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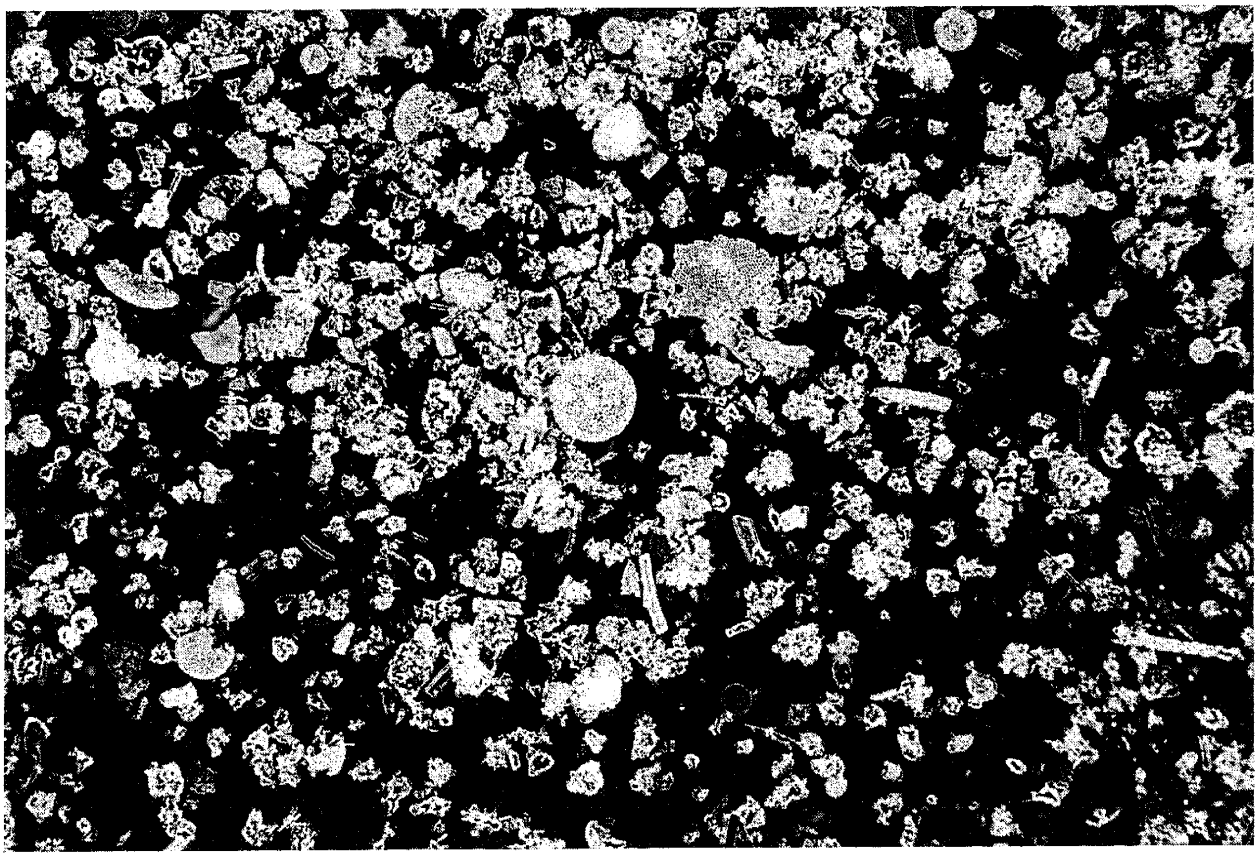
Diatomaceous Earth: Fossil Frustules and Filtration

Richard M. Jefts



There frequently comes a time in the varied lives and multiple pursuits of many of us, (this is shaping up to be quite an opening paragraph), when a feeling dawns that one is becoming engaged in a pastime with somewhat familiar overtones ... a feeling that, intentionally or not, one is drifting into what might easily become a modest, all be it very real cottage industry.

Having had the pleasure of calling attention to the presence of diatoms in two commercial brands of toothpaste and in one health oriented mineral tablet, (see Diatoms and Dentifrices, or The Tooth, The Whole Tooth and Nothing But The Tooth, and Dietary Diatoms published in this Journal, October, 1997 and November, 1998, respectively, I find myself frequently on the lookout for other commercial products that might harbor diatoms in greater or lesser amounts. This usually consists of stretching to full top shelf height or hobbling around on hands and knees in local drug store and supermarket product aisles, squinting at the fine print on content labels of such products as polish for shoes, boots and general leather goods, scouring powders for kitchen pots and pans, and automotive cleaning and polishing compounds.

It was, however, while recently sprawled around a friend's backyard swimming pool (consider that very casually said) that both the pleasures of such a pool ownership and its also attendant drawbacks were discussed. Among these latter where such things as the initial building costs, ensuing water bills, responsible security measures for keeping out wandering neighborhood children and general overall maintenance, and so, by a circuitous route, we come to the gist of the issue, for under the heading of general maintenance, the frequent need for recharging the pools water filtering system with diatomaceous earth was mentioned. When the light bulb lit, it was suddenly obvious that I had been looking in the wrong aisles, and so now a third commercial product, this one most certainly replete with no lack of diatom materials, was offered up as yet another ready source for the pleasure of prowling around with microscope and camera.

I located a local swimming pool supply emporium, and, never being one to do things by halves, purchased what was the smallest size bag of commercial diatomaceous earth in stock - a compact, thick walled paper sack, weighing in at an even ten pounds, net.

Overlooking the feeling of a possible slight volume overkill, I felt fortunate that the material was the product of a somewhat local, and certainly well known, company. The Celite Corporation of Lompoc, California is world famous for its Santa Barbara county deposits and beds of fossil diatoms, quite possibly the largest in the world. (The bagged material is labeled with the registered trademark names of "AQUACEL" and "CELITE" and is also labeled as Diatomite.) These diatomaceous earth deposits, many hundreds of feet thick and many acres in extent, are well known to devotees of the diatom, as being of marine origin, and were laid down some fifteen million years ago when the area was apparently a shallow coastal sea. Having visited these deposits in times past, and having been given a few chunks of their more choice Diatomite from selected open pit mine sites, I tackled my one two hundredth of a ton sack with some enthusiasm.

As in past similar approaches, the simple but effective principal of selective sedimentation or settling was adopted. From the four corners and one central spot of the approximate 200 square inch surface area of the flat lying bag, holes were punched with a one inch

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cork borer and from each sampling site, five grams of material were taken. The dry 25 gram total was well blended, and a one gram sample was winnowed out by quartering and was then suspended in 100 mls. of distilled water in a tall form vessel. A 100 ml glass tall-form cylindrical graduate worked well. The thoroughly wetted material was well shaken and then allowed to settle undisturbed under ambient conditions. Mechanical centrifugation was tried, but the more gentle method of natural gravitation was easier to control and was more productive. After letting the material stand for timed intervals, for 30 seconds to one minute, and then on up to five minutes, selected portions or strata were sampled with a medicine dropper and a longer glass dip tube. A pattern was thus established that allowed choosing a settling rate of particle size vs. time to reclaim material suitable for relatively uncluttered microscopic examination. In all, I worked with six such suspended preparations. Total separation of large, whole diatoms from larger broken shards is not entirely possible, but, fortuitously, many of the larger bits and pieces are of interest in themselves, and indicative of the material contents. Corrington, in his excellent book *Working With The Microscope,* pages 204 and 205, outlines a method of selected separation using melted sodium hyposulfite, which I have used elsewhere, but not here, which might prove effective with this crushed Diatomite material. The upper layers or strata are also of interest and show smaller, lighter weight diatom frustules, although these seem to be somewhat in the minority.

A number of semi-permanent slides were prepared, again, as in the past, by sealing a suitable size drop of a selected suspension under large size (24mm x 60mm) No. 1 coverslips that had been rimmed with a thin bead of Vaseline. When pressed down and sealed to a microscope slide, the resulting thin film, if handled with care, is secure from most outside influences. The particulate material is static, (except for very fine particle size Brownian movement), and is thus available for extensive viewing for as long as a week or ten days and, sometimes, longer if the Vaseline seal is not broached. Using the standard method for slide smear examination, that is, sweeping slowly from left to right, dropping down one overlapping field of view, then sweeping from right to left, etc., zig-zagging on down through the whole sample area, a large number of prepared slides were examined and objects of particular interest noted by jotting down the slide number and the X-Y coordinates from the microscopes graduated mechanical stage. There remained only the taking of the photomicrographs, and from the many negatives exposed, selecting a reasonable few that seemed representative of the whole. Figures No. 1 through No. 19 are a bakers dozen and a half, plus the Journal's front cover illustration. This latter serves as an establishing shot and shows a not atypical field of view for this diatomaceous earth material. Close examination of this photo will show a wealth of diverse objects, from both whole and broken disc and pennate forms, to girdle rings and shattered shards, etc.

The captioned photographs on the following pages are further explanatory. The text continues on page 8.

- Microscope: Leitz Ortholux
- Objectives: 6x and 10x Wild Fluotars and Leitz 40x APO, with correction collar.
- Camera: Olympus PM-6
- Film: Kodak 2415 Tech Pan
- Filter: Tiffen #58
- Film Developer: Kodak HC-110, Dilution 'D'
- Original Magnifications:
  - Front Cover - 56x
  - Fig. 1 - 94x
  - All others - 375x

Note that all images have been further slightly enlarged when the negatives were ultimately cropped to minimize extraneous background material.

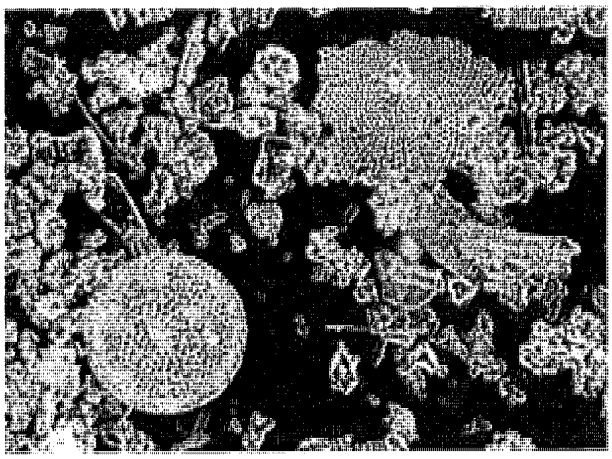


Fig. 1 A closer view, at a higher magnification, of the front cover shot. Some of the more interesting diversified structures are more easily seen.

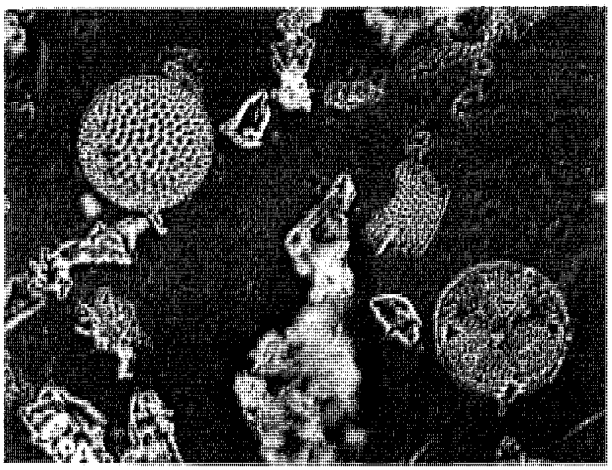


Fig. 2 Two centric or circular diatoms and a fragment. In the upper left, a Coscinodiscus and in the lower right, an Actinoptychus, possibly species undulatus.

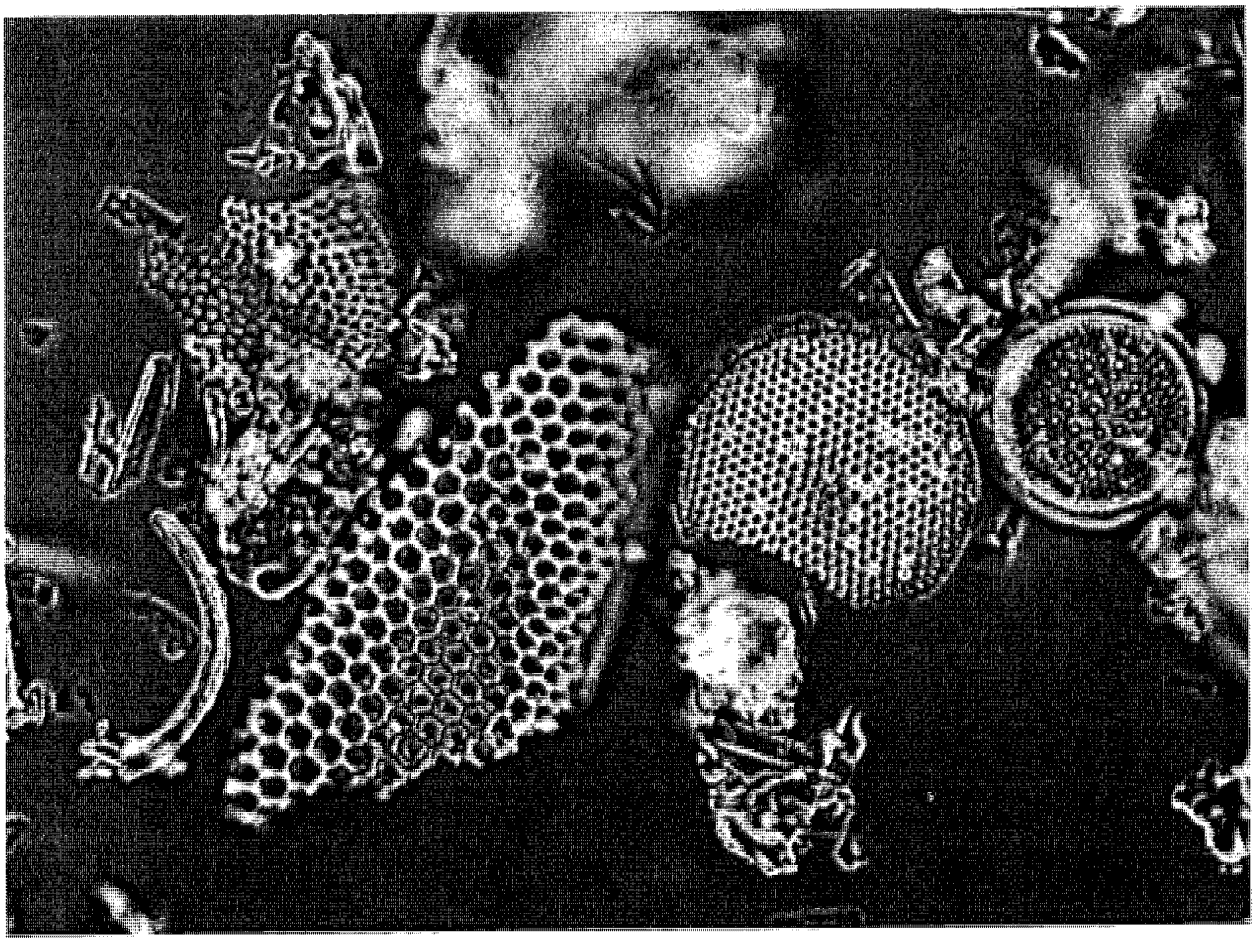


Fig. 3 An interesting field, with a whole circular girdle ring on the right, a smaller broken one on the left, and diatom fragments showing markedly different bead or puncta size.

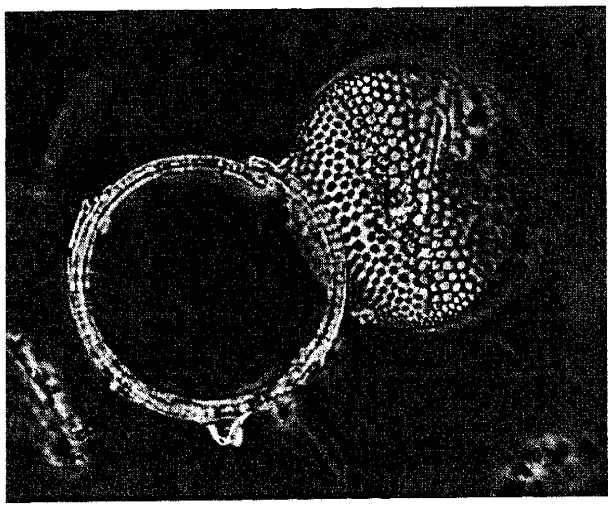
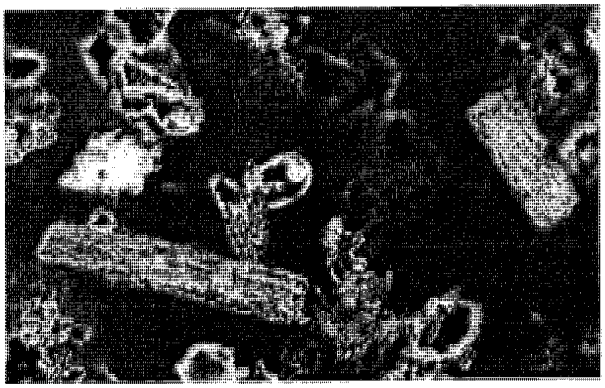


Fig. 4 A half in, half out of focus Coscinodiscus and an excellent girdle ring. The overlapping ends of the ring are evident at about the one o'clock position.



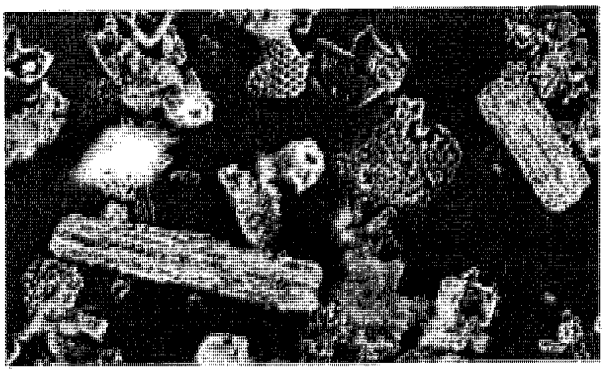


Fig. 5 and Fig. 6

Fig. 5 and Fig. 6 Two photos showing the same field of view, but at two different (upper and lower) levels of focus, and in each case, illustrating two rather scarce bark-like structures, each with interesting and branching rib-like designs on the top surfaces. The lower focus, Fig. 6, shows broken bits of diatoms scattered elsewhere in the field that could be easily missed if considerable up and down focusing was not resorted to. Even these thin films can have considerable depth.

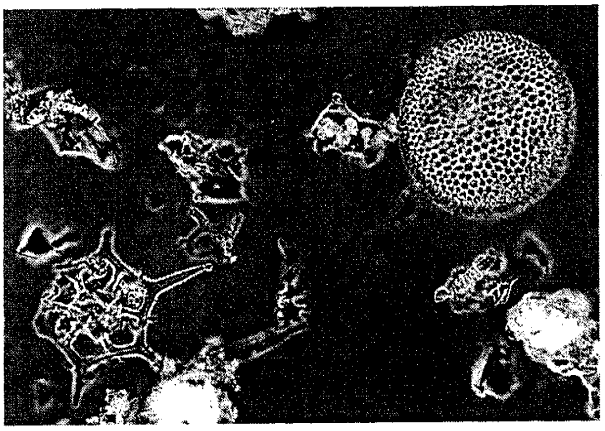


Fig. 7 In the upper right corner is another of the more common genus Coscinodiscus, and in the lower left, the central area of a shattered radiolarian fragment.

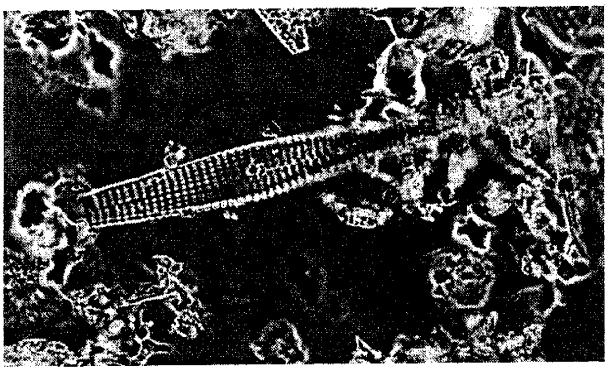
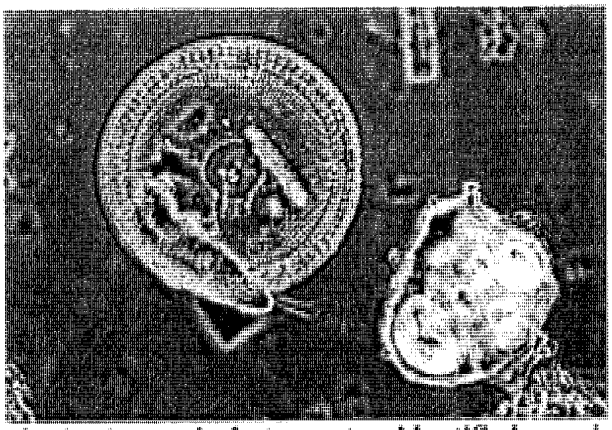
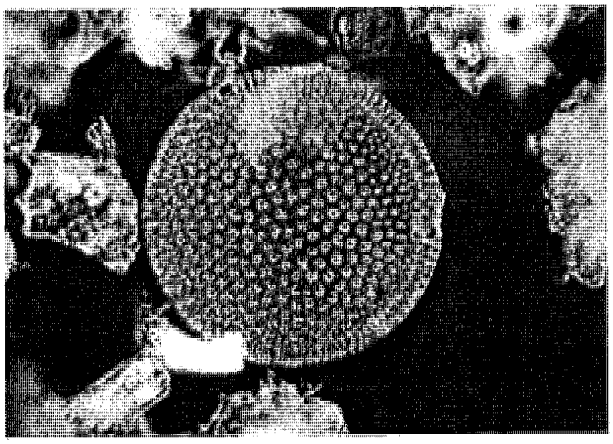


Fig. 8 One of the best, (that is, of moderate size and pretty well oriented), examples of the exception that proves the rule. It would seem that most diatoms in this material, of any great size, are centric or circular, but here an excellent elongated or pennate type is exposed, of the boat shaped genus, Navicular. This top or valve view, shows interesting patterned rows of dots or puncta.



Fig, 9 A centric, but as yet unidentified, specimen, with elegant highly detailed rim and interesting internal details.



ig. 10 An example of a diatom (Coscinodiscus) that is relatively scarce in the sense that it is of some size and yet, has escaped any damage. (An even better example is Fig. 19). As a general rule, the larger the frustule, the more subject it is to being crushed and broken.

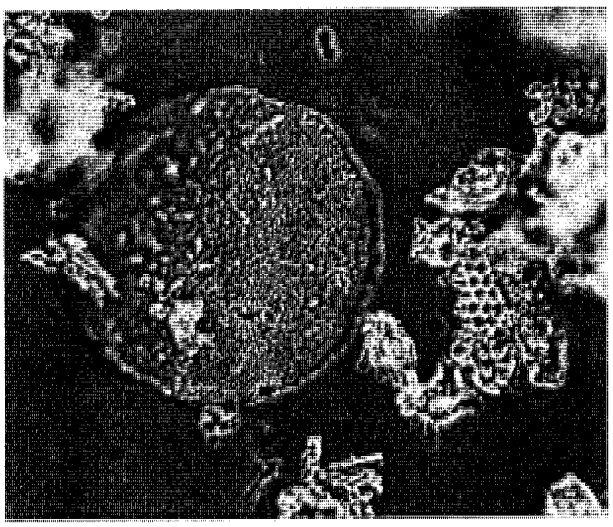


Fig. 11 A rarely found centric, possibly an Actinocyclus. Not spectacular, but the fineness of the minute radiating puncta that justifies high oil immersion examination, sets this one apart from many of the others.

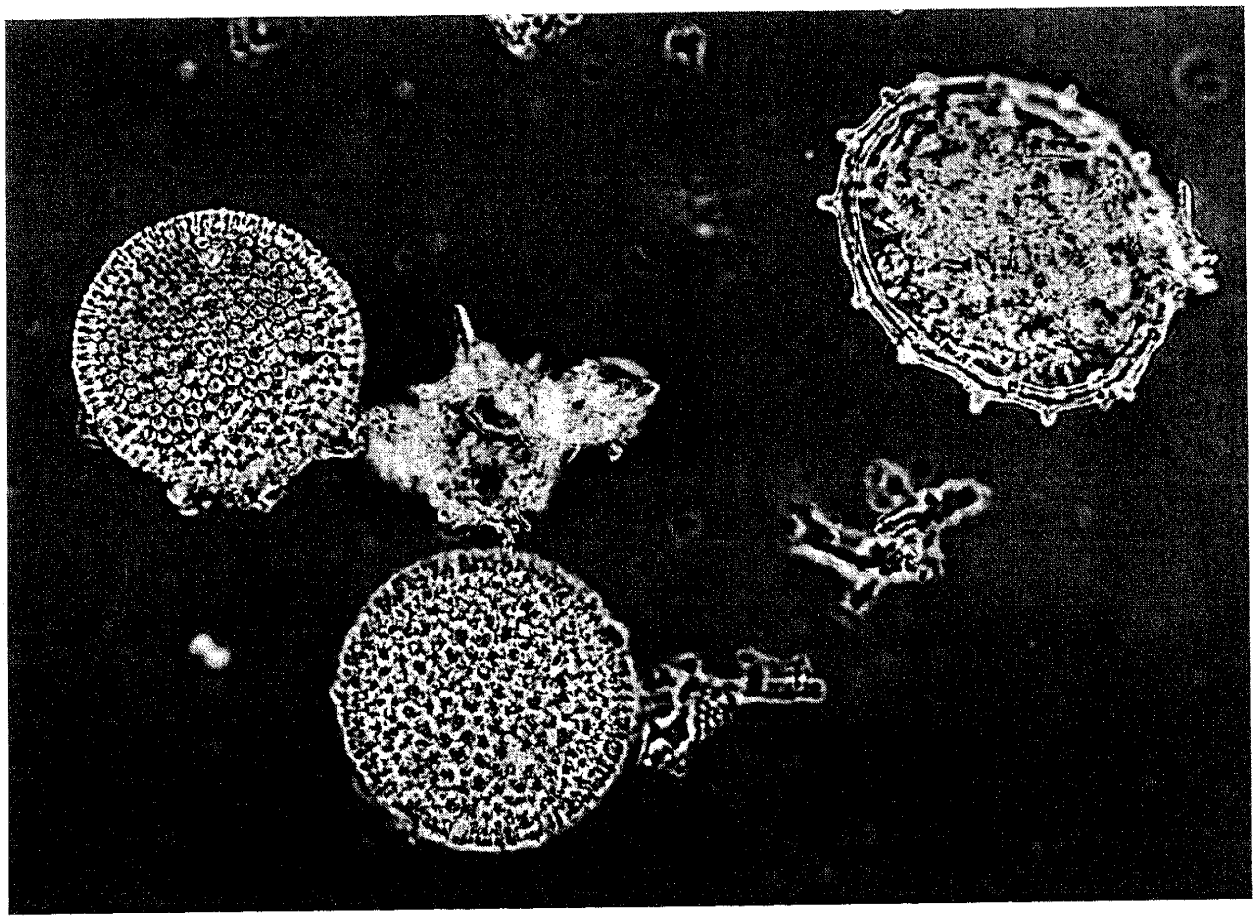


Fig. 12 A fortuitous field of view. Two excellent whole centrics on the left, with well delineated rim band details and pores, but also, and especially, a very handsome 'crown of thorns' siliceous ring at the upper right.

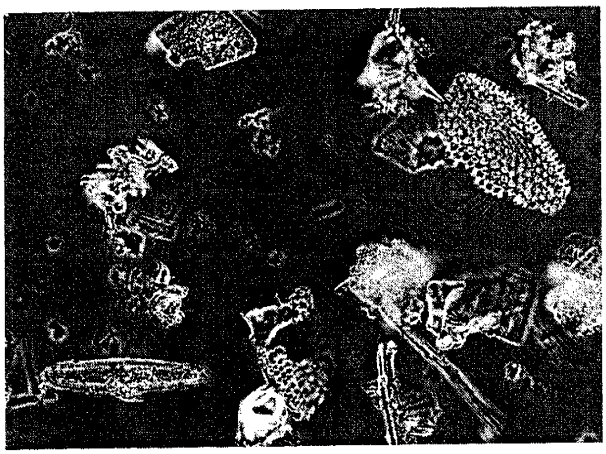


Fig. 13 Two fragments of larger centric types. Of more interest, at the lower left, is another of the relatively scarce (of any great size) pennate types. Of a different species, and smaller and less ornate than that shown in Fig. 8, it too, is a top or valve view of the genus Navicular. High power oil immersion shows simple, but interesting edge detail.

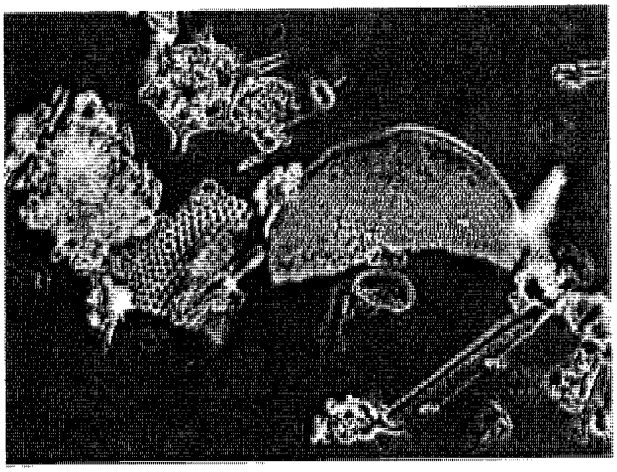


Fig. 14 Three structures of interest: two disc remnants, again showing interesting marked differences in pore or puncta size. To the upper left, a fragment, as in Fig. 7 - an hexagonal pattern of all that is left of a broken radiolarian.

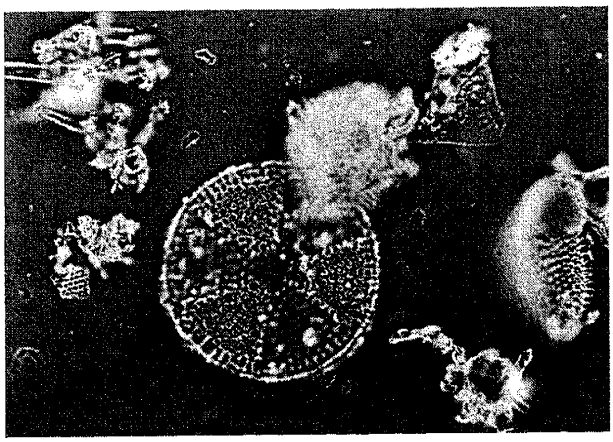


Fig. 15 One of the best examples found (slightly larger than in Fig. 2) of the 'pie' or 'pizza' detailed centric, Actinoptychus undulatus.

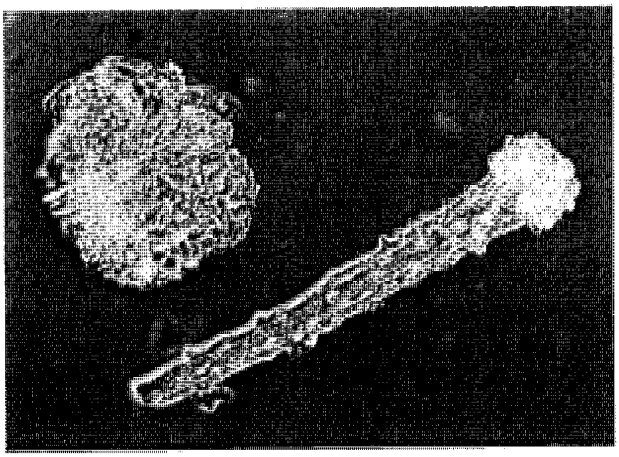


Fig. 16 As in Figs. 5 and 6, a deviation from the norm of fields of mostly diatoms, whole or in fragments. Here is what appears to be a massive and awesome looking, club shaped radiolarian spicule.

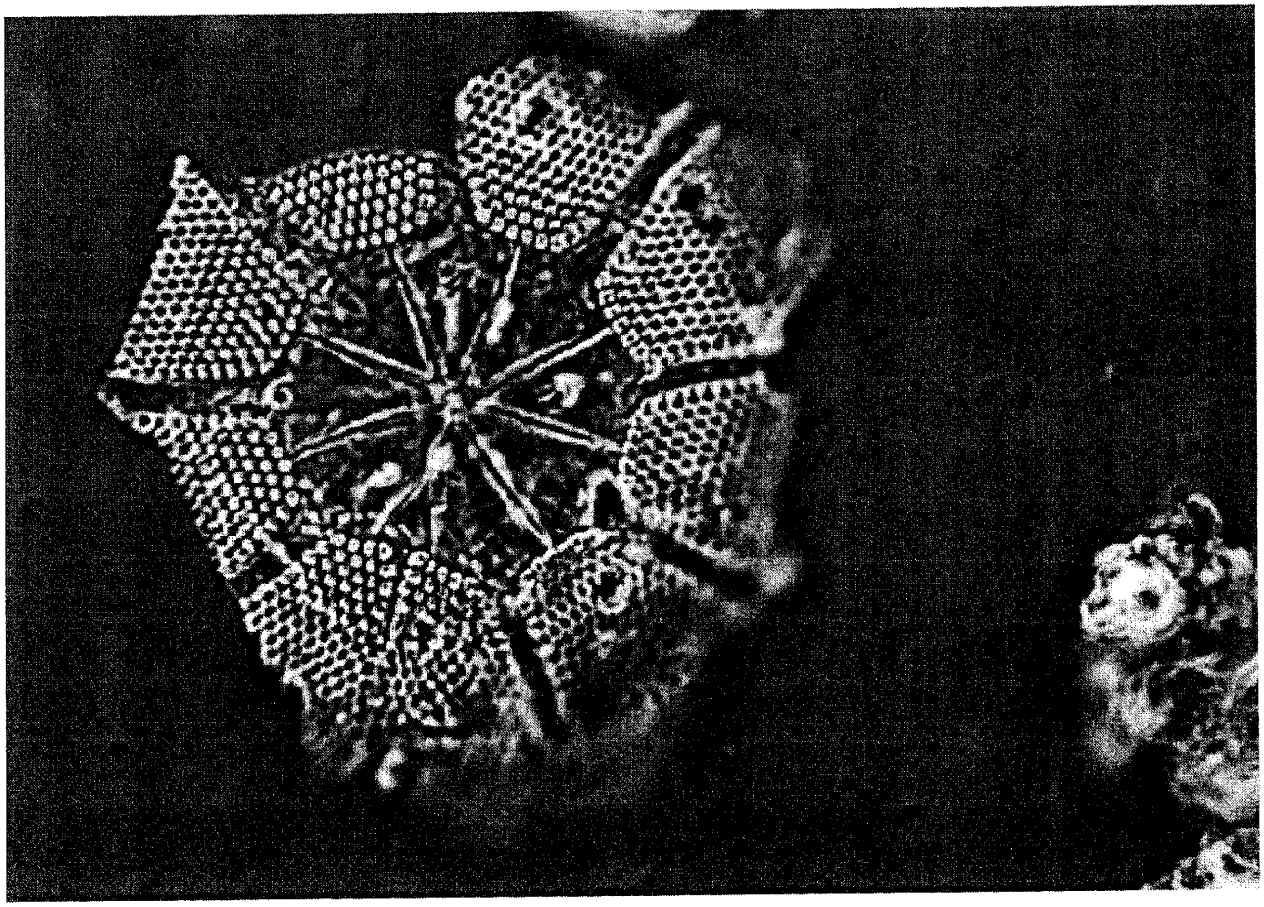


Fig. 17 This is the most spectacular fragment found. Finding this, fairly early in the game, kept me going longer than perhaps otherwise, in the hopes of finding another, more complete or (hope springs eternal) a totally complete specimen. Although quite distinctive, even of what remains (of an obvious centric type) I was unable to pin this one down as to either genus or species. Having been shattered more or less symmetrically, it is still, however, intriguing, and an example of the beauty to be found in these ancient fossil frustules.

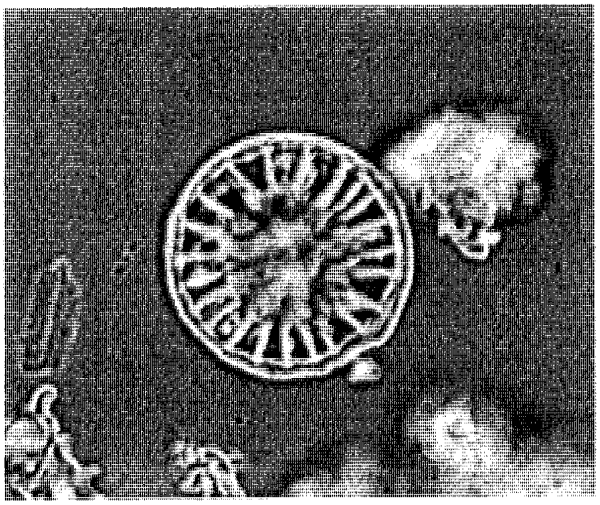


Fig. 18 One of the smallest, still whole, diatoms found, with a discernible structure. A disc shaped centric, quite possibly Cyclotella.

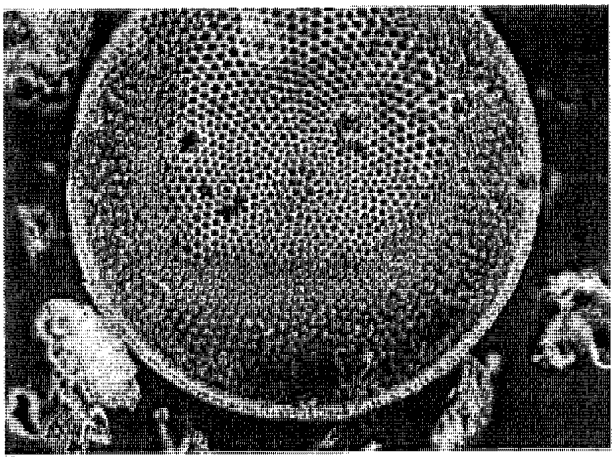


Fig. 19 By way of dramatic contrast with Fig. 18, this is the largest whole diatom found. Of the genus Coscinodiscus, it is of such a size that with oil immersion, it is easily possible to peer down 'on' or 'inside' the individual pores or puncta and see further fine point detail.

Continued from page 3.

One minor disappointment in handling this diatomaceous earth, at least so far, has been the seeming lack of the more ornate, sometimes spectacular circular shaped diatoms for which the area is so well known. It is true, however, that the whole of the ten pound sack was obviously not completely examined, and that the initial sampling procedure itself is, admittedly, not the more complicated method usually prescribed for winnowing down a large volume of dry, powdered solids to a smaller volume, which will still be representative of the whole. Also, this and other packaged Diatomite materials are, I'm sure, a heterogeneous blend of materials taken from many diverse areas in the vast open pit mining operation. Furthermore, from the practical standpoint of the Celite Corporation, there is no need to be particularly selective of the diatomaceous earth, certainly not in terms of what would most please the enthusiastic microscopist. In short, all genus and species of diatoms probably serve nicely as an effective filtering agent (and as a product for other commercial uses). In actuality, all of the Diatomite material on hand is certainly more than adequate for our modest purposes and all specimens found to date, are, indeed, of interest in themselves.

As an off the wall example of a thing of dubious importance but with still a certain amount of charm, there is, so to speak, another way of looking at this material. It stems from having remembered reading, and having managed to find again, a short passage in an old issue of the magazine, *Scientific American*. It is not too long, so let me quote it here:

"The $50,000,000 annual product value of chewing gum in the U.S., divided by five cents (the price of a packet), represents roughly a billion purchases containing about ten billion chews. Allowing three hours per chew, and assuming the brake horsepower of the prime mover at, say, one thirtieth ... we arrive at something like one billion horsepower-hours of power expended the nation over, each year, in chewing gum."

Not to be outdone, even by such a prodigious publication as the *Scientific American*, I have calculated that the average sealed coverslip wet mount slide preparation contains approximately ten milligrams of dry Diatomite. There is, then, in this ten pound sack, at sixteen ounces to the pound, one hundred and sixty ounces, and at twenty eight point three five grams to the ounce, four thousand five hundred and thirty six grams. This, then, at one thousand milligrams to the gram, yields four million, five hundred and thirty six thousand milligrams, which, divided by the ten milligrams per slide, will allow enough material for four hundred and fifty three thousand, five hundred and ninety slide preparations and, in so doing, probably expend far less horsepower than gum chewing, and will further yield enough material to keep one occupied for many years to come.

Further work with this material that might be suggested would be, as noted, to institute a more refined method of diatom sampling and perhaps reclamation, adopt an appropriate procedure for the cleaning and bleaching of the individual frustules (although little organic material is apparent here) the measurement of each cell size, and, in combination with this, establish a more thorough identification of each chosen diatom specimen. The work here is a cursory first approximation, but is also, and perhaps more importantly, a part-time and pleasurable pastime. And if the prospect of sifting and winnowing further through all of the materials at hand should prove less than daunting and the challenge irresistible, there is always the prospect of still further siftings and winnowings ... for I know where there are a lot of other modestly priced, readily available and conveniently packaged ten pound paper sacks!

PRIESTLY ON THE BICENTENNIAL OF THE INVENTION OF THE MICROSCOPE

Stuart L. Warter

As we enter into the new century, we observe what might be the quadricentennial of the invention of the compound microscope. Who actually invented the microscope - and the telescope, as well - is a question whose answer may well be lost forever in the mists of time.

The origins of the telescope and microscope are inextricably linked - "joined at the hip" as it were - since they are essentially the same instrument - one reversed from the other. A good field biologist caught without a magnifier knows to reverse his binocular and use one barrel - actually a prismatic telescope - as a low power microscope.

The earliest confirmed records of actual instruments go back to the earliest years of the Seventeenth Century, but there are indications that one or both types may have been in existence one, two, or even three centuries earlier. Nonetheless, the name of Zacharias Janssen, a spectacle maker of Middleburg in Zeeland (Holland), has been championed by some as inventor of both, along with his father, Hans, although others feel that Hans (Jan) Lippershey, another Middleburg spectacle maker who was also making telescopes at the time, has a stronger claim on that invention. The claim of the latter on the invention of the microscope is widely discounted.

While the name of Galileo is often considered as synonymous with the telescope, his actual contribution was that he recognized the significance of the invention of which he had only heard, and can certainly be credited with the development of that instrument, having quickly constructed his own, improved on his early design, and applied its use to scientific endeavors. He had even used a form of extended telescope as a microscope. *Time Magazine* has chosen a scientist, Albert Einstein, as Person of the Century, for the Twentieth Century; had there been one for the Seventeenth, it might well have been Galileo Galilei.

In *The Literary and Biographical Magazine and British Review for June, 1793*, the great Eighteenth Century scientist Joseph Priestly wrote what might be considered a bicentennial history of the telescope and microscope. Bear in mind that, even though two centuries closer to the time in question, he was still writing two centuries after the fact. Even so, we can still find it well worth while to read this essay on Janssen and Galileo, one of the earlier histories written expressly on the subject in the English language. Remember, too, that when Priestly was writing, the achromatic microscope had yet to be invented, so we can see how important even those instruments we consider primitive by more modern standards were considered by those who used them two centuries ago.

References

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Priestly, Joseph. Of the Invention of Telescopes and Microscopes. *The Literary and Biographical Magazine and British Revue for June, 1793.* Vol. X, pp 407 - 411.
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"Quick and Easy Digital"

In response to G. Vitt's e-mailed digital camera photo with a description of the ease of setup (page 16), Peter Fischer immediatly put his wrist watch under a handy Wild Stereo and took this photo under room light. Peter just hand held his Fuji 2000 digital camera against the eyepiece. The image is at the lowest resolution of 460 x 640, but still looks good and the photographic technique could not be less complicated.

Of the INVENTION of TELESCOPES and MICROSCOPES, with their first IMPROVEMENTS.

BY JOSEPH PRIESTLEY, LL.D. F.R.S.

IT was in the period of my hiſtory that mankind began to derive an advantage from the ſcience of optics, which muſt have appeared, a priori, to have been out of the power of ſcience to beſtow. For who could have imagined that the refraction of light in glaſs, and other tranſparent ſubſtances, the ſame power by which a ſtraight rod appears crooked in water, whereby viſion is variouſly diſtorted, and whereby we are liable to innumerable deceptions, ſhould ever be ſo circumſtanced, as to extend the bounds of ſight, enabling us to diſtinguiſh objects vaſtly too remote, or too ſmall, for our natural organs. Upon this principle, however, depends the conſtruction of the teleſcope, which not only gives us a diſtinct view of diſtant terreſtrial objects, without the trouble of conveying ourſelves to them, but enables us to extend our enquiries to the utmoſt boundary of the ſolar ſyſtem, and even carries us far beyond it.

The application of the ſame powers in nature alſo produced the microſcope, which gives us an inſight into the minute, but no leſs wonderful works of God in the creation around us; unfolding the admirable ſtructure of plants and animals, and diſplaying to us the exquiſite texture of their conſtituent parts. By means of theſe inſtruments, the bounds of human knowledge have been amazingly extended, and by the ſame helps new and exhauſtleſs ſources of information and pleaſure are continually opening to us; ſo that a perſon who is poſſeſſed of theſe inſtruments, and who has a taſte which every man ought to be aſhamed to be deſtitute of, can never want ſubjects of the moſt rational entertainment.

With reſpect to this great addition to our furniture, both for the purſuits of ſcience, and for the elegant enjoyment of life, human genius has but little to boaſt; the invention, if it may be ſo called, having been as caſual, and as unexpected, as it is, in its own nature, extraordinary. This hiſtory, therefore, furniſhes a ſtriking leſſon to all philoſophers, not to deſpiſe the moſt trifling obſervation; or to withdraw their attention and ſtudy from thoſe powers of nature, or even thoſe ſingle facts, which may ſeem, at firſt ſight, to be the moſt inſignificant, and the moſt remote from every poſſible uſe. Every new fact, or property of any of the conſtituent parts of nature, ſhould be carefully examined, as a treaſure of unknown value, the real worth of which, time, and the diſcovery of other kindred powers in nature, may bring to light.

The very great importance of the teleſcope, has made the firſt diſcovery of it an intereſting ſubject of enquiry; and notwithſtanding it is agreed, on all hands, that the firſt conſtruction of this inſtrument was a caſual thing, and that the rationale of it was not known till many years after, we find ſeveral candidates for this ſmall portion of honour. Deſcartes conſiders James Metius, a perſon who was no mathematician, though his father and brother had applied to thoſe ſciences, as the firſt conſtructor of a teleſcope; and ſays, that, as he was amuſing himſelf with making mirrors, and burning glaſſes, he caſually thought of looking through two of his lenſes at a time; and that happening to take one that was convex, and another that was concave; and happening alſo, to hit upon a pretty good adjuſtment of them,

them, he found that, by looking through them, diſtant objects appeared very large and diſtinct. In fact, without knowing it, he had made a teleſcope.

Other perſons ſay, that this great diſcovery was firſt made by John Lipperſheim, a maker of ſpectacles at Middleburgh, or rather by his children; who, like Metius, were diverting themſelves with looking through two glaſſes at a time, and placing them at different diſtances from one another. But Borellus, the author of a book entitled De vero teleſcopii inventore, gives this honour to Zacharias Joannides, i. e. Janſen, another maker of ſpectacles at the ſame place, who made the firſt teleſcope in 1590; and it ſeems now to be the general opinion that this account of Borellus is the moſt probable.

Indeed, Borellus's account of the diſcovery of teleſcopes is ſo circumſtantial, and ſo well authenticated, that it does not ſeem poſſible to call it in queſtion. It is not true, he ſays, that this great diſcovery was made by a perſon who was no philoſopher; for Zacharias Janſen was a diligent enquirer into nature: and being engaged in theſe purſuits, he was trying what uſes could be made of lenſes for thoſe purpoſes, when he fortunately hit upon the conſtruction.

This ingenious mechanic, or rather philoſopher, had no ſooner found the arrangement of glaſſes that produced the effect he deſired, than he encloſed them in a tube, and ran with his inſtrument to Prince Maurice, who immediately conceiving that it might be of uſe to him in his wars, deſired the author to keep it a ſecret. But this, though atttempted for ſome time, was found to be impoſſible; and ſeveral perſons in that city immediately applied themſelves to the making and ſelling of teleſcopes. One of the moſt diſtinguiſhed of theſe was Hans Laprey, called Lipperſheim by Sirturus. By him ſome perſon in Holland being very early ſupplied with a teleſcope, he paſſed with many for the inventor; but both Metius above-mentioned, and Cornelius Drebell, of Alcmar, in Holland, applied to the inventor himſelf in 1620; as alſo did Galileo, and many others.* The firſt teleſcope made by Janſen did not exceed 15 or 16 inches in length; but Sirturus, who ſays that he had ſeen it, and made uſe of it, thought it the beſt that he had ever examined.†

Janſen, having a philoſophical turn, preſently applied his inſtrument to ſuch purpoſes as he had in view when he hit upon the conſtruction. Directing it towards celeſtial objects, he diſtinctly viewed the ſpots on the face of the moon, and diſcovered many new ſtars, particularly ſeven pretty conſiderable ones in the great bear. His ſon, Joannes Zachariæ, noted the lucid circle near the limb of the moon, from whence ſeveral bright rays ſeem to dart in different directions; and he ſays, that the full moon viewed through this inſtrument, did not appear flat, but was evidently ſpherical, the middle part being prominent.‡ Jupiter alſo, he ſays, appeared round, and rather ſpherical; and ſometimes he perceived two, ſometimes three, and at the moſt four ſmall ſtars, a little above or below him; and, as far as he could obſerve, they performed revolutions round him; but this, he ſays, he leaves to the conſideration of aſtronomers.§ This I make no doubt, was the firſt obſervation of the ſatellites of Jupiter, though the perſon who made it was not aware of the importance of his diſcovery.

One Francis Fontana, an Italian, alſo claims the invention; but as he did not pretend to have made it before the year 1608; and as it is well known that the inſtruments were

* De vero teleſcopii inventore, p. 37. † Ib. p. 24, 30. ‡ Ib. p. 39. § Ib. p. 40.

were made and ſold in Holland, ſome time before, his pretenſions to a ſecond diſcovery are not much regarded.

There are ſome, who ſay, that Galileo was the inventor of teleſcopes; but he himſelf acknowledges, that he firſt heard of the inſtrument from a German;* but he ſays that, being informed of nothing more than the effects of it, firſt by common report, and a few days after by a French nobleman, J. Badovere, at Paris, he himſelf diſcovered the conſtruction, by conſidering the nature of refraction.† If this be true, he had much more real merit than the inventor himſelf. But Montucla queſtions the veracity of this great man in this caſe, eſpecially as he pretended that he did not know ſo much as the form of the glaſſes which the Dutch inſtrument makers made uſe of, and that he diſcovered a priori, that both a convex and concave glaſs were neceſſary for the purpoſe, which is not true in fact. To me, however, it appears very probable, that this philoſopher might, before he purchaſed any teleſcope of Janſen, have received a very imperfect account of the inſtrument, perhaps from a perſon who had only looked through it, and who knew nothing of its conſtruction. But being merely certified of the poſſibility of effecting the purpoſe of a teleſcope, may well be ſuppoſed to have put a man of ſo much genius and curioſity as Galileo upon making trials, which might enable him to accompliſh the thing, even though he could not give a perfectly rational account of the powers of it; and might in many reſpects, be very much miſtaken concerning it. I am not willing, without the cleareſt grounds, to queſtion the veracity of ſo reſpectable a perſon as Galileo.

The account of what Galileo actually did in this buſineſs, is ſo circumſtantially related by the author of his life, prefixed to the quarto edition of his works, printed at Venice, in 1744, and it contains ſo many particulars, which cannot but be pleaſing to every perſon who is intereſted in the hiſtory of teleſcopes, that I ſhall abridge a part of it, intermixing circumſtances collected from other accounts.

About April or May, in 1609, it was reported at Venice, where Galileo (who was profeſſor of mathematics in the univerſity of Padua) then happened to be, that a Dutchman had preſented to Count Maurice of Naſſau, a certain optical inſtrument, by means of which, diſtant objects appeared as if they were near; but no farther account of the diſcovery had reached that place, though this was near twenty years after the firſt diſcovery. Struck however with this account, Galileo inſtantly returned to Padua, conſidering what kind of an inſtrument this muſt be. The night following the conſtruction occured to him; and the day after, putting the parts of the inſtrument together, as he had previouſly conceived of it, and notwithſtanding the imperfection of the glaſſes that he could then procure, the effect anſwered his expectations, as he preſently acquainted his friends at Venice; to which place he ſix days afterwards, carried another, and a better inſtrument that he had made, and where, from ſeveral eminences, he ſhewed to ſome of the principal ſenators of that republic, a variety of diſtant objects, to their very great aſtoniſhment. When he had made farther improvements in the inſtrument, he with his uſual generoſity, and frankneſs in communicating his diſcoveries, made a preſent of one of them to the Doge, Leonardo Donati, and, at the ſame time, to all the ſenate of Venice; giving along with the inſtrument, a written paper, in which he explained the ſtructure and wonderful uſes that

* Severien's Hiſtoire, p. 247.

† Nuncius Sidereus, p. 4.

might be made of it, both by land and at ſea. In return for ſo noble an entertainment, the republic, on the 25th of Auguſt, in the ſame year, more than trippled his ſalary as profeſſor.

Our philoſopher having amuſed himſelf for ſome time with the view of terreſtrial objects, at length directed his tube towards the heavens; and, obſerving the moon, he found that the ſurface of it was diverſified with hills and vallies, like the earth. He found that the *via lactea* and *nebulæ* conſiſted of a collection of fixed ſtars, which, on account either of their vaſt diſtance, or extreme ſmallneſs, were inviſible to the naked eye. He alſo diſcovered innumerable fixed ſtars diſperſed over the face of the heavens, which had been unknown to all the ancients; and examining Jupiter, with a better inſtrument than any he had made before, he found that he was accompanied by four ſtars, which, in certain fixed periods, performed revolutions round him; and which, in honour of the houſe of Medici, he called Medicean planets.

This diſcovery he made in January 1610, new ſtyle; and continuing his obſervations the whole of February following, in the beginning of March next he publiſhed an account of all his diſcoveries, in his Nuncius Sidereus, printed at Venice, and dedicated to Coſimo, great Duke of Tuſcany, who, by a letter which he wrote to him on the 10th of July, 1610, invited him to quit Padua, and aſſigned him an ample ſtipend, as primate and extraordinary profeſſor at Piſa, but without any obligation to read lectures, or to reſide.

The extraordinary diſcoveries contained in the Nuncius Sidereus, which was immediately reprinted, both in Germany and France, was the cauſe of much ſpeculation and debate among the philoſophers and aſtronomers of that time; many of whom could not be brought to give any credit to Galileo's account, while others endeavoured to decry his diſcoveries, as being nothing more than fictions, or illuſions. Some could not be prevailed upon even to look through a teleſcope; ſo devoted were they to the ſyſtem of Ariſtotle, and ſo averſe to admit any other ſource of knowledge beſides his writings.* When it was found to be in vain to oppoſe the evidence of ſenſe, ſome did not ſcruple to aſſert, that the invention was taken from Ariſtotle; and producing a paſſage from his writings, in which he attempts to give a reaſon why ſtars are ſeen in the day time from the bottom of a deep well, ſaid that the well correſponded to the tube of the teleſcope, and that the vapours which aroſe from it, gave the hint of putting glaſſes into it, and laſtly, that in both caſes, the ſight is ſtrengthened by the tranſmiſſion of the rays, through a thick and dark medium. Galileo himſelf tells this ſtory with a great deal of humour, comparing ſuch men to alchymiſts, who imagine that the art of making gold was known to the ancients, but lay concealed under the fables of the poets.†

In the beginning of July, of the ſame year 1610, Galileo, being ſtill at Padua, and getting an imperfect view of Saturn's ring, imagined that that planet conſiſted of three parts; and therefore, in the account which he gave of this diſcovery to his friends, he calls it *planetam tergeminum.*

Whilſt he was ſtill at Padua, which muſt have been either in the ſame month of July, or the beginning of Auguſt following, he obſerved ſome ſpots on the face of the ſun; but, contrary to his uſual cuſtom, he did not chuſe, at that time, to publiſh his diſcovery; partly for fear of incurring more of the hatred of many obſtinate Peripatetics;

* Vita del Galileo, p. 57, &c.

† Galileo's Works, vol. iv. p. 91.

WORKSHOP of the Microscopical Society of Southern California

Date: Saturday, 7 January 2000
Location: Ernie Meadows' residence - 26 persons attended

George G. Vitt, Jr.

1. **George Vitt** reported that he had scanned photos taken at the November 1999 Exhibit and that B&W versions will be published in the Journal.

2. **Ken Gregory** displayed a cased c.1900 Reichert Hemometer, used to measure the percentage of hemoglobin in blood, and described the manner of its use. It behaves much like a visual comparison colorimeter. There are two glass chambers: the first is filled with distilled water and the second with distilled water plus the blood sample which is measured with a capillary. The blood cells burst in the distilled water, releasing the hemoglobin, and forming a uniformly colored pink solution. Below the chamber filled with distilled water there is a slidable linear wedge made of pink colored glass. Both chambers are trans-illuminated from below by light reflected from an adjustable diffuse white surface. One observes both chambers by looking down through a split-field prism eyepiece while moving the wedge until there is a color match. Since the wedge is linear, its optical density is a linear function of its thickness and of its position under the sample. The % of hemoglobin is read directly from an engraved scale on the wedge, where equal increments of % are equally spaced.

3. **Jim Solliday** showed a June 1892 catalog of Queen & Co. (Philadelphia) who, at the time, were the sole agents in the USA for Reichert. The above described hemometer is illustrated in this catalog.

4. **Stuart Warter** displayed a c.1887 Watson (Edinburg) microscope which was the "grand-daddy" of the Van Heurck design, with a Continental style fine focus and a horseshoe foot, used as a polarizing microscope equipped with vertical illumination capability, cased, with a set of eyepieces and objectives (one being of American make). Stuart pointed out that the horseshoe foot was not popular in England, where the tripod foot was preferred.

5. **Jim Solliday** related the events in the development of APO microscope objectives. Watson, Abbe, and Zeiss were in a frenzy of competition in making APO objectives and the English did some reverse engineering of the German objectives, while being ignorant of the fact that the Germans were using fluorite. Watson, who did not use fluorite, called his product the "Holos Objective". These were 20X with NA=0.65! These had to be used with great care to avoid flare, especially since there was no anti-reflection coating in those days. Jim described Watson's orthoscopic "Holos eyepiece" where the distance between the field and eye lens is adjustable to correct for the spherical aberration of the objective. Jim stressed that Watson was the 'ultimate microscopist' who did and made everything! Jim then gave a history of the development of dark field (DF) condensers, citing Watson's quartz paraboloid design. He then described ultramicroscopy developments and how Edwin Nelson, then President of the RMS, developed the cassegrain condenser, NA=1.4, for use with oil (not water). This allowed the DF observation of an object and its morphology at high magnification and NA.

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On the Invention of Teleſcopes and Microſcopes. 411

patetics; and partly, in order to make more exact obſervations on this remarkable phænomenon, and to form ſome conjecture concerning the probable cauſe of it. He therefore contented himſelf with communicating his obſervations to ſome of his friends at Padua and Venice, among whom I find the name of father Paul. This delay, however, was the cauſe of this diſcovery being conteſted with him by the famous Scheiner, who likewiſe made the ſame obſervation in October 1611, and I ſuppoſe had anticipated Galileo in the publication of it.

6. **Alan de Haas** showed a c.1870 Reichert "C" stand with a 3-objective turret and a special Reichert DF condenser, to be used only with slides 0.8-0.9mm thick. The instrument had been restored by Alan Bishop, who marveled at the fact that the entire fine-focus mechanism comes out as a unit by the simple removal of four screws! He then showed a bench mounted shadowgraph projector with interchangeable screen, possibly made by Nikon, and explained the type of lighting used in shadowgraphs.

7. **Izzy Lieberman** displayed his cased 1927 Leitz monocular microscope that had very recently been beautifully restored by John de Haas. This microscope features a calibrated draw tube, rotating stage, and substage abbe type condenser that is moved by rack & pinion to decenter it and provide oblique illumination. Rotation of this assembly allows oblique illumination from any azimuth angle. (The writer has the identical microscope and can attest to its fine and utilitarian design). Izzy then showed a 1946 A/O catalog of microscopy equipment.

8. **Jim Clark** told us that his son-in-law, a new orthopedic surgeon, has John de Haas' A/O stereo microscope, which Jim had given him.

9. **Herb Gold** showed a cased c.1910 Reichert saccharimeter in excellent condition, which he had gotten from Maurice Greeson, and gave a history of the development of the polarimeter. The instrument uses 100 and 200 mm long glass tubes and a quartz wedge adjusts with two fields of view and reads directly in % sucrose. Rotatory polarization was discussed and explained. Barry Sobel described "L" glucose that does not metabolize, nor "L" lactic acid which has been detected in human bodies. Alan de Haas added that hydrogenated animal fats are not digestible and recommended that we all 'stick with olive oil'!

10. **Gaylord Moss** showed a recently acquired pair of eyeglasses with a titanium wire frame and high-index polycarbonate lenses, weighing some 10 grams. They, and their aesthetically designed case were a marvel of engineering! There was a discussion of magnifiers and what is needed for close inspection. Alan de Haas cited 300bc Greek magnifying lenses, 2x-3x, which had been ground and polished on lathes made of wood - and Roman surveying instruments at the Getty Museum.

11. **John de Haas** showed a restored c.1924 research model B&L microscope with large body tube, centerable rotating stage, and 4 Apo objectives.

12. **Gary Legel** described a chemical etching material for glass, and showed examples of its action in the making of fine ground glass. The material is based on fluoride.

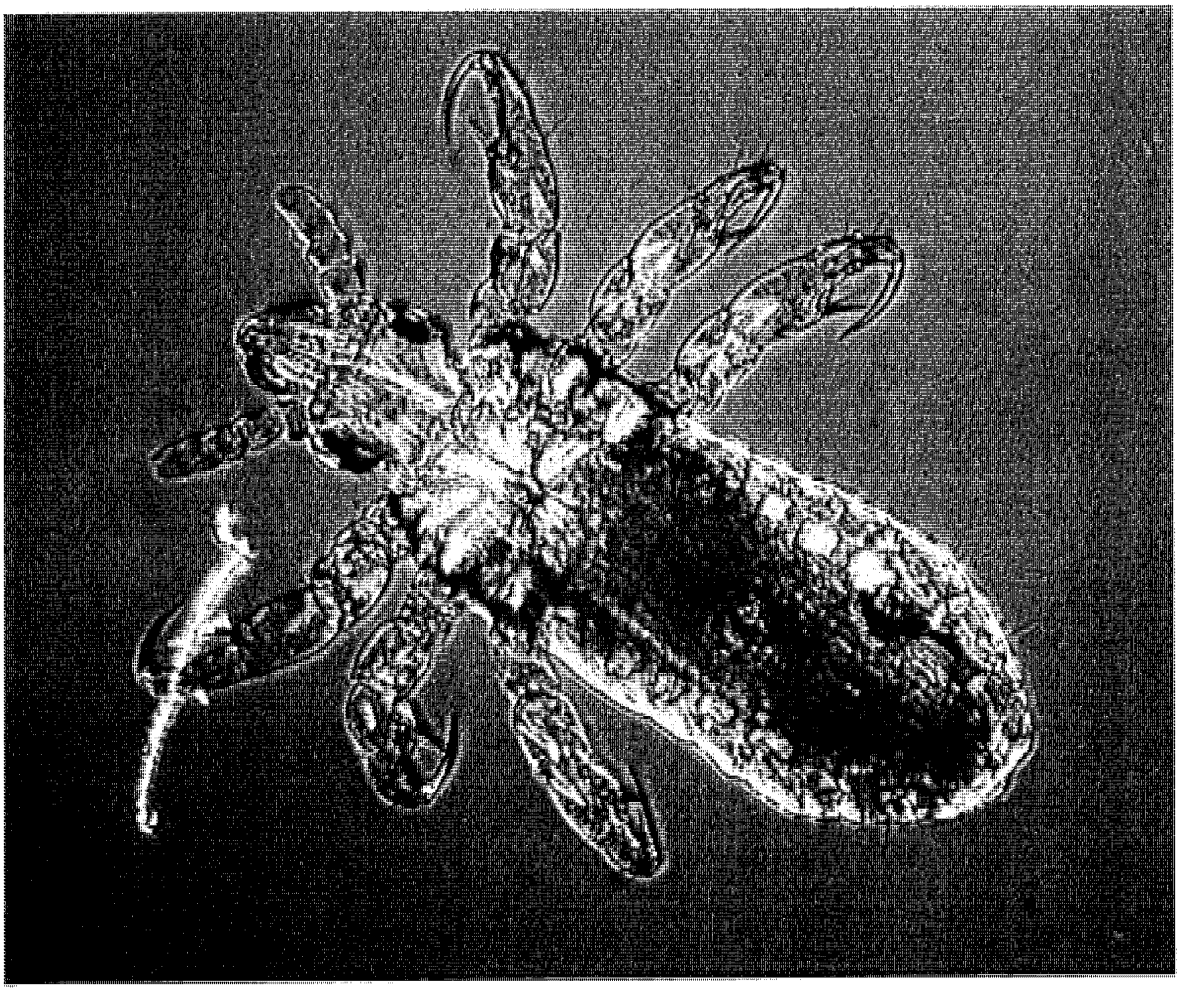
13. **Larry McDavid** showed some very handy, light and inexpensive cylindrical aluminum containers (about 1" in diameter and about 1" high) with glazed lids. They are suitable for holding all the sorts of small items and specimens used by microscopists and are available from LeeValley & Veritas Hardware, POB 1780, Ogdensburg, NY 13669; To order: 1-800-871-8158; Customer Service: 1-800-267-8735.

Then Larry showed a most remarkable antique art object of great scientific interest: a Tibetan music bowl, some 10" in diameter, made of bronze-like metal, hand hammered, with a thickened rim, and beautifully patinated. The bowl is supported from underneath on the tips of one's fingers and, with the right hand, a 2" diameter baton of heavy polished hard wood, about a foot long, is rotated around the outer periphery of the rim with very gentle pressure. With continued rotation, oscillations gradually build up to produce a low melodious note and the amplitude becomes so large that it is impossible to maintain a steady contact between the baton and the rim! The long decay period indicates that the material is of very high "Q", i.e., has extremely low mechanical damping losses, which speaks highly of the quality of the alloy. George Vitt stated that this was a direct analogy to the electronic Van der Pohl oscillator, which also simulates the bowed violin string. Many such music bowls are used in unison in Tibetan Lamaseries during times of prayer and meditation. Larry certainly comes up with some marvelous items to show us - mixtures of art and science

14. **Larry Albright** showed a fine, cased, c.1885 R&J Beck petrological microscope having a small condenser lens built into the stage, a Bertrand lens, triangular foot, 3-objective turret, 2+ orders quartz wedge and two retardation plates. He also showed a c.1910 slide cabinet with about 50 thin rock sections, and with a drawer in the bottom of the cabinet containing a card catalog of the slides contained. All is for sale at $1,500.

15. **Jack Levy** showed a Jan 23 Butterfield & Butterfield auction catalog of natural history items.

16. **Peter Fischer** described the type of damage suffered by incident light objectives when these are used in the semiconductor industry. Their front surface is etched with fumes of hydrofluoric acid used in processing integrated circuits on silicon wafers. Peter then described how he had restored several of these lenses by first making, in a Petri dish, a silicone rubber mold of the front of the objective. He then made a light distilled water slurry with Linde A (0.3 micron particle size aluminum oxide) in this cavity and polished the objective by mounting it in the chuck of a drill press, while manually holding the slurry containing rubber mold lightly against the lens. There being some 'wobble' to the chuck, the center part of the lens surface was also effectively polished.



First photomicrograph with Nikon 950 digital camera. PMS slide of head louse. 4x objective, 10x eyepiece, partially crossed polars, Leitz binocular microscope, Koehler illumination. GG Vitt-03-31-2000.

Nikon Mod.950 Digital Camera and the Microscope

George G. Vitt, Jr.

Looking through a box of PMS slides, I came across a well mounted specimen of a nasty looking head louse. Deciding that this fellow should be immediately put into my Rogue's Gallery, I set up the Nikon 950 and took my first photomicrograph with this camera. No special equipment or adapters were needed.

Equipment used:

Microscope: Leitz biological binocular stand, c.1950, with substage mirror.
The upper lens of the substage condenser was swung out to reduce the numerical aperture and give uniform illumination across the entire FOV of
the 3x objective.

Illumination: Illumination was provided by a A/O mic. lamp - the small focusable unit on articulated arm on top of the transformer which was set to 5 volts. The lamp lens was placed about 8" from the microscope mirror and its filament was focused on the diaphragm of the substage condenser. The filament image was large enough to fill the entire aperture of the condenser. Final adjustment of lamp and mirror was made by observing the back focal plane of the objective (with the specimen moved out of the FOV) to make sure that the filament image in the back focal plane filled the objective aperture. The substage diaphragm was then closed a bit. This is the procedure for setting up Koehler illumination.

Polarization: The partially crossed polars not only show the birefringencs in the specimen, but also provide a grey background, which I prefer.

Objective: The objective was a Nikon 3x plan achromat.

Eyepieces: The eyepieces were the Nikon CFWN 10x/20. The OD of the eye lens is 22mm and the OD of its surrounding rim is 35mm. The 32mm OD of the 950 camera lens flange made a good match and light seal.

Procedure: The microscope was placed in an upright position on the base of a small copy stand and all was

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Akersten MD	William	Mus.Nat.Hist. Idaho State U.	Pocatello	ID	83209	208-236-2680		
Albright	Larry	1704 Mandeville Lane	Los Angeles	CA	90049	310-471-0424	310-392-9222	albrite@Plasma-Art.com
Bailey	Kirk A.	P.O. Box 1599	Corvallis	OR	97339	541-754-7226		
Barnett	Peter D.	3053 Research Drive	Richmond	CA	94806	510-482-3060	510-222-8883	pbarnett@crl.com
Bell	John	106 Highway 201 South #303	Ozark	AL	36360	334-774-5149		
Bennet	Kevin E.	819 - 4th. St. S.W.	Rochester	MN	55902-2975	507-286-1077	507-284-8761	kbennet@alum.mit.edu
Bernstein	Jerry	2661 Butler Ave.	Los Angeles	CA	90064	310-473-8552	http://www.wlamicro.com	
Bird	Timothy J.	717 NW 36th Street	Corvallis	OR	97330	503-757-3087		
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Blankenhorn	Rick C.	P.O. Box 2560	Fallbrook	CA	92088	760-728-3321	rcb@gemmary.com	
Blitch	Norman H.	1725 Sunrise Lane	Fullerton	CA	92833	714-879-7236	normblitch@aol.com	
Boulger	Tom	124 So. Guadalupe Ave.	Redondo Beach	CA	90277	310-379-3509	tomboulger@aol.com	
Bruce	Peter J.	33 Avery Close	Lutterworth, Leicestershire,	LE17 4PX	U.K.			
Brunt	Chris	P.O. Box 325	Topanga	CA	90290	310-455-3102		
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Christensen	Daniel W.	PO Box 68	Clifford	VA	24533	804-277-8738	804-277-8054FAX	christensen@lynchburg.net
Clark, Jr.	James D.	11518 Valle Vista Road	Lakeside	CA	92040	619-443-6154	jdjeclark@home.com	
Cohen	Ellen	PO Box 2645	Malibu	CA	90265	310-457-5783		
Coulson M.D.	Walter F.	329 So. Swall Drive	Beverly Hills	CA	90211	310-659-1703	wcoulson@pathology.medsch.ucla.edu	
Craig	Steve	3455 Meier Street	Los Angeles	CA	90066	310-397-8245	srcraig@mediaone.net	
Cytron	Dan	637 Strand St.	Santa Monica	CA	90405	310-396-2432	faci@flash.net	
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de Haas	Alan	2734 Midvale Ave	Los Angeles	CA	90064	310-475-2873	310-475-2873	microscope@mediaone.net
de Haas	John	3516 Sawtelle Blvd	# 104 Los Angeles	CA	90066	310-391-5205		
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del Cerro MD	Manuel	14 Tall Acres Drive	Pittsford	NY	14534	716-275-4027	mdelcerro@medinfo.rochester.edu	
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Dingley	PMS, Michael	P.O. Box A1017	Sydney, South PO	NSW	1235	Australia	michaeld@amsg.austmus.gov.au	
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Faust MD	Robert	18370 Burbank Blvd. #511	Tarzana	CA	91356	818-788-3065	818-788-1166	
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Field MD	John Austin	117 Arroyo Place	Santa Cruz	CA	95060-3139	408-246-1383	408-236-4265	
Fischer	Peter Gerhard	5543 Shoreview Drive	Rancho Palos Verdes	CA	90275	310-375-1250	310-375-7604	allswiss@aol.com
Ford	Brian J.	Rothay House, Mayfield Rd.	EASTREA	Cambridgeshire	PE7-2AY	U.K.	bjford@sciences.demon.co.uk	
Giordano	Raymond V.	PO Box 448	Southampton	MA	01073-0448	413-529-2731	antiqsci@ma.ultranet.com	
Gold	Herbert A.	2065 Balmer Drive	Los Angeles	CA	90039-3047	323-665-8391	herbgold@concentric.net	
Golubovs	Paul	11240 Briarcliffe Drive	San Diego	CA	92131	619-549-3331	619-578-5540	pgolubovs@aol.com
Greeson	Maurice M.	232 Long Beach Blvd.	Long Beach	CA	90802	562-436-6102	mckay90802@att.net	
Gregory	Kenneth M.	2124 Ocana Avenue	Long Beach	CA	90815	562-596-1762	gregory1@csulb.edu	
Hantsch	Fred L.	936 Berkeley Street	Santa Monica	CA	90403	310-828-0286	micromania@earthlink.net	
Harding	Lynn	103 West Aliso Street	Ojai	CA	93023	805-646-0204		
Herman	Al	1200 Lachman Lane	Pacific Palisades	CA	90272	310-454-4266	alherm@loop.com	

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Last Name	First Name	Street	City	State	Zip Code	Home Phone	Work Phone	E-Mail
Herzon	Garrett	2132 Century Park Lane #108	Los Angeles	CA	90067	310-556-1010		gherzon@earthlink.net
Hesse	Kenneth	1221 La Paloma Glen	Escondido	CA	92026	619-747-3195		
Hieb	Bill	3674 Rossmoor Pkwy. Apt 4	Walnut Creek	CA	34595-3808			
Hirsch	David L.	11815 Indianapolis St.	Los Angeles	CA	90066-2046	310-397-8357		dlhirsch@pacbell.net
Hudson	William	23963 Sapphire Canyon Rd.	Diamond Bar	CA	91765	909-860-5729		
Jefts	Richard M.	PO Box 2437	Fallbrook	CA	92088	760-731-6091		
Jones, Jr.	Edwin L.	2425 Scoter Avenue	Ventura	CA	93003	805-654-8548	805-654-2333	
Kile	Daniel E.	333 Salem Street	Aurora	CO	80011	303-341-0135		
Kleinman M.D.	George M.	20 East Common Rd.	Easton	CT	06612-1505	203-256-5990	203-384-3591	gmkleinman@home.com
Krause	Bill	9 Wilton Rd. Hornsea	East Yorkshire		HU 18-IQU	U.K.		savonabooks@savonabooks.free-online.co.uk
La Rue	Budd J.	P.O. Box 219	West Chicago	IL	60186-0219	-		blarue@panamseed.com
Lamb, Sec.,PMS	Colin G.	32 Clement Ave.,Balderton	Newark,Notts.		U.K. NG24 3NT	01636-77888		
Landegger	Herbert	361 Vernon Ave. Unit # 7	Venice	CA	90291	310-452-5354		
Laxer	Jack	16952 Dulce Ynez Lane	Pacific Palisades	CA	90272	310-459-1213		
Layfield	Herbert A.	14439 Hayward	Whittier	CA	90603	562-696-7383		
Legel	Gary	1306 Sheppard	Fullerton	CA	92831-1827	714-870-0439		
Levy	Jack	PO Box 83489	Los Angeles	CA	90083	310-670-8434		
Lieberman	Isaiah U.	3300 Corinth Avenue	Los Angeles	CA	90066	310-391-6076		iul@gte.net
Lind M.D	Myron	6120 Village #6	Camarillo	CA	93012	805-388-0542		alind4915@aol.com
Lohmann	Philip D.	4418 Faculty Ave.	Long Beach	CA	90808	562-429-8665		
Loro	Bert	943 Foul Bay Road	Victoria, B.C.		Canada V8S 4H9	250-592-1693		
Loxton, Edit.,PMS.	Fred	86 Haymoor Rd.,	Poole, Dorset		U.K. BH15 3NU	01202 731545		
Martella	David J.	11-F Brooklyne Court	Princeton	NJ	08540	609-683-5664		
Martin	Fred	4072 Kulamanu St.	Honolulu	Hawaii	96816	808-737-5235		takena@att.net
McCormick	Thomas J.	5924 Bonsall Drive	Malibu	CA	90265	310-589-5552	310-828-1098	tom@ntaudio.com
McCormick, MD	James B.	2740 West Foster Ave. #110	Chicago	IL	60625	-		
McDavid	Larry	185 South Alice Way	Anaheim	CA	92806-4032	714-630-5672		Lmcdavid@Lmceng.com
McDonald	Kate	1440 Veteran Ave #204	Los Angeles	CA	90024	310-575-4044		kate@ucla.edu
Meadows	Ernest	707 Greentree Road	Pacific Palisades	CA	90272	310 -459-4788		
Meek	Parke	2701 Main Street	Santa Monica	CA	90405	310-396-3477		
Micro Soc.	R. Winsby,	Manchester 214 East Lancs. Road	Swinton, Manchester		U.K. M27 1QJ	061-794-4182		
Microscopical Club		Quekett Brit.Mus.Nat.Hist,	Cromwell Rd.	London	U.K. SW7 5BD	-		
Microscopical Soc.		Royal 37/38 St. Clements	Oxford		U.K. OX4 1AJ			
Microscopical Soc.		San Francisco Morris Planet.,Cal.Acad.Sci.	G.G.Pk; San Francisco	CA	94118	-		
Milan	Leo J.	3320 Stoner Avenue	Los Angeles	CA	90066	310-391-9654		tronm@earthlink.net
Molnar	Charles J.	2570 Burgener Blvd.	San Diego	CA	92110	619-276-6348		
Moorehead	Wayne	10449 Placer River Circle	Fountain Valley	CA	92708-7128	714-965-1590		WayneKip@ix.netcom.com
Morris	Ronald F.	1561 Mesa Drive #25	Santa Ana Heights	CA	92707	714-557-6567	714-573-6765	tronm@earthlink.net
Moss	Gaylord E.	P.O. Box 9130	Marina Del Rey	CA	90295	310-827-3983	310-827-3983	gmoss@mediaone.net
Ordonez	Eugenia	1545 Yale St. # 6	Santa Monica	CA	90404	310-453-2411		mcordonez@aol.com
Ottenheimer	Paul N.	PO Box 339	Mantua	NJ	08051	-		
Paris	Robert S.	12420 Cascade Cyn Dr.	Granada Hills	CA	91344	818-366-2432		packman@socal.rr.com
Portell NYMS	Jean	13 garden Place	Brooklyn	NY	11201-4501	718-643-1222		
Price	Zane	12424 Everglade	Los Angeles	CA	90066	310-398-0861		
Pulido	Julian S.	11619 Cozumel St.	Cypress	CA	90630	714-897-8756		
Roberts	Alan & Roberta	221 Oceano Drive	Los Angeles	CA	90049	310-476-6277		
Samuels	Allan A.	2800 Bard Ranch Road	Prescott	AZ	86301	520-717-0120		samuels@mwaz.com
Samworth	Mike	24 Greenslade Grove	Hednesford, Staffordshire		WS125QR	U.K.		Apochrom@ukgateway.net

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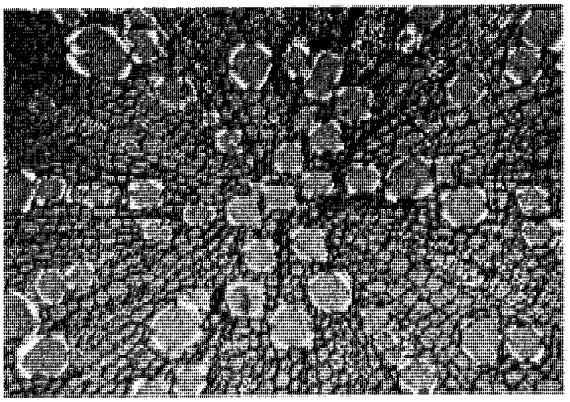
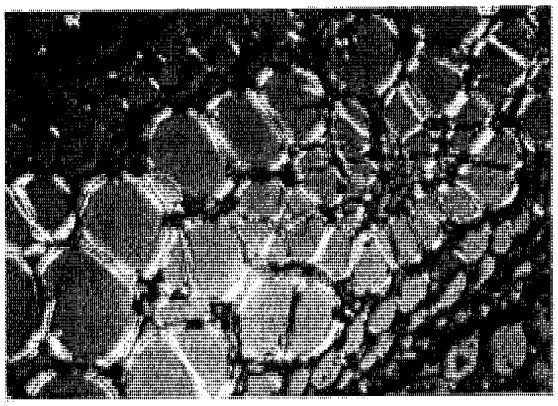
Last Name	First Name	Street	City	State	Zip Code	Home Phone	Work Phone	E-Mail
Schwan	Tom	601 So. 5th St.	Hamilton	Montana	59840			
Skladany	James D.	470 W. 25th St.	San Bernardino	CA	92405-3728	909-886-1101		
Skvara	Frederick C.	617 Country Club Rd.	Bridgewater	NJ	08807-1658	fcskvara@bellatlantic.net		
Sobel M.D	Barry J.	16133 Ventura Blvd.,#360	Encino	CA	91436-2424	818-986-5887	818-986-6009	ak657@LAFN.org
Soc. of Canada	Historical Micro.	RR #2, Priceville	Ontario	Canada	NOC-1KO	519-369-2955		
Solares	Dario D.	521 26th St.	Santa Monica	CA	90402-3145	310-394-6280	solares2@aol.com	
Solliday	James D.	1130 S. Austin St.	Santa Ana	CA	92704	714-775-1575	714-557-0580	jdsolliday@att.net
Stabinsky	Leon	9610 Quartz Avenue	Chatsworth	CA	91311	818-886-1979	stabin@earthlink.net	
Taylor	Peter C.	2960 Fillmore St. #7	San Francisco	CA	94123	415-922-6768		
Teti	Pierino	974 Edgecliffe Drive	Los Angeles	CA	90026	323-660-9259		
Tulleners	F.A.	8410 Manana Way	Fairoaks	CA	95628	-		
Vitt, Jr.	George G.	2127 Canyon Drive	Los Angeles	CA	90068	323-464-6503	gvitt@worldnet.att.net	
Warter	Stuart L.	Dept. of Biology, Cal State Univ.	Long Beach	CA	92647	714-847-0529	562-985-5502	swarter@csulb.edu
Wise	Joseph	1714 - 21st. Street	Santa Monica	CA	90404	310-829-7391	jwise@kmsi.org	
Wissner MD	Dr. Allan	31 Wood Avenue	Ardsley	NY	10502-1025	914-693-4628		
Worden	Bill	2132 Walnut Ave	Venice	CA	90291	310-390-5757	fantods@greenheart.com	
Wright	Myron	13720 Karen Street	Anchorage	AK	99515	( ) 345-6014	mwright@alaska.net	
Yaruss	Gary S.	1189 Cynthia Court	La Verne	CA	91750	909-593-4242		
Ziff	Stuart	1045 24th St.	Santa Monica	CA	90403	310-829-5116	stuartziff@home.net	

Nikon 950 Continued from page 16



Foeniculum Vulgare, Transverse root section.
Nikon 950 GG Vitt -03-31-2000



Pteridium Aquilinum, Rhizome section, Transverse.
Nikon 950 GG Vitt -03-31-00

adjusted for accurate Koehler illumination. The camera was inclined to match the eyetube angle and lowered to be not quite in contact with the rim of the right eyepiece. (The camera could just as well have been set up to have its LCD horizontal, and the camera's lens/CCD assembly rotated to the required angle.) I looked through the left eyepiece just to make sure of things - the final framing being done on the LCD display on the camera. This autofocus camera was set to aperture priority and its flash was disabled. Exposure was about 0.25 sec. Camera resolution was set to 1600x1200 pixels with JPEG compression of about 5:1, giving a final file size of about 1Mb.

Comments: The lens on the 950 is not removable, so it is necessary to use an eyepiece for photomicrography. This results in too high a magnification in many cases, necessitating the use of a low power (say 3x to 5x) objective. When this is done, however, the camera's FOV imay be considerable smaller than that provided by the microscope optics for visual observation. (I have yet to experiment with the zoom capability of the camera in this application). The low NA of the low power objective degrades image sharpness somewhat, but provides a greater depth of field which is desirable for relatively thick specimens, such as the one pictured here. It is a tradeoff. Note that the claws are rather well defined, which would not have been the case had a higher power objective been used.

MSSC April Meeting
Wednesday, April 19 at 7 PM.
Crossroads School, 1714 21st Street
Santa Monica, CA.

Viewing Brownian Motion.

Bill Davies

In the literature, there are a number of devices for viewing Brownian motion. Bill Davies will demonstrate four of these that he has constructed with his own modifications and improvements. He will show his final design which is extremely simple and effective so that anyone can in a short time build a good demonstration.

Along with the actual device demonstrations, Bill will show a series of slides and a video.

This will be an especially interesting as a follow-up to the fascinating lecture by Brian Ford on the discovery of Brownian motion.

De Haas Optics Discussion

Following the coffee break, Alan deHaas will continue with his lecture on the fundamentals of light and optics.

Editor's Notes

George Vitt's photos on page 16 and 19 demonstrate the excellence of the Nikon 950 2.1 megapixel digital camera which has now been surpassed by the Nikon 990 which offers improvements such as: a 2048 x1536 pixel image for 3.34 megapixels, full manual exposure option, 7 blade iris 1/3 stop exposure control, histogram display to ensure that exposures do not "blow out" highlights, shutter 8 to 1/1000 sec plus bulb, USB connection for fast download and a host of other improvements such as provision to use the self timer in macro mode. The list price is about $1000.

For extensive reviews of the Nikon 950, 990 and other digital cameras including comparison sample photographs and more information than on the manufacturers own web sites, go to:
http://www.imaging-resource.com
http://www.steve's-digicam.com.

Olympus and Fuji also make 3 megapixel cameras in the same price range and other models are flooding onto the market.

Gaylord Moss