DESMIDS: WHAT ARE THEY?

Nowadays most people have heard about freshwater algae, especially the unpleasant kinds; they may have forgotten all about the harmless and beautiful Green alga Spirogyra they saw as one of the 'types' in the biology class. Most people also appreciate that nearly all freshwater algae are very small and invisible to the naked eye. In fact, they were unknown until the middle of the 17th Century when microscopes were developed as practical instruments though at that time very few people had one (Allen 1976). Nevertheless, about 30 years after Abel Tasman sailed up our West Coast, van Leeuwenhoek, a fellow countryman, had become one of the early microscopists and in a letter dated 7th September 1674 described a microscopic organism, from a nearby pond, which long afterwards was named Spirogyra (Dobell 1932).

Among the close relations of Spirogyra there is a large group of freshwater algae referred to as desmids. The name 'desmid' derived from the Greek word for 'chain', has become something of a misnomer because the number of named unicellular desmids now far exceeds the number of filamentous and colonial species. Like many other Green algae, desmids were claimed by botanists and zoologists until the middle of the last century and after this argument ceased, they were confused with another group of mainly unicellular algae, diatoms; the Oxford Dictionary quotes phrases from literature, published up to 1871, where the word 'desmid' seems to refer to diatoms.

Although most desmids are single cells, they display a 'bewildering variety of shape' (Fritsch 1953). In some genera the shape is simple, in others it is complex and extremely elegant. Ornament on the cell wall is often elaborate and arranged in complicated patterns. Fritsch 1935) thought desmids included some of the most beautiful microscopic objects; the Wests, authors of the Monograph on British desmids, went further and asserted that the beauty of desmids was unsurpassed, even by diatoms.

With a few exceptions, desmids have the following features in common:-

1. cells are divided into two parts or semicells, one being the mirror image of the other (Figs. 3-5,7,10,11)
2. cells are constricted in the middle; the constriction is the sinus and the central part, where the semicells join, is the isthmus.(Figs.3,4,21-24)

Closterium is one of the genera where the cell is not constricted.
3. cell division is the commoner method of multiplication; in genera with constricted cells, the isthmus lengthens slightly and two new semicells grow between those of the parent cell and separate; the two progeny each have one semicell a generation older than the other.
4. sexual reproduction consists of conjugation, similar to the process in Spirogyra, the contents of the two cells (gametes) fuse and form a thick-walled zygospore which in due course germinates, usually into two new individuals. (Figs. 6,12,16,18c,35c). Conjugation is rarely seen in the wild though Fritsch (1953) thinks this may be more apparent than real and reflect the 'natural limits set on the collecting zeal of the student'.
5. flagella are absent throughout the life-cycle of all desmids; gametes display amoeboid movement and vegetative cells of some genera (eg. Closterium, Cosmarium) glide over a surface or have a jerking movement.

The shape of the cell may be oval (Fig.1), cylindrical (Fig.2), elongated, tapering and curved (Figs.10,11) or flattened (Figs.17,21-23), even flattened like a disc (Figs.13-15); semicells may have a radial symmetry (Figs.25-28,30,31). The more complex shapes with elaborate ornament on the cell wall (i.e. depressions, pores, stripes, granules, spines) must be examined in front, side and end views (Figs.3,4,13-15,17,18,21-24).

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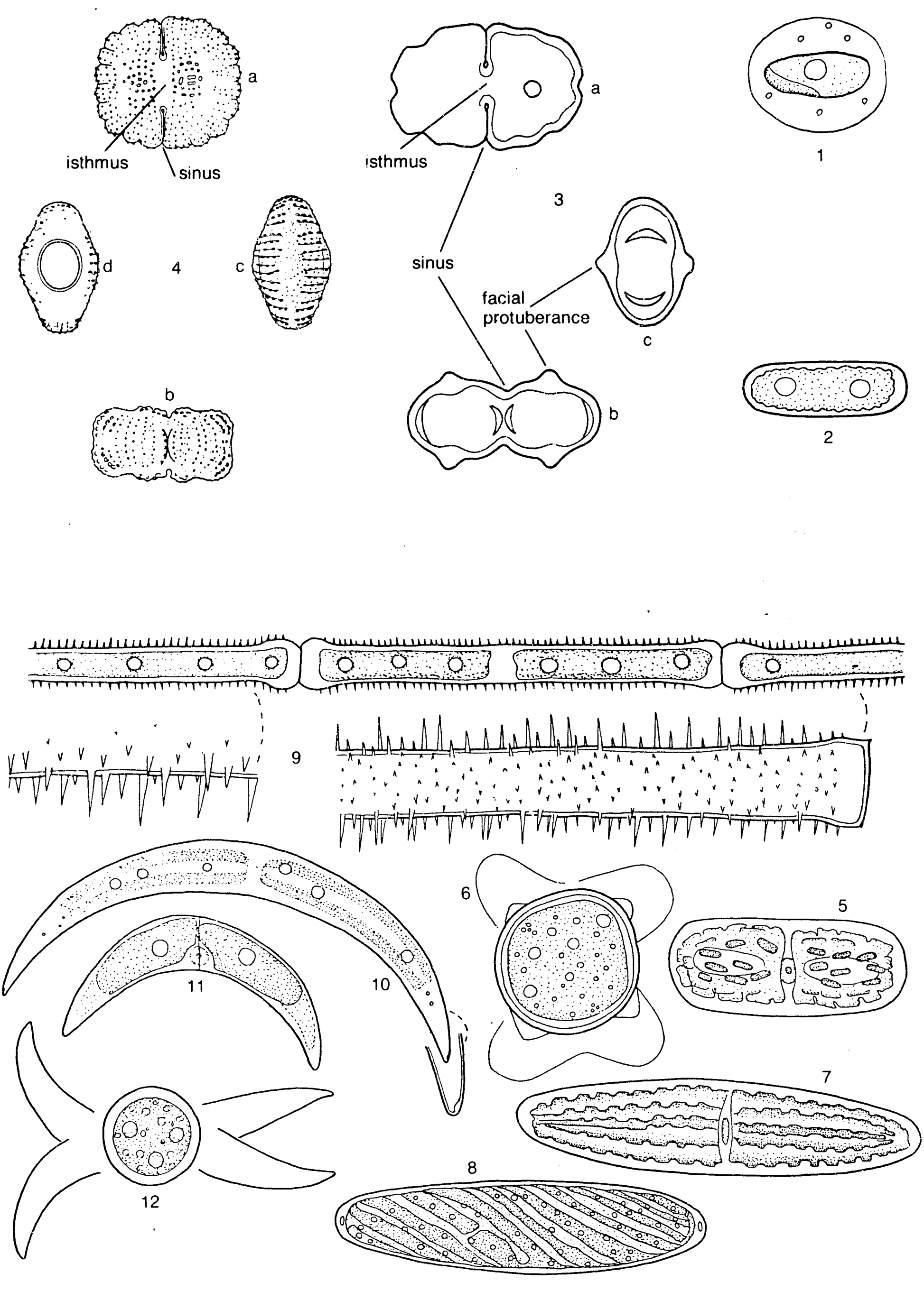
See opposite page for figs. Whenever possible, habitats in Canterbury have been given. a - e below apply to all figs.

a = front view b = side view c = end view (upper or lower end)

d = view of a isthmus of a semicell e = zygospore

Figs: 1. Mesotaenium chlamydosporum var. violascens x700 Omatangi near L. Taupo. 2. M. macrococcum x700 Okarito mire, soil at Bealey.
3. Euastrum cornubiense x1000 Not yet recorded in New Zealand.
4. Cosmarium caelatum x300 School pond in Hutt V. 5. Cylindrocystis brebissonii x600. 6. C.b., x500 zygospore and wall of parent.
7. Netrium digitus var. naegelii x350 L. Sarah. 8. Spirotaenia obscura x400 Christchurch, site unknown. 9. Gonatozygon aculeatum x400 L. Tikitapu. 10. Closterium parvulum. x500 L. Okareka.
11. C. incurvum x600 Unidentified mire in South Id. 12. C. parvulum x350 The filoments readily separate into single cells.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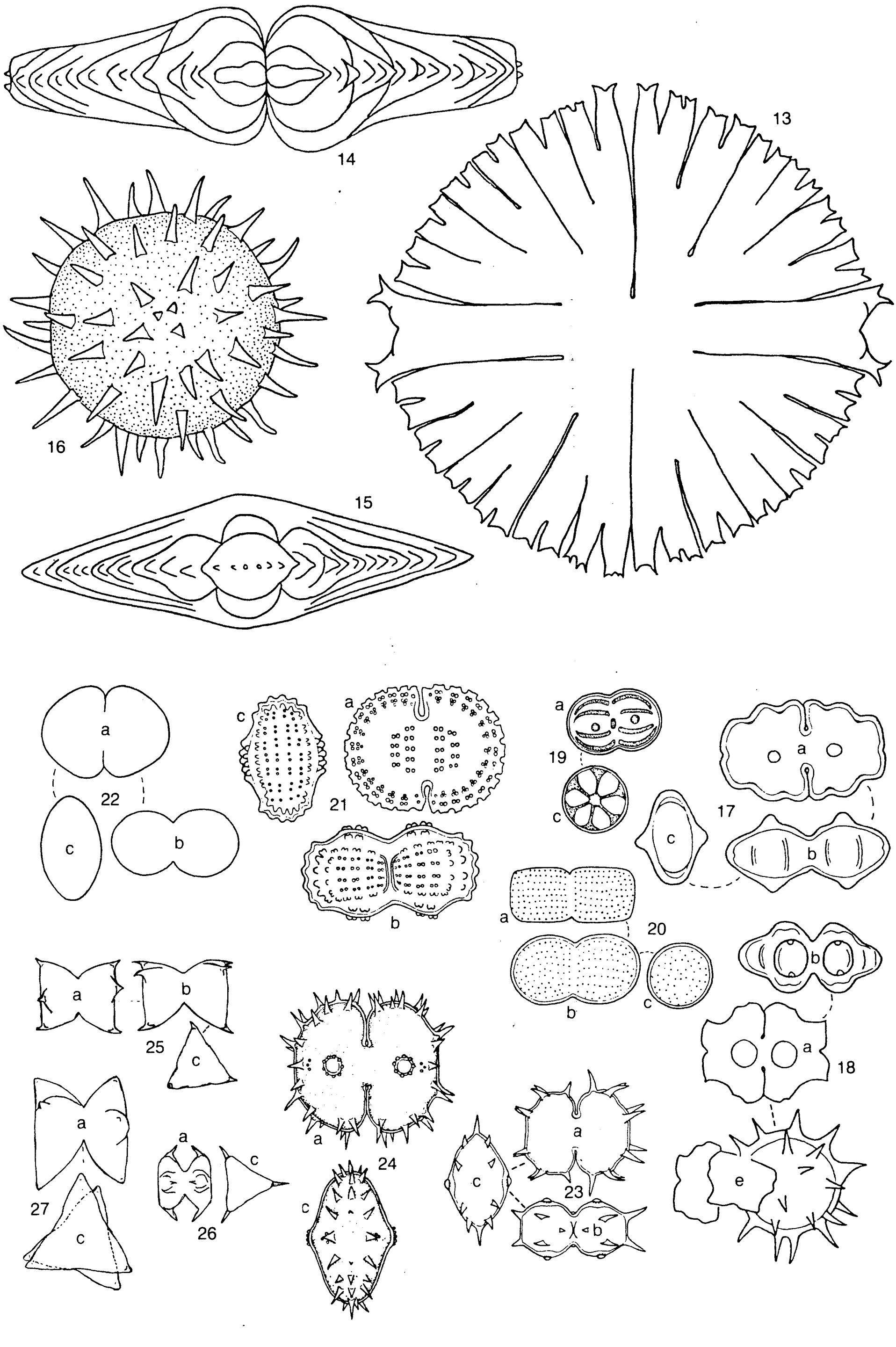
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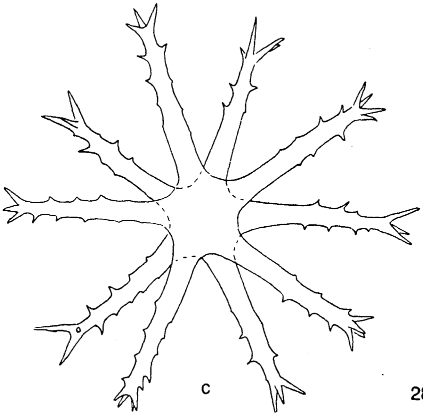

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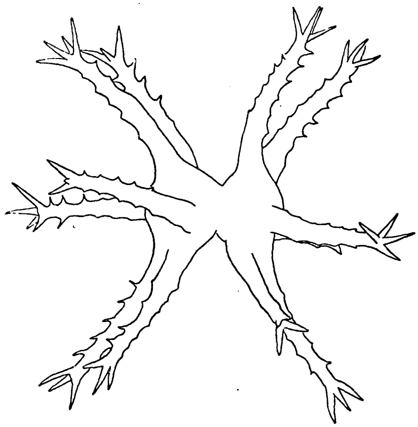

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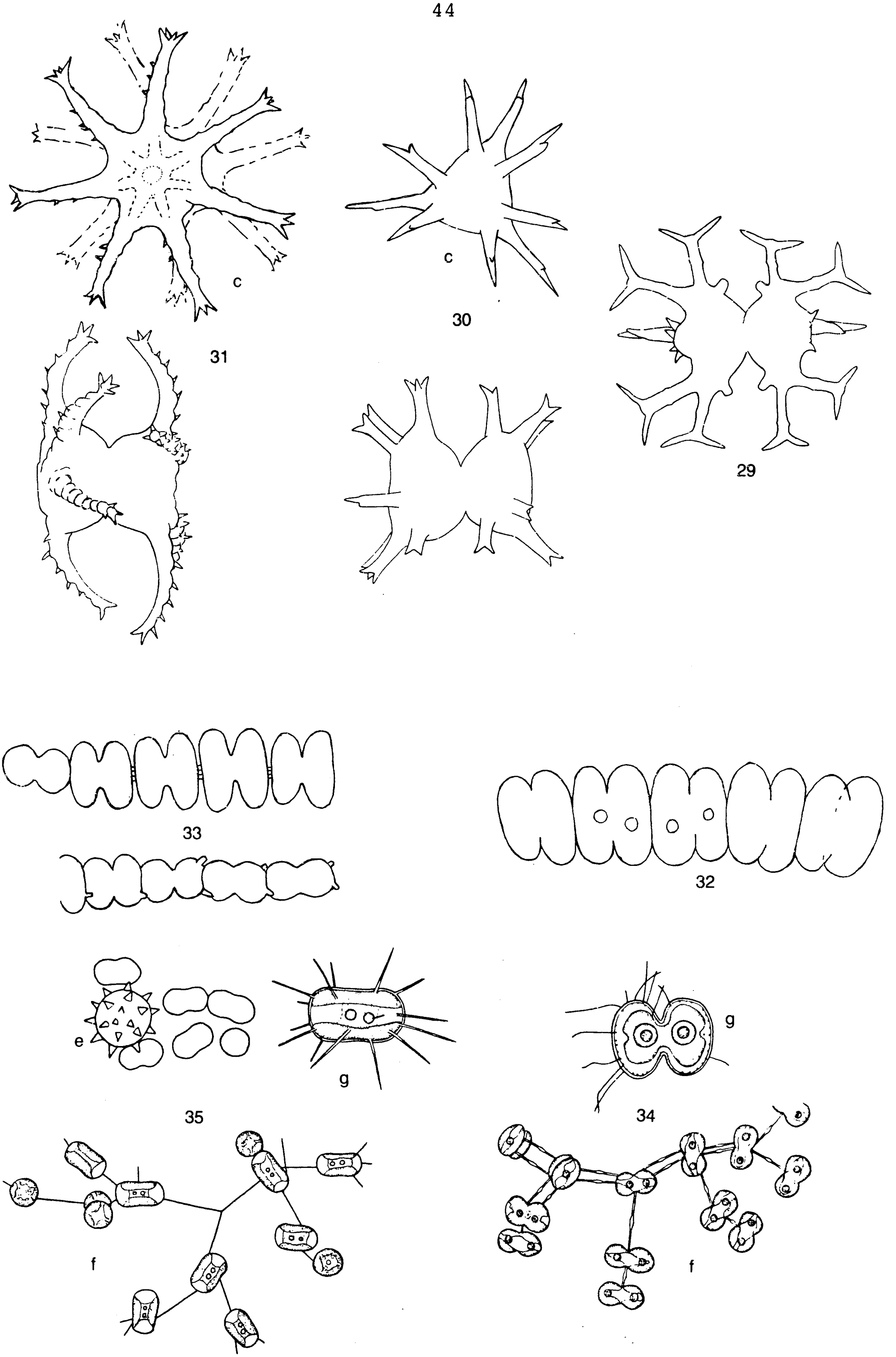
Figs: 13-16. Micrasterias rotata 13 x425, 14-16 x275 Cells recorded from Lakes Wakatipu and Poerua. Paerl et. al. (1979) found it in Lady L. Lakes Ahaura and Kangaroo. 17. Euastrum cornubiense var. cornubiense x1000 Not yet recorded in New Zealand. 18. E. binale var. gutwinskii x1000 Mire on Addisons Flat. 19. Actinotaenium globusum x325 L. Middleton. 20. A. colpopelta x425 May be in mire near Otaki. 21. Cosmarium quadrifarium var. hexastichum x300 Arthurs Pass; Waimakariri R. among water plants. 22. Cosmarium lundellii x200 L. Tikitapu.
23. Xanthidium cristatum x225 Hawkes Bay; site unknown. 24. X. aculeatum x225 as last. 25. Staurodesmus corniculatus x225 Ls Camp, Clearwater and Poeura. 26. Staurodesmus glaber x350 Pond near Craigburn. 27. S. spetsbergensis var. limneticus x350 L. Okataina, Okareka. 28. Staurastrum limneticum x375 L. Wanaka.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Cells are often enveloped in colourless mucilage which in some genera is secreted through special pores; the production of mucilage is involved in the movement of some desmids.

One of the most striking features inside the cell is the chloroplast; it can be simple but is often complicated (Figs.5,7-11,19) and contains one or more pyrenoids (structures associated with the formation and storage of starch.)

There are about 42 genera of desmids (depending on which classification is used); the most numerous are Cosmarium and Staurastrum, each with nearly 2000 species, varieties and forms. Only about a quarter of the genera are filamentous (Figs.9,32,33) or colonial (Figs.34,35).

Desmids are widespread in freshwater habitats; many thrive in bogs and swamps, among Sphagnum and other submerged mosses; some are common in lakes and ponds, they may be free-floating in open water but are more often in the littoral zone among submerged parts of higher plants (eg. Myriophyllum, Nitella, Potamogeton). A few grow on damp soil, moist rock or wood.

Figs: 29. Staurastrum rosei var. novizelandicum x525 L. Rotokakahi. 30. S. tohopekaligense var. brevispina x525 L. Rotoma. 31. S. sagittarium x525 L. Tarawera. 32. Spondylosium planum x550 Ls Lyndon, Middleton; pond near Craigieburn. 33. Sphaerozosma vertebratum x550 Pond near Craigieburn. 34. Cosmocladium saxonicum f = part of a colony x150, g = cell x400 L. Rotoiti (North Island). 35. C. constrictum e = zygospore x200, f = part of a colony x150, g = cell x300 Ls Camp, Clearwater, Georgina, Lyndon, Sarah, Pearson, Middleton,

Authorities for the taxa are not given in the test or legends to the plates. They may be obtained from the work to be published shortly under the title :

FLORA OF NEW ZEALAND FRESHWATER ALGAE
CHLOROPHYTA DESMIDIALES Vols. I,II,III

By Hannah Croasdale, Emeritus Professor, Dartmouth College, U.S.A. and Elizabeth A. Flint, formerly D.S.I.R. N.Z.

Desmids have specific needs that vary in kind and amount with the varying quality of the water and with the changing seasons of the year. On the whole they prefer soft acid water, poor in plant nutrients; some grow in a range of conditions, judging by their widespread distribution; a few are characteristic of water rich in plant nutrients and even grow in polluted water of farm ponds and oxidation ponds.

The species found in lakes are usually more abundant in summer or autumn than at other seasons and a large number of individuals may be present. In Lake Hayes, *Closterium aciculare* increased in autumn to a maximum of 600 cells per ml of water; in Lake Johnson, *C. acutum* var. *variabile* reached a maximum in summer of 20 300 cells per ml (Burns and Mitchell 1974). The same species was nearly as abundant in Oak Mere, England, where its maximum in autumn was 13 800 cells per ml (Swale 1968).

For a long time desmids were regarded as important in their own right, on account of the great variety of shape, the large number of species, the structure of the cells, their life-cycle, and the mystery surrounding their origin and evolution. As knowledge of their ecology increased, desmids became important for the 'applied' information they might give. For example those desmids present as subfossils in deposits of peat might be useful in tracing the post-glacial history of the site (Cranwell & Von Post, 1936, noted unidentified desmids among other organisms in a New Zealand peat). Similarly subfossils of desmids in the sediments at the bottom of lakes might yield information about the history of the lake.

When monitoring the quality of water in lake or pond, the presence or absence of certain desmids can point to changes in the quality. In Loch Leven in Scotland desmids changed very much between 1904 (when they were first collected), 1954, 1955 (Brook 1965) and 1968/1971 (Bailey-Watts 1972/73). Out of 7 desmids present in 1904, 4 disappeared by 1954, another by 1968/71; only one was seen on all occasions, the seventh rather spoils the picture - it was recorded in 1904 and in 1968/71 but not in 1954/55. Other desmids came into the lake, two were restricted to 1954/55 and 6 more arrived by 1968/71. These changes are attributed to farming practices and urban development in the catchment area which presumably altered the chemical content of the drainage water. A similar change, on a smaller scale, occurred in the Horseshoe Lake (on Lewis Pass Road). Desmids were conspicuous in the lake in 1964, they decreased and by spring 1983 there was a superabundance (= water bloom) of a potentially noxious blue-green alga. Some pasture in the catchment area was top-dressed and cattle had access to the lake, both of which must have contributed to changes in the quality of the water.

Desmids grow almost exclusively in freshwater. Some species are ubiquitous, though how they are dispersed from one region to another, is uncertain; other species appear to be restricted to particular areas and Fritsch (1935) suggests that a sound knowledge of their distribution might shed light on the problem of former connections between land masses now widely separated by sea.

If such studies involving desmids are to be worth while, species must be identified accurately, for which appropriate literature, preferably floras, are essential. In England Ralfs (1848) published a monograph on British desmids with illustrations on 35 plates, many in colour; he explained why he thought desmids are plants and gave advice on where they can be found. The work stimulated much research and has since been recognised internationally as the 'starting point' for the taxonomy of desmids.

The second land mark in the study of British desmids was 'A Monograph of the British Desmidiaceae' by W. & G.S. West, in five volumes with 167 plates, some in colour. The first volume appeared in 1904, the fourth in 1912, but both Wests (they were father and son) died before Volume 5 was finished and Dr. N. Carter prepared it for the press in 1923 (last year she autographed a reprint of Volume 5 before it and the other four volumes were sent to the Falkland Islands to replace the set lost during the recent conflict).

In North America Wolle (1884) described desmids of U.S.A. illustrating them on 53 plates. Between 1972 and 1983 Prescott et al. published 'Synopsis of North American Desmids' in six volumes and 470 plates of illustrations.

In other parts of the northern hemisphere desmids have been studied for a very long time, especially in Northern Europe and floras have been published, especially in Sweden, Germany and Czechslovakia.

By comparison little work has been done in the southern hemisphere and so far as is known there are no floras on desmids of Australia, South America or Africa. Swedish algologists, with special interest in desmids, have published outstanding papers on material collected in New Zealand (Nordstedt 1888; Thomasson 1960,1974,1980; Skuja 1976) but until relatively recently the only resident to study desmids was W.M. Maskell (1881,1883, 1886,1888,1889); at first he worked in Canterbury, but soon after moving to Wellington, to be registrar of the newly formed University of New Zealand, he dropped desmids and took up scale insects. The tradition in the study of desmids, established long ago and still upheld by British naturalists, failed to develop in New Zealand.

In his work on Staurodesmus Teiling (1967) writes 'Desmid research is a very attractive subject because of the beauty of the organisms. It is also easily accessible, only a microscope is necessary for an interested botanist to leave the Phanerogams and devote himself to the more comfortable work at the microscope. Consequently a great many scientific-minded, so-called amateurs, many of them very sharp-eyed and even good drawers, have done extremely valuable work in discovering new taxa and enlarging our knowledge of the distribution.'

Miss M.F. Rich (1865-1939) could be described as one of Dr. Teiling's so-called amateurs; she was not trained as a botanist but the study of freshwater algae was a hobby during the first part of her career and a full time occupation during the second. She was a teacher in a well known school for girls, founded and ran another. She retired at 58, entered Professor F.E. Fritsch's department at Queen Mary College, University of London, became an honorary research fellow and published many papers, some as co-author with Fritsch (1939), with whom she had first published in 1907. Desmids must have charmed Miss Rich because the house she shared with her sister was called 'Cosmarium' and her designs for embroidery included Staurastrum. She studied algae from ponds in South Africa and published at least one paper with Dr. M. Pocock who was an authority on Haematococcus (= Sphaerella) and Volvox which grew in pools of rain water (Dr. J. Ramsbottom, Keeper of Botany at the British Museum called her the 'Volvox

Queen'). The name 'Pocock' brings us full circle - Dr. Pocock visited New Zealand several times, primarily to see her brother (Professor of Classics at University of Canterbury) but she also made a large collection of New Zealand seaweeds, found the widespread but ephemeral Stephanosphaera (a relative of Haematococcus and Volvox) in a rain-filled hollow on rock above Mt. Pleasant and noticed another green alga in a pond on Marley's Hill which proved to be an undescribed genus-Parallela, since recorded in North and South America.

Returning to desmids - there is a large amount of literature on the group, as shown by Prescott's bibliography of reference (in press) to material published between 1744 and 1982: it contains 6800 references. The difficulty of tapping such a fund of information stresses the value of regional floras where facts about species of a region are assembled and made accessible. Algologists with the knowledge and skills to do this exacting work are so few and far between that New Zealand biologists are extremely fortunate that Dr. H. Croasdale agreed to study our desmids and publish her results. Her original plan was expanded into an illustrated description of all desmids recorded from New Zealand. When the three volumes are complete (volume 1 is now in press), they will contain illustrated descriptions of all species, keys for identifying them, list of relevant literature, comments* on the biology of the species and on the places where samples came from. At present there are about 30 genera in New Zealand (about 700 taxa) and Cosmarium and Staurastrum are probably the most numerous. The work is being published as part of the series 'The Flora of New Zealand'. It could have been published abroad but that would have made it less readily available to readers here and tended to defeat one of the objectives, namely, to encourage more people to study New Zealand's desmids.

Biologists in Canterbury have some of the best places for desmids almost on their doorstep, according to Nordstedt (1888) whose study of our freshwater algae showed 'the swampy ground in the Canterbury Alps and the highland round the Taupo Lake to be the best localities, especially for desmids'. Although Nordstedt's samples were collected by Berggren in 1874/75, 'the swampy ground in the Canterbury Alps' is still there and more or less unspoilt.

* by Dr. Flint (Ed.)

Desmids can be collected from bogs and swamps by squeezing water from a clump of _Sphagnum_ (or other submerged moss) into a jar, allow suspended material to settle when a drop of it can be withdrawn with a pipette, mounted on a slide and examined under a miscroscope. If filamentous algae or submerged parts of higher plants in bogs or swamps are put in jars with a little water and agitated to dislodge desmids, a drop of sediment can be mounted on a slide.

Desmids are far more beautiful alive than dead so if they are to be kept alive for several days, allow adequate aeration by filling jars half full of water, keep them in a cool place in diffuse light. If a sample is to be preserved, put it in an airtight vial, in 3% formalin and a drop of glycerine (to prevent complete drying out).

Acknowledgement:

The writer is indebted to Dr. H. Croasdale for permission to use Xerox copies of her drawings to illustrate this article. Nos. 25-27 are taken from her drawings in Teiling (1967; P12, Fig. 16; Pl. 13, Figs. 1,15).

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