.*

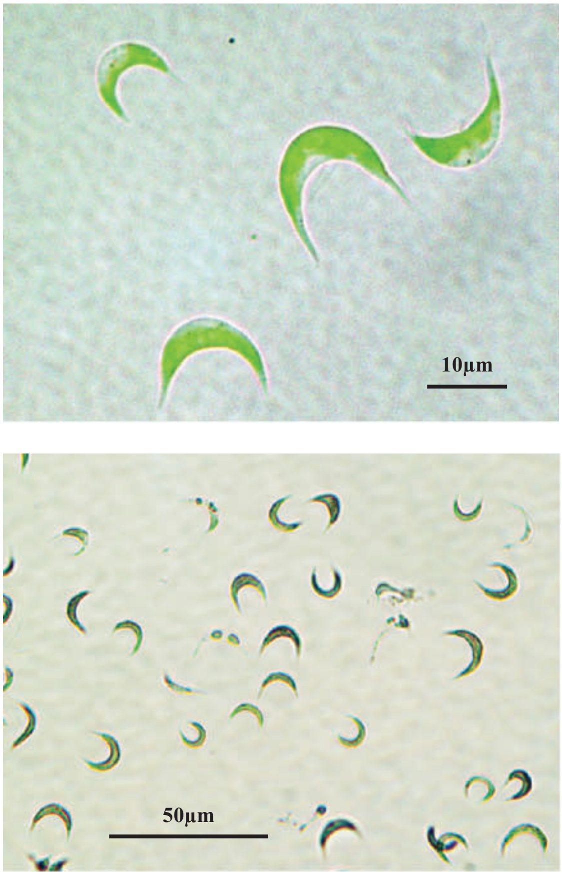


Figure 4.78 *Selenastrum.* Top: DIC image of crescent-shaped cells. Bottom: General view of culture showing range of cell size (iodine–stained preparation).

without a mucilaginous surround being present. Each cell has a single chloroplast which fills the whole cell. Cells 2–8 μm wide and 13–50 μm long. Common in the plankton. Chlorophyta. Plate XXX. Fig. 4.78.

(b) Cells spindle-shaped to fusiform, straight, curved or sigmoid. Either solitary or in loose aggregations **221**

221 (220) (a) Cells fusiform with ends drawn into long narrow spines, one of which has a forked end . . . . **Ankyra**

Cells of **Ankyra** are fusiform or spindle-shaped with long drawn out apices. There is a single chloroplast with one to several pyrenoids. Common in the plankton of lakes. Chlorophyta. Plate XXX.

(b) Cells do not have one of the spines forked at the end and are not markedly fusiform **223**

222 (221) (a) Cells needle-shaped and solitary . . . . **Monoraphidium**

Monoraphidium has needle- or sickle-shaped cells and does not form colonies. Single chloroplast almost filling the cell. A pyrenoid may be present. Cells 1–5 μm wide and 7–100 μm long. Abundant in the plankton of eutrophic lakes. Chlorophyta. Plate XXX. Fig. 4.79.

(b) Cells needle-shaped and occurring in loose, irregular bundles or tangled groups . . . . **Ankistrodesmus**

The cells of this species are very similar to **Monoraphidium** but they occur in groups or bundles. A mucilage envelope may be present. Cells a narrow spindle shape and may be curved or twisted in shape. A single parietal chloroplast is present with or without a pyrenoid. Cells 1–5 μm wide and 20–165 μm long. Very common in eutrophic lakes and slow flowing rivers. Some species also occur in more acid waters. Chlorophyta. Plate XXX.

223 (219) (a) Cells straight with rounded or truncated ends . . . . **Penium**

Cells of **Penium** can be up to 10 times long as broad. They are cylindrical in shape. A small median constriction may be present in the truncated apices. The cell wall is smooth or sometimes punctuate. The cell is arranged in two halves each of which has a chloroplast with one to several

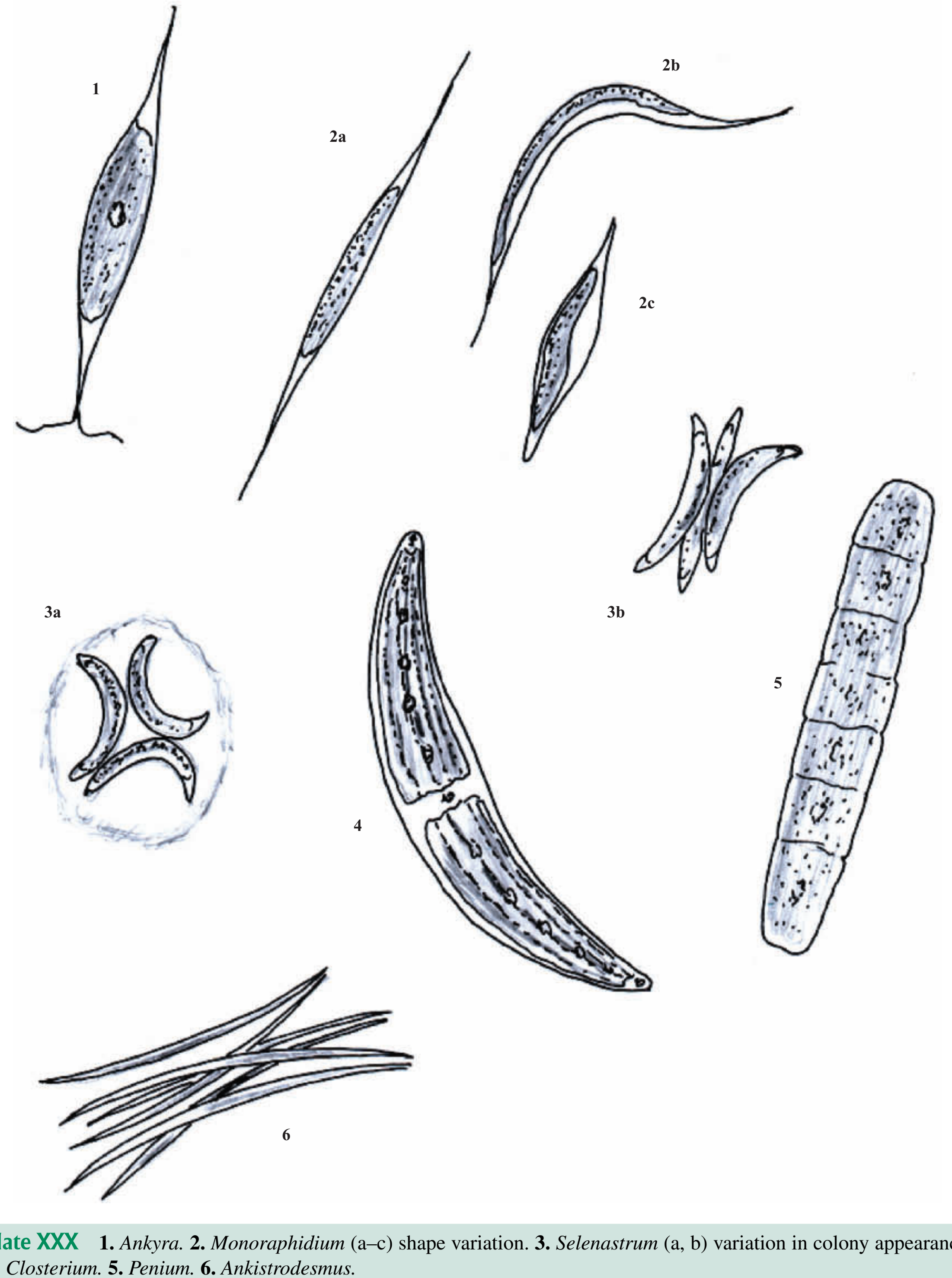


Plate XXX **1.** *Ankyra.* **2.** *Monoraphidium* (a–c) shape variation. **3.** *Selenastrum* (a, b) variation in colony appearance. **4.** *Closterium.* **5.** *Penium.* **6.** *Ankistrodesmus.*

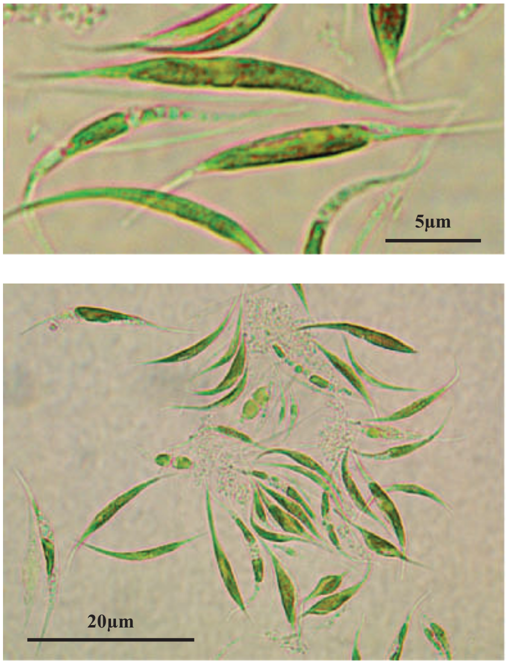


Figure 4.79 *Monoraphidium*. Top: Detailed view of elongate cells containing dispersed (iodine stained) starch grains. Bottom: General view of culture.

pyrenoids. Cells 7–26 µm wide and 10–274 µm long. Common. Chlorophyta. Plate XXX.

(b) Cells slightly or strongly curved with tapering ends . . . . **Closterium**

Cells elongate and tapering towards the ends. The outline may be bow-shaped, sickle-shaped or more or less straight. The cells are divided into two halves but there is no median constriction. There are two chloroplasts, each lying either side of the central area. There are several prominent pyrenoids along each chloroplast. The cell walls may be smooth or have longitudinal striae. Cells 35–1000 µm long. Widespread in waters ranging from acidic nutrient-poor to alkaline nutrient-rich. It can occur in the plankton or in amongst moss plants. Chlorophyta. Plate XXX. Fig. 4.80.

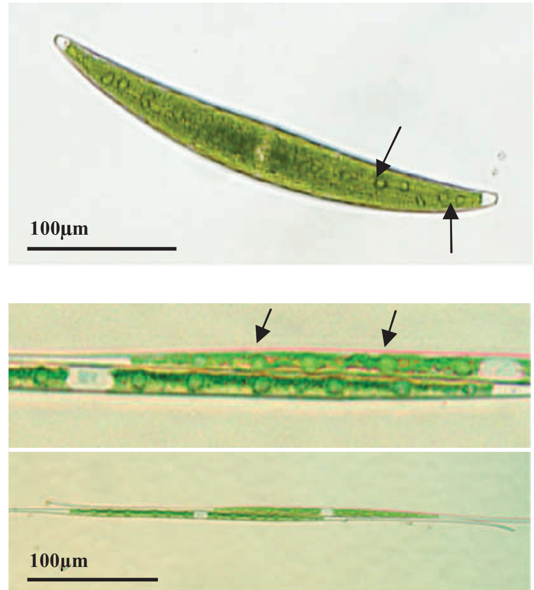


Figure 4.80 *Closterium*. Top: Crescent-shaped species (*C. moniliferum*) with two chloroplasts containing pyrenoids (arrows). Bottom pair: Very narrow (>500 µm long) celled species (*C. aciculare*) common in phytoplankton, showing a pair of cells (lower figure) and chloroplast detail with pyrenoids (arrows – upper figure).

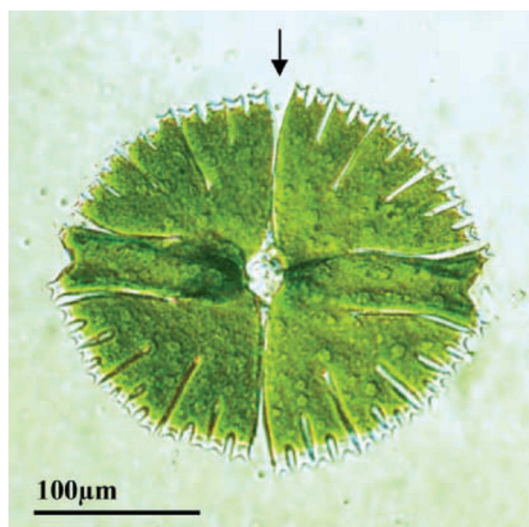


Figure 4.81 *Micrasterias*. The two semicells of this desmid are demarcated by a deep median groove (arrow).

4.3 List of algae included and their occurrence in the key

The number at which particular genera key out is given below. Where a particular species of a genus would key out differently to the main genus these are listed by species in addition to the genus.

Genus or species	Key number
Acanthoceras	143
Achnanthes	175
Actinastrum	81
Actinocyclus	138
Actinoptychus	129
Actinotaenium	214
Anabaena	52
Amphipleura	202
Amphora	162
Ankistrodesmus	222
Ankyra	221
Aphanizomenon	51
Aphanocapsa	67
Aphanochaete	15
Aphanothece	66
Asterionella	78
Asterococcus	89
Asteromphalus	128
Aulacodiscus	135
Aulacoseira	27
Auliscus	135
Batrachospermum	11
Botryococcus	86
Brachysira	198
Bulbochaete	15
Caloneis	194
Calothrix	48
Campylodiscus	151
Carteria	116
Centronella	147
Ceratium	123
Chaetoceros	143
Chaetopeltis	95
Chaetophora	16
Chamaesiphon	57
Chara	2
Chlamydomonas	122
Chlorella	209
Chlorogonium	117
Chodatella	208
Chromulina	113
Chroococcus	65
Chroomonas	120
Cladophora	23
Closterium	224
Cocconeis	152
Coelastrum	98
Coelosphaerium	61
Coleochaete	12
Coscinodiscus	138
Cosmarium	216
Craticula	199
Crucigenia	105
Cryptomonas	120
Cyclotella	137
Cylindrospermum	50
Cymatopleura	154
Cymbella	164
Desmidium	33
Diadesmis	189
Diatoma	29 and 146
Diatoma mesodon	184
Diatoma hyemalis	185
Dictyosphaerium	85
Didymosphenia	169
Dinobryon	7
Diploneis	153 and 203
Draparnaldia	17
Elakatothrix	84
Ellerbeckia	133
Encyonema	164
Enteromorpha	35
Epithemia	172
Eudorina	74
Euglena	112
Eunotia	161
Fragilaria	28
Fragilaria crotonensis	189
Fragilaria capucina	189
Fragilariformis	187
Frustulia	203
Geminella	31
Glenodinium	125
Gloeocapsa	65
Gloeocystis	89
Gloeotrichia	49
Golewkinia	207
Gomphonema	169
Gomphosphaeria	60
Gongrosira	20
Gonium	74

4.4 Algal identification: bibliography

This bibliography is provided as a supplement to the main reference list at the end of the book, and is intended to help readers who wish to go into more detail with identification of both genera and species within the genera.

Anagnostidis, K and Komarek, J. (1985) Modern approach to the classification system of cyanophytes 1 – Introduction. *Archiv für Hydrobiologie*, Suppl. 71 (Algological Studies 38–39): 291–302.

Anagnostidis, K and Komarek, J. (1988) Modern approaches to the classification system of cyanophytes 3-Oscillatoriales. *Archiv für Hydrobiologie*, Suppl. 80 (Algological Studies 50–53) 327–472.

Barber, H.G. and Haworth, E.Y. (1981) A guide to the morphology of the diatom frustule. Freshwater Biological Association, Scientific Publication No. 44, Ambleside, UK.

Bellinger, E.G. (1992) A Key to Common Algae, Freshwater and Some Coastal Species, 4th edition. Institute of Water and Environmental Management, London.

Bourelly, P. (1966) Les Algues D'Eau Douce. Tome 1: les Algues vertes. Editions N. Boubee and Cie, Paris.

Bourelly, P. (1968) Les Algues D'Eau Douce. Tome 2: Les Algues jaunes et brunes. Chrysophycees, Pheophycees, Xanthophycees et Diatomees. Editions N. Boubee and Cie, Paris.

Bourelly, P. (1970) Les Algues D'Eau Douce. Tome 3: Les Algues blues et rouges. Les Eugleniens, Peridiniens et Cryptomonadines. Editions N. Boubee and Cie, Paris.

Brook, A.J. (1981) The Biology of Desmids. Blackwell, London.

Capstick, M.E. (2004). An assessment of the Bacillariophyceae (diatoms) present in the sediments of Rostherne Mere, Cheshire. Life Sciences MSc thesis, University of Manchester, UK.

Carr, N.G. and Whitton, B.A. (Eds) 1982. The Biology of Cyanobacteria. Blackwell, London.

Chorus, I and Bartrum, J. (eds) 2002 Toxic Cyanobacteria in Water. Spon press, London and New York.

Cox, E.J. (1996) Identification of Freshwater Diatoms from Live Material. Chapman & Hall, London.

Croasdale, H. and Flint, E.A. (1988) Flora of New Zealand, Desmids vol. II. Botany Division, D.S.I.R., Christchurch, New Zealand.

Desikachary, T.V. (1959) Cyanophyta. Indian Council of Agricultural Research, New Delhi.

Fritsch, F.E. (1956) The Structure and Reproduction of the Algae, volumes 1 and 2. Cambridge University Press, Cambridge, UK.

Hartley, B. (1996) An Atlas of British Diatoms based on illustrations by H.G. Barber and J.R. Carter, edited by P.A. Sims. Biopress Ltd, UK.

Hendey, N. Ingram (1964) An Introductory Account of the Smaller Algae of British Coastal Waters. Part V: Bacillariophyceae (Diatoms). HMSO, London.

Hustedt, F. (1930) Bacillariophyta (Diatomeae) Heft 10. In A. Pascher: Die Susswasser-Flora Mitteleuropas. Gustav Fischer, Jena.

John, D.M., Whitton, B.A. and Brook, A.J. (2002) The Freshwater Algal Flora of the British Isles. Cambridge University Press, Cambridge, UK.

Kelly, M. (2000) Identification of common benthic diatoms in rivers. Field Studies, 9, 583–700.

Leedale, G.F. (1967) Euglenoid Flagellates. Prentice-Hall Biological Science series. Englewood Cliffs, N.J.

Lind, E.M. and Brook, A.J. (1980) Desmids of the English Lake District. Freshwater Biological Association UK. Scientific publication No. 42. FBA, Ambleside, UK.

National Rivers Authority (1990) Toxic Blue-green Algae. National Rivers Authority, Water Quality Series No 2, UK.

Palmer, C.M. (1962) Algae in Water Supplies. US Department of Health, Education, and Welfare, Washington DC.

Pascher, A. (1913–36) Die Susswasserflora Deutchlands, Osterreichs und der Schweiz 15 vol.

Patrick, R. and Reimer, C.W. (1966, 1975) The Diatoms in the United States, 2 vols. Monographs of the Academy of Natural Sciences, Philadelphia.

Pentecost, A. (1984) Introduction to Freshwater Algae. Kingprint Ltd, Richmond, UK.

Prescott, G.W. (1951) Algae of the Western Great Lakes Area. Wm. C. Brown, Dubuque, IA. Reprint edition (1982) by Otto Koeltz Science Publishers, Koenigstein, Germany.

Prescott, G.W. (1964) The Freshwater Algae. WM. C. Brown Publishers, Dubuque, IA, USA.

Round, F.E., Crawford, R.M. and Mann, D.G. (1990) The Diatoms: Biology and Morphology of the Genera. Cambridge University Press, Cambridge, UK.

Smith, G.M. (1950) Freshwater Algae of the United States. McGraw Hill, New York.

Van Den Hoek, C., Mann, D.G. and Jahns, H.M. (1995) Algae. An Introduction to Phycology. Cambridge University Press, Cambridge, UK.

Wehr, J.D. and Sheath, R.G. (2003) Freshwater Algae of North America. Ecology and Classification. Academic Press, London.

West, G.S. and Fritsch, F.E. (1927) A Treatise on the British Freshwater Algae. Cambridge University Press, Cambridge, UK.

West, W. and West, G.S. (1904) A Monograph of the British Desmidiaceae, Vols I to III. The Ray Society, London.

Glossary

Acicular Needle-shaped

Acuminate Tapering gradually towards the apex

Akinete Blue-green algal resting spore with thickened walls, formed from a vegetative cell. Usually much larger than vegetative cells

Algae Phylogenetically-diverse group of simple (mainly unicellular to colonial) organisms that have chlorophyll-*a* as their main photosynthetic pigment and lack a sterile covering of cells around reproductive cells. Carry out oxygenic photosynthesis, and include eukaryotes and prokaryotes.

Algal bloom Dense population of planktonic algae that distinctly colours the water and may form a scum on the surface

Algal trophic index Quantitative expression of algal species counts, providing a measure of the trophic (nutrient) status of the aquatic environment

Allochthonous Material, usually organic, produced outside the particular aquatic system and then entering into it, e.g. tree leaves falling into a stream

Alternating series Group of cells arranged side by side but with every other cell displaced either up or down relative to the mid-line (contrast with linear series)

Annular Shaped like a ring

Anterior Front end, i.e. the end at the front of motile forms, or top end

Apical axis Axis linking the two poles (ends) of the cell

Araphid Diatom without a raphe system on either valve

Arcuate Bow-shaped, strongly curved

Areolae Regular perforated markings on the wall of a diatom, forming a distinct pattern

Attenuate Narrowing to a point

Autochthonous Material (usually organic) produced within a water body

Autotroph Organism capable of synthesizing organic matter by means of photosynthesis (see also *phototroph*)

Auxospore Diatom resting spore, formed by sexual or vegetative activity. Allows size restitution of the cell to occur

Axial area Clear or hyaline area in diatom frustule, running along the apical axis and usually containing the raphe

Baeocyte Blue-green algal spore produced by successive divisions of a mother vegetative cell. These cells are then released into the surrounding water

Benthos Organisms living at the bottom of an aquatic system, associated with the sediments

Bifurcate Forked into two branches

Freshwater Algae: Identification and Use as Bioindicators Edward G. Bellinger and David C. Sigee

Bioindicators Particular species or groups of organisms with distinctive ecological preferences. Their environmental presence indicates physico-chemical aspects such as high pH, low inorganic nutrient level and high turbulence

Biseriate Double row of cells or pores on a cell wall

Biodiversity Range of taxonomic, phenotypic or genetic characteristics within a taxonomic unit, population or community

Biofilm Community of microorganisms occurring at a physical (e.g. water/solid) interface, typically present within a layer of extracellular polysaccharide that is secreted by the community

Biomass Mass of individual organisms or a set of organisms, usually expressed as dry weight

Biotic index See *algal trophic index*

Biovolume Volume of single algae and algal populations. Usually expressed for phytoplankton in three ways – the average volume of organisms in a particular species (mean unit biovolume), the volume occupied by single species populations per unit volume of lake water (species population biovolume) or the total volume of mixed phytoplankton per unit volume of lake water (total phytoplankton biovolume)

Bloom See *algal bloom*

Blue-green algae Phylum Cyanophyta. Major group of prokaryotic organisms that contain chlorophyll-*a* and carry out oxygenic photosynthesis. Also referred to as 'cyanobacteria'

Branching (true) Along the length of a filament one mother cell gives rise to two or more daughter cells, one of which continues the main axis whilst the others grow at an angle to produce an additional filament (the branch – see Figure 4.20)

(false) Lateral branches occur along a filament but they are formed by a second filament growing sideways and not by a single cell giving rise to two or more others which themselves form lateral branches (see Figure 4.21)

Brown algae Phylum Phaeophyta. Group of attached brown-pigmented eukaryote algae, poorly represented in freshwater environments

Bulbous Bulb-like, swollen at one end

Calyptra Hood or cap-like covering usually appearing on the apical cells of some filaments

Capitate With one or both ends of a cell swollen into a head

Carinal dots Dots or short bar like markings spaced evenly along the keel (at one margin) edge of some diatoms (particularly *Nitzschia*)

Cell viability Ability of a cell to perform the range of functions typical of a living entity

Central nodule Central thickening on a diatom cell wall, between the raphe endings

Centric Diatoms that are radially symmetrical and usually circular in outline from the valve view

Chaetae Hair or bristle like growths of the cell wall

Chemical fixation Addition of chemicals (e.g. aldehyde, alcohol, iodine) to an algal sample to kill and preserve the cells, retaining as much of the original colour and morphology as possible

Chloroplast Organelle within the cell concerned with photosynthesis and containing the photosynthetic pigments. Often green in colour but can be golden to brown (or other colour) depending upon the combination of pigments present

Chrysolaminarin Polysaccharide storage product found in several algal groups. Also called leucosin

Chrysophytes Phylum Chrysophyta. Group of golden-brown eukaryote algae

Cingulum Part of the girdle region of a diatom associated with one valve

Clathrate With obvious spaces between the cells

Clavate Club shaped

Coccoid Cells that are rounded or spherical

Coenobium Colony of cells, often arranged in a specific way and of constant number (typically a multiple of four). The number is determined early on in its development and no further increase takes place until a new generation develops.

Coenocytic Having multinucleate cells or structures (e.g. in *Vaucheria*) with no division into cells

Colony A discrete group of cells joined together more or less permanently, or enclosed within the same mucilage or sheath

Contractile vacuole Small, usually spherical, body which regularly fills and then contracts, expelling water from the cell. Associated with osmoregulation, typical of flagellates

Costae Elongate thickening (rib) on a diatom valve (singular costa)

Crenulate Gently wavy

Crescent-shaped Shaped like the arc of a circle and tapering towards the ends

Cruciform Having four arms and shaped like a cross

Cryptomonads Phylum Cryptophyta. Group of unicellular motile eukaryote algae

Cuneate Wedge-shaped

Cyanobacteria See *blue-green algae*

Cyst Thick-walled resting spore whose walls may be impregnated with silica

Daughter cells Cells formed by division of the mother cell

Daughter colony New colony arising within a mother cell or mother colony

Dendroid Tree like, branching like a tree or bush. Used to describe the colony shape in *Dinobryon*, which is not truly filamentous

Diatoms Phylum Bacillariophyta. Group of non-motile eukaryote algae, with silica cell walls (see *frustule*)

Diatom indices Use of diatom species counts to assess trophic status of a water body (see also *algal trophic index*)

Dichotomous Branching or dividing to form two equal-sized branches

Dominant species An algal species that is able to grow actively in a particular situation, out-competing other algae and forming the major part of the phytoplankton biomass

Dinoflagellates Phylum Dinophyta. Group of unicellular, highly motile eukaryote algae

Dinospores Flagellated stage in the life cycle of parasitic forms

Dorsal Upper or more convex surface of a cell (as opposed to lower or ventral) e.g. in the diatom *Cymbella*

Dorsiventral Cell with two margins showing different curvature

Dorsiventral flattening Flattened in cross section (cell), similar to laterally flattened or flattened in side view

Dystrophic Waters rich in organic matter where the rate of decay of that organic matter is slow. These waters are typically coloured brown or yellow and have a low pH

Ecosystem Self-regulating biological community living in a defined habitat

Ellipsoidal Figure with curved margins but elongate ends which are sharply rounded

Endospores Non-motile spores produced in indefinite numbers from a parent cell e.g. in *Chamaesiphon*

Environmental stress factor External change that impairs biological function at the level of ecosystems, individual organisms and molecular systems

Epicingulum Girdle sections produced from the parent cell in diatoms

Epicone The upper or anterior part of a dinoflagellate cell

Epilimnion The surface layer of a stratified water body

Epilithic Living on rock surfaces

Epipelic Living on fine sediments

Epiphytic Living on plant surfaces – including macrophytes, phytoplankton and benthic algae (see also *phycosphere*)

Epipsammic Occurring on sand grains

Epitheca Part of the cell wall of a dinoflagellate above the transverse furrow or in diatoms the epivalve + epicingulum derived from the mother cell

Epivalve Valve derived from the mother cell

Euglenoids Phylum Euglenophyta. Group of unicellular motile eukaryote algae

Eukaryote Unicellular or multicellular organism, with cells that contain a membrane-bound nucleus and characteristic cytoplasmic membrane-bound organelles (see also *prokaryote*)

Euphotic zone See *photic zone*

Eutrophic Aquatic system rich in inorganic nutrients, especially nitrogen and phosphorus, with high primary productivity

Eutrophication Increase in the aquatic concentration of soluble inorganic nutrients such as phosphates and nitrates

Exospore Blue-green algal spore, produced by budding from another cell

Eye-spot Complex of granules, usually red or brownish in colour, sensitive to light and found at the anterior end of some motile species

False branching See *branching*

Fibula In diatoms, a bridge of silica between parts of the valve either side of the raphe

Filament Series of cells forming one or more rows in a linear arrangement (cells stacked end to end)

Flask-like Broad at the base and abruptly narrowing to a neck

Flow cytometry Automated technique used to quantify particulate suspensions

Fluorimeter Instrument used to measure the intensity and wavelength distribution of light emitted as fluorescence from chlorophyll and other pigments

Food chain Linear progression of feeding from one major group of organisms to another, describing the main sequence of biomass transfer

Fossil algae Term used to describe the remains of algae that persist within (particularly lake) sediments

Frustule Cell wall in diatoms, made of silica and composed of two halves (valves) linked together by a number of bands -collectively called the girdle

Fusiform Elongate shape broadest at the centre and tapering at each end (spindle or cigar shaped)

Gas vacuole Gas-filled vacuole, found in some aquatic blue-green algae and bacteria, that increases buoyancy. It is composed of gas vesicles, which are made of protein

Genuflexed Crooked in the middle, bent at an angle – similar to a person bowing at the knee

Gibbous Swollen to form a small locally occurring bump, usually at the centre

Girdle Zone of silica bands linking the two halves of a diatom frustule

Girdle view Aspect of diatom frustule, with the girdle or area where the two halves of a diatom cell being visible (as opposed to the valve view when the girdle generally cannot be seen)

Glaucous Greyish-green or green with a white overcast

Glycogen Starch-like storage product found in blue-green algae

Gonidia Spore-like thick-walled reproductive cells in blue-green algae

Green algae Phylum Chlorophyta. Major group of eukaryote algae that have predominantly green coloration

Gullet Canal or groove at the anterior end of the cell, opening at its base into a chamber. Found in some flagellates

Habitat The living place of an organism or community, characterized by its physicochemical and biotic properties

Heterocyst Distinctive enlarged cell present in some blue-green algae, with thickened walls and often with a highly refractive appearance. Involved in nitrogen fixation

Heteropolar The two ends (poles) of a diatom cell are differently shaped

Heterotroph Organism that obtains organic matter from an external source (see *phototroph*)

Heterovalvar Each valve of a diatom is a different shape

H-pieces Sections of the cell wall in a filamentous alga where the wall is composed of two overlapping halves that appear shaped like an 'H'. When the cells of the filament separate (or break up) they do so at the centre rather than the end, releasing the H-pieces

HPLC High-performance liquid chromatography

Holoplanktonic Aquatic organisms which are present in the water column over most of the annual cycle

Hormogonium Short part of a filament in blue-green algae that can be released and form a new filament, thus serving as a reproductive and dispersal mechanism

Hyaline Transparent and colourless

Hydrology All aspects of water flow connected with an aquatic system, including inflow and outflow of water.

Hypertrophic Also called *Hypereutrophic*. Waters with extremely high levels of dissolved inorganic nutrients

Hypocone Lower part or posterior portion of a dinoflagellate cell

Hypotheca Lower half of the cell of a dinoflagellate

Imbricate Overlapping

Integrated depth sample Mixed sample, derived from different depths in the water column

Intercalary Arranged within a series of cells rather than being at the end or alongside, such as can occur with heterocysts in blue-green algae

Inverted microscope Compound microscope with the objective lens placed below the specimen, facing upwards

Iodine test The application of weak iodine solution to stain starch a blue-black colour

Isobilateral Each side of the cell, as divided by the longitudinal axis, is the same shape

Isopolar Both ends (poles) of the cell are the same shape and size

Isthmus The narrow central part of a desmid cell connecting the two semicells

K-selected species (K-strategist). Organism adapted to survive, grow and reproduce in a crowded environment, where it is subjected to high levels of competition from other biota (see also *r-selected species*)

Keel The channel or flange, sometimes raised on ribs or struts, in which the raphe runs. Present in some diatoms, e.g. *Surirella*

LAB Long as broad, used to compare length and breadth dimensions of cells

Lamellate Composed of layers (also laminate)

Lanceolate Lance-shaped, long and narrow with a small increase in diameter in the mid region and tapering towards the ends

Lentic Standing bodies of water such as lakes and ponds

Lenticular Lens-shaped or hemispherical

Leucosin Whitish food reserve characteristic of many chrysophytes and usually found as highly refractive rounded particles

Limnology Study of aquatic systems contained within continental boundaries.

Linear series Row of cells arranged side by side in a straight line (for comparison see *alternating series*)

Littoral zone Peripheral shoreline at the edge of lakes and rivers

Lorica Shell or open flask like structure in which the organism lies. The shape varies but there is always an opening at one end, sometimes with a collar through which a flagellum may pass

Lotic Flowing waters such as rivers and streams

Lunate Crescent or moon shaped

Macrophyte Large aquatic plant (e.g. water-lily – *Nuphar*), as opposed to smaller plants such as duckweed (*Lemna*), macroscopic algae (e.g. *Cladophora*) and phytoplankton

Mantle Marginal part of a diatom frustule

Marginal lines Lines of markings, or clear areas within markings, running parallel to the margin of a cell. Usually used in descriptions of diatom morphology

Marginal processes Structures that occur around the margin of some diatom cells

Matrix Organic material, especially mucilage, surrounding a cell

Median groove Groove or channel running around the mid-region of a cell. Present in dinoflagellates (where one of the two flagella occurs in the median groove) and some desmids (where there is an indentation between the two semicells)

Meroplanktonic Algae with only a limited planktonic existence in the water column. Most of the annual cycle is spent on sediments as a resting stage

Mesotrophic Waters with moderate levels of inorganic nutrients and moderate primary productivity. Intermediate state between oligotrophic and eutrophic

Metaboly Ability of a unicellular organism (without a rigid cell wall) to change its shape – as in some species of *Euglena*

Microalgae Term generally applied to microscopic algae, planktonic or benthic, with sizes up to about 200 μm

Microenvironment Small-scale habitat occurring within a general ecosystem.

Microorganism Organism not clearly visible to the naked eye, requiring a microscope for detailed observation

Microplankton Unicellular and multicellular planktonic organisms in the size range 20–200 μm

Mixotrophy Ability of organisms to combine autotrophic (using inorganic electron sources) and heterotrophic (organic carbon sources) nutrition. The term is sometimes used more specifically to describe algae that can carry out photosynthesis and phagotrophy

Molecular probe Short-chain oligonucleotide produced in the laboratory as a diagnostic tool. Specifically attaches to target nucleotide in algal cells, permitting *in situ* identification of species

Mother cell Cell that divides to form two or more offspring (daughter cells)

Mucilage Organic material, often made of polysaccharides, which swells in water and is slimy to touch (see also *matrix*)

Multiseriate Composed of many rows

Nanoplankton Unicellular planktonic organisms in the size range 2–20 μm

Nephelometer Submerged instrument used to determine particulate concentration (turbidity) of water by collecting light from suspended matter

Obliquely flattened Flattened at an angle, neither horizontally or vertically

Obovoid Approximately oval but with one end (termed the anterior) broader than the other

Ocelli Singular ocellus. Thickened rimmed plate of silica with a number of pores on its surface on a centric diatom valve

Oligotrophic Waters low in dissolved inorganic nutrients (particularly nitrogen and phosphorus) resulting in low levels of biological productivity

Organotroph Organism that either uses reduced organic compounds as its source of electrons or carries out organotrophy (osmotrophy)

Osmotrophy Obtaining organic nutrition from an external source by uptake of soluble organic compounds over the cell surface. Also referred to as organotrophy, saprotrophy

Ovoid Egg shaped

Paramylon Solid starch-like food reserve found in some euglenoids

Parietal Arranged at or around the wall of a cell

Pelagic Organisms normally present in the water column of water bodies, divided into plankton and nekton

Pelagic zone The main central part of a lake

Pellicle Thin membrane covering a cell that has no true wall

Pennate Diatoms that are bilaterally symmetrical about the apical axis

Peptidoglycan Mucopeptide: large cell wall polymer typical of bacteria and blue-green algae, composed of long chains of alternating *N*-acetylglucosamine and *N*-acetylmuramic acid residues

Perforation With holes or spaces between the cells

Periphyton Community of mainly plant-like organisms present on underwater substrata – including algae, bacteria and fungi

Periplast Cell membrane of euglenoids, or other bounding membrane

Periphyton Algal communities living on submerged surfaces

Phagotrophy Obtaining organic nutrition from an external source by ingestion and intracellular digestion of particulate organic matter

Photic zone Upper part of water column in which net photosynthesis can occur (also known as the *euphotic zone*). The lower limit is referred to as the photic depth

Phototroph Organism that uses solar energy to manufacture organic compounds by photosynthesis

Phycobilins Water soluble pigments present in blue-green algae, red algae and cryptomonads

Phycocyanin Blue-green pigment in the cells of blue-green algae

Phycosphere Microenvironment occuring within and immediately around the surface of algae

Phytoplankton Free-floating photosynthetic microorganisms, including algae and bacteria

Picoplankton Unicellular planktonic organisms in the size range 0.2–2 μm. Mainly prokaryotes

Polar nodule Body on the inner wall at the end (pole) of some diatoms and other algae

Posterior Rear end, i.e. the end at the back of motile forms, or bottom end.

Primary production Synthesis of biomass by photosynthetic organisms – higher plants, algae and photosynthetic bacteria. The first stage of biomass formation in freshwater ecosystems

Productivity The intrinsic rate of increase in biomass (growth rate) in a population of organisms. Can be expressed as net or gross productivity (see also *primary production*)

Programmed cell death PCD. Genetically determined sequence of cellular changes, leading to death

Prokaryote Unicellular or colonial organism, with cells that lack a membrane-bound nucleus and do not have the membrane-bound organelles seen in eukaryotes

Prostrate Creeping or growing over a substrate and being closely adhering to it

Pseudocilium Flagellum-like structure, but not an organ of locomotion. Found in the Tetrasporales

Pseudoparenchymatous Appearing like parenchyma but in reality is made up of closely packed filaments

Pseudoraphe False raphe in diatoms. A clear area between makings on the valve surface which forms an area in the position of a true raphe – but no canal, visible as a line, is present

Punctate Small dots or pores on the surface of a diatom frustule usually forming a characteristic pattern

Pyrenoid Protein body in the cell associated with the chloroplast. May have a sheath of starch (depending on genus) which stains darkly with iodine

Pyriform Pear shaped, with a wider base than top

Quadrate Square or rectangular in shape

r-selected species (r-strategist) Organism adapted to an uncrowded environment, with low competition from other biota. Typically pioneer organism (see also *K-selected species*)

Raphe Longitudinal canal (visible as a line on the surface) in the wall of some diatoms. Some genera have a raphe on one valve some on both and others no raphe at all. The raphe is associated with gliding movements in some genera

Raphe ribs Longitudinal ribs running alongside the raphe

Red algae Phylum Rhodophyta. Group of red-pigmented eukaryote algae that are typically attached (non-planktonic)

Reniform Kidney shaped

Reticulate Like a net in its arrangement

Rhomboid Parallelogram with oblique angles and adjacent sides unequal

Ribbon like Large numbers of elongate cells joined by their sides to form a filament like structure. In transverse section, however, a ribbon is never circular (see *Fragilaria crotonensis*)

Rostrate Narrowing or ending in a beak

Saprobic pollution High concentrations of soluble organic nutrients.

Saline lakes Sometimes called Salt lakes. These are lakes where evaporation from the surface greatly exceeds any inputs so that dissolved chemicals become concentrated often resulting in white salt 'crusts' round their margins

Scalariform Ladder like

Secchi depth Depth within a water column at which a suspended sectored plate (Secchi disc) can no longer just be seen. Provides a useful measure of water turbidity and phytoplankton biomass

Sedgwick–Rafter slide Commonly used counting chamber for phytoplankton samples

Sedimentation Sinking of non-motile plankton in the water column due to gravitational forces

Segment shaped Shaped like the segment of an orange

Semicell One half of a desmid cell

Senescence Series of structural and metabolic changes leading to death

Septum Cross partition either completely or partly across a diatom cell dividing it into chambers

Seta Hair-like growth arising from a cell

Setiferous Bearing setae or hairs

Sheath A covering envelope (sometimes thin) enclosing a filament or group of cells

Sickle shaped Acutely curved or crescent shaped

Sigmoid Shaped like an S

Siliceous wall Cell wall impregnated with silica in diatoms and often bearing distinctive markings. Its presence can be detected by digesting the organic matter with an oxidizing agent leaving the silica wall behind. Diatoms have distinctive silica cell walls but some other algae have small silica scales on the outside of the cell wall e.g. in some members of the Chrysophyta

Sinus Deep furrow between the semicells of a desmid

Siphonaceous Tubular or filamentous-like thallus having no cross walls e.g. in *Vaucheria*

Spathulate Broad upper part tapering gradually to form a stalk

Starch test When a solution of iodine is applied to the specimen, if starch is present a blue or blue-black colour is produced (see *iodine test*)

Stauros Thicker hyaline region on a diatom valve extending from the central nodule to the margins of the valve

Stellate Star shaped

Sternum Hyaline region running along the long axis of a diatom valve in diatoms that have no raphe (araphid) with striae either side

Stomatocyst Resting stage with a silicified cell wall found in chrysophytes

Strand Group of cells joined side by side to form a filament-like structure (see also *ribbon*)

Stratification Vertical structuring of static or very slow moving water bodies into three distinct layers – epilimnion, metalimnion and hypolimnion. Determined by temperature and circulatory differences within the water column

Striae Delicate, sometimes long narrow markings or lines on the valve of a diatom

Sub-pyramidal Shaped like a pyramid but with the top cut off

Succession Temporal sequence of organisms that occurs in a developing community such as a biofilm or lake pelagic community

Sulcus Narrow pair of furrows that may be found in the girdle area of some filamentous diatoms

Test Rigid urn- or pot-shaped surround to a cell with a space between it and the cell inside

Thallus Plant body with little differentiation into tissues

Theca See *test*

Transapical At right angles to the apical or long axis in diatoms

Transfer functions Mathematical models that allow contemporary phytoplankton data to be applied to fossil diatom assemblages for the quantitative reconstruction of past water quality

Trichome Thread-like series of cells, exclusive of the sheath, found in blue-green algae

Triradiate With three arms radiating out from a central position

Trophic Connected with nutrition and feeding. The term is used to describe the inorganic nutrient status of different water bodies (oligotrophic to eutrophic), and the feeding relationships (trophic interactions) of freshwater biota

Trophic index See *algal trophic index*

True branching See *branching*

Truncate Cell with a flat top or end

Turbidity Cloudiness in water caused by suspended particulate matter. Used as a measure of phytoplankton biomass (see *Secchi depth* and *nephelometer*)

Tychoplankton Organisms circumstantially carried into the plankton, often from plant or rock surfaces. Also referred to as ‘accidental plankton’ or ‘pseudoplankton’

Undulate With a wavy surface or edge

Unilateral Pertaining to one side only

Uniseriate Formed as a single row (of pores in diatoms or cells in other algae)

Vacuole Space in the cytoplasm lined by a membrane, filled with fluid or occasionally granules

Valve One of the two halves of a diatom frustule

Valve mantle Margin of a diatom valve, sometimes with a definite slope or structure

Valve view View of a diatom cell looking at the valve face and not seeing any overlapping portions (as opposed to the girdle view)

Ventral The less convex margin of a dorsiventral cell, e.g. in the diatom *Cymbella*

Water bloom See *algal bloom*

Water column The vertical depth of water in a river or lake, from surface to bottom (sediments).

Water quality Range of organic and inorganic chemical characteristics of the water in a particular aquatic system.

Whorls Several branches arising at the same point around a main axis e.g. in *Chara*

Xanthophylls Yellow, carotene derived, photosynthetic pigments

Yellow-green algae Phylum Xanthophyta. Non-motile, single-celled or colonial algae with a yellow or fresh green coloration

Zooplankton Diverse assemblage of invertebrate planktonic organisms

Zoospore Motile sexual spore

Zygospore Thick-walled resting spore formed from the fusion of two gametes