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The Amateur Diatomist

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Little Imp Publications

In this Issue:-

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Cover Picture: Pleurosigma angulatum - Photo by Mike Samworth

Snell's Law and its relevance to diatoms

Willebrord Snell* was a Dutch astronomer and mathematician, who in 1621 discovered the law of refraction which now bears his name. Whilst refraction itself is of course of great importance in the working of the microscope, it is of particular relevance to the visibility of diatoms and therefore of interest in relation to the myriad of mountants used for slides.

Snell's Law is:-

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

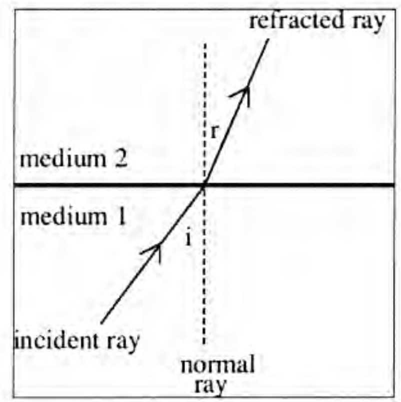
where: i = the angle between the incident ray and the normal to the surface

r = the angle between the refracted ray and the normal

n1 = refractive index of the medium on the incident side

n2 = refractive index of the medium on the refracted side of the interface

A diagram may help explain:



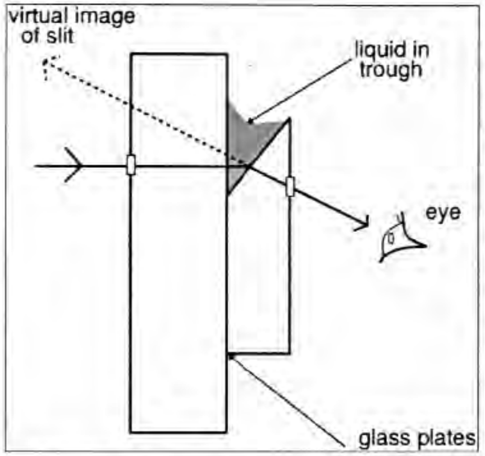
In microscopy, it is often required to know the refractive index (RI) of the liquids and solids being used, and this is particularly true of mountants. The degree of contrast exhibited by a transparent object in a mountant relies on the difference in RI between object and mountant. As a guide, a difference of 0.02 gives low contrast, 0.05 moderate and 0.20 high. Now of course we must not confuse resolution and visibility, as they are very different and unrelated quantities. Except to say that of course we need to see the image to resolve it! In looking at our favourite diatoms, the visibility of striae or dots depends largely on the difference of RI between the silica frustule and the mountant.

Mounting diatoms dry is very useful in this regard, as the difference is great, due to the silica RI being 1.43 and air 1.0. However, diatoms are not all suited to being mounted dry, and many of such slides have not lasted too well. So, what we want in a mountant, apart from any other consideration like cheapness, ease of use , longevity etc. is RI well above (or well below) 1.43. Thus, we might use any of the following:

Dirax = 1.65	Hyrax = 1.71	Naphrax = 1.69
Pleurax = 1.75	Realgar = 2.18	Sirax = 1.81

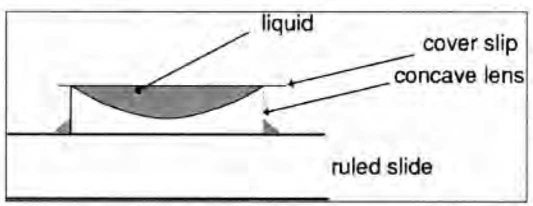
Since Realgar contains arsenic sulphide, it is rather dangerous! As suggested above, there are other factors that need to be taken into consideration when choosing a mountant. We would welcome comments regarding the mountants that people use, and in particular how exactly they use them.

At the extreme of this, Dall, and others, have used vacuum deposition of metals, including aluminium, platinum and titanium dioxide. The latter give a RI of somewhere between 2.6 and 2.9!



The question I often find myself asking when I see a list of RI values is, how do they measure them? The simple answer of course is that they use a refractometer, but that is a rather unhelpful answer. I knew from my talks with microscopist and bee-keeper Harry Taylor of Staffordshire that beekeepers check the quality of the honey using a simple and relatively inexpensive instrument that is hand-held. This I believe is the Leitz-Jelley pattern, which allows small amounts of liquids to be measure within the range 1.33-1.90.

In this device, the liquid is placed in a triangular-section trough which is formed between two glass plates; a large one and smaller one cemented to it. The object slit is viewed through the trough, and its un-deviated image will appear brightly lit and colourless when the liquid in the trough is of RI 1.52. For liquids of other RI a lower intensity deviated image of the slit is seen superimposed on the scale of the instrument. The RI of the liquid may thus be read off directly from the scale, which is calibrated in increments of 0.01. A monochromatic filter is advisable to avoid misreading due to dispersion. The question arises, how is this achieved for mountants, whose RI only fuller develops when the solvent is driven off? Surely, an instrument such as this is not used for such resins. Indeed, Hewlett made a stage refractometer, using a haemocytometer and a plano-concave lens.



The divisions on the haemocytometer are measured using an eyepiece graticule, and this is calibrated by taking such micrometer readings for a series of liquids of known RI. The RI of the liquid in question will be linear to the reciprocal of the micrometer reading.

References

Dictionary of Light Microscopy RMS OUP 1989

H E Dall 'Mounting methods for high resolution optical microscopy' Microscopy 35, p281, 1985.

Hewlett 'A stage refractometer' Microscopy 32 part 10, p432-434, 1974.

*Willebrord Snell (1581-1626)

Dutch mathematician and physicist who devised the basic law of refraction, known as Snell's law, in 1621. He also founded the method of determining distances by triangulation.

Snell was born in Leiden, where he studied and eventually became professor.

Snell developed the method of triangulation in 1615, beginning with his own house and the spires of the nearby churches as reference points. He utilised a large quadrant some 2 metres (nearly 6.5ft) long to determine angles, and by plotting a series of triangles was able to obtain a value for the distance between two towns on the same meridian. From this Snell made an accurate determination of the radius of the Earth.

The laws describing the reflection of light were well known in antiquity, but the principles governing the refraction of light were little understood. Snell's law was published by French mathematician Descartes in 1637. He expressed the law differently from Snell, but could easily have derived it from Snell's original formulation. Whether Descartes knew of Snell's work or discovered the law independently is not known.

The use of Berlese's Fluid for mounting diatoms in their Natural State

Hoyer's Medium - gum arabic 30.0 g, glycerol 16.0 ml, chloral hydrate 200.0 g, distilled water 50.0 ml. Dissolve gum in water, a little heat helps; add chloral hydrate, then glycerol.

Hoyer's solution consists of 50 ml distilled H_2O, 30 g gum arabic, 200 g chloral hydrate, and 20 g glycerin. The gum arabic should be the crystalline form since the powdered form is difficult to wet. Ingredients are mixed in the given sequence, taking care that one ingredient is completely dissolved before adding the next. This medium is also called Berlese's fluid; there are numerous modifications such as de Faure's (using 50 g chloral hydrate). NOTE: Care must be taken with chloral hydrate compounds; breathing the fumes and exposure to the chemical are dangerous. The final product is filtered through bolting cloth or glass wool.

Experiments are ongoing with this mountant as an alternative to the Styrax method previously described. Certainly the diatoms are preserved in their natural state. However, the mountant suffers considerable shrinkage. Some method of ringing may be required thereby creating what is in effect a fluid mount.

Berlese's Fluid may be purchased from David Henshaw. (djhagro@aol.com)

David Henshaw's Instructions:-

Berlese's Fluid is an ideal mounting medium for entomological microscopy. Being water soluble, little preparation is required of the specimens as the usual dehydration step is not necessary.

Dry specimens should first be wetted thoroughly using water (preferably distilled) with a VERY LITTLE detergent added. Specimens in preserving fluid may be directly transferred into the medium but better results are obtained if first washed as with the dry specimens.

Place the prepared specimen in a drop of Berlese's fluid on a microscope slide and arrange it approximately to the final required setting. Allow the fluid to thicken by evaporation; gentle heat will aid the process, but do not overheat, 30-45°C is suitable.

PROTECT FROM DUST WHILST DRYING

When the medium is dry or at least very stiff add a small drop of Berlese's fluid onto the specimen and allow to soften (two or three minutes) and rearrange as required, whilst avoiding entrapping air bubbles, then place a coverslip over the specimen. To avoid trapping air between coverslip and specimen touch the edge of the coverslip to the Berlese's fluid on the slide then gently lower it, at an angle so that the air is pushed out and not trapped.

Altenatively, and perhaps preferably, allow the medium on the slide to dry until touching the mountant surface does not disturb the specimen at all, then add a drop of Berlese's fluid to the surface of the coverslip and lower this, again at an angle, onto the specimen and allow to dry.

If the specimen needs to be removed or repositioned, add a few drops of water to the edge of the coverslip which will quickly penetrate and soften the Berlese's fluid. If the coverslip has been ringed, this will have to be removed first.

When dry the mount should be cleaned to the coverslip edge with a sharp knife or blade and ringed with any suitable medium, e.g. cellulose paint, nail varnish, etc., but NOTE: Euparal, or other resinous media should not be used, as interaction may occur.

CAUTION: If ingested in quantity, vomiting a should be induced, follow by drinking copious quantities of water to flush the stomach; contains chloral hydrate which will induce deep sleep; contact medical advisor.

Famous Diatomists

Robert Hagelstein

Hagelstein was born on May 16th, 1870, in Brooklyn, New York.

He graduated from high school in Brooklyn and subsequently joined J. & D. Lehman Co., a glove manufacturer located at 15 Union Square West, New York City.

He retired from this establishment in 1925 where he had reached the position of Manager He then dedicated all his time and efforts to his scientific studies.

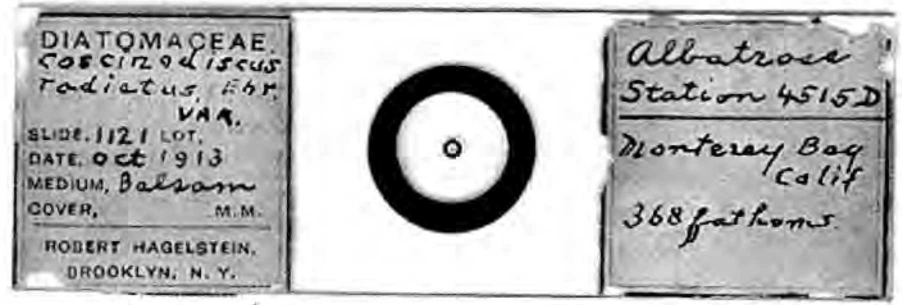
His primary interest was microscopy. This he had studied at the Brooklyn Institute of Arts and Sciences whilst still a young man. Throughout his career he continued to do his own photomicrography. The photographs in his monograph The Mycetozoa of North America, based on the specimens in the herbarium of the New York Botanical Garden, are examples of his microphotographical achievements. Hagelstein served as President of the New York Microscopical Society for the session 1923/24. At this particular juncture he was engaged in the study and photomicrography of diatoms.

He accompanied Nathaniel Lord Britton on the Scientific Survey of Porto Rico and the Virgin Isles in 1926, 1928, and 1929. Hagelstein's interests turned to the myxomycetes (mycetozoa). Initially he split his efforts between these and the diatoms though eventually they became his main interest. He made collecting trips throughout the length and breadth of the United States, from Canada to Florida, though he concentrated on the areas around Long Island and Pennsylvania. His first publication on Mycetozoa appeared in 1927. Honorary Curator of Myxomycetes for The New York Botanical Garden (1930-1945).

He addressed the New York Microscopical Society's first session of 1934 and also established (with Roy M. Allen and others) the Society Saturday Group, so named because they met on a Saturday.

In February 1936 the first New York Microscopical Bulletin was 'The Mycetozoa' by Robert Hagelstein. In 1936 he was invited by the New York State Museum to examine its myxomycete collections, including materials collected by Charles H. Peck.

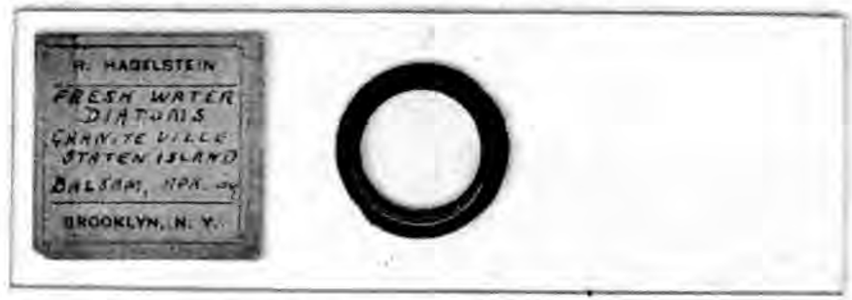
When he began his Honorary Curatorship of the New York Botanical Garden's myxomycete collection, the collection consisted of some 2,000 specimens collected by



Photograph by Paul Ottenheimer

J. B. Ellis. Hagelstein augmented the collection with the purchase of the W. C. Sturgis collection of 3,200 specimens. By 1943 the collection had increased to in excess of 13,000 specimens, of which Hagelstein himself had collected 4,970, and a further 2,700 were acquired through the exchange of materials he had personally collected.

In 1938 The New York Academy of Sciences published a paper by Robert Hagelstein (Diatomaceae of Porto Rico and the Virgin Islands) in which he named three new diatoms, naming them after members of the New York Microscopical Society - Diploneis Gravelleana (named after Philip O. Gravelle, Fellow of the New York Microscopical Society, Fellow of the Royal Photographic Society, Recepient of Barnard Medal from London Photographic Society 1923, died January 4th 1955), Nitzschia Brittonii, and Pinnularia Titusiana (after Charles P Titus, President of the New York Microscopical Society 1921-22)



Photograph by Mike Samworth

In 1940, he loaned his collection of 15,000 slides of diatoms to the New York Botanical Garden. The collection included the personal collections of D. B. Ward, W. A. Poysner, and examples from other eminent diatomists that he had purchased over the years.

On January 11, 1941, a room in the Cryptogamic Herbarium was dedicated to Hagelstein's two interests-diatoms and myxomycetes.

Throughout his career, Hagelstein enthusiastically shared his interests with amateurs.

He died on October 20, 1945, in Mineola, Long Island, New York.

Waterfalls

Splash zones may be encountered in all sorts of habitat. There are the areas along a rocky shoreline that are drenched with spray by crashing waves, the walls of a mill race and the rocks around a waterfall. There are small patches of constant moisture below the condensation pipes of mainframe computer cooling systems (look for the big fans) and areas at the base of cooling towers where the constant drip of condensation provides an ideal habitat for diatoms (wait until maintenance is being done before being tempted near).

I have already written of my favourite, the watermills. Waterfalls, however, run a very close second.

Waterfalls only occur in magical places, at least that's my experience. There is almost always an abundance of wildlife and lots of opportunity to be precipitated unceremoniously into the torrent (you really haven't been on a 'real' diatom collecting trip unless you return home absolutely sodden!). Water that is pleasant to swim in above the waterfall is somehow transformed into a freezing shower simply by sliding over the lip of the fall, so a flask of hot coffee is a must. Verdant green mosses and algae festoon the rocks and hang, dripping, just out of reach from a safe foothold. A shimmering brown slime has found a home on the rocks just to the back of the curtain of water, the same brown slime, but of a lesser richness, coats the rocks upon which you stand. Any sensible person would simply scrape those rocks and come up with exactly the same species as those to be found in the more inaccessible

spots. Not for me the scrabbling at the margins. With scant regard to the prospect of a bout of

pneumonia, or the threat of drowning, I am lured in to the heart of the cascade. Ears are filled with the tremendous thundering roar of water releasing its potential as it barley twists itself into columns which are smashed upon the rocks beneath. Shortly afterwards all becomes somewhat muffled as ears are filled with water.

When at last I emerge from the spray I have the sample (or what is left of it) and repair to the bank for that warming cup of coffee. A perfect day.

Years later I can take out a slide made from the prepared material collected at such a site and the name of the location written on the label evokes all that magic anew and in a sort of trance my ears are again filled with that familiar thundering roar. I am startled from my reverie as my wife flicks me with the tea towel and continues berating me about the state of the garden.

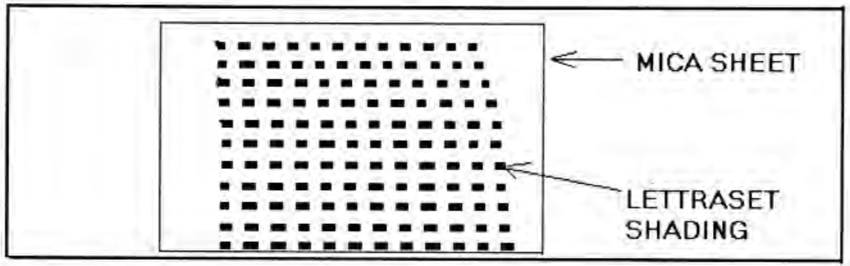
Dry storage of selected Diatoms

by Klaus D. Kemp

As I may have indicated in previous articles, my interest in Diatoms was aroused some 45 years ago while working at Flatters & Garnetts Ltd.. It was on seeing for the first time a Möller 400 type slide, that I determined that one day I would make such a slide for myself, little realising just what organization it takes to make such a slide. The following it is hoped will allow others to utilise some of the techniques I have discovered since that first look at such a work of art.

Clearly the first problem to overcome is one of finding 400 separate species. It soon required being able to access the same species several times, so that they can be mounted in the same order as all the previous slides. This must, prior to the advent of modern technology such as Computers, have required a good method of logging Diatoms in a logical manner.

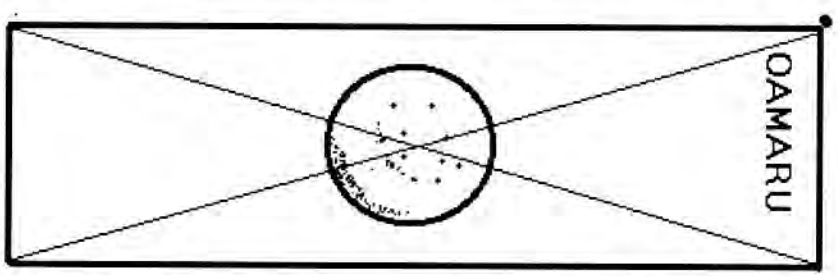
Method 1). On a thin slide transfer Letraset shading dots. I cut sheets up into 10 by 10 dots to give me 100 clear areas, I then mount a thin sheet of Mica over this area with Balsam or



any other clear mountant. This now gives me clear areas, which can be determined by rows and square numbers. See photograph No 1. Note that the clear areas are large enough to allow me to store five different species in the area. As it is my intention to make more than one 400 slide I have assembled lots of 20 diatoms of each species, the Diatom name and location where it came from is then kept in a simple data sheet. On this basis one slide with the 100 spacings each able to hold 5 different species would produce a type slide with 500 forms on it.

Method 2) Save selected species in a cavity slide which has had a very thin layer of adhesive rubbed on to it. This was the preferred method of storage By Mr. Gosden for his Oamaru New Zealand project. Providing the Diatoms are robust this is an excellent and easy method of storing Diatoms , as when you have added Diatoms to the slide, you can protect them from dust by inverting a second cavity slide onto it and taping these together, care must be taken when taking off the tape as static electricity can make the Diatoms jump off.

Method 3) Mark the center on a standard 3X1 slide mark center by ruling diagonally across the slide on each corner. Place the slide on the Microscope stage and look for where the diagonal lines cross, this will determines where center is. Where the top right hand edge of the slide is, mark a small white dot on the stage, now whenever you search a strew slide, if a rare or interesting Diatom is found you can pick it up and by moving the top right hand edge of the slide to the white dot, this will allow you to deposit the Diatom in the center of the slide. If at a



later date you wish to mount any saved specimens, you need only look in the area where Diatoms have been placed and saved. There are distinct advantages in this method of storing

you can place a range of sizes or forms in the center of the slide haphazardly, but when you want to mount them you can select according to size or shape. See Photograph 2

Method 4) If Diatoms are very fragile, mount Mica sheets as in method one, but without the Lettraset. When the mountant has set, rub the Mica in a North/South direction with a cotton cloth, this should leave furrows cut into the Mica, now when sample drop of the delicate forms is placed on the Mica and as soon as the sample has dried, it is possible to move the Diatoms, as the grooves allow the needle of the manipulator to readily go under the Diatom and lift it.

It is essential to note that whatever method is used, before putting a drop of the sample on the slide, you should pipette off the supernatant liquid with preservative in it. Samples that have been preserved in Formalin are perhaps the most difficult to work with, as the Formalin forms a crust around the Diatom and prevents you from lifting it without damage. I much prefer preserving my samples in dilute Phenol.

Old Papers - Revisited

In this series of articles we will reproduce some hard to find papers from years gone by.

This particular paper is evocative of an era when collecting was the pursuit of gentlemen, with private means.

The article is extracted from The Intellectual Observer Volume I. There is no author name associated with the article but the same article is noted in Roper as being by George Norman of Hull.

Hunting for Diatoms

(Provided by William Krause from Intellectual Observer)

Let us suppose the diatom collector and his friends to be setting forth, properly equipped with the necessary apparatus for securing and preserving the gatherings they may meet with. Here it will be as well to describe the arrangement of apparatus used by the writer of this paper in his expeditions after Diatomaceae.

First of all, is a morocco leather bag, with a strap to go over the shoulders. This bag contains several pockets, to carry a dozen or more wide-necked bottles of say two-ounce capacity. A small leather case, with six narrow one-ounce phials, with wide necks, the phials slipping into partitions. This case is carried in the pocket of the shooting coat when out on a trip.

Next comes a box with small tubes and a camel-hair pencil, for painting off pure gatherings, or when it is inconvenient to bring home a larger quantity of the material.

In addition to the bottles and tubes some pieces of gutta-percha paper, or waterproof macintosh cloth, nine inches square, are very useful to wrap up Algae, masses of Confervae, and other diatom-yielding plants, into bundles, after slightly pressing out part of the water. These bundles, kept from unfolding by an elastic ring, are put at once into the bag. For scraping the surface of the mud, the sides of jetties, etc., the writer uses a copper spoon, with a screw clamp, to fasten to the end of a walking stick when used. On one side of the neck of the spoon is riveted a small knife blade, which forms a convenient means of cutting away portions of aquatic plants covered with diatoms, and lifting them out of the water.

The only lens necessary to the diatomist when out collecting is a Coddington; but the writer has found a small compound hand microscope very useful occasionally. This, with some slips of glass, are carried in a separate compartment of the leather satchel.

We will now suppose all these arrangements made, and the diatomists, who live in some large sea-port town, are sallying forth, as mentioned in the commencement of this paper.

A knowledge of the most likely places to look for Diatomaceae is only to be gained after some experience, and it is the wish of the writer to give the result of his experience in the matter, which has induced him to pen these lines. In mentioning the various species of Diatomaceae in connection with given habitats and localities, it may be as well to say that the writer has in most cases found the species named in such localities; not necessarily in one particular district, but at various times and in different parts of the country.

We will now suppose the collectors are commencing their imaginary collecting tour, and, before leaving town, let us take a stroll round the Docks - for here we may meet with material in places where such might be the least expected. For instance, let us examine the logs of Baltic or American timber as they come from the vessels. If the timber has remained for any length of time afloat before shipping, the logs are almost sure to have traces of Conferva, either fresh-water or marine, growing on them, and these, on being carefully scraped off, will in all probability, yield diatoms to reward the collector. Some of the logs from the St. Lawrence or the Ottawa will yield us American forma, while logs from Dantzig will give us interesting gatherings from the Vistula and the interior of Poland.

Should a vessel be unloading "Kaurie spars," from New Zealand, or some of those gigantic "sticks" which have lately been imported from Vancouver's Island, we may, probably, be rewarded by finding beautiful Antipodean forms of Diatomaceae on the former, and the exquisite Arachnoidiscus or Triceratium Wilksii from the latter, perhaps even Aulacodiscus Oregonus.

Let us not go past these mahogany logs landing from Mexico or Honduras, as the case may be, without casting an eye over them, for these may have been rafted for some time in the sea before shipment, or may have brought down new or little known forms from the interior of Central America. Here, on the first log we examine, is a copious incrustation of a form, either identical with or closely allied to Melosira nummuloides, abundant likewise in our Docks. The gathering is so copious that it fairly glistens in the sun.

Let us also scrape away some of the shelly incrustation of Balanus, which completely covers some of the logs, for possibly among this we may find that exquisite American form Terpsinoe musica, so called, I suppose, from the costae appearing like so may musical notes.

Here are some fishermen just coming in. Let us examine their nets, for these men are trawlers, and have been fishing in deep water, and the meshes of their nets may still have diatom bearing Algae attached to them. On such Algae we may probably find Rhabdonema arcuatum or Adriaticum, Grammatophora serpentina and marina, with species of parasitic Synedras; possibly singular Synedra undulata, may reward our search.

Some of the oyster shells from deep water are worth examining for marine Algae, or, what is even better, the greenish, leathery-looking ascidians attached to them. The ascidians are regular feeders on diatoms, and their stomach contents often yield a rich harvest of deep-water forms difficult to obtain in any other way. Perhaps we may be securing the rare Biddulphia regina, at any rate Bidd. Baileyii and aurita. We will take some for future examination, for the curious Rhizosolenia styliformis is almost sure to be there.

Let us step into a boat and examine that ship's bottom and sides, which look so brown with a growth of conferva and barnacles. Here the spoon becomes of use. Scrape very gently where the deposit is the darkest in colour, and let us see what we have got - Achnanthes longipes and brevipes in abundance. These are common enough elsewhere in the timber ponds, so we will only secure the little thing in zig-zag filaments, for this is probably Diatoma hyalinum, or, perhaps the rare Hyalosira delicatula.

Is it not singular that such delicate filaments, hanging together by the angles of the frustules, should be able to withstand the rushing of the vessel through the water during the long voyage she has just completed?

The ballast heap must not be passed without examining. Here are stones densely covered with marine Algae and Corallines, which we will scrape off, and store away for after examination. Biddulphia pulchella, Amphitetras, Grammatophora serpentina, or possibly some of the beautiful foreign species of Aulacodiscus, may reward our trouble, for this ballast is brought from all parts of the world. The only matter of regret is the difficulty in ascertaining the exact localities.

Let us now take some of the Zostera which is being landed on the quay in large bales; it is extensively imported from the Baltic as Alva marina, for stuffing chairs and mattresses. Cocconeis scutellum and diaphana, with Epithemia and a medley of other forms, are generally found parasitic on the Zostera, and may be easily separated by maceration in weak acid.

But what are those brown bundles landing from the steamer? These are 'Dutch rushes,' for coopers' purposes and chair bottoms, and are well worth examining, for, growing as they do in brackish water in Holland, the sheath at the base is often completely coated with diatoms, Coscinodiscus subtilis, for instance, with other good things, such as Eupodiscus argus and Triceratium favus.

Nor must we pass these cargoes of bones discharging into lighters. See, some of the larger bones have evidently been lying in water some time, for they are covered with a green incrustation. Let us scrape away the incrustation, for we may find among it the fine Synedra crystallina or undulata, together with valves of Coscinodiscus and Eupodiscus. Many good gatherings have been procured from this source, especially from cargoes coming from Constantinople, Smyrna, and the Black Sea.

Ask this sailor if he has any foreign shells still in the rough state; if he has any for sale, they are certainly worth securing for the small Algae and Corallines found growing on them. These, on being cleaned, often yield splendid results. Many of the most beautiful and rare species of Campylodiscus have been obtained from this source. The Californian Haliotus shell is almost certain to yield the fine Aulacodiscus Oregonus, Arachnoidiscus, Hyalodiscus cervinus, and Biddulphia Roperi; while the Haliotus from New Zealand will probably furnish the rare Aulacodiscus Beeveriae and Macraeanus.

The West Indian Strombus shells invariably yield beautiful forms, such as Campylodiscus ecclesianus, ambiguus, and imperialis.

Vessels with guano are worth visiting. The Peruvian guano, when properly prepared, yields the magnificent Asterolampras and Aulacodiscus scaber; while the Bolivian is even richer in fine things, such as the superb Aulacodiscus formosus and Comberi. Californian guano yields, among an infinite variety of forms, many of great beauty and rarity, such as Aulacodiscus margaritaceus and Biddulphia Tuomeyii. Algoa Bay is frequently rich in Aulacodiscus Petersii; and, finally, the Ichaboe guano, Eupodiscus Ehrenbergii, and other good things.

brown mass completely covering the stones in the bed of the stream is Cocconema lanceolatum, not often found so pure.

Let us see what causes the green colour on the surface of the mud in the roadside puddle. Ah! this is indeed a treasure, for it is seldom that Navicula cuspidata occurs as perfectly free from mixtures. The green colour is also remarkable, being so different from the usual brown endochrome of most diatoms.

Here is another roadside puddle left by the recent rain, and see what a brown coating has grown at the bottom in so short a time. At any rate we have here Diatomaceae in abundance, though small in size, probably Nitzschia palea and Pinnularia pygmaea.

Proceeding further inland we are supposed to be passing a water-mill, and as the mill race is covered with confervoid growths, let us examine some of the coating from the wooden aquaduct. The brown streamers are in all probability Diatoma vulgare and elongatum, and the beautiful stellate form is the local Asterionella formosa, which by the way, seems to select its habitat always in some out of the way place, such as the present one in the mill aquaduct, water tanks, and reservoirs.

Having climbed up some distance on the hill sides, let us collect some of the weeds from the sides of the boggy pool, for in such localities we may expect to find some of the rarer alpine forms, Navicula rhomboides, obtusa, Pinnularia divergens, lata, and Alpina, for instance. The pale green flocculent mass growing in quantities like a conferva, is well worth collecting, for it is a pure gathering of Tabellaria flocculosa and fenestrata.

In tramping over this quaking bog it is well to roll up a bundle of the Sphagnum, for on afterwards squeezing out the water, we may be rewarded by finding some of the rarer species of Pinnularia, such as Hemiptera and Alpina.

Before leaving this rocky part of the country for the flat country below, let us scrape some of the brown mucus from the face of the dripping rocks, for it will probably yield such forms as Epithemia, Cocconeis Thwaitsii, Navicula Trinodis, Denticula sinuata, etc.

The weather being warm we will quench our thirst at the little spring in the cavern-like hollow in the rocky roadside. Observe the roof of the little cavern is quite covered with a chocolate-brown mass, which feels rough and gritty to the fingers. Here is a splendid and pure gathering of Orthosira arenaria, and I recommend you to take a good store of it away with you, for it is seldom one finds this fine form so pure and unmixed.

Proceeding towards the low country let us take a scrape from the side of this horse-trough, for it is quite brown. It is well we have done so, for it is a nice pure gathering of Cyclotella operculata and Pinnularia pygmaea.

Passing a little further on we come to a clump of ash trees, with a crop of moss growing on their trunks. Perhaps you may smile when I proceed to peel off this moss and store it away in a bundle in my satchel. On washing the moss afterwards, however, I may be rewarded with some of our most local and rare species, viz. Orthosira mirabilis, mixed with Navicula tumida, Pinnularia borealis, and Orthosira spinosa.

Having secured a bundle of moss from the tree trunks, we will take another from the roof of this old thatched cottage, the north side of which is quite covered with beautiful green moss. This will probably yield Nitzschia Amphioxys and Pinnularia borealis.

The white-coloured stratum of earth exposed in the cutting on the roadside must now be examined, for it is probably a deposit of fossil, diatomaceous earth, in which case a large piece

must be secured.

These fossil deposits are generally composed of a compact mass of Diatomaceae of recent as well as extinct species. The deposit we are at present examining is several feet thick, and has at some remote period formed the bed of a lake, the diatoms accumulating at the bottom until the present thickness was attained. You will observe that the endochrome has been removed by long rotting, and the entire mass is now composed of the pure white siliceous valves. Pray also observe that this richness in silex suits the cereal crops growing over it, but does not seem to furnish much nutrient to the potatoes and turnips.

The adjacent peat beds may also be examined, for frequently rare Diatomaceae are found in the turf which is cut for fuel.

The dark hair-like mass growing on the woodwork of this sluice-gate, is a nice pure gathering of Schizonema neglectum, the frustules arranged in regular rows in the interior of the long filaments.

Before leaving this pond let us pull out a mass of the Myriophyllum, which seems rusty in colour. Well! here is a medley of forms, but the gathering is worth bottling up, owing to the abundance of Amphipleura pellucida.

The clear ditch by the roadside is a likely place for such forms as Pleurosigma attenuatum, Spencerii and lacustre, Nitzschia linearis and tenuis, Surirella ovata, Navicula elliptica and Cymbella maculata.

The yellow mass attached to the plants a little further on is Cyclotella operculata, Amphora ovalis and Nitzschia sigmoidea, while the brown covering on the Anacharis is Gomphonema tenellum, dichotomum and curvatum. The stones in the running beck, issuing from the clear spring close by, are covered with long, yellowish-brown streamers, which are well worth collecting. Take them out very gently, for they are very fragile and likely to drop again into the water. The species is the beautiful Meridion circulare, with Melosira varians.

At the bubbling spring itself, which forms the head of the streamlet, the sand, which is tossed and heaved about by the ascending water seems tinted of a brown colour. Let us secure some of the sand, when we shall find the brown colour is caused by a dense parasitic growth of Odontidium Harrisonii quite pure.

Further on the dark brown streamers must be collected, for here are two species of Fragillaria, Capucina and virescens, mixed with Diatoma elongatum. The stones and aquatic plants are likewise covered with a dense brown coating of Synedra radians, and Ulna, species found in almost every clear water-ditch.

The boggy place where he plants are coated with a yellow coating of the oxide of iron, is not to be passed without collecting a little of the light flocculent surface mud. This will be almost sure to yield some fine diatoms, such as Campylodiscus spiralis, Pinnularia nobilis, Stauroneis Phoenicentron, Surirella splendida, and Cymatopleura solea.

Here we must finish our day's work, having arrived at the railway station, from whence we proceed home with our treasures. The work of collecting has been finished, yet much remains to be done before the material is cleansed and mounted on slides for microscopical investigation.

Let us hope our fatigue has not been in vain, but that the store of riches we have collected together, will furnish us with ample material for much interesting study and instruction.

Field Microscopes

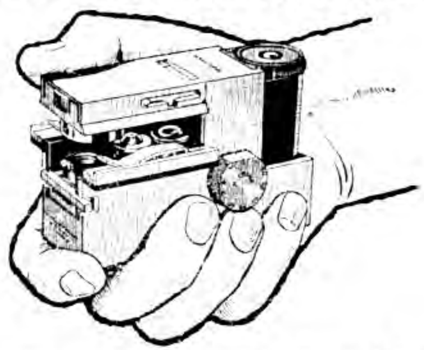
Part I - The McArthur Model.

This innovative microscope has a surprisingly long history having been designed in 1930 by John N. McArthur. (A history of the development appears in the Quekett Journal of Microscopy (1986) 35, 405-419). Very occasionally models as originally designed appear on the market, though these tend to be expensive. They were made by McArthur himself and also by a number of other well-known and not-so-well-known manufacturers e.g. Hearson in the mid 1930s, Cooke, Troughton and Simms in the 1960's, Prior in the 1980's. The design didn't really get into the hands of the amateur until the advent of the plastic version that was produced for the Open University early in the 1970s. Copies of this plastic version have been made throughout the world since then, a version even being supplied to the Eritrean Public Health Programme in 1982 (see Bracegirdle - Notes on Modern Microscope Manufacturers).

We are fortunate in having two models to illustrate and describe here together with some advertising literature and instructional notes. The notes were associated with the first model we are going to look at.

APPLICATIONS OF THE

McARTHUR MICROSCOPE



The Microscope specially designed for Tropical Medicine

Rugged, vibration-free, operable in the hand
Measuring 4 × 2½ × 2 inches and weighing 18 oz

Providing:

- The highest magnifications, 1200 or more
- Wide range of standard optics
- Automatic focusing
- An erect image
- Self-contained illumination

Operations on the bench or in the field of which no other microscope is capable

Accessories for:

- Examination of blood films, smears, sections, surfaces, suspensions and sediments in depths of fluid
- Transmitted and incident illumination
- Automatically adjusted phase contrast and oil immersion dark ground illumination
- Dissection, polarizing, fluorescence
- Blood counts, traversing, measurement
- Photo, ciné and television microscopy, video-recording
- Binocular and other bench stands

The McArthur Microscope
Landbeach, Cambridge
CB4 4ED (England)

Telephone:
Waterbeach 629

This is one of the Kirk Technology models constructed of beautifully machined metal in the mid 1980s.

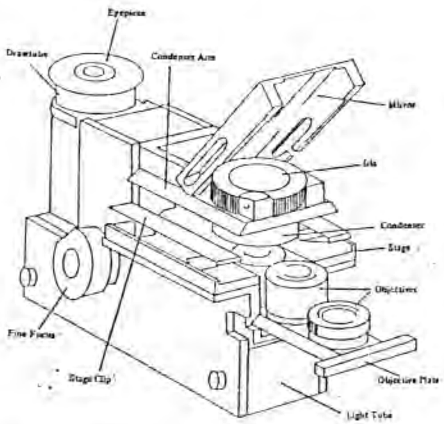
Because of its all metal construction this model is very robust. It has quality optics and even includes a phase condenser and phase optics in its accessory list. These are pictured below together with a later addition, made to the same exacting specifications, a battery powered light source.

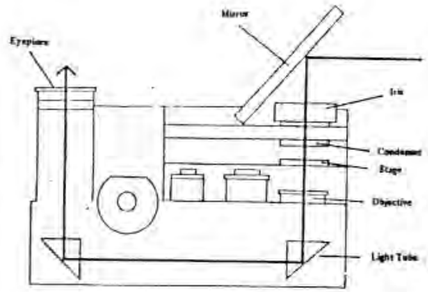
In the field it was easy to operate and quick to set up. The diagrams below are from the original literature for this model and show the component parts and the light path.

The following is from the description supplied with the microscope:-

Operating principles

Unlike the conventional microscope, light enters the McArthur Microscope from above. A mirror reflects light downwards through the iris and condenser to the specimen on the stage, and into the objective. A reflector then passes the light along the light tube in the base of the microscope to a second reflector. Finally, the light is reflected upwards into the eyepiece to form the





Using the microscope

The microscope can be used on any convenient flat surface, on a tripod or similar mounting, or simply held in the hand.

1. Make sure the fine focus is in the centre position.

2. Slide the mirror forwards as far as it will go and raise it to about 45 degrees.

3. Place the slide on the stage FACE DOWNWARDS by sliding in under the stage clips.

4. Position the microscope so that the mirror faces a suitable source of light. DO NOT point the microscope directly at the sun.

5. With the objective plate pushed fully in, look through the eyepiece and examine the specimen through the 10x objective.

6. If necessary, adjust the fine focus to bring it into perfect focus.

7. Adjust the iris to obtain the correct aperture. Remember, too much light can be just as detrimental to accurate observation of a specimen as too little light.

The specimen can then be examined through the other objectives without further adjustment of focus other than to sharpen detail. The iris will need to be adjusted to suit each objective.

Once focused, the microscope can be used to examine a whole series of similar specimens with practically no further adjustment other than a touch of the fine focus to sharpen the detail. Unlike a conventional microscope, it is not necessary to rack the objective away and disturb focus to change the slide. Slides can be replaced without disturbing any adjustment, and provided the microscope is properly focused, there is no risk of touching the lens with any normal specimen.

Oil Immersion (for x100 lens only)

Immersion oil can be applied to the immersion lens in two ways:

a) Remove the slide, place a drop of oil on its centre and return the slide to the stage.

b) Slide the objective plate forward until the immersion lens just projects beyond the slide, and

The advertisement above is probably by Hearson and refers to the British Commonwealth Trans Antarctic Expedition of Sir Vivian Fuchs in 1955. The following extracts are from various accounts:-

"In summer the sealing vessels were frequently chartered out for government purposes. In 1955 one such vessel, 'the Theron" was used to transport Sir Edmund Hillary's expedition to the Antarctic."

"November 14 1955 Fuchs leaves London on the Theron, British Commonwealth Transantarctic Expedition."

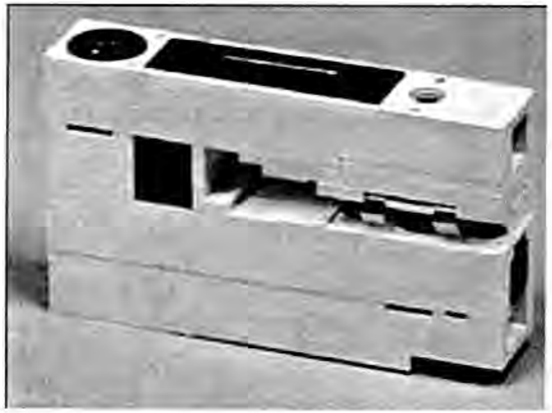
"Sir Vivian Fuchs's qualities of leadership were apparent from the beginning: in his equanimity during the Theron's daunting passage of the ice-bound Weddell Sea in 1956, and in the speed and resolution with which he put ashore his advance party late in the season and in worsening weather. Swift action was vital if enough stores and equipment were to be landed to enable Ken Blaiklock and his team to build the foundations of a base for the expedition's main task in the following year. They had to be landed before the winter ice, already closing in, blocked the Theron's passage home. The survival of the advance party and the accomplishment of their programme, despite the loss of stores in a gale, says much for the skill with which Fuchs had picked his men."

The Open University Model.

This model is probably the one most likely to be encountered.

It is lightweight and ideal for packing in a coat pocket or collecting bag. It is battery operated and easily provides sufficient magnification to detect diatoms in fresh samples.

It's main drawback is its electrics. These are often in a sorry state and often one has to make up



one working model from three others. With a little ingenuity it should be possible to convert the bulb circuit to an LED system which would not only provide better illumination but have the added advantage of making the batteries last longer. We will include this as a project in a later issue. Occasionally these appear at the various Microscopical Society meetings in the UK.

A particularly useful article on servicing these microscopes appears on the Microscopy-UK website:- Cleaning and Adjusting the Open University McArthur Microscope: Notes and Recommendations by Guido Santacana, Puerto Rico.

There are other manufacturers producing an instrument based on McArthur's design,. One such is the Nikon Model H, Pictured here.

John Norrie McArthur (9th November 1901-26th April 1996)

Extract from the obituary in The Glasgow Herald of the 11th May 1996. Overleaf.

Dr John Norrie McArthur, MRCS, LRCP, Hon FRMS, Hon Doctorate Open University, Hon FRS; born Glasgow, November 9, 1901, died Cambridge, April 26, 1996

Dr. John McArthur, probably best-known in the scientific world as the inventor of a revolutionary design for a miniature microscope, has died at the age of 94.

Although he was a Glaswegian by birth, McArthur and his parents moved to London when he was a year old, and he never returned to live in his native land although he visited Scotland frequently, including the gathering of Clan McArthur some five yeas ago, at which a new chieftain was elected.

For this and other notable occassions, including his 90th birthday, McArthur wore the kilt, which he did with great distinction. His lean frame and rather aquiline features, with his flowing silver locks and silver beard, were admirably complemented by the kilt, and he looked the archetypal Scottish gentleman which, indeed, he was.

McArthur studied medicine at University College, London, and obtained his MRCS and LRCP in 1933, having already met and married his first wife, Kitty. He had intended to become a medical missionary, but for various reasons this did not come about and he worked first as a

medical officer with a diamond mining company in Sierra Leone.

He soon moved, with his wife, to North Borneo as malaria researh officer and ultimately became director of malaria research for North Borneo, Sarawak and Brunei.

Between his arrival in North Borneo in 1938 and the Japanese invasion in 1943, McArthur did some of his most valuable research on the mosquito vectors of malaria in that country and the means for their control by "natural" methods such as clearing the undergrowth from streams which provided the mosquitos with the shade they needed for their larval development in the water.

McArthur always felt that this work had been overlooked, when the World Health Organisation decided in the early post-war years to concentrate on the use of the "new" insecticide DDT in its campaign against malaria.

The McArthur's son, Malcolm was born on the day that the Japanese Army landed in Borneo, and before long McArthur was imprisoned by the Japanese authorities. Ever since his days as a medical student , McArthur had been working on his truly portable microscope, which he achieved by the then novel idea of using prisms to "concertina" the light path in the instrument so that, instead of the conventional instrument which stood some 15 inches high, his version was only about 4x3x1 inches in size.

When captured by the Japanese, he had the only prototype model with him and this, together with all his mosquito research records, was confiscated by his captors. Amazingly both were recovered after his release by Allied forces in 1945.

After returning to England in 1951, McArthur concentrated on the development of his microscope. He became even more determined that nothing less than perfection would do. Working initially in a converted wooden chicken shed in the garden of his village home near Cambridge, and with machinery made by a local garage, he finally achieved, if not perfection, an instrument which was capable of performing all the functions of a normal microscope.

It had the advantage of being able to be fitted directly on to the lens of a television camera, and one instrument was used by the BBC to transmit images of "moon dust" brought back by the first Apollo mission to the moon.

In 1962, McArthur was saddened by the death of his first wife. However a year later he remarried to Ruth, a friend of many years' standing. Ruth supported him in his continuing efforts to improve the microscope, although his insistence on perfection and lack of concern for the commercial aspects of the venture must have made this difficult at times.

In the course of this work, John McArthur produced an inexpensive version of the microscope with a plastic body, which was adopted by the Open University. This model received awards from the Council of Industrial Design, and the Design Council, and McArthur himself was rewarded with an honorary doctorate from the Open University.

Useful Notes

Many older texts and samples that refer to soundings often use fathoms as a measurement of depth. Modern soundings tend to use metres. The table on the next few pages provides an easy lookup conversion.

Fath.	Metres	220	402.3294	445	813.80265
1	1.82877	225	411.47325	450	822.9465
5	9.14385	230	420.6171	455	832.09035
10	18.2877	235	429.76095	460	841.2342
15	27.43155	240	438.9048	465	850.37805
20	36.5754	245	448.04865	470	859.5219
25	45.71925	250	457.1925	475	868.66575
30	54.8631	255	466.33635	480	877.8096
35	64.00695	260	475.4802	485	886.95345
40	73.1508	265	484.62405	490	896.0973
45	82.29465	270	493.7679	495	905.24115
50	91.4385	275	502.91175	500	914.385
55	100.58235	280	512.0556	505	923.52885
60	109.7262	285	521.19945	510	932.6727
65	118.87005	290	530.3433	515	941.81655
70	128.0139	295	539.48715	520	950.9604
75	137.15775	300	548.631	525	960.10425
80	146.3016	305	557.77485	530	969.2481
85	155.44545	310	566.9187	535	978.39195
90	164.5893	315	576.06255	540	987.5358
95	173.73315	320	585.2064	545	996.67965
100	182.877	325	594.35025	550	1005.8235
105	192.02085	330	603.4941	555	1014.96735
110	201.1647	335	612.63795	560	1024.1112
115	210.30855	340	621.7818	565	1033.25505
120	219.4524	345	630.92565	570	1042.3989
125	228.59625	350	640.0695	575	1051.54275
130	237.7401	355	649.21335	580	1060.6866
135	246.88395	360	658.3572	585	1069.83045
140	256.0278	365	667.50105	590	1078.9743
145	265.17165	370	676.6449	595	1088.11815
150	274.3155	375	685.78875	600	1097.262
155	283.45935	380	694.9326	605	1106.40585
160	292.6032	385	704.07645	610	1115.5497
165	301.74705	390	713.2203	615	1124.69355
170	310.8909	395	722.36415	620	1133.8374
175	320.03475	400	731.508	625	1142.98125
180	329.1786	405	740.65185	630	1152.1251
185	338.32245	410	749.7957	635	1161.26895
190	347.4663	415	758.93955	640	1170.4128
195	356.61015	420	768.0834	645	1179.55665
200	365.754	425	777.22725	650	1188.7005
205	374.89785	430	786.3711	655	1197.84435
210	384.0417	435	795.51495	660	1206.9882
215	393.18555	440	804.6588	665	1216.13205

670	1225.2759	895	1636.74915	1125	2057.36625
675	1234.41975	900	1645.893	1130	2066.5101
680	1243.5636	905	1655.03685	1135	2075.65395
685	1252.70745	910	1664.1807	1140	2084.7978
690	1261.8513	915	1673.32455	1145	2093.94165
695	1270.99515	920	1682.4684	1150	2103.0855
700	1280.139	925	1691.61225	1155	2112.22935
705	1289.28285	930	1700.7561	1160	2121.3732
710	1298.4267	935	1709.89995	1165	2130.51705
715	1307.57055	940	1719.0438	1170	2139.6609
720	1316.7144	945	1728.18765	1175	2148.80475
725	1325.85825	950	1737.3315	1180	2157.9486
730	1335.0021	955	1746.47535	1185	2167.09245
735	1344.14595	960	1755.6192	1190	2176.2363
740	1353.2898	965	1764.76305	1195	2185.38015
745	1362.43365	970	1773.9069	1200	2194.524
750	1371.5775	975	1783.05075	1205	2203.66785
755	1380.72135	980	1792.1946	1210	2212.8117
760	1389.8652	985	1801.33845	1215	2221.95555
765	1399.00905	990	1810.4823	1220	2231.0994
770	1408.1529	995	1819.62615	1225	2240.24325
775	1417.29675	1000	1828.77	1230	2249.3871
780	1426.4406	1005	1837.91385	1235	2258.53095
785	1435.58445	1010	1847.0577	1240	2267.6748
790	1444.7283	1015	1856.20155	1245	2276.81865
795	1453.87215	1025	1874.48925	1250	2285.9625
800	1463.016	1030	1883.6331	1255	2295.10635
805	1472.15985	1035	1892.77695	1260	2304.2502
810	1481.3037	1040	1901.9208	1265	2313.39405
815	1490.44755	1045	1911.06465	1270	2322.5379
820	1499.5914	1050	1920.2085	1275	2331.68175
825	1508.73525	1055	1929.35235	1280	2340.8256
830	1517.8791	1060	1938.4962	1285	2349.96945
835	1527.02295	1065	1947.64005	1290	2359.1133
840	1536.1668	1070	1956.7839	1295	2368.25715
845	1545.31065	1075	1965.92775	1300	2377.401
850	1554.4545	1080	1975.0716	1305	2386.54485
855	1563.59835	1085	1984.21545	1310	2395.6887
860	1572.7422	1090	1993.3593	1315	2404.83255
865	1581.88605	1095	2002.50315	1320	2413.9764
870	1591.0299	1100	2011.647	1325	2423.12025
875	1600.17375	1105	2020.79085	1330	2432.2641
880	1609.3176	1110	2029.9347	1335	2441.40795
885	1618.46145	1115	2039.07855	1340	2450.5518
890	1627.6053	1120	2048.2224	1345	2459.69565

1350	2468.8395	1575	2880.31275	1800	3291.786
1355	2477.98335	1580	2889.4566	1805	3300.92985
1360	2487.1272	1585	2898.60045	1810	3310.0737
1365	2496.27105	1590	2907.7443	1815	3319.21755
1370	2505.4149	1595	2916.88815	1820	3328.3614
1375	2514.55875	1600	2926.032	1825	3337.50525
1380	2523.7026	1605	2935.17585	1830	3346.6491
1385	2532.84645	1610	2944.3197	1835	3355.79295
1390	2541.9903	1615	2953.46355	1840	3364.9368
1395	2551.13415	1620	2962.6074	1845	3374.08065
1400	2560.278	1625	2971.75125	1850	3383.2245
1405	2569.42185	1630	2980.8951	1855	3392.36835
1410	2578.5657	1635	2990.03895	1860	3401.5122
1415	2587.70955	1640	2999.1828	1865	3410.65605
1420	2596.8534	1645	3008.32665	1870	3419.7999
1425	2605.99725	1650	3017.4705	1875	3428.94375
1430	2615.1411	1655	3026.61435	1880	3438.0876
1435	2624.28495	1660	3035.7582	1885	3447.23145
1440	2633.4288	1665	3044.90205	1890	3456.3753
1445	2642.57265	1670	3054.0459	1895	3465.51915
1450	2651.7165	1675	3063.18975	1900	3474.663
1455	2660.86035	1680	3072.3336	1905	3483.80685
1460	2670.0042	1685	3081.47745	1910	3492.9507
1465	2679.14805	1690	3090.6213	1915	3502.09455
1470	2688.2919	1695	3099.76515	1920	3511.2384
1475	2697.43575	1700	3108.909	1925	3520.38225
1480	2706.5796	1705	3118.05285	1930	3529.5261
1485	2715.72345	1710	3127.1967	1935	3538.66995
1490	2724.8673	1715	3136.34055	1940	3547.8138
1495	2734.01115	1720	3145.4844	1945	3556.95765
1500	2743.155	1725	3154.62825	1950	3566.1015
1505	2752.29885	1730	3163.7721	1955	3575.24535
1510	2761.4427	1735	3172.91595	1960	3584.3892
1515	2770.58655	1740	3182.0598	1965	3593.53305
1520	2779.7304	1745	3191.20365	1970	3602.6769
1525	2788.87425	1750	3200.3475	1975	3611.82075
1530	2798.0181	1755	3209.49135	1980	3620.9646
1535	2807.16195	1760	3218.6352	1985	3630.10845
1540	2816.3058	1765	3227.77905	1990	3639.2523
1545	2825.44965	1770	3236.9229	1995	3648.39615
1550	2834.5935	1775	3246.06675	2000	3657.54
1555	2843.73735	1780	3255.2106	2005	3666.68385
1560	2852.8812	1785	3264.35445	2010	3675.8277
1565	2862.02505	1790	3273.4983	2015	3684.97155
1570	2871.1689	1795	3282.64215	2020	3694.1154

2025	3703.25925	2255	4123.87635	2480	4535.3496
2030	3712.4031	2260	4133.0202	2485	4544.49345
2035	3721.54695	2265	4142.16405	2490	4553.6373
2040	3730.6908	2270	4151.3079	2495	4562.78115
2050	3748.9785	2275	4160.45175	2500	4571.925
2055	3758.12235	2280	4169.5956	2505	4581.06885
2060	3767.2662	2285	4178.73945	2510	4590.2127
2065	3776.41005	2290	4187.8833	2515	4599.35655
2070	3785.5539	2295	4197.02715	2520	4608.5004
2075	3794.69775	2300	4206.171	2525	4617.64425
2080	3803.8416	2305	4215.31485	2530	4626.7881
2085	3812.98545	2310	4224.4587	2535	4635.93195
2090	3822.1293	2315	4233.60255	2540	4645.0758
2095	3831.27315	2320	4242.7464	2545	4654.21965
2100	3840.417	2325	4251.89025	2550	4663.3635
2105	3849.56085	2330	4261.0341	2555	4672.50735
2110	3858.7047	2335	4270.17795	2560	4681.6512
2115	3867.84855	2340	4279.3218	2565	4690.79505
2120	3876.9924	2345	4288.46565	2570	4699.9389
2125	3886.13625	2350	4297.6095	2575	4709.08275
2130	3895.2801	2355	4306.75335	2580	4718.2266
2135	3904.42395	2360	4315.8972	2585	4727.37045
2140	3913.5678	2365	4325.04105	2590	4736.5143
2145	3922.71165	2370	4334.1849	2595	4745.65815
2150	3931.8555	2375	4343.32875	2600	4754.802
2155	3940.99935	2380	4352.4726	2605	4763.94585
2160	3950.1432	2385	4361.61645	2610	4773.0897
2165	3959.28705	2390	4370.7603	2615	4782.23355
2170	3968.4309	2395	4379.90415	2620	4791.3774
2175	3977.57475	2400	4389.048	2625	4800.52125
2180	3986.7186	2405	4398.19185	2630	4809.6651
2185	3995.86245	2410	4407.3357	2635	4818.80895
2190	4005.0063	2415	4416.47955	2640	4827.9528
2195	4014.15015	2420	4425.6234	2645	4837.09665
2200	4023.294	2425	4434.76725	2650	4846.2405
2205	4032.43785	2430	4443.9111	2655	4855.38435
2210	4041.5817	2435	4453.05495	2660	4864.5282
2215	4050.72555	2440	4462.1988	2665	4873.67205
2220	4059.8694	2445	4471.34265	2670	4882.8159
2225	4069.01325	2450	4480.4865	2675	4891.95975
2230	4078.1571	2455	4489.63035	2680	4901.1036
2235	4087.30095	2460	4498.7742	2685	4910.24745
2240	4096.4448	2465	4507.91805	2690	4919.3913
2245	4105.58865	2470	4517.0619	2695	4928.53515
2250	4114.7325	2475	4526.20575	2700	4937.679

2705	4946.82285	2805	5129.69985	2905	5312.57685
2710	4955.9667	2810	5138.8437	2910	5321.7207
2715	4965.11055	2815	5147.98755	2915	5330.86455
2720	4974.2544	2820	5157.1314	2920	5340.0084
2725	4983.39825	2825	5166.27525	2925	5349.15225
2730	4992.5421	2830	5175.4191	2930	5358.2961
2735	5001.68595	2835	5184.56295	2935	5367.43995
2740	5010.8298	2840	5193.7068	2940	5376.5838
2745	5019.97365	2845	5202.85065	2945	5385.72765
2750	5029.1175	2850	5211.9945	2950	5394.8715
2755	5038.26135	2855	5221.13835	2955	5404.01535
2760	5047.4052	2860	5230.2822	2960	5413.1592
2765	5056.54905	2865	5239.42605	2965	5422.30305
2770	5065.6929	2870	5248.5699	2970	5431.4469
2775	5074.83675	2875	5257.71375	2975	5440.59075
2780	5083.9806	2880	5266.8576	2980	5449.7346
2785	5093.12445	2885	5276.00145	2985	5458.87845
2790	5102.2683	2890	5285.1453	2990	5468.0223
2795	5111.41215	2895	5294.28915	2995	5477.16615
2800	5120.556	2900	5303.433	3000	5486.31

The Points of the Compass

The compass has four Cardinal points - North, south, East and West. Between these Cardinal points there are intermediate points allowing us to describe direction in English, with reference to the nearest Cardinal point. Altogether there are twenty eight of these points in general use. Between each Cardinal point there is a halfway point called a Collateral point. Thus the Collateral point between North and East is given the description North-East (N.E.). Between these Collateral points the compass is further sub-divided to provide three other points of reference. Each point in each quadrant thus has a particular angle and may be further sub-divided referencing each point as a quarter point offset from your starting point (which is usually a Cardinal point).These points and the angles they prescribe, together with the Naming conventions for each of the major intermediate points is detailed in the table overleaf. In the table below the Points are relative to the Cardinals - N = 0.

Points of the Compass and the angles made with the meridian.

Points.	Angle (degrees, minutes, seconds)	North		South	
/	2 48 45				
fi	5 37 30				
fl	8 26 15				
1	11 15 0	N. by E.	N. by W.	S. by E.	S. by W.
1 /	14 3 45				
1 fi	16 52 30				
1 fl	19 41 15				
2	22 30 0	N.N.E.	N.N.W.	S.S.E.	S.S.W
2 /	25 18 45				
2 fi	28 7 30				
2 fl	30 56 15				
3	33 45 0	N.E. by N.	N.W. by N.	S.E. by S.	S.W. by S.
3 /	36 33 45				
3 fi	39 22 30				
3 fl	42 11 15				
4	45 0 0	N.E.	N.W.	S.E.	S.W.
4 /	47 48 45				
4 fi	50 37 30				
4 fl	53 26 15				
5	56 15 0	N.E. by E.	N.W. by W.	S.E. by E.	S.W. by W.
5 /	59 3 45				
5 fi	61 52 30				
5 fl	64 41 15				
6	67 30 0	E.N.E.	W.N.W.	E.S.E.	W.S.W.
6 /	70 18 45				
6 fi	73 7 30				
6 fl	75 56 15				
7	78 45 0	E. by N.	W. by N.	E. by S.	W. by S.
7 /	81 33 45				
7 fi	84 22 30				
7 fl	87 11 15				
8	90 0 0	E.	W.	E.	W.

Continuing the theme of Soundings and Navigation

Longitude and Latitude explained.

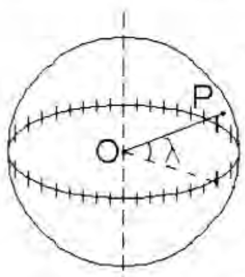
Positions of soundings are nearly always given as a latitude/longitude.

Any location on Earth can be denoted by two series of numbers--latitude and longitude. Soundings (ocean bed samples) are normally given these type of co-ordinates. These numbers are actually two angles, each measured in degrees, minutes of arc and seconds of arc. These are denoted by the symbols (°,',") e.g. 32° 23' 7" means an angle of 32 degrees, 23 minutes and 7 seconds ('," may easily be confused with the symbols for feet and inches and this is one of the reasons that most soundings are measured in fathoms.). Each degree contains 60 minutes of arc and a minute contains 60 seconds of arc.

In Algebra these values are often represented by lower case letters of the Greek alphabet, latitude being represented by l (lambda, Greek L), and longitude by f (phi, Greek F).

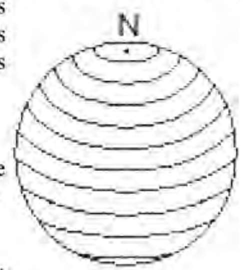
Latitude

Imagine the Earth as a transparent sphere (ignoring the fact that the earth bulges at the equator due to the Earth's rotation). Inside the drawing of the sphere of the earth you can see its equatorial plane, and its middle point denoted as O, the centre of the Earth.



To specify the latitude of some point P on the surface, draw the radius OP to that point. Then the elevation angle of that point above the equator is its latitude (l).

On a globe, lines of latitude areactually circles of different size. The largest is at the equator, whose latitude is zero, whilst those at the poles--at latitudes 90° north and 90° south (or -90°) the circles are nothing but a dot.

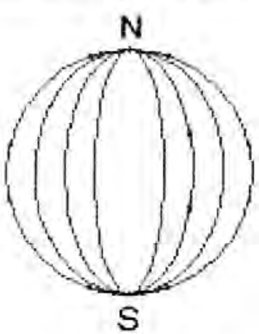


Longitude

On the globe, lines of constant longitude ("meridians") extend from pole to pole, like the segments of an orange.

Lines of latitude

Every meridian must cross the equator. Since the equator is a circle, it can be divided into 360 degrees, and the longitude f of a point is then the marked value of that division where its meridian meets the equator.



Longitude lines or "meridians"

What that value is depends of course on where we begin to count--on where zero longitude is. For historical reasons, the meridian passing the old Royal Astronomical Observatory in Greenwich, England, is the one chosen as zero longitude. Located at the eastern edge of London, the observatory is now a public museum and a brass band stretching across its yard marks the "prime meridian."

A line of longitude is also called a meridian, derived from the Latin, from meri, a variation of "medius" which denotes "middle", and diem, meaning "day." The word once meant "noon", and times of the day before noon were known as "ante meridian" (a.m.), while

after it were "post meridian." (p.m.) All points on the same line of longitude experienced noon (and any other hour) at the same time and were therefore said to be on the same "meridian line", which became "meridian" for short.

Numerical Aperture and Resolving Power

by Barry Ellam

There are certain topics that appear to have perennial interest, The performance of objectives is one such. In the nineteenth century and earlier years of the twentieth century there was a great deal of interest in the use of test objects. I do not intend to write about this in any detail. Modern objectives, computer designed, coated and parfocal are of predictable performance. It was not always so. Watson's would send a known customer a few objectives to choose from. Hence, test objects were of real value in assessing objectives. Carpenter and Dallinger and Spitta both devoted a good deal of space to reviews of objectives of the day.

Today, probably the most important use for test objects is in testing microscopists. There is much to be said for having a few slides with which you are thoroughly familiar. My favourite, if I must name one, is the diatom Pleurosigma angulatum. It is not the most difficult test object but it does have a wide application.

Professor Hawkins reckons that an author loses half his readers for each equation. At the risk of this I wish to pursue the calculation of values for resolving power. Firstly however, a definition is in order.

The simplest definition is - Resolving power is the ability of a microscope to show detail. I do not wish to pursue this definition further at present but briefly to consider the factors influencing resolution.

Some writers have made much of the fact that several versions of the formula power have been published. This is a reflection of the fact that the theoretical background is by no means straightforward. In practice they all yield rather similar results. This being so, we may as well use the simplest version:-

$$R = \frac{\text{lambda (l)}}{2x\text{NA}}$$

R=resolving power. This will be expressed in um.

Lambda (l) is the wavelength of light being used. Of course, we are normally using white light (a combination of wavelengths), but there is a way around this.

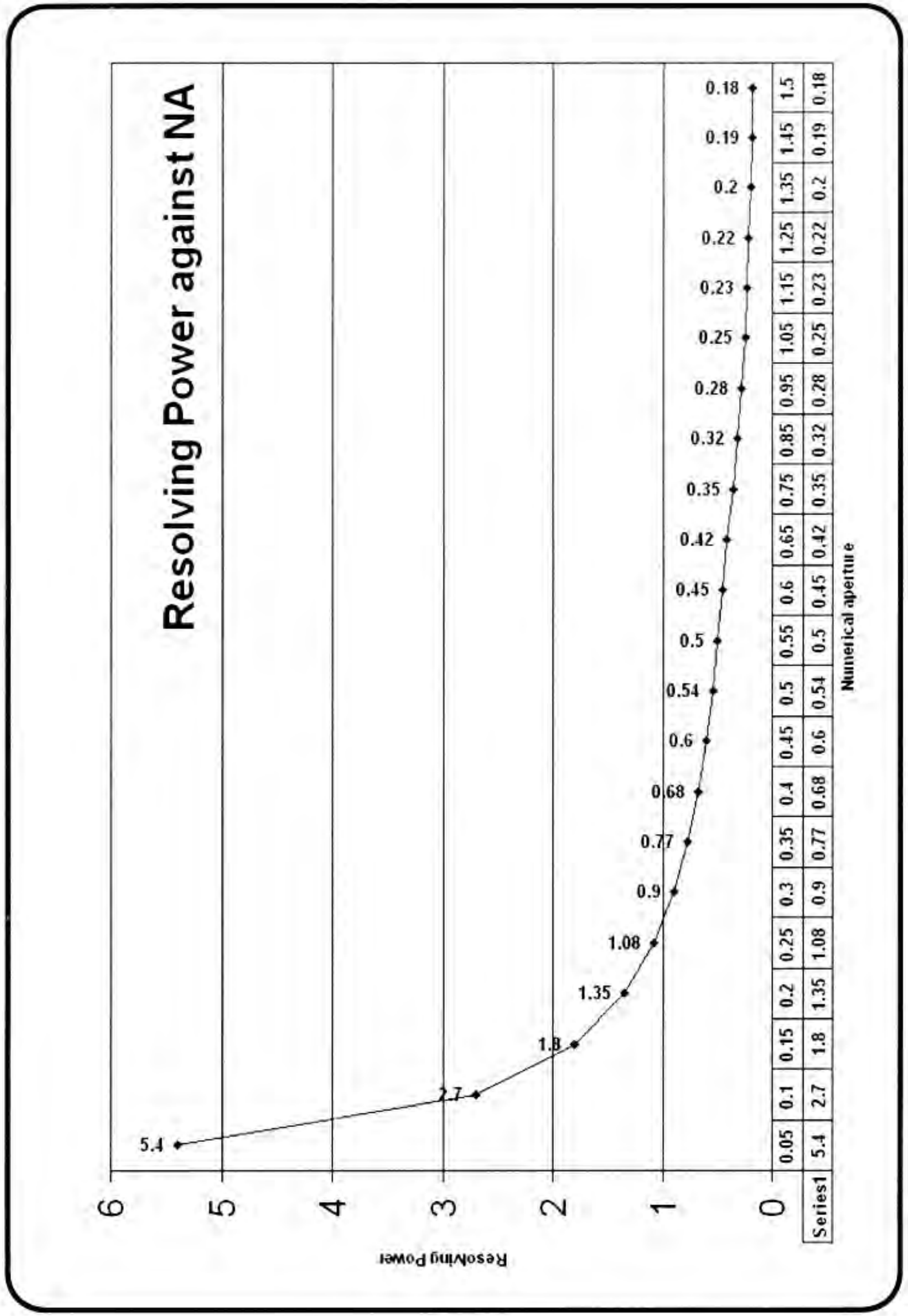
NA is the numerical aperture of the objective. This value is normally engraved on the objective.

Before proceeding, let us think how to proceed.

R, resolving power is to be calculated.

Lambda (l), the wavelength of the light to be used. The visible spectrum extends from violet light with a wavelength of about 400nm to the far end of red light with a wavelength of about 700nm. For the purpose of calculation we will opt for green light, with a wavelength of 540nm.

To tidy up the units, we will find it useful to convert our wavelength in nm into um. 540nm = 0.54um.



With the use of a calculator, it is easy to arrive at values of R for any numerical aperture. The results are given in the table below.

NA	R(um)
0.05	5.4
0.10	2.7
0.15	1.8
0.20	1.35
0.25	1.08
0.30	0.90
0.35	0.77
0.40	0.68
0.45	0.60
0.50	0.54
0.55	0.50
0.60	0.45
0.65	0.42
0.75	0.35
0.85	0.32
0.95	0.28
1.05	0.25
1.15	0.23
1.25	0.22
1.35	0.20
1.45	0.19
1.50	0.18

Table 1

A simple inspection of this table is instructive. A change in the NA of the objective from 0.05 to 0.15 results in a change in the calculated resolving power from 5.4um to 1.8um, a change of 3.6um. If we now take two values from the middle of the table, a change of NA from 0.55 to 0.65. the resolution changes from o.50 to 0.42um, a change of only 0.08um.

Now look at some figures from the bottom of the table. An increase of NA from 1.25 to 1.35 gives a change in the value of R from o.22 to o.20, a change of only 0.02um. A law of diminishing returns. This is particularly well shown if the results are presented as a graph.

At this stage it is worthwhile looking at what happens if we change the wavelength. These values are calculated for a single numerical aperture, 1.30. This is a widely used value for NA of oil immersion objectives. One would not, in the main, be tempted to try changing the wavelength to improve resolution for a low power objective. One might, of course, do exactly that to improve visibility, but that is another subject.

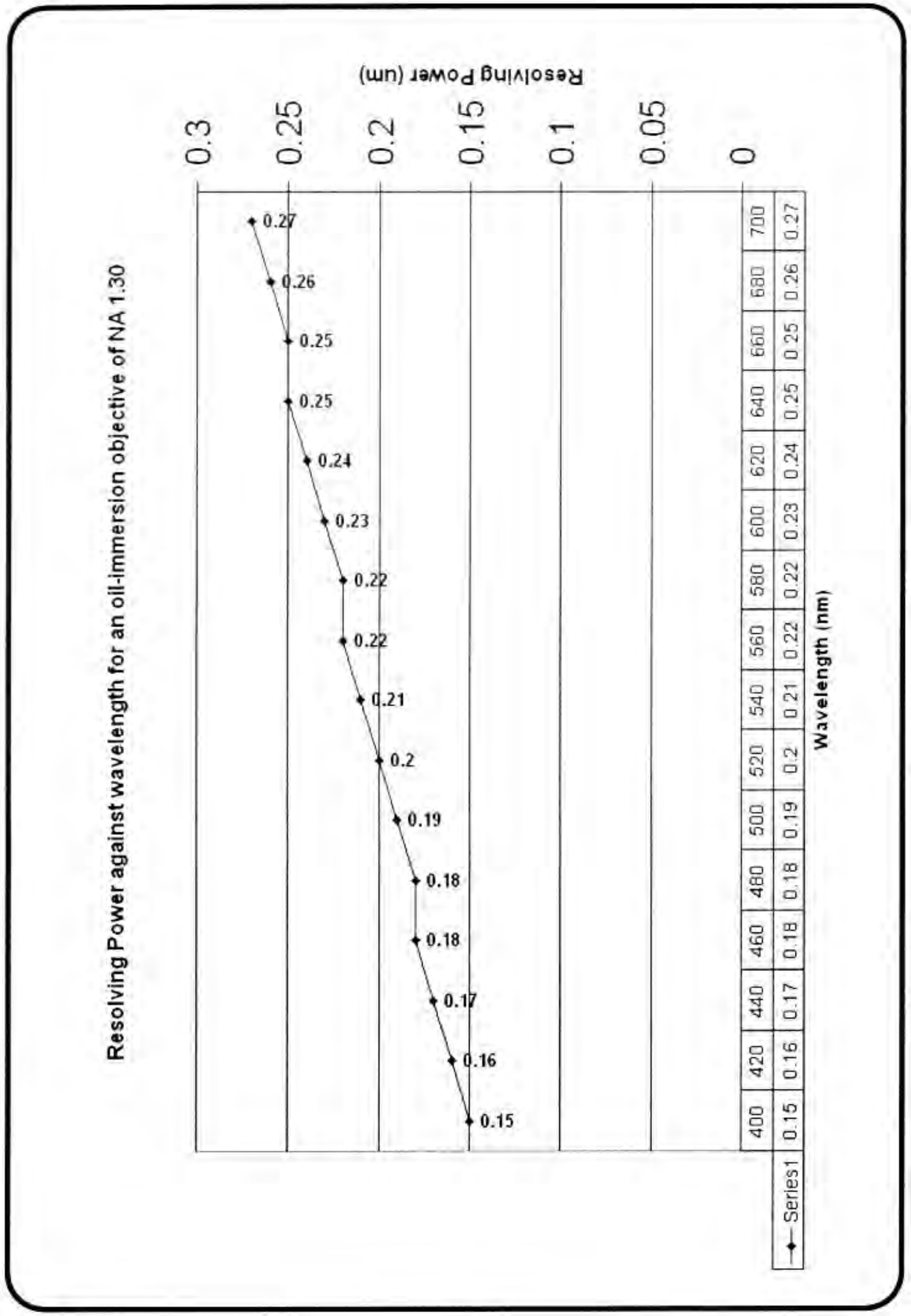


Table 2. Resolving power against wavelength for an oil immersion objective of NA 1.30

Wavelength - lambda (nm)	R (um)
400	0.15
420	0.16
440	0.17
460	0.18
480	0.18
500	0.19
520	0.20
540	0.21
560	0.22
580	0.22
600	0.23
620	0.24
640	0.25
660	0.25
680	0.26
700	0.27

Someone, I am sure will notice that the result (graph on previous page) should really be a straight line, but I have rounded all values to two decimal places.

Now we come to the point. What conclusions can the practical microscopist draw from all this? The first is that the advantages to be derived from a simple interest of NA are marginal. That does not mean that they may not occasionally be important. However, it does mean that it is worth thinking very hard before raising a second mortgage to pay for that high NA plan-apo.

As to the advantages to be gained from the use of light of a shorter wavelength, these are, perhaps, more subtle. The use of a deep blue filter looks as though it would offer a small but significant advantage. It is, however, worth remembering that the retina is less sensitive to this than to light in the middle of the visual spectrum. However - photography, particularly in the digital age, is a different matter.

Yes - I know, the resolution of some of the really difficult diatoms requires everything you've got! Now - a confession. Were I offered a high aperture objective at an affordable price, I would probably have a sudden rush to the head, and but it. No, it isn't entirely rational, but I strongly suspect that were such a lens on offer I might be trampled in the rush.

It only remains for me to wish you all 'good dotting'.

Diatoms in Archaeology

Some time ago the Channel 4 'Time Team' program was excavating some posts embedded in the Thames mud. As part of this program the back room boys and girls used diatom identification of frustules in the mud excavated from the very base of the post to indicate the likely composition of the water in the river at the time the post was sunk into the river bed.

The very nature of the diatom frustule, its siliceous composition, and each species preference for a particular environment lends it extremely useful in determining bygone states of habitat and environment.

Taxonomy - Again

Our sojourn into taxonomy has made us realise the breadth and variety of proposed taxonomies relating to the diatoms. One of the reasons for the multiplicity is the ease with which new categories may be generated. This may or may not be a good thing, certainly it causes problems in keeping up to date with the taxonomists, but on the other hand allows flexibility as more and more definitive features are brought to light.

The list below illustrates the scope of the hierarchy available and will, we hope, enable our readers to more fully understand any of the new taxonomies that are brought to their attention.

We believe the listing includes all the current categories and a few of the older ones where we think they might be met with.

- Kingdom
  - Legion
    - Phylum
      - Subphylum
        - Infra Phylum
          - Superclass
            - Class
              - Subclass or Cohort
                - Infra Class
                  - Superorder
                    - Order
                      - Suborder or Phalanx
                        - Infra Order
                          - Superfamily
                            - Family
                              - Subfamily
                                - Infra Family
                                  - Supertribe
                                    - Tribe
                                      - Subtribe or Cluster
                                        - Infratribe
                                          - Genus
                                            - Subgenus
                                              - Species
                                                - Subspecies
                                                - Form
                                                - Variety
                                                - Morpha
                                                - Abberation
                                                - Mutation
                                                - Cultivar

In addition to the above, at any point below Kingdom and above species, a taxonomist may introduce other groupings which have no formal definition, using the terms - Level, Division, and Section.

These three terms may have already been split Super-, sub-, infra- etc.

We wait with bated breath to see:- Group, Supergroup, Subgroup, Infra Group, Thread, Superthread, Subthread, InfraThread, Cosmos, Supercosmos, Category, Supercategory, Subcategory, Caste, Clan and a whole host more. For all we know these may have already been coined somewhere.

Our intention is not to sound scathing. The problems we perceive are to do with continuity. The more we juggle the taxonomy the more time is spent adjusting all the things that don't quite fit into it and because they don't, creating an arbitrary grouping for them to fall into. Perhaps this is the very nature of taxonomy. If there is a taxonomist out there who would like to 'put us right' then we would gladly print another article or letter/s on this subject.

Diatom Genera List - R-S

Genera	Authority	Date
Radialiplicata	Z.I. Glezer	1992
Radiodiscus	(W. M. Bale) Mills	1932
Radiodiscus	A. Forti & P. Schulz	1932
Radiopalma	J. Brun	1891
Ralfsia	E. O'Meara	1875
Rancia	L. Mangin ex J. Chavaillon	1939
Raphidodiscus	T. Christian	1887
Rattrayella	G. B. De Toni	1889
Reicheltia	Henri-Ferdinand van Heurck	1896
Reimeria	J. P. Kociolek & E.F. Stoermer	1987
Rhabdium	C. F. W. Wallroth	1833
Rhabdonema	F. T. Kützing	1844
Rhabdosira	C. G. Ehrenberg	1870
Rhaphidogloea	F. T. Kützing	1844
Rhaphidophora	J. A. Long, D.P. Fuge & J. Smith	1946
Rhaphiophorasphaera	B. L. Clark & A.S. Campbell	1945
Rhaphoneis	C. G. Ehrenberg	1844
Rhipidophora	F. T. Kützing	1844
Rhizonotia	C. G. Ehrenberg	1843
Rhizosolenia	C. G. Ehrenberg	1843
Rhizosolenia	T. Brightwell	1858
Rhoicosigma	A. Grunow	1867
Rhoicosphenia	A. Grunow	1860
Rhoikoneis	A. Grunow	1863
Rhopalodia	O. Müller	1895
Rhynchopyxis	R. Gersonde & D.M. Harwood	1990
Richelia	J. Schmidt in C.H. Ostenfeld & J. Schmidt	1901
Riedelia	A. P. Jousé & V.S. Sheshukova-Poretzkaja	1971
Robinsetta	G. D. Hanna & A.L. Brigger	1964
Rocella	G. D. Hanna	1930

Roperia	A. Grunow in Henri-Ferdinand van Heurck	1883
Rosaria	Carmichael in Hooker	1833
Rossia	M. Voigt	1960
Rossiella	T. V. Desikachary & C.L. Maheshwari	1958
Rossithidium	F. E. Round & L. Bukhtiyarova	1996
Rouxia	J. Brun & Frére J. Héribaud in Frére J. Héribaud	1893
Rutilaria	R. K. Greville	1863
Rutilariopsis	Henri-Ferdinand van Heurck	1896
Rylandsia	R. K. Greville & J. Ralfs in R.K. Greville	1861
Salacia	J. Pantocsek	1889
Salpa	P. Lefébure	1947
Sameioneis	D. J. Russell & R.E. Norris	1971
Sawamuraia	S. Komura	1976
Scalptrum	A. C. J. Corda	1835
Scapha	Edwards ex C. Johnston	1860
Sceptroneis	C. G. Ehrenberg	1844
Sceptronema	H. Takano	1983
Schimittia	P. Lefébure	1947
Schimperiella	G. Karsten	1905
Schizonema	C. A. Agardh	1824
Schizostauron	A. Grunow	1867
Schmidtia	C. Janisch	1888
Schmidtiella	C. H. Ostenfeld	1902
Schroederella	J. Pavillard	1913
Schuettia	G. B. De Toni	1894
Schulziella	G. D. Hanna & A. Forti in A. Forti	1933
Schumanniana	P. Lefébure	1947
Scoliodiscus	A. Jurilj	1954
Scolioneis	D. G. Mann in F.E. Round, R.M. Crawford & D.G. Mann	1990
Scolioneis	F. Meister	1918
Scoliopleura	A. Grunow	1860
Scoliotropis	P. T. Cleve	1894
Scoresbya	N. I. Hendey	1937
Scytellum	C. A. Agardh	1827
Scytonema	C. A. Agardh	1824
Secallia	F. Azpeitia	1911
Sellaphora	C. Mereschkowsky	1902
Sembeya	P. Lefébure	1947
Seminavis	D. G. Mann in F.E. Round, R.M. Crawford & D.G. Mann	1990
Semiorbis	R. Patrick in R. Patrick & C.W. Reimer	1966
Semseyia	J. Pantocsek	1902
Sheshukovia	Z. I. Glezer	1975
Sigma	M. Peragallo in Frére J. Héribaud et al.	1920

Sigmatella	F. T. Kützing	1833
Simonsenia	H. Lange-Bertalot	1979
Simonseniella	J. Fenner	1991
Skeletonema	R. K. Greville	1865
Skeletonemopsis	P. A. Sims	1994
Smithiella	H. Peragallo in H. Peragallo & M. Peragallo	1901
Solium	P. A. C. Heiberg	1863
Spatangidium	A. de Brébisson	1857
Spermatogonia	G. Leuduger-Fortmorel	1892
Sphaerophora	(A. H. Hassall) J. Lindley	1846
Sphaerotermia	C. G. Ehrenberg	1852
Sphaerozosma	Corda	1835
Sphenella	F. T. Kützing	1844
Sphenoneis	V. B. A. Trevisan di San Leon	1848
Sphenophora	F. T. Kützing	1833
Sphenosira	C. G. Ehrenberg	1843
Sphinctocystis	A. H. Hassall	1845
Sphynctolethus	G. D. Hanna	1927
Spinigera	H. Heiden & R.W. Kolbe	1928
Spinivinculum	R. Ross	1990
Spinodiscus	T. V. Desikachary & K.A. Ranjitha Devi in T.V. Desikachary	1986
Spirodiscus	A. Jurilj	1949
Spongia	Linnaeus	1753
Spongophyllium	C. G. Ehrenberg?	
Staurogramma	L. Rabenhorst	1853
Stauroneis	C. G. Ehrenberg	1843
Stauronella	C. Mereschkowsky	1901
Staurophora	C. Mereschkowsky	1903
Stauropsis	A. Meunier	1910
Stauroptera	C. G. Ehrenberg	1843
Staurosigma	A. Grunow	1860
Staurosira	C. G. Ehrenberg	1843
Staurosira	P. Petit ex J. Pelletan	1889
Staurosirella	D. M. Williams & F.E. Round	1988
Staurotropis	T. B. B. Paddock	1988
Stelladiscus	J. Rattray	1890
Stellarima	G. R. Hasle & P.A. Sims	1986
Stenoneis	P. T. Cleve	1894
Stenopterobia	A. de Brébisson ex Henri-Ferdinand van Heurck	1896
Stenopterotia	F. Habirshaw	1878
Stephanocostis	S. I. Genkal & A.E. Kuzmina	1985
Stephanocyclus	A. P. Skabitschevsky	1975
Stephanodiscus	C. G. Ehrenberg	1845
Stephanogonia	C.G.Ehrenberg	1844

Stephanopyxis	C.G. Ehrenberg	1845
Stephanosira	C. G. Ehrenberg	1848
Stephanosira	G. Karsten	1906
Stichostaura	C. G. Ehrenberg	1853
Stictocyclus	A. Mann	1925
Stictodesmis	R. K. Greville	1863
Stictodiscus	R. K. Greville	1861
Stigmaphora	G. C. Wallich	1860
Stilus	T. B. B. Paddock	1988
Stoermeria	J. P. Kociolek, L. Escobar & S. Richardson	1996
Stoschia	C. Janisch ex Grunow in Henri-Ferdinand van Heurck	1883
Stoschiella	C. Gardner & K. Wenderoth in Gardner, Schulz, Crawford & Wenderoth	1995
Strangulonema	R. K. Greville	1865
Strelnikovia	R. Ross & P.A. Sims	1985
Streptotheca	W. H. Shrubsole	1890
Striatella	C. A. Agardh	1832
Striatocellina	Z. I. Glezer x	
Strombus	F. Schütt ex A.F. Castracane	1892
Sturtgrovea	O. Kuntze	1898
Sturtiella	R. Simonsen & H.-J. Schrader	1974
Styllaria	Draparnaud ex J. Bory de Saint-Vincent	1822
Stylobiblium	C. G. Ehrenberg	1845
Styloneis	C. G. Ehrenberg	1845
Subsilicea	H. A. von Stosch & B.E.F. Reimann	1970
Suriraya	E. Pfitzer	1871
Surirella	P. J. F. Turpin	1828
Symblepharis	C. G. Ehrenberg	1872
Symbolophora	C. G. Ehrenberg	1844
Syncyclia	C. G. Ehrenberg	1837
Syndendrium	C. G. Ehrenberg	1845
Syndetocystis	J. Ralfs ex Greville	1866
Syndetoneis	A. Grunow	1888
Synedra	C. G. Ehrenberg	1830
Synedrosphenia	(H. Peragallo & M. Peragallo) F. Azpeitia	1911
Syringidium	C. G. Ehrenberg	1845
Syrinx	A. C. J. Corda	1835
Systephania	C. G. Ehrenberg	1844
Szechenyia	J. Pantocsek	1903
Szechenyia	J. Pantocsek	1904
Tabellaria 1844	C. G. Ehrenberg ex F.T. Kützing	
Tabularia	(F. T. Kützing) D.M. Williams & F.E. Round	1986
Tabulina	J. Brun in J. Brun & Jean-Clodius Tempère	1889

Temperea	A. Forti	1912
Temperea	M. Peragallo in Jean-Clodius Tempère & H. Peragallo	1908
Temperella	Frederick William Mills	1935
Terebraria	R. K. Greville	1864
Terpsinoe	C. G. Ehrenberg	1843
Tertiarius	H. Håkansson & G. Khursevich	1997
Tessella	C. G. Ehrenberg	1837
Tetrachaeta	C. G. Ehrenberg	1844
Tetracyclus	J. Ralfs	1843
Tetragramma	C. G. Ehrenberg	1843
Tetramphora	C. Mereschkowsky	1903
Tetrapodiscus	C. G. Ehrenberg	1843
Thalassiocyclus	H. Håkansson & A. Mahood	1993
Thalassioneis	F. E. Round in F.E. Round, R.M. Crawford & D.G. Mann	1990
Thalassionema	(H. Peragallo & M. Peragallo) M. Peragallo	1921
Thalassiophysa	P. S. Conger	1954
Thalassiosira	P. T. Cleve	1873
Thalassiosiropsis	G. R. Hasle in G.R. Hasle & E.E. Syvertsen	1985
Thalassiothrix	P. T. Cleve & A. Grunow	1880
Thaumaleorhabdium	V. B. A. Trevisan di San Leon	1848
Thaumatonema	R. K. Greville	1863
Thumia	P. T. Cleve ex P. Lefébure & E. Chenevière	1938
Tibiella	C. E. Bessey	1900
Tortilaria	W. J. Barker & S.H. Meakin	1948
Toxarium	J. W. Bailey	1854
Toxonidea	A.S.Donkin	1858
Toxosira	A. de Brébisson ex M. Peragallo	1903
Trachyneis	P. T. Cleve	1894
Trachysphenia	P. Petit in Folin & Perrier	1877
Triaulacias	C. G. Ehrenberg	1844
Tribrachia	A. Mann	1925
Triceratium	C. G. Ehrenberg	1839
Trichotoxon	F. M. Reid & F.E. Round	1987
Trigonium	P. T. Cleve	1867
Trinacria	P. A. C. Heiberg	1863
Tripodiscus	C. G. Ehrenberg	1840
Trochiscia	F. T. Kützing	1834
Trochiscia	F. T. Kützing	1845
Trochiscia	J. T. C. Montagne	1837
Trochosira	F. Kitton	1871
Trochosiropsis	Z. I. Glezer	1984
Trochus	R. Gersonde & D.M. Harwood	1990
Tropidoneis	P. T. Cleve	1891

Truania	J. Pantocsek	1886
Tryblionella	W. Smith	1853
Tryblioptychus	N. I. Hendey	1958
Tschestnovia	J. Pantocsek	1889
Tubaformis	A. M. Gombos, Jr.	1983
Tubularia	J. Brun	1894
Tubulariella	P. C. Silva	1970
Tumulopsis	N. I. Hendey	1982
Ulnaria	F. T. Kützing	1844
Ulva	C. Linneaeus	1753
Undatella	T. B. B. Paddock & P.A. Sims	1980
Undatodiscus	E. G. Lupikina	1984
Upothema	J. A. Long, D.P. Fuge & J. Smith	1946
Urosolenia	F. E. Round & R.M. Crawford in F.E. Round, R.M. Crawford & D. G. Mann	1990
Valdiviella	A. F. W. Schimper in G. Karsten	1907
Vanheurckella	J. Pantocsek	1892
Vanheurckia	A. de Brébisson	1868
Vanhoeffenus	H. Heiden & R.W. Kolbe	1928
Vavia	A. Missuna	1914
Vernadskowia	A. Missuna	1914
Vesiculifera	A. H. Hassall	1845
Vibrio	O. F. Müller	1773
Vorticella	O. F. Müller	1773
Weissflogia	C. Janisch	1888
Willemoesia	F. Castracane	1886
Williamsonii	P. Lefébure	1947
Wittia	J. Pantocsek	1889
Wrightia	E. O'Meara	1867
Xanthiopsis	F. Wolle	1890
Xanthiopyxis	C.G. Ehrenberg	1845
Xystotheca	G. D. Hanna	1932
Yoshidaia 1976	S. Komura	
Zotheca	J. Pantocsek	1902
Zygoceros	C. G. Ehrenberg	1839

Bacillaria paradoxa .... a puzzle

by Mike Samworth

Recently (October 2002) myself and another member of the Editorial team were engaging in that most mysterious pastime to the onlooking public, that is searching for live diatomaceous material. For some reason not always clear to the keen diatomist, scraping various surfaces with your finger for 'brown gloop' is seen to be rather peculiar. Anyway, such a scraping was done at a stretch of the Coventry Canal in the centre of Atherstone, Warwickshire. On return to base

seen this genus in the flesh, and it intrigued me for two reasons. Firstly, I realised that this was the so-called 'Carpenter's Rule' diatom that I read about, and who's movement was of interest. Secondly, because I had recently read of a request for information regarding its occurrence in freshwater, despite being commonly described as brackish. So, I set about finding out more, and the following is a distillation of some of that information.

Firstly, some background. The following was written by Thomas Bolton in 1881. Bolton was well known as a provider of material for study, together with instructions notes etc.

I enclose some of these curious and interesting Diatoms with a variety of other species including Nitzschia sigmoidea which I have found attached to alga in the Canal in this neighbourhood. It's usually attributed habitat is brackish water but I have before found it in this Midland district.

It is best examined by placing a little of the sediment and alga in a hollow slide, covering with a thin glass, under a fi inch or / inch objective. The characteristic movement will be more readily seen if the slide is laid aside flat for 5 or 10 minutes before examining. The following extract from Dr. Carpenter's Revelations of the Microscope (new edition just published and much enlarged price 16/-.) Paragraph 221 clearly describes this movement.

"Most of the Diatoms that are not fixed by a stipes possess some power of Spontaneous Movement, and this is especially seen in those whose frustules are of a long narrow form, such as that of the Naviculae generally. The motion is of a peculiar kind, being usually a series of jerks, which carry forward the frustule in the direction of its length, and then carry it back through nearly the same path. Sometimes, however, the motion is smooth and equable; and this is especially the case with the curious Bacillaria paradoxa, whose frustules slide over each other in one direction until they are all but detached, and then slide as far in the opposite direction, repeating this alternate movement at very regular intervals. In either case, the motion is obviously quite of a different nature from that of being possessed of a power of self-direction. 'An obstacle in the path,' says Prof. W. Smith, 'is not avoided, but pushed aside, or, if it be sufficient to avert the onward course of the frustule, the latter is detained for a time equal to that which it would have occupied in its forward progression, and then retires from the impediment as if it had accomplished its full course.' The character of the movement is obviously similar to that of those motile forms of Photophyta which have been already described; but it has not yet been definitely traced to any organ of impulsion; and the cause of it is still obscure."

Thos. Bolton, 57 Newhall St. Birmingham. Augt 12th 1881

As you can see, this describes quite nicely the movement of colonies of this diatom, as well as suggesting its occurrence in inland waters of the Midlands.

Next, some information of the diatom itself.

Genus: Bacillaria J.F. Gmelin 1791

Type species is Bacillaria paradoxa (Gmelin)

This is a monospecific genus. The correct name is Bacillaria paxillifera

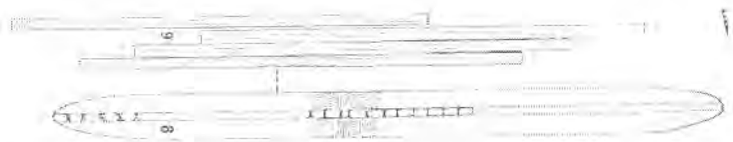
Bacillaria paxillifera (Müller 1783) Hendey 1951

Original description. Müller, O.F., 1783, p. 277; as Vibrio paxillifer. The epithet means "bearing little pegs", and refers to the visible fibulae of the raphe system.

Synonyms.

Nitzschia paxillifer (Müller) Heiberg 1863

Description. Valves are linear or slightly lanceolate with acute or occasionally somewhat capitate ends. The raphe extends from apex to apex in a slightly raised keel which is in the middle of the valve. Striae are parallel, and perpendicular to the median keel raphe. In girdle view, individual cells are narrowly rectangular. Cells are joined into colonies by means of close association of the keel raphes of adjoining cells (so living colonies mostly seen in girdle view). Arrangement not rigid, and individual cells of a colony slide back and forth over each other with a very characteristic movement (characteristic). Two chloroplasts.



Dimensions. The apical axis is mostly 80-100μm, transapical axis is 5-6μm. Striae number 18-21 in 10μm. Colonies may consist of over 100 cells, but 20-50 cells per colony is most common.

Comments. Although most frequent on sand/mud sediment surfaces, it is very common in the plankton of estuaries and nearshore areas throughout our area.

References.

Hendey, N.I. 1951. Littoral diatoms of Chichester Harbour with special reference to fouling. J. Roy. Micr. Soc. 71: 1-86.

Gmelin, J.F. 1791. Bacillaria paradoxa. In: Linneaeus, "Systema Naturae" , ed. 13, 1(6): 3903.

Kapinga, M. & R. Gordon. 1992. Cell attachment in the motile colonial diatom Bacillaria paxillifer. Diat. Res. 7: 215-220.

Müller, O.F. 1786. Animalcula Infusoria Fluviatila et Marina. Havniae: N. Moller. 367p.

The occurrence of this organism in "freshwater" rather puzzles me. The odd valve here and there may just indicate random "contamination" from bird's feet, but it has been found it in some quantity at a number of sites, as the data from Martyn Kelly below indicates. He found the greatest abundance in a "freshwater" was fairly close to the M25, and has wondered if it reflects at least episodic brackish conditions, perhaps from road salt. However, this is very much a working hypothesis that he has not been able to test. As he also says an equally plausible hypothesis is that the ecological preferences cited in floras are wrong, and this is a good example of where the Amateur can help, with personal records that may never get into the 'literature' by conventional means. So please do get in touch with us if you have any such records, we would be pleased to hear from you.

The following table below is reproduced by kind permission of Dr Martyn Kelly of Bowburn Consultancy, Durham. Martyn was kind enough to comment on my idea and contribute his records, which are the result of studies on diatoms as indicators of water quality. Readers may also recognise his name as being that of the author of the AIDGAP key to Diatoms recently published. This affordable guide is well worth getting.

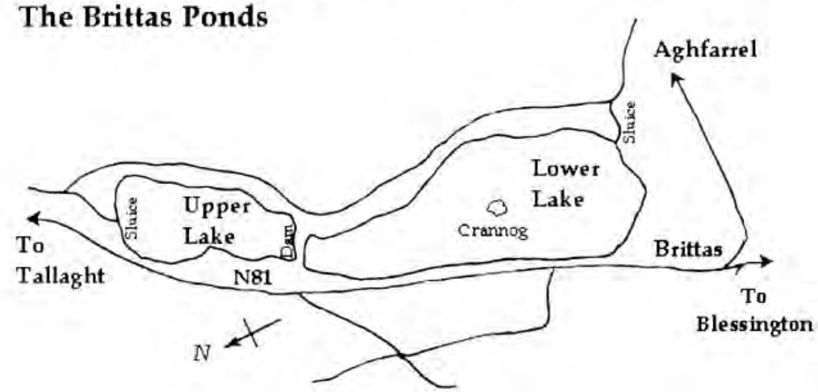
Stream	**Reach**	**Grid reference**	**Sample date**	**Percent**
River Avon	Eckington	SO 909 417	04-Oct-2001	2.9%
River Avon	Bredon	SO 919384	04-Oct-2001	0.6%
River Avon	d/s Rugby STW	SP 492 763	10-Oct-2001	2.2%
River Erewash	Shipley Gate	SK 462 454	18-Sep-2001	0.3%
River Idle	Misterton	SK 765 962	03-Aug-2001	0.3%
River Meden	Hammerwater Br.	SK 556 675	12-Jul-2001	Present
River Ryton	Potters Nook Br.	SK 554816	10-Jul-2001	1.5%
River Severn	u/s Malvern STW	SO 835 460	03-Sep-2001	1.0%
River Severn	d/s Malvern STW	SO 849 444	03-Sep-2001	Present
River Severn	u/s Chelt confl.	SO 848 263	04-Sep-2001	0.3%
River Sowe	u/s Finham STW	SP 337 738	10-Oct-2001	0.3%
River Sowe	d/s Finham STW	SP 331 731	10-Oct-2001	0.3%
Temple Brook	Oathill Br., 20m u/s	ST 407059	19-Nov-2001	0.3%
River Trent	Gunthorpe	SK 681436	20-Dec-2001	0.3%

Diatoms of the Brittas Ponds: Part 1

by Ed Markham, Charles Markham and Tim Markham

Introduction

The Brittas Ponds are situated some twelve miles to the south west of Dublin city on the Tallaght to Blessington Road (N81) in the foothills of the Dublin/Wicklow mountains. The ponds lie beside the small village of Brittas at a height of about 790 feet above sea level.



Nowadays there is only the lower pond but some years ago there were generally two. The second, upper pond, however, was extremely shallow and apt to dry up during the summer months. The larger, permanent pond of about 15 acres has been in existence for a long time and over the years has undergone a number of developments. A map of the environs of Dublin by John Taylor in 1816 shows a small, unnamed lough. This was enlarged, probably during the end of the nineteenth century, to become known as McDonnell's Ponds. These ponds became a source of water for a paper mill in Saggart, a village some five miles to the northwest. The introduction of two small dams with sluice gates to allow the mills to store water and control the levels of the ponds generally resulted in one full pond and a very shallow pond more like a flood plain. The paper mill flourished until fairly recent times. However, the mill was closed some twenty years ago and an angling club is now the main user of the ponds. In 1985 a small island in the middle of the pond was formally recognised as a crannog, a prehistoric water dwelling. The whole area of the ponds has been a recognized bird sanctuary for many years. Mallard, whooper swans, cormorants and scoters are regular visitors, as are herons, kingfishers, great crested grebes, little grebes and grey wagtails.

The water in the pond is slightly acidic with a pH just below 7.0. The water flora is largely Curly pondweed (potamogeton), Canadian pondweed (elodea)and Horsetails (equisetum). The insect life is quite varied but seasonally Midges (chironomids), Sedge or Caddis flies (trichopterans) are numerous. Some Mayfly (ephemeropterans) were prevalent some years ago but have disappeared in recent years. The ponds have always sported a small population of beautiful wild brown trout that breed in the small river that feeds the pond. Rainbow trout are now also stocked each year to liven up the fishing. There is no evidence of any roach or pike but some splendid perch abound. The authors, whilst fishing the ponds, have had ample opportunity to take samples to record the diatom flora of this small freshwater pond.

The Literature of the Irish Diatomaceae

Irish diatom flora has been strangely neglected over the years, with three notable exceptions. The earliest records are by the Rev. William Smith who was born in Ballymoney, Co.Antrim in 1808. In 1850 his ministry took him to Lewes in Sussex, England, where in 1853 he published the first volume of his work, "A Synopsis of the British Diatomaceae" (1). By 1855 he had returned to Ireland to become Professor of Natural History at Cork University, where he subsequently published the second volume of this work (1). He died at the age of 49 in 1857. Unfortunately one has to search these volumes to find samples that relate to Ireland per se. The second work on the Irish diatomaceae was published in 1876 by the Rev. Eugene O'Meara of Newcastle Rectory in Hazlehurst, Dublin. This was "A Report on the Irish Diatomaceae, Part 1" (Part 2 was never published) (2). Some other smaller works were published but it was not until Niels Foged toured Ireland in 1953 and subsequently published his findings in 1977 (3) that the only full synopsis of Irish diatoms came into being. This work included 757 excellent photographs of the various taxa. Foged visited some 15 counties and took 263 samples from 143 localities and finally recorded 460 different taxa.

Sampling and Processing of Material

The authors collected diatom samples from 1986 to 1998. The samples, after sedimentation and decantation, were cleaned using a preliminary charring and digestion with concentrated sulphuric acid, followed by a final oxidation by the addition of small quantities of sodium nitrate to the still hot mix. The ponds, being somewhat peaty, were virtually free of calcium salts and did not require any prior treatment with hydrochloric acid. Samples were then washed by sedimentation in deionised water seven times. A suitably dilute sample was allowed to dry on a

coverslip was then passed through a flame and mounted in Naphrax.

Nomenclature

The taxonomy of diatoms is difficult and continually changing. In order to standardize the nomenclature for this work Bernard Hartley kindly supplied the authors with a copy of his "Check list of the Freshwater Brackish and Marine Diatoms of the British Isles and Coastal Waters" published in 1986 (4). A most useful reference source late on in this work was the subsequent publication of Hartley's "Atlas of the British Diatomaceae" (5). All taxa, after identification by the standard works (Hustedt, Kramer u. Lange-Bertalot, Schmidt etc.) (6), were related to the 1986 checklist. In general most taxa are consistent with the nomenclature used by Foged.

Taxa identified

Achnanthes	minutissima Kütz 1833
Amphora	ovalis (Kütz) 1844
Caloneis	amphisbaena (Bory) Cleve 1894
	ventricosa (Ehrenb.) Meist. 1912
Campylodiscus	noricus var. hibernicus (Ehrenb.) Grun. 1862
Cocconeis	pediculus Ehrenb.1838
	placentula Ehrenb. 1838
Cyclotella	compta (Ehrenb.) Kütz 1849
	compta var. glabriuscula (Grun.) in Van Heurck 1882
Cymatopleura	elliptica (Breb. ex Kütz) W.Sm. 1851
	librile (Ehrenb.) Pant. 1902
Cymbella	affinis Kütz 1844
	aspera (Ehrenb.) H. Perag. in Pell 1889
	cistula (Ehrenb.) Kirchner 1878
	cymbiformis Ag. 1830
	hebridica (Grun. ex Cleve) Cleve 1894
	prostrata (Berkeley) Brun 1880
	silesiaca(Bleich. in Rabenhorst) see Hartley Atlas plate 71 p158
Diatoma	vulgare Bory 1824
Diploneis	elliptica (Kütz) Cleve 1894
Epithemia	adnata (Kütz) Rabenh. 1853
	adnata var porcellas (Kütz) R.Ross 1950
	turgida (Ehrenb.) Kütz 1844
Eunotia	curvata (Kütz) Lagerst. 1884
Fragilaria	hyalina (Kütz) Grun 1862
Frustulia	rhomboides (Ehrenb.) De Toni 1891
Gomphonema	acuminatum (Ehrenb.) 1832
	acuminatum v.coronatum (Ehrenb.) W.Sm. 1853
	truncatum var capitatum (Ehrenb.)Patr. In Patr. et Reimer 1975
Gyrosigma	attenuatum (Kütz) Rabenh. 1853
	acuminatum (Kütz) Rabenh. 1853
Melosira	varians Ag. 1827
Meridion	circulare (Grev.) Ag 1831
Navicula	oblonga (Kütz) Kütz 1844

	radiosa Kütz 1844
	tripunctata (Mull.) Bory 1822
Nitzschia	acicularis (Kutz) W.Sm. 1853
	linearis W.Sm.1853
	sigmoidea (Hitsch) W.Sm. 1853
Orthoseira	epidendron(Ehr) RM Crawford see Hartley Atlas plate198 p412
Pinnularia	major (Kütz) W.Sm. 1853
	nobilis (Ehrenb.) Ehrenb. 1853
	viridis (Nitzsch.) Ehrenb. 1843
Stauroneis	phoenicenteron (Nitzsch.) Ehrenb. 1843
Stephanodiscus	hantschii Grun. In Cleve et Grun. 1880
Surirella	biseriata Breb. et Godey 1835
	biseriata var bifrons (Ehrenb.) Hust.1911
	patella Kütz 1844
Synedra	ulna (Nitzsch.) Ehrenb. 1836
	capitata Ehrenb. 1836
	tenera W.Sm. 1856
	ulna var biceps (Kütz.) Schönf.
Tabellaria	flocculosa (Roth) Kütz 1844

53 Taxa recorded to date

Foged described some 460 taxa he found in a tour around most of Ireland. This list included brackish, marine, river, stream and lake samples together with some samples from turf bogs, fossil deposits, springs and oozing rock faces. The authors, to date, have identified some 53 different taxa from the Brittas ponds. All taxa recorded by the authors were recorded by Foged at other sites in the 15 counties he visited in Ireland. Strangely Foged did not take any samples from sites in Co. Dublin although he extensively sampled the neighbouring county of Wicklow.

It is hoped to relate the taxa prevalent to the nature and eutrophic state of the state of the Brittas Ponds. Further taxa still have to be identified and the work continues.

Acknowledgments

The authors thank Mr. Bernard Hartley for his encouragement with this work and his help in confirming many of the taxa listed. Thanks also go to Dr. Catherine Markham for preparing the illustrations. Any errors are entirely the authors' responsibility.

References

1. Smith,W., A Synopsis of the British Diatomaceae, Vol 1&2, van Horst, London, 1853 & 1857

2. O'Meara, E., Report of the Irish Diatomaceae Part 1, Proc. of the Roy. Irish Acad., 2nd Series, Vol .2, p.,235-425, 1876

3. Foged, N., Freshwater Diatoms in Ireland, Cramer, 1977

4. Hartley, B., A Check-List of the Freshwater, Brackish and Marine Diatoms of the British Isles and Adjoining Coastal Waters, J. mar.biol.Assoc. (UK), 1986, 66, p.531-610

5. Hartley,B. et al., An Atlas of British Diatoms, Biopress, 1996

6. For a really excellent and authoritative list of these works see Kelly, M., "Identification of Common Benthic Diatoms in Rivers", Field Studies, 9, 2000, p.697. This publication is an essential for amateurs, as is Cox's "Identification of Freshwater Diatoms from Fresh Material", Chapman and Hall, London 1966.

Three Photographs

The following three photographs of a Surirella were taken in brightfield. They show some structure, external to the frustule itself. The question is 'What are these structures forming a fringe around the frustule?

In the old days these structures were seen as 'cilia' and were cited as the means of locomotion. This is not the case. They are not cilia, they exhibit no regular motion. This is not a revelation as it has long been discounted. However, this is the first time someone on the editorial team have seen these structures. Is this evidence of cytoplasmic streaming as one sees so often in the Foraminifera, or are they, as some have suggested fungal hyphae?

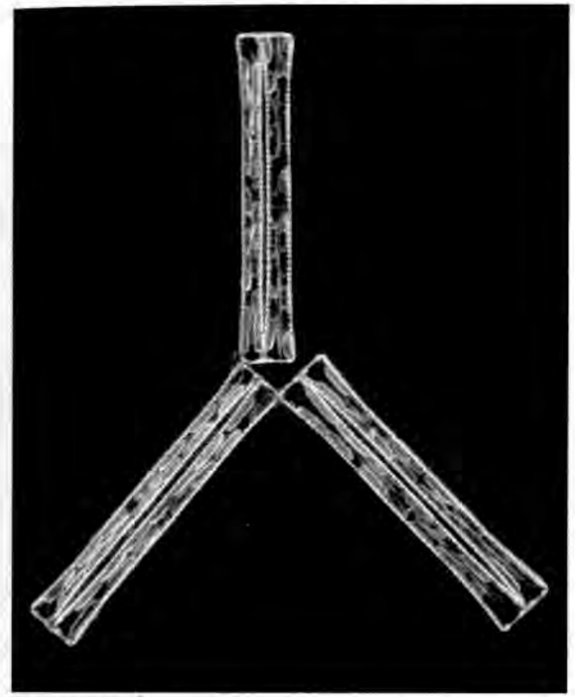
Diatom filaments - revisited

I have received a number of phone calls asking whether I could explain the diagram from the article - Further Notes on Reproduction - where I used numbers to represent frustule size in a filament of diatoms. I have to admit that the representation, once transferred to the printed page didn't really convey what I intended very clearly. As a consequence I wrote a small program to display what had been intended, in graphical form. Though the differences in size are exagerrated somewhat the essence of what I was getting at is shown.

This diagram represents 9 divisons, again each frustule dividing at the same time (which is unrealistic) but if you start at the top left corner and work across the page left to right and then down, finishing at the bottom right, this represents a single filament. You can see that it has an irregular wave.

The next issue of

The Amateur Diatomist



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Hertford Diatoms

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Diatomite Use

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"No one of us know all there is to know, and yet we do not know what we do not know." - Anon.