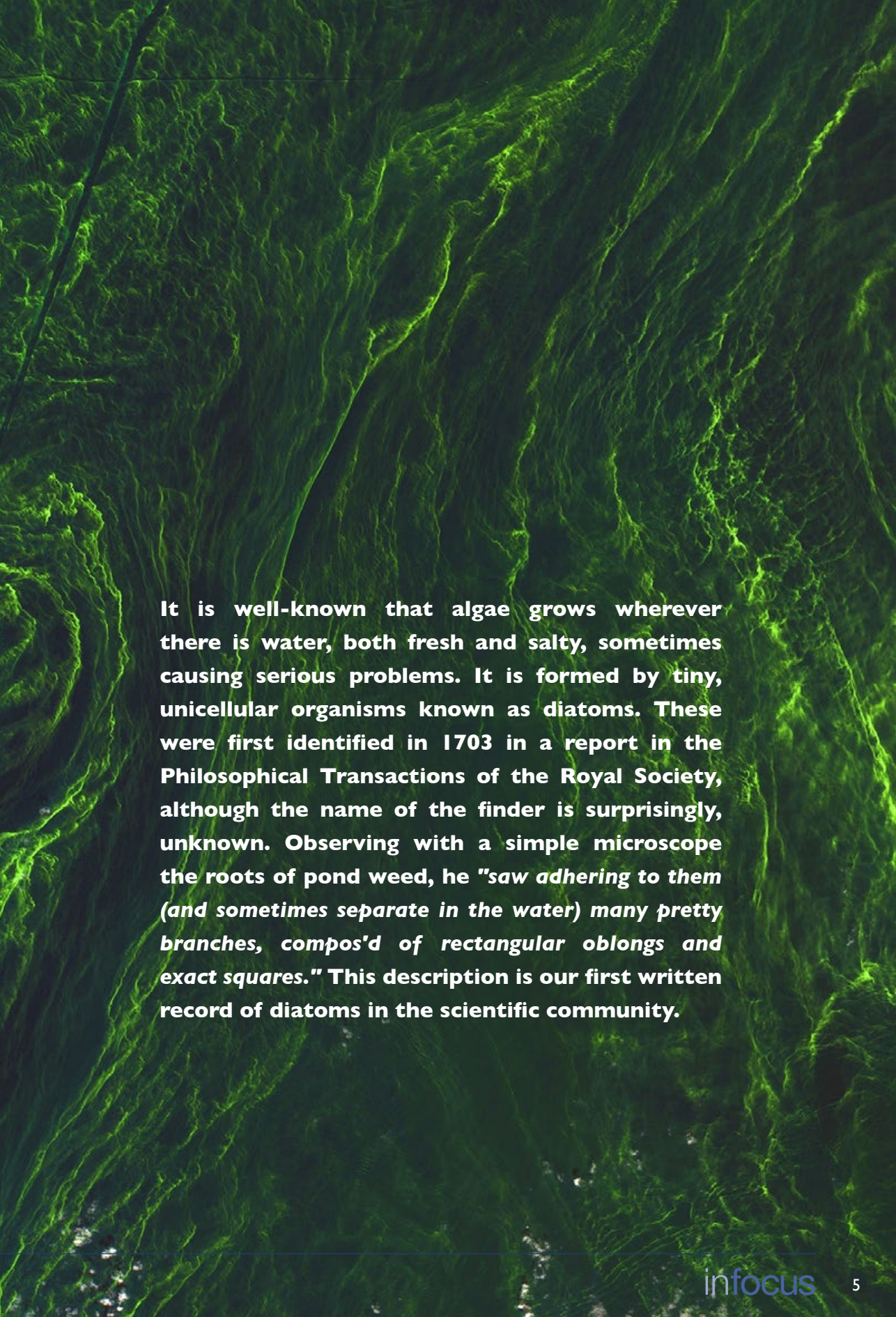
NATURE'S SMALLEST GLASS-HOUSES VISIBLE FROM SPACE

John Hutchison Hon FRMS



It is well-known that algae grows wherever there is water, both fresh and salty, sometimes causing serious problems. It is formed by tiny, unicellular organisms known as diatoms. These were first identified in 1703 in a report in the Philosophical Transactions of the Royal Society, although the name of the finder is surprisingly, unknown. Observing with a simple microscope the roots of pond weed, he *"saw adhering to them (and sometimes separate in the water) many pretty branches, compos'd of rectangular oblongs and exact squares."* This description is our first written record of diatoms in the scientific community.

In 1844, Friedrich Kutzing published a monograph in which he classified all diatoms as algae. The close of the 19th century left us with a huge collection of diatom types obtained on a world-wide basis. Diatoms were also among the first specimens in which the details of cell division (i.e. mitosis) were examined. The exquisite drawings of diatom mitosis by Robert Lauterborn, published in 1896, illustrate this. Diatoms exist in huge numbers, and when conditions are 'just right', they can even form 'algal blooms' on the surfaces of lakes or oceans that are visible from space (Figure 1)! Being toxic, these cause serious environmental problems, and are harmful to wildlife. 'Blue-green algae' deposits are more familiar in the UK, when they affect lakes and riverbanks.

On the other hand, diatoms are in fact also beneficial in that they absorb CO_2 and actually produce much of the oxygen (over 20%) that we breathe – more than all the world's rainforests. They are also important contributors in the food chain for invertebrates and fish. They live relatively close to the surface and banks or shores of water bodies – both fresh and salt - and even moist earth, where there is light for photosynthesis.

Being the only organisms that produce them, diatoms are interesting for their silicaceous (i.e. glass) outer skeletons. These are highly porous structures that enclose the organism and are remarkably regular. They were given the name "frustules" (little pieces), but this rather ugly word's similarity to an unpleasant skin ailment perhaps led to the 'diatom' name being used for both the organism and also its glass cage. The many thousands of different diatom species occur in two types: those with cylindrical or prismatic skeletons displaying radial symmetry and those with bilateral symmetry, being elongated and often cigar-shaped, called pennates.

The shells all have two valves, and reproduction takes place by their splitting apart.

Being silica, the shells of diatoms survive after the cell dies, and accumulate in huge numbers on lake- and sea-beds, forming a fine sediment, 'diatomite'. Fossilised deposits are also known. Being hard, very fine-grained and highly porous, this material finds widespread uses, as toothpaste additive, or tooth powder, being marketed as "Sozodol" in America in the 1880s, metal polishes, facial cleansing cream and many others. As 'kieselguhr', it is also widely used

Figure 1. NASA Landsat-8 image of Algal bloom on Lake Erie.

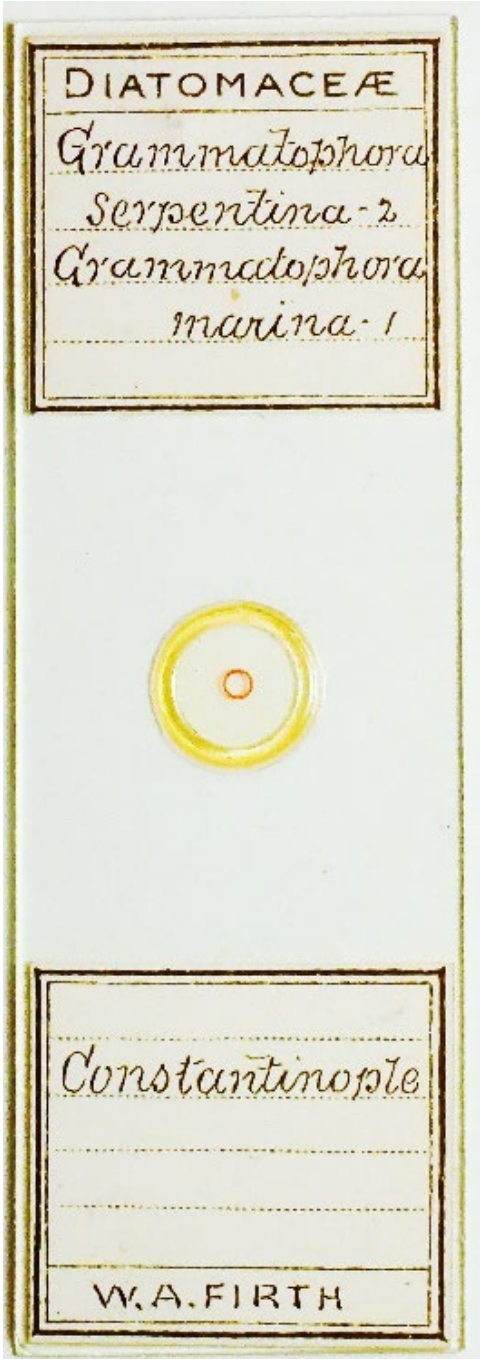


Figure 2. 3x1 inch slide with a single diatom at the centre of the red marker. The circular cover slip is sealed with yellow varnish.

in beer filtration and as the stabilising ingredient in dynamite. Highly pure diatomaceous earth can also be taken as a food supplement, and at the other end, it is also sold as cat litter. Diatoms are now also used by specialist, forensic pathologists, their occurrence and identification in a corpse's lung tissue and

1882

WANTED—Diatomaceous material from New Hampshire containing *Amphipleura Lindheimeri*, in exchange for materials from North of Ireland.—William A. Firth, Whiterock, Belfast, Ireland.

Figure 3. 1882 Firth advertisement for diatoms.

other organs indicating death by drowning, and possibly even – depending on the species of diatom identified - where that drowning occurred.

At this point you might well be wondering just what relevance all this has to popular microscopy? Well, just read on……

In the mid-1800s (the early days of the RMS), diatoms became popular objects for the growing fashion for examining novel materials, particularly as microscopes became more widely available. As optical resolving power improved, diatoms often were used as resolution test specimens. Elaborate protocols were developed for removing the organic material and other debris from the diatoms and mounting them in suitable arrangements to satisfy the rapidly developing market for novel and interesting microscope slides. This usually involved boiling the diatoms in sulphuric or nitric acid before washing and drying.

As an indication of the superb skills of the mounters, consider that the largest diatoms are barely visible to the naked eye, most being much smaller, ranging from ~2 to ~200 microns in size. Once cleaned and dried, they had to be carefully placed in position on a slide using a very fine filament or hair (often a

MICROSCOPIC SLIDES
OF
DIATOMACEÆ.

Highest class mounts of selected **Diatoms** in large variety from rare and interesting **British** and **Foreign** materials, prepared with the best **Styrax.**

NAMED SPECIMENS, TYPE SLIDES & CIRCLES.

Specially prepared Slides for Photo-micrography.
Slides on approval. *Lists free.*
SELECTED SPECIMENS OF
FORAMINIFERA and POLYCYSTINA.

WILLIAM A. FIRTH,
348, Ravenhill Road, BELFAST.

Figure 4. William Firth advertisement of 1897.

pig's eyelash!), then fixed in position in resin, usually Canada Balsam, before the cover slip was placed on top. Alternatively, they could be laid on balsam on the underside of a cover slip which was then placed on the slide. A small, coloured circular marker was then frequently positioned to help the microscopist to locate the diatoms – as shown in Figure 2

In response to the growing popularity and demand for diatom slides, several individuals both in the UK and in Europe rose to the forefront of this business. Among them was William A Firth, whose family moved with its bleachworks from Barnsley to Belfast in the 1860s, from where he developed his own trade in diatom slides. He advertised widely for new samples from overseas (Figure 3) and all of his diatom slides include not only the species' names, but also the exact location where they were found (see Figure 2).

By the 1890s, Firth had developed superb skill in preparing microscope slides of diatoms. The 1893 *Proceedings of the Belfast Naturalists' Field Club* gave an award:

"*... to William A. Firth for his very superior slides of grouped diatoms, a set remarkable for the amount of manipulated skill displayed in each separate slide, as well as in the taste and general excellence of the entire set.*"

In 1897, Firth's expanding business placed an advertisement in the '*For Sale*' section of an issue of *The English Mechanic and World of Science* (Figure 4). It is not clear how long before that date he had begun to sell significant numbers of his slides.

Dr Edmund Spitta, a well-known Victorian expert in photomicrography, wrote in 1899:

"*We know of no mounter of diatoms in the United Kingdom that can surpass Mr. Firth, of Belfast, and few that can equal him....*"

Praise indeed!

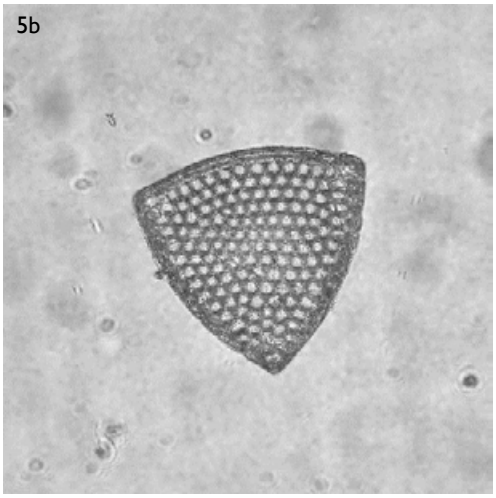
Our recently acquired collection of slides (see in**focus** issue 69, March 2023) includes over fifty

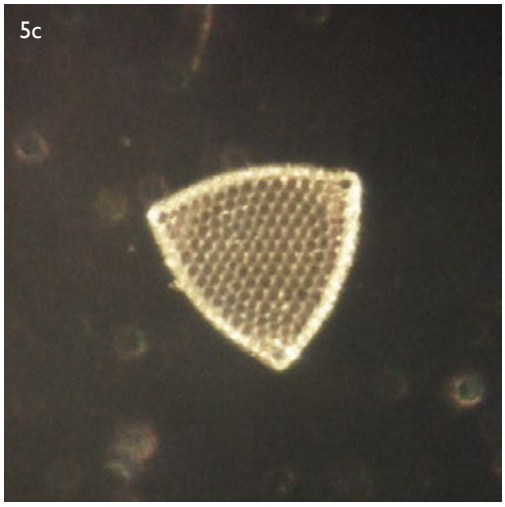
Figure 5a. Firth slide containing a single diatom, from Sendai.

Firth slides with diatoms from a wide variety of sources.

Some of Firth's slides contain only a single diatom; Figure 5 shows an example of the species Triceratium Bergonii, from Sendai.

The slide was mounted in 1896. The diatom is located at the centre of the black marker ring.





Figures 5b and 5c: the diatom imaged with (b) transmitted and (c) oblique, incident illumination.

Some individuals prepared mounts with two identical specimens carefully placed side-by-side, as in Figure 6 – probably also by Firth, although the slide is anonymous.

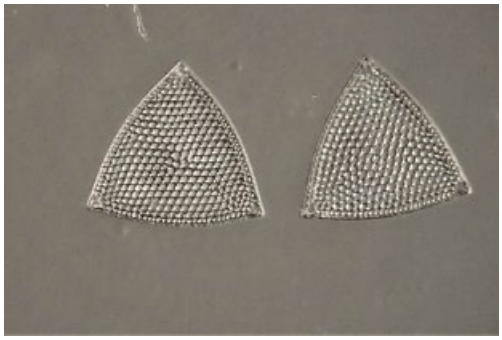


Figure 6. Two identical diatoms arranged together.

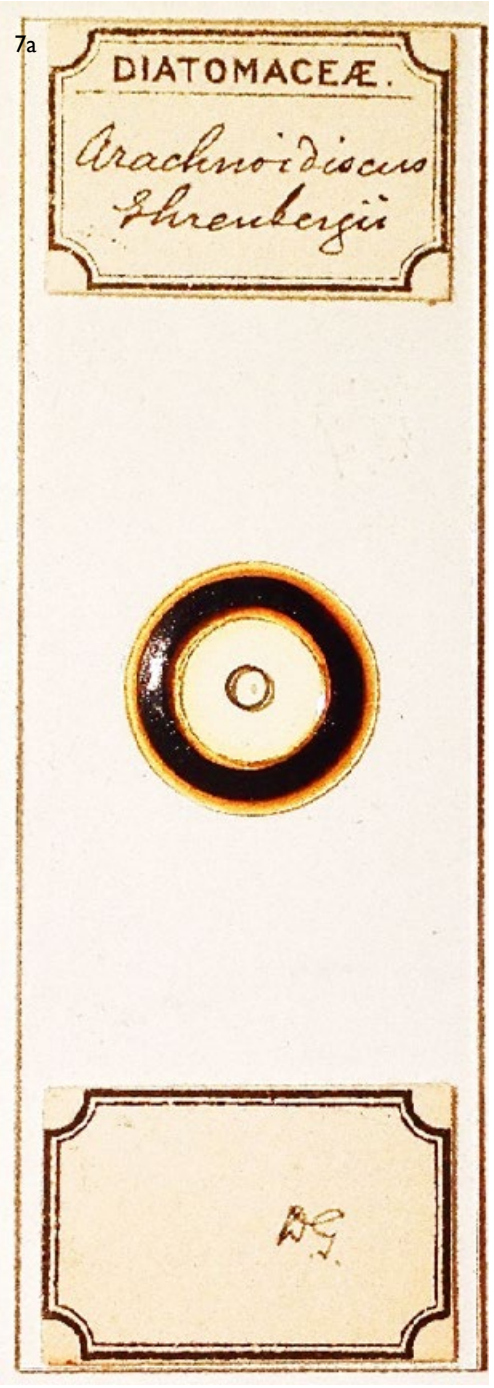
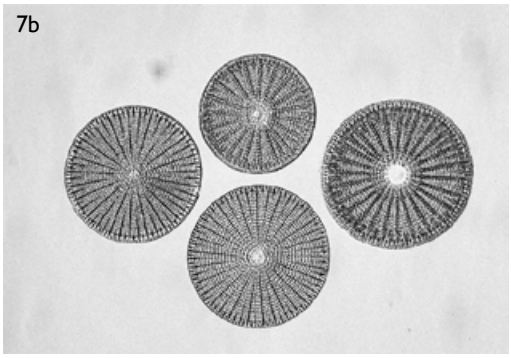
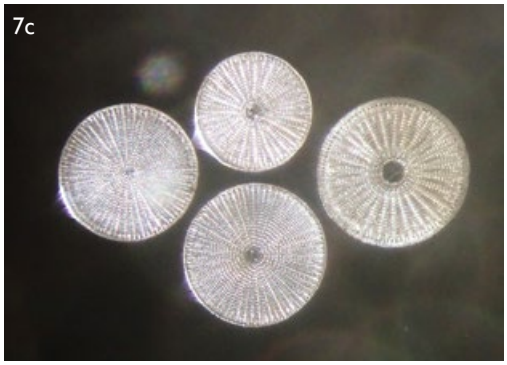


Figure 7a. Mounted slide with four Arachniodiscus diatoms imaged overleaf with (7b) transmitted and (7c) oblique, incident illumination.

A particularly nice example of several diatoms of a single species is shown in Figures 7a-c.

The slide labels indicate the species, and bear the signature "*DG*". This signature appears on many slides





by other mounters such as Firth, but otherwise he is unknown. Perhaps he either provided the diatoms or else sold his own mounted slides through the more well-known names.

Examples of several identical diatoms are shown in Figures 8 and 9.

Firth later taught John Long, a schoolmaster based in Bradford, the skills required to mount good diatom slides. Examples of his work are shown in Figures 10 and 11.

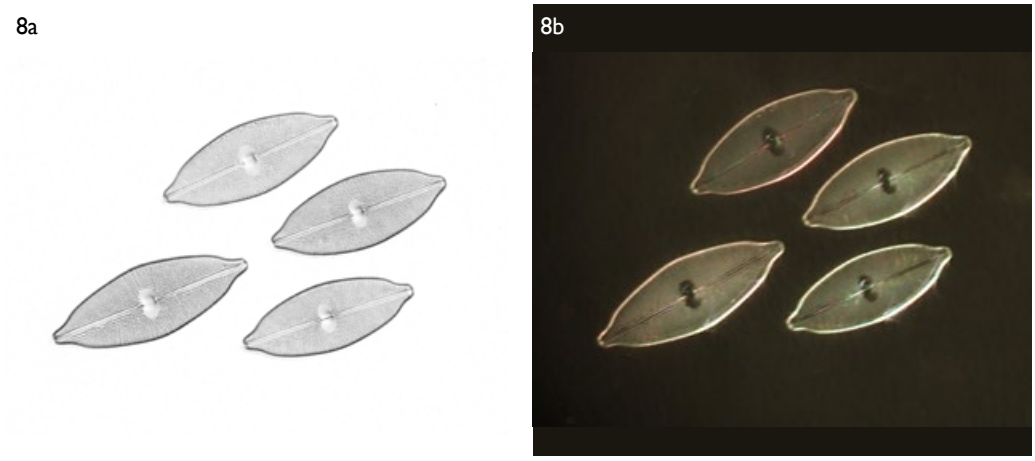


Figure 8. Four identical diatoms, resembling UFOs flying in close formation! (a) transmitted light and (b) oblique illumination.

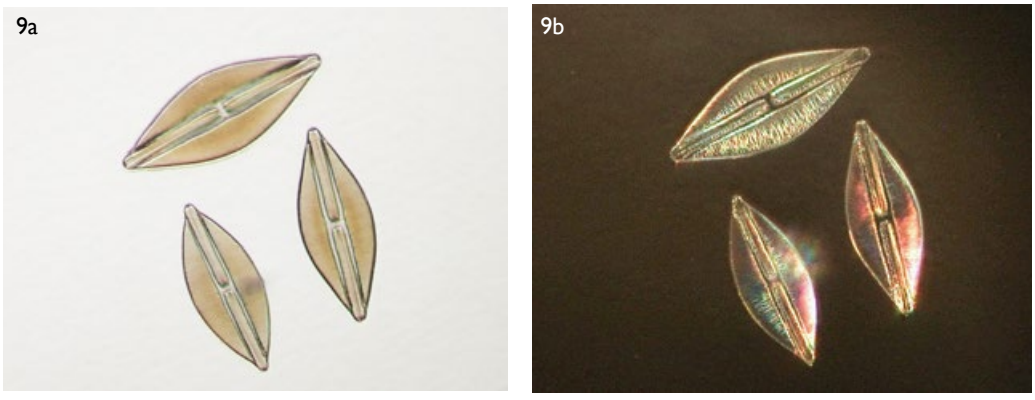


Figure 9.Three identical diatoms imaged with (a) axial and (b) oblique illumination.

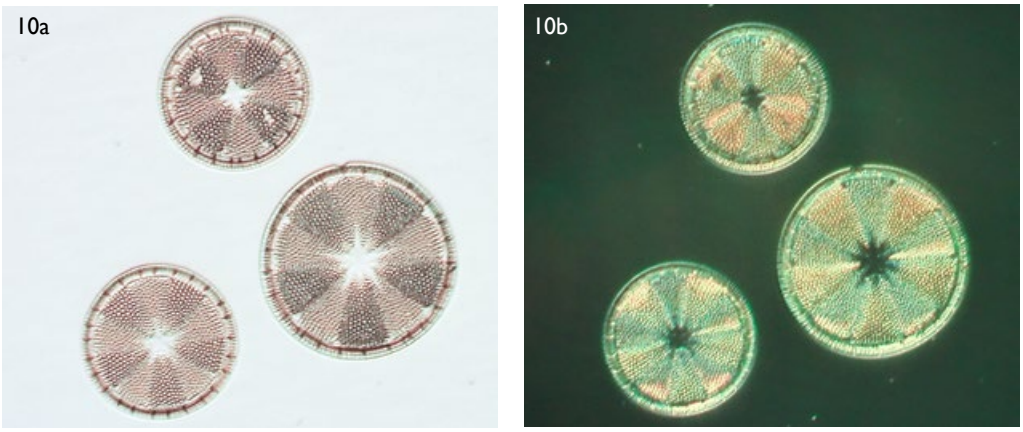


Figure 10. Diatoms mounted by John Long, imaged with (a) transmitted and (b) oblique illumination. Note the five-fold symmetry, and the four-fold symmetry of the smallest one.

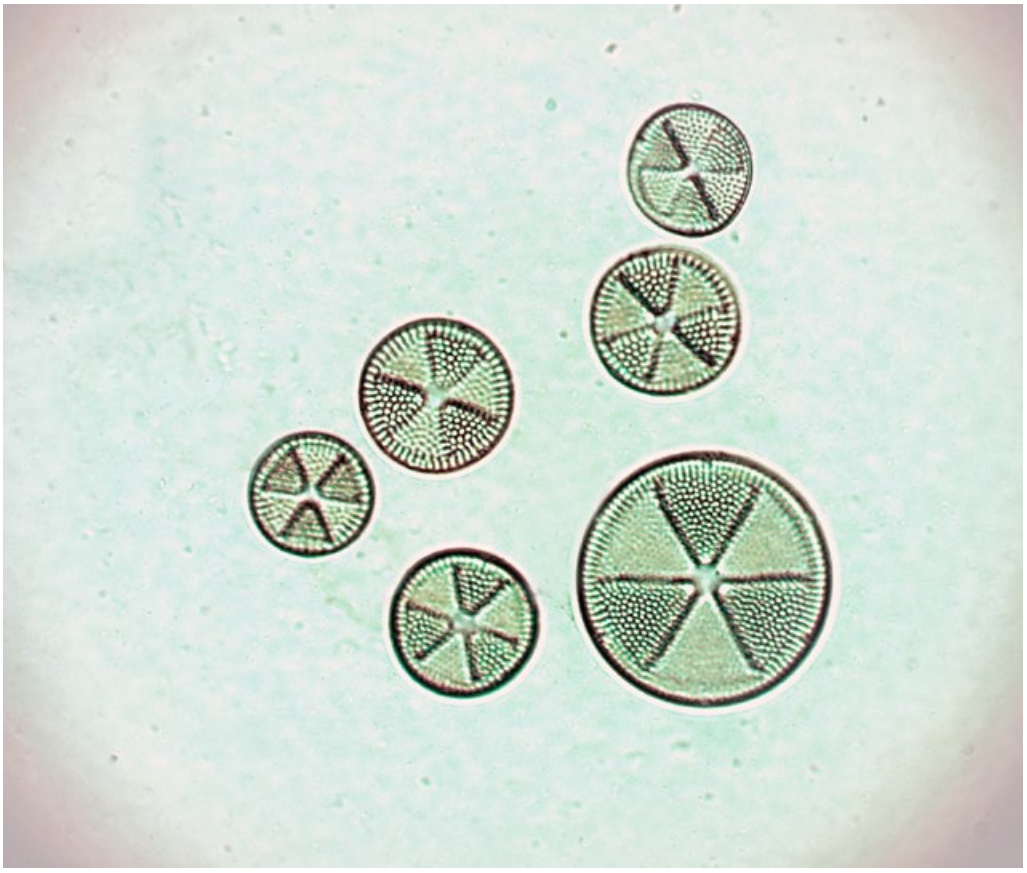
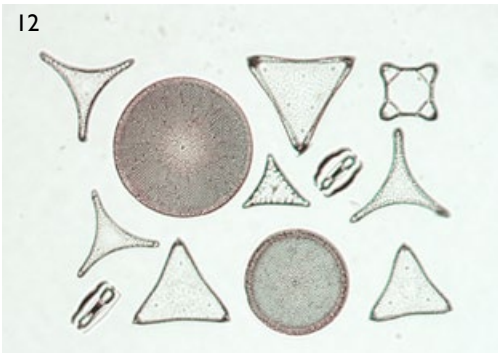


Figure 11. J. Long mount with diatoms showing three-fold symmetry.

More elaborate mounts

As demand for fancy layouts of diatoms grew, so the best mounters created ever-more elaborate arrangements, ranging from relatively simple groupings of one (Figures 8 - 11) or several different species (Figures 12 – 14) to others containing over 100 diatoms in geometrical patterns (Figure 15).

Eduard Thum (1847 – 1926) of Leipzig, with his own self-styled 'Microscopy Institute', was another of the foremost preparers of diatom slides of his time. His



Figures 12 and 13. Firth mounts showing a variety of different species.

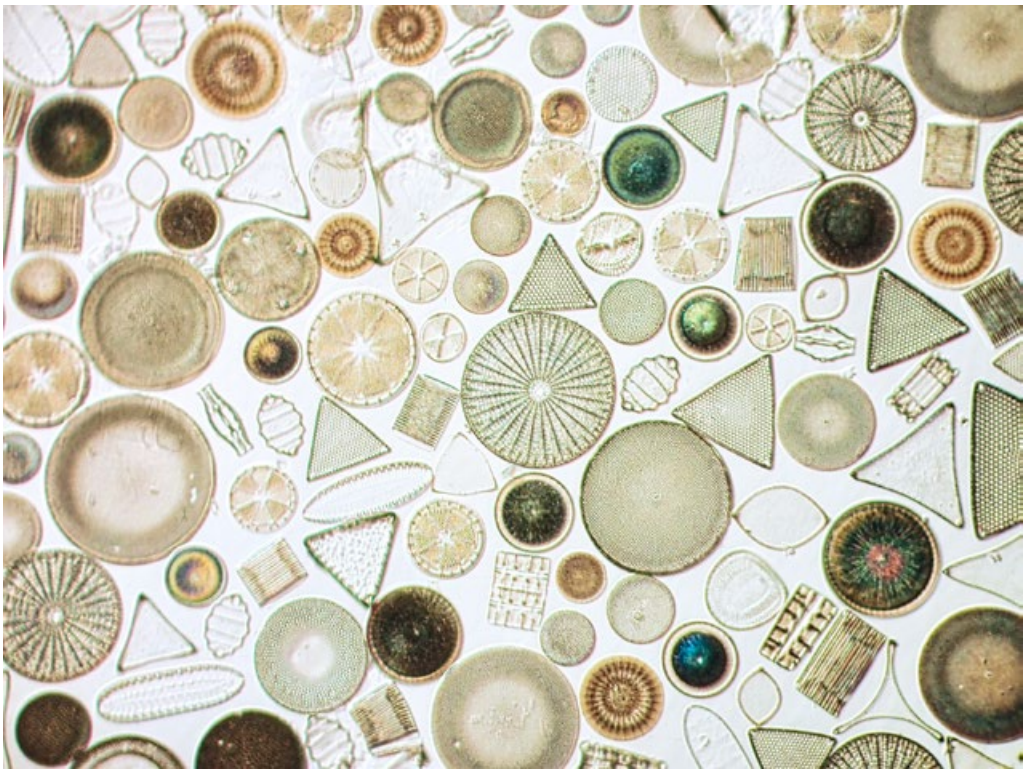


Figure 14. Mount by Clarke and Page, a London firm of the early 1900s containing a large variety of different species.

mounted slides range from simple arrangements of diatoms, to elaborate layouts that are keenly sought-after by collectors today. Our recently acquired collection includes several of his slides, and an example is shown in Figure 16.

When mounting narrow, pennate diatoms having very low contrast Thum adopted a trick of positioning larger, cylindrical specimens on either side of the main items of interest as a kind of 'navigational aid' for the microscopist. A nice example of this is shown in Figure 16a.

Being thicker than the main subjects, these markers appear much darker, but oblique illumination can be used to enhance their contrast, and also that of the pennates, as shown in Figure 16b.

Mounters also prepared slides on which single species were simply 'strewn' onto a slide before being fixed. These often produce interesting effects, particularly when the 'strews' are viewed by

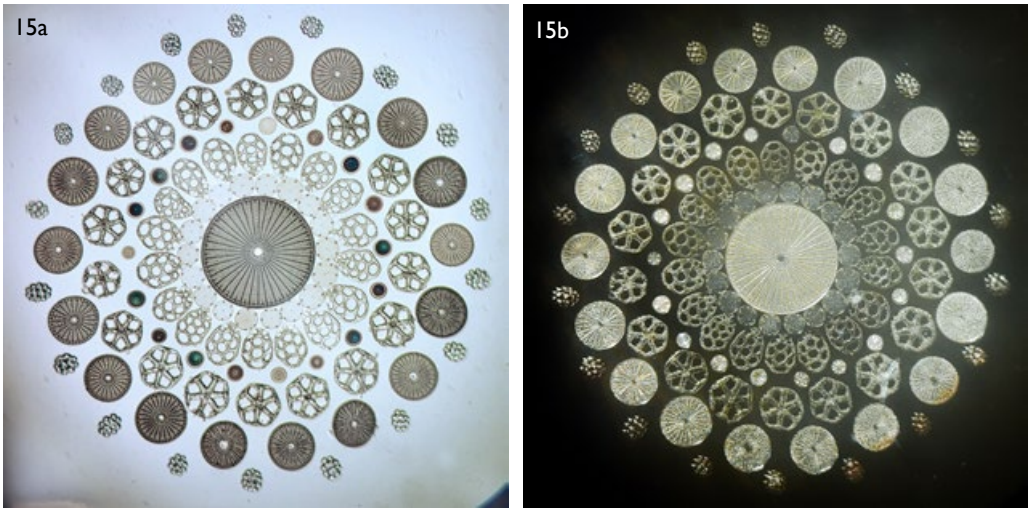


Figure 15. An unusually complex mount by Firth, containing six concentric rings of 18 diatoms each, surrounding a single, large diatom. Imaged with (a) transmitted illumination and (b) oblique illumination.

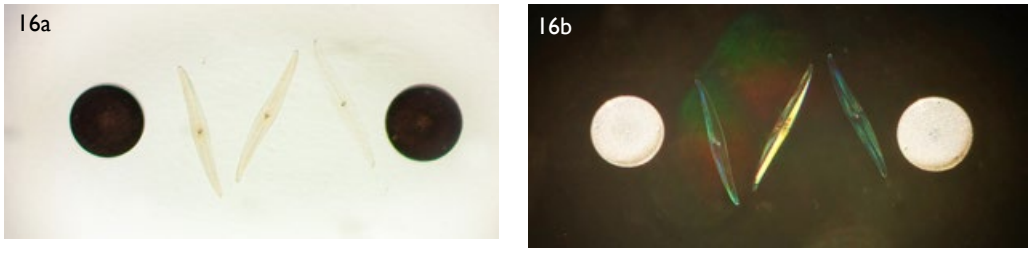


Figure 16. Thun mount showing the position of two 'markers' surrounding smaller, narrower diatoms. Imaged with (a) transmitted and (b) with oblique illumination to enhance their contrast.

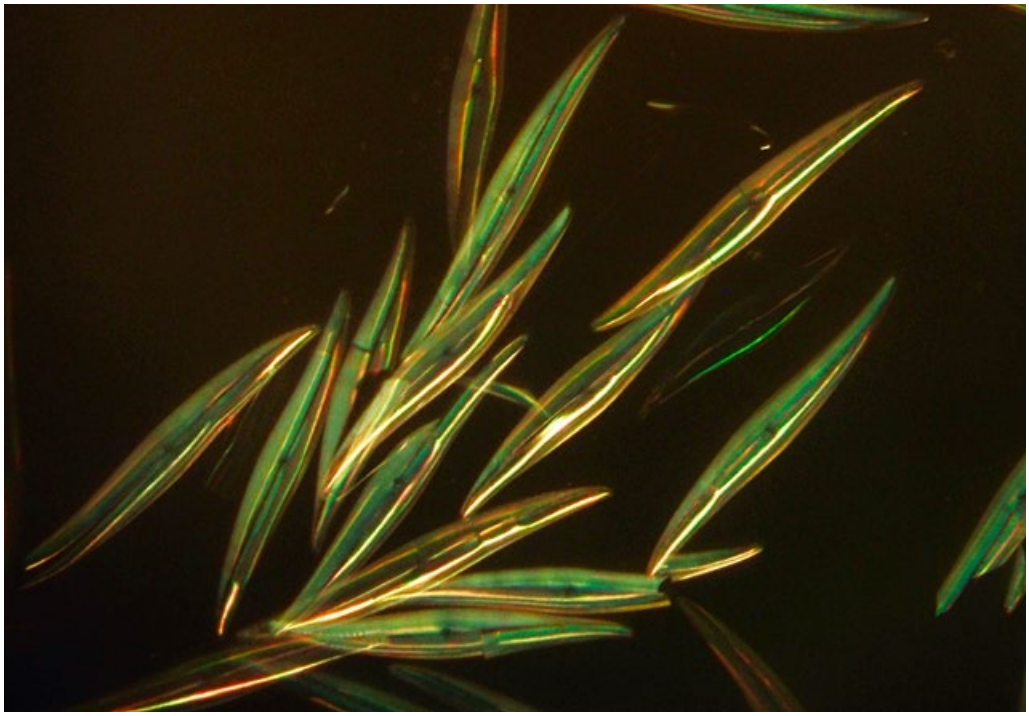


Figure 17. An example of Thun's 'strews', viewed by oblique illumination.

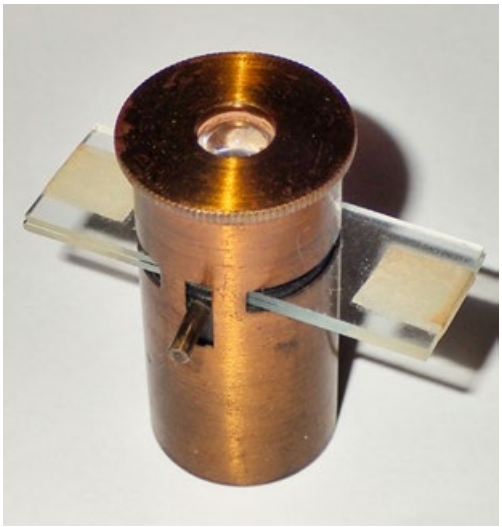


Figure 18. Thum's Algensucher microscope.

oblique illumination. Thun's 'strews' are well known examples, as shown in Figure 17.

As an aid to finding, and hopefully identifying diatoms in the field, Thum also developed a simple, but remarkably effective, miniature, compound microscope which he called the "Algensucher" (lit. "algae seeker"), shown in Figure 18. He advertised this device around 1880, at a selling price of 6 DM. Our slide collection includes one of these unusual instruments. We note that it used slides which, being 5 x 1.7 cm in size, are much smaller than the standard 'RMS' 3 x 1-inch ones.

Johan Möller, of Holstein, was also well-known for his diatom slides. He exhibited them at the St. Petersburg Exhibition of 1869, where they were apparently awarded Gold Medals. An example is shown in Figure 19.

Möller also produced novel diatom slides which included microphotographs – precise arrays of spaces along with species' names which he printed onto slides. He then managed to position the correct diatom in each of the spaces, before fixing everything in place with balsam.

In 1874, 'The Quarterly Journal of Science' reported: *"Herr Möller has introduced a very ingenious modification of his celebrated Diatomacean typenplatte … The new arrangement consists of a photograph about 4 millimetres square, of eighty circles, ten in a longitudinal and eight in a vertical direction; beneath each circle is the name of the object and its author, and in the centre of each of these circles is a diatom, and in many cases two are mounted in order to show front and side views. The whole collection independently of its great value to the student of Diatomaceae is a marvel of manipulative skill."*

Our collection contains one of Möller's 'Typen Platten' slides, containing 80 individual diatoms (Figure 20).

To leave the viewer in no doubt about the mounter, Möller even included his name and institute along with a diatom in the corner of the grid, shown in Figure 23.

'Typen-Platten' slides of this sort are quite rare, and keenly sought after. In addition to the 80-diatom slide shown here, examples containing 400 and even 1715 diatoms are known, the latter of which was prepared for the Emperor of Brazil in 1890.

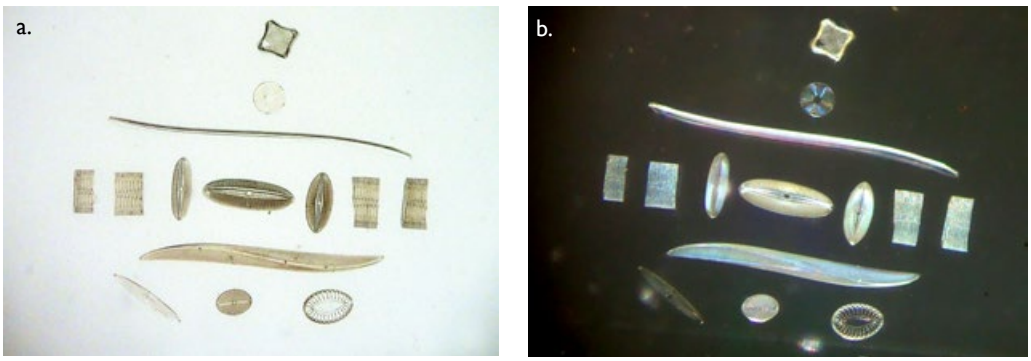


Figure 19. Mount showing a variety of diatoms with (a) axial and (b) oblique illumination.

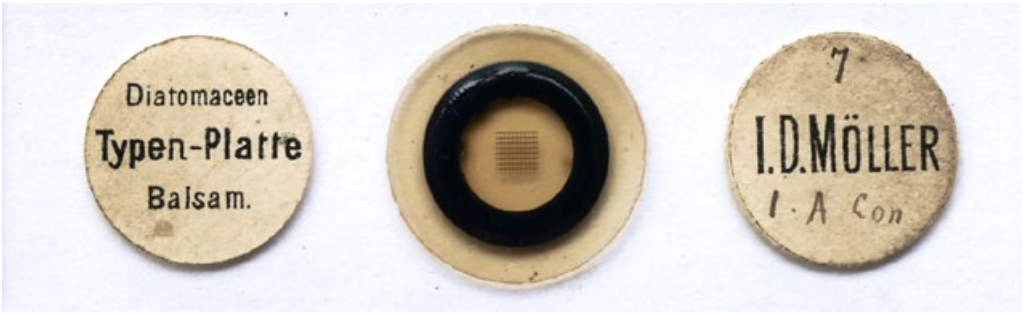


Figure 20. The entire 3 x 1 inch slide, indicating the small size of the diatom array.

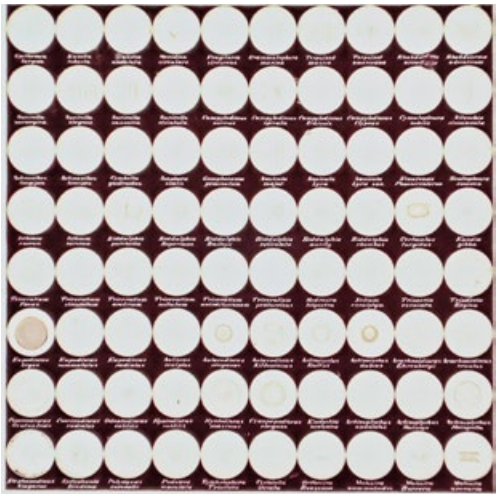


Figure 21. The complete array of diatoms mounted in their correct positions.

Figure 22. Illustrating the precision with which Moller placed the diatoms within the array.

Conclusion

Diatoms are still studied widely, with an International Society for Diatom Research. And for enthusiasts there is a fascinating magazine "The Amateur Diatomist", published regularly. Superb, modern slides with selected diatoms are still sold by e.g. The Diatom Shop, and the late Klaus Kemp continued producing amazing arrangements of diatoms and foraminifera until his death in 2022.

Figure 23. Möller even included his name and institute along with a diatom in the corner of the grid.

My brief foray into the microscopic world of diatoms has revealed some truly astonishing structures, preserved in all their beauty by the amazing skills of the mounters who didn't have the benefits of modern microscopes and micro-manipulators. If you would like to see some of these wonders for yourself, call in at the RMS Learning Zone during mmc2023 in July – we will look forward to meeting you. Meanwhile next time you step in a puddle, or visit a rock-pool by the beach, just pause a moment to think of all the tiny glass cages lurking beneath the surface!

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