Henry Pocklington, 1842 - 1913

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Microscope slides such as those illustrated in Figure 1 frequently create a lot of excitement at auction, and often sell for prices well in excess of $100 each. The specimens are usually botanical, generally leaves or fern fronds, although other subjects are occasionally found (Figure 2). The slides are well constructed, wrapped back and sides in a solid colored paper, and the front covered with an off-the-shelf variety of gold-patterned cover paper. Specimen descriptions are nicely rendered in a distinctive hand, and are written on plain paper below the cover paper, being visible through holes cut in the covers. The holes cut through the covering papers to show the specimen and the labels are imperfect, evidently cut by hand with a knife. That crude feature points toward an amateur mounter, rather than a professional who would have made use of cutting dies for clean, efficient cuts. Exact duplicates of slides are not known, further suggesting that these slides originated from a single private collection, rather from a commercial maker, who would undoubtedly have made numerous identical slides of each specimen. The identity of the maker of these attractive slides has long been a mystery for collectors. Two slides have recently been discovered which suggest that the maker was Henry Pocklington, a well-published authority in all aspects of microscopy.

Figure 1. *Examples of microscope slides that were probably prepared by Henry Pocklington. He generally used the same pattern of off-the-shelf cover paper, in colors that include green, blue, red and pink. Although his slides are occasionally found with commercial dealers' labels attached (e.g. C. Baker, fourth from the left) – which might suggest a professional preparer – it is important to remember that dealers such as Baker frequently re-sold slides that they obtained from a variety of sources. The second slide from the left has a label with the monogram "OCS" or "OSC" – the absence of such stickers from the majority of these slides implies that it was applied by a later owner. Bracegirdle's Microscopical Mounts and Mounters illustrates two slides by this maker, on Plate 40, one of which also carries an OCS/OSC monogram, and the other a monogram of PCG, evidently another later owner.*

Figure 2. *Three uncommon slides from this maker, being specimens of fish skins.*

Two slides have come to light that bear important clues about their most probable maker (Figure 3). Both contain leaf samples which are labeled as being "*Malvastrum mimroanum*". This was a misspelling of the plant's actual name, *Malvastrum munroanum* (now *Sphaeralcea munroana*). Both specimens came from Idaho, USA, and one was recorded as having been supplied by Dr. J. Curtis of the U.S. Geological Survey. Internet searches came up with only one record of the plant's misspelling, an 1872 *English Mechanic and World of Science* article on "*Leaves microscopically considered*", by "*H.P.H.*":

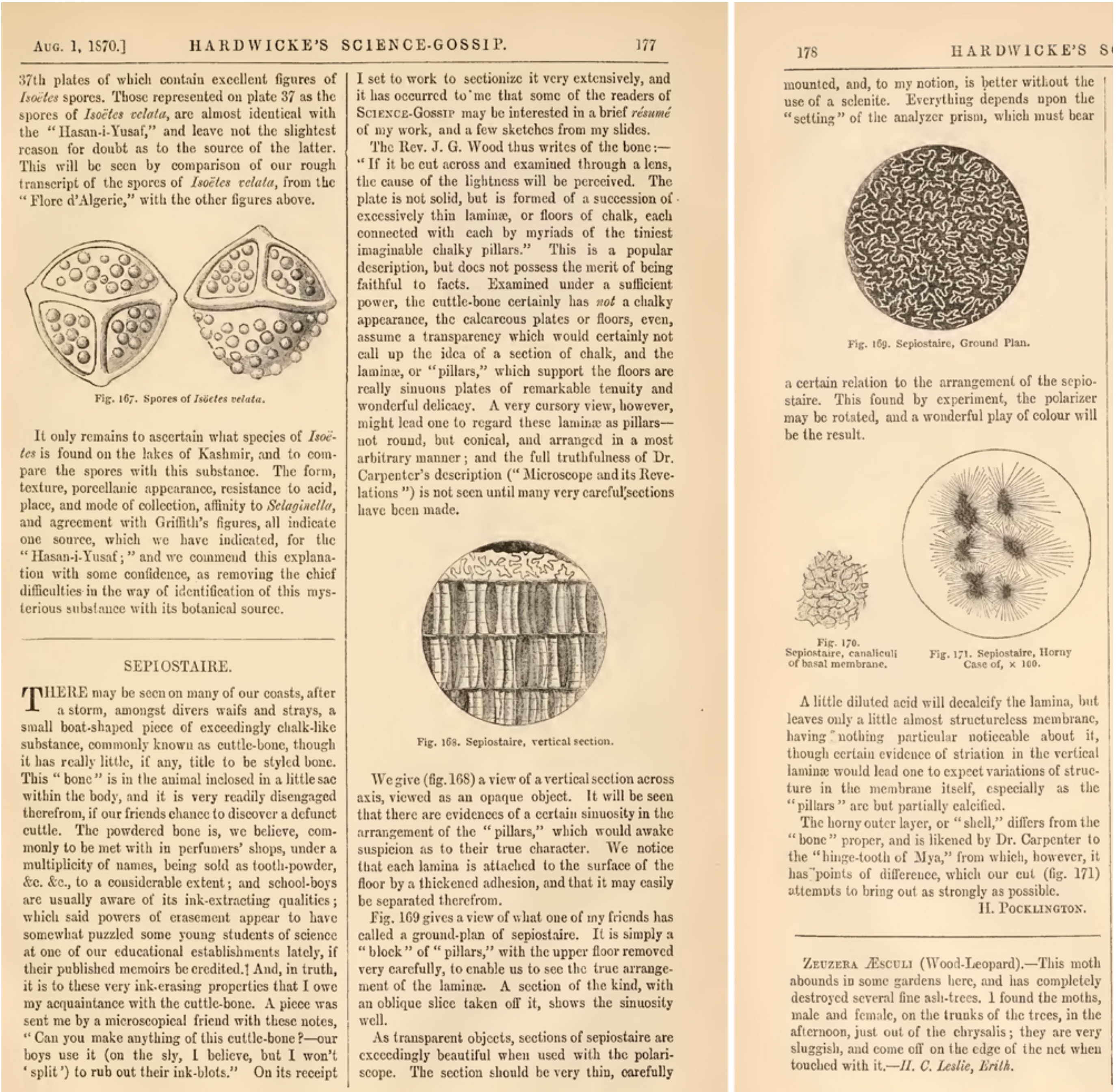
"*From the New World has come a leaf 'with stellate pubescence,' interesting not only on account of its hairs, but because of the place from whence my good friend Dr. Curtis gathered it, and sent it from one extreme of this portion of cosmos to the other. High up in the world in the new United States Park, at Idaho, with 'literally thousands of geysers, and mud volcanoes round it,' was this leaf gathered, and there at least would one of its new friends like to go. My friend's account of its habitat is interesting, and though out of place here, should be incorporated, did space permit. The hairs on the surfaces of this leaf (of Malvastrum mimroanum (?) gray) are radiate, the radii being of considerable length and needle-shaped. Those on the lower surface are more tufted, and somewhat resemble the hairs on the calyx of our homely English mallows*".

Figure 3. *Two slides of "Malvastrum mimroanum".*

The misspelling, the attribution of Dr. Curtis as the specimen source, and the Idaho origin in both the publication and the slides all point to "*H.P.H.*" as the slides' maker. Who was "*H.P.H.*"? Luck was again on our side, as *The English Mechanic and World of Science* has published a list of the pen names used by frequent contributors. "*H.P.H.*" was Henry Pocklington. His contributions were also often signed "*H.P.,H.*", meaning "*Henry Pocklington, of Hull*", that being the city in which he lived during the 1870s. Pocklington's early contributions were signed "*H.P.*", with the second "H" added to later publications to differentiate him from another writer who had the same initials.

A third slide is known that also alludes to Pocklington (Figure 4). This is an unpapered slide, with labels written in the same hand as the above-described slides. It is a specimen of "*sepiostaire*" (cuttle fish bone) and includes a reference to an article by Henry Pocklington on the subject (Figure 5). In light of the above-described *Malvastrum* slides, this slide was likely made by Pocklington, either for studies described in his paper or for exchange with a colleague who was interested in the subject.

Figure 4. *A microscope slide of "sepiostaire" (cuttle fish bone), citing an 1870 paper on the topic written by Henry Pocklington (see Figure 5).*



37th plates of which contain excellent figures of *Isoëtes* spores. Those represented on plate 37 as the spores of *Isoëtes velata*, are almost identical with the "Hasan-i-Yusaf," and leave not the slightest reason for doubt as to the source of the latter. This will be seen by comparison of our rough transcript of the spores of *Isoëtes velata*, from the "Flore d'Algerie," with the other figures above.

Fig. 167. Spores of *Isoëtes velata*.

It only remains to ascertain what species of *Isoëtes* is found on the lakes of Kashmir, and to compare the spores with this substance. The form, texture, porcellanic appearance, resistance to acid, place, and mode of collection, affinity to *Selaginella*, and agreement with Griffith's figures, all indicate one source, which we have indicated, for the "Hasan-i-Yusaf;" and we commend this explanation with some confidence, as removing the chief difficulties in the way of identification of this mysterious substance with its botanical source.

SEPIOSTAIRE.

THERE may be seen on many of our coasts, after a storm, amongst divers waifs and strays, a small boat-shaped piece of exceedingly chalk-like substance, commonly known as cuttle-bone, though it has really little, if any, title to be styled bone. This "bone" is in the animal inclosed in a little sac within the body, and it is very readily disengaged therefrom, if our friends chance to discover a defunct cuttle. The powdered bone is, we believe, commonly to be met with in perfumers' shops, under a multiplicity of names, being sold as tooth-powder, &c. &c., to a considerable extent; and school-boys are usually aware of its ink-extracting qualities; which said powers of erasement appear to have somewhat puzzled some young students of science at one of our educational establishments lately, if their published memoirs be credited.! And, in truth, it is to these very ink-erasing properties that I owe my acquaintance with the cuttle-bone. A piece was sent me by a microscopical friend with these notes, "Can you make anything of this cuttle-bone?—our boys use it (on the sly, I believe, but I won't 'split') to rub out their ink-blots." On its receipt I set to work to sectionize it very extensively, and it has occurred to me that some of the readers of SCIENCE-GOSSIP may be interested in a brief *résumé* of my work, and a few sketches from my slides.

The Rev. J. G. Wood thus writes of the bone:—"If it be cut across and examined through a lens, the cause of the lightness will be perceived. The plate is not solid, but is formed of a succession of excessively thin laminæ, or floors of chalk, each connected with each by myriads of the tiniest imaginable chalky pillars." This is a popular description, but does not possess the merit of being faithful to facts. Examined under a sufficient power, the cuttle-bone certainly has *not* a chalky appearance, the calcareous plates or floors, even, assume a transparency which would certainly not call up the idea of a section of chalk, and the laminæ, or "pillars," which support the floors are really sinuous plates of remarkable tenuity and wonderful delicacy. A very cursory view, however, might lead one to regard these laminæ as pillars—not round, but conical, and arranged in a most arbitrary manner; and the full truthfulness of Dr. Carpenter's description ("Microscope and its Revelations") is not seen until many very careful sections have been made.

Fig. 168. Sepiostaire, vertical section.

We give (fig. 168) a view of a vertical section across axis, viewed as an opaque object. It will be seen that there are evidences of a certain sinuosity in the arrangement of the "pillars," which would awake suspicion as to their true character. We notice that each lamina is attached to the surface of the floor by a thickened adhesion, and that it may easily be separated therefrom.

Fig. 169 gives a view of what one of my friends has called a ground-plan of sepiostaire. It is simply a "block" of "pillars," with the upper floor removed very carefully, to enable us to see the true arrangement of the laminæ. A section of the kind, with an oblique slice taken off it, shows the sinuosity well.

As transparent objects, sections of sepiostaire are exceedingly beautiful when used with the polariscope. The section should be very thin, carefully

mounted, and, to my notion, is better without the use of a selenite. Everything depends upon the "setting" of the analyzer prism, which must bear

Fig. 169. Sepiostaire, Ground Plan.

a certain relation to the arrangement of the sepiostaire. This found by experiment, the polarizer may be rotated, and a wonderful play of colour will be the result.

Fig. 170. Sepiostaire, canaliculi of basal membrane.

Fig. 171. Sepiostaire, Horny Case of, × 100.

A little diluted acid will decalcify the lamina, but leaves only a little almost structureless membrane, having nothing particular noticeable about it, though certain evidence of striation in the vertical laminæ would lead one to expect variations of structure in the membrane itself, especially as the "pillars" are but partially calcified.

The horny outer layer, or "shell," differs from the "bone" proper, and is likened by Dr. Carpenter to the "hinge-tooth of Mya," from which, however, it has points of difference, which our cut (fig. 171) attempts to bring out as strongly as possible.

H. POCKLINGTON.

ZEUZERA ÆSCULI (Wood-Leopard).—This moth abounds in some gardens here, and has completely destroyed several fine ash-trees. I found the moths, male and female, on the trunks of the trees, in the afternoon, just out of the chrysalis; they are very sluggish, and come off on the edge of the net when touched with it.—*H. C. Leslie, Erith.*

Figure 5. *A paper on microscopical examination of sepiostaire, by Henry Pocklington, that appeared during 1870 in Hardwicke's Science-Gossip.*

Muddying these conclusions is the existence of another slide by the same maker, but with the name "*Dr. Herapath*" on the label (Figure 6). William Bird Herapath was a medical doctor and scientist. He is most famous for the discovery of "herapathite", a crystal of iodoquinine sulfate, which form the basis of Polaroid camera film. Herapath was a man of his age, and explored a broad range of the sciences. In 1864, he described a new type of synapta (sea cucumber) acquired from Guernsey, which he named *Synapta gallieni vel sarniensis* (i.e. *Synapta gallieni* or *S. sarniensis*, now known as *Leptosynapta galliennii*). The microscope slide shown in Figure 6 is a specimen from that animal. I feel it unlikely that Herapath made this slide, though. For one thing, no other known slide produced by this maker is labeled "*Herapath*" – if Herapath made all these slides, one would expect many of them to be similarly labeled. Second, the honorific "*Dr.*" would be excessive for someone labeling his own slides for his own collection, even if he felt the need to write his name on the slides. Third, Herapath primarily named the species "*gallieni*", after the man who collected the first specimens, so it is highly unlikely that Herapath would have labeled a slide as only "*Synapta sarniensis*". The strongest conclusion is that this slide was actually made by someone else, probably Henry Pocklington, who either attended or read about Herapath's lecture, then made his own slide of the synapta.

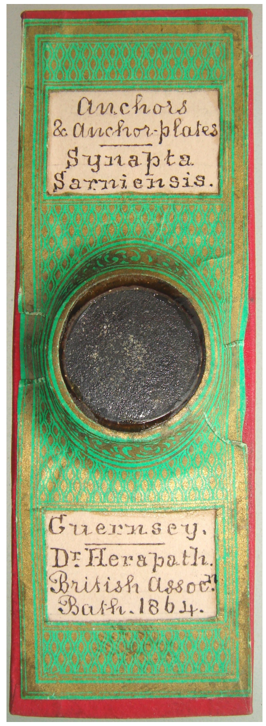


Figure 6. *Anchors of the sea cucumber Synapta sarniensis. William B. Herapath actually named the species "Synapta gallieni vel sarniensis" (i.e. Synapta gallieni or S. sarniensis).*

Henry Pocklington was born during late 1842, the first child of Christopher and Eliza Pocklington. At the time of the 1841 census (mid-summer of that year), Christopher was recorded as being a "*scrivener*", as was also his older brother Osbourn, while younger brother Henry was a "*grocer*". The three young men, all around 20 years of age (the 1841 census rounded off ages), lived with their widowed mother, a "*baker*", in Boston, Lincolnshire. Later that year, Christopher married Eliza Banks. The 1851 census recorded Christopher, Eliza, son Henry and three other children as living in Stilton, Huntingdonshire. Christopher's mother lived with them. She was recorded as being a "*grocer general dealer*", and Christopher was a "*shopman*". The family was doing moderately well financially, as they then employed an 18 year old girl as a live-in domestic servant.

Henry Pocklington initially planned to follow in his father's and grandmother's trade. The 1861 census recorded Henry as being a "*grocers assistant*", living with and working for Edward Cooper in Cookham, Berkshire. He later entered the insurance business. In early 1869, Henry married Emma Janette Lilly, the daughter of an insurance manager. They had five children, two boys and three girls, although one girl died in infancy. Their eldest child, Henry Cabourn Pocklington, became renowned as a mathematician, physicist and astronomer, and was a Fellow of the Royal Society. Henry C. Pocklington's 1953 obituary offered the following description of his father:

"*Henry was self taught; in his private life he interested himself in optics, astronomy, electricity, mathematics and chemistry. This was at the time when the desire for popular higher education was sweeping the country. Electrical instruments were one of his hobbies; he used to make his children stand on small insulating stools and hold the knob of some electrical apparatus, presumably of the Wimshurst type. Miss Ida Pocklington (one of Henry's daughters) recalled this vividly; she remembered how her hair used to stand on end and how her scalp used to tingle and feel uncomfortable for several days after such an experience. Once H.C.P. received a severe shock and was thrown across the room.*"

The first probable published record that I found by Henry Pocklington was a short note in *Hardwicke's Science-Gossip*, 1867, "*A Stick Without End - there may be seen in the churchyard at Shaftesbury, a somewhat remarkable freak of nature. In the language of the foreman at the gas-works, it is 'a stick without an end'. A branch of a goodly elm has grown into, and become part of another branch of the same tree, in such wise that it has become really 'a stick without an end'. - H. Pocklington".*

Exactly when Henry Pocklington became interested in microscopy is not yet known to me. He was writing authoritatively in *The English Mechanic and World of Science* by early 1870 (Volume 11 is the earliest to which I have access – if a reader can provide information from prior issues, it will be greatly appreciated). The tone of Pocklington's contributions, plus the apparent familiarity readers had with him, indicate that he was already a frequent contributor on microscopy. His writings in 1870 indicate that he had already been teaching classes in microscopy for several years.

Of particular note, the July 8, 1870 issue included a description of making microscope slides of cuttlebone or sepiostaire (see also Figures 4 and 5, above). Other contributions by Pocklington in that volume included a detailed description of the plant *Anacharis*, and notes on making slides of flower petals and butterfly wings, where in England to find abundant diatom and foraminifera specimens, microscopic investigation with polarised light, immersion lenses, Wenham's binocular, wood sections, plant physiology, mounting microscopical objects with glycerine, arranging a microscope slide cabinet, the music of the cricket, medical galvanism, and pre-Adamite man.

In general, Pocklington's writings were both authoritative and friendly, with frequent jokes and off-the-cuff remarks. This occasionally got him into trouble. In an 1870 article on how to use the microscope and what equipment was desirable, Pocklington remarked, "*beware of opticians, unless you have a long purse: make what you want when possible - that is nearly always*". The next week, he backpedaled, writing, "*As my caution to our readers appears to have been misunderstood by some of the makers, I may, perhaps, be allowed to say that nothing was further from my intention than to reflect upon that most painstaking section; I merely wished to advise our readers to make as much as possible and to buy as little as possible. It is only just to our opticians to say that they are always willing to help the amateur to save his pocket if he will trust himself to them*". That same year, he was also chastised by professional microscope slide maker John Barnett about a comment that appeared to rate Charles Topping's work above that of Barnett. A series of exchanges in *The English Mechanic and World of Science* went as follows:

"*(Sept. 23, 1870) Can any of your numerous microscopic readers give me any information respecting the cleaning and preparing diatomaceous earths? I have been trying for a long time, and with very ill success. I have this week been examining some of Topping and Barnett's preparations, and am disgusted with my own efforts, - the last named gentleman's slides being astonishingly beautiful. If any of your scientific readers can give me a hint as to the manipulation, I should be glad. - F.G.*

(Sept. 30, 1870) Perhaps Dr. Carpenter's recipe will answer 'F.G.'s' purpose. It is to first wash the earth several times in pure water, which should be well stirred and the sediment allowed to subside several hours before the water is poured off. The deposit is then to be treated in a flask or test-tube with hydrochloric acid (muriatic acid or spirits of salts), and after the first effervescence is over a gentle heat may be applied. As soon as the sediment has subsided the acid should be poured off and another portion added, and this should be repeated so long as any effect is produced. When hydrochloric acid ceases to act, strong nitric acid should be substituted; and after the first effervescence is over, a continuous heat of 200° Fahr. should be applied for some hours. When sufficient time for subsidence has elapsed, the supernatant acid must be poured off and a fresh portion added; the process being repeated so long as any effect is produced. The sediment is then to be carefully washed until all trace of acid is removed. This recipe will, of course, only apply to calcareous earths, organic deposits, as guanos and the like. For siliceous deposits Professor Baily's plan must be followed. This is to boil the deposit for a short time in as weak an alkaline solution as possible (carbonate of soda as well as anything). It must be borne in mind that this solution will act upon the frustule as well, though not as much as upon the cementing matter. 'F.G.' must not expect to attain to Mr. Topping's pitch of excellence 'all in a hurry'. - H.P.

(Oct 14, 1870) Mr. Barnett complains that I have ignored him in my reply to the query of 'F.G.' a fortnight since; need I say that I used, as probably 'F.G,' used, the two names, Mr. Topping's name in a generic sense, and that nothing was further from my intention than to exalt one professional preparer of objects at the expense of another. As is well known to all microscopists, there are several gentlemen of nearly equal merit, each of whom excels in some one department. Mr. Barnett's preparations being certainly not inferior to those of Messrs. Topping, Norman, or any other of half a score mounters, place him out of any need for puffing. - H.P."

Perhaps to further make amends with Barnett, Pocklington wrote in the November 4, 1870 edition: "*put a drop of the water containing the diatoms on a slip, and having allowed the water to evaporate, may either mount them in water or dry, as he may elect. He might do worse than arrange the diatoms nicely in a circle a la Mr. Barnett, and then mount them in balsam. But as he probably will find this rather difficult - I for one can't equal* *this maker's slides - he may be content if he succeeds in keeping the diatoms separated, and does not float them out with the wave of balsam*". The slide shown in Figure 7 may be an example of Pocklington's attempts to emulate Barnett.

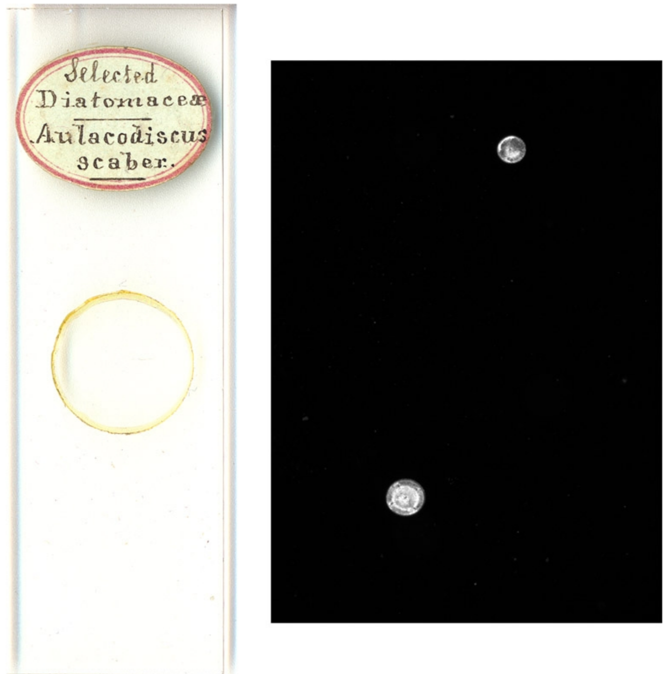


Figure 7. *A microscope of selected diatoms, containing 3 randomly-placed circular diatoms. Only two of the diatoms are shown in the photomicrograph, as the diatoms are so widely dispersed that they cannot all be seen simultaneously with a 4x objective lens. This obviously amateur slide may have been an attempt to copy the arranged diatom slides produced by professional preparers such as John Barnett.*

Pocklington also wrote, in December 1870, that "*a pinch of most of the washing-powders used in the kitchen or laundry department of our domiciles, dissolved in hot water and allowed to re-crystallize in a thin stratum on a slip, and then mounted in balsam forms a splendid object, preferred by many to even the gorgeous salicines of Mr. Barnett. An immense number of delicately beautiful feathery stars are seen on a dark ground when the object is viewed without a selenite*". It is not known whether Barnett took that as a compliment or an attempt to deprive him of business.

In 1871, the Pocklingtons lived in Sulcoates, Yorkshire. Henry was then an inspector of his insurance company's agents. From the mid-1870s through the end of his Henry's life, the Pocklingtons lived at several addresses in the general area of Leeds, Yorkshire.

In 1872, Pocklington wrote the above-described article on how to examine plant leaves under the microscope, which included a description of "*Malvastrum mimroanum*" (Figure 4).

Also in 1872, Pocklington wrote a series of article for the *Pharmaceutical Journal*, on "*the microscope in pharmacy*". He contended that a pharmacist should be able to examine his wares for purity under the microscope. He also advocated for pharmacist education to include microscopic examination of beneficial plants and other objects. His papers specifically described examination of beeswax for adulterants and identification of samples of "*Conii Fructus*" (hemlock fruit) contaminated with a poisonous plant. In 1873, Pocklington lectured on "*sugar and its adulterations*". His son's obituary commented on Henry Pocklington's skill and enthusiasm for ensuring product purity, "*Henry became quite an expert at analyzing substances to be tested for adulteration; it seems that samples of sugar had frequently to be investigated. Chemical and optical methods (involving the use of a polarimeter) were used. He became so expert that his friends among the city analysts often used to ask him to visit their laboratories and check their work*."

I located only one published offer from Henry Pocklington to exchange microscopical objects with other enthusiasts, in an 1873 issue of *Hardwicke's Science-Gossip*, "*Aecidium are offered in exchange for equally rare fungi, good botanical or polariscope objects. - Henry Pocklington, 12, Margaret Street, Hull*".

In January, 1875, Henry Pocklington was elected to be a Fellow of the Royal Microscopical Society. In

September, 1877, Pocklington was voted into the Quekett Microscopical Club. He was also a member of the Leeds Naturalists' Club and Scientific Association from 1874 onward, serving as president in 1878. He joined the Leeds Geological Association in 1874. In 1881, he was elected to the British Association for the Advancement of Science, and in 1898, joined the Royal Society of Arts.

The *Leading Insurance Men of the British Empire* (1892) wrote, "*Pocklington, Henry, the Leeds Manager of the Commercial Union Assurance Company, entered upon his career of a District Manager in the year 1869, in the service of the Britannia Fire Association, whom he represented first at Exeter and Hull, and subsequently at Leeds, having supervision of the counties of Yorkshire, Durham, Northumberland, and Lincolnshire. He at the same time acted for other offices, in the capacity of Surveyor and Assessor of Losses. He entered upon his present duties as District Manager for the Commercial Union Assurance Company in January of 1878, when that Company opened their Yorkshire Branch, and being in want of a good Insurance man to supervise its business, were fortunate enough to obtain Mr. Pocklington's services. Mr. Pocklington was at one time a frequent contributor to the scientific press. He is very strongly in favour of the thorough practical education in their business of young Insurance men, and devotes much of his spare time to the furtherance of this object. He is a Fellow of the Royal Microscopical Society of many years' standing, a Member of the Yorkshire Geological and Polytechnical Society, of the Society of Chemical Industries, and of several other scientific and literary societies*".

For the year 1907, Henry served as President of the Insurance Institute of Yorkshire. The 1908 *Proceedings* of the institute included a copy of the President's year-end address, and a picture of Henry Pocklington, which is reproduced below as Figure 8. Pocklington was presented a gold watch on December 31, 1907 for his 30 years' service as Leeds District Manager of the Commercial Union Assurance Company.

Henry's wife, Emma Janette, died in 1908, at the age of 65. In 1913, the *Journal of the Royal Society of Arts* reported, "*Mr. Henry Pocklington, who died at Leeds on the 13th inst., was for thirty years local manager of the Commercial Union Insurance Company. He joined the Royal Society of Arts in 1898, and he was also a member of the Society of Chemical Industry, the Royal Microscopical Societies, and various other scientific bodies. At one time he conducted some researches for the Royal Pharmaceutical Society into the adulteration of food and its detection by microscopical methods. He was a keen photographer, and devoted much attention to microphotographs. Deeply interested in education, he took a prominent part in forming the Mechanics' Institutes of the North of England, and many of the popular science classes in Leeds, Hull and Bradford owe their origin to him*". He was then 70 years old.

During 1870, Pocklington wrote a series of article on "*the microscope – how to chose it and how to use it*", for *The English Mechanic and World of Science*. Excerpts are reprinted below, both as an example of Pocklington's proficiency with the microscope and for general interest of the historical microscopist:

"*As the optical principles of the microscope are essentially the same as those of the telescope, and have been so frequently treated upon in the pages of this journal, it would be unwise to occupy further space than by saying that a microscope is simply a means by which the eye of the observer is removed further from the object observed, whilst the telescope carries the eye nearer to the object in its field of view. The microscope may be either 'simple' or 'compound'. The former class is commonly represented by the single lens of the botanist, but a simple microscope may consist of a combination of several lenses, arranged so as to act as a single one. Of the latter class are 'doublets' and 'triplets'. The compound microscope necessarily consists of at least two lenses, one of which is called the eye-glass, the other the object-glass, the two or more lenses being usually connected by a tube of metal. By the use of the compound microscope we obtain a much greater amplification than is possible with a simple lens, inasmuch as the eye receives a magnification of the image formed by the object-glass, and not the image itself. A microscope of this land may be very easily made by any one possessing the least mechanical ingenuity, but when made will be useless. Every object viewed by its aid will be seen to be surrounded by a 'beautiful' coloured fringe, and to be terribly distorted. These several defects, known as chromatic and spherical aberrations, were for a long time insuperable obstacles in the way of microscopic progress; but, thanks to ceaseless effort on the part of the fathers of our science, we may now say that our instrument is about as perfect as can be desired; and that the tale it tells is in the main true and faithful. It is the compound achromatic microscope of which we intend to speak in these papers. To this achromatic microscope there are two essential parts - the mechanical and the optical - i.e., the stand and the* *lenses.*

We now come naturally enough to the enquiry - What constitutes a good microscope? Certain things must be essential. What are they? 1st, as regards the stand. This must be solid, heavy, so that it may be free from vibration, and well balanced. It must be capable of being placed in either a vertical, an inclined, or a horizontal position, and of remaining there without being clamped. The stage should be sufficiently large to admit either edge of a glass slide, 2" in diameter, to be brought under the object-glass. The aperture in the stage should not be less than 1 1/2" or 2" in diameter, and the stage should be thin to allow the oblique pencil to be thrown by the mirror upon any object on the stage. The stage may be either simple or mechanical. If the former be chosen, either the 'magnetic stage', the 'lever stage', or the 'concentric rotating' stage will be found useful. The plan adopted by Messrs. Beck is useful and exceedingly simple, but with high powers is slightly tantalizing, as the focus is disturbed by every movement of the stage, which is merely a thin plate of metal held down by a double spring, the pressure of which may be regulated by a screw (in practice it is advisable to screw this down tightly, as otherwise it has an awkward knack of flying in one's face, to the serious detriment of one's nerve, and possibly of the object), and this plate is doubled under the stage on one side, so as to be grasped by the thumb and forefinger of the right hand. This stage is extremely useful to the working microscopist, and after some years of use we are disposed to speak very highly of it. There is nothing to get out of order, and practised fingers will perform all needful movements quite as delicately as would be possible with the most elaborate 'mechanical' stage. Below the stage should be fixed a diaphragm, which should be furnished with a series of holes, in order that a variety of apertures may be available, and the whole arrangement should be capable of being easily turned aside. Mr. Collins's 'graduated diaphragm' is perhaps the best possible. The mirror should be full sized and double (concave on one side, plane on the other), and should be capable of movement in all directions, as well as of adjustment nearer to or further from the stage. It is convenient if the mirror be carried by a jointed arm, as a more oblique illumination may be thus obtained.

Every microscope should have a coarse and fine adjustment. The former may be obtained by a rack-and-pinion movement, by a chain and pulleys, or by a watch-spring band. The chain movement is peculiarly smooth and easy, and in practised hands entirely obviates the necessity for a fine movement. This latter is usually obtained by the action of a finely cut screw on a lever. The screw may be graduated so that the distance through which the object-glass passes may be measured and the thickness of an object approximately obtained. The milled heads of all these adjustments should be so placed as to be conveniently accessible, and they must work smoothly or they are utterly worthless.

A student's microscope is usually furnished with two eyepieces, called A and B, being, as nearly as possible, in the following ratios, 1, 2 ; and with two object-glasses - or, to use henceforward the correct technical term - objectives of 1" and 1/2" focus respectively (i.e. these lenses have the same magnifying power as simple lenses of those foci). The range of these powers is about as follows: 55, 90, 210, 350 diameters. These should be accurately centered and be perfectly corrected. Means of estimating the quality of these lenses shall be given later. A stage condenser and a stand, or bull's-eye condenser, for opaque illumination, will complete the instrument.

The next question that arises is, where shall we go for our instrument? Mr. E. Ray Lankester has lately written in praise of foreign instruments; but we do not see what there is to be gained by going abroad for that which may be obtained better at home. English makers will beat the world for quality, and now - thanks to the Society of Arts and some of our more enterprising manufacturers, - a really good English instrument may be obtained at about the same price as the continental ones. There is hardly any comparison between the convenience of the two classes of instruments. These remarks apply only to the stands.

In lenses, the Germans surpass us by far, Price being taken into account, although within the last year our English makers have contrived to turn out very decent lenses at less than half the prices formerly charged. We need only instance Crouch's or Swift's 1/2" and Mr. Wheeler's 1/4". We will, therefore, look at home for our stand. Where all are equally good it is a difficult (not to say an invidious) task to instance the best. Those who wish a better-finished class of workmanship may either select their higher priced stands, or look over the catalogues of half a hundred makers and make their choice. The better plan is to select a good stand, capable of being increased as funds are available, and to add objectives and accessories from time to time. Such a stand will cost about £10 or £15 with two eyepieces. The price of objectives will vary with different makers. A fair English inch may be purchased for £2 10s., and a good quarter for about £3. German lenses (Grundlach, of Berlin) of these foci will not cost more than 17s. 6d. and 21s. respectively, and are about equal in quality. Of course the first-class lenses of our best makers are unequalled by those of any continental maker; but Messrs.

Beck's first-class 1/4" costs £5 5s. - a sum as large as many can afford to spend on the whole affair. To such we commend the German lenses.

It will have been seen in what we have said that the essentials of a stand are steadiness in all positions of the body, ample stage room, and proper adaptation for the reception of extra apparatus. The appearance of an instrument is of secondary importance. To test the steadiness of the instrument use the 1/4" power, focus carefully, and get some one to walk sharply round the room whilst you observe an object. If there be excessive tremor, reject the instrument at once. Next, try the adjustments, and see that they work smoothly and without 'loss of time' - i.e., that they 'answer"' promptly to the slightest movement of the milled heads in either direction. Use the 1" and 1/4" objectives, and also a 3", and see that a small object remains truly in the centre of the field of each power, and that there is no 'twist' or sideway movement on altering the focus. So far for the mechanical portion of the instrument. We will add that a short-bodied microscope having a draw-tube for elongation when increased power is desired, is much to be recommended, on the ground that it is far easier to work with. The corrections of the lenses must be carefully tested, and unless the tyro go to a good and well-reputed maker, we would advise him to get some experienced friend to select his lenses for him. The lenses of even the best makers vary considerably, so that it is possible for an experienced man to select a far better lens than might fall to his lot. The power of 1" should not be less than 30 diameters with the A eyepiece. It should give a large, clear field, free from colour, and with a clean, sharp, circular margin. For chromatic aberration the severest test is said to be a radial section of fir. The glandular markings in this should be well shown, and be free from colour with the C eyepiece. For flatness of field the section of an Echinus spine is useful. For definition the pollen of mallow. For 1/4" a good test for definition is the scale of the Podura or the frustules of Pleurosigma hippocampus. The markings on either of these should be clearly resolved. Dr. Carpenter specially recommends Mr. Lealand's preparations of muscular fibre as giving a fair test for lenses of from 4-10th" to 1-5th" focus. Every objective should be tested with a series of eyepieces, as a glass will often perform well with a shallow eyepiece, when a deeper one will render manifest the most atrocious defects.

Having selected our instrument, we will proceed to use it. Before us lie slides of Echinus, of Foraminifera (mounted as opaques), of Diatoms, and the eye of a fly. Having taken our instrument out of its case and put it in order (the maker of each instrument will put the purchaser in the way of doing this), we will select a table having a good light. If in the daytime, we will avoid direct sunlight as having too much glare, and select a position in which we can receive light from a white cloud. The microscope should be placed in an inclined position, and the mirror adjusted so as to throw, an equable light upon the slide, neither too intense, or too much the reverse. Careful use of the diaphragm apertures and focussing of the mirror will give us any variety. We now take our slide of Echinus, and having an inch objective on, place the slide on the stage and in the field. We run down the rack motion until the objective is brought within 1/4" of the slide, and then, with our eye to the eyepiece, focus back until we obtain a clear definition. Having turned aside the diaphragm, we proceed to tilt the minor into different positions, in order to get various degrees of obliquity of the illuminating pencil. We will substitute a slide of Foraminifera for the Echinus spine, and proceed to examine it as an opaque. Having closed the aperture of the diaphragm, we throw a good light on the object by means of the bull's eye, varying its angle of obliquity until we gain the best effect. The working of the 1/4" is essentially the same, but unless we have the aid of accessories, 'transparent' objects alone can be used with it, and greater care must be paid to the focussing, &c, of the mirror. We cannot urge too strongly upon our readers the importance of paying special attention to this vital, but, to the beginner, seemingly unimportant, matter of illumination, as truthful interpretation almost entirely depends upon it. The best possible light for microscoping is daylight from a white cloud, but as most of our readers (the author amongst the number) are compelled to work almost solely by night, it is encouraging to know that good results may be obtained from the use of a candle, even if it be protected by a glass shade, and it be not more than 10in. or 15in. from the instrument. The author has used for some years a small paraffine lamp, costing at the outset about eighteen pence, and has found it to answer every purpose, and to be most convenient, inasmuch as it permits a vast variety of dodges in illumination to be tried with little trouble. And here let us whisper to the readers of the Mechanic, 'beware of opticians, unless you have a long purse: make what you want when possible - that is nearly always'.

We have now, we think, gone through our A B C. We have seen what our tool is - what are its essentials, and how to put it through its A B C. But that is not learning how to use the microscope. We have but learned to make a plaything of it, or at best to look at bought slides. Again, we have but learned the use of a very simple and unadorned compound microscope. We will, accordingly, if our readers be not a-weary, glance at the use of a few accessories, and then try to learn how to use the microscope whether in its simplest or most complete form.

We do not propose any rigid order of sequence in our further notes upon the microscope, but we will endeavour to take the several pieces of apparatus as they appear to stand in the order of desirability. To this end we will allow ourselves considerable latitude in our interpretation of the word accessory, and include therein all apparatus not supplied with an ordinary student's microscope. And the question we will set ourselves to answer shall be, What extra apparatus, and in what order, would you recommend to a student ? I think we may place the polariscope in the first place, partly because whether we do or no the student is tolerably sure to do so, and partly because in proper hands it is an invaluable instrument of research. In the form most commonly applied to the microscope the polariscope consists of two parts - the polarizer and the analyzer. These are precisely similar in construction and may (provided their fittings admit) be interchanged at pleasure. The polarizer and also the analyzer may consist of a rhomb of Iceland spar, or a thin plate of tourmaline or of herepathite (sometimes called artificial tourmaline). On account of its cheapness and freedom from colour, as well as its greater freedom from danger of accidental damage, the Iceland spar is generally used, and in the form known as Nicol's prism. Instead of the spar as a polarizer thin plates of glass may be used, but as they do not permit of rotation readily their disadvantages are great. The polarizer fits into the stage from beneath, and it is well if a bayonet catch or some simple appliance be arranged to hold it firmly in position. The prisms are fitted into a collar, which rotates easily by a milled head, unless the stage be an elaborate mechanical affair, when special arrangements are made to receive the prisms. The analyzer may be fitted either immediately above the objective, in which position there is some loss of definition, or above the eye-piece, in which case there is a considerable loss of field. In general work the former position is the best. In any case the prisms should be made capable of rotation with exact centering. If it be desired to carry the analyzer above the eye-piece either tourmaline or herepathite should in all cases be preferred to Iceland spar. The price of a good polariscope and fittings adapted for a student's microscope varies from 30s. upwards. A selenite of some kind is almost a necessary accompaniment of a polariscope. Sometimes a thin film (to give red, yellow, or blue, according to fancy) is fixed in a collar and made to rotate with the polarizer. But this is a barbarous arrangement. In all cases the film of selenite should be mounted on a glass or in a brass slide, and some means adopted by which it may be removed from the field at pleasure without disturbing the object. It is also convenient to have three films giving different colours set in the same frame, their axes of polarization being in the same plane, that a series may be tried without trouble. A very efficient selenite stage has been described in a recent number of this journal, the price, however, is past a joke to most.

Having obtained the polariscope, the student, if he be a worker and use his 1/4" much, will find that he needs a steady and pure light such as is thrown upon the field by what is known as the achromatic condenser. This is optically little other than an objective of 1/2" or 1/4" focus made capable of approximation to the lower surface of the slide under view. It is a somewhat expensive piece of apparatus, costing from 30s. upwards. Mr. Brooke recommends a Kellner eye-piece in the place of the usual short focus objective. In any case the student may remember that he can always use his 1/2" objective as a condenser for his 1/4", and so on. In this case he need only purchase fittings which need not be very costly. Mr. Collins has, within the last few years, introduced a new condenser, which he calls the Webster. From what we hear of it it seems a most efficient affair, especially in connection with his adjusting diaphragm.

Our student will now probably seek to increase his ‘power’. He can do this by the addition of a draw-tube to his instrument at the cost of a few shillings, but unless his lenses are very good this plan is not to be recommended. The drawtube in connection with an erector (for rectifying the inversion produced in the apparent position and movement of objects when they are viewed through a compound mirror) is, however, most useful, as it enables the observer to got a range of from four linear to 100 linear with an 8-10ths objective. Or he may add a C, D, E, and F eyepiece to his instrument, gaining in power approximately 1, 2, 4, &c. But the better plan is to got a C and then to add to his objectives first a 1/2", l-12th, l-20th, or l-25th to l-50th, as he is able. But he will probably stop at l-12th, and seek other accessories.

The first thing will most likely he a mechanical stage, - that is, a stage capable of movement in all directions by means of milled heads. Their forms are legion, every maker appearing to have his special type. Let our student see that whatever form he purchases possesses the power of concentric rotation and that the amount of movement can be read off accurately by a scale. He will now want a Maltwood's finder, a very simple and inexpensive arrangement for enabling a person to register the position of any object in the field. It consists merely of a slip of glass whereon is photographed a series of numbers in squares. A little ‘stop’ is placed at one end of the stage against which the end of the slide is placed, when any object of special interest is found the slide containing the object has to be removed and the ‘finder’ placed in its stead and the numbers in the field read off and registered. It is obvious that the reverse process is simply to work the stage until the finder *now comes into the field, remove the finder and place the object slide on the stage when the desired object will be found in the field. The price of a Maltwood varies from 5s. upwards. Substitutes have been proposed for the Maltwood, but the latter is so simple and inexpensive that we need not trouble to examine these.*

Every observer ought to draw and measure his objects, but as this subject will come before us in another paper we will simply mention the names of the apparatus commonly used for these purposes. For measuring, either the stage micrometer or the eye-piece micrometer is used. For drawing, a camera lucida (a prism properly set), a neutral tint reflector, known as Beale's neutral tint, or a small disc of steel.

We have omitted to mention the spot lens a simple and inexpensive, but very efficient means for procuring what is known as the dark ground illumination. This apparatus consists merely of a lens of moderate focus with a spot of black paper on its centre to stop out all rays except those which pass through the periphery and converge at so oblique an angle upon the object that were it not for its refraction they would not enter the object-glass at all. Certain objects, such as diatoms, are seen by this mode of illumination brilliantly illuminated on a black ground. Mr. Wenham has introduced what is known as Wenham's parabaloid reflector.

The celebrated diatom prism which has recently caused such a sensation does not require any explanation beyond this, that it is a right angled prism fitted either to the stage or on a stand, and that its great advantages are that it enables us to obtain a beam of parallel rays of such intensity and in such direction as we require. The goniometer for measuring the angles of crystals we need not describe, as a well-constructed mechanical stage will serve most of its purposes. Neither will we do more than mention Amici's prism for obtaining oblique light; and several other accessories but seldom used must be entirely passed over.

For 'opaque' illumination we may use either the parabolic illuminator known as Crouch's but made also by several makers, or the side reflector, or with very high powers Messrs. Becks' patent illuminator, whereby the objective is made its own illuminator by a most ingenious contrivance. The cost of all these is comparatively trifling. It strikes us very forcibly that we have spoken of nearly all accessories appertaining to the microscope proper. In our next we will hurry through such things as processes and mounting materials. If any reader wishes further information respecting any apparatus mentioned in this paper, perhaps the editor will allow him to ask any question he chooses.

P.S. In my last article I appear by some oversight to have said that a fair English 1" objective could be purchased for 50s.; I should have said 30s. I am pleased to learn that a London maker is selling a tolerably fair 1" for the astonishingly low price of 12s. As my caution to our readers appears to have been misunderstood by some of the makers, I may, perhaps, be allowed to say that nothing was further from my intention than to reflect upon that most painstaking section; I merely wished to advise our readers to make as much as possible and to buy as little as possible. It is only just to our opticians to say that they are always willing to help the amateur to save his pocket if he will trust himself to them.

We have not spoken of binocular microscopes as yet. Chiefly because the price of a good one would prevent many of our readers from purchasing, and also because those who wish for information respecting them can easily obtain it from the price list of our makers. We will therefore content ourselves with expressing our satisfaction that a good binocular with two powers may now be purchased for £10, and with mentioning that such an instrument (provided it can readily be used as a monocular) has many great advantages and should where possible be purchased. If any reader require special information respecting this instrument we shall be happy to afford it through the usual medium.

We may divide the minor accessories of the microscope into two sections. Those used in preparing objects for observation, and those required by the mounter. Commonly the preliminary preparation of the object has to be done, if it be minute, under a magnifying power; several forms of microscopes, called dissecting microscopes, are sold for this purpose, amongst which Collins', Lawson's, Baker's, and Quekett's, are the best. The author, however, has always contented himself with a simple pocket lens, costing eighteen pence, which he fixes on a small stand, and finds to answer every purpose as well as, or nearly so, the most expensive instrument. For the dissection of animals and insects the student will need a glass dish, a small piece of leaded cork and a few pins; a number of needles fixed into camel's-hair pencil-holders, some of these needles being bent at different angles and being of various degrees of fineness. These are most useful in dissecting or teasing out small details of structure, and no histologic can dispense with them. Besides needles a fine pair of scissors and a couple of, or three, scalpels made specially for this work, and to be purchased of any instrument maker. These are all that will be required at the outset in the way of cutlery. A few fine glass tubes of a few inches in length, ground smooth at the end, will also be of use, especially to the animalcule student. The use of these, called *dipping tubes, is simple. The worker places his finger upon the upper end and lowers his tube until it comes into close proximity to the object; removing his finger the water rushes into the tube, carrying with it the object, and the finger being replaced the whole can safely be removed. It is convenient to have some of these dipping tubes curved to enable them to go into corners and out-of-the-way places. They are also useful in dissecting, to enable a current of water to be directed against any tissue to wash away any impediments.*

'You have omitted the live box,' says one. The author has two or three, which he uses once in three years, and would gladly sell for what they cost him, were they not old friends. A little ingenuity will save our friend this expenditure.

Forceps will be required. Those for picking up may be made by cutting out a piece of sheet brass or tinned iron. A former class of ours made a complete set out of waste tin; some specimens produced at the next 'lesson' were really very creditable productions. Those for dissecting must be purchased unless the plan we once adopted be followed; that of fixing needles to a very ordinary pair. But the 'real things' are cheap enough to save trouble in manufacturing make-shifts. Pieces of apparatus, such as compressorium, we must pass over for want of space. Others will turn up as we proceed.

Glass slips.- These must be clear and free from air bubbles. They should be of the orthodox size, 3in. x lin., or their user will be precluded from exchanging with his neighbour, and be likely to be snubbed if he shows his cabinet to a less heretical friend. Their edges may be either rough or smoothed. The latter save the troubling of papering the slides, and to our notion more business like. But this is a matter of taste. Only if the immersion lens be used good-bye to the pristine beauty of the grandly papered slide.

Thin covers. These must be of glass. They may be square or round. The latter being used for unpapered slides. For papered slides it is somewhat immaterial which are used - of the two the square are preferable.

The covers must be fastened to the slides. For this purpose cements and varnishes are used in cases where the 'medium' used is not itself adhesive. Marine (glue, gold size, or India-rubber varnish may be used for this purpose. Objects of any but the most extreme tenuity require something to protect them from pressure by the cover. This is afforded by what is known as a cell. The cell, if the object be thin, may be formed of the cement itself. A little instrument, called after its inventor 'Shadbolt's turn-table', is generally sold for the purpose. This instrument consists of a small slab of mahogany, at one end of it is fixed a pivot whereon a circular plate of brass about 4in. in diameter is made to revolve. The glass slide is laid on this table so that its two edges may be equidistant from the centre, and is held there by two springs. A brush dipped in, say varnish, is held in the hand with its point just touching the slide at say 1/4in. from the centre, and the plate being revolved a true circle of 1/2in. diameter is described. A pupil of the author's made an excellent Shadbolt out of an old canister. Verbum sap. Thicker cells may be punched out of card or leather for dry objects, or out of metal or vulcanite for fluids or balsam. Thicker cells may be made out of glass tubes or built up out of glass slabs. But an English Mechanic need not be instructed herein.

The student may now provide himself with a bottle or two of cement, glass slips and covers (papers, too, if he like), a bottle of Canada balsam, of glycerine (Price's), of turpentine, chloroform, and benzole. Having provided himself with these he may, if he will, accompany the author through a week's mounting campaign, and then through a week's work at vegetable histology, with a touch at that of animals, and, finally, wind up with a day in the country. Whether this be all accomplished time will prove.

We cannot perhaps do better than confine ourselves as well as possible to the actual work of a busy week, such a one as we have had when 'holiday keeping', for instance; but, for convenience, we will allot different days for special work:

Monday. We have to-day before us a collection of wild flowers, of seeds, fronds of ferns, and butterfly wings, all of which we will mount dry; some as opaques, others as transparents.

The flower of the mallow (Malva moschata), or cheeses lies before us. Taking it up we seize one of the green sepals, and placing it on the stage of our microscope, find it to be furnished with stellate hairs which we wish to keep. The leaf is sufficiently thick to require a cell. This we make out of a piece of card and gum to the slide. In the centre we fix our sepal, gumming it down at each end, to ensure its fixity. When the gum is perfectly dry we place our square, which is of course perfectly clean, accurately on the cell. and secure it there by a narrow strip of gummed paper. This done, we proceed to paper the slide, and to neatly label it top and bottom.

If we wish to have unpapered slides we use one of Pumphrey's 'vulcanites' or Collins's 'tins', and neatly finish off with black varnish, by means of our Shadbolt. At the bottom of the cell we place a piece of 'dead' black *paper, in order that the object may stand boldly out when it is to be viewed solely as an 'opaque'. Some, however, and they not the least wise, mount all objects in 'transparent' fashion, because, say they, the diaphragm plate will always give a black ground. On the other hand, the use if the black paper gives a slide a finish, and also, we think, gives a much better background than as possible by any 'well stop'. From the centre of the flower of our mallow we remove the anther and its pollen, and having dried it by gentle pressure between bibulous but smooth paper, mount it in a cell in two fashions—one, on a dark ground for opaque, the other as transparent. When nicely mounted this object is very beautiful, the little pollen grains with their tiny spines looking like jewels on the exquisitely coloured anthers. The wing of the butterfly we mount in like fashion. From the little blue Polyomnatus Alert we remove some battledore scales, which we mount in a shallow cement cell made by aid of our Shadbolt. Care must be taken that the cell becomes nearly dry before we put on the cover, or we shall have the varnish run in. The author well remembers how in his young days he was annoyed by the mischievous freaks in his gold size, and to this day he regards that cement with considerable aversion, and generally uses 'Photographic black varnish' in preference. Asphalt varnish will answer excellently well for these shallow cells, and is indeed commonly used. If 'rounds' and 'ground edges' be used the slide must be carefully finished off with a ring of varnish round the cover, and every slide should be ticketed the moment it is covered in, whether it be papered or no. For want of this simple precaution a valuable slide will often be rendered valueless, or at best, valuable time be wasted in guessing at the name of an object. From the seed-vessels of the chickweed (Stellaria media), catchfly (Silene nutaiu, S. maritima, S. pendula, See.), toadflax (Linaria cymbellaria), &c., &c., we secure most beautiful seeds for low powers. These we mount in shallow cells as opaques. Others, as the Eccremocarpus, bee-orchis, Paulownia, being furnished with wings often of great beauty and delicacy, we mount as transparents. The cell should be just deep enough to allow of slight movement, and round cells had better be used. The fronds of the commonest ferns may be easily scoured, and we mount them in shallow cells. In some cases (chiefly exotic) the frond of the fern is furnished with scales, which we may remove and mount dry (in balsam commonly, but not to-day). Chief of these we may mention Ctenach officinalis, Goniophlobium, and Lepicytis. Nearly all plants are furnished with hairy leaves, which may be easily mounted dry in either card cells or 'rounds'. Easily obtained are evergreen oak (Quercus ilex), common lavender, nettle, thistle, and in some localities the sea-buckthorn. Less easily obtainable are Deutzia scabra, Alyssum spinosa, Durio, Tillandsia, and Rhododendron Nuttali, with a host of others of almost equal beauty. Perhaps enough has been said to enable our readers to secure a number of 'dry' objects, and to mount them successfully.*

Tuesday and Wednesday. We may spend at least two days in learning to mount in balsam.

'Plague take it', said an impetuous acquaintance of ours once upon a time, 'I shall never learn to mount in balsam, these precious (we don't think he meant that) air-bubbles will 'come for ever,' and don't 'go'." But our friend has learnt to mount, and at that very successfully, and so may all our readers – with practice. Some folks when they begin mounting in balsam get a lot of things – hot-water bath, spirit lamp, and mounting table, and enough things to frighten a weak-minded slide. Very good things all of them, but we wonder whether an old hand uses any of them. We seldom do now, whatever we might do 'years gone by'. A piece of brass of fair thickness furnished with four legs is handy, but we like it better without the legs, so that we can stick it on blocks of wood or place it on the rings of a retort-stand at any height above the lamp we choose. But we are anticipating; we have not got our slide ready for the plate yet. Our Canada balsam should not be too thick - should be in a glass stoppered bottle, furnished with a glass rod, by which we can remove a small quantity of the balsam as we require it and keep the store free from dirt. Many like to keep their balsam in a small syringe, from which they can expel a small quantity as they choose. This plan has many advantages. We may also have a supply of diluted balsam (an ethereal solution or a solution in chloroform) for use with such objects as sections of Sepiostaire. We shall require also a few American clothes-clips at a few pence per dozen, a bottle of turpentine in which to soak certain objects, of liquor potasso: and of benzole. Let us to work.

One or two correspondents have kindly given information relative to the mounting of insects, and by the kindness of one of those gentlemen the author has been able to see specimens of insects put up by their mode of treatment, and has been gratified by the highly successful results. But we must caution our readers against soaking the insect too long in strong potash, which is apt to result in producing a very transparent but very uninsect-like specimen. The preparer should always bear in mind that he does not want to make Nature's works, but to persuade Nature to show him how she has made them, and that mode of preparation is best, therefore, which least destroys the natural appearance of an object. The microscopist must place truth in the first place - to his consolation, 'art' always accompanies it. In mounting insects it is generally desirable to use balsam which has been thinned with chloroform or turpentine, as by this means air-bubbles are more readily *got rid of. Certain parts of various insects, such as some antenna), require bleaching. For this purpose nothing is better than the following: Hydrochloric acid, 10 drops; chlorate of potash, 1/2 drachm; distilled water, 1 oz. The antennae may be soaked in this for a day or two, washed well, dried, and then mounted. From the shallot, or the Portugal onion, we remove the thin outer rind, carefully dry it, cut a small and perfectly square piece from it, and soak it in turpentine for a few hours. Having lighted the spirit-lamp and warmed our 'table' whereon to the slide and cover, we place the piece of 'rind' in the centre of the slide and put on it a small drop of balsam, and carefully lower the cover on to it and press it down as closely as possible. If nicely done no air-bubbles will be included; but if there be a few they will most likely escape if the slide be allowed to remain warm for a few hours. When finished we had better allow the slide to remain in a warm room for some days, in order that the balsam may become thoroughly set prior to our cleaning off the slide. The rind of onions, we may remark, contains very fine crystals, called raphides (from rapltis, a needle). Sections of wood, of rocks, of shells, hairs of animals and plants, insects and parts of insects, may all be mounted in balsam, which, though the most troublesome, is perhaps, taking it altogether, the most valuable 'medium'.*

The 'tongue' of the butterfly may well occupy us for a short time. It is of great length in most butterflies, and is always, when nicely mounted, of great beauty and interest. The only thing we will notice about it are a double row of little barrel-shaped bodies which run along the outer surface for some distance from the extremity of the proboscis (haustellium). Sir Newport supposes these to be organs of taste. Along the interior of the proboscis may be seen two tracheal tubes, probably connected with the suctorial apparatus, for there seems no doubt that the 'sipping' of man and the 'pumping' of the moth or butterfly are analogous operations.

The eyes of insects generally are most interesting. Mounted nicely as an 'opaque', the complete head of such insects as the crane fly (daddy longlegs) is very good, but if we wish to understand the theory of vision amongst these creatures we must make up our minds to a close examination and dissection of the organ itself. We may choose either the house-fly or honey-bee, since either are close at hand. We will choose the latter. On a superficial examination we notice that the eyeball is divided into a vast number of hexagonal figures (in the house-fly, 4,000 in number, in the dragon-fly, 24,000. Each of these is the front lens of an eye, and is called the corneule. We may, on the face of it, liken these to the facets of a multiplying glass. But then the question arises, does the fly see 4,000 lumps of sugar, the dragon-fly 24,000 aphides? If so, what an endless state of fog the creature must be in. This question has greatly exercised the minds of some, and they have gravely proposed that the so-called eye is a sense of feeling, and that is the fine hair, which as an eye-lash often bounds the corneule, that acts as the whisker of a cat, and gives notice of approach to any object. A little patience will, I hope, enable my readers to see the fallacy of this theory, and also to understand how a fly or a bee may, with its thousand of eyes, be essentially in the position of the vertebrate with its two eyes. Those who have tried to catch flies or butterflies know well that it is no easy matter to get within reach of them if you let them 'see' you coming, and we don't think it likely that any one with practical experience of this kind will doubt for an instant that these insects have uncommonly good organs of vision. But we have stronger ground still. We may take an 'eye' with its facets, and having properly mounted it place it under a good power. Using our achromatic condenser we throw on the under surface of the slide an image, say of the tassel of the window blind. Looking at the eye through the microscope we see to our delight a multiplication of tassels, each corneule. giving us a perfect but a miniature image, acting, in short, in conjunction with the microscope, as a perfect eye. Now from this we can get the solution of the mystery. The microscope tube and eye lens act as the ocellus of the corneules. We have only provided one ocellus for the 2,000 corneules, but it is easy to see that if we provide a tube for each, that in looking down any one of these we shall see but one image. Lot us cut up the eye of the bee and we shall discover that this is what Nature has done.

Behind each corneule is a layer of dark pigment which takes the place and serves the purpose of the 'iris' in the eyes of vertebrated animals, and this is perforated by a central aperture, or pupil, through which the rays of light that have traversed the corneule gain access to the interior of the eye. Each ocellus is pyramidal, and each corneule a double convex lens. But we need not go further into the minute anatomy of the eye. We have said enough to show that the eyeball is composed of a great number of pyramidal eye-tubes with their points converging to the optic nerve. A number of rays of light, proceeding from, say, a pin's point fall upon the corneules of these. A moment's reflection will convince us that the rays proceeding from one point can only coincide with the axis of one corneule. In other words, that an image of the pin's point can only be formed at the base of that ocellus whose corneule is exactly opposite to it. Because all rays which enter the corneule in any other direction than one parallel to the axis of the ocellus strike against the sides of the latter and are absorbed. And thus, although the bee has 4,000 eyes, it only uses one of them at one time. A large body, of course, is visually dissected by the corueules, and the resultant vision is the sum total of the images *transmitted.*

There is in the insect kingdom so large a field that we feel tempted to occupy more space than we have at our disposal. We must content ourselves with urging our readers to make the development of insects a study, and to work up the life history of some one insect, rather than cut up and embalm, out of mere acquisitiveness, a whole genera. This will occupy any man for years, and will give him a name which is better than fame. Lowndes' magnificent monograph on the housefly is a case in point. Those who are indisposed to undertake such 'a toil of a pleasure' may very profitably engage themselves in working out the homologues of certain insect organs; in tracing the modification of the respiratory system and the circulatory organs, the Arachnidia they may trace a higher stage in the development of the organs of vision in the multiplied single eye, each devoid of the power of motion in the socket, but characterized by a decided approach in similarity to the highly developed visual organ of the vertebrate. In studying the tracheal system of insects, the student must be cautious in his interpretation of the 'watered-silk' appearance of the tracheal tubes when these are mounted under pressure. The true spiral character of these, owing to the folds being brought so closely together that the under is nearly in focus with the upper, is so far disguised that a tyro might easily form wrong conclusions respecting them. And, perhaps, a few general cautions respecting errors of interpretation may be admissible here. The most frequent source of error (supposing good lenses are used) is want of accuracy in focussing. We cannot too strongly impress upon our readers the importance of being quite sure that any object they have under observation is exactly in focus. With some objects, and with high powers, this is not easy. Indeed, with some, as the discoidal diatom Actinoptychux undulattu, but a small portion can be in focus at the same time, and the student must in this case take care to have this portion in the centre of the field and to look only at that. Another common source of fallacy is what is known as diffraction. If any opaque object be held in the course of a pencil of light its shadow will not possess a sharply defined edge owing to the rays being slightly inflexed as they pass by it. In passing through a transparent body a similar phenomenon takes place, and if the light be polychromatic the shaded diffraction band will exhibit prismatic fringes. Error of interpretation from this source can only be avoided by the exercise of great care and the careful comparison of the appearances the object exhibits under several modes of illumination. When the object is entirely a new one, the student must never repose any confidence in his first interpretation of its appearance either by transmitted or reflected light. Certain objects will reverse their lights and shadows, owing to their own refractive power. This is noticeably the case with blood discs. The form of other objects leads to errors respecting them. We need only mention one case - that of the human hair, which to the novice when viewed in a dry state always conveys the idea of being a tube. This source of error also causes the learner to be greatly troubled by the appearance which air bubbles and oil globules assume under high powers. The student cannot do better than make a careful study of air bubbles in water, in glycerine, and in balsam, of oil globules in water and of water globules in oil. We will also impress upon our readers the great importance of making themselves familiar with the appearance, when magnified highly, of those substances which float in the air and are commonly deposited in the form of dust; especially will we name starch granules, butterfly scales, fragments of wood, wool, and hair".

HENRY POCKLINGTON,

Figure 8. *Henry Pocklington, photograph probably in late 1907 or very early 1908. Adapted from the Proceedings of the Insurance Institute of Yorkshire, 1907-1908*

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